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A TRANSDIAGNOSTIC APPROACH TO THE USE OF VIRTUAL REALITY IN THE PREVENTION OF EATING DISORDERS

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SUMMARY

INTRODUCTION

"Virtual Reality" (VR) includes an array of technologies that allows individuals to experience and interact with computer-generated three-dimensional environments and objects through a head-mounted display (Maples-Keller et al., 2017). Immersivity and realism offered by VR helps individuals to experience a sense of "emotional presence" comparable to reality in inducing emotional responses (Gorini et al., 2010; Riva et al., 2002). Therefore, the application of VR in clinical psychological contexts as an instrument to offer patients a systematic and controlled exposure therapy without the complications of in vivo exposure (Wiederhold & Wiederhold, 2005) has been supported and VR showed to improve existing cognitive-behavioral treatments (CBT) and prevention protocols especially in anxiety, psychotic, substance-related, and eating disorders (EDs) (Emmelkamp & Meyerbröker, 2021; Freeman et al., 2017a; Riva, 2022). Recently, VR software capable of being administered transdiagnostically across different clinical and non-clinical populations have also been designed (Colombo et al., 2021). According to the transdiagnostic approach, indeed, many psychological disorders and comorbid psychiatric diagnoses are maintained or caused by similar cognitive and/or behavioral processes (Harvey et al., 2004), defined as transdiagnostic factors. While research has yet to come to a consensus regarding a fixed-number of specific transdiagnostic factors leading to the main psychological disorders, studies showed how, especially within the more recent third-wave cognitive-behavioral theory of mental disorders (Hayes & Hofmann, 2017), several psychiatric diagnoses (e.g. mood and anxiety disorders, substance use disorders, and EDs) would all be characterized by psychological inflexibility (Hayes et al., 2006), emotion dysregulation (Aldao et al., 2010a; Fairholme et al., 2010), and experiential avoidance (Hayes, 2004; Hayes et al., 1996). However, to date VR protocols capable of being administered transdiagnostically across different clinical and non-clinical populations have been designed to improve emotion regulation (ER) strategies only (Colombo et al., 2021).

One of the clinical fields in which transdiagnostic approaches found the most evidence is EDs (Atwood & Friedman, 2020). According to the main transdiagnostic cognitive-behavioral theoretical model for EDs (Fairburn et al., 2003), all EDs are characterized by similar specific ED features (e.g. over-evaluation of shape and weight, and excessive control over eating) and maintained by shared non-specific ED factors (e.g. low self-esteem, clinical perfectionism, and interpersonal difficulties). Third-wave cognitive-behavioral transdiagnostic factors (i.e. psychological inflexibility, emotion dysregulation, and experiential avoidance) would also play a role in the onset and maintenance of EDs both in the clinical (Heffner et al.,

2003; Rawal et al., 2010; Westwood et al., 2017) and general population (GP) (Della Longa & De Young, 2018a; Han & Pistole, 2014; Masuda et al., 2010). Therefore, their reduction could help improving dysfunctional eating behaviors (Bluett et al., 2016; Holmqvist Larsson et al., 2020; Skinner et al., 2017a).

Despite the literature supporting both transdiagnostic treatments (Atwood & Friedman, 2020) and VR-based interventions for EDs (Ciążyńska & Maciaszek, 2022; Clus et al., 2018; Ferrer-García & Gutiérrez-Maldonado, 2012; Riva et al., 2021), so far no transdiagnostic VR-based intervention for the treatment or prevention of EDs in the GP have yet been designed to concurrently tackle, together with ER, also other third-wave cognitive-behavioral transdiagnostic factors such as psychological flexibility and emotional avoidance. Therefore, the Ph.D research project object of this dissertation was designed with several aims: (Study-1) to explore the acceptability (in terms of sense of presence, user experience, and elicited motion sickness) of an innovative VR software (H.O.M.E. – How to Observe and Modify Emotions) designed to concurrently tackle these transdiagnostic factors in GP with ED risk; (Study-2) to evaluate its feasibility and effects in improving the aforementioned transdiagnostic factors and reducing eating-related symptoms in this population, also when compared to waiting-list and at 3- and 6-months follow-up; and (Study-3) to qualitatively investigate opinions about the H.O.M.E. intervention of those completing it.

The present Ph.D dissertation has been divided in two parts. The first part of the dissertation (chapters one, two, and three) will summarize the present literature about eating disorders, transdiagnostic factors, and the use of virtual reality in clinical psychology. More specifically, the first chapter of the dissertation will focus on summarizing the literature regarding EDs and transdiagnostic factors associated with these psychopathologies. In particular, the role of psychological flexibility, experiential avoidance, and emotion regulation in the onset and maintenance of EDs will be discussed. In chapter two, a definition of VR will be given and its application in the fields of clinical psychology (and, in particular, in the treatment and assessment of EDs) will be highlighted. Chapter three will, instead, focus on reporting the results of a systematic review of the literature (Gardini et al., 2022) that was conducted to explore the use of VR-based interventions on transdiagnostic factors for mental health. Chapter three will also include the description of H.O.M.E. as a novel VR software and intervention that has been used, in this Ph.D. research project, to prevent eating disorders in the general population.

The second part of the Ph.D. dissertantion, instead, will focus on presenting the experimental studies that were part of the Ph.D. research project. In particular, chapter four

will summarize the rationale supporting the three studies mentioned above, as well as the methodology that was used to recruit participants. Chapter five, six, and seven will, instead, provide a summary of the methodology and results of each of the three studies that were carried out. The results of the experimental studies will then be discussed in the last chapter of this Ph.D. dissertation.

PART 1.
OVERVIEW OF THE CLINICAL CHARACTERISTICS OF EATING DISORDERS, THE TRANSDIAGNOSTIC APPROACH, AND THE USE OF VIRTUAL REALITY IN CLINICAL PSYCHOLOGY

CHAPTER 1.
A TRANSDIAGNOSTIC APPROACH TO EATING DISORDERS

1.1 Feeding and eating disorders

According to the DSM-5-TR (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision) (American Psychiatric Association, 2022), eating and feeding disorders encompass a range of clinical conditions characterized by persistent disturbances in eating patterns, behaviors, and attitudes towards food and body weight.

Due to the alterations in food consumption, EDs are associated with *impairment of physical health* (such as malnutrition, alterations in the cardiovascular system, dermatological, neurological, gastrointestinal consequences) and *impairments in psychological functioning* (e.g., presence of distress and anxiety and/or depressive symptoms) and *social functioning* (impairment of interpersonal relationships, family conflicts) (Ballardini & Schumann, 2011). The DSM-5-TR (APA, 2022) provides standardized criteria to aid in the diagnosis and classification of these complex mental health conditions. The DSM-5-TR (APA, 2022) reports eight diagnostic categories of EDs: Anorexia Nervosa, Bulimia Nervosa, Binge-eating Disorder, Pica, Rumination Disorder, Food Intake/Restrictive Avoidant/Restrictive Disorder, Eating or Feeding Disorder with Other Specification, Eating or Feeding Disorder Without Specification. Anorexia Nervosa, Bulimia Nervosa and Binge-eating Disorder are the EDs that tend to manifest in different age groups, while Pica, Rumination Disorder, Avoidant/Restrictive Food Intake Disorder usually manifest in younger individuals. Other Specified Feeding or Eating Disorders and Unspecified Feeding or Eating Disorders refer to those disorders that cannot fall into the above categories.

Although categorical classification of EDs is important in order to facilitate the diagnostic process and communication between clinicians, in the clinical setting authors encourage to also consider a more dimensional approach to EDs (Ballardini & Schumann, 2011). Indeed, ED symptoms are often present transdiagnostically in different clinical pictures: for example, cognitive and behavioral food restriction and body dissatisfaction can be present

in almost all ED categories. In addition, it has been observed that, with respect to the longitudinal development of the disorder, ED symptoms can change over time and disorders can switch from one category to another, such as from anorexia nervosa to bulimia nervosa (Ballardini & Schumann, 2011). Moreover, comorbidities are common in EDs, both in terms of other psychiatric disorders (e.g. anxiety disorders, mood disorders, obsessive-compulsive disorder, substance use disorders), but also in terms of personality traits associated with EDs, such as low self-esteem, perfectionism, social insecurity (Coelho et al., 2015).

Identifying transdiagnostic dimensions makes it possible to collect more information, placing the person in a broader frame of reference, and consequently allows for the identification of personalized therapeutic plans.

When considering a categorical approach to EDs, however, the most up-to-date international data on the prevalence and incidence of these disorders come from a recent study published in Lancet Psychiatry on the epidemiology and burden of twelve mental disorders, including EDs (GBD 2019 Mental Disorders Collaborators, 2022). Data show that in 2019 the global prevalence of EDs in men and women was around 13 million people, with around 174 cases per 100,000 people in Europe. The results confirm previous literature that EDs are more common in women rather than in men and more frequent in high-income regions (American Psychiatric Association, 2022).

In Italy, according to the Istituto Superiore di Sanità, ED prevalence estimates concern about three million people (5% of the population), of which 70% are adolescents. Onset seems to have become increasingly early among younger people (Mastrobattista & Pacifici, 2022). However, the epidemiological data are considered by several authors to be inaccurate, for example due to the heterogeneity of the diagnostic tools used, and are believed to lead to an underestimation of the extent of the phenomenon. Therefore, further studies characterized by methodological rigor are needed that can provide more accurate epidemiological estimates.

1.1.1 Anorexia nervosa

Anorexia Nervosa (AN) is characterized by: a restriction in caloric intake compared to needs, leading to a significantly low body weight compared to what is considered appropriate for age, biological sex, development, and physical health; an intense fear of gaining weight or becoming fat, or persistent behavior that interferes with weight gain; an alteration in the way weight or body shape is experienced; an excessive influence of weight or body shape on self-esteem, or a lack of recognition of the severity of the underweight condition (APA, 2022).

Specifiers for AN included in the DSM-5-TR (APA, 2022) refer to: type, remission, and current

severity. As far as AN type is concerned, in *Restricting type* Anorexia Nervosa the patient presents no episodes of binge eating or purging behaviors in the past three months, therefore weight loss is achieved primarily through dieting, fasting, and/or excessive physical activity. In *Binge-eating/purging type* Anorexia Nervosa the person has endorsed in episodes of binge eating or purging behaviors in the past three months to achieve weight loss. Moreover, the DSM-5-TR (APA, 2022) includes *partial remission* (when the low body weight criterion is no longer met) or *Complete remission*, (if none of the criteria are met for a period of time) as additional specifiers. The severity specifier, instead, considers the patient's current severity as based on their Body Mass Index (BMI = kg/m2): mild BMI ≥ 17 kg/m2, moderate BMI 16-16.99 kg/m2, severe BMI 15-15.99 kg/m2 and extreme BMI < 15 kg/m2.

The DSM-5-TR (APA, 2022) also reports the 12-month prevalence of AN in young females (0.4%) with an approximate female-to-male ratio of 10:1 in the clinical population. More up-to-date data on prevalence in the international general population are reported in a systematic review by Galmiche and colleagues (2019), which considers 121 studies conducted from 2000 to 2018 in America, Asia and Europe. The authors found that 1.4% of women and 0.2% of men are diagnosed with AN during their lifetime. In Italy, data reported by the Ministry of Health estimate a lifetime prevalence of 0.9% for AN in the general female population (over 18 years of age), while incidence estimates account for 8 new cases per 100,000 women per year (between 0.02 and 1.4 for men) (Pezzana, 2019), with an age of onset of 15-19 years and a sharp increase in cases with an early onset (Pezzana, 2019).

1.1.2 Bulimia Nervosa

Bulimia Nervosa (BN) is characterized by: recurrent episodes of binge eating followed by inappropriate compensatory behaviors (i.e. self-induced vomiting, use of laxatives, etc.) to prevent weight gain, occurring at least once a week for three months and low self-esteem levels that are severely affected by body shape and weight (APA, 2022). Binge eating episodes consist in the ingestion of significantly higher quantities of food in a given period of time compared to what most people would eat in the same amount of time under similar circumstances. These episodes are also characterized by feelings of loss of control over while eating. Compensatory behaviors consist of behaviors such as self-induced vomiting, use of laxatives, diuretics, or other medications, fasting, or excessive physical activity. Similarly to AN, specifiers for BN in the DSM-5-TR (APA, 2022) concern remission (partial or complete) and current severity, which is based on the frequency of compensatory behaviors.

The American Psychiatric Association (2014) indicates a prevalence estimate for BN of 1-

1.5%, with a similar ratio of females to males as that seen for AN (10:1). Peaks of onset occur during late adolescence and early adulthood. The data of Galmiche & Colleagues (2019) report that BN can be diagnosed in 1.9% of women and 0.6% of men in the general population at least once in their lifetime.

In Italy, the lifetime prevalence of BN is estimated to be 1.5%, with an incidence of 12 cases per 100,000 women per year (0.8 in men) (Pezzana, 2019).

1.1.3 Binge-Eating Disorder

Binge-eating disorder (BED) is characterized by recurrent episodes of binge eating which, contrarily to BN, are not followed by compensatory behaviors. Binge eating is associated with: eating large amounts of food very quickly, even when not feeling hungry and until one feels unpleasantly full, eating alone because of embarrassment, feeling disgusted with oneself, depressed or very guilty after the episode, feeling marked discomfort (APA, 2022). The specifiers include remission (partial or complete) and level of severity, which is based on the frequency of binge eating episodes.

The DSM-5-TR (APA, 2022) reports prevalence estimates for BED of 1.6% in women and 0.8% in men, with a less asymmetric sex ratio than AN and BN (American Psychiatric Association, 2014). More recent data estimate the prevalence of BED in 2.8% of the female population and 1.0% of the male population (Galmiche et al., 2019). In Italy, a lifetime prevalence of 3.5% is estimated (Pezzana, 2019).

1.1.4 Pica

Pica is a psychiatric disorder that consist in the persistent ingestion of inedible substances (i.e. which are not food or that do not have any nutritional content) for at least one month. The substances ingested can vary with age: some examples are paper, soap, cloth, soil, chalk, rubber and ice. Thise behavior is inappropriate for the developmental stage of the person and does not fall within cultural or social practices. If the disorder occurs in the course of another mental disorder or medical condition, the severity is such that it warrants further clinical attention.

Pica prevalence rates are unclear (American Psychiatric Association, 2014). A recent study evaluated the prevalence of Pica in children aged 2 to 6 years in a sample composed of children with autism spectrum disorders and intellectual disability, as Pica frequently occurs within these frameworks. In this study, Pica was found in 23.2% of children with autism spectrum disorders, in 8, 4% of children with intellectual disabilities and 3.5% of children in

the control group (Fields et al., 2021). Data concerning the prevalence and occurrence of Pica in the Italian population are not available.

1.1.5 Rumination disorder

Rumination disorder is characterized by repeated regurgitation of food over a period of time of at least one month. Regurgitated food can usually be rechewed, swallowed, or spit out. Repeated regurgitation is not attributable to a medical condition and does not only occur during the course of another eating disorder. In a study conducted in Switzerland on a sample of 1400 children, the prevalence of rumination disorder is estimated in 1.7% of subjects (H. B. Murray et al., 2018).

1.1.6 Avoidant/Restrictive Food Intake Disorder

Food avoidant/restrictive disorder is a psychiatric disorder characterized by persistent inability to meet adequate nutritional needs, which can also be associated with significant weight loss, significant nutritional deficits, dependence on nutritional supplements, and marked impact on psychosocial functioning. The disorder does not depend on lack of food availability or associated culturally established practices. It also does not occur exclusively during the course of AN, BN or other EDs and it is not associated with alterations in the way the person experiences weight or body shape. The disorder is not attributable to another medical condition and is not better explained by another mental disorder. A recent study estimated the prevalence of the disorder in the adult population, finding values of 0.8% in women and 0.9% in men (Hilbert et al., 2021).

1.1.7 Other specified feeding or eating disorder

EDs with other specification is an umbrella category that includes manifestations of symptoms characteristic of a feeding or eating disorder, which cause significant discomfort and impairment of one or more areas of life, but do not meet the criteria for any of the previously described EDs. Examples of clinical presentations which can fall into this category are: *atypical AN* (when the person's weight is within the normal range), *low-frequency and/or limited duration BN* (when binge eating and compensatory behaviors occur less frequently than once a week and/or for less than three months), *low-frequency and/or limited duration BED* (when binge eating episodes occur less than once a week and/or for less than three months), *Purging disorder* (if binge eating is not present but frequent purging behaviors are engaged in order to control weight or body shape), and *Night eating syndrome* characterized by episodes of

nocturnal eating with awareness and memory of eating. In a sample of about 3000 women aged 22 to 27, the presence of the disorder is estimated to be present in 1.5% of cases (Mustelin et al., 2016).

1.1.8 Unspecified feeding or eating disorder

In unspecified eating or feeding disorders, the patient reports symptoms that cause discomfort or impaired functioning in one or more areas of life, but do not meet the criteria for one of the other EDs. The difference between this category and EDs with other specification (previous paragraph) is that in EDs without specification the clinician decides not to specify the reason why the criteria are not met. For example, this category can include cases where there is insufficient information to make a specific diagnosis. Prevalence estimates for unspecified EDs are 4.3% in women and 3.6% in men (Galmiche et al., 2019).

1.2 Risk factors associated with eating disorders

Risk factors can be defined as observable characteristics which can lead to the onset of a considered disorder and that allows to distinguish a population into a high-risk and a low-risk group. These factors can be present at the biological, psychological, family, community, or cultural level and are associated with a higher likelihood of negative outcomes (Kraemer, 1997). EDs can emerge as a result of the interaction of multiple complex variables and risk factors, which can interact in different ways to lead to the onset and maintenance of these psychopathologies (Barakat et al., 2023).

Two of the most investigated risk factors associated to EDs are ***gender*** and ***age***. In fact, EDs have been found to have a higher prevalence in women than in men and to have an onset more frequently in adolescence and early adulthood, although for BED age of onset is usually higher (Jacobi et al., 2004). As pointed out by authors (Mitchison & Mond, 2015), despite the efforts also evident in the DSM-5 (2014) to make ED diagnoses more inclusive towards men, for example by eliminating the criterion of amenorrhea from AN, these psychopathologies have historically been considered as typical of the female gender and almost absent in males. As a result, methodological tools, classification systems and interventions are still mostly women-oriented. These circumstances make it difficult for affected men to recognize and communicate eating problems, as well as for clinicians to diagnose and treat them. In addition, the eating disorders most frequently encountered in adult men are BED and other specified eating disorders, categories often not included in large-scale epidemiological studies, which tend to investigate AN and BN (Mitchison & Mond, 2015).

Socio-cultural factors also play a very important role in the onset and maintenance of EDs, in particular those reinforcing the stereotypically ideal female physique which, especially in Western cultures, is slender and with little fat mass (Keel & Forney, 2013). In fact, in conjunction with the progressive spread of these ideals of thinness, during the twentieth century an increase in cases of EDs, especially AN, was observed in adolescents and young adults. Although it cannot be said with certainty that the diffusion and internalization of this ideal of thinness by young women has increased ED diagnoses, it has been shown that continued media exposure to contents that encourage ideals of thinness, perceived pressure to be thin, and expectations related to thinness (e.g., living longer) can predict increases in levels of cognition and behaviors associated to EDs, such as body dissatisfaction, restrictive diets, and disordered eating behaviors (Culbert et al., 2015). Pressures regarding male physical appearance also emerged through the years, but the ideal male body type tends to be associated with muscularity rather than thinness. This can act as a partial protective factor against EDs characterized by the fear of gaining weight or attempts to lose weight (Keel & Forney, 2013).

However, despite the pervasiveness of exposure to these messages and pressures from society, only some individuals internalize these ideals and even fewer develop an ED, leading to the conclusion that there are other risk factors at play and that EDs are multifactorial psychopathologies (Culbert et al., 2015).

In a society that glorifies ideals of thinness, ***dieting*** is also a common practice that is endorsed by many young people, especially girls. According to studies (Grunbaum et al., 2004), 56.2% of teens tend to eat less food, fewer calories, or foods low in fat to lose weight or keep from gaining weight, whereas 65.7% exercises in order to lose weight. Dieting behaviors have been seen to be corelated with ED symptoms and even ED onset (Messer et al., 2024; Spear, 2006). Indeed, Patton and colleagues (1999) found that dieting was the most important predictor of EDs, with young people adhering to strict and rigid dietary rules, whether because of society standards or pressures from peers and family, presenting a risk 18 times higher of developing an ED in the 6 months following the diet (Patton et al., 1999).

Early dieting also seems to constitute a risk factor for the development of obesity. Indeed, voluntary restriction of food intake can lead to denial of hunger cues and to stop or skip meals even while hungry. Moreover, dieting causes an irregular nutrients intake in the body, which would cause a dysregulation of the normal appetite system, thus promoting weight gain (Field et al., 2003). This would lead to a subsequent overeating as well as binge-eating episodes (Huon, 1994; Messer et al., 2024; Stice et al., 2005; Westenhöfer & Pudel, 1996). Studies found

that dieting and radical weight-loss behaviors predicted greater subsequent weight gain and increased the risk for onset of obesity and binge eating (Field et al., 2003; Messer et al., 2024).

On the opposite side, childhood overweight or obesity have also been observed to represent a risk factor for the development of EDs in adolescent (Cena et al., 2017; Micali et al., 2015; Rancourt & McCullough, 2015). This association might be caused by the fact that EDs and obesity often share many risk factors (such as the ones mentioned above) (Stabouli et al., 2021; Taylor et al., 2018). Moreover, weight-related teasing that children with obesity or overweight might experience from family or peers, the negative impact on self-esteem, self-evaluation and body image caused by thin beauty ideal perceptions deriving from the social environment or media, as well as the stigma associated with obesity (Puhl et al., 2020) may lead these individuals to engage in extreme behaviors to lose weight (e.g. strict dieting) or to psychological distress which might further increase binge-eating episodes or bulimic symptoms (Dingemans et al., 2017; Goldschmidt et al., 2008; Puhl et al., 2020).

Characteristics related to the ***family*** can also represent other risk factors associated to EDs. The family can, for example, influence levels of body dissatisfaction experienced by the person, through pressure and comments about weight or body shape. In addition, dysfunctional behaviors such as following strict diets for a long time may be present within the family: in particular, in families of people with BN usually more attempts at diets with the aim of losing weight are made (Dalle Grave, 2014). The presence of parents with high expectations of their children or, on the contrary, who are not interested in them, and a tense family climate, are also more frequently found in patients with AN and BN, making them potential risks for ED development (Le Grange et al., 2010). In this regard, several theoretical models, in particular the psychodynamic and systemic models (which will be illustrated in subsequent paragraphs), have posed high attention to the role of the family in the onset of EDs.

In addition, although more studies are needed to precisely separate genetic influence from environmental influence, behavioral genetics has shown, using twin studies, that there is moderate-to-high heritability in AN, BN and binge eating disorder (Culbert et al., 2015). However, the rate of heritability is influenced by age, as in preadolescent twins the genetic effects implicated in the origin of EDs are negligible (0-5%) and environmental factors seem to predominate, while the same genetic effects have a fundamental weight in adolescence and early adulthood (>50%) (Klump et al., 2009). Adolescence is, therefore, represent a critical period for the genetic diathesis of EDs, stimulated by the psychosocial and biological changes that puberty brings with it, which seem to increase the incidence of the disorders under study, especially in girls (Culbert et al., 2015).

As previously stated, individual ***psychological and personality factors***, such as low self-esteem, body dissatisfaction, and preoccupation with one's weight, have been seen to facilitate the internalization societal ideals and pressure towards thinness and the implementation of dysfunctional eating behaviors, increasing the risk of developing an ED (Baldissera, 2018; Dalle Grave, 2014; Keel & Forney, 2013). In particular, low levels of ***self-esteem*** were found to be a specific risk factor for both AN and BN, as these levels were significantly lower when compared with other psychiatric and healthy controls (Keel & Forney, 2013; Stice, 2002). Negative self-evaluation specifically seems to precede the onset of EDs and can worsen ED symptomatology in various stages of illness by increasing the endorsement of dysfunctional behaviors: in people with AN and BN, body shape and weight become self-evaluation tools through which the person often defines his or her personal worth (Baldissera, 2018).

Another important psychological risk factor that has been widely studied in the literature is the difficulty in recognizing, identifying, and regulating emotions. As it will be illustrated in subsequent paragraphs, according to some authors (Jacobi et al., 2004; Stice, 2002) difficulty in regulating emotions is a non-specific risk factor for ED development. ***Neuroticism***, defined as the disposition to experience negative emotions more frequently and more easily (e.g. anxiety, sadness, anger), also seems to predict the development of problems related to people's relationship with food and EDs, in particular AN and BN (Cervera et al., 2003).

Perfectionism, defined as an evaluation of oneself that is overly dependent on achieving demanding, self-imposed standards, is another frequently encountered personality trait that has been shown to be a risk factor for the development of attitudes and behaviors typical of disorganized eating, whether considered individually or in combination with other factors (Culbert et al., 2015). As pointed out by Vacca et al. (2021), perfectionism is a multidimensional construct characterized by two dimensions, namely perfectionistic strivings (PS) and perfectionistic concerns (PC): the first dimension allows for the pursuit of ambitious goals and has been associated with positive outcomes, such as a sense of self-efficacy and well-being (Perrone-McGovern et al., 2015), while the latter represents the concern of making mistakes and being judged negatively by others for this and has been considered a transdiagnostic factor of psychopathology (Vacca et al., 2021). Many studies support the correlation between PC and ED symptoms, in particular CP seems to predict the increase in eating disorder symptoms (Vacca et al., 2021). However a study (Esposito et al., 2019) showed that it is mixed perfectionism, which includes both PS and CP, that is associated with the higher

levels of ED symptoms and, hence, it represents the most maladaptive combination. In fact, the tendency to strive for perfection gives patients the motivation to continue with dietary restrictions and weight control, while high levels of self-criticism and concerns about possible failures, typical of CP, maintain the beliefs of not being competent enough and the loop of negative self-evaluation, elements underlying many EDs (Vacca et al., 2021).

Another personality trait that could increase, in particular, the risk of binge eating and purging is ***impulsivity***, which is taking actions or making choices without appropriate control (Baldissera, 2018). Impulsivity is more frequently found in patients with BN, BED or AN with binge eating and purging behaviors, compared to patients with restrictive AN or controls (Claes et al., 2005). In particular, negative urgency, defined as the tendency to commit impulsive actions when under stress, has been shown to be the prevalent form of impulsivity for binge eating and purging symptoms (Fischer et al., 2008). A study (Racine et al., 2017) revealed that genetic factors influencing negative urgency have a strong correlation with genetic factors that contribute to dysregulated eating and that negative urgency can increase the risk of developing binge eating and emotional eating behaviors (the subject eats to regulate his emotions, especially negative ones) mostly through genetic mechanisms, thus being among the risk factors for the development of EDs.

In addition, as reported by Culbert et al. (2015), there are two ***neurocognitive processes*** that serve as potential risk factors for the development of a EDs. The first is ***cognitive flexibility***, defined by authors (Roberts et al., 2007) as the ability to move between multiple tasks or cognitive operations, which is localized in different brain regions, including the pre-frontal cortex, the anterior cingulate cortex and the posterior parietal cortex. This ability is deficient in patients with AN and BN and in the case of AN sometimes the deficit persists even during remission (Tchanturia et al., 2011). The second process is ***inhibitory control***, which involves the suppression, deactivation or substitution of an automatic process or cognitive response in favor of a non-automatic one, and is mediated by the right inferior frontal gyrus, the basal ganglia, the pre-frontal cortex and the anterior cingulate cortex (M. C. Anderson & Weaver, 2009). Deficits in this neurocognitive process have been recorded especially in EDs characterized by binge eating and purging behaviors, such as BN and BED, in which reduced activation of the frontostriatal regions, compared to controls, makes it difficult to resist the urge to consume palatable foods in large quantities (Marsh et al., 2011). However, more prospective longitudinal studies are needed to investigate these two neurocognitive processes also in patients in remission or who already recovered, in order to be able to determine with certainty

that deficits in cognitive flexibility and inhibitory control can actually predict the development of EDs and therefore constitute risk factors (Culbert et al., 2015).

Other frequently studied risk factors are ***psychiatric disorders.*** In particular, anxiety and mood disorders, obsessive-compulsive disorders, and personality disorders were found to increase the likelihood of developing an ED (Jacobi et al., 2004), as research has demonstrated high rates of psychiatric comorbidity that can increase the risk of ED onset, constituting a non-specific risk factor (Coelho et al., 2015). Jacobi et al. (2004) have also observed a higher incidence of ***sexual abuse and life events*** in people with EDs. However, it appears that a history of sexual abuse and other traumatic experiences are equally present in other mental disorders, making this factor transdiagnostic across EDs and other psychiatric conditions (Dalle Grave, 2014).

While other risk factors could be mentioned, it is important to note that these risk factors alone are not sufficient to determine the onset of EDs. Triggering events can also play a key role in the development of EDs, such as experiencing abuse or harassment, family problems, abandonment or neglect, difficulties or failures at school or sports, traumatic experiences, poor relationships with the peer group, and puberty (Cella, 2018). At the same time, however, a single stressful or traumatic event does not necessarily trigger the onset of the disorder without underlying vulnerabilities. In the clinical practice, identifying the risk factors and vulnerabilities present in the patient (especially those that can be changed and improved) represents a fundamental part of the treatment process (Ballardini & Schumann, 2011).

1.3 Traditional theoretical models regarding the onset and maintenance of EDs

In the literature, several theoretical models have been developed to attempt and explain the etiological mechanisms involved in EDs. The main theoretical models that will be described in the present paragraph are the psychodynamic, systemic-relational, neurobiological, cognitive-behavioral and transdiagnostic theoretical models. In addition to these aforementioned models, nowadays one of the main models that used to explain the onset and maintenance of EDs is the Biopsychosocial model developed by Engel in the 1960s as an alternative to the traditional biomedical model (Engel, 1960). The Biopsychosocial model views psychiatric illnesses (including EDs) as resulting from the interaction of different systems, such as cellular, tissue, organic, interpersonal, and environmental systems. Therefore, clinicians should always consider psychiatric disorders as multifactorial conditions and take into account both biological, psychological and social factors (Fava & Sonino, 2008).

1.3.1 Psychodynamic model

Historically, the first theoretical model that was developed to explain the onset and maintenance of EDs is the psychodynamic model, which includes different currents. These models have focused on several aspects such as the unconscious and symbolic meanings of EDs, and have subsequently shifted their focus from internal conflicts to object relations, up to family dynamics.

Psychodynamic formulations of EDs date back to late 1940s and 1950s, when clinicians began to theorize that ED symptoms would be the expression of unconscious motives. In 1940, authors (Waller et al., 1940) proposed that AN would be a defensive response to unconscious conflicts and fears of oral impregnation. Early psychoanalytic authors indeed defined this disorder as the manifestation of an unconscious resolution of internal conflicts and as the patient's resistance to growing up (Freud, 1946). In later years, Hilde Bruch (Bruch, 1962), was the first clinician to link ED symptoms (e.g. body image distortions and fear of becoming fat) to distorted attempts of gaining in control over the environment, especially in people who lived in an oppressive family context. The author further developed this theory in her most famous book, "*The golden cage: The enigma of anorexia nervosa*" (Bruch, 1979), where she explained how children whose experiences and initiatives were limited by parents would be more prone to develop dependency, a negative self-value and incapacity of understand and discriminate their corporeal sensations and emotional states. According to Bruch (1979), when not properly managed these thoughts would be likely to persist even after childhood and, therefore, food would turn into a way to ease the distress caused by parents' deafness to their needs and emotions. Striving for thinness through diet would also offer these patients the chance to feel capable, accomplished, and in control of their internal and external environment (Bruch, 1966).

In the same years, Selvini Palazzoli, who initially followed the current of Object Relations proposed by Klein (Klein, 1930), brought out the importance of the mother-daughter interaction as having a fundamental role in the dynamic processes of EDs (Selvini Palazzoli, 1974). The author came to the conclusion that patients with AN experience their body as threatening, as it is comparable to a negative part of the mother, who tends to be overprotective and unable to recognize the daughter as a separate entity from herself. Therefore, the patient would engage in dysfunctional behaviors as a result of distorted mental representations with respect to the body, the self, and the mother, and ED symptoms would represent an attempt to reduce and resolve a confused identification with the mother.

Other authors as well (Glucksman, 1989; Zerbe, 1993b, 1993a, 2010) have considered the way the unconscious tends to associate food with love and memories regarding the mother. Glucksman (1989) described this as an "unconscious equation" of mother and food that would remain in the individual's unconscious also in adulthood. Food, therefore, would be a source of access to memories, unconscious conflicts, and family dynamics, as well as a way for the patient to self-regulate his/her emotions. For example, patients with BN would use food as a way of self-caring and survival, responding to unconscious memories of being ignored by parents that date back to infancy (Zerbe, 2010).

Even though psychodynamic models have developed through the decades, this approach still looks at ED symptoms as caused by some sort of emotional pain that the patient is not able to recognize and confront directly (Zerbe, 2010). ED symptoms (e.g. binge eating, purging behaviors, restriction, body checking, etc.) would therefore become a way for the individual to cope with life's struggles and would be motivated by unconscious drives and needs. ED symptoms represent a way to avoid facing painful and dangerous thoughts that threaten to possibly dysregulate the personality structure. Thus, EDs become a "defense against remembering and a form of remembering through action" (*Psychoanalytic Terms and Concepts*, 2012).

The concept of "repetition compulsion", first described by Freud (1914), is another psychodynamic principle that authors have used to explain ED symptomatology. According to Auchincloss & Samberg (2012), repetition compulsion can be found in acts such as vomiting or purging. Even when conscious that such dysfunctional behaviors might not necessarily lead to weight loss, patients would still repeat these behavior in an attempt to recreate episodes of their infancy or personal history in a symbolic way.

Lastly, the concepts of "True Self" and "False Self" developed by Winnicott (Winnicott, 1965) seem to find application in modern psychoanalytic models of EDs. According to his theory, when the environment does not allow the individual to elaborate "spontaneous gestures" or does not welcome them, the natural life force of the individual can be disrupted. According to Winnicott, parents have the role of providing a "good enough" environment for their children, in which the "True Self" of the child can be creative, imaginative and feel validated. When the child does not grow up in this kind of environment, the individual can develop a "False Self" that has the role of hiding and protecting the "True Self" by dealing with environmental demands and being its caretaker in an environment that failed him. In relation to EDs, ED symptoms would provide a function of self-protection for

people that lack a cohesive "core-self" and to create a false sense of security from the dissolution of their "self" (Zerbe, 2015).

In conclusion, psychodynamic theories see ED symptoms as an expression of emotional suffering that is managed through dysfunctional behaviors, such as restrictive dieting, binge eating, and compensatory behaviors. Therefore, psychodynamic treatment for EDs focuses on the reduction of internal self-criticism, helping the patient to develop the Self, the importance of the patient's attachment to the therapist (transfert), and the examination of dysfunctional interpersonal relationships (K. Zerbe, 2015).

1.3.2 Attachment theory

First theorized by Bowlby (Bowlby, 1969, 1973, 1980), the "Attachment Theory" puts its main focus on the child's relationship with parents and on the measure in which they are capable of providing a secure base where the child can safely explore the environment. According to the author, the interaction between infants and caregivers determines the attachment style the child develops and it is responsible for the formation of internal working models the child (even in adult life) will use to predict how themselves and others will respond to their personal needs. Different and complex categorization of "attachment styles" have been provided by several authors (Ainsworth et al., 1978; Ainsworth, 1979; Hesse, 1996). These styles can be summarized into 4 main categories:

- Type A (*Anxious-avoidant attachment*), characterized by the avoidance of intimacy or interaction with the caregiver and the rejection of close relationships and negative feelings about the self;
- Type B (*Secure attachment*), found in people who have a positive view of themselves and securely value relationships and intimacy;
- Type C (*Anxious-ambivalent attachment*), which refers to people who present both resistance and demand for intimacy and relationships and that feel negatively about themselves;
- Type D (*Disorganized attachment*), seen in individuals who are unable to form and use strategies for managing relationships.

In research, attachment styles have also been categorized as "secure" (Type B) or "insecure" (Type A, C, D) attachments. Insecure attachment, in particular, is the result of parents or attachment figures that were not able to respond to the child's needs. The person, which at this point felt unloved or rejected, would therefore develop strategies to protect

themselves from their emotional distress. Attachment serves as a framework for building emotion regulation processes and interpersonal relationships, factors that have been seen to have an influence on the development and maintenance of EDs (Abbate-Daga et al., 2010).

Reviews of the literature found that insecure attachment has a strong association with EDs and it represents the attachment style that can be found in almost the entirety of the ED population (Ringer & Crittenden, 2007; Zachrisson & Kulbotten, 2006). Even though it is still not clear whether ED subgroups report a differences or specific attachment styles when compared to other subgroups, some studies suggest that AN would be highly associated with "avoidant/dismissing" styles (Candelori & Ciocca, 1998; Ward et al., 2001), while BN with more "preoccupied" styles (Candelori & Ciocca, 1998). This is in line with studies that described families of BN patients as conflictual, isolated and depriving (Humphrey, 1987). According to the same author, since their family environment is also unpredictable, BN patients would use binge-eating as an attempt to satisfy their needs and compensate their feelings of emptiness with food. Families (and, more specifically, mothers) of AN patients, on the other hand, have been described as more intrusive, overprotective and resistant to the child's need of independence (Minuchin, Rosman, & Baker, 1978). This would cause AN patients to try and avoid the distress associated with their intrusion by complying to the mother's demands (Johnson & Connors, 1994), just like people with a "dismissing" attachment would deny and ignore their emotional distress.

Even though the aforementioned literature seems to agree that individuals with EDs perceive or experience higher rates of familiar dysfunction and poorer parental relationships than controls, more methodologically robust studies comparing controls with ED samples are needed to further confirm these conclusions.

1.3.3 Systemic-relational model

Developed by Ludwig von Bertalanffy (von Bertalanffy, 1950), the systemic theory postulates that it is impossible to explain an individual's behavior and development without taking into consideration the environment and the system of relationships they're part of. In the theory, a family is seen as a system in which each member is an interdependent member necessary for its functioning. The behavior of every family member can be the cause and/or the consequence of the processes that occur within the system/family. According to systemic authors (Minuchin et al., 1978), someone's behavior is not only the result of their individual elements, but also of the interactions that occur between the members of the family.

Psychopathologies would be the consequences of a dysfunction within the family or between the family and the patient.

The systemic-relational model has been applied to EDs in the 1970s, starting the works of Minuchin and colleagues (1978). According to this model, the family is conceptualized as a system, that is, as a set of objects, each of which plays a precise role in relation to the other members and to the family as a whole. The central assumption of the model is that family relationships are mutually influenced by the bonds between members and the rules implicit in the family: as a result, family structure can influence the behavior of individual members over time. In the systemic perspective, therefore, the object of study is no longer the individual or the dyadic relationship between parent and child, but the entire system of interactions in which the members of the family live. Systemic-relational theory identifies the relationships between family members as the element that plays a key role in the onset and maintenance of EDs.

Anorexia nervosa is a psychopathology that has been frequently studied by systemic and family therapy approach (Minuchin, Rosman, & Baker, 1978). In their "psychosomatic family model" Minuchin and colleagues (1978) stated that there is a particular family context which may lead to the development of eating disorders and AN in particular. The authors described this context as characterized by a specific process that can be summarized with four focal factors:

- *Enmeshment*, which is the tendency of the family members to be excessively intrusive regarding thoughts, feelings and actions of the other members; it is a condition in which personal spaces and autonomy are almost non-existent.
- *Rigidity*, represented by the implementation of the same stereotypical rules, that cannot be changed and are meant to give an image of a cohesive family in which there are no problems.
- *Over-involvement*, which is given by the lack of boundaries in the family that causes the behavior of one member of the family having an immediate and excessive effect on the others.
- *Conflict Avoidance*, which manifests in the mechanisms the family members use to hide and avoid conflictuality and disagreement, which remain latent and unresolved.

This process grows together with the symptoms of the disorder and interacts with vulnerabilities in the child, with them being a mediator in cross-generational alliances (Minuchin, et al., 1975). ED symptoms would therefore develop with the function of maintaining family balance (also called homeostasis in the systemic approach): the sick patient is therefore called the "designated patient", as they have the function of maintaining balance in

the family (Minuchin et al., 2014). Unfortunately, researches that tried to confirm the existence of these so-called "psychosomatic families", which the authors considered a necessary context for the development of eating disorders, were inconclusive and unconvincing and indicated that families of ED patients are heterogeneous in sociodemographic characteristic, in the nature of the relationships, in emotional climate and in the patterns of family interactions (Eisler, 1995).

1.3.4 Neurobiological model

Neurobiological theory, through neuroscientific and neurophysiological studies, attempts to define how neurobiological vulnerabilities contribute to the onset and maintenance of EDs (Mishra et al., 2017).

Neuroimaging studies have been conducted on brain responses to salient stimuli, such as food and body image, which have allowed us to investigate the brain areas and structures involved in food image processing and body image (Madden, 2015). For example, the amygdala is central to threat perception and is activated in response to food in people with AN (Joos et al., 2011). Other brain alterations include a lower activity of the inferior parietal lobe, which is important for pleasure related to food (Santel et al., 2006), and lower anterior cingulate cortex activity, which is important for anticipatory reward (Joos et al., 2011). In eye-tracking studies, people with AN showed less attention to images depicting food than controls (Giel et al., 2011) and fMRI studies have shown less activity of the occipital lobes (where the visual cortex is located) in response to images of food (Santel et al., 2006). Studies suggest that people with AN manage to ignore food even during periods of fasting, as well as to ignore the normal hunger response, and tend to respond to food as if it were a threat (Madden, 2015). Regarding body image processing, studies suggest that when people with AN look at images of themselves, they show less activity of the occipital cortex, insula, and prefrontal cortex, with a suppression of normal cognitive and emotional perception of body image. When looking at images of other people, they also put more focus on the details of specific parts of the body rather than on the body in general (Urgesi et al., 2012).

In summary, people with AN show a lower activity of the amygdala (important for fear, threat perception and anxiety), an ability to focus less attention on food and a decreased activity of the areas responsible for processing visual information: these results are consistent with the clinical presentation of AN characterized by intense fear of food, of gaining weight and a distortion of body image (Madden, 2015). In addition, people with AN appear to have a less efficient reward system and rely more on complex cognitive strategies: this may explain the

high levels of anxiety in response to normal stimuli, the lower ability to make decisions, and the high levels of perfectionism that have been observed in this clinical population (Madden, 2015).

Studies that have delved into the neurobiological processes of other EDs are quantitatively inferior. In BN, abnormal brain activation was found in the insula, thalamus, and anterior cingulate cortex, which are structures involved in the processing of enteroceptive perception and the alteration of regions responsible for reward mechanisms, such as basal ganglia and thalamus (Klabunde et al., 2017).

Studies that have investigated the most common brain alterations in EDs have shown damage to the frontal, right temporal and parietal lobe. In particular, the prefrontal cortex is implicated in cognitive control in both AN and BN, while parietal alteration seems to be associated with body image distortions (Mishra et al., 2017). A growing interest in the literature also concerns the study of emotion processing, in particular the identification and description of emotions: deficits in ER have been found in people at risk of developing EDs (Hatch et al., 2010), together with a deficit in recognizing facial emotions, specifically a difficulty in accurately recognizing positive or neutral emotions (Jones et al., 2008).

1.3.5 Cognitive-behavioral model

Starting from the 1980s, the first cognitive-behavioral models were developed to separately explain the onset and maintenance of AN and BN (Fairburn, 1981; Garner & Bemis, 1982). These models viewed AN and BN as "essentially cognitive disorders"(Fairburn, 1997), with the core ED symptomatology involving the overvaluation and control of weight and shape.

In particular, cognitive-behavioral authors (Garner & Bemis, 1982) tried to describe AN as a disorder that was caused and maintained by different predisposing factors regarding the patient and their environment. Temperamental traits such as perfectionism, obsessionality and hypersensitivity have been considered in different theoretical approaches (Bruch, 1979), including the cognitive-behavioral one, as playing a big role in the aetiology of AN. Cognitive-behavioural researchers contributed to explain how these traits interact with sociocultural aspects to cause ED symptoms (Vitousek & Brown, 2015). According to these theorists (Smolak & Levine, 1996; K. M. Vitousek & Brown, 2015), eating and weight concerns may get triggered by external stressors (such as interpersonal conflicts, life changes, comments and/or teasing from peers/parents, etc.) and/or by individual characteristics linked to AN. For example, traits such as persistence, perfectionism and the ability to suppress hedonic impulses may lead to (and be rewarded by) long dieting. Thus, the dysfunctional belief that weight is the

most relevant index of self-worth would form and that may cause AN stereotypical eating behaviours and elimination tactics (Vitousek & Brown, 2015). By releasing anxiety and bringing a sense of reward (e.g. by aiding weight loss or avoiding food), these dysfunctional eating behaviors also serve as a (positive or negative) reinforcement for the maintenance of ED symptoms (Murphy et al., 2010) and, consequently, they would cause abnormal information processing and the formation of cognitive biases (Vitousek & Brown, 2015). For example, "*thought-shape fusion*" (the thought that thinking about food might lead to weight gain, body dissatisfaction and a feeling of doing something morally wrong) and "*thought-action fusion*" (the belief that thinking about a negative event might make it happen) are two cognitive distortions that might be linked to eating pathology (Coelho, Ouellet-Courtois, Purdon, & Steiger, 2015). "All-or-nothing thinking" (e.g. having a lot of food or none at all), "over-generalization" (e.g. the belief that eating something will drastically make you fail in losing weight), "jumping to conclusions" (making a negative prediction even though there is no evidence to support it) and "emotional reasoning" (e.g. if you feel fat, then you must be fat) are some other cognitive distortions reported in ED patients (Parish-Walker, 2012). These maladaptive cognitions developed by ED patients regarding weight and food would produce an automatic way of processing information. For example, through these schemas patients would automatically select signals possibly related to "fatness", would pose a weight-relating meaning to neutral comments or events, and would ignore information that are in conflict with their personal schemas (like ignoring evidences of their excessive weight loss and thinness) (K. B. Vitousek & Hollon, 1990).

When talking, instead, about BN, the first cognitive-behavioural model that tried to explain this ED was developed by Fairburn in 1980s (Fairburn, 1981, p. 198) and, unsurprisingly, it did not differ drastically from the AN model. Similarly to AN, BN was also described as a disorder characterized by the said core psychopathology (i.e. overvaluation and control of shape and weight), which would produce behaviours such as limitation of food intake, compulsive body checking and use of compensatory behaviour. Binge eating episodes (which are probably the most prominent feature of BN) would be caused indirectly by this core ED psychopathology (Fairburn et al., 1986, 2003, p. 19). Self-imposed food restriction, for example, would end up, contrarily to AN cases, in frequent failures to respect the rigid dietary rules imposed by the patient on themselves, to which the patient would react by abandoning dietary restraint altogether. These episodes would be experienced by BN patients as signs of weakness and as episodes of loss of control and would therefore intensify patient's concerns about food, shape and weight. Consequently, BN patients would react to these failures by

making further excessive attempts to restraint their caloric/food intake and by using vomiting or laxatives/diuretics in order to compensate the bingeing episode. By attenuating their anxiety and guilt, these behaviours serve as reinforcement for the bulimic cycle (Fairburn, 2008; Fairburn & Beglin, 2008) and produce cognitive biases (Fairburn, 1997).

1.3.5.1 Transdiagnostic cognitive-behavioural model

Despite the existence of the aforementioned separate models for AN and BN, nowadays researchers agree more and more on the instance that different EDs are caused by common underlying mechanisms (Beumont, Garner, & Touyz, 1994; Holmgren, Humble, Norring, & Roos, 1983). Because of this, a ***transdiagnostic cognitive-behavioral model*** for EDs was proposed (Fairburn, 2008; Fairburn, Cooper, & Shafran, 2003) and, today, it represents the most widespread theoretical model in the field of EDs. This model emerged as a result of several limitations in the traditional cognitive-behavioral models for single EDs, such as the instability of diagnoses, the similarity of symptoms, the pattern of longitudinal development of the disorders, and the evidence of familial risk that suggests common mechanisms.

This model sees a dysfunctional system of evaluation of one's own value at center of the development and maintenance of EDs. While healthy subjects evaluate themselves on the basis of the perception of their performance in different areas of life, such as work and the quality of their relationships, patients with EDs rely largely or exclusively on their eating habits, body shape and weight, and their ability to control them, defining excessively high standards and rules for themselves, which revolve around the goal of thinness. In addition, other maintenance factors have also been identified, which include ***perfectionism*** of clinical relevance, for which the judgment of the self depends on the ability to achieve very demanding goals, even neglecting the potential negative consequences; a ***core low self-esteem***, which implies a negative self-evaluation that, unlike what is theorized by the traditional cognitive-behavioral model, exists regardless of rigid dietary goals; an ***intolerance of negative emotional states***, which are regulated in a dysfunctional way, predominantly through dysfunctional eating behaviors (e.g. binge eating episodes); and ***interpersonal difficulties***, especially in the family, which can trigger episodes of binge eating or reinforce restrictive eating behaviors as control over food compensates for the perceived lack of control in relationships with others (Fairburn et al., 2003). As described in this and previous paragraphs, these maintenance factors are present in BN, AN, and also other EDs, leading to the conclusion that these disorders would be characterized by the same pathological processes and thus corroborate the transdiagnostic perspective (Fairburn et al., 2003). In addition, it has been observed that ED patients often shift

between different ED diagnoses (e.g. it is common for those who do not recover from AN to develop BN), further proving that similar transdiagnostic factors may play a role in all EDs (Fairburn et al., 2003).

According to this approach, all EDs would be caused by the core ED symptoms seen above (e.g., overvaluation of weight, shape and eating and its consequent dysfunctional eating behaviors typically found in EDs) and by four common transdiagnostic factors (perfectionism, core low self-esteem, mood intolerance and interpersonal difficulties) that interact with the said core ED psychopathology.

The transdiagnostic model for EDs has been widely supported by studies that showed how eating, weight and shape concerns correlate with (and sometimes predict) other ED symptoms (Cooper, 1997; Cooper, 2005; Vitousek, 1996; Williamson, White, York-Crowe, & Stewart, 2004). Moreover, the presence of cognitive biases regarding food and weight in ED patients has also been confirmed by several studies (Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Cooper, 1997; Cooper, 2005; Dobson & Dozois, 2004; Lee & Shafran, 2004).

1.4 The transdiagnostic approach

The transdiagnostic approach has been developed within the cognitive-behavioral theoretical framework as a model that aims to identify the common fundamental processes underlying psychopathologies (Barlow et al., 2004). This model was born from some considerations regarding the etiological and maintenance processes underlying mental disorders and the limitations of the current psychiatric approach (Fusar-Poli et al., 2019).

The transdiagnostic approach was born as an alternative proposal to the nosographic system that characterizes contemporary psychiatry and is based on the DSM-5-TR classification systems (American Psychiatric Association, 2014) and ICD-10 (World Health Organization, 1990). The DSM-5-TR (APA, 2022), most widely used in clinical psychology, adopts a categorical approach, i.e. the disease is considered present or absent, based on the clinical assessment of the presence or absence of a certain number of symptoms. According to this approach, a psychiatric disorder is the sum of this set of symptoms and a single person can satisfy criteria for more than one diagnosis, which are called comorbidities (Avasthi et al., 2014). Due to the adoption of classification systems both in research and in the clinical practice, many researchers have attempted to identify the risk factors and specific causes of psychiatric disorders by studying the etiological factors separately for the various disorders (Nolen-Hoeksema & Watkins, 2011). However, authors noticed several limitations with this approach. First, mental disorders frequently exhibit similar etiological and maintenance processes, with

common cognitive and/or behavioral processes being clinically defined as transdiagnostic factors. Some of the transdiagnostic factors that are more commonly studied in the field of psychiatric disorders include, for example, environmental experiences and traumatic events (such as sexual and physical abuse), family experiences (such as inadequate parental relationships, presence of psychopathology in family members), cognitive processes (attention, memory, rumination), personality traits (such as neuroticism, perfectionism, etc.) (Nolen-Hoeksema & Watkins, 2011). Secondly, the classical psychiatric approach takes little account of comorbidities: it has been observe in the clinical practice that more than half of individuals diagnosed with a psychiatric disorder also meet the criteria for at least another disorder, and over time the transition from one diagnosis to another occurs (Kessler et al., 2005). Despite this, clinicians tend to apply the same main psychotherapeutic interventions on patients who are quite heterogeneous among themselves, without taking into account aspects such as the patient's clinical history, symptomatology, previous treatments and the stage of illness the patient is at at the time. Stigmatization can also derive from the diagnostic label attributed to the patient (Nolen-Hoeksema & Watkins, 2011).

Although the traditional nosographic approach also presents several advantages, such as the facilitation of communication between mental health professionals in both clinical and research settings, where it is necessary to have common definitions and criteria in order to study the etiology and epidemiological data of disorders, and the possibility of providing the patient with an accurate explanation through a specific diagnosis (Avasthi et al., 2014), main limitations were also highlighted. The transdiagnostic approach attempts to overcome such limitations concerning the nosographic approach by creating an alternative classification system (Fusar-Poli et al., 2019).

Although this approach may represent a new paradigm that can influence the way mental health professionals classify, prevent, and treat disorders, the main criticism that has been posed to this model stands in the fact that it is difficult to concurrently explain the mechanisms by which the same transdiagnostic risk factor leads to multiple disorders and the mechanism by which an individual presenting a particular transdiagnostic risk factor develops one set of symptoms while another patient a different one (Nolen-Hoeksema & Watkins, 2011).

A transdiagnostic model is that of Nolen-Hoeksema and Watkins (2011), which identified the main transdiagnostic factors associated to psychiatric disorders and attempted to explain how they affect each other to cause psychopathology. The authors organized transdiagnostic factors into distal and proximal to psychopathology. The ***Distal Factors*** include

the environmental context and biological alterations, aspects which are independent from the person's actions: some examples are the presence of psychopathology in the parents, traumatic events, genetic alterations or congenital abnormalities in brain structures. These factors are an initial predisposition towards ***Proximal Factors***, which may lead more directly to the development of symptoms. These factors have been identified from evidences in the literature and have been grouped into three categories: biological factors (such as amygdala overactivity), cognitive deficits (such as attention deficit) and individual psychological differences, which lead to people responding differently to situations. Personality traits such as neuroticism and negative affectivity and emotional regulation also fall into this latter category. Distal and proximal factors are connected in different ways: distal factors can influence the way a person responds to the environment, but also their beliefs and self-image or their ability to adopt appropriate coping strategies. Finally, there are the ***Moderators,*** which determine the symptoms that the individual will develop from proximal factors: one of the mechanisms considered is the change in sensitivity and reinforcement to certain internal or external stimuli. Going into the merits of specific disorders, a transdiagnostic model for anxiety and mood disorders has been hypothesized, with respect to common genetic, familial and environmental risk factors and cognitive, interpersonal and behavioral maintenance factors (Newby et al., 2015). This theory finds psychotherapeutic application in Transdiagnostic Cognitive Behaviour Therapy (tCBT), a protocol developed for the treatment of anxiety and mood disorders from a transdiagnostic perspective. tCBT, which developed from the identification of cognitive and behavioral processes common to anxiety and mood disorders, is an example of how a single treatment can be applied in a range of clinical pictures (Andersen et al., 2016). tCBT integrates some of the main components of CBT, such as psychoeducation, self-monitoring, cognitive restructuring, and exposure to feared stimuli. Cognitive restructuring is applied to the general discomfort experienced by the person in daily life, rather than to the most urgent and obvious fears. (Erarslan & Yorulmaz, 2021). tCBT has also shown good results in the transdiagnostic treatment of anxiety disorders in group settings (Norton et al., 2008).

1.4.1 The transdiagnostic approach in ED treatment

Apart from the treatment of mood and anxiety disorders, nowadays the transdiagnostic approach has also been applied to the treatment of EDs. Fairburn's transdiagnostic model argues that at the base of EDs there is a common psychopathology, characterized by an excessive evaluation of eating, weight and body shape, which leads the person to define their personal value starting from the ability to control their eating habits, weight and body shape

(Fairburn et al., 2003). Self-evaluation based on these parameters can lead the person to engage in dysfunctional and unhealthy behaviors, such as food restriction, binge eating, and compensatory behaviors, which expose them to a higher likelihood of developing an eating disorder. All this triggers a circle, reinforced by the feeling of being able to control one's affective states through eating symptoms.

As mentioned in previous paragraphs, according to Fairburn et al. (2003), in some ED patients one or more common maintenance processes intervene, which interact with the mechanism just described: clinical perfectionism, low self-esteem, mood dysregulation and interpersonal difficulties.

Clinical perfectionism is a form of clinically significant perfectionism that can be defined as the overestimation of the importance of achieving high standards imposed by the person that are excessively demanding, despite the negative consequences that might arise. The person's self-evaluation system depends on success in achieving those goals (Shafran et al., 2002). In EDs, perfectionism applies to the control of nutrition, body shape and weight, but also to other aspects of life (such as sports or school). Some expressions of perfectionism in EDs can be: fear of failure (understood as the fear of gaining weight), selective attention (e.g., counting calories, body shape and weight control behaviors), and strong self-criticism (resulting from negative evaluation of one's own performance) (Fairburn et al., 2003).

Low self-esteem, instead, consists in a pervasive negative view of oneself, which becomes part of one's identity and can be independent from actual performance or goals achieved (Fairburn et al., 2003). This component can represent a strong obstacle in the healing process, both because it can lead to a lower motivation to change and because of the perseverance in achieving goals consistent with one's values (hence the importance of control over nutrition, weight and body shape) (Fairburn et al., 2003).

Emotional dysregulation is conceptualized as the inability to manage certain emotional states such as anger, anxiety and depression. Instead of accepting changes in mood and emotions, ED patients tend to use dysfunctional behaviors as a dysfunctional way of regulating mood and motions, such as engaging in binge eating, compensatory behaviors, and strenuous exercise (Fairburn et al., 2003).

Finally, ***Interpersonal difficulties*** can also contribute to the maintenance of EDs in a number of ways. For example, family tensions can intensify restrictive and dieting behaviors, used as a means of gaining a sense of control over the situation. Some interpersonal relationships can also directly increase concerns about body shape, weight, and controlling behaviors through comments and societal standards being reiterated by peers and family

members. Pressure to be thin, for example, may also be strongly present in certain social environments, such as work or society.

1.4.2 Enhanced Cognitive Behavior Therapy (CBT-E)

Based on the transdiagnostic model of EDs, Fairburn also developed a transdiagnostic treatment protocol named Enhanced Cognitive Behaviour Therapy (CBT-E), which can be applied according to the specific psychopathological characteristics presented by the patient rather than the specific diagnosis (Fairburn et al., 2015). CBT-E focuses on the disruption of maintenance mechanisms, through the modification of the cognitive processes involved. It is important that the treatment is personalized to the patient, who is actively involved in the formulation of the therapeutic plan.

Currently, there are two versions of CBT-E, a *focused version* (CBT-Ef) that focuses mainly on the central mechanism underlying EDs (i.e. the excessive importance given to weight and body shape in self-evaluation and dysfunctional eating behaviors) and on the intolerance of emotional states, especially very intense negative ones, and a *broad version* (CBT-Eb), which instead extends the focus also to other maintenance processes of EDs mentioned previously, adapting the therapeutic targets to the individual needs of the patient (Fairburn, 2008). Both cognitive-behavioral and psychoeducational techniques are used in CBT-E: the patient is guided in making gradual changes regarding nutrition and weight, through self-monitoring and the execution of personalized and planned homework.

CBT-E was born as an individual and outpatient protocol aimed at adult patients, but its use has also been extended to adolescents, inpatients and group patients. The number of sessions changes according to the Body Mass Index (BMI): for patients with a BMI equal to or greater than 17.5 the recommended sessions are 20, while for patients with a BMI between 15 and 17.5 the recommended number of sessions, to be started only after weight regain, doubles (Fairburn, 2008).

A systematic review (Atwood & Friedman, 2020) showed that CBT-E is an effective treatment for adults and adolescents with various ED diagnoses, to reduce binge eating and purging behaviors, improve ED symptomatology and, in the case of patients with AN, increase BMI. However, patients who approach treatment with high levels of binge eating episodes and purging behaviors, despite the reduction of those episodes thanks to CBT-E, tend to remain symptomatic at the end of treatment. No differences in efficacy between the two versions of treatment (CBT-Ef and CBT-Eb) were found, except for patients defined as complex who present multiple ED maintenance mechanisms mentioned above, for whom CBT-Eb appeared

to produce greater outcomes and have better remission rates. The simplest version of the treatment, CBT-Ef, is recommended for use in standard pictures, as it is easier to learn and implement, while CBT-Eb should be reserved for more complex clinical pictures (Fairburn et al., 2009).

In general, the efficacy of CBT-E was found to be comparable to that of other therapies (i.e. IPT) with the same purpose (Atwood & Friedman, 2020). However, a study by Fairburn et al. (2015) compared 20 sessions of CBT-E with interpersonal therapy (IPT) in 130 patients with EDs and with BMI lower than 17.5 or greater than 40, with a 60-week follow-up. The study observed that, at post-treatment, CBT-E had better results than IPT in terms of symptom reduction. The gap, however, narrowed down during follow-up, leading to the conclusion that CBT-E tend to have faster but equally effective therapeutic results.

When looking at specific ED subgroups, network meta-analyses also suggested that CBT-E for AN may be superior to both the Maudsley Anorexia Nervosa Treatment for Adults (MANTRA) and Specialist Supportive Clinical Management (SSCM) recommended by the NICE guideline (NICE, 2017) in terms of weight restoration, though heterogeneity or inconsistency between studies limited the reliability of these results (Solmi et al., 2021). For patients with BN or BED, the literature has also proved the effectiveness of CBT-E in terms of producing better improvements in ED symptoms and general psychopathology than other treatments, such as psychoanalytic psychotherapy or IPT (Fairburn et al., 2015; Poulsen et al., 2014).

Despite CBT-E representing the treatment of choice with the strongest evidence base for EDs (Treasure et al., 2020), systematic reviews and meta-analysis of the literature also highlighted some limitations concerning this psychotherapy. In particular, drop-out rates are still high (up to 70% for outpatient treatments and up to 51% for hospitalizations) (Fassino et al., 2009; Swan-Kremeier et al., 2005) and recovery rates remain perfectible (around 50-65% depending on criteria and methodology used) (de Jong et al., 2020; Fairburn et al., 2009, 2015), especially in patients who present other comorbid psychopathologies and/or have low levels of insight (Halmi, 2013). Moreover, even in ED patients who manage to achieve recovery, the present of clinically significant residual symptoms has been observed (Tomba et al., 2019), highlighting the need to improve current treatment approaches (including CBT-E) and to target ED symptoms before the onset of a full diagnosis.

1.5 Transdiagnostic factors associated with EDs

Considering the still perfectible success rates associated with CBT-E mentioned above, research and clinical practice have focused on the development and application of new cognitive-behavioural third-wave approaches to EDs (Buerger et al., 2021; Starzomska et al., 2018). These approaches, dialectical behaviour therapy (DBT), acceptance and commitment therapy (ACT), and mindfulness-based interventions (MBI), further helped switching the assessment and treatment perspective to EDs from disorder-specific characteristics of the disorders to shared transdiagnostic factors that can play a role in the onset and maintenance of these psychopathologies (Linardon et al., 2017). In the following subparagraphs, some of the most important transdiagnostic factors linked to EDs will be illustrated.

1.5.1 Emotion regulation

According to James (1884), emotions are adaptive physiological and behavioral responses developed from situations which hold evolutionary significance. Lang (1979) emphasized how emotional responses are brief and involve different systems, such as the behavioral, experiential, autonomic, and neuroendocrine systems. Emotions have multiple functions, as they facilitate the decision-making process, prepare the individual for rapid motor responses, provide information about the environment, and can also have social functions, for example, by informing the individual about the behavioral intentions of others (Gross, 1998).

According to Gross (1998), the way a person emotionally responds to the environment can be modulated during the process of ER, and depending on the regulation strategy used, there will be a certain emotional response. Emotional regulation is defined by this author as the set of processes by which people can influence the type of emotions they feel, the time and modality with which they feel and express them. These processes can be automatic or controlled, conscious or unconscious, and have an effect at one or more levels of the emotion generation process. Therefore, there can be processes involved in the initiation, maintenance, modification, intensity and duration of emotions (Gross, 2015). When describing the process of ER, Gross (1998) distinguishes a type of regulation that occurs before the generation of the emotion from a regulation focused on the emotional response. For each level, there are different emotional regulation strategies.

Antecedent strategies involve situation selection, situation modification, attention distribution, and cognitive restructuring. ***Situation selection strategies*** refer to approaching or avoiding certain people, places, or objects to help with ER. An example of this strategy is avoidance (Gross, 1998). In ***situation modification***, the person makes active efforts to

directly modify the situation in order to alter its emotional impact: this strategy is also called "problem-centered coping", or problem-solving (Folkman, 2013).

On the other hand, distraction, concentration and rumination are part of the **attention distribution strategies**. Distraction consists of redirecting attention to non-emotional aspects of the situation (Nix et al., 1995), while concentration allows the person to direct cognitive resources towards a specific target (Erber & Tesser, 1992). Rumination directly involves attention, but it is directed to emotional distress, its causes and consequences (Nolen-Hoeksema, 1993).

Cognitive restructuring, instead, consists of changes made from the individual at the cognitive level to alter the emotional impact of the situation (Dandoy & Goldstein A.G., 1990).

Finally, **response modulation strategies** refer to physiological, experiential or behavioral responses which occur when response patterns towards emotions have already started to happen. An adaptive strategy that falls into this category is acceptance, which consists of experiencing the emotional experience without trying to change it (Hofmann & Asmundson, 2008). Instead, a dysfunctional strategy is expressive suppression, defined as the conscious inhibition of the expression of one's emotion (Gross & Levenson, 1993). This latter category of strategies also includes the use of alcohol, drugs, and food taken and consumed as a way to attempt to modify the emotional experience. Strategies are not identifiable as functional or non-functional in an absolute way, as much depends on the context in which they are used (Gross, 1998). However, strategies such as acceptance, cognitive reappraisal, and problem solving appear to be adaptive, while others such as rumination, avoidance, and expressive suppression appear dysfunctional and can represent risk factors for emotional distress and dysfunctional behaviors (Gratz & Roemer, 2004).

For the assessment of emotional regulation, Gross and John (2003) have developed the Emotion Regulation Questionnaire (ERQ), which has also been validated in Italian (Balzarotti et al., 2010): the questionnaire, consisting of 10 items, investigates through two scales the use of cognitive reappraisal and expressive suppression strategies.

Another questionnaire widely used in the assessment of emotional dysregulation is the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The instrument was initially developed in a 36-item version and later in a 16-item version (Bjureberg et al., 2016). The tool assesses difficulties in engaging in specific ER strategies. This tool will be described further in the *Methods section* of this dissertation.

1.5.1.1 Emotion regulation in EDs

Dysfunctional eating patterns, such as food restriction, binge eating, and compensatory behaviors, can serve as maladaptive strategies that have the function of regulating stressful or negative emotional states (Smyth et al., 2007). In fact, as already pointed out, a growing number of studies show a difficulty in identifying, describing and regulating emotions in patients with EDs (Christensen & Haynos, 2020; Perthes et al., 2021; Prefit et al., 2019). Research suggests that difficulties in ER, such as difficulties in managing the expression, intensity, and duration of emotions, can affect the risk and maintenance of EDs (Brockmeyer et al., 2014). In addition, habitual use of specific dysfunctional ER strategies, such as avoidance, rumination, and expressive suppression is associated with increased ED severity, while habitual use of more functional ER strategies like cognitive reappraisal, problem-solving, and acceptance tends to be linked to a less intense symptomatology (Aldao et al., 2010a).

A meta-analysis (Prefit et al., 2019) that evaluated the use of ER strategies in people with EDs found that, in general, adaptive emotional regulation strategies had a significantly negative relationship with EDs, such as awareness of emotions, emotional clarity, acceptance of emotions, reappraisal, and problem solving. In contrast, maladaptive strategies, like rumination, avoidance of emotions, and suppression of emotions, showed a significantly positive relationship with ED symptomatology. It is important to note that in the current meta-analysis, no differences in ER were found between various EDs, which supports the transdiagnostic element of ER in EDs. Even in a study that considered a sample of adolescents, comparing people with a clinical diagnosis of AN or BN with healthy controls, it was found that, compared to controls, people with AN and BN reported lower levels of adaptive ER strategies and higher levels of maladaptive ER strategies (Perthes et al., 2021).

Byrne and colleagues (2016) confirmed that ER can be a predictor of clinical impairment in EDs and a study conducted on a clinical sample of people with EDs showed a linear relationship between individual ER profiles and the severity and general psychopathology within the ED (Munguia et al., 2021).

A recent network meta-analysis was also conducted with the aim of identifying which aspects of ER are most associated with ED symptomatology (Leppanen et al., 2022). In general, this network meta-analysis confirmed an association with high effect size between ED symptomatology and dysfunctional ER strategies, such as rumination, non-acceptance of emotions, difficulty in problem solving, suppression of emotions, avoidance of emotions, lack of awareness of emotions, and lack of cognitive reappraisal. In particular, it emerged that rumination (d=0.51) and non-acceptance of emotions (d=0.43) were the most associated with

EDs, while difficulty in cognitive reappraisal was the least associated with symptomatology among all the emotional regulation strategies considered (Leppanen et al., 2022).

When considering, instead, differences in ER strategies between different ED subtypes, one study using the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) found that all participants with EDs reported greater difficulties in ER than healthy controls in experiencing, differentiating, attenuating, and modulating emotions (Brockmeyer et al., 2014). When considering differences in ER within the various diagnostic ED categories, the binge-eating/purging and restricting types of AN and BN did not differ in DERS subscales except for difficulties in impulse control: the binge-eating/purging type AN reported higher scores than restricting type AN and BED on this scale, but did not differ from BN. People with BED reported fewer difficulties in certain domains, such as clarity of emotions, while remaining significantly different than controls. Overall, these findings support transdiagnostic features in the ED spectrum (Brockmeyer et al., 2014). In one review, emotional dysregulation in AN and BN was investigated (Lavender et al., 2015). The results show that people with AN have trait difficulties in regulating emotional states and show higher levels of global emotional dysregulation compared to controls (Svaldi et al., 2012). Diagnostic subtypes of AN, instead, do not seem to differ in levels of emotional dysregulation (Haynos et al., 2014).

Analyzing the deficits in the specific strategies, compared to controls, people with AN had deficits in perceiving the effectiveness of the emotional regulation strategies implemented (Harrison et al., 2010). Studies have found lower outcomes in the use of adaptive strategies in people with AN compared to controls, such as less use of cognitive reappraisal, personal growth, mindful observation, and positive thoughts (Svaldi et al., 2012). In BN, evidence suggests results similar to AN, with a general difficulty in ER compared to controls. Indeed, no significant differences in ER were found between people with AN and BN (Brockmeyer et al., 2014; Harrison et al., 2010).

A recent systematic review also compared people with AN, BN, and controls on the use of ER strategies (Puttevils et al., 2021). Compared to healthy controls, patients with AN and BN unsurprisingly reported a lower use of adaptive strategies and a greater use of maladaptive strategies. However, when differences between ED subtypes were considered, no significant difference emerged concerning the use of maladaptive strategies, but rather regarding the use of adaptive strategies. In particular, people with AN seem to use less adaptive strategies than those with BN, in particular less use of reappraisal and acceptance. The authors explained this result in the light of one of the typical characteristics of AN, which is the difficulty in

psychological flexibility, which prevents the use of adaptive strategies in a flexible and adaptable way to various situations (Puttevils et al., 2021).

1.5.2 Experiential avoidance

Hayes (2006) defined experiential avoidance as attempts to avoid thoughts, feelings, memories, physical sensations, and other internal experiences that might be considered distressful, even when doing so leads to harmful consequences. When experiential avoidance is used, negative emotions are anticipated, evaluated, and avoided. Experiential avoidance reflects a reluctance to stay in touch with negative or stressful internal events, such as bodily sensations, emotions, thoughts, memories, desires, and behavioral needs, along with attempts to alter the form or frequency of these experiences (Litwin et al., 2017). However, attempts to avoid internal events that cause discomfort can often lead to an increase in the functional importance of such events, as they become more salient (Hayes et al., 2006). This results in reducing the range of behaviors the individual engages in because many of them can evoke internal events that generate fear. In fact, what makes this tendency problematic is the fact that people implement it regardless of the context, so sometimes these attempts can be maladaptive (Litwin et al., 2017). People who exhibit high levels of experiential avoidance, indeed, tend to use maladaptive coping, such as avoidance behaviors in multiple contexts (Hayes et al., 1999). Some examples of behaviors that fall under experiential avoidance can be: avoiding certain situations, engaging in distracting activities to avoid thoughts or emotions, and engaging in dysfunctional behaviors to regulate emotions (e.g. substance use, self-harm behaviors). Although experiential avoidance is an attempt to alter the internal experience, it can cause the frequency of negative experiences to increase, together with the associated distress caused by the resources spent to modify the situation the individual wants to avoid (Hayes et al., 2006). Continuous effort to control or avoid events can hinder action toward goals that are meaningful for the person and can interfere with behaviors consistent with personal values (Kashdan et al., 2006). Indeed, according to Hayes (2006), experiential avoidance plays an important role in the etiology and maintenance of different psychological disorders, including eating disorders.

To measure experiential avoidance, the Acceptance and Action Questionnaire was designed (Hayes, 2004), now in its second version (Bond et al., 2011), consisting of 10 items. This psychometric questionnaire will be illustrated in the Methods section of this dissertation.

1.5.2.1 Experiential avoidance in EDs

Experiential avoidance appears to be a risk and maintenance factor for several psychopathologies, including EDs, and is associated with short- and long-term negative effects (Fledderus et al., 2010; Hayes, 2004; Hayes et al., 2006). In particular, experiential avoidance appears to contribute to disordered eating patterns (Lavender et al., 2011). Experiential avoidance can be observed, in the context of EDs, in relation to internal experiences involving the body and food (such as feeling fat or fear of consuming specific foods), but also to more general negative thoughts ("I will never be enough") and emotional states (fear, anger, depression, anxiety) (Haynos et al., 2016). According to the Acceptance and Commitment Therapy (ACT) theoretical model, dysfunctional eating behaviors may arise as coping mechanisms that people develop to temporarily avoid stress-generating thoughts, feelings, and physical sensations (Haynos et al., 2016).

Studies conducted on patients with EDs have, indeed, found high levels of experiential avoidance in this clinical population (Wildes et al., 2010) and have observed that ED patients can become hyper-focused on one's body and caloric intake as a way to avoid feelings of rejection, imperfection, failure, and vulnerability (Haynos et al., 2016). A consequence of these high levels of experiential avoidance seems to be the inability to get a psychological distance from internal experiences, i.e. to experience a defusion from one's internal states: this leads to an increase in dysfunctional eating behaviors that aim to reduce suffering (Manlick et al., 2013). Among the maladaptive strategies used by people with EDs identified in a meta-analysis by Prefit and colleagues (2019), rumination and experiential avoidance emerged. Authors found that people who experience frequent negative thoughts and feelings about their appearance tend to engage in more bulimic behaviors if they tend to avoid negative emotions related to their body image, compared to those who do use experiential avoidance (Cowdrey & Park, 2012; Lavender et al., 2015).

A study investigated, in a sample of adults from the general population, whether rumination about nutrition, weight and body shape, experiential avoidance and low levels of mindfulness were associated with eating symptoms (Cowdrey & Park, 2012). Regarding experiential avoidance, measured with the AAQ-II (Bond et al., 2011), it turned out that it had a positive association with eating symptoms as measured with the EDE-Q (Fairburn & Beglin, 2008).

Even in the general population, several studies in the literature have found higher levels of experiential avoidance in non-clinical samples of people with food-related symptoms such

as binge eating and compensatory behaviors, compared to healthy controls (Della Longa & De Young, 2018b; Prefit et al., 2019).

Some studies have also evaluated experiential avoidance as a mediator between other mechanisms underlying EDs and dysfunctional eating behaviors. One study considered the mediating role of experiential avoidance in a sample composed of people from the general population who had not received an ED diagnosis: it emerged that experiential avoidance mediated between negative emotions and emotional eating, understood as the tendency to eat in response to negative emotions (Litwin et al., 2017). Specifically, negative emotions significantly predicted experiential avoidance, and the latter significantly predicted emotional eating. As a result, the authors of the study highlighted that targeting experiential avoidance during psychological interventions could have beneficial effects on the reduction of emotional eating as well. Another study that considered the mediating role of experiential avoidance was conducted Skinner's (2017) in a clinical sample of people with a history of suicide attempts or self-harm behaviors and EDs. After dividing experiential avoidance into subdimensions, distress aversion and procrastination were the two specific mechanisms by which disordered eating seemed to predict an increased risk of suicidal behaviors.

The review of Lavender et al. (2015) mentioned for ER, also considered experiential avoidance. The authors expected to find, consistent with previous literature, a tendency to avoid situations with emotional impact and high levels of experiential avoidance in people with EDs: one study included in the review found greater behavioral avoidance but only of positive and non-negative emotions (Lampard et al., 2011), another study found avoidance of situations that would generate negative emotions (Corstorphine et al., 2007) and another that avoidance of situations that generated negative emotions differentiated people with AN from healthy controls (Hambrook et al., 2011).

When comparing people with AN and BN, instead, the review by Puttevils and colleagues (2021) found inconclusive results. One study included in the review found that people with BN made significantly greater use of experiential avoidance than people with AN, while other authors found no differences between the two diagnostic groups.

Overall, from the literature emerged that experiential avoidance is found at greater levels in people with EDs than in controls and that it can be considered a transdiagnostic risk factor, with scarce differences between diagnostic ED subgroups.

1.5.3 Psychological flexibility

Psychological flexibility can be defined as the ability to experience one's thoughts without judgment and realize that negative thoughts do not reflect a negative self (Bond et al., 2011; Hayes et al., 2012). It can also represent the ability to connect to the present moment in a more conscious way, engaging in behaviors that are consistent with personal values (Hayes et al., 2006). The word *flexibility*, in particular, refers to the possible ways in which the individual can alter the function of internal experiences by responding flexibly to negative thoughts, feelings, and events, leading to increased well-being (Rolffs et al., 2018). Psychological flexibility, therefore, helps people to open up to these experiences, even negative ones, and to accept and become aware of them without trying to change them, making choices in relation to the areas of life that are important to the person (Rolffs et al., 2018). The opposite construct of psychological flexibility has been hypothesized to be ***psychological inflexibility***, understood as a rigid style of thinking that includes ruminating on thoughts and assuming that negative thoughts reflect negative qualities of the self, which can lead to an inability to act in accordance with one's values (Morton et al., 2020).

Just like experiential avoidance, psychological flexibility is a central target of Acceptance and Commitment Therapy (ACT), which aims to increase it (Hayes, 2004). ACT is one of the third-generation therapies that, rather than focusing on changing psychological events directly, seek to change the function of these events and the way the person experience their thoughts and feelings through processes of change such as acceptance, awareness of the present moment, self as context, defusion, values, and commitment to act (Hayes et al., 2006). The content of a dysfunctional thought, in fact, is not considered problematic in itself and its modification it is not always considered necessary: instead, having good or low levels of psychological flexibility is the element that, according to this approach, can predict negative affective and behavioral outcomes (Griffiths et al., 2018).

1.5.3.1 Psychological flexibility in EDs

Research suggests that a lack of psychological flexibility is related to EDs (Griffiths et al., 2018). Psychological flexibility allows you to tolerate negative emotions, including those associated with thoughts and feelings related to your body and weight, becoming a protective factor for the development of these disorders (Whiteside et al., 2007). In fact, low levels of psychological flexibility have been found in people with EDs (Masuda et al., 2012). Taking up the dimensions of psychological flexibility, these can be applied to the symptomatology of EDs: the main targets of ACT (acceptance, awareness of the present

moment, self as context, defusion, values and commitment to act), for example, seem to be important in the development and maintenance of EDs and the impairment of these abilities seem to represent temperamental characteristics that precede the onset of the disorder (Zucker et al., 2010).

In particular, the dimension of acceptance is related to high levels of experiential avoidance, previously discussed. In the dimension of awareness of the present moment, since people with EDs have difficulties in ER, one consequence resulting from low levels of this ability could be a difficulty in recognizing stressful thoughts and emotions and concentrating in the here and now, observing thoughts in a non-judgmental way (Haynos et al., 2016). The self as a context is particularly implicated in EDs, as one of the main characteristics of the disorder is their ego-syntonic nature, i.e. the high degree of identification of the person with his or her disorder (Haynos et al., 2016). Values and commitment to concrete action in people with EDs also represent another important factor to take into account, as these patients often report an overevaluation of weight, body and eating behaviors, while other areas of life, such as relationships with others, are not considered a priority and there is a difficulty in identifying values not related to food and body image (Haynos et al., 2016). One study assessed psychological flexibility and inflexibility in relation to internalized disordered eating and the ideal of thinness (Morton et al., 2020). Measuring psychological flexibility and inflexibility through the Multidimensional Psychological Flexibility Inventory (MPFI; Rolffs et al., 2016), the study (Morton et al., 2020) showed that psychological inflexibility (in particular, the dimensions of Fusion, Lack of Present Moment Awareness, Lack of Values, and Inaction) was positively associated with disordered eating and ideal of thinness. In particular, they also seemed to moderate the relationship between internalization of ideals of thinness and disordered eating. The authors explained these findings by stating that people with EDs seem to accept their own dysfunctional thoughts that lead to dysfunctional behaviors.

Some studies have also investigated psychological flexibility in relation to body image. Body image flexibility has been defined as the ability to openly experience thoughts and feelings about one's body without acting on them, trying to change or avoid them (Sandoz et al., 2013). This construct is relevant in the context of body image and nutrition, as people with high levels in this domain are able to experience intrusive thoughts and feelings about the body in a non-judgmental way, without ruminating on them and without trying to change them (Linardon et al., 2021). Many disordered eating behaviors, such as restriction and purging behaviors have the function of relieving negative thoughts and feelings about weight and body shape (Stice, 2001).Body image flexibility would be a protective factor against these behaviors,

since it may help people recognize these negative thoughts and feelings on onset, view them non-judgmentally, openly, and with an attitude of compassion. This would also help them continue to pursue meaningful goals in other life domains without attempting to suppress their negative thoughts and feelings through dysfunctional coping strategies, such as dysfunctional eating behaviors.

In a systematic review, indeed, body image flexibility was found to be positively associated with other protective psychological factors, such as lower levels of body image concerns, lower ED symptoms and less psychological distress, and high levels of intuitive eating, well-being, and self-compassion (Rogers et al., 2018).

Indeed, a meta-analysis showed that there is a strong relationship between levels of body image flexibility and various indices related to body image disorders. In particular, people with a better ability to accept, rather than suppress, negative body-related experiences tend to report less body image concerns, engage in less behaviors aimed at achieving cultural beauty ideals, and exhibit less dysfunctional attitudes and behaviors concerning food (Linardon et al., 2021). This result is consistent with the hypothesis that psychological flexibility can act as a protective factor for body image and EDs, through adaptive mechanisms (Webb et al., 2014). People who can accept fearful and worrying body image thoughts and feelings would be less likely to feel the need to react to these internal experiences by enacting dysfunctional coping strategies such as restriction, binge eating, and compensatory behaviors. In addition, the findings suggest that people who possess psychological flexibility traits also show greater levels of intuitive eating, body appreciation, life satisfaction, and self-esteem (Linardon et al., 2021).

1.5.4 Other transdiagnostic factors associated to EDs

1.5.4.1 Perfectionism

The lack of psychological flexibility can be linked to one of the most typically found traits in EDs: perfectionism. Perfectionism is, as already highlighted in the previous chapter, a risk and maintenance factor for EDs, according to the transdiagnostic cognitive-behavioral model (Fairburn et al., 2003). The term perfectionism refers to an evaluation of oneself that depends on the achievement of excessive and self-imposed standards (Baldissera, 2018). One study examined the relationship between perfectionism, emotional dysregulation, and presence of affective disorders (anxiety and depression) both in patients with EDs and in people at risk of developing such psychopathologies and showed that all the considered constructs (including perfections and emotional dysregulation) significantly predicted ED-related psychosocial

damage (Byrne et al., 2016). In particular, it emerged that perfectionism interact with emotional dysregulation in predicting clinical impairment in ED patients.

A recent study also investigated which specific aspects of perfectionism were most related to food restriction (Solomon-Krakus et al., 2022). A distinction was made between self-critical perfectionism (which involves rigid self-criticism when goals are not met, extreme concern about mistakes and one's own actions, and fear of not living up to others' expectations) and perfectionism based on personal standards (which involves a strong commitment to high standards and goals, but without the component of self-criticism when goals are not met). The results showed that, indeed, the construct can be considered multidimensional and that self-critical perfectionism was associated with behavioral restriction, while perfectionism based on personal standards was related only to cognitive restriction. Self-critical perfectionism, instead, led to more severe eating symptoms (Solomon-Krakus et al., 2022).

Many authors hypothesized that acting on perfectionism may actually lead to a reduction in dysfunctional eating behaviors both in the general population at risk for the development of EDs and in patients with a full diagnosis (Robinson & Wade, 2021).

1.5.4.2 Rumination and worry

Rumination refers to a cognitive process, consisting of behaviors and thoughts that passively focus one's attention on negative emotions and on their possible negative implications (Nolen-Hoeksema, 1991).

Rumination has been studied largely in the context of depressive symptomatology, but it has also been identified as a transdiagnostic factor and as a risk factor that can lead to the development of several disorders, including EDs (Nolen-Hoeksema & Watkins, 2011). In a meta-analysis by Smith and colleagues (2018) evidence emerged on the correlation between rumination and EDs. In particular, people with EDs show higher levels of rumination than controls and the construct is associated with higher ED symptomatology. In addition, the differences between ED diagnoses on rumination were not significant, supporting the transdiagnostic nature of this psychological factor (Smith et al., 2018).

Worry, instead, is characterized by thoughts or fears about negative events that may happen in the future (Borkovec et al., 1998). Worry differs from rumination in several aspects. More specifically, while rumination is primarily about the past, worry is about the future: therefore, the content of thoughts is about loss, meaning, and personal worth in rumination and menace in rumination. The events to which thoughts are directed are certain and uncontrollable in rumination and uncertain and controllable in worry. Finally, motivations in rumination are

about understanding certain negative emotions, while in worry they are about anticipating the threat (Nolen-Hoeksema & Watkins, 2011).

The literature suggests that people with EDs have higher levels worry rumination than controls, and higher levels of the construct are associated with higher symptomatology in the clinical population (Sassaroli et al., 2005). In a longitudinal study, worry was also found to be a predictor of the drive to thinness and is therefore considered a transdiagnostic risk factor (Sala & Levinson, 2016).

1.5.4.3 Mindfulness

Mindfulness is a concept first introduced in psychology by Kabat-Zinn who defined it as "awareness that arises through paying attention, on purpose, in the present moment, non-judgementally " (Kabat-Zinn, 2015). Mindfulness is a complex construct that encompasses several aspects: as a state it is a temporary experience of being mindful, while as a trait it is a disposition to act in a way that is *mindful* in different contexts and situations. Several dimensions of mindfulness are commonly studied: observing (detecting and paying attention to internal/external phenomena), describing (using words or definitions to describe the observed phenomenon), acting with awareness (engaging totally and without automatisms in the activity that was being carried out), nonjudging of inner experience (non-judgmental attitude towards thoughts and emotions), nonreactivity to inner experience (accepting thoughts and emotions, letting them come and go, without getting trapped or distracted) (Baer et al., 2012).

In the literature, mindfulness was found to be a mediator between disordered eating thoughts and disordered eating behaviors (Masuda et al., 2012). Eating behaviors, in particular, have been suggested to represent dysfunctional ways of coping with negative internal states. Because of this, mindfulness-based interventions are currently finding evidence both in the prevention and treatment of EDs (Wanden-Berghe, 2013), but further studies are still needed in order to evaluate the effectiveness of this therapeutic approach. The focus of this therapeutic intervention is on developing awareness and changing the person's relationship with their thoughts, rather than trying to change their content (Haynos et al., 2016). Consequently, mindfulness can improve ER through the acceptance of emotions and the increase in tolerance of negative emotional states (Vanzhula & Levinson, 2020) and it can also train people to identify emotions as transient, so that they can tolerate events experienced as threatening (Baer et al., 2012). This can help reducing the need to avoid negative thoughts and emotions by engaging in dysfunctional eating behaviors, such as binge-eating, restrictive, or compensatory

behaviors. Mindfulness can also help people recognize physiological sensations of hunger or fullness and thus to become less reactive to external triggers, such as the presence of food: in fact, people with EDs are believed to have low enteroceptive awareness (Vanzhula & Levinson, 2020).

1.5.5 The role of transdiagnostic factors in the prevention of EDs

Despite the significant importance of transdiagnostic factors for the development and maintenance of EDs illustrated in previous paragraphs, no study in the literature seems to have evaluated the role of transdiagnostic factors in the prevention of EDs using a standardized and controlled methodology. However, as described previously, mindfulness-based interventions have been used in ED prevention, at the universal level, and have shown a reduction of certain ED risk factors, such as concerns about weight and body shape, calorie intake restriction, socio-cultural pressures, eating symptoms, and psychosocial impairment (Schwartz et al., 2019). In a correlational study, the protective role of body appreciation, body image flexibility (a construct closely related to psychological flexibility), intuitive eating, and self-compassion with respect to eating symptoms was investigated, finding a protective role for all factors considered (Linardon et al., 2021). However, these studies lacked methodological rigor and the several limitations require further studies in order to confirm these results.

Several authors have also underlined the need to conduct further research on the possible beneficial role of targeting transdiagnostic factors in the prevention of EDs. In Byrne's study (2016), for example, perfectionism and ER have been found to be mediators for ED symptoms, which led authors to assume that targeting these constructs could reduce the risk of developing EDs. However, further longitudinal research is needed to investigate how many people at risk for the development of EDs who show high levels of perfectionism and emotional dysregulation actually develop an ED later in life (Byrne et al., 2016). Due to the multiple possible negative consequences of ED symptoms (i.e. on the physical, psychological, social, and quality of life levels), it is of fundamental importance to intervene in early stages such as adolescence and early adulthood (Litwin et al., 2017). As a result, identifying those factors related to ED development and maintenance could have important clinical implications in prevention.

Since it has been described that altered levels of the considered transdiagnostic factors are present in people with EDs, these could be taken into account when planning and testing the efficacy of prevention interventions.

1.6 Conclusion of the chapter

The present chapter summarized to the best of our knowledge the clinical characteristics of EDs as well as the complex clinical relationship between transdiagnostic factors and these psychopathologies, in particular by focusing on some of the most studied transdiagnostic factors, namely emotion regulation, experiential avoidance, and psychological flexibility.

In the literature regarding EDs, the transdiagnostic approach emerged as one of the most prevalent theoretical and treatment models and led to identification of factors, called *transdiagnostic factors*, shared among multiple ED diagnoses that can contribute to their onset and maintenance (Fairburn et al., 2003, 2009). Together with the well-known transdiagnostic factors hypothesized by Fairburn and colleagues (2003) (i.e. clinical perfectionism, low self-esteem, mood dysregulation and interpersonal difficulties, which were described in previous paragraphs), three third-wave cognitive-behavioral transdiagnostic factors mentioned above (i.e. emotion regulation, experiential avoidance, and psychological flexibility) have also emerged as playing a crucial role in the onset and maintenance of EDs (Levin et al., 2014; Prefit et al., 2019; Rawal et al., 2010). In particular, the intricate interplay between difficulties in regulating emotions and the severity of EDs underscored the transdiagnostic nature of emotion regulation within these psychopathologies, both in terms of adaptive ER strategies representing a protective factor for EDs and in terms of maladaptive ER strategies representing a risk and maintenance factor that may exacerbate ED symptoms and/or lead to their onset (e.g. Brockmeyer et al., 2014; Leppanen et al., 2022; Prefit et al., 2019). Similarly, experiential avoidance surfaced as a prominent risk and maintenance factor for these psychopathologies, influencing disordered eating patterns and exacerbating negative affective states (Cowdrey & Park, 2012; Della Longa & De Young, 2018), which in turn can lead to a worsening of ED symptoms (Litwin et al., 2017). Ultimately, impairments in psychological flexibility were linked to heightened vulnerability to EDs, emphasizing the importance of acceptance, present-moment awareness, and value-driven action in mitigating ED risk (Masuda et al., 2010; Morton et al., 2020). A more specific component of psychological flexibility, that is body image flexibility, also emerged as a protective factor for EDs, as it is associated to healthier attitudes and behaviors surrounding people's relationship with their body image and food (Rogers et al., 2018).

These findings emphasize the need for a nuanced understanding beyond disorder-specific characteristics of EDs and offer valuable insights for clinical practice and prevention strategies. By addressing underlying mechanisms shared across ED diagnoses, transdiagnostic interventions can be able to target core vulnerabilities, therefore leading to more effective

treatment and prevention approaches (Fairburn et al., 2015; Newby et al., 2015). However, although third-wave cognitive-behavioural approaches, such as Mindfulness-based approaches, were effective in targeting ED risk factors (e.g. emotion regulation) (Wanden-Berghe, 2013), the development of prevention interventions for EDs targeting transdiagnostic factors remains an area warranting further investigation. Indeed, while the literature summarized in this chapter highlighted the significance of emotion regulation, experiential avoidance, and psychological flexibility in the onset and maintenance of EDs, future research should aim to elucidate the potential of transdiagnostic interventions in mitigating ED risk factors and preventing the onset of these clinically severe psychopathologies. Prioritizing the investigation of these shared underlying mechanisms can advance the clinical understanding of EDs and pave the way for more personalized, cost-effective, and comprehensive approaches to their treatment and prevention.

CHAPTER 2.
THE USE OF VIRTUAL REALITY IN THE TREATMENT AND PREVETION OF EATING DISORDERS

As it has been illustrated in the previous chapter, despite the advancements made in understanding and treating EDs, traditional psychotherapeutic treatments are not universally effective (Fassino et al., 2009; Swan-Kremeier et al., 2005) and recovery rates remain perfectible (de Jong et al., 2020; Fairburn et al., 2009, 2015). Moreover, the stigma associated with traditional approaches (e.g. psychological support, psychotherapy, etc.) can often represent a barrier that prevents people from seeking help at the earlier stages of the disorder (Bharadwaj et al., 2017; Hamilton et al., 2022). Because of this, there is a need to develop and implement innovative approaches such as virtual reality (VR) in this field. VR is a form of technology that can induce a high sense of presence and immersivity in users (Diemer et al., 2015; Kilteni et al., 2012; Riva et al., 2002) and, in light of these characteristics, its use has been recently extended to the field of clinical psychology and mental health (Emmelkamp & Meyerbröker, 2021; Riva, 2022). In the paragraphs that will be presented in this chapter, it will be highlighted how VR, thanks to its immersive and interactive nature, could offer a complementary approach to standard psychological interventions in clinical psychology and, more specifically, in the treatment and prevention of EDs (Ciążyńska & Maciaszek, 2022; Emmelkamp & Meyerbröker, 2021; Riva, 2022).

2.1 Virtual Reality: definition and technological characteristics

Virtual reality (VR) has been defined by Schultheis & Rizzo (2001) as an advanced form of human-computer interface that allows users to interact and immerse themselves in a computer-generated yet entirely realistic environment. However, the definition of virtual reality varies depending on which technological devices is used: in fact, this term can simply include headsets, whether in the form of *head-mounted displays* (HMDs) or glasses, or it can refer more broadly to any system that allows its user to immerse themselves in a virtual environment (Turner & Casey, 2014).

As a rule, a VR system consists of input devices, output devices, and a virtually simulated environment. Input devices allow the user to interact with the virtual world, recording their actions (e.g. hand or head movements) and sending the information to the computer, which updates the images in real time. Output devices, on the other hand,

continuously transmit information to the user through different modalities, such as feedback, sound, and visual stimuli. The virtual environment is the three-dimensional, computer-generated environment, which the user can explore and in which he can interact with the objects within it with a set of actions specific to each object (e.g. picking up, rotating, zooming in or out) (Parsons et al., 2017). Some virtual environments are designed to be multi-user virtual environments (MUVEs), i.e. they can host two or more users together who have the ability to communicate and share experiences using *avatars*, defined as graphic representations of themselves controlled directly by the user within the virtual environment. In other cases, the virtual environment may include other social entities that are not controlled by real humans, but by the computer itself via an artificial intelligence program (*embodied virtual agent*) (Parsons et al., 2017).

As described by Riva (2022), virtual reality can be divided into immersive and non-immersive. VR technologies are defined as ***immersive*** when they succeed in the goal of separating the user from the physical world and replacing it, for the time of use, with the virtual scenario created by the computer. This generally happens through the use of HMDs. The helmet or HMD visor precludes any kind of visual contact with the outside world and computer-generated images take its place through a display placed inside the device: the user can explore the virtual environment thanks to the presence of sensors, placed on the helmet or visor and sometimes even on hands and feet, which detect their movements and allow the computer to adapt the field of vision to the user's movements (Gregg & Tarrier, 2007). A more advanced but also more expensive way to create an immersive virtual environment is the *cave automatic virtual* environment (CAVE), a cubic space in which images are projected on the walls, including floor and ceiling, that the user can view wearing 3D glasses. In this context, the user can move within the environment and his movements are recorded in real time to adapt the images in order to constantly preserve the right visual perspective.

Non-immersive virtual environments, instead, use high-resolution monitors, such as computer screens, as output devices but do not completely occlude the user's vision and contact with the outside world and allow limited interaction. This type of VR includes, for example, 3D video games.

VR devices have undergone an evolution in terms of technological performance and costs (Cipresso et al., 2018; Riva, 2022; Segal et al., 2011). In fact, the first generation of these devices, marketed between 1990 and 2015, was characterized by a low screen resolution, which caused significant symptoms of motion sickness, such as nausea and dizziness, limited field of vision and uncomfortable designs, such as HMDs being too heavy and causing neck pain to

users. In addition, immersive virtual reality required very expensive HMDs and computers connected to them, and a high level of technological expertise and knowledge to design the virtual environment and operate it. All these factors made it difficult for consumers (and especially clinicians) to use VR systems outside of laboratories.

In March 2016, however, the Oculus Rift (an innovate, smaller and less expensive HMD) was released to the public as an alternativo to first-generation devices. The Oculus Rift represented a turning point in the use of VR: in just a few years since its release, the cost of a complete VR system, including input and output devices and computers for 3D graphics, drastically dropped from thousands of euros to a few hundreds, thus facilitating its use in various fields, including clinical psychology and mental health (Emmelkamp & Meyerbröker, 2021; Riva, 2022). In particular, the possibility of experiencing VR even through mobile phones has made this technology accessible to anyone who owns a smartphone, expanding its popularity and use within the general population: this is the case of 360-degree videos, which are filmed with a special type of camera, also applicable to smartphones, with multiple lenses that allow recording from all directions at the same time and, once projected to an HMD or viewed with ad hoc applications, allow the user to feel totally immersed in the video and explore its environment (Riva, 2022).

2.1.1 Sense of presence in virtual reality

Virtual reality systems cannot be defined as simple technological devices, as there is an additional element compared to other forms of media that makes the VR experience different. This element is the sense of presence (or telepresence), described by the International Society for Presence Research (2000) as a psychological state in which, although part or all of the individual's experience is generated or filtered by technology, a part or all of the individual's perception does not accurately recognize the role of technology in the experience. In the case of virtual reality, the sense of presence manifests itself as the sensation that the individual feels like they are physically and mentally present in the virtual environment at the moment while exploring and interacting with it (Parsons et al., 2017).

A first line of research about the sense of presence in VR sees it as determined largely, if not entirely, by the specific medium, so that it would be the result of the individual's interaction with a technological device capable of generating a strong sense of presence, such as immersive VR systems (e.g. CAVE) (Parsons et al., 2017). In this conceptualization, the sense of presence is guaranteed by a *perceptual illusion of nonmediation*, the phenomenon whereby the sensory, cognitive and emotional systems of the user continuously send responses

to objects and entities present in the environment, causing the individual not to perceive or recognize the existence of the technological medium in the environment, despite being aware of being inside a virtually created environment, and to consequently respond as if there was no technological medium between them and the environment (Lombard & Ditton, 1997). The illusion of non-mediation can occur when the medium is not visible and the user interacts with objects and entities in the environment generated by the medium, or when the medium is visible but appears to have been transformed by something other than a technological device, such as a social entity. The sense of presence allows the user to perceive the virtual environment as if it was a real environment in which he is immersed and, therefore, to experience the same range of emotions and physical sensations, although sometimes in a limited or less intense form, that he would experience in a real environment (Parsons et al, 2017).

A second line of research, in the neuroscientific field, recognizes a sense of presence which is natural and intrinsic to the individual, defined by Waterworth et al. (2010) as the awareness of being physically present in the place where the body is and in the current moment. This sense of presence mediated by a technological device is only possible if the medium, in particular the VR system, is capable of reproducing the same mechanisms that the human brain uses to generate the sense of presence. In fact, in order to effectively control the body and to limit the sense of surprise when confronted with real life situations, the brain develops simulations, which contain sensorimotor information on how the body acts in the external world (*embodied simulations)* (Gallese, 2007). In this way, the brain can predict how the body will act and feel in certain situations produced by the external and internal environment and compares them with the actual actions and sensations experienced, updating the simulation if necessary. This is similar to VR since, through the hardware, the user's movements are recorded and, thanks to the software, the images on the display are adjusted so that they are congruent with the changes that the user has generated in the virtual environment with their movements. In order to do this, the VR system creates a simulation of the user's body and the space in which they are immersed, on the basis of which sensory inputs are sent through the output devices to the user. These sensory inputs are meant to imitate the functioning of the human brain as closely as possible. The more realistic the virtual environment will be and the more accurate the inputs, the more the individual will feel immersed in it.

Because of this, VR is also defined as an *embodied* technology (Kilteni et al., 2012; C. D. Murray & Sixsmith, 1999; Popat, 2016), that is a technology that has concrete effects on the user's perception of one's own body. Indeed, VR allows the user's sense of presence to be modified by exploiting the sense of presence already created naturally by the human brain,

making them experience the virtual environment as if it were a real environment (*embodiment of* the virtual environment) or the virtual avatar as if it were their body (*embodiment*). The side effects of this can manifest in a set of symptoms called *cybersickness,* which can include nausea, dizziness, fatigue, headaches, visual difficulties and a general sense of disorientation that occur in some individuals who use VR technologies. Cybersickness differs from classic *motion sickness*, which is activated by the stimulation of the vestibular system alone, as it requires a visual stimulus to manifest (LaViola, 2000). Although a definite cause of *cybersickness* has not yet been identified, it has been hypothesized that it could be due to the mismatch between the movement perceived visually in the virtual world and the physical condition of the individual (e.g. sitting down or standing still), recorded by the vestibular system (Riva et al., 2016).

Given the centrality of the sense of presence in the functionality of all VR systems, several studies have analyzed which factors are able to increase it. Riva et al. (2007) investigated the role of the emotional state on the sense of presence in a sample of 61 healthy individuals between the ages of 19 and 25. The participants were immersed into three virtual environments, one relaxing, one anxiety-inducing and one neutral. Results showed that VR was able to induce emotions in users, which can increase their utility also in the clinical psychological field. The results also confirmed that the emotional state has an impact on the sense of presence experienced by the users, as it was significantly higher in the relaxing and anxiety-inducing virtual environment compared to the neutral environment. The same study found that this relationship is, indeed, bidirectional: emotional states influence the sense of presence but, similarly, the intensity of the sense of presence tends to predict the intensity of the emotions experienced in the VR environment.

The role that emotions play in determining the sense of presence has also been studied by Gorini and colleagues (2011). In their study, the authors asked 84 individuals between the ages of 19 and 25 to find blood containers in a virtual hospital and divided them into four groups based on the level of immersivity of the virtual environment and the presence of an underlying emotional story. In the two groups using non-immersive VR participants explored the environment using only a joystick, while in the two groups with immersive VR, in addition to the joystick, participants were also provided with an HMD with a motion sensor. An emotional narrative was present in one group using immersive VR and in one group using non-immersive VR. In the narrative, participants were asked to act quickly as blood was necessary for the survival of a child and, moreover, a gunman was chasing them to prevent them from completing the assignment. In the two other groups with no emotional narrative, participants

were given the assignment without any explanation. The results showed that the highest sense of presence was recorded in the group with immersive VR and with background emotional storytelling, while the lowest rate of sense of presence was found in the group with non-immersive VR and without background emotional storytelling. This proved that immersivity increases the illusion of feeling present in a place, even knowing that you are not physically there, while an underlying narrative that gives context and emotional value to the virtual experience ensures the user's actions to be motivated by needs and goals, which reinforce the sense of presence.

2.2 The use of virtual reality in clinical psychology

Given the high sense of presence that VR is capable of inducing in users (Diemer et al., 2015; Kilteni et al., 2012; Riva et al., 2002) and the costs that have been consistently decreasing to use this technology outside of laboratories (Cipresso et al., 2018; Riva, 2022; Segal et al., 2011), the use of virtual reality has been recently extended to the field of clinical psychology and mental health (Emmelkamp & Meyerbröker, 2021; Riva, 2022). Of particular relevance is the use of virtual reality in the assessment and treatment of psychiatric disorders (Geraets et al., 2022; Wiebe et al., 2022). The elements that make virtual reality an effective clinical psychological tool are its ability to simulate reality, to induce emotional responses, to reproduce the cognitive mechanisms underlying the functioning of the brain and to deceive those cognitive mechanisms that regulate bodily sensations, which can help replacing or changing the patient's experience of their body in order to achieve therapeutic goals.

In subsequent paragraphs the possible application of VR to the treatment and assessment of different psychopathologies will be briefly underlined.

2.2.1 Anxiety disorders

Their main treatment-approach for anxiety disorders includes exposure to anxiety-provoking stimuli, such as feared and avoided situations, which are usually replicated in-vivo or imaginative contexts to help the patient to accept his anxious feelings and to challenge and modify their thoughts about possible catastrophic consequences (Lindner et al., 2017). Exposure is effective in most anxious situations but recreating phobic stimuli, such as airplanes and natural disasters, in-vivo can be very difficult. Because of this, VR can represent a useful alternative because of its ability to generate personalized experiences and to produce similar anxious emotions as feared real-life situations (Lindner et al., 2017; Maples-Keller et al., 2017; Rothbaum & Hodges, 1999).

Because of this, anxiety disorders were the first category of psychopathologies to which VR was applied in the late 1990s (Maples-Keller et al, 2017). In fact, the first study on the subject, conducted by Rothbaum and colleagues (1995), tested virtual reality *exposure therapy* (VRET) in students with acrophobia (i.e. fear of heights), using an HMD and an electromagnetic sensor that recorded the user's head and hand movements. After 7 weeks of gradual exposure to virtual environments that simulated anxiety-provoking situations (decks of different heights, balconies, glass elevators), students who underwent VRET reported a reduction in height-related anxiety and in avoidance symptoms compared to students assigned to the waiting list conditions, who did not receive treatment and whose symptomatology remained unchanged.

Similarly to in-vivo exposure, VRET induces an initial fear and anxiety response, together with the associated physiological correlates, which gradually decrease during the exposure session and throughout the VRET intervention process until habituation to anxiety is generated in the patient. The purpose of repeated exposure is to weaken the association between the anxiety-inducing stimulus and the anxiety response, making the patient aware of the fact that, despite the presence of threatening stimuli, avoidance of these stimuli only worsens their anxious symptomatology and, therefore, alternative and more functional strategies should be adopted (Scozzari & Gamberini, 2011). In this regard, a review by Scozzari & Gamberini (2011) found that VRET was equally effective to in vivo exposure as traditionally proposed by the cognitive-behavioral approach for the treatment of various anxiety and phobic disorders, such as arachnophobia, acrophobia, fear of flying, social anxiety, panic disorder and agoraphobia. However, limitations should be considered, which are related to the lack of studies on VR and the methodology adopted by them, such as poorly defined clinical protocols and short-term follow-up (Maples-Keller et al., 2017). Because of this, in vivo exposure still remains the reference standard for the treatment of anxiety-spectrum psychopathologies (Wechsler et al., 2019), despite the advantages associated to VR over traditional in vivo or imaginative exposure, such as the aforementioned possibility of exposing patients to fear-provoking situations that are not easily recreated or available in real life. The level of immersion and involvement in the environment that is lacking in imaginative exposure may also increase effectiveness and adherence to treatment, together with the ability to interact with the environment which allows for greater control and personalization of what the patient experiences (e.g. by adding or modifying elements that can make the situation more or less threatening, such as height in cases of software for acrophobia or the introduction of protective factors like a friend's avatar). Finally, the possibility of exposing the patient to the feared

stimuli inside a safe space that is the therapeutic office guarantees a level of protection, as well as confidentiality, often not available in reality, which may reduce the risks of drop-out and encourage therapeutic alliance (Levy et al., 2023).

2.2.2 Post-traumatic stress disorder

VR has also emerged as a potential treatment approach for post-traumatic stress disorder (PTSD), defined by the DSM-5-TR (APA, 2022) as a psychopathology that can arise from firsthand exposure to a catastrophic event or through direct witnessing, learning about the event happening to a close person, or repeated exposure to raw event details. PTSD is characterized by intrusive symptoms, such as flashbacks and dreams about the traumatic event, avoidance of event-related stimuli, negative alteration of thoughts and mood, and symptoms of hyperactivation, such as hypervigilance and irritable behavior with outbursts of anger. Given the traumatic nature of the events that cause this psychopathology, which are difficult to recreate in vivo and whose simulation would also pose ethical problems, in the therapeutic process there is a tendency to prefer imaginative exposure, in which the patient, with the help of the therapist, mentally retraces the event, processing the emotions associated with it and modifying unrealistic and catastrophic beliefs (Arntz et al., 2007). VRET could help overcome these limitations of traditional psychotherapeutic approaches by recreating multisensory environments similar to those in which the traumatic event occurred but without exposing the patient to the real risks related to the event (Kothgassner et al., 2019).

Historically, the first application of VR to the treatment of PTSD dates back to a 1999 case report of a Vietnam veteran undergoing exposure therapy with VR. The patients' clinical-rated PTSD symptoms decreased by 34% and his self-rated PTSD questionnaires by 45%. The results were also maintained at a six months follow-up (Rothbaum et al., 1999). Starting from these results, in 2000 authors (Rothbaum et al., 2000) conducted an open clinical trial on a sample of 10 veterans sample undergoing 16 sessions of VR exposure in two different VR environments: a virtual helicopter and a jungle. Participants showed reductions of PTSD symptoms, with maintenance of results at follow-up.

Unsurprisingly, most recent VRET interventions for PTSD have also focused on war veterans and, therefore, the creation of virtual environments that resemble war scenarios, with elements such as explosions, weapons, and other injured soldiers and civilians, with good results in reducing the intensity of PTSD symptoms (Scozzari & Gamberini, 2011). A meta-analysis by Kothgassner et al. (2019), which included nine studies on the topic, found that VRET has moderate effects in reducing the severity of PTSD symptoms compared to

traditional therapies, particularly CBT with exposure and eye movement desensitization and *reprocessing therapy (Eye Movement Desensitization and Reprocessing*, EMDR), which tend to have greater effects. Other reviews of the literature highlighted the utility of VR compared to waiting list as a control group and other active therapies, although VR did not seem to have greater effectiveness when compared to traditional trauma-focused psychotherapeutic treatments (Deng et al., 2019; Eshuis et al., 2021; Maples-Keller et al., 2017). Based on these results, traditional psychotherapies remain the first-choice treatment for PTSD, but the ability of VR to replicate scenarios that are not ethical or feasible to replicate in-vivo also make VRET a viable alternative in cases where other types of exposure are not possible. However, further studies are needed to further prove the effectiveness of VRET, especially research with fewer methodological limitations and conducted on more varied PTSD samples.

2.2.3 Psychotic disorders

Psychotic disorders are considered severe mental health problems leading to abnormal thoughts and behaviors, including delusions, hallucinations, disorganized speech, grossly disorganized or catatonic behavior, or negative symptoms (e.g., lack of emotional responsiveness, extreme apathy) (APA, 2022). Although methodological studies carried out in this clinical population are still few (Monaghesh et al., 2022), in the literature VR has been successfully applied to the treatment and assessment of psychotic disorders and schizophrenia.

In the literature, VR was found to be useful in the assessment of paranoia, a symptom which is widely present in psychotic disorders, as this technology is capable of exposing patients to a variety of social situations where their psychotic symptom can be observed at play (Freeman et al., 2017a). Moreover, using VR in patients with psychosis can have many different positive aspects, such as offering brief and effective interventions that can be tailored to patients' specific needs (e.g. tailored to replicate specific hallucinations and teach patients how to contrast them; Novak, 2002) and that could also help increase adherence to pharmacological treatment (Bisso et al., 2020).

A systematic review by Rus-Calafell and colleagues (2018), indeed, found that VR systems are effective in assessing executive functioning, social competence and paranoid symptoms, which can be easily elicited in the patient by introducing elements of social nature, such as avatars with different appearances and intentions. The same review reports that VR can also be used to carry out treatments that have been proven to be effective for psychotic disorders, such as cognitive remediation therapy (a therapeutic intervention aimed at restoring and improving cognitive functions, which are often damaged in psychotic patients) (Ali et al.,

2017), and social skills training, which aims to increase social skills(Bellack et al., 2013). In this field, VR showed more promising results than traditional interventions (Fernández-Sotos et al., 2020), as it includes interactive tasks that make the treatment more engaging and enjoyable and allows patients to try activities that are considered difficult several times, until they acquire new skills to use in real life (Freeman et al., 2023). Despite its excellent potential, the use of VR for the assessment and treatment of psychosis is still at an early stage and further studies, with larger sample sizes and longer follow-ups, are needed to further test its efficacy and systematically integrate it in the clinical practice.

2.2.4 Substance use disorders and addictions

Another field in which VR has been successfully use in the clinical psychological field is the assessment and treatment of substance use disorders and addictions associated to different substances, such as tobacco and nicotine (Liu et al., 2022; Zamboni et al., 2022), alcohol (Zhang et al., 2023), and drugs (Samora et al., 2024). This has been predominantly done thanks to the possibility of VR of modulating the environment and the variety of stimuli present in the virtual context in order to generate the desire that motivates the intake of the substance (*craving*) and, thus, to evaluate the dysfunctional behavior that the patient puts in place. Through this mechanism, a recent systematic review observed that VR can help patients with substance use disorders and addictions to learn more adaptive strategies to reduce craving and to avoid dysfunctional behaviors (Samora et al., 2024; Segawa et al., 2019). VR also proved to have the potential to improve mood and anxiety symptoms in these patients, as well as retention of treatment, particularly if VR therapy targeted these psychological symptoms directly (Taubin et al., 2023). However, further studies with fewer methodological limitations are needed to understand which specific types of addictions and substance use disorders can benefit the most from VR-based interventions and at what point during the therapeutic process would be more useful to include VR into clinical protocols.

2.3 Virtual reality in the treatment and assessment of eating disorders

2.3.1 VR-based assessment of eating disorders and ED-related symptoms

The assessment of body image disorders is a key part of ED assessment, as they often precede and explain the onset of these psychopathologies. Among these, body image distortion (defined as the inability of the person to perceive and correctly evaluate the size of their body) and body image dissatisfaction (defined as the inability to appreciate and accept the size and

shape of their body) are components that have been widely targeted and investigated through the use of VR (Ferrer-García & Gutiérrez-Maldonado, 2012).

Traditionally, body image distortion and dissatisfaction are assessed respectively by means of visual tasks to assess one's body size and by means of questionnaires and tasks to score silhouettes of different types (Thompson, 2001). Therefore, several studies have analyzed the use of VR with the same purpose (Ferrer-García & Gutiérrez-Maldonado, 2012). In particular, Riva (1998) developed a tool for the assessment of body image-related disturbances, the Body Image Virtual Reality Scale (BIVRS), which consists of a non-immersive VR software with a 3D graphic interface where the user is asked to choose between seven figures, varying from underweight to overweight, the one that most reflects their real body and the one that is closer to their ideal body. The user is also asked to assume the discrepancy between the two, which represents an indicator of their level of body dissatisfaction. The author pointed out that the assessment of body image carried out through this VR system had several advantages compared to traditional assessment tools, such as the possibility for the patient to perceive more accurately the difference between the figures thanks to the 3D nature of the images and to focus all the attention on the task to be carried out thanks to the greater immersivity of this technology. In addition, thanks to the possibility of the BIVRS software to also work online, it allows researchers to reduce cultural biases by creating a cross-cultural database with immediately accessible body image data, facilitating research.

Similarly, Perpiñá et al. (1999) developed a software for the assessment of body image discomforts. This software consists of a 3D human figure, inserted in an immersive environment, whose size of the different parts of the body can be changed using a scroll bar. The user shares the same virtual environment with the three-dimensional figure in a way that leads them to assume that they have the same body size. Therefore, the changes that the user makes to the avatar give information about different dimensions of body image, such as the perceived body, the desired body and the body the user considers healthy. Both of these software have been used within therapeutic interventions for the assessment of patients with body image disorders, both before and after treatment to measure changes, and for increasing the patient's awareness of their disorder. However, to date, no psychometric studies have been published on the subject (Ferrer-García & Gutiérrez-Maldonado, 2012).

VR is also used in ED assessment to elicit and analyze dysfunctional or pathological behaviors related to food. In fact, a study by Gorini and colleagues (2010) compared the effect that virtual food-related stimuli (compared to similar real stimuli and stimuli shown in photographs) had on the levels of anxiety and physiological parameters (e.g. heart rate,

respiratory rate and skin conductance) of 20 patients with AN and BN compared to 10 healthy controls. The results showed that virtual food had the same efficacy as real food and greater efficacy than food shown in photographs in generating anxiety responses in patients with EDs, regardless of the specific diagnosis and severity of the disease. In healthy controls, as expected, no emotional response was detected in any of the conditions, as food did not represent an anxiety-inducing stimulus for them. In addition, the authors observed how the anxiety of ED patients increased proportionately to the experienced sense of presence, which is the element making exposure to virtual stimuli more emotionally engaging than food photographs. Therefore, VR stimuli related to food, introduced in a virtual environment capable of inducing a sense of presence in the user, can represent a possible alternative to the use of real stimuli to expose and generate emotional responses in patients.

Starting from this observation, several studies have investigated the ability of virtual environments containing virtual food to elicit and maintain dysfunctional behaviors typical of eating disorders and the responses associated with them. Perpiñá and colleagues (2013) analyzed the behavior of 22 ED patients, compared to 37 healthy controls, in a virtual environment consisting of a kitchen in which the patient is encouraged to prepare food and a second room in which the patient is encouraged to eat it virtually, with chewing sounds and the vision of food gradually disappearing from the plate. In addition to all the elements necessary for the preparation and consumption of the meal, there are also distracting elements in the environment, such as the telephone and the radio, with which the patient can interact to implement behaviors that can distract them from the urge to eat. Before eating, patients reported moderate to high scores on fear and avoidance and low scores on desire to eat, while after eating, they reported eating-related sensations, such as the perception of having gained weight, the urge to eat again and negative feelings, and dysfunctional behaviors, such as pressure to exercise to compensate for the "meal", to eliminate what they had just "eaten" or, on the contrary, to binge.

These studies suggest, therefore, that VR can be used in the clinical practice for the assessment of EDs to investigate the presence of disorders related to body image and to elicit emotions and behaviors related to food similar to those that are typically enacted by ED patients in daily life.

2.3.2 VR-based treatment of eating disorders and ED-related symptoms

One of the most common applications of VR in the treatment of EDs is in *cue exposure therapy* (CET), used especially in cases of BN and binge eating disorder, which consists of

repeatedly exposing the patient to a stimulus that generates a very strong desire (*craving*) – food – but preventing them from enacting the associated maladaptive behavior (e.g. binge eating), to break the stimulus-response association and to extinguish maladaptive behaviors (Ciążyńska & Maciaszek, 2022; Clus et al., 2018). Unlike in vivo or imaginative exposure, VR exposure allows the patient to be subjected to the stimulus that induces *craving* and negative emotions in a safe environment, which simulates the real environment in a personalized way, presenting the stimulus accompanied by multisensory stimulation repeatedly until the response subsides.

The effects of VR exposure therapy were demonstrated by a randomized controlled trial by Ferrer-García et al. (2017), with a six-month follow-up (Ferrer-García et al., 2019), in which 64 patients (29 with BED and 35 with BN) who did not respond to a first-level treatment with CBT *(cognitive behavioral therapy*), underwent a second-level treatment, consisting of six additional CBT sessions (A-CBT) for one group, with the aim of consolidating the techniques learned in the first treatment cycle and focusing more on the areas still problematic, and for the other group six sessions of CET with VR (VR-CET). Patients assigned to the VR-CET group, before starting the actual treatment, were asked to order thirty foods and three environments (i.e. kitchen, bedroom and canteen) based on the level of *craving* and the consequent anxiety generated in them. This hierarchy was then used in VR-CET sessions, in which subjects were exposed to the foods and environments they marked as having the greatest impact, until the level of anxiety, recorded on a scale from 0 to 100, was reduced by 40% compared to the level experienced at the beginning of exposure. The results showed that, although both second-level treatments were effective in reducing *craving* and anxiety associated with food that often induced binge eating episodes, VR-CET had better outcomes in both the short and long term, with a higher reduction in anxiety, number of episodes of binge eating *and purging*, and tendency to eat more than necessary compared to A-CBT.

The efficacy of VR-CET was also demonstrated in a single case study conducted on a patient with restrictive AN by Cardi and colleagues (2012), in which a non-immersive VR software consisting of a kitchen containing foods of different caloric amounts was used to gradually expose the patient to feared foods, until negative emotions and thoughts decreased in intensity. At the end of seven one-hour sessions, the patient reported a reduction in food-related anxiety and guilt, depressive symptoms, fear of losing control and number of safety behaviors engaged. At the same time, an increase in body mass index, variety of foods consumed, and self-esteem was also reported. This study suggests that the use of VR for exposure to feared stimuli may be a useful adjunct to standard treatment for AN, especially in

cases where traditional psychotherapy is not sufficient, but controlled studies with large sample sizes are necessary to further generalize this conclusion.

Another use of virtual reality in the treatment of EDs is in the correction of multisensory deficits, present in those suffering from these psychopathologies (Brizzi et al., 2023). Indeed, according to a theory by Riva & Dakanalis (2018), patients with EDs lack the multisensory integration that the brain normally operates between the information concurrently received from different sensory modalities which are computed together to create the *body matrix*. The ***body matrix*** is an internal model of the body that arises from sensory information of different kinds, recalibrated on the basis of conceptual (i.e. the meaning that the person attributes to the body), perceptual (e.g. body shape and size), and episodic (deriving from life events related to the body) information already present in the memory. In patients with EDs, this integration process is impaired, leading to a difficulty in recognizing internal signals that predict potential adverse emotional consequences and in updating memories of negative body-related events, once they are replaced by new ones. Respectively, these deficits make it difficult to identify and use appropriate emotional regulation strategies, leaving room for maladaptive behaviors (e.g. binge eating in emotionally stressful situations), and could explain body image distortions and dissatisfaction common in these patients.

In light of this theory, VR can be used to modify negative body-related memories and reorganize patients' multisensory integration processes, using a technique called *frame shifting approach* (Riva et al., 2021). The ***frame shifting approach*** was elaborated starting from the technique of *imagery rescripting*, used in the cognitive-behavioral field to bring the patient to an alternative and updated reading of the negative events that occurred in the past, eliciting new emotions and previously unsatisfied needs, in order to process them and reduce the associated discomfort (Arntz & Weertman, 1999). In this regard, Riva and colleagues (2018) developed a *virtual reality imagery rescripting* protocol for body image that can be integrated into the CBT therapeutic approach. Starting from the *Allocentric Lock Theory* (Riva, 2012), which hypothesizes that patients with EDs would be locked to an allocentric representation of their body stored in long-term memory (defined as *allocentric lock*) and incongruent the real body, the protocol aims to unlock body memory by increasing the contribution of new egocentric somatosensory information related to allocentric negative memory. The protocol consists of four phases. In the first phase, the patient is asked, through a clinical interview, to relive the negative memory responsible for the distorted view they have of the body, describing in detail the situation in which it was created and reinforced and the meaning it holds. In the second phase, the clinician recreates the setting described by the patient in VR. In the third

phase, the patient experiences the event described in VR in first person, therefore without seeing their body in the scene (egocentric vision), and is asked to reinterpret it in a positive way, using some cognitive techniques, such as the replacement of negative adjectives about the situation with more articulated descriptions (*label shifting*). In the fourth and final phase, the patient experiences the event again in VR but in third person, thus seeing their body in the scene in the form of an avatar (allocentric vision), and is asked to intervene to reassure and calm their own avatar with the learnt cognitive techniques, such as recognizing errors in catastrophic perceptions and cognitions and thinking of alternative interpretations of the situation before making decisions. This protocol proved to be effective in updating body memory content and consequently in achieving clinical goals, including the reduction of preoccupations with weight, binge eating and *purging* episodes, and the increase of body satisfaction, especially in patients with BED (Manzoni et al., 2016).

Moreover, taking inspiration from the *Rubber Hand Illusion* (Botvinick & Cohen, 1998), in which participants came to perceive a rubber hand as their own thanks to the simultaneous sensory stimulation of the real hand and the artificial hand, it has been observed that this kind of bodily illusion can also occur in virtual environments, as users come to perceive the virtual avatar as their own real body (Riva et al., 2021). In particular, patients suffering from EDs experience the illusion of the rubber hand more intensely than healthy controls, both perceptually and cognitively, as they themselves report in the questionnaires, and from this it can be inferred that the plasticity of the bodily self in these patients is greater than in healthy controls (Eshkevari et al., 2012). For this reason, VR has been used to modify patients' perception of the body, through body *swapping*. Keizer and colleagues (2016) asked 29 patients with AN and 30 healthy controls to estimate the width of their shoulders, abdomen and hips before and after being subjected to a full body illusion (*full body illusion*), induced through simultaneous visual-tactile stimulation in the experimental condition (which was not simultaneous but *alternated* in the control condition) of the real and corresponding virtual body parts. In the experimental condition, the virtual body was perceived as one's own, while this did not happen or happened with less intensity in the control condition. As expected, patients with AN showed a greater overestimation of their body size than healthy controls. However, after being exposed to the VR procedure, they also reported a reduction in the overestimation of shoulder, abdomen and hip measurements, especially in terms of circumference, regardless of whether they belonged to the experimental or control condition, confirming the hypothesis that VR can help in the treatment of body image disturbances, which are common in EDs (Thompson, 2001).

As described in this section, the possible uses of VR in the treatment of EDs are varied. However there are still limitations related to costs, to the limited number of VR software on the market that are ready and available to all clinicians, and to the need for further studies that investigate the effectiveness of VR on these psychopathologies on larger samples and with longer follow-ups (Riva et al., 2021).

2.4 Conclusion of the chapter

This chapter summarized how the use of virtual reality (VR) can be beneficial in clinical psychology for the treatment and assessment of several psychopathologies, especially due to the ability of VR-based intervention to improve traditional CBT-based interventions (Clus et al., 2018; Freeman et al., 2017; Riva, 2022). Even in the field of EDs, VR has successfully been used for the assessment and treatment of such psychopathologies (e.g. Ciążyńska & Maciaszek, 2022; Ferrer-García & Gutiérrez-Maldonado, 2012; Riva et al., 2021). Indeed, VR emerged as a valuable tool that can be used for evaluating body image disturbances, as well as for eliciting and measuring maladaptive behaviors related to food (e.g. Clus et al., 2018; Gorini et al., 2010; Gutiérrez-Maldonado et al., 2016). Additionally, VR exposure therapy showed promising and effective results in reducing ED symptoms, especially those related to craving and anxiety associated with food (Riva et al., 2021), especially for its ability to safely expose patients to fear-provoking stimuli (Gorini et al., 2010). Moreover, VR interventions targeting multisensory deficits and body image distortions have demonstrated effectiveness in modifying negative body-related memories and perceptions (Ferrer-García & Gutiérrez-Maldonado, 2012; Manzoni et al., 2016; Riva et al., 2021). Regarding the prevention of these psychopathologies, however, no study has explored the potential held by VR-based interventions in preventing EDs. Moreover, despite the advancements made in regards to the use of VR in clinical psychology, the literature shows that some challenges still persist that limit its applicability in the clinical field, such as the high cost and the tendency of VR software to be disorder-specific (Segal et al., 2011). One possible solution for this could be to develop and test transdiagnostic VR software and VR-based interventions that can target transdiagnostic factors shared by different psychopathologies, such as the ones introduced in the first chapter (i.e. emotion regulation, experiential avoidance, and psychological flexibility). However, the use and effectiveness of VR targeting transdiagnostic factors have only partially been explored, as we will show in the systematic review that will be reported in the third chapter of this Ph.D. dissertation (Gardini et al., 2022). While VR was found effective in improving emotion regulation strategies , research on the efficacy of VR interventions targeting experiential avoidance and psychological flexibility remains limited, especially in the field of EDs and their prevention.

CHAPTER 3.
THE USE OF VIRTUAL REALITY FOR THE IMPROVEMENT OF TRANSDIAGNOSTIC PSYCHOLOGICAL FACTORS

Virtual reality has also been used, albeit to a lesser extent, to improve transdiagnostic factors (such as the ones mentioned in previous paragraphs) common to several psychopathologies. A systematic review of the literature conducted by our research team and published in the special issue "*Clinical Applications of Cyberpsychology and Virtual Reality for Mental Disorders*" of the Mental Health section of the Journal of Clinical Medicine (Gardini et al., 2022) has attempted to collect a wide range of articles to assess the effectiveness of VR-based interventions in the improvement of transdiagnostic factors. The full text of the review has been included in the present chapter.

3.1. The effects of virtual reality in targeting transdiagnostic factors for mental health: a systematic review of the literature

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MDPI

Systematic Review

The Effects of Virtual Reality in Targeting Transdiagnostic Factors for Mental Health: A Systematic Review of the Literature

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3.1.1 Introduction

In recent years, virtual reality (VR) has emerged as a new tool to assist clinicians in the treatment of several psychiatric disorders especially in anxiety, psychotic, sub-stance-related, and eating disorders (Emmelkamp & Meyerbröker, 2021; Freeman et al., 2017a) because of its ability to provide a systematic and controlled exposure therapy without the complications of in vivo exposure (Wiederhold & Wiederhold, 2005). Moreover, VR can also be used in association with cognitive-behavioral treatments (CBT) and other psychotherapeutic interventions such as Mindfulness-Based Cognitive Therapy (Damen & van der Spek, 2018) and Dialectical Behavioural Therapy (Lamb et al., 2023) to improve existing treatment pro-

tocols for several psychiatric disorders (e.g. anxiety disorders, eating disorders, sub-stance-use disorders, psychosis, etc.) (Emmelkamp & Meyerbröker, 2021).

Nonetheless, several downsides in relation to VR have also been reported that make its application difficult in the clinical setting, such as its high cost (Lindner et al., 2021) and the need to have different software specifically tackling different psychiatric disorders. In-deed, the disorder-specific approach that has been predominantly used to design VR software and interventions is also the approach that is most widely used for traditional CBT. CBT interventions, in fact, are usually designed for the treatment of one single disorder at a time (McEvoy et al., 2009; McManus et al., 2010; Titov et al., 2011), since they are based on assumptions coming from the conventional nosological systems, such as the DSM-5 and the ICD-10 (American Psychiatric Association, 2022; World Health Organization (WHO), 2010). These diagnostic systems view psychopathologies as distinct, independent, and categorical constructs, with patients either meeting or not the diagnostic criteria for a specific psychiatric dis-order (Krueger & Eaton, 2015).

Things, however, are much more complicated than this in the clinical experience, where often a person can present more than one psychiatric disorder in comorbidity.

Recently clinical research turned in fact to transdiagnostic model to explore men-tal disorders and overcome the limits of disorder-specific approach (Dalgleish et al., 2020). The transdi-agnostic framework emphasizes in particular that mental health disorders share com-mon underlying psychological factors, or transdiagnostic factors (Eaton et al., 2015) which targeted simultaneously may allow to treat both the main disorder and its comorbidities (Barlow et al., 2004; Titov et al., 2011). Thus far, while the literature has no accordance about a shared list of transdiagnostic factors that can cause and maintain several psychological disorders, the Internalizing-Externalizing Model of Psychopathology is one of the most widely accepted transdiagnostic model (Carragher et al., 2015). In the model, transdiagnostic factors are divided into two main categories: internalizing factors, which include several over-inhibited or internally-focused symptoms (e.g. avoidance, negative emotions, social withdrawal, somatic complaints, etc.), and externalizing factors, which in turn include disinhibited or externally-focused behavioral symptoms (e.g. aggression, impulsivity, disinhibition, conduct problems, delinquent behavior, oppositionality, hyperactivity, attention problems, etc.). Subsequently, transdiagnostic interventions based on CBT therapy have been developed to target these specific internalizing and externalizing transdiagnostic factors such as the Unified Protocol, the Shared Mechanisms Treatments, and the Transdiagnostic Cognitive-Behavioral Therapy (Norton & Roberge, 2017). More specifically, the Unified Protocol for Transdiagnostic

Treatment of Emotional Disorders (Ellard et al., 2017) is the most widely studied evidence-based protocol (Sakiris & Berle, 2019), which resulted to be effective in particular for the treatment of anxiety and mood disorders (Ellard et al., 2010; Farchione et al., 2012) with results similar to disorder-specific treatments (Barlow et al., 2017; Steele et al., 2018).

Since many authors agree that transdiagnostic treatments would be more advan-tageous than disorder-specific treatments for their ability to increase cost efficiency (McHugh et al., 2009; Titov et al., 2011), if transposed to the development of VR software the transdiagnostic approach might be able to overcome also the limits (in terms of costs and training) of this technology in the field of clinical psychology.

In order to understand the transdiagnostic potential of VR, this systematic review of the literature aims to explore whet her some of the main internalizing and external-izing transdiagnostic factors for mental health disorders (Eaton et al., 2015; Krueger & Eaton, 2015) can be improved by VR-based treatments.

3.1.2 Materials and methods

3.1.2.1 Protocol and search strategy

This systematic review has been conducted accordingly to the Preferred Reporting Items for Systematic Reviews (PRISMA) criteria guidelines (Page et al., 2021) and was not registered on a public repository. Two databases (PubMed and PsycINFO) were used to retrieve articles for the present review: authors selected six keywords to identify some of the main internalizing and externalizing transdiagnostic factors for mental health disorders (Eaton et al., 2015; Krueger & Eaton, 2015): “avoidance”, “aggression”, “disinhibition”, “emotion regulation”, “reappraisal”, and “impulsivity”. In particular, due to the lack of a set list of transdiagnostic factors in the literature, the authors decided to select clinically relevant transdiagnostic factors that have been found to be present and play a role in many psychopathologies. For example, different types of avoidance (e.g., avoidance behaviors, social avoidance, experiential avoidance, cognitive avoidance, etc.) characterize a wide variety of mental health disorders, such as mood and anxiety disorders, post-traumatic stress disorders (PTSD), psychotic disorders, and obsessive-compulsive disorders (Bach & Eikenaes, 2021; Besharat et al., 2019; Harvey et al., 2004; Im & Kahler, 2022). Similarly, difficulties in using emotion regulation strategies and cognitive reappraisal are linked to the maintenance and development of several psychopathologies and represent some of the main targets of transdiagnostic CBT-based treatments (Barlow et al., 2017; Riepenhausen et al., 2022; Sheppes et al., 2015; Sloan et al., 2017). Finally, aggressive behaviors, impulsivity, and disinhibition

can also be found in diagnostic criteria and clinical presentations of different psychiatric diagnoses and especially externalizing disorders (e.g., substance-use disorders, antisocial personality disorder, attention-deficit-hyperactivity disorder, etc.) (American Psychiatric Association, 2014; Johnson et al., 2013; Krueger & Eaton, 2015; Nelson et al., 2016; Ten Have et al., 2014; World Health Organization (WHO), 2010; Young et al., 2009).

All of the keywords identifying these transdiagnostic factors were combined with the keyword "virtual reality" using the Boolean operator "AND".

During the database search, results were filtered for English and Italian language, journal articles, clinical trials (PubMed), and academic journals (PsycINFO). With regard to publication dates, the authors selected a range between 2010 and September 2022. Duplicate articles generated across databases were identified and excluded.

Titles and abstracts were screened by two authors (G.G., S.M.) in order to asses which ones would fulfill the aforementioned aims of the review. Articles that appeared potentially eligible for the review were retrieved and reviewed by two authors (V.G., G.G.), who independently assessed each of the full reports, arriving at a consensus regarding eligibility. When disagreements between the two authors arose, multiple rounds of full-text revision and discussions were undertaken until consensus was reached, with the involvement of a third author (E.T.) when needed.

A visual representation of the article selection process is presented in the PRISMA flow diagram (**Figure 3.1**) below.

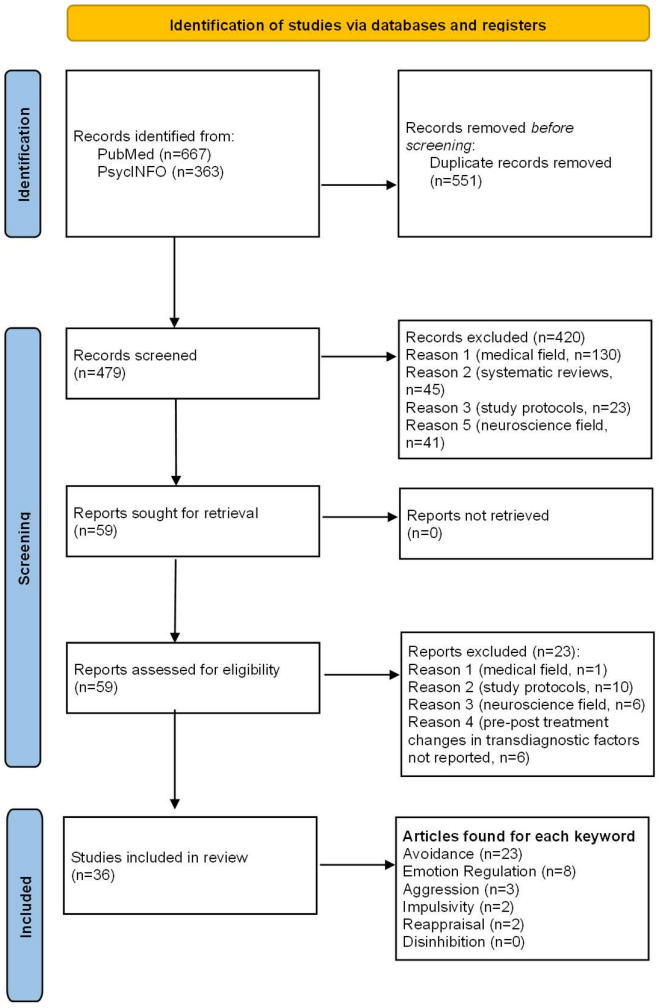


Figure 3.1. PRISMA flow diagram summarizing the article selection process (Page et al., 2021).

3.1.2.2. Eligibility criteria

Articles were considered eligible for the review if they were randomized controlled trials (RCTs), longitudinal studies, or case studies evaluating changes in patients' levels of the considered transdiagnostic factors between pre- and post- VR-based intervention. Study protocols, dissertations, systematic and non-systematic reviews, meta-analyses, medical or neuroscience studies and books (or book chapters) were excluded from the research. More information about inclusion and exclusion criteria for articles selection are summarized in the PICOS table below (**Table 3.1**) (Counsell, 1997).

Table 3.1. PICOS table for inclusion and exclusion criteria (Counsell, 1997).

PICOS	Inclusion Criteria	Exclusion Criteria
Patients	• Patients with mental health disorders • Individuals from the general population	• Individuals with physical diseases, hospitalized due to physical conditions or presenting brain damage
Intervention	Any intervention that included the use of Virtual Reality technologies	• Interventions that did not include the use of Virtual Reality • Neuroscience studies
Control Group	Any control group or absence of a control group	None
Outcome	Any type of change in patients' levels of emotion regulation, avoidance, impulsivity, aggression, reappraisal, and disinhibition.	None
Study Design	• Longitudinal studies (pre-post intervention) • Randomized and non-randomized controlled trials • Case studies	• Study protocols • Systematic and non-systematic reviews • Meta-analyses • Medical or neuroscience studies • Books (or book chapters)

3.1.2.3. Data extraction

Following the database search, duplicate articles generated across the two databases (PubMed and PsycINFO) were selected and removed. The authors then proceeded to screen titles and abstracts of the articles and excluded those which did not seem relevant to the keywords and aims listed above. All of the remaining articles were subsequently read thoroughly in order to examine whether changes in the aforementioned transdiagnostic factors following a VR-based intervention were assessed between pre- and post- treatment. When present, data regarding follow-ups were also collected. Data extraction was performed independently by two of the authors (G.G. and V.G.). The authors followed the PICOS pre-set extraction criteria (see **Table 3.1**) and systematically summarized the relevant data of each article in a separate table (see **Table S1** *in Gardini et al., 2022*).

3.1.2.4. Quality and risk of bias assessment

Quality and risk of bias assessment was conducted using a customized checklist retrieved from the National Institutes of Mental Health's tool (National Institute of Mental Health, 2008) on experimental articles only, while this assessment was not conducted on case studies. See **Table S2** (*in Gardini et al., 2022*) for criteria.

3.1.3 Results

3.1.3.1 Results of literature search

A total of 1.030 articles were retrieved from PubMed and PsycINFO. After the removal of 551 duplicates (53.50%) and the exclusion of 420 articles (40.78%) (see **Figure 3.1**), a total of 59 articles (5.73%) were considered potentially eligible for the review. After full-text screening of the articles, 36 articles (3.50%; n = 29 experimental studies and n = 7 case studies) were finally included in the review.

The number of studies taken into consideration for each transdiagnostic factor varied. Avoidance was the most studied transdiagnostic factor found in 23 articles (63.89%) (n = 19 experimental studies and n = 4 case studies) (Bouchard et al., 2017; Czerniak et al., 2016; Farrell et al., 2021; Freeman et al., 2022; Gujjar et al., 2018, 2019; Kampmann et al., 2016; Kaussner et al., 2020; D.-Y. Kim & Lee, 2019; M.-K. Kim et al., 2022; López et al., 2016; Malbos et al., 2011, 2013; Maples-Keller et al., 2017; Meyerbroeker et al., 2013; Michaliszyn et al., 2010; Miloff et al., 2019; Pot-Kolder et al., 2018; Roncero & Perpiñá, 2015; Rus-Calafell et al., 2014; Safir et al., 2012; Shiban et al., 2015; Wrzesien, Botella, et al., 2015), followed by emotion regulation, which was found in eight articles (22.22%; n =7 experimental studies and n =1 case study) (A. P. Anderson et al., 2017; Bosse et al., 2014; Hadley et al., 2019a; Nararro-Haro et al., 2016; Navarro-Haro et al., 2019; Otkhmezuri et al., 2019; Wrzesien, Rodríguez, et al., 2015; Yuan & Ip, 2018); aggression, which was found in three experimental studies (8.33%) (Jo et al., 2022; Klein Tuente et al., 2020; Zinzow et al., 2017); impulsivity, which was found in two studies (5.56%; n =1 experimental study and n = 1 case study) (Klein Tuente et al., 2020; Laforest et al., 2016); and cognitive reappraisal, which was found in two studies (5.56%; n = 1 experimental study and n = 1 case study) (Bosse et al., 2014; Falconer et al., 2019). No studies were found for the transdiagnostic factor of disinhibition. Moreover, two studies took into consideration two transdiagnostic factors simultaneously: emotion regulation and reappraisal (Bosse et al., 2014), and aggression and impulsivity (Klein Tuente et al., 2020).

3.1.3.2 Characteristics of the studies

Among the 36 articles that were selected for the review, different sample sizes were used. Sixteen experimental studies (44.44%) had less than 50 participants (A. P. Anderson et al., 2017; Bosse et al., 2014; Gujjar et al., 2018, 2019; Kaussner et al., 2020; D.-Y. Kim & Lee, 2019; López et al., 2016; Malbos et al., 2011, 2013; Michaliszyn et al., 2010; Navarro-Haro et al., 2019; Otkhmezuri et al., 2019; Rus-Calafell et al., 2014; Shiban et al., 2015; Wrzesien, Rodríguez, et al., 2015; Zinzow et al., 2017), nine (25%) included between 50 and 100

participants (Bouchard et al., 2017; Hadley et al., 2019a; Jo et al., 2022; Kampmann et al., 2016; M.-K. Kim et al., 2022; Meyerbroeker et al., 2013; Miloff et al., 2019; Safir et al., 2012; Yuan & Ip, 2018), and only a few (n = 4, 11.11%) had a sample size larger than 100 participants (Freeman et al., 2022; Klein Tuente et al., 2020; Maples-Keller et al., 2017; Pot-Kolder et al., 2018). Finally, seven (19.44%) articles were multiple or single case studies including between one and eight participants (Czerniak et al., 2016; Falconer et al., 2019; Farrell et al., 2021; Laforest et al., 2016; Nararro-Haro et al., 2016; Roncero & Perpiñá, 2015; Wrzesien, Botella, et al., 2015).

In terms of research design, only 23 out of 36 studies (63.89%) were controlled studies, of which 19 were randomized controlled trials (RCTs) (82.61%) (Bosse et al., 2014; Bouchard et al., 2017; Freeman et al., 2022; Gujjar et al., 2019; Hadley et al., 2019a; Kampmann et al., 2016; D.-Y. Kim & Lee, 2019; M.-K. Kim et al., 2022; Klein Tuente et al., 2020; Malbos et al., 2011, 2013; Meyerbroeker et al., 2013; Michaliszyn et al., 2010; Miloff et al., 2019; Navarro-Haro et al., 2019; Pot-Kolder et al., 2018; Safir et al., 2012; Shiban et al., 2015; Wrzesien, Rodríguez, et al., 2015) and four (17.39%) were non-randomized controlled studies (Jo et al., 2022; Kaussner et al., 2020; Otkhmezuri et al., 2019; Yuan & Ip, 2018). Six studies out of 36 (16.67%) were uncontrolled clinical trials (A. P. Anderson et al., 2017; Gujjar et al., 2018; López et al., 2016; Maples-Keller et al., 2017; Rus-Calafell et al., 2014; Zinzow et al., 2017), and seven (19.44%) were case studies (Czerniak et al., 2016; Falconer et al., 2019; Farrell et al., 2021; Laforest et al., 2016; Nararro-Haro et al., 2016; Roncero & Perpiñá, 2015; Wrzesien, Botella, et al., 2015). A total of 21 studies (58.33%) also included a follow-up (ranging from 1 to 12 months) (Bosse et al., 2014; Bouchard et al., 2017; Farrell et al., 2021; Freeman et al., 2022; Gujjar et al., 2018, 2019; Hadley et al., 2019a; Kampmann et al., 2016; Kaussner et al., 2020; M.-K. Kim et al., 2022; Klein Tuente et al., 2020; Laforest et al., 2016; Malbos et al., 2013; Michaliszyn et al., 2010; Miloff et al., 2019; Pot-Kolder et al., 2018; Rus-Calafell et al., 2014; Safir et al., 2012; Shiban et al., 2015; Wrzesien, Botella, et al., 2015; Zinzow et al., 2017).

Regarding sociodemographic characteristics of the samples in the reviewed studies, the age range went from young children to adults (around 8 to 51 years of age). However, the great majority of the studies were carried out on adult samples between ~19 and 51 years of age (n = 31, 86.11%), with only two studies (5.56%) carried out on children between ~8 and 10 years of age (Farrell et al., 2021; Yuan & Ip, 2018), and three (8.33%) on adolescents between ~12 and 15 (Falconer et al., 2019; Hadley et al., 2019a; Wrzesien, Rodríguez, et al., 2015). Moreover, mixed gender was predominant in the studies (n = 23; 36.11%), with some

exceptions: four studies (11.11%) had an all-male sample (Czerniak et al., 2016; Falconer et al., 2019; Jo et al., 2022; Zinzow et al., 2017), and four (11.11%) had an all-female sample (Laforest et al., 2016; Nararro-Haro et al., 2016; Roncero & Perpiñá, 2015; Wrzesien, Botella, et al., 2015). Moreover, five studies (13.89%) did not clearly state the participants' gender (Gujjar et al., 2018; M.-K. Kim et al., 2022; Klein Tuente et al., 2020; Meyerbroeker et al., 2013; Shiban et al., 2015).

Lastly, regarding the kind of VR technology that was used among all 36 studies, 28 (77.78%) used immersive VR (A. P. Anderson et al., 2017; Bouchard et al., 2017; Czerniak et al., 2016; Farrell et al., 2021; Freeman et al., 2022; Gujjar et al., 2018, 2019; Hadley et al., 2019a; Jo et al., 2022; Kampmann et al., 2016; D.-Y. Kim & Lee, 2019; M.-K. Kim et al., 2022; Klein Tuente et al., 2020; López et al., 2016; Malbos et al., 2011, 2013; Maples-Keller et al., 2017; Michaliszyn et al., 2010; Miloff et al., 2019; Nararro-Haro et al., 2016; Navarro-Haro et al., 2019; Otkhmezuri et al., 2019; Pot-Kolder et al., 2018; Rus-Calafell et al., 2014; Safir et al., 2012; Shiban et al., 2015; Wrzesien, Botella, et al., 2015; Wrzesien, Rodríguez, et al., 2015), 3 (8.33%) Cave Automatic Virtual Environment (CAVE) (Laforest et al., 2016; Meyerbroeker et al., 2013; Yuan & Ip, 2018), and only five (13.89%) used non-immersive VR technology (Bosse et al., 2014; Falconer et al., 2019; Kaussner et al., 2020; Roncero & Perpiñá, 2015; Zinzow et al., 2017). See **Table S1** (*in Gardini et al., 2022)* for characteristics of the studies and the specific contents, data and results of the selected papers.

3.1.3.3. Clinical and non-clinical populations included in the studies

The majority of the studies (n = 17; 47.22%) carried out on adults focused on clinical populations. Patients with anxiety disorders were the most frequent population involved in the studies (n = 15, 41.67%), of which eight (22.22%) included patients with specific phobias (Czerniak et al., 2016; Gujjar et al., 2018, 2019; Kaussner et al., 2020; Michaliszyn et al., 2010; Miloff et al., 2019; Shiban et al., 2015; Wrzesien, Botella, et al., 2015), four (11.11%) included patients with social anxiety disorder (SAD) (Bouchard et al., 2017; Kampmann et al., 2016; M.-K. Kim et al., 2022; Safir et al., 2012), and three (8.33%) included patients with panic disorder and agoraphobia (Malbos et al., 2011, 2013; Meyerbroeker et al., 2013). Patients with PTSD (López et al., 2016; Maples-Keller et al., 2017; Zinzow et al., 2017) and psychotic disorders (Freeman et al., 2022; Pot-Kolder et al., 2018; Rus-Calafell et al., 2014) were the second most found clinical populations, appearing in three (8.33%) studies each. Other less studied clinical populations included eating disorders (n = 1, 2.78%) (Roncero & Perpiñá, 2015), borderline personality disorders (n = 1, 2.78%) (Michaliszyn et al., 2010), OCD (n = 1,

2.78%) (Laforest et al., 2016) and forensic patients (n = 1, 2.78%) (Klein Tuente et al., 2020). Four (11.11%) studies, instead, were carried out on the general population or on healthy adults (A. P. Anderson et al., 2017; Bosse et al., 2014; Jo et al., 2022; Otkhmezuri et al., 2019).

In the studies carried out on children (n = 2, 5.56%), one (2.78%) was carried out on children with specific phobias (dogs) (Farrell et al., 2021) and one (2.78%) on children with autism spectrum disorder (Yuan & Ip, 2018). Adolescent samples in the studies, instead, were taken from the general population (n = 2, 5.56%) (Falconer et al., 2019; Maples-Keller et al., 2017) or involved teens with acute anxiety, suicidal thoughts and low mood (Falconer et al., 2019) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.3.4. Quality and Risk of Bias Assessment

Quality and risk of bias assessment was performed only on experimental studies. As shown in **Table S3** (*in Gardini et al., 2022*), the quality of the selected 29 experimental studies widely differed. In particular, 15 (51.72%) were ranked as having a strong quality (Bouchard et al., 2017; Freeman et al., 2022; Gujjar et al., 2018, 2019; Hadley et al., 2019a; Klein Tuente et al., 2020; Malbos et al., 2013; Meyerbroeker et al., 2013; Michaliszyn et al., 2010; Miloff et al., 2019; Pot-Kolder et al., 2018; Rus-Calafell et al., 2014; Safir et al., 2012; Shiban et al., 2015; Zinzow et al., 2017), eight (27.59%) were ranked as having moderate quality (Gujjar et al., 2018; Jo et al., 2022; Kaussner et al., 2020; D.-Y. Kim & Lee, 2019; M.-K. Kim et al., 2022; Maples-Keller et al., 2017; Navarro-Haro et al., 2019; Wrzesien, Rodríguez, et al., 2015), and six (20.69%) were ranked as weak (A. P. Anderson et al., 2017; Bosse et al., 2014; López et al., 2016; Malbos et al., 2011; Otkhmezuri et al., 2019; Yuan & Ip, 2018). A methodological issue often found throughout the reviewed studies was the absence of a follow-up: 11 (37.93%) out of the 29 experimental studies did not include follow-up for the selected outcomes (A. P. Anderson et al., 2017; Jo et al., 2022; D.-Y. Kim & Lee, 2019; López et al., 2016; Malbos et al., 2011; Maples-Keller et al., 2017; Meyerbroeker et al., 2013; Navarro-Haro et al., 2019; Otkhmezuri et al., 2019; Wrzesien, Rodríguez, et al., 2015; Yuan & Ip, 2018).

3.1.3.5 Results about the effects of virtual reality-based interventions on transdiagnostic factors

3.1.3.5.1 Avoidance

The first result that emerged from the 23 studies (63.89%) (n = 19 experimental studies and n= 4 case studies) (Bouchard et al., 2017; Czerniak et al., 2016; Farrell et al., 2021; Freeman et al., 2022; Gujjar et al., 2018, 2019; Kampmann et al., 2016; Kaussner et al., 2020;

D.-Y. Kim & Lee, 2019; M.-K. Kim et al., 2022; López et al., 2016; Malbos et al., 2011, 2013; Maples-Keller et al., 2017; Meyerbroeker et al., 2013; Michaliszyn et al., 2010; Miloff et al., 2019; Pot-Kolder et al., 2018; Roncero & Perpiñá, 2015; Rus-Calafell et al., 2014; Safir et al., 2012; Shiban et al., 2015; Wrzesien, Botella, et al., 2015) taking into consideration the transdiagnostic factor of "avoidance" was the heterogeneity of the different types of avoidance considered. More specifically, in the majority of the studies (n = 13; 56.52%) (Czerniak et al., 2016; Farrell et al., 2021; Gujjar et al., 2018, 2019; Kampmann et al., 2016; Kaussner et al., 2020; Malbos et al., 2011, 2013; Maples-Keller et al., 2017; Michaliszyn et al., 2010; Miloff et al., 2019; Shiban et al., 2015; Wrzesien, Botella, et al., 2015), VR was used to decrease the levels of behavioral avoidance (that is, the individual act of not entering or prematurely leaving a fear-evoking or distressing situation or stimulus) (Page et al., 2021) in a wide variety of clinical and non-clinical populations.

Virtual reality exposure treatment (VRET) in particular appeared to be a useful form of intervention to reduce behavioral avoidance in adults with specific phobias (such as flying, driving, going to the dentist, spiders) (Czerniak et al., 2016; Gujjar et al., 2018, 2019; Michaliszyn et al., 2010; Miloff et al., 2019; Shiban et al., 2015; Wrzesien, Botella, et al., 2015), social anxiety disorder (Kampmann et al., 2016), panic disorder with agoraphobia (Malbos et al., 2011, 2013), and PTSD (Maples-Keller et al., 2017), with results always maintained or even improved (Miloff et al., 2019) over time when a follow-up was present (Kampmann et al., 2016; Kaussner et al., 2020; Malbos et al., 2011; Michaliszyn et al., 2010; Shiban et al., 2015). The duration of follow-ups considered spanned between one month and a year. This same technique was also effective in reducing behavioral avoidance in children with a phobia of dogs, with results maintained at a one month follow-up (Farrell et al., 2021). When compared to other forms of treatment or control conditions, VRET turned out to be more effective than providing informative pamphlets to patients with dental phobia (Gujjar et al., 2019) and equally as effective as in-vivo exposure for patients with social anxiety disorder (Kampmann et al., 2016) or specific phobias (Michaliszyn et al., 2010). When traditional forms of psychological therapy were added to VR, such as cognitive therapy (Malbos et al., 2011, 2013), no additional improvement was found compared to using VR alone. Only in one study were greater changes in behavioral avoidance found in a group of patients with specific phobias (spiders) undergoing one-session treatment (a form of gradated and repeated systematic exposures to the feared stimuli) compared to VRET (Miloff et al., 2019).

Promising results also came from the application of VR-based treatments for the improvement of social avoidance, which is another type of avoidance similar to behavioral

avoidance but specific to social situations. This transdiagnostic factor was taken into consideration in six (26.09%) studies, where it was effectively reduced by VR-based treatments in patients with social anxiety disorder (Bouchard et al., 2017; Kampmann et al., 2016; M.-K. Kim et al., 2022; Safir et al., 2012) and with psychosis (Rus-Calafell et al., 2014; Safir et al., 2012). Once again, results were maintained over time for both populations (follow-ups range: 3-weeks to 12 months). The combination of VR with cognitive-behavioral therapy (VR-CBT) was also effective in reducing social avoidance more than a waiting list condition in patients with psychosis, with results maintained at six months follow-up (Pot-Kolder et al., 2018) and with no differences when compared to traditional CBT in patients with fear of public speaking (Safir et al., 2012). Regarding comparisons between VRET and in-vivo exposure, VRET was more effective than the latter in reducing social avoidance in SAD patients and more practical according to therapists in one study (López et al., 2016), but less effective in another (Kampmann et al., 2016).

Finally, fewer but promising results were found for the ability of VR-based treatment to improve other types of avoidance, such as agoraphobic avoidance in patients with psychosis (Freeman et al., 2022) or panic disorder with agoraphobia (Meyerbroeker et al., 2013), cognitive avoidance in city violence crime victims with PTSD or acute stress disorder (López et al., 2016), alcohol-approach avoidance in patients with substance-use disorder (D.-Y. Kim & Lee, 2019), and food avoidance in a patient with bulimia nervosa (Roncero & Perpiñá, 2015) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.3.5.2 Emotion regulation

Similarly to avoidance, emotion regulation was another transdiagnostic factor that was operationalized in several different ways in the studies. Across the eight articles (n = 7 experimental studies and n = 1 case study) (A. P. Anderson et al., 2017; Bosse et al., 2014; Hadley et al., 2019a; Nararro-Haro et al., 2016; Navarro-Haro et al., 2019; Otkhmezuri et al., 2019; Wrzesien, Rodríguez, et al., 2015; Yuan & Ip, 2018) that took into consideration this factor, different dimensions of emotion regulation and emotion regulation strategies were considered.

Three studies (A. P. Anderson et al., 2017; Navarro-Haro et al., 2019; Wrzesien, Rodríguez, et al., 2015) focused on the ability of VR to help regulating emotions by inducing relaxation both in the general population adults (A. P. Anderson et al., 2017; Navarro-Haro et al., 2019) and adolescents (Wrzesien, Rodríguez, et al., 2015). Interestingly, the characteristics of the VR scenarios seemed to increase this effect. For example, natural VR scenes were shown

to increase relaxation more than to control (empty indoor classrooms) VR scenes (A. P. Anderson et al., 2017). The same was seen for VR scenarios where an avatar resembling the participant helped adolescents to regulate their emotions and achieve relaxation more than neutral avatars (Wrzesien, Rodríguez, et al., 2015). VR also produced improvements in relaxation for patients with generalized anxiety disorder when combined with a mindfulness-based intervention (Navarro-Haro et al., 2019). Unfortunately, these studies did not include a control group or a follow-up.

A promising effect of VR in improving emotion expression and regulation was also found in children with autism spectrum disorders undergoing VR training (Yuan & Ip, 2018), with results better than the waiting list condition although no follow up was included. Healthy adults going through reappraisal-based training in a VR environment also managed to lower the emotional ratings they associated with negative images, showing that VR training can indeed have an impact on emotion regulation. This has been proved also by a case report finding that mindfulness exercises performed in VR reduced negative emotions in a patient with borderline personality disorder and substance use disorder (Nararro-Haro et al., 2016).

Moreover, when compared or combined with more traditional forms of psychological interventions, VR also produced some promising results in improving emotion regulation and emotion regulation strategies. The combination of emotion regulation training with risk reduction interventions in VR managed to reduce general population adolescents' levels of emotional awareness, emotional self-efficacy, emotion regulation strategies and affect regulation, with results often comparable or even better than those obtained by a group using role-playing instead of VR training, and maintained at three-months follow-up (Hadley et al., 2019a). Although VR in combination with a mindfulness-based intervention (MBI + VR) resulted in being as effective as the mindfulness-based intervention alone (MBI) in improving several emotion regulation strategies (i.e., the ability to act with awareness, to control impulses, to self-regulate, to listen to their own body, to describe internal experiences and levels of emotional clarity) in adults with general anxiety disorder (Navarro-Haro et al., 2019), MBI + VR even achieved additional improvements in teaching patients to not judge their inner experiences (e.g., thoughts, emotions) and to concentrate even when experiencing negative emotions. Similarly, a VR cognitive-bias modification of interpretations (VR-CBM-I) managed to reduce the emotional response to a stressor more and the resulting sadness more than the standard protocol (CBM-I) (Otkhmezuri et al., 2019) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.3.5.3 Aggression

Regarding the transdiagnostic factor of aggression, different results were found in three experimental studies carried out in both clinical and general population samples.

The first result showed that VR reduced aggressive behaviors while driving in a sample of war veterans with PTSD, driving anxiety and/or aggression problems, and also helped them to increase their skill training. Even if they rated the virtual experience as not very realistic, the results were maintained at a one-month follow-up (Zinzow et al., 2017).

In the second article, using a VR Anger Exposure Training, patients' levels of anger and aggression after experiencing conflict situations with a friend or a stranger in the virtual environment decreased. In particular, anger scores decreased, especially after anger management exercises when compared to anger expression exercises, regardless if the other person was a stranger or a friend (Jo et al., 2022).

In the final article, a specific form of VR therapy called Virtual Reality Aggression Prevention Therapy (VRAPT) was able to reduce levels of aggression in forensic patients, even though there was no significant difference with the waiting-list condition. This reduction was also maintained at the three months follow-up (Klein Tuente et al., 2020) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.3.5.4 Impulsivity

Impulsivity was a transdiagnostic factor that only produced two articles, out of which one was a multiple case study (Laforest et al., 2016) and one was an experimental study (Klein Tuente et al., 2020), both of which were carried out on clinical populations.

Starting from the experimental study, impulsivity was a secondary outcome taken into consideration in a RCT mainly focusing on aggression, showing results about how this factor decreased after VRAPT treatment was administered on forensic patients. In particular, following treatment, levels of non-planning impulsiveness improved more than in the waiting list condition, with maintenance of results at three months follow-up (Klein Tuente et al., 2020).

In the multiple case study, VR was able to reduce obsessive-compulsive symptoms (such as impulsive thoughts and compulsive behaviors) in three OCD patients, with results maintained at an eight months follow-up (Laforest et al., 2016) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.3.5.5 Cognitive reappraisal

Only two of the articles included in this review (Bosse et al., 2014; Falconer et al., 2019) observed the transdiagnostic factor of cognitive reappraisal (n = 1 experimental study and n = 1 case study).

The first study was an RCT comparing two different VR training groups (a reappraisal training group and a choice reaction task training group) on their ability to influence the emotional rating participants gave to pictures (Bosse et al., 2014). Although the main results on the study regarded emotional regulation, this article is relevant in showing that VR technologies can be useful in teaching cognitive reappraisal to healthy adults.

The second study, instead, was a double case study that showed that, following a VR treatment, two children (one with acute anxiety and posttraumatic flashbacks due to past medical treatments and another with suicidal thoughts and low mood) were able to achieve a better expression of their emotions and to reappraise their experience thanks to VR therapy, especially through the perspective-taking feature given by the VR software (ProReal) that was used during treatment (Falconer et al., 2019) (see **Table S1** *in Gardini et al., 2022* for additional details of each study).

3.1.4 Discussion

VR has emerged in the literature as a new frontier for the treatment of several psychiatric disorders, with several types of software being developed across the years to tackle a variety of mental disorders (Emmelkamp & Meyerbröker, 2021; Freeman et al., 2017a). However, the disorder-specific approach that has been adopted so far for the development of VR increases the costs needed to apply this technology in the field of clinical psychology (Lindner et al., 2021). Therefore, the aim of this review was to explore the transdiagnostic potential of VR by searching the literature to investigate the effects of VR-based treatments on a set of six internalizing and externalizing transdiagnostic factors that have been selected for being linked to multiple psychopathologies. Despite these keywords representing only some of the most clinically relevant transdiagnostic factors for mental health, the combination of these keywords with the term “virtual reality” led to a heterogeneous selection of studies carried out on very different clinical and non-clinical populations, further proving the transdiagnostic potential of these factors. While several promising results emerged about the ability of VR to improve these factors in different populations, the review also underlined some differences in the methodological quality of the studies found and in the number of studies carried out on each transdiagnostic factor. Generally, the majority of the results focused on avoidance

(especially behavioral and social avoidance) and emotion regulation, while the other transdiagnostic factors (i.e., aggression, impulsivity, cognitive reappraisal and disinhibition) turned out to be understudied. Similarly, patients with anxiety disorders represented the most studied clinical population, but interesting applications of VR on other clinical and non-clinical populations (e.g., PTSD, psychotic disorders, eating disorders, OCD, etc.) were also found. Moreover, although more than half of the studies were controlled (with a prevalence of RCTs and a few non-randomized controlled trials), only a small proportion compared VR-based interventions with traditional psychotherapies (e.g., CBT, Mindfulness, DBT, etc.) and a waiting-list control condition was often preferred. The absence of studies using VR in combination with drug therapy to improve these transdiagnostic factors also did not make it possible to collect information about the potential of VR to improve the results of pharmacotherapy or promote adherence to drug therapy for different mental health patients. Follow-ups were also included in more than half of the studies, but maintenance of results over time was never investigated beyond one year. These differences in methodologies across the articles explains the fact that only half of them reached a strong quality score.

More specifically, the transdiagnostic factors that were the focus of most of the selected studies were behavioral and social avoidance, which are largely associated with anxiety disorders (Maples-Keller et al., 2017; Opriş et al., 2012; Parsons & Rizzo, 2008). This was not surprising, considering that the very first applications of VR in clinical psychology consisted in using this technology to provide an alternative to in-vivo exposure (Gorini et al., 2010; Vincelli, 1999). In particular, through the use of VR, patients can improve their conditions by being exposed virtually to situations or objects that elicit the same sense of discomfort as the ones in real life (Gorini et al., 2010; Gutiérrez-Maldonado et al., 2016), thus reducing avoidance of these stimuli.

The results of the review further underline how this is still the way VR is most frequently implemented in psychological treatments, with very positive results. Indeed, in all the studies found, VR was able to reduce behavioral and social avoidance between pre- and post-treatment, confirming how this technology may represent a promising psychological tool that was also as effective as traditional in vivo exposure in some studies (Bouchard et al., 2017; Kampmann et al., 2016; Michaliszyn et al., 2010). However, various studies compared VR or used VR in combination with first-line treatments tackling behavioral and social avoidance, such as CBT. While these studies showed that VR combined with cognitive-behavioral therapy (VR-CBT) was effective in reducing social avoidance long-term (Pot-Kolder et al., 2018) and

with no differences when compared to traditional CBT (Safir et al., 2012), further studies are definitely needed in order to confirm these promising results.

Similarly, while VR was found to improve other types of avoidance (e.g., agoraphobic avoidance, cognitive avoidance, food avoidance, and alcohol-approach avoidance) that are linked to disorders outside of the anxiety category (e.g., psychosis, PTSD, substance-use disorders, and eating disorders, respectively) (Freeman et al., 2022; D.-Y. Kim & Lee, 2019; López et al., 2016; Meyerbroeker et al., 2013; Roncero & Perpiñá, 2015), our review of the literature was not able to find more than a few studies for these factors and clinical populations. Indeed, since the literature showed that different kinds of avoidance can be involved in the maintenance or development of different kinds of pathologies (Griffith et al., 2010; Rodríguez-Cano et al., 2012; Yarger & Redcay, 2020), investing in a VR software capable of tackling this factor transdiagnostically would be of clinical relevance.

Another transdiagnostic factor that plays a role in several psychopathologies is emotion regulation, which was also the second most found factor in the review. VR interventions were capable of increasing relaxation and diminishing negative emotions, particularly fear and anger, in several studies carried out in the general population (A. P. Anderson et al., 2017; Nararro-Haro et al., 2016; Wrzesien, Rodríguez, et al., 2015), as well as of teaching emotion regulation strategies in clinical and non-clinical participants (Bosse et al., 2014; Navarro-Haro et al., 2019; Yuan & Ip, 2018). Also successful was the combination of VR with other traditional interventions meant to improve emotion regulation, such as Mindfulness-Based Interventions (Nararro-Haro et al., 2016; Navarro-Haro et al., 2019). However, once again, studies comparing or combining VR with other forms of interventions were few, and further research is needed to test these results. The ability of VR to improve emotion regulation would hold clinical utility not only for the treatment of psychological disorders, but also for their prevention, as several authors underline how difficulties in emotion regulation are strictly linked to the development of several psychopathologies (e.g., anxiety and mood disorders, eating disorders, substance-related disorders, and more) (Aldao et al., 2010b; Cludius et al., 2020). Moreover, many of the types of software that tackle emotion regulation can already be considered transdiagnostic in nature because they can be used in many different populations, although there are no studies about the same software being applied to improve this transdiagnostic factor across clinical samples with different psychiatric diagnoses.

On the other hand, not many studies appeared for the transdiagnostic factors of impulsivity, aggression, and cognitive reappraisal. Nonetheless, the up-to-date literature showed promising results about VR software lowering levels of impulsivity and impulsive

behaviors in specific populations, more specifically patients with OCD (Laforest et al., 2016) and in forensic patients (Klein Tuente et al., 2020). In this latter population, VR was also capable of lowering levels of aggression (Klein Tuente et al., 2020) through Virtual Reality Aggression Prevention Therapy. By using VR, aggressive behaviors were also reduced in veterans with PTSD when driving (Zinzow et al., 2017) and in people of the general population (Jo et al., 2022), further proving that a single transdiagnostic VR software would have the potential to be applied on multiple clinical and non-clinical populations.

Finally, VR also emerged as a tool to teach cognitive reappraisal in children, highlighting the intergenerational potential of VR interventions to help clinicians to create a better alliance with children during treatment (Falconer et al., 2019). VR cognitive reappraisal training could also be used alongside emotion regulation training in VR, since it has been seen that participants rated negative images less severely after undergoing this kind of virtual training (Bosse et al., 2014). Tackling more than one transdiagnostic factor with a single piece of software would further decrease the costs linked to VR technologies. This would lead to a more frequent implementation of VR in the clinical field, which in turn might help to engage more people towards seeking psychological treatment, especially treatments that target cognitive reappraisal, such as CBT. Indeed, the resemblance between VR and technology used in everyday life could help to lower the stigma associated with traditional psychotherapy.

3.1.5 Conclusions

Results of this review further supported the use of VR in clinical psychology, in particular for improving transdiagnostic factors. Moreover, VR has also shown similar results compared to CBT, especially when treating behavioral avoidance (López et al., 2016; Malbos et al., 2013; Safir et al., 2012), which suggests that it might be a valid alternative to traditional psychotherapies for anxiety disorders. Third-wave cognitive-behavioral therapies, such as mindfulness-based intervention, might also benefit from the addition of a technological VR tool (Nararro-Haro et al., 2016; Navarro-Haro et al., 2019). However, additional studies are needed to prove the transdiagnostic potential of VR (in particular or what concerns its ability to improve aggression, impulsivity, and cognitive reappraisal, as well as understudied forms of avoidance), and clinicians still need to work on developing VR software that are truly transdiagnostic in nature and on testing them on more varied clinical and non-clinical populations. Moreover, while promising, the results of the present review need to be considered in light of its methodological limitations.

The main limitation of this review was the choice of a limited and arbitrary number of keywords representing transdiagnostic factors for the literature search. Indeed, we were not able to find a shared, set list of transdiagnostic factors to consider for our keywords. Although an attempt was made to choose the main internalizing and externalizing factors for mental disorders that are also linked to a wide number of psychopathologies (American Psychiatric Association, 2014; Bach & Eikenaes, 2021; Barlow et al., 2004; Besharat et al., 2019; Harvey et al., 2004; Im & Kahler, 2022; Johnson et al., 2013; Krueger & Eaton, 2015; Nelson et al., 2016; Riepenhausen et al., 2022; Sheppes et al., 2015; Sloan et al., 2017; Ten Have et al., 2014; World Health Organization (WHO), 2010; Young et al., 2009), this arbitrary selection might also have led to the neglect other important keywords. Future reviews might help with investigating the effects of VR-based interventions on other important transdiagnostic factors. Similarly, conducting the bibliographic research using only two databases (PubMed and PsycINFO) and only choosing articles published after 2010 might have led to the exclusion of other relevant studies. While not mandatory, not registering the systematic review protocol on any public repository (e.g., PROSPERO) might be another limitation of the review. However, although a PROSPERO registration has become a widely recommended practice for systematic reviews over the past few years, no differences in quality of research has been found in the literature between registered and non-registered systematic reviews (Rombey et al., 2020), and the use of PRISMA and PICOS criteria encourages and allows replicability of results.

Other limitations were also related to the quality and methodologies of the studies found. Indeed, future research should focus on carrying out studies with a stronger quality and less risk of bias, especially by including follow-ups and RCTs comparing VR to other more traditional psychotherapies (e.g., CBT, mindfulness, DBT, etc.), at least for what concerns the effects of VR-based interventions on transdiagnostic factors. Future studies may also try to investigate the transdiagnostic potential of VR when used in combination with drug therapy and whether VR may help with increasing adherence to treatment.

Ultimately, since the great majority of the articles had adult samples (with only very few studies carried out on adolescents or children), future studies should also consider testing the application of VR-based interventions for the improvement of transdiagnostic factors in people of different ages. Similarly, VR research on transdiagnostic factors should try to expand more outside the field of anxiety disorders and to explore the use of VR in other understudied clinical and non-clinical populations, including the general population at risk for the development of psychopathologies.

3.2 How to Observe and Modify Emotions - H.O.M.E. VR transdiagnostic software and intervention protocol

Results from the systematic review reported above (Gardini et al., 2022) show that there is no VR-based software and intervention in the literature capable of targeting more than one transdiagnostic factor and to be applied to more than one clinical or non-clinical populations. Because of this, a team of researchers (*Grandi, S., Ruini, C., Tossani, E., & Tomba, E.*) from the Department of Psychology of University of Bologna coordinated by prof. Grandi developed the H.O.M.E – *How to Observe and Modify Emotions*, a novel VR transdiagnostic software and protocol that has been used for this Ph.D. research project for the prevention of eating disorders in the general population. Specific characteristics of H.O.M.E. and of the related VR-based intervention protocol will be described in the paragraphs below and it has been published in a separate article published in the special issue "*Clinical Advances in Psychology and Psychological Distress in Real and Virtual Contexts*" of the Mental Health section of the Journal of Clinical Medicine (Gardini et al., 2023).

3.2.1 H.O.M.E. VR software

The VR software used for this Ph.D. research project is H.O.M.E – *How to Observe and Modify Emotions*, designed and developed by a team of researchers with expertise in clinical psychology and psychotherapy from the Department of Psychology of the University of Bologna coordinated by prof. Grandi. For specific author contributions, see *Gardini et al., 2023*. Through a Head-Mounted Display (currently an HTC Vive) and two controllers, the software allows the user to have an immersive and interactive experience in a virtual environment consisting of a house with several rooms and objects. H.O.M.E. is based on the transdiagnostic approach, according to which, as explained in the previous paragraphs, some common *transdiagnostic factors* (i.e. psychological inflexibility, experiential avoidance and emotional dysregulation) contribute to the onset and maintenance of psychopathologies (Hayes, 2004). For this reason, the software is aimed at individuals at risk for various clinical conditions, including alcohol, nicotine and drug abuse, addiction to technological tools (e.g. smartphones and video games) and gambling, and EDs, on the prevention of which we focused for the current Ph.D. research project. The nature of the software, however, allows elements to be added as needed in future versions of the software, such as items that could make H.O.M.E. usable even with individuals suffering from other clinical conditions not mentioned above.

The virtual environment is represented by a house consisting of four rooms, a living room/kitchen, a bathroom, a study and a bedroom, and a garden, where the user can move either

by simply walking while wearing the VR set or by using the controller. In all environments there are numerous objects and cues which may be relevant for the different aforementioned clinical issues (e.g. comfort foods, cigarettes, alcohol, technological devices), which the user can move and interact with. Particularly relevant to this Ph.D. research project, which focuses on ED prevention, are the different types of virtual food (e.g. snacks, soft drinks, pizza, cake) present on shelves, in the fridge and freezer in the kitchen, and objects such as the mirror, the scale and a medicine cabinet in the bathroom.

Figure 3.2 – Living room/kitchen in the H.O.M.E. virtual environment

H.O.M.E. also includes two separate but interactive phases which can be used in preventive and treatment interventions. In the ***assessment phase***, by approaching the objects present in the environment and pressing a button on the controller, the user will see a window appear, in which they are invited to indicate the type and intensity of elicited emotions. Users can choose between joy, sadness, anger, fear, disappointment, shame, boredom, surprise, disgust, guilt or "other" if the emotion they are feeling is not present among those already mentioned. To each emotion, the user can also assign a score from 1 to 5 according to its intensity.

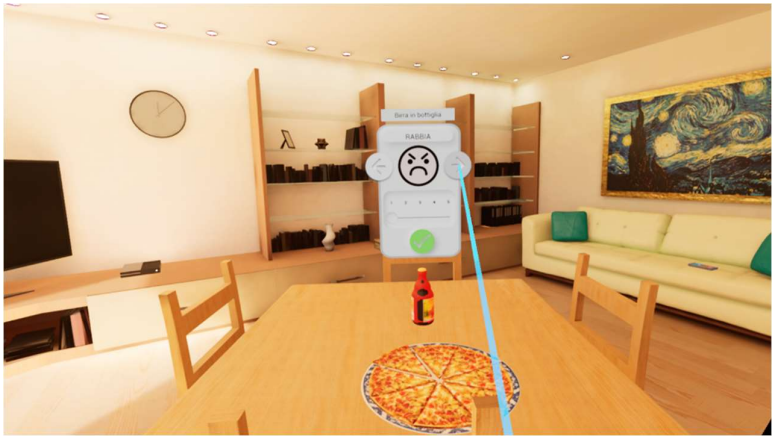


Figure 3.3 – Assessment of emotions in H.O.M.E.

In the ***intervention phase***, a *box of resources* will appear in the virtual environment. This box contains twelve psychological, social, or behavioral resources that the participant, guided by the clinician, can choose according to their preferences and needs to face distressful emotions previously attributed to the objects in the assessment phase. The twelve resources refer to two main theoretical models: the six dimensions of psychological well-being theorized by Carol Ryff (1989), namely autonomy, self-acceptance, personal growth, environmental mastery, positive relationships with others, and purpose in life; and the Peterson and Seligman's Value in action (VIA) classification of Character's Strengths and Virtues (2004), which defines the main virtues of human beings (i.e. wisdom and transcendence-spirituality) and the strengths that compose them (i.e. gratitude and forgiveness). The box of resources incentivizes the user to consider alternative thoughts and behaviors to use as an alternative to the potentially dysfunctional behaviors they would normally put in place to cope with negative emotions.

By approaching the box and pressing the trigger located on the back of the controller, a window will appear with twelve icons corresponding to the twelve selectable resources. For each one the user will be able to read the name and a short description:

1. *forgiveness*, which is the ability to forgive oneself and others for behaviors that have caused suffering and problems;
2. *awareness*, or being aware of ourselves, of the mind-body connection and of our role in the world;
3. *physical activity*, described as dedicating time to practicing sports and therefore taking care of the well-being of our body;
4. life goals, defined as the ability to find goals to devote ourselves to and to act tenaciously to achieve them, in order to give meaning to one's existence;

5. *interpersonal relationships,* the ability to value the important relationships in our life, knowing how to give and receive help and comfort when needed;

6. *recreational and artistic activities,* such as dedicating time to art and various hobbies in order to stimulate creativity and encourage recreation;

7. *self-esteem and self-acceptance*, defined as knowing how to appreciate ourselves for our own qualities and accept our own fragilities, trying to improve ourselves every day and pursuing our path of personal growth;

8. *gratitude*, described as the ability to notice and appreciate the positive aspects of life and to thank others for what they have done for us;

9. *transcendence and spirituality*, the ability to perceive a sense of oneness with the world, to feel part of a whole and to draw comfort from religious practices;

10. *wisdom*, described as the ability to evaluate situations and problems with objectivity and foresight, maintaining an open and lucid mind that allows one to see the connections between life events and understand the points of view of others;

11. *autonomy-assertiveness*, the ability to express our opinions with conviction and to affirm our needs;

12. *Self-control*, the ability to manage daily life, stress and intense emotions, while remaining determined and disciplined.

Figure 3.4 –H.O.M.E. box of resources

Once the resource has been chosen, by clicking on the green button inside the window, the icon related to the chosen resource can be moved, thanks to the grabbing option, to any object which elicits distressing emotions against which the participant intends to use it.

3.2.2 H.O.M.E. VR-based intervention protocol for the prevention of EDs

Using the H.O.M.E. software described in the previous paragraph, clinicians and researchers from the Department of Psychology of the University of Bologna have developed a psychological intervention aimed at users potentially at risk of EDs (Gardini et al., 2023). The goal of the intervention is to encourage the use of the personal resources that the participant already possesses and the acquisition of new resources, in order to acquire healthier strategies to face distressing stimuli concerning food, negative thoughts regarding body shape and weight, or other areas of life, therefore reducing the risk of developing EDs.

The protocol of the psychological preventive intervention consists of six sessions lasting a maximum of one hour each, in which the participant, always assisted by a clinical psychologist, gradually experiences the virtual environment and the phases present in H.O.M.E..

First session

The first session of the intervention protocol is aimed at getting to know the participant, who undergoes a 30-minute interview with a clinical psychologist trained in the administration of the preventive intervention. The aim of the interview is to identify the participant's problem areas, with a particular focus on their relationship with food, body shape and weight and on the presence of dysfunctional eating behaviors, such as calorie counting, very restrictive diets or compensatory behaviors. The clinical psychologist is required to ask the participant if there are aspects that they consider important but that have not been sufficiently investigated or deepened, as it is essential to exclude the presence of EDs, since the intervention is aimed only at individuals at risk and not at people already affected by EDs or other DSM-5-TR psychopathologies.

Subsequently, the clinical psychologist will proceed to explain the purpose of the intervention, which is to achieve a better management of emotions and behavioral reactions related to food-related stimuli (or other potentially triggering stimuli the participant considers relevant). The participant will then be instructed on how to use the VR headset and controllers, which the participant will then proceed to wear. Once the instructions have been understood, the participant will be able to begin to explore the virtual environment and familiarize with the H.O.M.E. software. After about twenty minutes of exploration, the clinical psychologist will invite the participant to remove the viewer and externalize their impressions and feedbacks regarding the experience, with particular focus on investigating any problems and feelings of discomfort (e.g. motion sickness, nausea, anxiety) arising from the use of VR.

Finally, the next session will be scheduled and the meeting will end.

Second session

Once the participant has been welcomed into the study for the second session, the clinical psychologist will proceed to explain the aim of the second session, which is interacting with the objects present in the environment that cause them the greatest difficulties, based on the participant's clinical condition. This session will use the assessment phase functionalities of the H.O.M.E. software, previously described. In particular, once the VR headset is on, the participant will have to select a couple of objects and the relative emotions that arose. The participant will also be asked to rate the intensity of the emotions on a scale from 1 to 5. When the window is closed, the emoticon corresponding to the selected emotion will remain above the object, the type and intensity of which will be recorded in the software. The psychologist will also ask the participant if they have experienced other emotions apart from those already selected, and if thoughts or mental images related to the stimuli have emerged.

Subsequently, once the VR equipment is removed, the psychologist will ask the participant for feedback on the VR experience. Subsequently, the psychologist will proceed to introduce the ABC cognitive-behavioral model (Ellis, 1962), according to which there is a link between life events (antecedents), thoughts and emotions and the behaviors that follow. Based on the ABC model, the participant will be asked, as homework, to fill-in some ABC forms in order to identify during the week some possible trigger events and stimuli (especially those similar to the ones faced in VR), as well as the thoughts and emotions in response to these events and the behaviors that follow. The ABC model application allows the participant to become more aware of their dysfunctional thoughts and behaviors towards food or other critical areas of their life.

Third session

After welcoming the participant, in the third session the clinical psychologist will start by reviewing the ABC forms the participant filled in during the week, with the aim of identifying recurring patterns of thoughts and behaviors: in this way, the clinician can begin to understand if there are similarities between the reported situations and objects and identify the main trigger stimuli for the participant, as well as the consequent dysfunctional thoughts, emotions, and behaviors.

Subsequently, the participant will be asked to put on the VR headset and replicate in the virtual environment a critical situation experienced during the week at home and reported

in the ABC sheets, for example by interacting with the same trigger object present both in real life and in the software. The aim of VR is to offer the participant a protected space for reflection, in which to examine their own experience from a new point of view. Using once again the functionalities present in the assessment phase of the H.O.M.E. VR software, the clinical psychologist will investigate the type and intensity of the emotions experienced by the participant towards the trigger stimulus and the possible similarity with the emotions felt during the week in front of the real stimulus. Once the VR equipment is removed, the clinician will guide the participant through a reflection on the connections between the interaction with trigger objects, thoughts and emotions experienced and the dysfunctional behaviors that follow.

Finally, the participant will be assigned some homework for the next session, which will consist of continuing to fill in the ABC forms.

Fourth session

After welcoming the participant and reviewing the ABC forms with them, the clinical psychologist will proceed to explain that the fourth session will focus on the exploration of some positive resources that the participant can use to better cope with difficult situations.

The participant will be asked to put on the VR headset and, taking inspiration from the situations they previously annotated in the ABC forms during the week, to interact with a trigger object within the virtual environment, indicating once again the type and intensity of the emotion experienced. The participant will also be informed that in the virtual room there is a *box of resources* (available through the *intervention phase* functionalities of the H.O.M.E. VR software), which they must find and select with the controller. Once the window with the twelve icons corresponding to the psychological resources opens, the clinical psychologist will illustrate them to the participant, who will proceed to select the resource that they consider to be the most suitable for their needs. The chosen resource will be used to cope with the emotions deriving from the interaction with the trigger object, in order to replace dysfunctional behaviors with healthier strategies. Using the controller, the participant can grab the icon representing the resource and place it on the trigger object to which they intend to use it.

Subsequently, once the VR headset has been removed, the clinician and the participant will discuss the motivation behind the choice of the resource, the concrete actions through which to implement it in everyday life, and if the participant believes that they already have it or not. The psychologist will also illustrate some exercises through which the participant will learn to implement the chosen resource. Homework for the participant will be to try and

implement the chosen resource in critical situations that may occur during the week, repeating the explained exercises.

Fifth session

In the fifth session, the psychologist will ask the participant if they were able to implement the resource chosen in the previous session in some critical situations. If the response is positive, the clinician will encourage the participant to put on the VR headset and choose another resource, in order to make the participant aware that often different resources can be used to cope with the same critical situation and to avoid dysfunctional behaviors. If, on the other hand, the participant's answer is no, the participant and the psychologist will continue to work on the chosen resource, trying to identify and eliminate the obstacles encountered. Alternative exercises may also be given in order to try and develop the chosen resource in an alternative manner.

According to the specific needs of the patients, homework may be to try and use the new resource, together with the one already chose in the fourth session, to cope with distressing situations in their daily life; or to try once again to implement the resource chosen during the fourth session, but by taking into consideration the new exercises and instructions the psychologist provided.

Sixth session

In the sixth and last session, the psychologist and the participant will look back at the previous sessions and they will summarize the journey so far, starting from the first interactions with the trigger objects, to the evaluation of the type and intensity of the emotions elicited by them, up to the choice of positive resources.

While using VR, the participant will now be able to see both the emoticon representing the elicited emotion and the chosen resource on the trigger object with which the participant interacted. The participants will now be asked if, as a result of the implementation of the learnt resources, the score attributed to the intensity of emotions related to the trigger stimuli has changed and if they feel more capable of handling critical situations.

Once the VR headset is removed, the psychologist will explain that it is crucial that the participants will continue to exercise the acquired resources even after the end of the intervention, as it takes time for changes in thoughts and behaviors to fully consolidate. The psychologist will also try and verify (for example, by using psychometric questionnaires or a

semi-structured interview) whether the intervention produced any improvements and the participant will be dismissed.

PART 2.
REPORT OF THE EXPERIMENTAL STUDIES OF THE PH.D. RESEARCH PROJECT

CHAPTER 4.
RATIONALE, ETHICAL APPROVAL AND PARTICIPANTS RECRUITMENT

4.1 Rationale

To further summarize what has been illustrated in the previous chapters, epidemiological studies have shown that, in Western societies, between 5.5% and 17.9% of young women and between 0.6% and 2.4% of young men can develop an ED by early adulthood, with similar prevalences also in Asia, Latin America and Central-Eastern Europe (Silén & Keski-Rahkonen, 2022). In Italy, three million people suffer from EDs, with numbers constantly increasing, especially following the COVID-19 pandemic (Colleluori et al., 2021).

Despite the increasing diffusion of these psychopathologies in our society and their clinically relevant consequences in terms of disability and mortality (Berkman et al., 2007), rates of individuals seeking and receiving help, especially before symptoms reach diagnostic severity, is still low (Hamilton et al., 2022). Barriers preventing people at risk for EDs from seeking treatment are multifaceted and can include the perceived stigma that still exists regarding mental health and traditional psychological treatments (Bharadwaj et al., 2017), and the egosyntonic nature of ED symptoms (Roncero et al., 2013). Even in cases where treatment is sought and administered, drop-out rates are high (up to 70% for outpatient treatments and up to 51% for hospitalizations) (Fassino et al., 2009; Swan-Kremeier et al., 2005) and complete recovery are often hard to achieve even with therapies of choice (such as CBT-E), especially in patients who present other comorbid psychopathologies and/or have low levels of insight (Halmi, 2013). Residual ED symptoms can also be present even in those who recover from EDs (Tomba et al., 2019), further increasing the risk of relapse after therapy (Sala & Levinson, 2016) and the clinical impact of these disorders on people's quality of life (Winkler et al., 2014).

Because of these reasons, research and clinical practice should focus on the development of effective prevention strategies, with the goal of preventing the development of EDs by acting on risk factors before symptoms can meet severity criteria for a full diagnosis

(Le et al., 2017). However, to date the number of studies that have focused on demonstrating the effectiveness of preventive interventions are still very limited (Ciao et al., 2014).

Among the risk factors for EDs, the transdiagnostic approach identifies factors, called *transdiagnostic factors*, which are common to multiple psychopathologies and EDs and can contribute to their onset and maintenance over time (Fairburn et al., 2003; Harvey et al., 2004). Together with the well-known transdiagnostic factors hypothesized by Fairburn and collegues (2003) in their *transdiagnostic model of EDs* (i.e. clinical perfectionism, low self-esteem, mood dysregulation and interpersonal difficulties, which were described in previous paragraphs), three third-wave cognitive-behavioral transdiagnostic factors in particular have also been found to be altered in ED patients and, therefore, could represent useful targets for preventive interventions: psychological inflexibility (Levin et al., 2014), experiential avoidance (Rawal et al., 2010) and emotion regulation (Prefit et al., 2019). However, no study has investigated their potential influence, even from a preventive perspective.

Another useful preventive tool for EDs may also be the application of VR protocols for the improvement of these transdiagnostic factors. The benefits of VR for the treatment of several psychopathologies, including EDs, has been widely proven in the literature (Clus et al., 2018; Freeman et al., 2017a; Riva, 2022). Although this technology also proved to be effective in improving some transdiagnostic factors, such as emotion regulation (Colombo et al., 2021), no VR software to date has been design to concurrently tackle psychological inflexibility and experiential avoidance together with VR (Gardini et al., 2022). Moreover, no research has focused on the use of VR in the prevention of EDs by targeting these three transdiagnostic factors.

Because of these reasons, the present Ph.D. research project consists of *three separate experimental studies* aimed at testing the quality of a innovative transdiagnostic VR software (H.O.M.E. – *How to Observe and Modify Emotions*) designed to concurrently tackle ER, psychological flexibility and experiential avoidance, as well as at testing the effects and feasibility of this VR-based transdiagnostic intervention (H.O.M.E.) for the prevention of EDs in the general population (characteristics and features of the software and intervention have been described in ***chapter 3, paragraph 3.2***).

In particular:

- Study-1 has a descriptive design and aims to explore the acceptability (in terms of sense of presence, user experience, and elicited motion sickness) of the H.O.M.E. VR software in the general population with ED risk;

- Study-2 is a longitudinal randomized-controlled trial (RCT) and aims to evaluate the feasibility and effects of the H.O.M.E. VR-based intervention for the prevention of EDs in terms of improving the aforementioned transdiagnostic factors and reducing eating-related symptoms in this population, also when compared to waiting-list and at 3- and 6-months;
- Study-3 is a qualitative study consisting in a semi-structured post-intervention interview and thematic analysis aimed to qualitatively investigate opinions about the H.O.M.E. intervention in participants who completed it.

Specific characteristics, methodologies, and results of each study will be illustrated in subsequent chapters (***chapters 5-7***).

4.2 Ethical approval

This project was approved on 14/12/2021 by the Ethical Committee for Psychological Research of University of Bologna (Protocol n°0314877).

4.3 Participants recruitment

All the three studies included individuals from the GP at risk for EDs. GP individuals were recruited via social media (e.g. Facebook, Instagram) for all studies. Individuals interested in taking part in the research were informed about aims and characteristics. Informed consent was requested.

General **inclusion criteria** for the studies were: a) 18 to 60 years of age; b) screening at risk for EDs; c) no prior diagnosis of EDs; and d) no health condition that better explains ED symptomatology.

General **exclusion criteria** included: a) lack of capacity to consent for research; b) current or former ED or other psychiatric diagnosis according to DSM-5-TR (APA, 2022); c) using medical devices (e.g. pacemaker, hearing aids) or having medical diagnoses (e.g. vertigo, vision impairments) interfering with VR.

Eligible participants were subsequently invited to take part in one or more of the studies. Those agreeing underwent a brief clinical interview based on DSM-5-TR (APA, 2022) criteria to exclude presence of EDs or other psychiatric disorders.

4.3.1 Sample recruitment results

N=189 people from the general population completed the online screening questionnaires on the platform Qualtrics. Of these, the number of people at risk for EDs was determined based on the *SCOFF Questionnaire* (Morgan et al., 2000; Pannocchia et al., 2011) and EDE-Q 6.0 (Calugi et al., 2017; Fairburn & Beglin, 2008) cut-offs of <2 and <1.56 (Ekeroth & Birgegård, 2014) respectively. A total of n=134 (70.8%) people screened with ED risk were all contacted to take part in the Ph.D. research project. Of these, n=70 (52.24%) accepted to take part in the research project and n=64 (47.76%) refused.

Descriptive analyses revealed that the n=64 participants that decided not to take part in the study were females, with a mean age of 23.6±8.08. Mean SCOFF score was of 3.33±.99, while mean EDE-Q score was 3.20±1.54. Independent samples t-test revealed that there was no significant difference between those deciding to take part in one of the studies included in the Ph.D. project and those who refused to participate. Socio-demographic and clinical characteristics of both groups, together with statistical indexes regarding the differences, are summarized in **Table 4.1**.

Table 4.1. Sociodemographic, clinical characteristics, and differences between the group that accepted to participate in the research and the group that refused

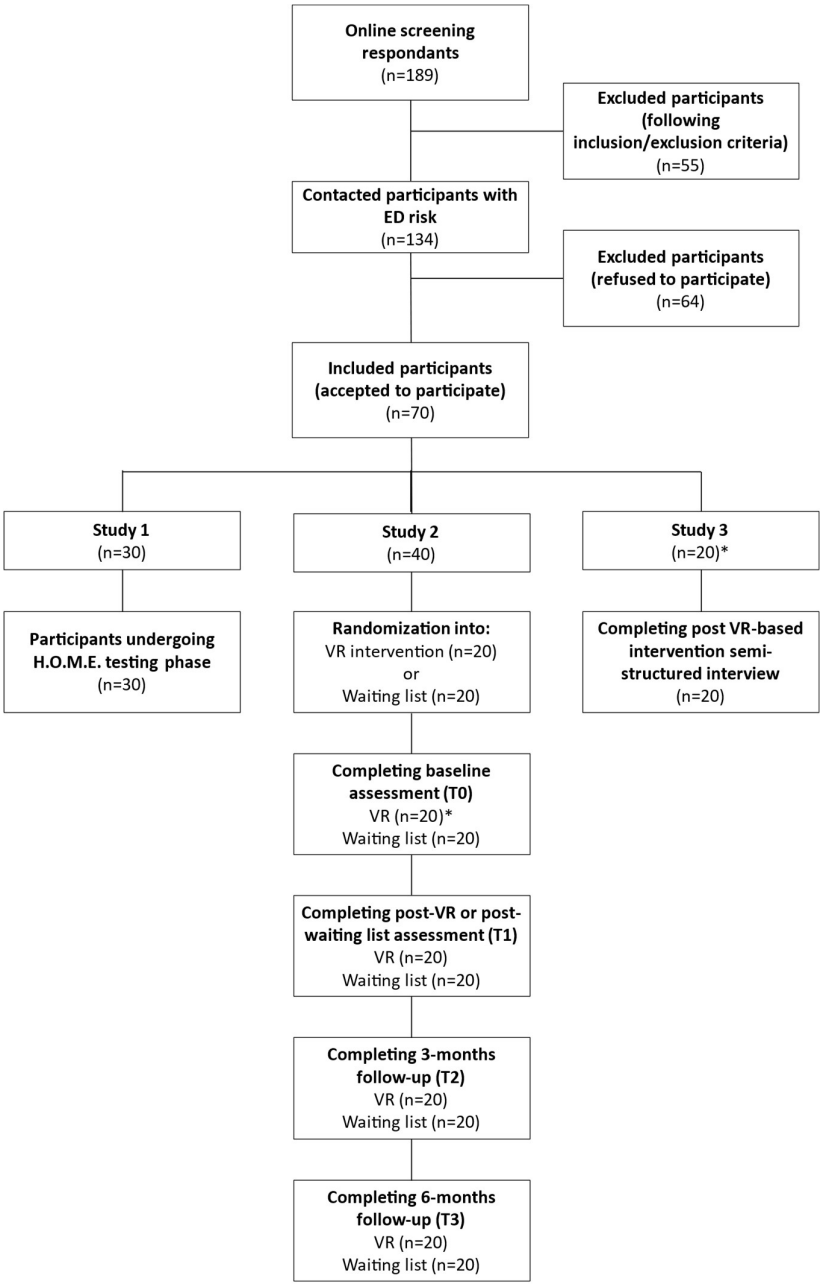
	Accepted to participate (n=70) M±SD *or* % (n=)	**Refused to participate (n=64) M±SD *or* % (n=)**	**t(df)**	**$\chi^2_{(df)}$**	**p**
Gender	100% (n=70) females	100% (n=64) females	-	-	-
Age	25.40±7.93 years	23.6±8.08 years	$-1.274_{(132.0)}$	-	.205
Marital status	87.14% (n=61) single 7.14% (n=5) married 1.43% (n=1) with partner 4.29% (n=3) divorced	92.19% (n=59) single 1.56% (n=1) married 1.56% (n=1) with partner 4.69% (n=3) divorced	-	$2.44_{(3)}$	.487
Educational level	35.71% (n=25) high school diploma 62.86% (n=44) university degree 1.43% (n=1) professional school diploma	53.13% (n=34) high school diploma 45.31% (n=29) university degree 1.56% (n=1) middle school diploma	-	$6.20_{(3)}$	.102
Occupation	71.43% (n=50) university students 18.57% (n=13) employed 2.86% (n=2) unemployed 7.14% (n=5) other	79.69% (n=51) university students 15.63% (n=10) employed 4.69% (n=3) unemployed	-	$5.34_{(3)}$	.148
SCOFF	3.43±2.70	3.33±.99	$-.574_{(132.0)}$	-	.567
EDE-Q-Total	3.17±1.16	3.20±1.54	$.109_{(132.0)}$	-	.913
EDE-Q-Restraint	2.70±1.55	2.68±1.79	$-.574_{(132.0)}$	-	.956
EDE-Q-Eating concerns	2.33±1.41	2.65±1.67	$1.219_{(132.0)}$	-	.225
EDE-Q-Shape concerns	4.20±1.16	3.97±1.62	$-.926_{(132.0)}$	-	.356
EDE-Q-Weight concerns	3.46±1.31	3.48±1.75	$.0673_{(132.0)}$	-	.946

Of the n=70 participants that decided to take part in the research, n=30 (22.39%) agreed to take part in Study 1 and N=40 (29.85%) in Study 2. At the end of the VR-based intervention

in Study 2, all n=20 participants in the VR group decided to also undergo the post-intervention semi-structured interview for Study 3.

Figure 4.1 summarizes the recruitment process and allocation of participants to each study.

Figure 4.1. Flowchart summarizing participants recruitment process and allocation



Annotations. **As mentioned in text, all Study 2 participants in the VR group also accepted to take part in the post-intervention semi-structured interview for Study 3 and, therefore, the sample is the same.*

CHAPTER 5.
STUDY 1: ASSESSING THE ACCEPTABILITY OF THE H.O.M.E. SOFTWARE

5.1 Study 1 Aims

Study 1 aimed to assess the acceptability (in terms of sense of presence, user experience, and elicited motion sickness) of the transdiagnostic VR software H.O.M.E. in GP individuals at risk for EDs.

5.2 Study 1 Hypotheses

It was hypothesized that the H.O.M.E. software would show good acceptability in terms of good user experience and sense of presence, and low or absence of elicited motion sickness in GP individuals at risk for EDs.

5.3 Study 1 Research design

Study 1 included a **screening phase** to recruit suitable participants from the general population at risk for EDs and a **testing phase** of the H.O.M.E. VR software.

Participants screening at risk for EDs were subsequently contacted via e-mail or telephone within 7 days and invited to take part in the testing phase, which took part at the Department of Psychology, University of Bologna. After being instructed on how to use the H.O.M.E. software, participants were asked to test it for around 20 minutes (***testing phase***), in which they could walk around the virtual environment, interact with virtual objects, and use the different functionalities present in the software. Following their experience in the virtual environment, participants completed online (using Qualtrics) some self-report questionnaires (described in the next paragraphs) assessing H.O.M.E. acceptability.

5.4 Study 1 Instruments

5.4.1 Study 1 Screening measures

In the **screening phase**, individuals taking part in Study 1 completed online (using the platform Qualtrics):

- a non-standardized **self-report questionnaire** to collect socio-demographic (age, marital status, educational level, occupational status) and clinical data (Body Mass Index-BMI, weight history, former ED or another DSM-5-TR (APA, 2022) diagnosis, clinical conditions and/or use of medical devices interfering with VR) and to investigate the

participants' familiarity with the use of a computer or technological devices (i.e. videogames) in their everyday life;

- two self-report screening questionnaires for the detection of ED risk: the **SCOFF questionnaire** (Morgan et al., 2000; Pannocchia et al., 2011) and the **Eating Disorders Examination Questionnaire** (EDE-Q 6.0) (Calugi et al., 2017; Fairburn & Beglin, 1994), both illustrated bellow.
- if scoring higher than the screening questionnaires cut-offs, potential participants were also asked to undergo a clinical interview based on DSM-5-TR criteria (APA, 2022) to exclude the presence of a full ED diagnosis and confirm ED risk.

SCOFF questionnaire

The SCOFF Questionnaire (Morgan et al., 2000; Pannocchia et al., 2011) is a self-report screening questionnaire for ED risk. It consists of 5 items with a dichotomous yes/no answer: 1. *Do you make yourself sick because you feel uncomfortably full?* 2. *Do you worry you have lost control over how much you eat?* 3. *Have you recently lost more than 6 kg in a three-month period?* 4. *Do you believe yourself to be fat when others say you are too thin?* 5. *Would you say food dominates your life?*

If an individual answers yes to at least two questions, the clinician is required to carry out a more thorough evaluation, as a >2 score could indicate a potential ED case (Pannocchia et al., 2011). Although the reliability of the Italian version is low (Cronbach α of .64), the tool has shown a good ability to discriminate between people affected and not affected by EDs (Pannocchia et al., 2011). The SCOFF is also recommended by the SISDCA (*Società Italiana per lo Studio dei Disturbi del Comportamento Alimentare*).

Eating Disorders Examination Questionnaire (EDE-Q)

The Eating Disorders Examination Questionnaire (EDE-Q 6.0; Fairburn & Beglin, 1994; Calugi et al., 2017) is a self-report version of the semi-structured interview developed by Fairburn and colleagues (1993), under the name of Eating Disorders Examination (EDE). Similarly to the EDE, the EDE-Q investigates the severity of ED symptomatology through 28 items that refer to the 28 days prior to completion of the questionnaire. The EDE-Q allows clinicians and researchers to obtain both a global score and subscores related to 4 subscales: Restraint, Eating concerns, Shape concerns and Weight concerns. It also includes additional items that measure the frequency of behaviors typically found in EDs, such as binge eating and compensatory behaviors.

The response scale is a 7-point Likert scale (0-6) and the global score is obtained by averaging the scores of the subscales. A higher score reflects a higher severity or frequency of symptoms: in particular, scores between ***1.56 and 3.91*** were frequently found in the general population at risk for EDs (Ekeroth & Birgegård, 2014) and, therefore, 1.56 was considered a cut-off for our study as well.

EDE-Q showed good psychometric properties: Fairburn & Beglin (1994) found it to have a good concurrent validity, while authors (Berg et al., 2012) found an acceptable test-retest reliability, measured after 14 days, both for the 4 subscales (Cronbach α between 0.66 and 0.94) and for the items measuring the frequency of ED-related behaviors (Cronbach's α between 0.51 and 0.92) and a good internal consistency for the subscales (Cronbach α between 0.70 and 0.93).

5.4.2 Study 1 Outcome measures

At the end of the **testing phase** (after 20 minutes spent using the H.O.M.E. software), recruited participants at risk for EDs also completed the following standardized questionnaires:

- **Simulator Sickness Questionnaire** (SSQ) (Kennedy et al., 1993) to evaluate cybersickness;
- **iGroup Presence Questionnaire** (IPQ) (Schubert et al., 2001) to evaluate sense of presence associated to the VR software;
- **User Experience Questionnaire – short form** (UEQ-S) (Schrepp et al., 2017) to evaluate user experience;
- **System Usability Scale** (SUS) (Brooke, 1995) to evaluate usability and ease of use of the VR software;
- in order to monitor the levels of anxiety experienced by participants while testing the software, the **Subjective Unit of Discomfort Scale** (SUDs) (Wolpe, 1973) was administered at baseline, at cue (food) presentation, and at the end of the session.

All questionnaires are described below.

Simulator Sickness Questionnaire (SSQ)

The Simulator Sickness Questionnaire (SSQ; Kennedy et al., 1993) is a 16-item self-report questionnaire that investigates motion sickness, which can be described as a set of physical symptoms that users might experience during or after the use of VR technologies. The SSQ allows to obtain both a global score that measures the severity of motion sickness and subscores related to 3 subscales: Nausea-related symptoms, Oculomotor symptoms and

Symptoms related to disorientation. Scores below 5 indicate that the symptoms generated by the use of the VR software are negligible, while scores greater than 20 render the tool unusable due to the severity of the symptoms provoked (Solimini, 2013).

The SSQ showed good reliability, with a Cronbach $\alpha > 0.70$ for all subscales (Sevinc & Berkman, 2020).

iGroup Presence Questionnaire (IPQ)

The iGroup Presence Questionnaire (IPQ; Schubert et al., 2001) is a self-report questionnaire consisting of 14 items that investigate the sense of presence experienced by users while using VR. The IPQ produces both a global score and subscores related to 3 subscales, Presence in space, Involvement and Realism experienced, with an additional scale that investigates the general feeling of being present (Sense of being there). Acceptable scores are considered to be around 4.50 or greater for the Presence in Space subscale, 4.00 or greater for the Engagement subscale, 3.38 or greater for the Experienced Realism subscale, and 3.86 or greater for the Sense of Being There subscale (Melo et al., 2023).

The IPQ showed good reliability overall (Cronbach's α of 0.85) and for the Sense of presence in space subscale (Cronbach's α of 0.80), acceptable reliability for the Involvement subscale (Cronbach's α of 0.76) and questionable reliability for the Experienced Realism subscale (Cronbach's α of 0.68) (igroup-project consortium, 2016).

User Experience Questionnaire – short form (UEQ-S)

The User Experience Questionnaire – short form (UEQ-S; Schrepp et al., 2017) is a self-report questionnaire consisting of 26 items that assess the user's experience, including attitudes, feelings, and impressions, associated with the VR software. Items are divided into 6 subscales, which describe potential characteristics of the VR software: Perspicuity, Efficiency, Dependability, Stimulation, Novelty, and Attractiveness. The first three subscales fall under the dimension of *Pragmatic quality*, which investigates the aspects related to the tasks and goals that the user aims to achieve with the VR software, while the other subscales are included in the dimension of *Hedonic quality*, which evaluates the aspects related to the sensations of pleasure or fun experienced during the use of the software.

The UEQ-S does not provide a global cut-off, but subscale scores, which can range from -3 to +3, with a score below 0.8 indicating a negative subjective experience with the VR software, while scores above 0.8 are indicative of a positive subjective experience. Scores between -0.8 and 0.8, instead, represent a neutral subjective experience (Schrepp, 2023).

UEQ-S has good internal consistency, with a Cronbach α of 0.85 for the pragmatic quality subscale and a Cronbach α of 0.81 for the hedonic quality subscale (Schrepp et al., 2017).

System Usability Scale (SUS)

The System Usability Scale (SUS; Brooke, 1996) is a self-report questionnaire that investigates how easy to use is the VR software. It consists of 10 items, whose response scale is a 5-point Likert scale (1-5). The score can vary from a minimum of 0 to a maximum of 100: a score > 85 is indicative of exceptionally easy to use software, while a score <70 represents an unacceptable level of usability (Bangor et al., 2008).

Bangor et al. (2008) found a Cronbach α of 0.91 for SUS, which is associated with good reliability.

Subjective Units of Distress Scale (SUDs)

The Subjective Units of Distress Scale (SUDs; Wolpe, 1969) is a self-report instrument consisting of a single item, which allows to measure the intensity of anxious sensations. The version of the SUD that has been used for the present research presents a score that can range between a minimum of 0, which represents a state of absolute calm, and a maximum of 100, which indicates the highest level of anxiety the individual has ever experienced (Kim et al., 2008). Other authors (Wolpe, 1990) has also developed a more compact version of the scale, with a score ranging from 0 (no anxiety) to 10 (maximum level of anxiety).

A study (Thyer et al., 1984) found statistically significant, positive, and high-intensity correlations between SUDs scores and autonomic correlates of anxiety, particularly with hand temperature ($rS = 0.85$, $p<0.01$ for the left hand, $rS = 0.83$, $p<0.01$ for the right hand), which is indicative of peripheral vasoconstriction and consequently activation of the sympathetic nervous system (Wolf, 1990). These results highlight the clinical validity of the SUDs.

5.5 Study 1 Data analyses

Data analyses were performed using SPSS Statistic vrs.25. Descriptive statistics were run to analyze socio-demographic (age, marital status, educational level, occupational status) and clinical characteristics (BMI, weight history, former ED diagnosis...) of the sample. To evaluate the sense of presence, user experience, and motion sickness related to the VR software, the mean IPQ, UEQ-S, SSQ, and SUS scores of the sample were calculated.

5.6 Study 1 Results

5.6.1 Study 1 Sample description

N=30 females were recruited for Study 1, with a mean age of 26.47±8.34 years (minimum age: 20; maximum age: 52). The majority of the sample consisted of single women and university students, with the most common educational level being a bachelor's degree.

The mean scores of the total sample on the screening questionnaires detecting ED risk and dysfunctional eating behaviors were equal to 3.20±1.03 for the SCOFF and 2.96±1.20 for the EDE-Q. The EDE-Q subscales of EDE-Q-Shape concerns (3.93±1.20) and EDE-Q-Weight concern (3.23±1.33) were found to be the ones with the highest mean scores in the sample. Mean BMI was equal to 22.55±3.50 and fell in the healthy weight range.

All participants were familiar with the use of technology (e.g. smartphones, computers, videogames, etc.) in their daily lives.

Sociodemographic and clinical characteristics of the sample are summarized in **Table 5.1**.

Table 5.1. Descriptive analysis of the socio-demographic and clinical characteristics of Study 1 sample (n=30)

Variables		*Mean ± SD or n= (%)*
Socio-demographic characteristics		
Age		26.47 ± 8.34
Gender	Females	30 (100%)
Marital status	Single	25 (83.3%)
	With partner	1 (3.3%)
	Married	3 (10%)
	Divorced	1 (3.3%)
Educational level	Professional School Diploma	1 (3.3%)
	High School Diploma	8 (26.7%)
	Bachelor's degree	21 (70%)
Occupation	Student	18 (60%)
	Employed	6 (20%)
	Unemployed	1 (3.3%)
	Other	5 (16.7%)
Clinical characteristics		
SCOFF		3.20 ± 1.03
Total EDE-Q		2.96 ± 1.20
EDE-Q Restriction		2.07 ± 1.44
EDE-Q Eating Concern		2.07 ± 1.44
EDE-Q Shape Concern		3.93 ± 1.20
EDE-Q Weight Concern		3.23 ± 1.33
BMI		10.55±3.50

Abbreviations. *BMI: Body Mass Index; EDE-Q: Eating Disorders Examination Questionnaire; SD: Standard Deviation*

5.6.2 Results about the H.O.M.E. VR software acceptability and quality

Questionnaires administered to Study 1 participants at the end of the testing phase with the H.O.M.E. VR software showed that H.O.M.E. did not produce concerning mean levels of cybersickness (SSQ-Total=13.09±13.09), with the highest symptoms reported in SSQ-Disorientation (15.31±19.80). Mean levels of SSQ-Oculomotor (12.63±10.96) and SSQ-Nausea-related (7±12.26) symptoms were also not concerning.

In the IPQ, a questionnaire designed to assess the sense of presence experienced while using the VR software, the mean scores were 3.07±0.72 for the IPQ-Presence in space subscale, 3.61±0.57 for IPQ-Involvement subscale, 2.66±0.79 for IPQ-Experienced realism, and 3.87±1.63 for IPQ-Feeling of being present in the VR environment.

The mean total score on the UEQ-S, a questionnaire aimed at assessing the user's subjective experience with the VR software, was 2.57±1.20, while the mean scores on the subscales investigating UEQ-S-Pragmatic quality and UEQ-S-Hedonic quality of the software were .83.±.39 and 1.74±.99 respectively, showing positive user experience.

Finally, the total score at SUS, which assessed ease of use of the H.O.M.E. VR software, was of 76.75 ± 14.07 which indicates an acceptable ease of use (Bangor et al., 2008).

CHAPTER 6.
STUDY 2: EVALUATING THE FEASIBILITY, EFFICACY, AND FOLLOW-UP MAINTENANCE OF RESULTS OF THE H.O.M.E. TRANSDIAGNOSTIC VIRTUAL REALITY-BASED INTERVENTION IN IMPROVING TRANSDIAGNOSTIC FACTORS AND DYSFUNCTIONAL EATING BEHAVIORS IN INDIVIDUALS AT RISK FOR EDS

6.1 Study 2 Aims

Study 2 aimed to:

1. evaluate the feasibility of the H.O.M.E. VR-based intervention both in terms of number of GP participants at risk for EDs completing the VR-based intervention and in terms of changes in dysfunctional eating behaviors and transdiagnostic factors (i.e. ER difficulties, psychological inflexibility, and experiential avoidance) between pre- and post-intervention in those completing it;
2. evaluate the efficacy of the VR-based intervention using H.O.M.E compared to a waiting-list condition in terms of dysfunctional eating behaviors symptoms and aforementioned transdiagnostic factors;
3. evaluate whether the effects in terms of eating-related symptoms and transdiagnostic factors achieved after the H.O.M.E. VR-based intervention were maintained at a 3- and 6-months follow-up compared to the waiting-list condition.

6.2 Study 2 Hypotheses

It was hypothesized that:

1. the H.O.M.E. VR-based intervention would show good feasibility with a low drop-out rate similar to rates seen in VR-based intervention studies in ED populations and with participants completing the intervention reporting a significant reduction of eating-related symptoms and a significant improvement of transdiagnostic factors (i.e. ER, psychological flexibility, and experiential avoidance) between pre- and post-intervention;
2. GP individuals at risk for EDs completing the VR-based intervention would report a greater reduction of eating-related symptoms and a greater improvement of transdiagnostic factors when compared to GP individuals at risk for EDs assigned to the waiting-list;

3. results obtained in eating-related symptoms and transdiagnostic factors after the VR-based intervention would be maintained at a 3- and 6-months compared to the waiting-list.

6.3 Study 2 Research design

Study 2 included three phases: a **screening phase** for the detection of suitable participants at risk for EDs from the general population, an **experimental phase** in which participants undertook the H.O.M.E. VR-based intervention or were assigned to the control (waiting-list) condition, and a **follow-up phase** of 3 and 6 months.

For study 2, a required sample size of 64 individuals was calculated using G*Power and considering an estimated 30% drop-out rate, as seen in other VR-based intervention studies in similar populations (Cesa et al., 2013; Manzoni et al., 2016).

Suitable participants screened as at risk for EDs during the **screening phase** were subsequently contacted via e-mail or telephone within 7 days and invited to take part in the **experimental phase** of the study.

In the **experimental phase**, participants were randomized in the intervention (VR) or control (waiting-list) group following a "block randomization" method (Kim & Shin, 2014). Participants in the intervention (VR) group underwent six 30-minutes sessions of the VR-based intervention administered using the software H.O.M.E. at the presence of a clinical psychologist (using the protocol described in ***chapter 3, paragraphs 3.2***). Controls (waiting-list) did not receive any intervention during the study, but they received minimal attention from the clinical psychologist through phone check-up sessions monitoring symptoms and general well-being. They were also be offered to receive the VR-based intervention after conclusion of study 2.

To test whether changes were maintained over time, both groups were re-contacted for **follow-ups** after 3 and 6 months after conclusion of the experimental phase.

Immediately before the first session of the experimental phase (T0), at conclusion of the experimental phase (T1), and at 3 and 6-months follow-ups (T2, T3) participants of both groups were asked to complete online (using the platform Qualtrics) a series of psychometric self-report questionnaires.

6.4 Study 2 Instruments

6.4.1 Study 2 Screening measures

Screening measures for Study 2 included the same screening instruments described for Study 1 (*see **chapter 5, paragraph 5.4.1)*** and were also administered online (using the platform Qualtrics):

- a non-standardized **self-report questionnaire** to collect socio-demographic and clinical data and to investigate the participants' familiarity with the use of a computer or technological devices (i.e. videogames) in their everyday life;
- the **SCOFF questionnaire** (Morgan et al., 2000; Pannocchia et al., 2011) and the **Eating Disorders Examination Questionnaire** (EDE-Q 6.0; Fairburn & Beglin, 1994; Calugi et al., 2016) to detect ED risk;
- if scoring higher than the screening questionnaires cut-offs, potential participants were also asked to undergo a clinical interview based on DSM-5-TR criteria (APA, 2022) to exclude the presence of a full ED diagnosis and confirm ED risk.

6.4.2 Study 2 Outcome measures

At T0, T1, T2, and T3, participants of both the experimental (VR) and control (waiting-list) group filled-in the following questionnaires:

- **Eating Disorders Examination Questionnaire** (EDE-Q 6.0) (Fairburn & Beglin, 1994; Calugi et al., 2016), described in the screening measures, to evaluate changes in dysfunctional eating behaviors and eating-related symptoms;
- **Difficulties in Emotion Regulation Scale-brief version** (DERS-16) (Bjureberg et al., 2016) to evaluate difficulties in emotion regulation;
- **Acceptance and Action Questionnaire-II** (AAQ-II) (Bond et al., 2011; Pennato, Berrocal, Bernini & Rivas, 2013) to measure psychological flexibility;
- **Experiential avoidance scale** (MPFI-EA) from the **Multidimensional Psychological Flexibility Inventory** (MPFI) (Rolffs, Rogge, & Wilson, 2016; Landi et al., 2021) to measure experiential avoidance.
- in order to monitor the levels of anxiety experienced by participants throughout the VR intervention sessions, the **Subjective Unit of Discomfort Scale** (SUDs) (Wolpe, 1973), previously described for Study 1, was similarly used.

All questionnaires (with the exception of the EDE-Q, already described for Study 1) are described below.

Difficulties in Emotion Regulation Scale-short version (DERS-16)

The Difficulties in Emotion Regulation Scale-short version (DERS-16; Bjureberg et al., 2016) is a self-report questionnaire for the assessment of difficulties in emotion regulation. The instrument was developed by Gratz and Roemer (2004) in a 36-item version. Subsequently, a 16-item short version was developed that assesses difficulties in ER concerning: 1) Non-acceptance: tendency to experience secondary negative emotions in response to other negative emotions or not to accept one's discomfort (e.g. "When I am upset, I feel weak"); 2) Goals: difficulty pursuing goal-oriented behaviors when experiencing negative emotions (e.g., "When I'm upset, I have difficulty completing my work"); 3) Impulse control: difficulty controlling one's behavior when experiencing negative emotions (e.g., "When I'm upset, I feel out of control"); 4) Strategies: limited access to strategies to regulate negative emotions (e.g., "When I'm upset, I don't think there's anything I can do to get better"); 5) Clarity: degree of understanding of the emotions you are experiencing (e.g., "I'm confused about what I'm feeling").

The response scale is a 5-point Likert scale (1=almost never, 5=almost always). A score can be derived from each of the DERS-16 subscales: high scores indicate difficulties in that specific dimension of ER. A total score can also be derived from the DERS-16 that reflects the overall degree of emotional dysregulation.

DERS-16 showed excellent internal consistency (α = .92), good test-retest reliability, and is strongly associated with the 36-item version (r = .93) with the original validation sample (Bjureberg et al., 2016). Hallion and colleagues (2018) confirmed internal consistency values (α = .87-.96). In addition, the results show that the construct validity is equivalent between the two versions and in the short version there is a significant reduction in the mean time of administration (Bjureberg et al., 2016).

Acceptance and Action Questionnaire-II

The Acceptance and Action Questionnaire-II (AAQ-II; Bond et al., 2011; Pennato, Berrocal, Bernini & Rivas, 2013) is a 7-item self-report questionnaire that measures psychological inflexibility. The questions are about negatively evaluating feelings, avoiding thoughts and feelings, and changing one's behaviors in the presence of difficult thoughts or feelings. The response scale consists of a 7-point Likert scale, where 1 corresponds to "is never true" and 7 to "is always true". A high score corresponds to high levels of psychological inflexibility.

The process of constructing AAQ-II involved a panel of researchers and practitioners who contributed to the development of ACT and AAQ-I: these authors created items that followed the domains of psychological flexibility and inflexibility and that reflected the reluctance to experience unwanted emotions and thoughts, the ability to be in the present moment, and the commitment to actions consistent with one's values when experiencing psychological events that can undermine them.

AAQ-II was developed because AAQ-I showed insufficient levels of consistency in different populations, while AAQ-II showed higher Cronbach's α=.78-.88 (Bond et al., 2011). The AAQ-II was developed in two versions, 7- or 10-item: the 7-item version showed better psychometric properties than both the 10-item version and the AAQ (Bond et al., 2011) and was, therefore, used for this study.

The Italian version of the AAQ-II has proven to be a reliable and valid measure of psychological inflexibility, with high internal consistency (.83) and modest test-retest reliability over a period of 12 months (.61) (Pennato et al., 2013).

Experiential avoidance scale from the Multidimensional Psychological Flexibility Inventory (MPFI-EA)

The Experiential Avoidance Scale (MPFI-EA) from the Multidimensional Psychological Flexibility Inventory (MPFI; Rolffs, Rogge, & Wilson, 2016; Landi et al., 2021) is a 5-item self-report scale that assesses experiential avoidance, resulting from the MPFI, a 60-item questionnaire that assesses global processes of psychological flexibility and inflexibility. Items are rated on a 6-point Likert scale, from 1 ("never true") to 6 ("always true"). The score of each MPFI scale, including MPFI-EA, is obtained by adding the scores to the various items that make up the dimensions and calculating their average.

The MPFI assesses both flexibility and inflexibility across six processes overall. The evaluated processes of psychological flexibility include acceptance, awareness of the present moment, self as context, defusion, values, and commitment to action. The processes of psychological inflexibility include experiential avoidance, lack of contact with the present moment, self as content, fusion, lack of contact with one's values, inaction.

The MPFI-EA subscale showed high reliability and validity in the Italian version (Cronbach α =.91; Landi et al., 2021).

6.5 Study 2 Data analyses

Data analyses were performed using SPSS Statistic vrs.25. Descriptive statistics were run to analyze socio-demographic (age, marital status, educational level, occupational status), clinical characteristics (BMI, weight history, former ED diagnosis…), as well as mean SCOFF, EDE-Q, DERS-16, AAQ-II, and MPFI-EA scores of the sample. To test pre-intervention/baseline differences between experimental (VR) and control group (waiting-list), Chi-squares were performed on categorical variables while independent samples t-tests on continuous variables.

To test the feasibility of the H.O.M.E. VR-based intervention, percentage of drop-out cases were calculated for the experimental (VR) group.

To test the efficacy of the H.O.M.E. VR-based intervention and to also compare its effects (in terms of changes produced in EDE-Q, DERS-16, AAQ-II, and MPFI-EA between pre- and post-intervention and between post-intervention and follow-ups) to those of the control (waiting-list) condition, repeated measure ANOVAs were performed using time (T0, T1, T2, T3) as within-subject factor and group (VR or waiting-list) as between-subject factor with post-hoc contrast analyses.

6.6 Study 2 Results

6.6.1 Study 2 Sample description

N=40 females at risk for EDs were recruited for Study 2 and were randomized to the experimental (undergoing the H.O.M.E. VR-based preventive intervention protocol) (n=20) or control (waiting-list) (n=20) group using a block randomization method.

Both groups were made of only female participants, with similar mean ages (VR: 24.35±6.02; waiting-list: 24.75±9.08). The majority of the sample in both groups were single (VR: n=18, 90%; waiting-list: n=18, 90%) and university students (VR: n=15, 75%; waiting-list: n=16, 80%). All participants in both groups were familiar with the use of technology (e.g. smartphones, computers, videogames, etc.) in their daily lives.

Similarly to Study 1, when considering dysfunctional eating behaviors participants of both groups reported the highest scores in the EDE-Q-Shape concerns (VR: 4.52±.93; waiting-list: 4.27±1.26) and EDE-Q-Weight concerns (VR: 3.92±1.11; waiting-list: 3.30±1.40) subscales.

Table 6.1 summarizes sociodemographic and clinical characteristics of both groups, as well as the statistical indexes relative to the independent samples T-Test and Chi-square tests

run to evaluate the presence of possible sociodemographic or clinical differences between groups at baseline (T0).

As it can be observed from **Table 6.1**, no significant difference was found between groups at baseline in any of the variables, including dysfunctional eating behaviors (SCOFF, EDE-Q) and transdiagnostic factors (DERS-16, AAQ-II, MPFI-EA).

Table 6.1. Sociodemographic and clinical characteristics of the VR and waiting-list group samples, and differences between groups

	H.O.M.E. VR group (n=20) M±SD *or* % (n=)	**Waiting-list group (n=20) M±SD *or* % (n=)**	**t(df)**	**$\chi^2_{(df)}$**	**p**
Gender	100% (n=20) females	100% (n=20) females	-	-	-
Age	24.35±6.02 years	24.75±9.08 years	$-.164_{(38.0)}$	-	.870
Marital status	90.0% (n=18) single 5% (n=1) married 5% (n=1) divorced	90.0% (n=18) single 5% (n=1) married 5% (n=1) divorced	-	-	-
Educational level	35% (n=7) high school diploma 65% (n=13) university degree	50% (n=10) high school diploma 50% (n=10) university degree	-	$2.39_{(2)}$	.303
Occupation	75% (n=15) university students 20% (n=4) employed 5% (n=1) unemployed	80% (n=16) university students 20% (n=4) employed	-	$3.03_{(4)}$	.552
BMI	25.72±3.19	22.93±3.28	$3.331_{(38.0)}$	-	.087
SCOFF	3.65±1.09	3.55±.95	$.310_{(38.0)}$	-	.758
EDE-Q-Total	3.48±1.07	3.18±1.18	$.850_{(38.0)}$	-	.400
EDE-Q-Restraint	2.79±1.68	2.75±1.38	$.082_{(38.0)}$	-	.935
EDE-Q-Eating concerns	2.69±1.44	2.36±1.33	$.753_{(38.0)}$	-	.456
EDE-Q-Shape concerns	4.52±.93	4.27±1.26	$.715_{(38.0)}$	-	.479
EDE-Q-Weight concerns	3.92±1.11	3.3±1.40	$1.480_{(38.0)}$	-	.147
DERS-16-Total	47.45±15.77	46.95±18.42	$.092_{(38.0)}$	-	.927
DERS-16-*Clarity*	5.75±2.34	5.15±2.76	$.742_{(38.0)}$	-	.462
DERS-16-*Goals*	10.35±3.30	9.80±3.82	$.488_{(38.0)}$	-	.629
DERS-16-*Impulse*	7.55±3.96	7.95±3.76	$-.328_{(38.0)}$	-	.745
DERS-16-*Strategies*	14.70±5.56	15.10±6.50	$-.209_{(38.0)}$	-	.836
DERS-16-*Nonacceptance*	9.10±3.14	8.95±3.94	$.133_{(38.0)}$	-	.895
AAQ-II	28.15±9.56	25.85±10.97	$.707_{(38.0)}$	-	.484
MPFI-EA	3.28±.99	3.34±1.10	$-.181_{(38.0)}$	-	.852

Abbreviations. *AAQ-II: Acceptance and Action Questionnaire-II; BMI: Body Mass Index; DERS-16: Difficulties in Emotion Regulation Scale, short version; EDE-Q: Eating Disorders Examination Questionnaire; M: mean; MPFI-EA: Multidimensional Psychological Flexibility Inventory-Experiential avoidance scale; SD: Standard Deviation*

6.6.2 Feasibility, effects of the H.O.M.E. intervention and comparison with waiting-list.

The H.O.M.E. VR-based prevention intervention showed good feasibility, with no participant dropping out after undergoing at least one session of the intervention.

The H.O.M.E. VR-based intervention was also capable of producing significative changes between pre- and post- intervention (T0-T1 changes) in participants undergoing it. In particular, mixed-model repeated measures ANOVAs with post-hoc contrast revealed significant improvements in EDE-Q-total (T0=3.48±1.07; T1=2.89±1.02; p=.003) and all EDEQ-subscales (EDE-Q-Restraint: T0=2.79±1.68, T1=2.22±1.19, p=.028; EDE-Q-Eating concerns: T0=2.69±1.44, T1=2.20±1.22, p=.035; EDE-Q-Shape concerns: T0=4.52±.93, T1=3.74±1.26, p=.003; EDE-Q-Weight concerns: T0=3.92±1.11, T1=3.38±1.18, p=.023), AAQ-II (T0=28.15±9.56, T1=24.35±10.43, p=.005), DERS-16-Total (T0=47.45±15.77, T1=41.20±16.20, p=.006), DERS-16-Difficulty in engaging in goal directed behaviors (T0=10.35±3.30, T1=9.10±3.68, p=.008), and DERS-16-Limited access to emotion regulation strategies (T0=14.70±5.56, T1=12.30±5.20, p=.001) were observed. All changes achieved at post-intervention (T1) were also maintained at both 3- (T2) and 6-months (T3) follow-ups, with a lack of significant T1-T2 changes and T1-T3 changes in all the improved aforementioned variables, with the only exception of DERS-16-Difficulty in engaging in goal directed behaviors (T1=9.10±3.68; T3=7.85±3.31; p=.008) which further improved between post-intervention and 6-months follow-up.

Table 6.2 shows mean levels of dysfunctional eating behaviors (EDE-Q) and transdiagnostic factors (DERS-16, AAQ-II, and MPFI-EA) at each assessment point, separately for each group.

Results from repeated-measures mixed-model ANOVAs and statistical data are, instead, summarized in **Tables 6.3-6.4**.

Looking at the results from the ANOVAs, all the changes reported by the H.O.M.E. VR-based intervention also resulted to be greater than those of the waiting-list condition (significant TimexGroup interactions, p levels and effect-sizes are reported in **Tables 6.3-6.4**).

The waiting-list also did not report any significant improvement in dysfunctional eating behaviors or any of the transdiagnostic factors between T0 and T1, but levels of EDE-Q-Restraint (T1=2.85±1.27, T3=3.33±1.23; p=.046), DERS-16-Total (T1=47.75±15.13, T3=52.30±12.76; p=.025), DERS-16-Difficulty in engaging in goal directed behaviors (T1=10.30±3.47, T3=11.40±2.70; p=.018), and DERS-16-Limited access to emotion

regulation strategies (T1=15±5.91, T3=16.70±4.95; p=.019) even worsened between T1 and 6-months (T3) follow-up.

Table 6.2. Means and standard deviations of levels of dysfunctional eating behaviors (EDE-Q) and transdiagnostic factors (DERS-16, AAQ-II, and MPFI-EA) at each assessment point for VR and control (waiting-list) groups.

	H.O.M.E. VR group (n=20) M±SD				***Waiting-list group (n=20) M±SD***			
	T0	**T1**	**T2**	**T3**	**T0**	**T1**	**T2**	**T3**
EDE-Q-Total	3.48±1.07	2.89±1.02	2.81±1.41	2.86±1.21	3.18±1.18	3.31±1.12	3.21±1.11	3.49±1.05
EDE-Q-Restraint	2.79±1.68	2.22±1.19	2.37±1.41	2.30±1.27	2.75±1.38	2.85±1.27	2.77±1.44	3.33±1.23
EDE-Q-Eating concerns	2.69±1.44	2.20±1.22	1.98±1.58	2±1.35	2.36±1.33	2.46±1.35	2.34±1.15	2.55±1.14
EDE-Q-Shape concerns	4.52±.93	3.74±1.26	3.65±1.81	3.71±1.53	4.27±1.26	4.33±1.31	4.25±1.38	4.36±1.37
EDE-Q-Weight concerns	3.92±1.11	3.38±1.18	3.25±1.68	3.41±1.37	3.3±1.40	3.59±1.45	3.50±1.47	3.70±1.32
DERS-16-Total	47.45±15.77	41.20±16.20	38.75±17.12	37.45±16.45	46.95±18.42	47.75±15.13	47.25±15.34	52.30±12.76
***DERS-16-C*larity**	5.75±2.34	4.90±2.17	5±2.70	5.20±2.55	5.15±2.76	5.60±2.23	5.40±2.30	6±2.15
***DERS-16-G*oals**	10.35±3.30	9.10±3.68	8.30±3.44	7.85±3.31	9.80±3.82	10.30±3.47	10.30±3.34	11.40±2.70
***DERS-16-I*mpulse**	7.55±3.96	6.50±4.19	6.20±3.58	5.95±3.47	7.95±3.76	7.75±3.09	7.45±3.17	8.30±2.90
***DERS-16-S*trategies**	14.70±5.56	12.30±5.20	12.10±6.21	11.45±6.05	15.10±6.50	15±5.91	15.10±5.86	16.70±4.95
***DERS-16-N*onacceptance**	9.10±3.14	8.40±3.49	7.15±3.41	7±3.28	8.95±3.94	9.10±3.26	9±3.26	9.90±2.61
AAQ-II	28.15±9.56	24.35±10.43	23.75±11.88	24.30±11.40	25.85±10.97	27.25±10.13	27.15±10.01	29..10±9.55
MPFI-EA	3.28±.99	3.40±1.12	3.08±1.28	3±1.18	3.34±1.10	3.79±1.08	3.54±1.03	3.65±1.06

Abbreviations. *AAQ-II: Acceptance and Action Questionnaire-II; DERS-16: Difficulties in Emotion Regulation Scale, short version; EDE-Q: Eating Disorders Examination Questionnaire; M: mean; MPFI-EA: Multidimensional Psychological Flexibility Inventory-Experiential avoidance scale; SD: Standard Deviation*

Tables 6.3. Results of the repeated-measures mixed-model ANOVAs investigating changes in the H.O.M.E. intervention and comparisons with waiting-list (EDEQ, AAQ-II, MPFI-EA)

		EDEQ-Total	**EDEQ-Restraint**	**EDEQ-Eating concerns**	**EDEQ-Shape concerns**	**EDEQ-Weight concerns**	**AAQ-II-Total**	**MPFI-EA-Total**
	Group ($F_{(df)}$; p; η^2_p)	0.759(38.1); .389; .020	1.77(38.1); .191; .044	.297(38.1); .589; .008	1.05(38.1); .313; .027	.0104(38.1); .919; .000	.492(38.1); .487; .013	2.12(38.1); .153; .053
	Time ($F_{(df)}$; p; η^2_p)	2.32(38.1); .079; .058	1.39(38.1); .249; .035	2.48(38.1); .065; .061	**2.98(38.1); .035; .073**	.906(38.1); .440; .023	1.31(38.1); .275; .033	1.148(38.1); .333; .029
	Time*Group ($F_{(df)}$; p; η^2_p)	**5.37(38.1); .002; .124**	**1.998(38.1); .017; .085**	**3.84(38.1); .012; .092**	**3.58(38.1); .016; .086**	**3.537(38.1); .017; .085**	**5.90(38.1); <.001; .134**	.883(38.1); .452; .023
Post-hoc								
VR MD (p)	**T0 x T1**	**.593(.003)**	**.570(.028)**	**.490(.035)**	**.775(.003)**	**.540(.023)**	**3.800(.005)**	-.120(.679)
	T0 x T2	**.667(.002)**	.420(.098)	**.710(.002)**	**.869(.006)**	**.670(.013)**	**4.400(.005)**	.200(.545)
	T0 x T3	**.624(.005)**	.490(.092)	**.690(.005)**	**.806(.004)**	.510(.062)	**3.850(.017)**	.280(.367)
	T1 x T2	.073(.657)	-.150(.507)	.220(.176)	.094(.679)	.130(.545)	.600(.551)	.320(.208)
	T1 x T3	.030(.381)	-.080(.732)	.200(.310)	.031(.866)	-.030(.888)	.050(.968)	.400(.094)
	T2 x T3	-.043(.683)	.070(.702)	-.020(.848)	-.063(.544)	-.160(.293)	-.550(.606)	.080(.428)
Waiting-list MD (p)	**T0 x T1**	-.130(.492)	-.100(.690)	-.100(.658)	-.063(.799)	-.260(.260)	-1.400(.274)	-.450(.126)
	T0 x T2	-.038(.848)	-.020(.936)	.020(.927)	.019(.950)	-.170(.512)	-1.300(.385)	-.200(.545)
	T0 x T3	-.308(.154)	-580(.047)	-.190(.415)	-.094(.727)	-.370(.172)	**-3.250(.042)**	-.310(.318)
	T1 x T2	.093(.575)	.080(.723)	.220(.176)	.081(.720)	.090(.675)	.100(.921)	.250(.323)
	T1 x T3	-.178(.296)	**-.480(.046)**	-.350(.389)	-.031(.866)	-.110(.607)	-1.850(.143)	.140(.552)
	T2 x T3	**-.270(.014)**	**-.560(.004)**	-.570(.180)	-.113(.277)	-.200(.190)	-1.950(.073)	-.110(.278)

Abbreviations. *AAQ-II: Acceptance and Action Questionnaire-II;EDE-Q: Eating Disorders Examination Questionnaire; MD: mean difference; MPFI-EA: Multidimensional Psychological Flexibility Inventory-Experiential avoidance scale*

Tables 6.4. Results of the repeated-measures mixed-model ANOVAs investigating changes in the H.O.M.E. intervention and comparisons with waiting-list (DERS-16)

		DERS-16-Total	**DERS-16-*Lack of emotional clarity***	**DERS-16-*Difficulty in engaging in goal directed behaviors***	**DERS-16-*Impulse control difficulties***	**DERS-16-*Limited access to emotion regulation strategies***	**DERS-16-*Nonacceptance of emotional responses***
	Group ($F_{(df)}$; p; η^2_p)	$2.41_{(38.1)}$; .129; .060	$.233_{(38.1)}$; .632; .006	$2.42_{(38.1)}$; .128; .060	$1.62_{(38.1)}$; .211; .041	$2.70_{(38.1)}$; .108; .066	$1.90_{(38.1)}$; .176; .048
	Time ($F_{(df)}$; p; η^2_p)	**$2.92_{(38.1)}$; .037; .071**	$.803_{(38.1)}$; .495; .021	$1.88_{(38.1)}$; .137; .047	$2.40_{(38.1)}$; .072; .059	**$2.81_{(38.1)}$; .043; .069**	**$2.81_{(38.1)}$; .043; .069**
	Time*Group ($F_{(df)}$; p; η^2_p)	**$9.63_{(38.1)}$; <.001; .202**	$2.403_{(38.1)}$; .071; .059	**$13.52_{(38.1)}$; <.001; .262**	$2.53_{(38.1)}$; .061; .061	**7.64; <.001; .167**	**$7.50_{(38.1)}$; <.001; .165**
Post-hoc							
VR MD (p)	**T0 x T1**	**6.250(.006)**	.850(.080)	**1.25(.008)**	1.050(.072)	**2.400(.001)**	.700(.204)
	T0 x T2	**8.700(<.001)**	.750(.844)	**2.050(<.001)**	**1.350(.023)**	**2.600(.005)**	**1.95(<.001)**
	T0 x T3	**10.000(<.001)**	.550(.249)	**2.500(<.001)**	**1.600(.004)**	**3.25(<.001)**	**2.100(<.001)**
	T1 x T2	2.450(.220)	-.100(.805)	.800(.056)	.300(.537)	.200(.759)	**1.250(.014)**
	T1 x T3	3.750(.061)	-.300(.426)	**1.25(.008)**	.550(.319)	.850(.229)	**1.400(.006)**
	T2 x T3	1.300(.283)	-.200(.400)	.450(.148)	.250(.328)	.650(.137)	.150(.591)
Waiting-list MD (p)	**T0 x T1**	-.800(.712)	-.450(.347)	-.500(.269)	.200(.726)	.100(.885)	-.150(.783)
	T0 x T2	-.300(.901)	-.250(.604)	-.500(.181)	.500(.385)	.001(1.00)	-.050(.923)
	T0 x T3	**-5.350(.028)**	-.850(.078)	**-.1.600(.008)**	-.350(.511)	-1.600(.075)	-.950(.102)
	T1 x T2	.500(.801)	.200(.622)	.001(1.00)	.300(.537)	-.100(.878)	.100(.837)
	T1 x T3	**-4.550(.025)**	-.400(.583)	**-1.100(.018)**	-.550(.319)	**-1.700(.019)**	-.800(.103)
	T2 x T3	**-5.050(<.001)**	**-.600(.015)**	**-3.100(.004)**	**-.850(.002)**	**-1.600(<.001)**	**-.900(.002)**

Abbreviations. *DERS-16: Difficulties in Emotion Regulation Scale, short version; MD: mean difference*

CHAPTER 7.

STUDY 3: A QUALITATIVE THEMATIC EVALUATION OF THE SUBJECTIVE EXPERIENCE OF GENERAL POPULATION PARTICIPANTS AT RISK FOR EDS COMPLETING THE TRANSDIAGNOSTIC H.O.M.E. VR-BASED INTERVENTION

7.1 Study 3 Aims

Study 3 aimed to qualitatively investigate opinions about the H.O.M.E. VR-based intervention of participants from the general population that completed it.

7.2 Study 3 Hypotheses

It was hypothesized that participants completing the H.O.M.E. VR-based intervention would report positive opinions about the intervention, with a subjective reduction of dysfunctional eating behaviors and a subjective improvement of targeted transdiagnostic factors.

7.3 Study 3 Research design

Participants that completed the H.O.M.E. VR-based intervention in Study-2 were asked to complete a semi-structured interview (performed in-presence by a researcher, at post-intervention) to collect their subjective opinions and experiences regarding the intervention.

7.4 Study 3 Instruments

7.4.1 Study 3 Screening measures

Since Study 3 included participants who completed the H.O.M.E. VR-based intervention for Study 2, screening measures were the same as described for Study 1 and 2:

- a non-standardized **self-report questionnaire** to collect socio-demographic and clinical data and to investigate the participants' familiarity with the use of a computer or technological devices (i.e. videogames) in their everyday life;
- the **SCOFF questionnaire** (Morgan et al., 2000; Pannocchia et al., 2011) and the **Eating Disorders Examination Questionnaire** (EDE-Q 6.0; Fairburn & Beglin, 1994; Calugi et al., 2016) to detect ED risk and measure dysfunctional eating behaviors.

7.4.2 Study 3 Outcome measures

Study 3 main outcome measure included an ***ad-hoc semi-structured interview*** for the collection of personal opinions and themes regarding the subjective experience of participants who completed the H.O.M.E. VR-based intervention. Questions included in the interview aimed to collect information about:

- overall knowledge or personal experience of VR technologies before taking part in the intervention;
- reasons why they decided to take part in the research;
- general opinions and feedbacks about the H.O.M.E. VR software (e.g. improvable aspects, most enjoyable or less enjoyable features);
- relationship with foods and other critical areas of life before undergoing the VR-based intervention;
- reported positive and negative aspects of the intervention (e.g. perceived benefits or lack thereof, most useful or less useful feature or session, etc.)
- utility of the H.O.M.E. VR-based intervention in improving dysfunctional eating-behaviors and targeted transdiagnostic psychological resources;
- the intention of undergoing other psychological interventions after the VR-based intervention or general past or present received psychological support.

7.5 Study 3 Data analyses

Statistical data analyses were performed using SPSS Statistic vrs.25. Descriptive statistics were run to analyze socio-demographic (age, marital status, educational level, occupational status), clinical characteristics (BMI, weight history, former ED diagnosis…), as well as mean SCOFF, EDE-Q, DERS-16, AAQ-II, and MPFI-EA scores of the sample.

Semi-structured interviews were performed, recorded and transcribed ad-verbatim. Thematic analysis with systematic coding and categorization of recurring themes was performed to identify, analyse, and report patterns and recurring themes within the data collected (Braun & Clarke, 2006).

7.6 Study 3 Results

7.6.1 Study 3 Sample description

All participants undergoing the H.O.M.E. VR-based intervention in Study 2 (n=20) accepted to also take part in Study 3. Sociodemographic and clinical characteristics of the sample are the same as the VR group for Study 2 and have been summarized in **chapter 6, Table 6.1.**

7.6.2 Thematic analysis

At the end of the intervention, the 20 participants agreed to undergo a semi-structured interview, carried out electronically, with the aim of investigating the subjective experience of each one. Starting from the answers obtained, n=10 themes were identified, each one related to the main question points included in the semi-structured interview.

In **Table 7.1** themes and most frequent replies are summarized. Each one will be further illustrated in details in subsequent paragraphs.

Table 7.1. Themes and most frequent replies emerging from the thematic analysis

Themes	*Most frequent replies*
Knowledge about VR	VR was known, but never used (n=13, 65%) Knew and tried VR, but outside clinical settings (n=5, 25%) Did not know VR (n=2, 10%)
Reasons for participation	Interest in EDs and need for support (n=12, 60%) Wanted to try VR (n=9, 45%) Desire to help research (n=3, 15%) Intervention was free of costs (n=2, 10%)
Issues about food	***Dysfunctional eating behaviors (n=20)*** Food restriction (n=11, 55%) Sporadic binge eating (n=6, 30%) Compensatory behaviors or exercise (n=5, 25%) Using food to regulate emotions (n=5, 25%) Counting calories (n=4, 20%) ***Negative cognitions and emotions towards food (n=20)*** Guilt towards food and eating (n=15, 75%) Frequent and persistent negative thoughts about food (n=5, 25%) Overevaluation of body weight (n=4, 20%)
Issues relative to other areas of life	Relationships with others (n=10, 50%) Excessive need for control (n=6, 30%) Anxiety management (n=4, 20%)
Thoughts and emotions about H.O.M.E intervention	***Thoughts*** H.O.M.E. was a space for reflection (n=8, 40%) H.O.M.E. was a welcoming and safe space (n=6, 30%) It was easy to open up (n=5, 20%) Presence of initial barriers (n=3, 15%) H.O.M.E. motivated people towards change (n=2, 10%) ***Emotions*** H.O.M.E. produced positive feelings (n=19, 95%) Initial fear, worry, or embarrassment (n=5, 20%)
Emotions, immersivity and realism associated with the H.O.M.E. software/environment	Elicited emotions similar to real life, but lower intensity (n=16, 80%) Unrealistic but very immersive (n=7, 35%) Rooms and objects with different degrees of realism (n=4, 20%) Not very immersive (n=3, 15%)
Learning coping strategies during the intervention	Exercises performed even after the intervention (n=18, 90%) H.O.M.E. effective in teaching coping strategies (n=16, 80%) H.O.M.E. improved participants' relationship with food (n=14, 70%) H.O.M.E. increased participants' self-awareness (n=10, 50%) Homework useful for learning coping strategies (n=6, 30%) H.O.M.E. was a safe space for reflection, but did not manage to teach coping strategies (n=4, 20%)

H.O.M.E. as a bridge towards psychological support	Encouraged participants to seek psychological support (n=17, 85%) Participants interested in undergoing psychotherapy, but not actively seeking (n=8, 40%) Participants began psychotherapy after the intervention (n=6, 30%) H.O.M.E. added new elements in psychotherapy for those who were already undergoing it (n=3, 15%) Participants did not feel the need to seek further psychological support (n=3, 15%)
Positive aspects of the intervention	Innovative type of intervention (n=14, 70%) Greater level of interactivity (n=10, 50%) Transdiagnostic nature (n=3, 15%) Presence of the clinical psychologist (n=2, 10%)
Negative aspects of the intervention/software	**Software** Improvable virtual environment and stimuli (n=10, 50%) Need for increased realism (n=6, 20%) Sporadic technical issues (n=2, 10%) **Intervention** Limited number of sessions (n=6, 30%)

7.6.2.1 Virtual Reality: a well-known but unexplored technology

The majority of participants (n=13, 65%) reported that they knew what virtual reality was before taking part in the intervention but had never tried it ("*I knew what it was but I never had any kind of experience with it*" [participant 2]; "*I had heard of it but had never tried it*" [participant 10]). Some (n=5; 25%), instead, had already experienced VR but only outside of the clinical field, for personal pleasure or entertainment ("*I tried it when the first VR for mobile phones came out [...] just for personal pleasure*" [participant 5]; "*Before the study, I had only tried it once at a video game fair*" [participant 18]). Only two participants (10%) did not know VR before taking part in the intervention.

7.6.2.2 Reasons for participation

Although for 60% (n=12) of participants the main reason that led them to undergo the VR-based intervention was a strong interest in the topic of EDs and a personal need to receive support in this regard ("*I was sure that I had a problematic approach to food [...], therefore I decided to participate in this intervention with virtual reality*" [participant 13]), having the chance to try VR was also a common factor that encouraged a good number of participants (n=9, 45%) to take part in the study ("*I wanted to participate in the project precisely because I was curious to try i*t [virtual reality]" [participant 17]).

For some participants (n=3, 15%) personal need was also combined with a desire to help scientific research, as in the case of participant 19 who reported that she had "taken the opportunity both to help myself through this project and to give the research person the opportunity to create a program that can help people who are suffering."

Finally, what encouraged participation in the intervention in two cases (10%) was the fact that the intervention was free of costs ("*I had already tried to go to a psychologist before but since I study and have to support myself with a student job, I could not afford it economically. This intervention, on the other hand, was free and so I did it*" [participant 9]).

7.6.2.3 Dysfunctional behaviors and negative cognitions and emotions towards food

All participants reported having or having had food-related problems of varying severity and entity.

The most frequently reported ***dysfunctional eating behaviors*** (n=11, 55%) in participants were restrictions in food intake, implemented by sporadic restriction ("*Sometimes I skip meals if it's a period when I feel bad and want to lose weight*" [participant 14]), strict diets that are often self-made ("*I've done a lot of diets but was never followed by a nutritionist*" [participant 15]) or actual fasting ("*I went from periods in which I ate normally to periods in which I stopped eating or ate very little*" [participant 1]).

On the opposite side, sporadic binge eating was also common in the sample (n=6, 30%) ("*the most acute thing I've suffered from, especially in the last period and in periods when I feel more down, are small binge eating episodes: I open a packet of cookies and finish it without realizing it*" [participant 9]), sometimes followed by compensatory behaviors (n=5, 25%), manifested in the form of elimination behaviors or excessive sports activity ("*A few I used laxatives and sports to compensate*" [participant 2]).

Food was seen by some participants (n=5, 25%) as a mean to regulate negative emotions ("*food has always been my "escape valve" whenever I have difficulties or experience negative emotions*" [participant 18]) or to experience positive ones, as reported by participant 5: "*maybe sometimes between meals I didn't eat a fruit, which would be healthier, but something sweet for my personal gratification, even after work sometimes I think: I worked a little, I struggled, I eat because it gratifies me*".

Other dysfunctional eating behaviors that emerged in the sample were counting calories ingested during the day (n=4, 20%; "*The dysfunctional behavior I had at that time was to make a mental calculation of how many calories I ate during the day*" [Participant 12]), difficulty in respecting regular meal times (n=1; 5%; "*I also struggle to eat at regular times*" [participant 6]), weighing themselves daily (n=1.5%; "*This study helped me understand that some of my behaviors were not very healthy, such as [...] weighing myself every day*" [participant 17]) or generally maintaining an unhealthy diet (n=1; 5%; "I have an unhealthy and irregular diet" [participant 14]).

In addition, the interviews showed that participants were also characterized by ***dysfunctional cognitions or negative emotions*** related to eating. The prevailing negative emotion (n=15, 75%) they associated to food and eating was guilt, as stated, for example, by participant 11: "*I eat and feel guilty afterwards, and I try to remedy it in some way*".

Other dysfunctional cognitive components that often characterized the sample were fixed and often negative thoughts about food that persisted over time (n=5, 25%; "*I have always had great difficulty in relation to food, it could become such a fixed thought that it monopolized my days*" [participant 7]) or attributing excessive importance to body weight over other areas of life, such as well-being, self-esteem and relationships with others (n=4, 20%; "*The way I see my body has always had a big impact on how I perceive myself and my relationship with others*" [Participant 14]).

7.6.2.4 Issues relative to other areas of life

In accordance with its transdiagnostic nature, during the 6 sessions that make up the intervention, other topics were addressed with participants, in addition to their relationship with food.

The most frequently discussed critical areas (n=10, 50%) concerned relationships with others ("*[The psychologist] helped me a lot to ask myself questions about who I am, to also think about, for example, the relationships with my friends, with university and with my ex-boyfriend, as well as the relationship with food*" [participant 9]).

Another recurring topic (n= 6, 30%) was an excessive need for control detected and reported by some participants. For example, participant 10 reported that she "*wants to keep everything under control, so when something doesn't go the way it was supposed to go in my head, I freak out*".

Anxiety management was also a topic that emerged (n=4, 10%) ("*the focus [of the intervention] was on anxiety, social relationships and emotions related to them*" [participant 4]).

Finally, only one participant (5%) expressed how she brought up her issue with online shopping and other moments of discouragement during the sessions: "*participating in the intervention helped me because we don't always analyze all areas of life, such as online shopping or moments of discouragement [...], but here [during the intervention] we did.*" [Participant 3].

7.6.2.5 Thoughts and emotions about the H.O.M.E. intervention

The intervention generated different thoughts and emotions in the participants.

The ***thoughts*** most frequently found in the participants' interviews (n=8, 40%) were about how they found in the virtual environment and in the intervention a space for reflection in which they could become more aware of their dysfunctional behaviors and distorted beliefs about food ("*[participating in the intervention] was useful to me because, although I realized that my attitudes towards food were dysfunctional, I had normalized them in the many years that I had perpetrated them. When I found myself inside virtual reality [...] I felt very uncomfortable but it was useful because it made me understand what the problem was*" [participant 17]). Participants (n=6, 30%) also underlined how VR and the entire intervention setting felt like a welcoming and safe place, where they felt listened to without being judged ("*it always seemed to me a place where I could be listened to without judgment*" [participant 3]; "*I felt very welcomed and safe*" [participant 14]). The welcoming atmosphere, combined with the sense of protection guaranteed by virtual reality, in some cases (n=5, 20%) made it easier to open up and talk about their problems ("*being in virtual reality and therefore being in a "separate" place helped me even more because it was a bit like reasoning with myself out loud [...] I was able to talk about myself in a much easier way without direct confrontation with the person in front of me*" [participant 1]). In a few cases (n=2, 10%), this made H.O.M.E. effective in motivating the participants towards change ("*[The intervention] helped me a lot to develop self-awareness, it made me think a lot about many aspects of myself, both positive and negative, and this motivated me a lot to change certain things and to want to continue to grow as a person*" [participant 19]).

This feeling of "safe place" in relation to virtual reality also emerged despite some initial barriers reported by a small number of participants (n=3, 15%), such as feeling uncomfortable or having difficulties in opening up ("*There were some moments when talking about how I was feeling made me a little uncomfortable [...] I knew it was useful for me but sometimes I didn't do it with ease, because I knew that I would be dealing with sensitive issues*" [Participant 11]).

The specific **emotions** arising from the intervention were ambivalent. The majority (n=19, 95%) of those who took part in the intervention experienced generally positive feelings ("*[I felt] pleasure, fun, I took it as a game. There were no anger and sadness, but positive emotions*" [participant 5]; "*I was comfortable the whole time, I had no problem thinking about having to go [to sessions], quite the contrary. These six meetings were a moment of relief*" [participant 7]). However, an initial feeling of fear, worry or embarrassment at the idea of opening up about personal issues with strangers, even if professionals was experienced by some

(n=5, 20%), but was gradually replaced by positive emotions, such as serenity and a sense of ease ("*I didn't think such personal topics would be addressed, at the beginning I was a bit embarrassed and I couldn't open up completely. [...] After a few sessions, however, I was able to open up more and work on myself*" [participant 15]).

7.6.2.6 Emotions, immersivity and realisms associated with the H.O.M.E. software and virtual environment

The most frequent opinion (n=16, 80%) that emerged was the fact that the stimuli present in the virtual environment, especially those related to food, were effective in making participants experience emotions similar to the ones in the real world but of lower intensity, often due to the impossibility of physically interacting with objects in a realistic way ("*the virtual stimuli did generate emotions in me, but less intense than when I can eat real food because you can't interact with them, you just see them*" [Participant 11]) and the awareness of being inside a virtual environment ("*emotions were downsized because there was still the awareness of being in virtual reality*" [Participant 19]). Only one participant (5%) said that she felt more intense emotions in the virtual environment than in real life: "*In real life I don't pay too much attention to it [the stimuli] because maybe I'm driven by hunger, but there I could think about my emotions rationally. Food scared me more than it did in real life*" [participant 13]

Other opinions and feedbacks that emerged were about the realism and immersivity of the H.O.M.E. VR environment and software. 35% (n=7) of participants considered the virtual environment unrealistic but still very immersive ("*It didn't feel completely real [...] I would call it a bit "cartoonish", but still very immersive*" [participant 18]), especially thanks to the use of the headset monitor that allowed a detachment from reality ("*I think it's impossible not to feel immersed, the viewer prevents you from seeing what surrounds you [in real life] and therefore you no longer realize where you are*" [participant 17]. Some participants (n=4, 20%) agreed that there were different degrees of realism associated with the different rooms in the virtual environment, with some rooms being more realistic than others, ("*I found the house very well done, but for example the garden was very empty and unrealistic*" [participant 16]) and with the objects ("*[It was] quite real overall, only some of the objects looked a bit fake and "plasticky*" [participant 15]).

However, a smaller number of participants (n=3, 15%) found the virtual environment to not be very immersive ("*it was obvious that it was a virtual reality, I didn't feel like I was in a real room [...] I didn't feel immersed*" [participant 9]).

7.6.2.7 Learning coping strategies using H.O.M.E.

During the intervention, participants were encouraged to learn and then implement strategies (coping strategies taken from the *box of resources*) in their daily lives to cope with negative emotional states and the dysfunctional behaviors that follow, based on the specific needs of each person. To choose the strategies, the participants picked one (or more) of those present in the *box of resources*, containing twelve selectable coping strategies, presented in ***chapter 3, paragraphs 3.2***.

The majority of participants (n=16, 80%) underlined that H.O.M.E. was effective in teaching them coping strategies to deal with their issues regarding food and other areas of life.

The specific coping strategies that participants selected during the H.O.M.E. intervention sessions are summarized in **Table 7.2**.

Table 7.2. Coping strategies selected by participants from the H.O.M.E. box of resources

Chosen strategies	*Prevalence*
Self-esteem/self-acceptance	(n=10, 50%)
Mindfulness	(n=7, 35%)
Self-control	(n=4, 20%)
Forgiveness	(n=4, 20%)
Interpersonal relationships	(n=2, 10%)
Autonomy/assertiveness	(n=2, 10%)
Gratitude	(n=1.5%)

However, four participants (20%) reported that the intervention helped them not by leaving them coping strategies but by offering them a safe space that encouraged reflections on the relationship with food or other issues that emerged during the intervention ("*It did not leave me with strategies [...], but it helped me because I had a space for reflection*" [participant 3]).

Participants (n=19, 95%) also reported that exercises implemented during the course of the H.O.M.E. intervention and as homework were useful in helping them learn the aforementioned strategies. In particular, the most useful exercises participants praised were the use of a diary to record or re-elaborate negative thoughts (n=6, 30%; " *Writing down what doesn't work and asking myself what I needed at that moment helped me a lot*" [participant 9]), meditation exercises (n=4, 20%; "*They recommended meditation [...] and they introduced it to me as a way to take ten minutes a day for myself*" [participant 6]), exercises aimed at increasing

self-esteem (n=4, 20%; "*The exercises helped me to increase my self-esteem, therefore I want to continue doing them*" [Participant 16]) and exercises to reduce the need for control (n=2, 10%; "*When I had already chosen to work on control, [the psychologist] advised me to do one little thing every day outside my comfort zone*" [Participant 19]).

It is also important to notice that 18 participants (90%) underlined that they wanted to continue practicing the coping strategies and excercises even after the conclusion of the H.O.M.E. intervention (*"Even now that the intervention is over, I want to keep practicing the excercises the psychologist gave me, because I found them helpful*" [participant 16]).

These exercises, together with the coping strategies they learnt during the intervention, led participants to report several perceived benefits from H.O.M.E.. In particular, an increase in self-awareness was reported by many of those who underwent the intervention (n=10, 50%; "*I have a little more awareness, which I lacked before*" [participant 2]; "*Now it's easier for me to recognize what my needs are and accept them*" [participant 17]), as well as a more serene relationship with food (n=14, 70%; "*I feel a little more at peace with food*" [participant 12]), also achieved by acting on stress ("*[the intervention] was useful in decreasing stress and this then spilled over to food a little*" [participant 15]), reduction of dysfunctional behaviors ("*I no longer had binge eating attacks after the intervention*" [participant 9]) and increasing emotion regulation that does not involve using food as a regulator ("*Taking time to write down [in a diary] emotions sometimes stops me from resorting to food*" [Participant 18]).

7.6.2.8 H.O.M.E. as a bridge towards psychological support

In 85% (n=17) of cases, taking part in the intervention encouraged participants to seek psychological support afterwards. Some (n=8, 40%) admitted that they were interested in starting it but not actively seeking it ("*Due to bigger issues at this moment I can't [undertake a psychological path] but it's something that I absolutely want to do*" [participant 7]), while others (n=6, 30%) reported that they had already began psychotherapy once the intervention was over ("*I had an interview, I will soon start a psychotherapeutic path*" [participant 3]). For those who were already undergoing psychotherapy before the H.O.M.E. intervention (n=3, 15%), they said that H.O.M.E. led them to include new elements in their psychotherapeutic path ("*With my psychologist I also had the opportunity to talk about the exercises done in virtual reality and I believe that this has also helped therapy with her*" [participant 14]).

Only three (15%) participants reported that they did not feel the need to seek psychological support following the intervention, as they considered the six sessions sufficient

("*I already felt better after the virtual reality intervention. I have reached an inner serenity, so I haven't sought any other psychological support*" [participant 20]).

7.6.2.9 Positive aspects of the H.O.M.E. intervention

The opportunity to try virtual reality and in general to experiment with a type of intervention that is innovative compared to traditional psychological approaches was the most frequent positive aspect noted by participants (n=14, 70%; "*I liked the fact that it wasn't a 'classic' psychological intervention, virtual reality made it more original and fun*" [participant 18]). In addition to the novelty element, the VR software allowed for a greater level of interactivity participants praised (n=10, 50%), which let them safely approach stimuli that in reality generated anxiety and negative emotions and, also, manipulate them ("*I liked the method with which we approached the sessions, especially the fact that I could put on the headset and talk about things when I had them in my hand*" [participant 6]).

The transdiagnostic nature of the intervention and the fact that it addressed in depth also issues and topics outside of the participants' relationship with food was another aspect that was positively evaluated by some participants (n=3, 15%), together with the fact that it offered participants a personalized path which covered all the problematic areas that they highlight ("*One thing I liked is that the whole intervention was not focused only on food*" [Participant 19]).

Finally, two girls (10%) who took part in the intervention also reported as essential the presence, during the sessions, of a clinical psychologist who could support them in times of need ("*I liked the fact that there was active participation on both parts, it was not only me speaking but also the psychologist who explained things to me and tried to ask me questions when I was struggling, she was a constant presence*" [Participant 7]).

7.6.2.10 Negative aspects of the intervention/software

Along with the many positive aspects, mentioned in the previous paragraph, the participants pointed out negative aspects that they felt needed to be improved, some of which were closely related to the VR software used and others to the intervention in general.

Regarding the ***characteristics of the H.O.M.E. software***, the virtual environment was considered improvable by participants (n=10, 50%), in particular with regard to the realism of the stimuli and the possibility of interacting with them ("*The environment itself in virtual reality can be improved, perhaps by making it more realistic or by putting a different setting, modifying the rooms and adding more objects*" [participant 1]). The need for increased realism, according

to some participants (n=6, 20%), could be achieved by increasing the number of virtual objects and the degree of interactions and manipulations that the user can do with them ("*There were not many possibilities of playing with food: you could only pick them up and move them, but you can't, for example, open a package or cut something, things that are actually very important in an eating disorder.*" [participant 19]).

Participants also complained about the sporadic presence of technical issues (n=2, 10%), which made it more difficult to use the VR software ("*I would also recommend fixing internet problems, which were sometimes a bit annoying*" [participant 18]), the poor variety of foods present in the virtual environment (n=1, 5%; "*There was little choice, the foods were all pizza, chips and chocolate, there was nothing healthier or, for example, vegetarian options. I am a vegetarian and all things were with meat so sometimes it was difficult to express emotions towards food because they were all unusual foods for me*" [participant 19]), the inability to save changes made to virtual rooms and object placement (n=1, 5%; "*I would change the possibility within the software to save what is done the previous session […],it would have given me more of a sense of continuity in the search and exploration of the house from where I had left off*" [participant 6]) and the absence of other characters with whom to interact within the virtual environment (n=1, 5%; "*I noticed the absence of other characters: in my relationship with food, however, it is very important also the relationship with people and the fact that there was never anyone [in the VR environment] took away a slice of situations that is important to analyze in my opinion*" [participant 19]).

On the other hand, as far as ***criticisms related to the intervention*** itself, and not strictly to the VR software, the negative side most frequently reported by participants (n=6, 30%) was the limited number of sessions, which prevented them from dealing with all the issues that emerged in depth and to fully consolidate the strategies learned ("*I didn't like that, being only a few sessions, there was no way to deepen some topics that would need more time*" [participant 8]; "*Maybe I would change it by adding more sessions, especially those with exercises because it is not easy to understand how to put into practice the techniques in such a short time*" [participant 17]).

DISCUSSION

The present Ph.D. research project was conducted with the aim to explore the acceptability and quality of an innovative VR software (H.O.M.E. – How to Observe and Modify Emotions) designed to concurrently tackle dysfunctional eating behaviors and transdiagnostic factors (i.e. emotion regulation, psychological flexibility, and experiential avoidance) in general population individuals at risk for EDs and to evaluate the feasibility and effects of a transdiagnostic VR-based prevention intervention run through the H.O.M.E. software in improving the aforementioned transdiagnostic factors and reducing dysfunctional eating behaviors in this population. Moreover, the research project aimed to collect the subjective opinions and experience of participants who underwent the H.O.M.E. VR-based intervention.

Through a battery of online self-report screening questionnaires, members of the general population at risk of developing an ED were detected. However, a wide range of respondents that were contacted decided not to take part in the intervention. This is not surprising, as people suffering from EDs are often reluctant or motivated to seek help, due to egosyntonic nature of these psychopathologies especially in the early stages (Roncero et al., 2013). Statistical analyses comparing the levels of severity of ED-related symptoms between those who decided to take part in the study and those who decided not to participate in the research revealed that there was no significant difference between the two groups, further underlying that lack of motivation towards change or insight about their issues might have been the main cause of this data (Kaplan & Garfinkel, 1999). However, as it will be subsequently discussed, no drop-out case emerged during the research project in those who decided to take part in the studies, which proved to be a promising factor in the implementation of H.O.M.E.

Among those who accepted to take part in the research, both the sample of people who tested the quality of the H.O.M.E. VR software and those who took part in the transdiagnostic VR-based preventive intervention consisted of mainly single women and university students. These characteristics of the samples are also unsurprising and in line with studies in the literature, which show that young women are more frequently affected by EDs (Jacobi et al., 2004).

These socio-demographic characteristics are also consistent with samples of prevention interventions, which are often targeted at young adults (Watson et al., 2016). In fact, epidemiological data underline that it is precisely this segment of the population that is most at risk of developing EDs (Mastrobattista & Pacifici, 2022) and, therefore, it is necessary to

identify effective preventive intervention strategies (Schwartz et al., 2019). The lack of male participants also highlights difficulties that men encounter in identifying ED symptoms early and in contacting a professional promptly, which could be mainly caused by the stigma related to these psychopathologies which are still considered as purely affecting the female gender (Murray et al., 2017).

Given the recruitment of participants carried out through social media platforms, it is possible that people already interested in or directly involved in the topic of EDs may have completed the battery of screening questionnaires. The importance of fitness and weight in today's society, which encourages young women in particular to pursue an ideal of thinness often unhealthy (Culbert et al., 2015), is reflected in the high levels of body shape concerns and weight concerns measured through the EDE-Q, which were the highest subscales in all samples. The levels reported by participants regarding difficulties in ER were also higher than in other studies. In a study that used the DERS-16 to assess difficulties in ER in a sample of about two thousand women from the general population (McClure et al., 2022), the average scores were lower than that of our samples. This can be explained by the nature of the samples involved in the presented studies, which consists of people at risk for EDs. As widely confirmed by the literature (Prefit et al., 2019), dysfunctional eating behaviors are often associated with difficulties in ER. In other clinical samples with a ED diagnosis, levels of difficulties in ER were closer to the ones reported in our samples (Mansueto et al., 2022; Monell et al., 2022).

With respect to psychological inflexibility, levels of this transdiagnostic factor found in the validation sample of the AAQ-II (Pennato et al., 2013) were also lower than those found in our samples, which is once again indicative of the close association between dysfunctional eating behaviors and psychological inflexibility (Morton et al., 2020). Levels of experiential avoidance, instead, were consistent with general population levels found in the literature (Landi et al., 2021). Rather than disconfirming the widely proven relationship between experiential avoidance and ED symptoms (Cowdrey & Park, 2012; Della Longa & De Young, 2018), these levels of experiential avoidance may be inaccurate due to characteristics of the psychometric instrument used to measure this variable, such as the low number of items.

The *first study (Study 1)* included in this Ph.D. research project focused on assessing the quality of the H.O.M.E. VR software, in terms of sense of presence, elicited motion sickness, software usability, and overall user experience with H.O.M.E. evaluated through means of quantitative self-report questionnaires.

Sense of presence was assessed by analysing the scores obtained on the IPQ questionnaire (Schubert et al., 2001) from the sample that tested the quality of the H.OM.E. VR

software. The software achieved scores that were not fully acceptable in the domains Involvement and Realism experienced, confirming the subjective impressions in Study 3 expressed in the semi-structured post-intervention interview carried out by participants who underwent the transdiagnostic VR-based intervention conducted through the software. According to participants, the H.O.M.E. virtual environment was immersive but unrealistic, due to the somewhat "cartoonish" aspect of the virtual environment and of the virtual objects available for interactions. This lack of perceived realism may also have negatively affected the Presence in Space domain, whose scores, based on the IPQ threshold scores defined by Melo and colleagues (2023), were below the level of acceptability. These results are important as they offer useful information about factors to improve in future versions and updates of the H.O.M.E. VR software, such as improving the design of the virtual environment and the variety of objects available, involving multiple senses at the same time in the VR experience, and giving participants the opportunity to interact with other users who are exploring the same virtual space (Sra, 2023). However, the feeling of being present in the environment, a subscale of the IPQ that investigates a more general sense of presence perceived, not only on a spatial level like in the subscale Presence in space (Schubert et al., 2001), reached a satisfactory level of acceptability, likely due to the high degree of immersivity which also emerged in the semi-structured post-intervention interview (Gorini et al., 2011).

Regarding levels of motion sickness elicited by the software, also defined as *cybersickness*, scores at all the subscales of the SSQ (Kennedy et al., 1993) showed that symptoms experienced by participants were not absent and require attention from the clinician who uses the software, although they have not reached levels so intense as to make it difficult or even impossible to use the VR software, or to negatively impact the user experience. The results are in line with current data in the literature regarding the incidence of *cybersickness* related to VR systems, which despite being lower than in the past continue to be present in some people with different degrees of severity, sometimes to the point of influencing their experience with VR (Ramaseri et al., 2022). Despite the fact that some factors that increase the likelihood of experiencing *cybersickness* while using VR, such as advanced age and the female gender, cannot be intervened directly, other elements can be acted upon to minimize their incidence, such as using head-mounted displays that have a field of view that is not too wide, reducing the latency between the input given by the user and the virtual output, and conducting VR sessions of limited duration (Ramaseri et al., 2022).

The H.O.M.E. software also resulted to be relatively easy to use, with acceptable levels of usability measured with the SUS questionnaire (Brooke, 1996). In addition to the factors

already mentioned, a greater ease of use could be achieved by making changes to the control system and by expanding the virtual environment and improving its graphics, as reported by the participants who underwent the VR-based prevention intervention carried out with the software. However, the general subjective experience with H.O.M.E. is to be considered positive, as can be observed from the score at the UEQ-S (Schrepp et al., 2017), which were well above the threshold score and close to the maximum score, and from the words of the participants who underwent the intervention.

The *second study* (Study 2) in this Ph.D. research project aimed to evaluate the feasibility and effects of the 6-session transdiagnostic H.O.M.E. VR-based intervention protocol in terms of improvement in dysfunctional eating behaviors and transdiagnostic factors between pre- and post-intervention in a group of n=20 people from the general population with ED risk. Initial hypotheses have been partially confirmed. Indeed, following the H.O.M.E. intervention, all dysfunctional eating behaviors improved in the sample. In particular, levels of concerns regarding body shape were the variable that showed the greatest improvement (in terms of the greatest mean difference reported between pre- and post-intervention scores). This scale was also the one with the highest scores at baseline, among those related to dysfunctional eating behaviors. The improvement reported after the H.O.M.E. intervention is in line with results from other studies, which found that body shape concerns represent one of the ED-related symptoms which can more easily be improved by VR-based interventions, especially when VR is offered in addition to CBT-based protocols (Freeman et al., 2017). Similarly to our results, reductions in the levels of concerns about eating and weight have also been found in the literature about VR (Irvine et al., 2020). For example, in a study by Irvine and colleagues (2020), a similar sample of young women with high levels of body image concerns (but without any ED diagnosis), reported improvements in concerns about weight, shape and eating after undergoing a VR-based training intervention program that helped them distinguish bodies with different BMIs through the use of an avatar. Even though the H.O.M.E. software does not provide participants the chance to use an avatar, our VR-based intervention was capable of producing similar beneficial results, which highlight that H.O.M.E. could indeed represent an helpful tool for the prevention of EDs and the reduction of dysfunctional eating behaviors in the general population at risk.

Concerning the results about the transdiagnostic factors we also considered as outcomes in Study 2, as hypothesized difficulties in ER and psychological flexibility also showed a significant improvement at post-intervention. Instead, contrarily to our hypotheses, no significant change was found for experiential avoidance.

Starting from the difficulties in ER, measured through the DERS-16 (Bjureberg et al., 2016), this transdiagnostic factor significantly improved both on a general level, and in terms of improvements in participants' abilities to engage in goal-directed behaviors and to access their ER strategies. Although other DERS-16 subscales did not show any improvements, possibly due to the small number of sessions of the intervention or the specific characteristics and targets of the intervention protocol, which mainly focused on helping people select strategies to face distressing emotions, this result also proves the beneficial effects of the H.O.M.E. VR-based intervention. Indeed, after the intervention, participants were better able to pursue goals and to control their behaviors in the presence of unpleasant emotions and acquired more strategies to use as an alternative to dysfunctional eating behaviors to regulate their emotions. The ability of VR interventions to improve ER is also supported by the literature and in line with what has been observed in studies using other VR software and protocols. For example, a study aimed at preventing risky behaviors in adolescents found that in VR, participants had less difficulty accessing emotional regulation strategies (Hadley et al., 2019b). This may depend on the emotional involvement that VR is able to elicit (Colombo et al., 2021). In fact, during the H.O.M.E. VR-based intervention participants were exposed to emotional stimuli, such as food or scales, and this allowed an introspective observation of the emotions experienced and their association with dysfunctional eating behaviors.

This Ph.D. research project was also, to our knowledge, the first in the literature to test the application of a VR-intervention for the improvement of psychological flexibility and experiential avoidance. Even though VR was applied in EDs to improve *body image flexibility*, producing significant changes (Marco et al., 2013), this study showed that VR also holds potential to produce significant improvements in psychological flexibility, which can be defined as a person's ability to react flexibly to negative thoughts, feelings and events, leading to an increase in well-being (Rolffs et al., 2018).

Although in the present study experiential avoidance did not change between pre- and post-intervention, this could be due both to limitations present in the tool used to assess changes (MPFI-EA, which is composed of only five items) or to the short duration of the intervention protocol. A higher number of sessions could produce changes in this aspect, as traditional psychotherapeutic interventions in similar populations usually entail a longer duration (Manlick et al., 2013).

Another aim of Study 2 was also to compare the effects achieved by the VR-based intervention to those achieved by the waiting-list condition, to establish whether the obtained significant differences could be attributed to the intervention and thus determine its efficacy in

reducing dysfunctional eating behaviors and improving transdiagnostic factors. Results confirmed our hypotheses and managed to establish the H.O.M.E. VR-based intervention efficacy compared to the waiting-list. Indeed, all the aforementioned changes achieved by the VR group were greater than those achieved by the waiting-list group, who also did not report any significant difference between pre- and post-intervention levels of dysfunctional eating behaviors or transdiagnostic factors. This can be explained in the light of the characteristics of the H.O.M.E. VR software, which exposed the participants to potentially anxiety-provoking virtual environments and stimuli, while ensuring the presence of the clinician who, during the six sessions, helped participants to evaluate their experienced emotions in response to those stimuli and to develop their coping strategies. In the literature, VR-based interventions have often proven their efficacy against non-active control groups for the treatment of several psychopathologies (including EDs) (Ferrer-García & Gutiérrez-Maldonado, 2012; Freeman et al., 2017a; Geraets et al., 2022; Riva et al., 2021). Although to date no preventive VR-based interventions are available for EDs specifically, the results achieved by the H.O.M.E. intervention can pave the path towards future studies to further confirm the potential benefits of VR for these psychopathologies, especially when targeting also transdiagnostic factors. Moreover, the preventive utility of H.O.M.E. was also proven by the maintenance of the achieved improvements at follow-ups of 3- and 6-months. Indeed, while participants in the waiting-list condition seemed to experience the same levels of symptoms after three months and even a worsening of dysfunctional eating behaviors and ER difficulties after six months, the VR group levels of said variables remained unchanged in the months following the intervention. Although longer follow-ups are needed to further prove these results, they confirm the potential of H.O.M.E. and VR in general to make long-lasting positive changes in the general population at risk for EDs.

Another important and promising element to underline is that no participant dropped out during the H.O.M.E. intervention and the entirety of the VR group underwent all the six sessions. This is of clinical relevance as drop-out rates in treatments targeting people with EDs are high (Dalle Grave, 2014): the interactive component of VR may have contributed to the motivation to continue the intervention, as it has also been underlined in the literature (Linardon et al., 2022).

Finally, *the aim of the third and final study* included in this Ph.D. research project was to evaluate qualitatively the subjective reported experience and opinions of participants who concluded the H.O.M.E. VR-based intervention, which we collected through a semi-structured qualitative interview carried out at the end of the intervention.

Answers showed that participants who decided to take part in the research and receive the VR-based intervention were mostly motivated both by curiosity to try VR and by a strong interest and involvement in the topic of EDs. The most common dysfunctional eating behaviors reported by participants included strong feelings of guilt and recurring negative thoughts related to food, an intense desire for thinness, and excessive emphasis put on body weight to determine their personal self-esteem, all of which are factors that could lead to a full ED onset in the future (Keel & Forney, 2013). Dysfunctional eating behaviors, however, were not the only topics brought up by participants during the sessions, which fully underlined the transdiagnostic nature of the intervention. Other issues that participants considered relevant spanned from the management of relationships with others, the need for control, anxiety related to other areas of life (e.g. work or university). This is unsurprising considering that people that present ED-related symptoms also present difficulties in other areas of life, which may even increase ED risk (Fairburn et al., 2003; Keel & Forney, 2013)

In the literature, authors explained how a lack of functional coping strategies to face negative emotions and distressing situation in daily life can lead to the implementation of dysfunctional eating behaviors as a way to regulate emotions and cope with negative situations and, therefore, it was found in individuals affected by EDs (Merwin et al., 2010; Rawal et al., 2010; Henderson et al., 2019). Because of this, prevention interventions (such as the H.O.M.E. intervention) should focus on the implementation of more functional coping strategies in order to reduce ED risk (Ghaderi, 2001).

During the interview, participants highlighted that, in their subjective experience, the H.O.M.E. intervention was indeed useful in targeting both dysfunctional eating behaviors and issues not related to food. Indeed, participants in the intervention were encouraged to choose and implement coping strategies present in the *Box of resources* (functionality present in the H.O.M.E. software, as described in previous chapters) through the practice of some targeted exercises both in VR and in their daily life. The girls reported that they benefited from participating in the intervention, not only in terms of improvements in their relationship with food and emotional regulation, but also in terms of an increase in their abilities to use the specific coping strategies they selected from the box. In particular, the strategies of self-esteem and *self-acceptance*, *mindfulness*, *self-control*, and *forgiveness* were the most frequently chosen by participants, together with less frequently implemented ones such as *interpersonal relationships*, *autonomy and assertiveness*, and *gratitude*. These results are in line with the data in the literature, according to which the development of more functional coping strategies, in particular those associated to a greater awareness of oneself and one's emotions and needs, can

reduce the likelihood of engaging in harmful, dysfunctional or unhealthy eating behaviors (Hernando et al., 2019).

Because of these reasons, the H.O.M.E. intervention was positively evaluated by all participants, who reported feeling a sense of ease and tranquillity that increased during the sessions and replaced an initial feelings of fear, embarrassment or worry. In fact, most of them found the ability of VR to represent a "safe place" where it is easier to open up and talk about themselves, confirming the ability of VR to offer a protected environment in which patients can reflect and address their problems (Riva, 2022).

Another strong point of the intervention participants also appreciated was the innovative way of facing their issues and negative emotions that VR provides, compared to more traditional psychological approaches (which some of them had already tried and, sometimes, dropped-out from). Curiosity about VR and the greater level of immersivity and involvement this technology offers has already been observed to help increase adherence to treatment (Riva, 2022). Indeed, participants judged the virtual environment as very immersive, so much so that it generated in most of the participants emotions similar – although less intense – to those arising from real-life stimuli, as already seen in studies using other VR software (Chirico & Gaggioli, 2019). However, in accordance with the low scores in sense of presence and experienced realism H.O.M.E. achieved at the questionnaires for Study 1, even during the qualitative interview for Study 3 those who underwent the H.O.M.E. intervention described the virtual environment to be unrealistic, especially due to the "cartoonish" appearance of some rooms and objects and for the lack of other characters to interact with. This problem is attributable to the software still being in its earlier version and can be solved by developing updates to improve the graphics, increase the range of interactions that can be carried out with the objects, and add the possibility to interact with other users or avatars.

Another factor of the H.O.M.E. intervention participants suggested to improve was the number of sessions, which according to many participants should have been higher to allow a more in-depth analysis of the issues at hand. However, a review (Ciao et al., 2014) aimed at identifying the common factors that characterize successful prevention interventions for EDs, found that most of the interventions consisted of 2-4 weekly sessions of one hour, with some exceptions of longer duration. The number of sessions in the H.O.M.E. transdiagnostic intervention protocol is, therefore, higher than the data present in the literature. As reported by participants during the semi-structured interview and as it was also found through Study 2 quantitative results, six sessions were still sufficient to achieve, at least in part, the preventive goals of the protocol.

Finally, thanks to the opportunity offered by the H.O.M.E. intervention to reflect on themselves and become more aware of their needs, many participants decided to seek more in-depth psychological support, in order to continue working in a more targeted way and for a longer period of time on the problems that emerged. This is particularly important as only a small proportion of individuals at risk for EDs seek professional help before the onset of a full syndrome and before it causes serious physical, cognitive and social consequences (Hamilton et al., 2022). As already explained in previous paragraphs, this may be due to the egosyntonic nature of symptoms, in particular those of a restrictive nature, which in the earlier stages of the illness are perceived by people as an integral part of their identity (Roncero et al., 2013). The more ED symptoms progress, the more people will feel like treating the disorder could mean losing part of themselves and this discourages them from seeking treatment (Roncero et al., 2013). In this regard, VR and, more specifically, the H.O.M.E. software and intervention could help encourage individuals at risk to seek psychological support and treatment before ED symptoms severity increase and meet criteria for a full ED diagnosis.

CONCLUSIONS

Although there are numerous studies in the literature that attest to the usefulness of VR systems in the treatment of EDs (Riva et al., 2021; Ferrer-García et al., 2017), those investigating the use of VR in the prevention of EDs in the general population at risk, especially through the improvement of transdiagnostic factors, are lacking (Ciao et al., 2014).

Our results highlighted that the H.O.M.E. VR software proved to be applicable, appreciated and positively evaluated by individuals of the GP with ED risk, despite some issues that emerged concerning the low levels of perceived realism of the virtual environment, which will require to be improved in future versions of the software (e.g. by improving the graphics and including a wider variety of stimuli and interactions with objects). Data also proved the potential role that the H.O.M.E. VR-based transdiagnostic intervention protocol can play in the prevention of EDs, as it effectively reduced dysfunctional eating behaviors, such as preoccupation with eating, shape, and weight, and improved some of the transdiagnostic factors that can lead to EDs, in particular ER and psychological flexibility (Levin et al., 2014; Morton et al., 2020; Prefit et al., 2019). An important aspect to underline is the applicability of this intervention in the clinical practice. Although the use of VR is gradually spreading in clinical psychology and, in particular, in the assessment, treatment and prevention of EDs (Brown et

al., 2020; Rizzo et al., 2019), many issues still hinder this transition, such as the high costs (in terms of software and hardware), the need for specific and continuous training, and the predominantly disorder-specific nature of the VR software and intervention protocols available to date (Brown et al., 2020; Emmelkamp & Meyerbröker, 2021; Freeman et al., 2017; Gardini et al., 2022). As far as the economic aspect is concerned, the development of software such as H.O.M.E, designed following a transdiagnostic approach, would make it possible to improve adaptability in the clinical practice, as the same tool could be applied to the prevention and treatment of different disorders.

Considering patients' point of view, in the literature VR is generally considered an acceptable tool and this leads to a higher frequency of intervention sessions and less drop-out (Hadley et al., 2019b), which was also confirmed by our research project. Taking into account the barriers that keep people at risk for EDs from seeking treatment and the high drop-out rates (Linardon et al., 2018), using VR technologies to increase patients' motivation and adherence to treatment could be of clinical benefit. Moreover, as previously pointed out, focusing on prevention interventions that precede the onset of a full-blown disorder would lead to a decrease in incidence rates (Stice et al., 2021) and to help avoiding the multiple and sever consequences ED can have on a medical-nutritional, but also psychological and social level (Ballardini & Schumann, 2011).

Given the transdiagnostic nature of the H.O.M.E. software and intervention protocol, if tested and found effective it could also be easily adapted to the prevention of other risky behaviors, in addition to those related to EDs, such as substance use, gambling, or internet addictions. For example, interventions of this type could be conducted at the school level, where ER could be targeted and improved, which acts as a protective factor for mental health issues (Aldao et al., 2010a). In particular, given the evidence suggesting that integrating VR into prevention interventions aimed at adolescents and young adults allows to increase motivation and engagement (Cullen et al., 2021), VR could also help increase attention and awareness towards mental health in young people.

Finally, it is also important to consider the role of the clinical psychologist in this intervention. The H.O.M.E. software requires, during the sessions, the presence of a clinical psychologist who, through clinical reasoning, guides the participant through the virtual environment, to help them become aware of their cognitive and emotional patterns, to highlight their resources, and improve coping strategies which can be used in daily life to face distressing emotions. The presence of the clinical psychologist increases the costs of using the H.O.M.E. software, but it also represents a strength of the software, as also underlined by some

participants of our research. Indeed, although the presence of a protocol helped to provide a standardized experience to participants, the clinician can also ensure that the H.O.M.E. intervention protocol is individualized and tailored on the participant's needs and can provide additional elements of reflection into the protocol sessions. However, since a dismantling study was not performed, it is not currently possible to identify whether the presence of the clinical psychologist might account for the effects that were observed in the VR-based intervention or if they are entirely attributable to VR.

However, the promising results achieved by the presented Ph.D. research project should be observed in light of the several methodological limitations, first of which is the small sample size we managed to collect. Although many people filled in the screening battery of questionnaires administered online through Qualtrics, only a small fraction of them decided to undergo the H.O.M.E. VR-based prevention intervention. The reasons could be various: the personal availability in terms of time needed to regularly participate in weekly sessions, the need to travel to the Department of Psychology of University of Bologna, or the ego-syntonic nature of ED symptoms which may reduce people's motivation to change (Roncero et al., 2013). The small sizes in our studies (which, for Study 2, is also slightly inferior to the needed sample size we calculated with G*Power) render the results, although encouraging, not generalizable. Recruiting a greater number of participants to further confirm data from these studies is needed and should be solved in future research. The samples also included people from the general population at risk for EDs and, therefore, the results obtained about the H.O.M.E. software and protocol are scarcely applicable to clinical samples, with a full ED diagnosis. Future research could repeat the H.O.M.E. intervention protocol in a clinical ED population to further test its potential in the treatment of EDs, also when used against or in addition to evidence-based treatments (e.g. CBT-E).

Moreover, in Study 1 and Study 2 specifically, the questionnaires used for the evaluation of the variables considered were self-report and administered through online platforms. Therefore, they include several limitations, such as the tendency participants may have to answer questions based on social desirability, the impossibility of asking for clarification in case of doubts, and the difficulties people may encounter in answering to questions with a reliable level of insight, especially when they concern complex psychological factors such as psychological flexibility and experiential avoidance (Chan, 2008). Another limitation related to the tools used concerns the questionnaire chosen for the assessment of experiential avoidance, the MPFI-EA (Landi et al., 2021; Rolffs et al., 2018), consisting of only five items. The reduced number of items probably influenced the results, leading to methodological biases. Similarly,

in Study 3 as well, the limited number of questions included may have led to the exclusion of other relevant factors (e.g. psychological well-being) which should be explore in future research investigating the full potential of the H.O.M.E. intervention.

The short duration of the follow-ups (i.e. 3- and 6-months), although linked to the duration of the Ph.D. course itself, also did not allow to verify the maintenance of changes in dysfunctional eating behaviors and transdiagnostic factors on a longer period of time (e.g. at one year following the end of the intervention).

Another aspect that is important to explore in future research is that of the application of the H.O.M.E. software and intervention protocol in the prevention and treatment of other mental disorders. In particular, further studies could investigate the use of H.O.M.E. in the prevention of psychopathologies, as the literature is currently lacking in research on the application of VR in the prevention of mental disorders (Lemieux et al., 2020). The H.O.M.E. software and intervention have the potential to be applied to the prevention and treatment of various dysfunctional behaviors and mental disorders related not only to nutrition (e.g. substance use, stress, gambling, etc.). Therefore, future studies could investigate the potential of H.O.M.E. in preventing and treating other mental health issues or disorders, also with additional comparisons with traditional psychological approaches.

Ultimately, in future studies, we also aim to expand the potential held by the H.O.M.E. protocol beyond the use of VR technologies, especially by developing H.O.M.E. versions of the software working with other kinds of digitalised interventions, such as augmented reality and mobile apps. The use of these technologies will, indeed, allow us to offer H.O.M.E. to and even wider range of people (Cipresso et al., 2018; Riva et al., 2016; Vinci et al., 2020), thus making the protocol more accessible and useful in preventing the onset of EDs and other mental health conditions in more individuals at risk.

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