Virtual Reality and Specific Phobias

Welcome to the real world

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Introduction

Phobias are among the most familiar aspects of psychopathology of every day life. In 1998, an epidemiological study was done in the Netherlands on the prevalence of psychiatric disorders in the general population (Bijl, Ravelli, & van Zessen). This study showed that phobias were the most common form of anxiety disorders, which themselves were the most common psychiatric disorders. The lifetime-prevalence of DSM-III-R diagnoses (American Psychiatric Association [APA], 1987) of specific phobias was 10.4 %. An epidemiology study in the United States reported a comparable lifetime prevalence of 11.3 % of specific phobias and more specifically a lifetime-prevalence of fear of flying of 3.5 % and of fear of heights of 5.3% (Curtis, Magee, Eaton, Wittchen, & Kessler, 1998).

While specific phobias appear to be a highly common disorder in the general population, a relatively low percentage of sufferers seek treatment (Chapman, Fyer, Mannuzza, & Klein, 1993; Kessler, Olfson, & Berlund, 1998). However, the natural course of specific phobias in adults is in the majority of cases chronic and anxiety-symptoms are mostly mild over decades (Öst, 1996; Noyes, Holt, & Woodman, 1996) indicating that treatment can be necessary and may relieve symptoms. This thesis will focus on the treatment of specific phobias, i.e. acrophobia and fear of flying.

1.1 Diagnostic criteria

A specific phobia is a psychiatric disorder defined by several diagnostic criteria described in the DSM-IV (APA, 1994). Criterion A comprises the marked and persistent fear that is excessive or unreasonable, cued by the presence or anticipation of a specific object or situation, e.g. flying or heights. Criterion B refers to an immediate anxiety response, which may take the form of a situationally bound or situationally predisposed panic attack after exposure to the phobic stimulus. Criterion C refers to the recognition of the subject him/ herself that the fear is excessive or unreasonable. Criterion D comprises all avoidance behaviour. Phobic situations must be either avoided or endured with intense anxiety or distress. Criterion E ensures that symptoms are sufficiently distressing or impairing to justify diagnosis. Criterion F refers to the duration of the specific phobia (a minimum of six months for individuals under 18). And lastly, criterion G refers to the fact that this anxiety or phobic

avoidance associated with the specific object or situation should not be better accounted for by another mental disorder.

The following subtypes may be specified to indicate the focus of fear or avoidance in specific phobia:

- Animal type. This subtype should be specified if the fear is cued by animals or insects.
- Natural environment type. This subtype should be specified if the fear is cued by objects in the natural environment, such as storms, heights or water.
- Blood-injection-injury type. This subtype should be specified if the fear is cued by seeing blood or an injury or by receiving an injection or other invasive medical procedure. This subtype is highly familial and is often characterized by strong vasovagal response.
- Situational type. This subtype should be specified if the fear is cued by a specific situation such as public transportation, tunnels, bridges, elevators, flying, driving or enclosed places.
- Other type. This subtype should be specified if the fear is cued by other stimuli. These stimuli might include the fear or avoidance of situations that might lead to choking, vomiting, or contracting an illness.

Acrophobia is thus specified in the DSM-IV as specific phobia, natural environment type and fear of flying is specified as specific phobia, situational type.

Age at onset for specific phobia, situational type, starts on average around childhood or in the mid-20s. Specific phobias, natural environment type, tend to begin primarily in childhood, although some subjects develop a height phobia in early adulthood (APA, 1994). Preliminary evidence suggests that there may be an aggregation within families by type of phobia. Several large-scale twin studies have found that the genetic contribution to specific phobias is modest though significant (e.g. Kendler, Karkowski, & Prescott, 1999). The genetic factor underlying specific phobias seems to be of a general nature, which means that subjects inherit a general trait that predisposes them to neurotic complaints rather than to a specific fear. Environment factors are of influence to the specific nature of this fear (Merckelbach, de Jong, Muris, & van den Hout, 1996).

1.2 Assessment

Measuring instruments are important not only to help classify phobic complaints but also to evaluate therapy results. Phobic anxiety is reflected in autonomic nervous system activation, self-report and avoidance behaviour (Lang, 1968). A complete assessment of phobic complaints would include self-report, behavioural and physiological measures. In practice, however, diagnostic classification and treatment outcome measures for anxiety have been based almost entirely on self-report (Wilhelm & Roth, 2001), i.e. structured interviews and questionnaires. The most common instruments used to assess fear of heights and fear of flying will be briefly discussed.

1.2.1 Structured interviews

The *Structured Clinical Interview for DSM-IV Axis I Disorders* (SCID-I; First, Spitzer, Gibbon, & Williams, 1996) evaluates the presence of major DSM-IV axis I disorders based on an assessment of their constituent diagnostic criteria. While data on the psychometric characteristics of the current instrument for the specific phobia module is lacking, the specific phobia module of the previous DSM-III-R (APA, 1987) version demonstrated a good interrater agreement on lifetime occurrence of any specific phobia (kappa = 0.70; Skre, Onstad, Torgersen, & Kringlen, 1991). The SCID-IV has demonstrated high interrater reliability on assessments of symptoms for a variety of disorders (Ventura, Liberman, Green, Shaner, & Mintz, 1998). It should be noted that there is a high degree of similarity between the SCID-IV and the earlier version, so potential differences in psychometric properties are likely to be negligible.

The *Anxiety Disorder Interview Schedule for DSM-IV: Lifetime Version* (ADIS-IV-LV; Di Nardo, Brown, & Barlow, 1994) is a semi-structured interview designed to establish reliable diagnosis of the DSM-IV anxiety, mood, somatoform, and substance use disorders and to screen for the presence of other conditions. The specific phobia module demonstrated a good interrater agreement on lifetime occurrence of any specific phobia (kappa = 0.86; Brown, Di Nardo, Lehman, & Campbell, 2001). Moreover, excellent reliability was obtained for each of the specific phobia types, although these findings should be interpreted with caution given the small sample sizes.

1.2.2 Self-assessment questionnaires

1.2.2.1 Acrophobia

The *Acrophobia Questionnaire* (AQ; Cohen, 1977) consists of two scales measuring anxiety and avoidance in height situations. The anxiety scale consists of 20 items with a 7-point Likert scale ('not anxious' to 'extremely anxious'). Total scores range from 0 to 120 and internal consistency is good (α = .80). The avoidance scale consists of 20 items, with a 3-point Likert scale ('I would not avoid this' to ' I would absolutely not do this'). Total scores range from 0 to 40 and the internal consistency of the scale is good (α = .70).

The *Attitude Towards Height Questionnaire* (ATHQ; Abelson & Curtis, 1989) assesses the attitudes from subjects towards height situations and consists of six items with an 11-point Likert scale (range 0-60; α = .81).

1.2.2.2 Fear of flying

The *Flight Anxiety Situations Questionnaire* (FAS) assesses anxiety related to flying experienced in different situations (van Gerwen, Spinhoven, Van Dyck, & Diekstra, 1999). The FAS is a 32-item self-report inventory with a 5-point Likert scale ('no anxiety' to 'overwhelming anxiety'). The questionnaire consists of three subscales: 1) Anticipatory Flight Anxiety Scale, measuring anxiety experienced when anticipating an aircraft flight (14 items; α = .88); 2) an In-flight Anxiety Scale, measuring anxiety experienced during a flight (11 items; α = .95); and 3) a Generalised-Flight Anxiety Scale, measuring anxiety experienced in connection to aircraft in general, regardless of personal involvement in a flight situation (7 items; α = .97).

The *Flight Anxiety Modality Questionnaire* (FAM) measures symptom modalities in which anxiety in flight situations is expressed (van Gerwen et al., 1999). The FAM consists of 18 items with a 5-point Likert format ('not at all' to 'very intensely'). The questionnaire is divided into two subscales: Somatic Modality measuring physical symptoms (11 items; α = .89) and Cognitive Modality measuring the presence of distressing cognitions (7 items; α = .89).

1.2.3 Behavioural avoidance test

The primary aim of a behavioural avoidance test (BAT) is to expose a subject to a feared stimulus under controlled and replicable conditions, in order to observe and collect objective information relating to the behavioural response. These tasks are used to assess fear and avoidance behaviour and treatment outcome. A BAT is conducted by asking the subject to approach the feared stimulus as close as possible or for instance in acrophobics, climb the stairs as high as possible. Subjective units of discomfort are sometimes used to examine levels of distress during the BAT. BATs are of great value in addition to self-reports because the effect of treatment is evaluated in a real phobic situation. However, there are a number of effects of instruction and level of demand that have shown a significant impact on performance (e.g., Smith, Diener, & Beaman, 1974; Bernstein & Nietzel, 1974; Trudel, 1979). Standardized instructions should thus be included.

1.2.4 Physiological measures

An important alternative in the assessment of anxiety is the use of physiological measures. Autonomic arousal is a key characteristic of anxiety, and a growing body of research addresses the measurement of these processes. The assessment of physiological processes in general applications has demonstrated adequate psychometric properties (Waters, Williamson, Bernard, Blouin, & Faulstich, 1987). Examples of physiological measures are heart rate (variability), electrodermal response and cortisol levels. The most common type of physiological assessment in specific phobias is measurement of heart rate.

Heart rate can be used as an indicator of anxiety and is easy to measure. A perceived threat in an anxiety-inducing situation results in escalation in heart rate. It can be recorded either continuously or at regular intervals across a specified period of time. Two studies have shown that videotaped scenes showing spiders (Fredrikson, Wik, Annas, Ericson, & Stone-Elander, 1995) and snakes (Wik et al., 1993) elicited higher heart rate compared to neutral stimuli in individuals with specific phobia. Patients fearful of driving showed higher heart rate while driving than non-phobic subjects (Alpers, Wilhelm, & Roth, 2005) and subjects with specific phobias showed

consistently larger psychophysiological responses to their own phobic imagery than social phobics or agoraphobics (Cook, Melamed, Cuthbert, McNeil, & Lang, 1988). Moreover, heart rate recordings have been shown to be sensitive to treatment effects in patients with spider phobia (Antony, McCabe, Leeuw, Sano, & Swinson, 2001), claustrophobia (Telch et al., 2004), fear of driving (Alpers et al., 2005) and acrophobia (Emmelkamp & Felten, 1985). These results indicate that heart rate can be a valuable measure in the assessment of specific phobias as well as the assessment of treatment outcome.

1.3 Theoretical background of specific phobia and its treatment

A summary of the theoretical underpinnings of the development and maintenance of specific phobias (in addition to general genetic factors) as well as the theoretical background of cognitive behaviour therapy will now be presented.

1.3.1 Classical conditioning

Traditional classical conditioning is based on the idea that a stimulus can form an association to an unconditioned stimulus (UCS) that results in a conditioned response (CR). For instance seeing a dog (conditioned stimulus; CS) reminds someone of a traumatic experience with a dog; being bitten by a dog (UCS), which results in the conditioned response (CR); fear (e.g. Rachman, 1977). Operant conditioning is responsible for the maintenance of avoidance behaviour (e.g., Rachman, 1977). Major criticism on the classical conditioning model arose, because several phenomena of specific phobias could not be explained, e.g. the fact that many phobics do not recall trauma at time of onset and the fact that not all people that have traumatic experiences develop a phobia. A new model was formed: the contemporary model of classical conditioning. This model is an attempt to incorporate cognitive components to the traditional classical conditioning model and therefore differs in a number of ways (Davey, 1997). First, processes that cannot be directly observed are included (e.g. existing beliefs about the CS). Second, many factors other than the pairings of CS and UCS experienced can affect the strength of the association between these

events. These include verbally or culturally transmitted information about the CS-UCS contingency. Thirdly the strength of a CR can be radically influenced, not just by the strength of the CS-UCS association, but also by the way in which the individual evaluates the UCS. Moreover, expectations of the emotional reaction itself (CR) are of influence to the actual amount of fear experienced (match-mismatch theory; Rachman, 1994; Marks & De Silva, 1994; Arntz, 1997). See Figure 1.1 for a schematic outline of the contemporary conditioning model (Davey, 1997) with addition of the match-mismatch model.

Presumably, exposure in vivo to the CS without occurrence of the UCS will result in extinction of the conditioned response to the CS, which therefore no longer needs to be avoided. Moreover, it is thought that exposure or cognitive techniques will change the evaluation and therefore meaning of the UCS, CS-UCS association or CR directly and therefore reduce the amount of fear experienced and diminish avoidance.

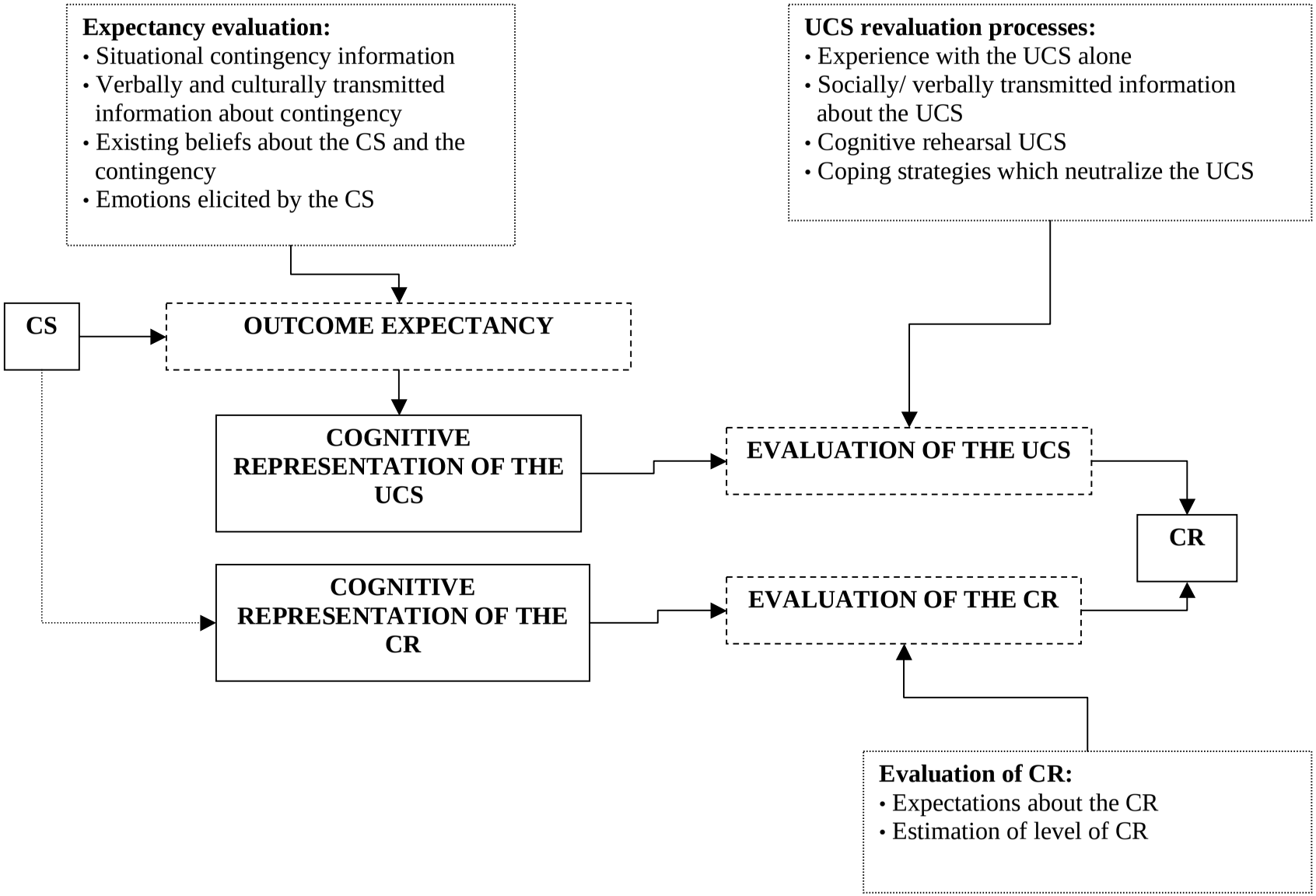
1.3.2 Cognitive biases

The maintenance of anxiety and avoidance can also be explained by cognitive biases that phobic patients generally have. Several studies showed an attentional bias (e.g., Lavy, van den Hout, & Arntz, 1993) as well as a judgmental bias in phobic patients. Attentional bias refers to the phenomenon of hyper-attention to threatening material. It seems likely that this hyper-attention to threatening stimuli perpetuates phobic fear, especially if it is followed by avoidance or in the development of a phobia poorly inhibited (Kindt & van den Hout, 2001).

Judgmental biases include covariation biases and emotional reasoning. Covariation bias is the tendency to overestimate the association between phobic stimuli and aversive outcomes and this bias is stimuli specific (e.g., Tomarken, Sutton, & Mineka, 1995; de Jong & Merckelbach, 2000). Covariation bias will sustain phobic fear (de Jong, van den Hout, & Merckelbach, 1995).

Emotional reasoning indicates that phobic subjects tend to believe that anxiety symptoms imply the presence of danger. Probably, this form of reasoning will legitimate phobic fear, which will result in the maintenance of this fear (Arntz, Rauner, & van den Hout, 1995).

Figure 1.1 Contemporary classical conditioning model with addition of match-mismatch model



In line with these biases, cognitive techniques could be used as treatment for specific phobias. Presumably, cognitive biases will decrease and fear and avoidance will diminish if information about the stimuli and its consequences is more fully processed. Behaviour therapy could also lead to information that might be incompatible with these biases and eventually create more rational alternatives.

1.3.3 Emotional processing

The emotional processing theory by Foa and Kozak (1986) provides an explanation for the fear-reducing qualities of exposure. It proposes two necessary conditions for fear reduction to take place. First the fear structure must be activated. The fear structure is a set of propositions about the stimulus, the response and interpretive information about the meaning of the stimulus and the response. Activation of this structure should occur when information is provided that matches part of the fear network. Through generalization of activation, the other sections of the network should become activated. The second condition to be fulfilled is that information incompatible with elements of the fear structure must be made available and cognitively processed. According to this theory of emotional processing exposure will lead to habituation, which will lead to incompatible information with the fear structure. Repetitive trials of exposure will lead to a perception of less harm and also the negative valence of the stimulus will decrease, resulting in less avoidance and more approach behaviour.

The clearest difference between behavioural and cognitive approaches to the treatment of specific phobias lies in the theoretical basis. Behavioural approaches emphasize the associative experiences and response deficits in relation to specific stimuli, while the cognitive approaches emphasize tendencies to perceive threat and safety. Methods underlying each treatment approach overlap considerably. Behavioural methods aim to weaken specific associations by repeated exposure to feared stimuli and/ or development of skills to approach phobic stimuli. Cognitive methods direct attention towards irrational appraisals about phobic stimuli and responses and create more rational alternatives. The methods overlap because

cognitive therapy uses direct experience with phobic stimuli to gather disconfirming information, and behavioural therapy provides information about phobic stimuli via direct experience.

In line with the contemporary model of conditioning, attentional biases and the emotional processing theory, behaviour therapy is effective as treatment of specific phobias and to date the golden standard (e.g. Craske & Rowe, 1997).
Moreover, some information is available on whether cognitive techniques enhance the effects of exposure in vivo. In acrophobics, cognitive exposure was found to be superior to exposure in vivo alone on subjective anxiety and cognitions during a behavioural avoidance test. However, cognitive techniques if added to exposure therapy did not enhance actual approach behaviour (Emmelkamp & Felten, 1985). Another study showed that cognitive techniques plus exposure was less effective than pure exposure for subjects with animal phobia (Ladouceur, 1983). Taken together, results are mixed and no conclusions can be drawn regarding the effectiveness of exposure in vivo plus cognitive therapy for specific phobias.

It is thought that if exposure in vivo is effective, exposure to the virtual counterparts of the phobic conditioned stimuli could be effective as well. Moreover, the addition of cognitive techniques to exposure therapy could be researched in a more controlled manner in virtual reality.

1.4 Virtual reality

Virtual reality (VR) integrates real-time computer graphics, body tracking devices, visual displays and other sensory input devices to immerse patients in a computer-generated virtual environment. There are many advantages to virtual reality exposure therapy (VRET) over exposure in vivo such as cost-effectiveness (for instance in the treatment of fear of flying), the possibility of generating more gradual assignments (sequence and intensity of treatment), creating idiosyncratic exposure, and ample opportunity of repeating exposure-assignments over and over again. More information is given on virtual reality and VRET in chapter 2.

This current thesis will focus on the possibilities of virtual reality and virtual reality exposure therapy (VRET) in acrophobia and fear of flying.

1.5 Aim and outline of this thesis

The present series of studies examines the effectiveness of VRET of patients fearful of heights and/ or fearful of flying. Also, different types of VRET and different other techniques (relaxation and cognitive techniques) are evaluated and compared.

In chapter 2 an overview is given of all the research published to date on virtual reality exposure therapy for anxiety disorders. Moreover, virtual reality, VRET and different systems used during VRET are explained in this chapter.

In chapter 3 a study is described in which feelings of presence in VRET were systematically varied by using either a head-mounted display (HMD) (relatively low presence) or a computer automatic virtual environment (CAVE) (relatively high presence). Effects of both treatments and a waiting list control group were evaluated and compared in patients with acrophobia, directly after treatment and after six months.

In chapter 4 a study is described in which VRET and VRET plus cognitive techniques were evaluated and compared in patients fearful of flying or fearful of heights in a randomised crossover design. A follow-up after six months was also taken and long-term effects were evaluated.

In chapter 5 a study is described in which individually tailored cognitive behavioural therapy (CBT) was compared to VRET or bibliotherapy as treatment in patients fearful of flying. Moreover, after CBT or VRET patients were given a CBT-group training and the effectiveness of CBT or VRET plus group training was investigated.

In chapter 6 the main findings of the presented studies are discussed. This thesis is concluded with recommendations and suggestions for further research on VRET.

Chapter 2 and 3 of this thesis have been published and two other chapters (4 and 5) will be submitted for publication as separate manuscripts, therefore some overlap was inevitable.

2

Virtual reality exposure therapy of anxiety disorders: A review*

Virtual reality exposure therapy (VRET) is an altered form of behavioral therapy and may be an alternative to standard in vivo exposure. Virtual reality (VR) integrates real-time computer graphics, body tracking devices, visual displays, and other sensory input devices to immerse patients in a computer-generated virtual environment. Research on this type of treatment for anxiety disorders is discussed in this article, and the mediating and moderating variables that influence VR treatment effectiveness as well. Evidence is found that VRET is effective for participants with fear of heights and of flying. For other phobias, research to date is not conclusive. More randomized clinical trials in which VRET is compared with standard exposure are required. Furthermore, studies are needed in which VRET is not just a component of the treatment package evaluated, but in which VRET should be assessed as a stand-alone treatment.

* Krijn, M., Emmelkamp, P. M. G., Ólafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical Psychology Review, 24*, 259-281

2.1 Introduction

Anxiety disorders can be treated quite effectively with cognitive behavior therapy (CBT). Research over the past three decades has shown that exposure is rather effective, with exposure in vivo being superior to imaginal exposure, especially in the treatment of specific phobias (Emmelkamp, 2004). According to the emotional processing theory of Foa and Kozak (1986), successful exposure therapy leads to new and more neutral memory structures that 'overrule' the old anxiety provoking ones. In this line of thinking, virtual reality exposure therapy (VRET) could be a viable alternative to exposure in vivo. If a virtual environment could elicit fear and activate the anxiety-provoking structure, it can function as an alternative mode to induce exposure. As is the case in exposure in vivo or in imagination, the information that disconfirms anxiety beliefs could be experienced, and habituation may occur.

In 1992, the first experiments on virtual reality exposure were conducted, although the technology was still premature (North, North, & Coble, 1996a, 1996b, 1996c). Since then, the number of studies assessing the effectiveness of VRET increased rapidly, empowered by progresses in computer technology, which brought more sophistication and possibilities in VR treatment. Most research has focussed on anxiety disorders, although research into the possibilities of the virtual reality treatment of eating disorders, addictions (by means of virtual cue exposure), psychological assessment, pain control, palliative care, and rehabilitation are in progress as well.

This chapter has two objectives. First, the technique and usage of virtual reality in VRET are discussed, as well as the mediating and moderating variables (e.g., presence). Second, results pertaining to the effectiveness of VRET of anxiety disorders are critically reviewed. By evaluating these studies, ideas are generated for future research into VRET.

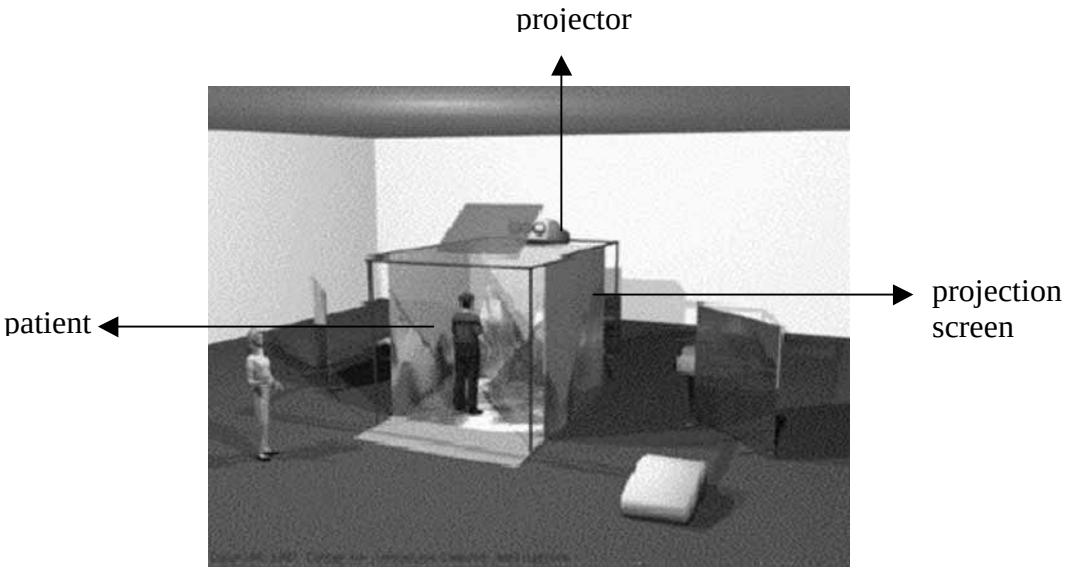
2.2 Virtual reality and immersion

To emerge participants into a virtual environment, virtual reality (VR) integrates several hardware and software techniques. VR appears in different forms subordinate to different hardware and software. The objective description of the aspects of the

system, such as field of view, display resolution, and so forth, is called immersion (Slater & Wilbur, 1997). The main techniques used to immerse participants in the virtual environment are a head-mounted display (HMD) or computer automatic virtual environment (CAVE). HMD and CAVE differ in many immersion aspects.

The CAVE (Figure 2.1) is a multiuser, projection-based VR system. In the installation, the patient and therapist are surrounded by stereoscopic computer-generated images on four to six sides (cubicle). The patients (and therapists) wear shutter glasses that lighten and darken in synchronization with the images on the screens (if the images generated are stereoscopic). An electromagnetic tracking system is used, and a sensor is attached to the patient's shutter glasses to generate a correct perspective view. The patient can walk naturally and freely through the installation, longer distances are traveled by means of the wand (most of the time a fixed path is followed).

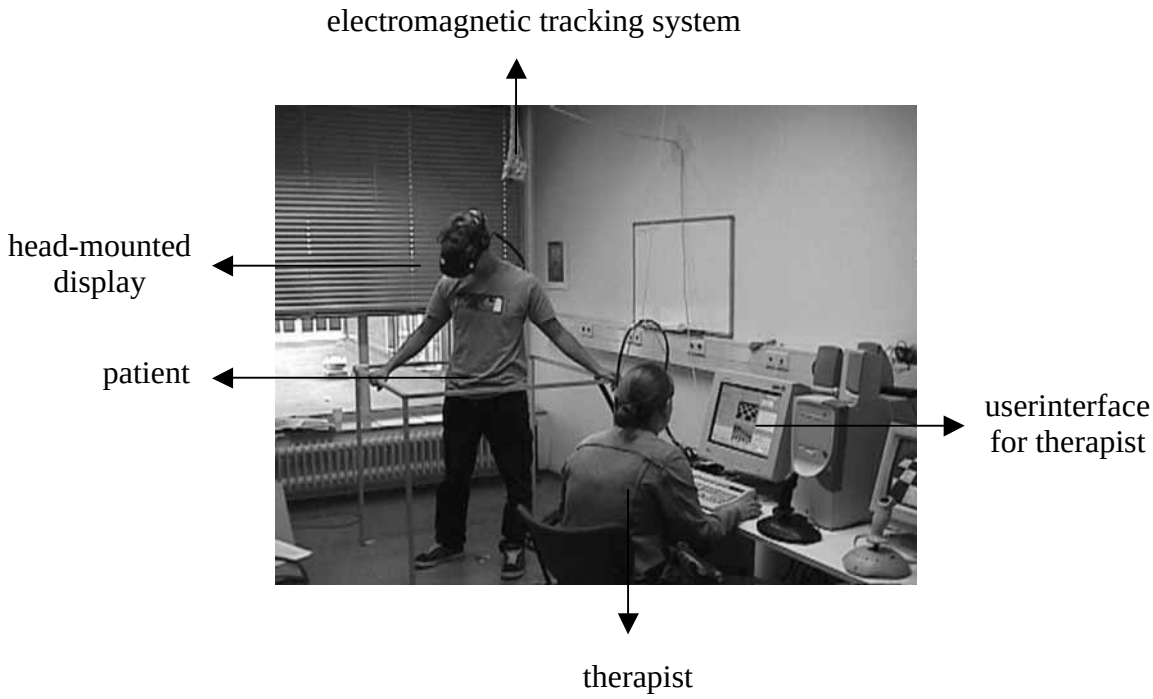
Figure 2.1 CAVE-system



An HMD system is only for individual use. A patient is standing or sitting in a room wearing the HMD. The HMD has screens inside the glasses and speakers near the ears. The sight of the patient is focused on computer-generated images on the screens, and the real world is shut out and not perceived anymore. A sensor is attached to the

helmet, and a tracker allows the patient's view of the virtual world to change in correspondence with the head movements made in the real world. When the patient moves his/her head, the computer calculates the position of the sensor and new images are shown inside the glasses. For instance, if a patient turns his/her head to the left, the left side of the virtual environment is shown, if a patient lifts his/her head, s/he sees the virtual sky, if s/he turns his/her head down, s/he sees the virtual ground (Figure 2.2).

Figure 2.2 HMD-system



The HMD is connected to the computer operated by the therapist. On the computer screen, a user-interface can be used by the therapist. S/he can see what the patient is viewing, can fill in anxiety scores, can see where the patient is in the virtual world, and can move the patient through the virtual environment if necessary.
Both CAVE and HMD avoid factors that can influence movement. The movement mode and other options depend on software and user interfaces employed.

To immerse patients into the virtual world, visual, and auditory stimuli are almost always present in virtual environments, and, to a lesser extent, tactile stimuli are added. Examples of these tactile stimuli are a railing to hold on to in a height

virtual environment, vibrations in the airplane chair during take-off or turbulence, or a hairy fabric to touch while seeing a spider in the virtual world.

2.3 Presence and moderating variables

VRET is based on the assumption that people feel ‘‘present’’ in the virtual environment. Presence is therefore assumed to be an important mediating variable. Presence is defined as ‘‘a psychological state or subjective perception in which, although part or all of an individual’s current experience is generated by and/or filtered through human-made technology, part or all of the individual’s perception fails to accurately acknowledge the role of the technology in the experience. Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at *some level* and to *some degree*, her/his perceptions overlook that knowledge and objects, events, entities and environments are perceived as if the technology was not involved in the experience’’ (Lombard, 2000).

Presence can be measured by objective (e.g., heart rate, body posture) or subjective measures (usually questionnaires). Generally, questionnaires are administered. Some methodological disadvantages need to be pointed out. First, VRET researchers employ a wide variety of questionnaires to measure presence. Comparing and weighting the results of projects is therefore complicated, if not impossible.

Second, one measure (e.g., heart rate) is often used for determining both presence and anxiety. This complicates research into the relationship between those variables and their interaction, which should be subject to research itself. Experimental research into presence (as well as cognition and perception in VR) and anxiety is essential to understanding their relationship.

Furthermore, individual differences can moderate presence. Examples of moderating individual traits are the propensity of participants to get involved passively in some activity (like reading a book), the ability to concentrate and block out distraction (Witmer & Singer, 1998), and possibly, hypnotizability (Wiederhold & Wiederhold, 2000). Research into these moderating individual traits will be of value because it may enhance selecting patients who profit most from treatment by means of VRET. However, research on the mediating and moderating variables is still in its infancy.

2.4 Virtual reality exposure therapy

VRET uses VR techniques to create environments that are immersive and provoke anxiety. In VRET, these virtual situations are 'visited' for a prolonged period of time for extinction to occur.

In line with the theory of Foa and Kozak (1986), three conditions should be met for VRET to be effective. First, participants need to feel present in the virtual environment to be able to experience the environment fully as a place visited, instead of a film seen (i.e., first vs. third person view; Slater, Pertaub, & Steed, 1999). Second, the virtual environment should be able to elicit emotions (e.g., anxiety; Hodges et al., 1994; North, North, & Coble, 1998; Regenbrecht, Schubert, & Friedman, 1998; Schuemie et al., 2000), otherwise, extinction will not occur. Finally, extinction and co-occurring cognitive changes have to generalize to real situations so that real-life situations will not be avoided any longer or will be endured with less anxiety.

VRET is conducted like any other form of graded exposure therapy. Patients are exposed to those stimuli that elicit fear. To give patients a gradual and optimal exposure treatment, patients have to rate their anxiety regularly during the exposure session by means of subjective units of discomfort (SUDS; 0–10 or 0–100). The therapist's comments are roughly similar with what would be expected for conventional in vivo exposure. In general, patients are instructed during treatment to expose themselves to the anxiety-provoking situations in a gradual manner. After anxiety has been reduced as measured by a relatively low SUD, patients are encouraged to take a next step, which provokes more anxiety (for instance, move up one floor, take off by airplane, walk closer to the spider, etc.). VRET generally uses only exposure techniques and encouragements, no cognitive interventions or relaxation. In the review below, these techniques will be mentioned separately if used concurrently in any trial. Patients are usually instructed to become as involved as possible and focus on the most frightening stimuli of this particular part of the virtual environment. This is normally done to avoid dissociation from the VR experience.

2.5 Review of research on the effectiveness of VRET of anxiety disorders

In this chapter, all research articles found on VRET of anxiety disorders are discussed. Most articles are based on case studies. The results of case studies can be seen as heuristic for further, more reliable research, although firm conclusions cannot be drawn. Fortunately, a number of randomized control studies on acrophobia and fear of flying have been published in the last few years. The most attention will be given to the reliable and valid clinical trials.

In the majority of randomized clinical studies, VRET was often just one component of a treatment protocol under investigation. In the minority of trials, VRET was compared with other treatment or a waiting list as a stand-alone treatment. Treatment components will be mentioned in more detail per phobia.

The number of sessions differed immensely between the studies and also the number of sessions solely spent on VRET, instead of other components of the treatment protocol varied. The number of sessions will be mentioned for every study.

The dependent variables chosen in the different studies were always specific and relevant to the phobia treated. Moreover, in some cases, a behavioral avoidance test (BAT) was included, which is relevant with respect to generalization effects of VRET. Long-term effects were sometimes investigated by follow-up tests.

Most studies on VRET have been conducted with specific phobias, that is, claustrophobia, spider phobia, fear of driving, acrophobia, and fear of flying. The other anxiety disorders that have been treated with VRET are posttraumatic stress disorder, social phobia, and agoraphobia. The effectiveness of VRET with these anxiety disorders will be discussed by separate disorder in the next paragraphs, respectively.

2.5.1 Claustrophobia

In a case study by Botella et al. (1998), one participant was exposed to claustrophobic situations during eight sessions of 35 to 45 min. The virtual environments used were (1) a balcony or small garden of 2 × 5 m, (2) a room of 4 × 5 m with windows and doors, (3) a room of 3 × 3 m, without furniture or windows, and (4) a wall that could move leaving only a 1-m 2 room. Between Sessions 6 and 7, this participant was

exposed to a real anxiety-provoking situation, namely, a CT scan where no avoidance was possible. The treatment was evaluated after eight sessions, including the exposure in vivo session. Results showed a decline in anxiety and avoidance on all measures.

In a following study by the same research group (Botella, Baños, Villa, Perpiña, & Garcia-Palacios, 2000), the effects of VRET were evaluated with one claustrophobic patient and three patients with panic disorder. All patients were treated for claustrophobia by means of eight sessions of VRET. In addition to the virtual environments used in the prior study by Botella et al. (1998), a virtual elevator was used. There was variation in the elevator, a spacious version, a smaller version, an operating elevator, and a blocked elevator. Each session lasted approximately 35 to 45 minutes. A multiple baseline showed fluctuations in scores for two of the participants, indicating lack of stability of symptom severity before treatment. Treatment was found to be effective on all measures, including a BAT, for all four participants at posttreatment and 1- and 3-month follow-ups. Given the fluctuations during the baseline period and the small sample size, no firm conclusions can be drawn from both studies (Table 2.1).

Table 2.1 Claustrophobia

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Botella et al. (1998)	1 VRET	1	0	8	FAS, FCSM, PRIQ, SETBM, TAM, SUDS	Reduction on all measures. Stable at 1-month follow-up.
Botella et al. (2000)	1 VRET (multiple baseline design)	4*	0	8	PRIQ, ASI, BAT, SETCS, SUDS	Reduction on all measures. Stable at 3-month follow-up.

n compl. = *n* (completers), *n* drop. = *n* (dropout). **Treatment:** VRET = virtual reality exposure therapy. **Dependent variables:** FAS = Fear and Avoidance Scales (one item), FCSM = Fear of Closed Spaces Measure (one item), PRIQ = Problem-Related Impairment Questionnaire, SETBM = Self-Efficacy Towards the Target Behavior Measure (one item), TAM = The Attitude towards the target problem Measure (one item), SUDS = Subjective Units of Discomfort (during treatment), SETCS = Self-Efficacy Towards Closed Spaces.
* DSM-IV diagnoses: *n* = 3, panic disorder with agoraphobia, *n* = 1, specific phobia: claustrophobia.

Conclusion: The effectiveness of VRET of claustrophobia is unclear. The two case studies published show positive results. Future randomized controlled clinical trials are necessary to evaluate VRET's effectiveness.

2.5.2 Fear of driving

Only one single case study has been reported on VRET of driving phobia (Wald & Taylor, 2000). A female with a diagnosis of specific phobia (driving phobia) according to the DSM-IV (APA, 1994) was treated with three sessions of VRET, each session lasting 60 min. Each virtual ride took between 1 and 5 min and was repeated until anxiety attenuated. The equipment used was an HMD-type system with the addition of a wheel and gas and brake pedals (tactile augmentation). The four virtual worlds used were rural residential driving, highway driving with bridge, residential driving with school zone, and highway driving with merging. At posttest, the participant showed less anxiety (also during the BAT) and avoidance, and the driving phobia was partially in remission, as assessed with the Structural Clinical Interview for the DSM-IV (First et al., 1996). The results remained stable at follow-up, 1 and 7 months after treatment (Table 2.2).

Conclusion: Research into VRET of fear of driving is still in its infancy. This case study holds promise for future research.

Table 2.2 Fear of driving

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Wald &Taylor (2000)	2 (within subject, baseline and VRET)	1	0	3	SCID, BAT, driving diaries	Reduction of fear and avoidance. Diagnosis partly in remission at 1- and 7-month follow-up.

Dependent variables: SCID = Structured Clinical Interview for the DSM-IV, BAT = Behavioral Avoidance Test.

2.5.3 Acrophobia

Most research on VRET has been done on the effectiveness of treating acrophobia. Four case studies and four controlled studies have been reported. All studies offered, besides visual and audio stimuli, some form of tactile stimuli as a platform or a railing that the participant could hold on to. Three case studies show that acrophobia can be treated effectively with VRET (Choi, Jang, Ku, Shin, & Kim, 2001; North et al., 1996a, 1996b, 1996c; Rothbaum et al., 1995a). However, in a single case study

reported by Kamphuis, Emmelkamp, and Krijn (2002), VRET (three sessions of 1 h each) did not lead to clinically significant improvement. Only after nine exposure in vivo sessions (90 min to 3 h each) did the patient improve substantially.

Rothbaum et al. (1995b) reported the first controlled study on VRET. Participants were students who feared heights, and they were assigned randomly either to VRET (seven sessions; 35–45 min each, *n* = 12) or a no-treatment control group (*n* = 8). Seven of the 12 students exposed themselves to height situations in vivo between sessions that probably influenced the results. The virtual worlds used were three footbridges, four outdoor balconies, and one glass elevator. VRET was found to be significantly more effective than no-treatment on all subjective measures of anxiety and avoidance (Table 2.3).

Three controlled studies have been reported with patients who suffered from acrophobia. Emmelkamp, Bruynzeel, Drost, and van der Mast (2001) conducted a study using a within-group design, in which standard exposure in vivo was compared with VRET. All participants (*n* = 10) were treated first with two 1-h sessions of VRET followed by two 1-h sessions of exposure in vivo. Virtual environments were a diving tower plus swimming pool and a tower building with a glass elevator. In vivo situations were a fire escape, balconies of an 18-story building, and a roof of a 5-story building. VRET was found to be as effective as exposure in vivo on all subjective measures. Firm conclusions about the comparative effectiveness cannot be drawn because of a potential order effect; all participants received in vivo exposure after VRET. In a following study of the same research group (Emmelkamp et al., 2002), patients were assigned randomly to either VRET (*n* = 17) or exposure in vivo (*n* = 16). VRET and exposure in vivo consisted of three sessions of 60 min. Furthermore, the real situations used in exposure in vivo were replicated exactly in VR and used in treatment (a shopping mall, a fire escape, and a roof garden). VRET was found to be as effective as exposure in vivo on all measures, even on a BAT, consisting of climbing open stairs. The improvements were maintained at 6-month follow-up.

The third study of this research group (Krijn et al., 2004) was designed to investigate the effectiveness of two different conditions of VRET, varying in the degree of presence. A very advanced CAVE system was compared with a more basic system: HMD. A no-treatment control group was added to study the effect of time. Thirty-seven patients were assigned randomly across the three conditions. The virtual environments used were a fire escape, a roof garden, and a building site. Therapy

consisted of three sessions of VRET of 1 h each. No time effect on any measure was found for the waiting period. Therefore, participants in the no-treatment control group were randomly assigned to either VRET/HMD or VRET/CAVE after the waiting period and their no-treatment posttests were used as pretests for the treatment conditions. The results showed that there were no differences in effectiveness between the two systems on any measures. As expected, presence was significantly higher in the CAVE, but this did not result in a more effective treatment. VRET, in general (either with the CAVE or HMD), was significantly more effective than the no-treatment. Unfortunately, the dropout rate in this study was high (10 out of 35 patients). Results of this study showed that dropouts experienced significantly less presence and anxiety in the virtual environments than the completers did.

Conclusion: The effects of VRET in the treatment of acrophobia are well established. The four controlled studies all show that VRET is effective in treating acrophobia. However, the high dropout rates during therapy due to low levels of experienced presence temper the optimism somewhat (Emmelkamp et al., 2002; Krijn et al., 2004).

2.5.4 Fear of flying

In the treatment of fear of flying, the advantages of VRET over standard exposure therapy are enormous. It is highly cost effective, components of the flight can be repeated endlessly in the therapist office, and different weather conditions can be created in milliseconds.

Four case studies, all with positive results, have been published. North, North, and Coble (1997) described a five-session VRET of a male with fear of flying. The virtual environment used was a helicopter flying over Atlanta, a river, and a lake. A vibration apparatus was placed under the physical ‘cockpit’ to add tactile augmentation to the visual and auditory stimuli. SUDS increased while entering a new anxiety-provoking situation and decreased while staying in that situation, therefore indicating that habituation occurred. After treatment, the patient was able to make a real flight without anxiety. Unfortunately, no questionnaires or tests were used (except SUDS) to evaluate the effects of treatment. Second, Wiederhold, Gervirtz,

Table 2.3 Acrophobia

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Choi et al. (2001)	1 VRET	1	0	6	ASI, ACQ, BSQ, FQ, AQ, ATHQ	Improvement in reducing anxiety and avoidance.
North et al. (1996)	1 VRET	1	0	8		Improvement in reducing anxiety and avoidance.
Rothbaum et al. (1995a)	1 VRET	1	0	5	AQ, ATHQ, BAT, SUDS	Reduction of fear and avoidance on all measures.
Rothbaum et al. (1995b)	2 (VRET or WL)	20 (12 VRET, 8 WL)	3	7	AQ, ATHQ, RFQ, SUDS	VRET was found to be more effective than WL (unchanged).
Emmelkamp et al. (2001)	2 (within subjects) SE, VRET	10	0	4	AQ, ATHQ, SUDS	VRET was as effective as SE. Order-effects cannot be ruled out.
Emmelkamp et al. (2002)	2 (between subjects) SE, VRET	38	5	3	AQ, ATHQ, BAT, SUDS	VRET was as effective as SE. Exact the same situations were used. 6-month follow-up showed a stable result of therapy.
Kamphuis et al. (2002)	2 VRET, in vivo (within)	1	0	12	AQ, ATHQ, BAT, SUDS,	VRET was not effective as treatment, exposure in vivo was.
Krijn et al. (2004)	3 (between subjects) VRET/ HMD, VRET/ CAVE, WL	29	7	3	AQ, ATHQ, BAT, SUDS	VRET no matter which equipment was used was more effective than WL. No differences in effectiveness between HMD and CAVE.

Treatment: WL = Waiting List, SE = Standard Exposure, HMD = Head-Mounted Display, CAVE = Computer Automatic Virtual Environment. **Dependent variables**: ASI = Anxiety Sensitivity Index, ACQ = Agoraphobic Cognition Questionnaire, BSQ = Body Sensation Questionnaire, FQ = Fear Questionnaire, AQ = Acrophobia Questionnaire, ATHQ = Attitude Towards Heights Questionnaire, RFQ = Rating of Fear Questionnaire

and Wiederhold (1998) reported a reduction in skin conductance as a result of one 20-min session, in which the participant was exposed to virtual flights. No results on other outcome measures were reported.

The last case studies involved a treatment package, including anxiety management training (AMT), in addition to VRET. The case study by Klein (2000) showed that the combination of AMT (three sessions) and VRET (about 18 sessions) was effective for a 47-year-old woman. AMT consisted of relaxation training and thought-stopping techniques; VRET consisted of sitting in an aircraft, engines off/on, taxiing, take-off, flying, landing, thunderstorms, and turbulence. The evaluation of the effects of VRET are hampered by the fact that the duration of the sessions was not mentioned and homework was assigned between sessions, for example, visiting an airport, watching airplanes, and calling airlines. After treatment, the patient was able to fly with a reduction of fear. Rothbaum, Hodges, Watson, Kessler, and Opdyke (1996) reported another case study in which one participant was treated with seven sessions of AMT, followed by six sessions (35–45 min each) of VRET subsequently. Virtual environments used were sitting in a plane, engines on, taxiing, take-off, normal flight, landing, turbulent flight, and rough take-off. Each component on its own was found to be effective on measures of anxiety, (behavioral) avoidance, depression, and general improvement (Table 2.4).

Kahan, Tanzer, Darvin, and Borer (2000) reported an uncontrolled study in which the effects of AMT and VRET were evaluated in a package. Results were not presented for each treatment component separately. AMT consisted of psycho-education, relaxation, and cognitive techniques. VRET consisted of gradual exposure to flight scenarios. In total, 31 participants completed the study, of which 68% were able to make a real flight after treatment. No other measures, then flight attendance, were reported. The number of sessions differed across participants (with an average of 5.75), and 6 participants dropped out during treatment. Moreover, 10 participants were on medication before entering the trial, 5 started medication during treatment, and 10 received additional CBT during treatment, creating a highly heterogeneous sample. Because of the design of the study that consisted of a package rather than pure VRET, variable amount of sessions, additional medication, and additional CBT, any conclusion with respect to the effectiveness of VRET is precluded.

In a randomized (partly) uncontrolled study, Mühlberger, Herrmann, Wiedemann, Ellgring, and Pauli (2001) compared VRET with relaxation training. In

one long session (of 4 h), all participants received psycho-education, after which they were randomly assigned to either VRET (four flights of 16 min each) or relaxation (two muscle relaxation trainings of 32 min each). Both treatments resulted in a significant reduction of heart rate, skin conductance, and SUDS. VRET was found to be more effective than relaxation, but only on specific fear of flying questionnaires. On more global questionnaires (like the danger and the anxiety expectancy scale), both treatments were found to be equally effective.

In a controlled randomized study by Rothbaum, Hodges, Smith, Lee, and Price (2000), 45 patients were randomly assigned to either (1) four sessions of VRET and four sessions of AMT (1 h each), (2) two sessions of standard exposure in vivo (2 h each) and four sessions AMT (1 h each; SE), or (3) a waiting list. The situations used in SE were not the same as in VRET. VRET consisted of virtual flying, taxiing, taking off, and landing. The situations in SE were walking through an airport and sitting in a stationary aircraft. Both treatments were found to be more effective than a waiting list period. No differences between the treatments were found, neither at posttest nor at 12-month follow-up (Rothbaum, Hodges, Anderson, Price, & Smith, 2002).

In a second controlled randomized study by Maltby, Kirsch, Mayers, and Allen (2002), 45 patients who were not able to fly on a test flight were randomly assigned to either five sessions VRET or five sessions attention-placebo group treatment (GT). The first 90-min session consisted of psycho-education, AMT, and cognitive techniques, e.g. creating positive self-statements. The next four sessions lasted 50 min each and were devoted to graded exposure to flying in a virtual environment (airport, airplane, start, taxiing, takeoff, cruising and landing). The attention placebo group consisted of education on the safety of a flight and mechanics of an airplane and conversation about the patient's fear and fear history. Groups consisted of four to six patients. At posttreatment, VRET showed more clinically significant decline of fear of flying than GT on four out of five measures. At 6-month follow-up, results remained stable. However, most group differences disappeared, with VRET resulting in a superior outcome on only one out of five measures.

Table 2.4 Fear of flying

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Rothbaum et al. (1996)	2 (within subject) AMT+ VRET	1	0	AMT (7) VRET (6)	QAF, FFI, SSR, STAI, BDI, CGI, SUDS, BAT (after total treatment)	Both components (AMT and VR) were effective.
North et al. (1997)	1 (VRET)	1	0	5	SUDS	Decrease in SUDS, subject could fly 'comfortably' in vivo after treatment.
Kahan et al. (2000)	1 (AMT + VRET)	31	6	Average 5.75 sessions	% of subjects that flew after treatment	56 % response rate at follow-up. 68% of the subjects flew (with anxiety) after treatment. 10 subjects received medication as well. 10 subjects received CBT as well.
Rothbaum et al. (2000)	3 (between subjects) SE, VRET, WL	45	4	8 (4 AMT + 4 VRET or SE) or 8 WL	QAF, CGI, FFI, BAT (after treatment)	Both treatments were more effective than WL. No difference between treatments were found.
Rothbaum et al. (2002)	2 (between subjects) SE or VRET	24	6	12-month follow-up (of Rothbaum et al (2000))	QAF, CGI, FFI	Both treatments showed long-term effects of treatment. No differences between treatments were found. VRET-subjects used more alcohol and drugs on subsequent flights than SE-subjects.
Klein (2000)	2 (within subject) AMT + VRET (+ homework SE)	1	0	3 (AMT) + ± 18 (VRET)	QAF, STAI, SSR, SUDS	The combination of treatments was effective.

Table 2.4 Fear of flying continued

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Mühlberger et al. (2001)	2 (between subjects) VRET or relaxation, both plus one session psycho-education	30	7 (+3 excluded post-hoc)	1 (relaxation or 4 VR flights)	Within session: SCL, HR, SUDS. Outcome: FFS, GFFQ, DES, AES, ASI	Relaxation and VRET both resulted in reduction of HR, SCL and SUDS. A significant reduction on all measures for both treatments. VRET was more effective than relaxation (FFS, GFFQ). Both were even effective on DES, AES and ASI.
Wiederhold et al. (1998)	1 VRET	2 (1 phobic, 1 normal)	1 (20 minutes)	1	QAF, FFI, SSR, STAI (outcome) SCL (within session)	A reduction in skin conductance levels. No results published on outcome questionnaires.
Mühlberger et al. (2003)	3 CT + VRET (with motion simulation or CT + VRET without motion simulation or CT. A nonrandom WL	45 (10 in nonrandom WL)	8 (1 did not find location), 7 did not complete fu	1 (CT one hour + VRET, 80 minutes)	FGSQ, ASI, STAI. Outcome: FFS, GFFQ, behavioural measure: making a flight reservation.	It could be said that VRET is the most effective treatment component and not information about flying or treatment rationale or cognitive techniques. Drawback: the time spent in therapy was different between conditions. WL was nonrandom. No comparison to SE, no 'real' BAT.

Treatment: AMT = Anxiety Management Training, consisting of cognitive and relaxation techniques and psycho-education. **Dependent variables:** QAF = Questionnaire on Attitudes toward Flying, FFI = Fear of Flying Inventory, SSR = Self-Survey of Stress Responses, STAI = State Trait Anxiety Inventory, BDI = Beck Depression Inventory, CGI = Clinical Global Improvement, SCL = Skin Conductance Level, HR = Heart Rate, FFS = Fear of Flying Scale, GFFQ = General Fear of Flying Questionnaire, DES = Danger Expectancy Scale, AES = Anxiety Expectancy Scale, FGSQ = Fear and General Symptoms Questionnaire, FHF = Flight History Form, SSR = Self-Survey of Stress Response.

Finally, in a controlled randomized study by Mühlberger, Wiedemann, and Pauli (2003), 37 participants with fear of flying were randomly assigned to one session of either (1) cognitive treatment and VRET with motion simulation (*n* = 13), (2) cognitive treatment and VRET without motion simulation (*n* = 13), or (3) cognitive treatment alone (*n* = 11). A nonrandom waiting list group of community controls was added (*n* = 10). All participants received an information booklet. VRET (with or without motion simulation) consisted of 1 h of cognitive therapy and four virtual flights of 18 min. Cognitive treatment alone consisted of one 60-min session of cognitive techniques. Results measured by questionnaires revealed reduced fear of flying only in the VRET groups. Motion simulation did not enhance treatment effectiveness. Results suggest that VRET is the most effective treatment component if compared with information about flying, treatment rationale, or cognitive techniques. A flaw of this study is the difference in treatment time between the conditions. Cognitive therapy took only 1 h, while VRET plus cognitive techniques took around 140 min.

Conclusion: VRET could be an effective component in the treatment of fear of flying. Especially the controlled studies by Rothbaum et al. (2000, 2002), and Mühlberger et al. (2003) show that VRET is effective. Moreover, the cost effectiveness and superb control over flight and weather conditions are such great advantages that VRET could be tried before exposure in vivo is an option. However, an obvious evaluation of the effectiveness of VRET alone has not been made. For firmer conclusions to be drawn, studies comparing different treatment forms have to include comparable treatment conditions regarding the number of sessions, the length of the sessions, and the environments used (e.g., virtual worlds replicating in vivo situations).

2.5.5 Spider phobia

One case study shows that VRET with tactile augmentation was found to be effective on all measures (Carlin, Hoffman, & Weghorst, 1997). Tactile augmentation consisted of a ‘hairy’ fabric that gave sensations of feeling a spider, while watching a virtual spider through the HMD. The therapy was given during 12 sessions of 50 min. The fear of spiders was reduced in this one participant (Table 2.5).

A controlled study by Garcia-Palacios, Hoffman, Carlin, Furness, and Botella (2002) supports the abovementioned result. In total, 23 participants were randomly assigned to either VRET (*n* = 12) or a waiting list control group (*n* = 11). VRET consisted of virtual exposure to spiders with tactile augmentation. The endpoint of treatment was holding a big virtual spider with tactile feedback while reporting low levels of anxiety. The average amount of sessions needed to achieve this goal was 4 (range 3 to 10; each session lasting 60 min). Results show that VRET is more effective than is a waiting period on all measures, including BAT.

Table 2.5 Spider phobia

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Carlin et al. (1997)	1 VRET (augmented)	1	0	12 (1 hour)	6 questions on anxiety of spiders, SUDS	Reduction of fear on SUDS and 6 questions.
Garcia-Palacios et al. (2002)	2 VRET (augmented) or WL	23 *n* (VRET)= 12 *n* (WL) = 11	0	Average of 4 (1 hour). Range: 3-10	FSQ, BAT, clinician rating,	VRET was more effective than WL on all measures. Drawback: end goal was set instead of fixed amount of sessions.

Dependent variables: FSQ = Fear of Spiders Questionnaire

Conclusion: VRET could be an effective treatment for spider phobia, as concluded in both studies mentioned above. However to firmly support this conclusion, more research is imperative, especially a between-group comparison of exposure in vivo, the golden standard to date with VRET is necessary.

2.5.6. Fear of public speaking/ social phobia

Anxiety-provoking virtual environments have been developed for treatment of patients with public speaking anxiety (Botella et al., 2000; Lee et al., 2002). In a study by Pertaub, Slater, and Barker (2002), 40 participants had to give a 5-min presentation to a neutral, a positive, or a negative audience that consisted of eight avatars, virtual people. This study confirmed that all three virtual environments (neutral, positive, and negative) could generate anxiety in participants with elevated scores on the standard

Personal Report of Confidence as a Public Speaker (PRCS) at pretest. Furthermore, regardless of their PRCS score at pretest, participants experienced anxiety when talking to a negative virtual audience (Pertaub et al., 2002). Given the finding that a virtual audience can elicit anxiety, research into the use of such environments in the treatment of public speaking is useful. In the first study in this area (North et al., 1998), 16 participants were either treated with VRET or participated in a comparison group. Unfortunately, no information is given on the content of this comparison group. VRET consisted of five weekly sessions lasting 10 to 15 min. Although it is concluded that participants experienced less anxiety in public speaking after treatment on one questionnaire and on SUDS, no data or analyses are provided to substantiate these claims.

Anderson, Rothbaum, and Hodges (2003) have recently reported two case studies on VRET and social phobia. Both participants met diagnostic criteria for social phobia with prominent public speaking fears. The first patient was treated with four sessions of AMT, one session of exposure in vivo, and four sessions of VRET. The second patient was treated with two sessions of exposure in vivo, five sessions of VRET, and one session was devoted to relapse prevention. AMT consisted of breathing retraining exercises and cognitive restructuring. Talking in front of a video camera and watching the videotape were the exposure in vivo components. VRET consisted of giving a presentation to a virtual audience on video. There was a neutral, positive, and negative audience controlled by the therapist. Results after the whole treatment package were a decline in specific anxiety symptoms, as measured with the PCRS, self-statements during public speaking (SPSS), and SUDS, and a stable pattern on more global measures. A BAT was administered only at posttest, which excluded any comparison with the status at pretest. Unfortunately, the treatment components are not evaluated separately. Nonetheless, the authors mentioned that the results for those two cases are similar with the effectiveness of group CBT.

Finally, a study by Harris, Kemmerling and North (2002) was done with students with fear of public speaking. Students who scored above a cut-off score on the PRCS and wanted to participate in the study were randomly assigned to either VRET (n = 8) or a waiting list control group (n = 6). VRET consisted of four exposure sessions of 15 min each. The virtual environments consisted of an empty auditorium and a gradually filling auditorium, with a positive or negative audience. Results show that the VRET group improved after treatment on several

questionnaires. The post-tests of the waiting list group differed significantly on one questionnaire from the VRET group. On other measures, the differences approached significance (Table 2.6).

Conclusion: Research into VRET of fear of public speaking is still in its infancy. Only one controlled study with a small sample size (of which results and analyses are available) has been published. Because of the sample size and its nature (students), results must be considered with caution, although it looks promising.

Fear-eliciting virtual environments are already created, and these could be used in a clinical trial to evaluate their use and the treatment effectiveness of VRET.

Table 2.6 Fear of public speaking/ social phobia

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
North et al. (1998)	2 (VRET or comparison group)	16	0	5 (10 to 15 minutes each)	ATPS, SUDS	Significant decrease in symptoms on ATPS and SUDS, ability to face the phobic situations in the real world. No analyses or data published or info on the comparison condition.
Anderson et al. (2003)	Variable	2	0	Case 1: 10 (5 AMT, 1 IV and 4 VRET Case 2: 2 IV, 4 VRET and 1 RP	SUDS, PRCS, SSPS, LSAS, STAI, BDI, CGI	Decrease in symptoms on PRCS, SSPS and SUDS. Scores on STAI and BDI stayed relatively stable. Scores on LSAS decreased for case 1 and increased for case 2. results are similar to CBT group therapy and hold promise for future research.
Harris et al. (2002)	2 (VRET or WL)	14 (8 VRET and 6 WL)	3	4 (15 minutes each)	PRCS, LSAS, ATPS, HR	Significant differences between VRET and WL at post-test on PRCS, approaching significance on ATPS, HR and LSAS. Holds promise for future research.

Treatment: IV = exposure in vivo, RP = relapse prevention. **Dependent variables:** ATPS = attitude towards public speaking, PRCS = Personal Report of Confidence as a Speaker, SSPS = Self-Statements During Public Speaking, LSAS = Liebowitz Social Anxiety scales - Self Report

2.5.7 Panic disorder with agoraphobia

Panic disorder with agoraphobia is a highly disabling disorder. Treatment protocols using exposure to anxiety-provoking virtual environments as a part of the treatment program are available (Vincelli, Choi, Molinari, Wiederhold, & Riva, 2000). Virtual environments for treating participants with panic disorder and agoraphobia have been created as well, for example, an elevator, supermarket, square, and a beach. These environments have only been tested on nonphobics; there have been no trials in a clinical population (Moore, Wiederhold, Wiederhold, & Riva, 2002).

Table 2.7 Panic disorder with agoraphobia

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Jang et al. (2000)	1	0	7	2	ASI, ACQ, BSQ, FQ, SUDS, physiological data	VRET was stopped because most subjects could not be immersed into the virtual environments. Treatment-effectiveness was not measured because of this.
North et al. (1996a, 1996b)	2 (VRET or control group	60	0	8 (15 minutes each)	ATAQ, SUDS	Significant decrease in negative attitudes towards agoraphobic situations in VRET not in the control group. Decrease in SUDS across sessions (VRET). Validity and reliability of ATAQ questionable.
Vincelli et al. (2003)	3 (ECT, CBT or WL)	12	0	ECT = 8 CBT = 12	BDI, STAI, ACQ, FQ	No differences between ECT and CBT. Significant differences between pre and post-test in ECT and CBT. No differences between pre and post-test for the WL-group. Drawback is the small sample size (4 subjects in one condition).

Treatment: ECT = Experiential-Cognitive Therapy, CBT = Cognitive Behavioral Therapy.
Dependent Measures: ATAQ = Attitude Towards Agoraphobia Questionnaire.

In a study published in 1996, VRET was compared with a no-treatment control group using students as participants, with some degree of agoraphobia (North et al., 1996a, 1996b, 1996c). Students were selected by means of a high score on an agoraphobia questionnaire. In total, 60 undergraduate students voluntarily agreed to participate in the study and were randomly assigned to either VRET or a waiting list control group. At pre- and posttest, a modified 10-point attitude towards agoraphobia questionnaire (ATAQ) of unknown psychometric qualities was used along with SUDS. Participants in the VRET group were gradually exposed to eight (or less) virtual scenes of 15 min each. These scenes were balconies, empty room, dark barn, dark barn with a black cat, covered bridge, elevator, canyon, and hot air balloons. At post-treatment, the VRET group was significantly more improved than the no-treatment control group was. Although these results are limited given the non-clinical student sample studied and the lack of state of the art measures of agoraphobia, they might hold promise for the future (Table 2.7).

Another effort was made by Jang, Ku, Shin, Choi, and Kim (2000) to investigate the efficacy of VRET in treating agoraphobia. Most of the seven participants that participated in their study were not able to feel present in the virtual environment (tunnel scene with traffic jam), which led the investigators to stop the project. The negative results of this study suggest that more research must be done to investigate which parameters are necessary for creating a valid and anxiety-provoking virtual world for the treatment of agoraphobia.

Vincelli et al. (2003) conducted a controlled randomized study in which eight sessions of experiential cognitive therapy (ECT) were compared with 12 sessions of CBT and a waiting list group. Twelve participants with DSM-IV diagnosis of panic disorder with agoraphobia were included. ECT consisted of psycho-education, virtual reality exposure (an elevator, a supermarket, a subway ride, and a large square), cognitive therapy, interoceptive exposure, exposure in vivo homework assignments, and relapse prevention. CBT consisted of cognitive restructuring, interoceptive exposure, and imaginative exposure to feared situations. Exposure in vivo was not mentioned. Analyses of the data by means of nonparametric tests show a significant decline in anxiety and depression symptoms on all measures for the ECT and BCT groups. The waiting list group showed no differences between pre- and posttest. Moreover, no differences at posttest were found between ECT and BCT. These results

look promising and should be validated in a large clinical sample. In addition, long-term effects should be investigated.

Conclusion: Two studies on agoraphobia hold promise for the future, although the second study (Jang et al., 2000) suggests that more research is prerequisite on the design of valid and anxiety-provoking virtual worlds. To date, unfortunately, no firm conclusions can be inferred on the effectiveness of VRET on agoraphobia.

2.5.8 Posttraumatic stress disorder (PTSD)

One case study (Rothbaum et al., 1999) and one clinical trial (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001) have been published on the effects of treatment with VRET as one component for Vietnam veterans diagnosed with PTSD. In both reports, VRET is only part of the treatment protocol. Relaxation, VRET, and imaginary exposure were combined in one treatment protocol, and the effectiveness of the overall protocol was investigated. Patients were emerged into the virtual environments designed for treatment, which were a helicopter flight and a jungle clearing, and were exposed to their own anxiety-provoking memories by means of imaginal exposure. Before formal exposure started, the participants received breathing relaxation training (Table 2.8).

In the case study (Rothbaum et al., 1999), a Vietnam veteran was treated in fourteen 90-min sessions over 7 weeks. Effectiveness was measured by means of questionnaires and interviews. All measures showed a decline in symptoms at post-test and at 6-month follow-up. The participant experienced a 34% decrease on clinically rated PTSD and a 45% decrease on self-rated PTSD.

The other study published (Rothbaum et al., 2001) was an open clinical trial using a package consisting of VRET, imaginary techniques, and relaxation to treat Vietnam combat veterans who had PTSD according to the DSM-IV criteria. In total, 16 participants were included in this study. Six dropped out during treatment and one participant dropped out at posttest. All participants showed severe psychopathology at pretest and comorbidity with depression and past abuse was present in most participants. The required number of sessions differed between participants (between 8 and 16; 90 min per session). At pre-, post-test, and follow-up, participant-rated, as well as clinician-rated measures were used. From baseline to post-test and follow-up, clinician-rated PTSD symptoms indicated an overall statistically significant reduction

in symptoms associated with reported traumatic experiences. All patients reported reduction in PTSD symptoms from 15% to 67%. This reduction in symptoms is quite impressive for participants with such severe levels of psychopathology. Although the dropout rate was substantial (30%), it is in the same range as the dropout rates in studies where standard treatments as imaginal exposure and CBT were used for Vietnam veterans with PTSD.

Conclusion: VRET, combined with imaginal exposure concurrently, holds promise in treating Vietnam combat veterans with PTSD. Controlled studies that compare VRET with and without imaginal exposure techniques with state of the art treatments for PTSD would contribute to the research field. Moreover, research on the use of VRET and imaginal techniques for participants with PTSD caused by different traumatic events (car accidents, assault, rape, etc.) is necessary.

Table 2.8 Posttraumatic stress disorder

Author(s), (year)	Condition(s)	*n* compl.	*n* drop.	Sessions	Dependent variables	Outcome (effectiveness)
Rothbaum et al. (1999)	1	1	0	14	CAPS, CES, IES, BDI, STAXI	Reduction on all measures, maintained at 6-month follow-up.
Rothbaum et al. (2001)	1 (Imaginal exposure + psycho-education + relaxation + VRET)	16	6 (do), 1 (no posttest)	8-16 (90-minutes)	CAPS, CES, SCID, IES, BDI, CGI, PGI	At follow-up (6-months) a significant reduction on the CAPS. IES lower at 3-month follow-up not at 6-month follow-up. Severe patients (co-morbidity, depression, abuse in past, etc), impressive reduction for this group. Drop-up same as for standard treatment.

Dependent variables: CAPS = Clinician-Administered PTSD Scale, CES = Combat Exposure Scale IES = Impact of Events Scale, STAXI = State-Trait Anger Expression Inventory, CGI = clinical global improvement scale, PGI = patient related version of the CGI

2.6 Discussion

Research on the effectiveness of VRET has been conducted on claustrophobia, fear of driving, acrophobia, fear of flying, spider phobia, fear of public speaking, panic

disorder with agoraphobia, and PTSD.

The present review indicates that VRET is more effective than no-treatment for acrophobia, fear of flying, and spider phobia. Few studies have been published in which VRET is compared with exposure in vivo, the gold standard for treatment of phobias to date. Promising results show that VRET is as effective as exposure in vivo in treating fear of heights and fear of flying. The cost effectiveness in fear of flying is a particular advantage of VRET. Unfortunately, in earlier studies on fear of flying, only the combined effectiveness of VRET with other therapy forms, such as cognitive therapy or anxiety management techniques, has been evaluated. The effectiveness of VRET as a stand-alone treatment is somewhat unclear. Fortunately, a more recent study of fear of flying (Mühlberger et al., 2003) shows that VRET can be effective on its own as well.

Firm conclusions on the effectiveness of VRET in other anxiety disorders (e.g., claustrophobia, fear of spiders, fear of public speaking, fear of driving, posttraumatic stress disorder and agoraphobia) are less clear. More controlled and randomized studies are needed to investigate whether VRET can be recommended for use in clinical practice. Moreover, an evaluation should take place of what the additional value of VRET is over exposure in vivo for some of the phobias (e.g., spider phobia). Thus, VRET appears to hold some promise as a valuable treatment form for some anxiety disorders. However, a number of complications are unsolved.

An important issue is whether the effects of VRET generalize to the world outside the laboratory. Only few researchers have included a BAT in their studies, which was usually done only once in one specific situation. Although follow-up results are promising, these are based on self-report rather than on formal behavioural tests.

To compare the effects of VRET with exposure in vivo, ideally, patients should be exposed to the same worlds in VRET as in exposure in vivo and for the same amount of time. To date, situations used in exposure in vivo and virtual exposure were kept identical in one study (Emmelkamp et al., 2002). This comparison should be made more often in future research. Only if virtual worlds are created that are copied from real world situations, an actual comparison between the effectiveness of both exposure programs can be made.

In most studies, VRET is embedded in a multimodal intervention program; research on treatment effectiveness is less focused on VRET as a sole therapeutic

mode. When VRET is not studied in isolation with sound uniform measures, inferring any conclusions on the effects of VRET as a therapeutic method is erroneous.

Another weak point of most research reported to date are the small sample sizes. Most published research has been done with too few participants to draw firm conclusions. Case studies are necessary to investigate whether there is any clinical potential of VRET, but the time has come to conduct randomized controlled studies in a variety of phobic populations.

A last draw back is the substantial number of dropouts in some VRET studies. In VRET, presence (feeling of being in the virtual world instead of the real one) is essential, at least to some degree. There is some evidence now that a relationship between dropout and low levels of presence experienced exists (Krijn et al., 2004).

Some participants are not able to involve themselves in the virtual world to the extent that they experience relevant emotions, thus precluding extinction and emotional processing to occur. Research on the mediating and moderating variables of success of VRET has just begun. There is some evidence that the quality of the system has some influence on the level of presence felt (Krijn et al., 2004; Schubert, Regenbrecht, & Friedmann, 2000).

Furthermore, there is some evidence that personal characteristics such as degree of absorption and hypnotizability may mediate the effectiveness of VRET as well (Wiederhold & Wiederhold, 2000). Further studies are needed to investigate which system characteristics and which personality characteristics are related to successful treatment with VRET. Furthermore, safety issues should be considered. To date, the only disadvantage discovered is simulation sickness. In the real world, when the head changes position, the image of the world immediately moves on the retina, that is, at the same time and rate as the vestibular system indicates movement of the head. However, in current VR systems, there is a delay between inputs by the user and the new scene appearing. This is known as an update lag and can cause simulation sickness with symptoms like nausea, sweating, stomach awareness, dizziness, bodily warmth, headache, increased or decreased salivation and drowsiness. Most patients do not have these problems, and if they experience simulation sickness, it is mostly in weakened form. Symptoms also disappear when VRET is stopped. To avoid simulation sickness, patients should be given breaks during VRET sessions. No other safety issues have emerged up to now. In conclusion, VRET seems to be safer than exposure in vivo, because the whole situation can be controlled easily, no

unexpected factors can be of influence, such as a crowd watching while practicing or rain while on an open stairs.

VRET is still considered to be a black box. Participants are exposed to virtual environments that technicians and psychologists think are immersive and anxiety provoking. Fortunately, the immersive qualities of a system are investigated more often. There is some evidence, although far from being conclusive, that the more advanced a system is, the more presence is generated. However, research to date has not been able to convincingly show that a linear relationship exists between presence and the amount of anxiety provoked, one of the essential assumptions made in VRET research. Some studies have confirmed a linear relationship between presence and anxiety experienced (Schuemie et al., 2000), but others have not (Regenbrecht et al., 1998). Other studies found that presence is the best predictor of fear (Regenbrecht et al., 1998; Slater et al., 1999). It seems that some level of presence is necessary to generate emotions. To which extent a higher level of presence relates to more anxiety experienced and, hence, to a better emotional processing and more effective treatment is not clear yet.

There are many advantages of VRET over exposure in vivo, such as cost effectiveness, the possibility of generating more gradual assignments (sequence and intensity of treatment), creating idiosyncratic exposure, and ample opportunity of repeating exposure assignments over and over again (e.g., landing with an airplane). These benefits extend mostly to acrophobia, fear of flying, and fear of public speaking because clinically relevant situations can be hard or difficult to find (and can be difficult to repeat). In case of, for instance, spider phobia and claustrophobia, the beneficial aspects of VRET are less clear, and the disadvantages of VRET (dropout rates, possibility of simulation sickness, and prize of equipment) could counterbalance the advantages (control over stimuli and repeated exposure endlessly).

VRET combines some of the advantages of both imaginal exposure and exposure in vivo. Some patients find it hard to imagine situations, while most participants find this less difficult in a virtual environment because it has immersive qualities by itself.

The research published on the treatment of PTSD by means of VRET shows these and other possibilities as well. Imaginal techniques are combined with VRET. This creative use of virtual reality techniques should be studied further. For example,

the use of VR technology provides the opportunity of challenging negative cognitions 'on the spot.'

Another important advantage of VRET is the opportunity of conducting experimental research in the context of VR. Parameters can be kept constant easily, and situations can be replicated exactly between participants. More research into the process variables (physiology, cognitions) of exposure can be conducted by means of VR and could be more reliable than similar research projects using real situations. Research on the use of VR for diagnostic purposes may be looked into as well. Questionnaires and interviews are normally used as diagnostic tools and, to a lesser extent, BATs, if available. If virtual environments could serve as BATs, this could help detect those stimuli that can be useful in exposure therapy (whether in vivo or by means of VR). Furthermore, it could create a sensitive new measurement of effectiveness, if administered before and after treatment. Obviously, research into virtual environments as a diagnostic tool should be properly evaluated first.

Certainly, VRET should be distinguished from different forms of treatments in which computers are also used. One of them is called computer-assisted vicarious exposure. This consists of directing a person on a computer screen to self-expose him/her to anxiety-provoking situations. Participants identify themselves with this person on the screen that models his/her behavior. A fear thermometer is shown on the screen, which increases while approaching the fearful situation and decreases over time while staying in the situation, simulating habituation. This treatment has been investigated for participants with spider phobia (Dewis et al., 2001; Gilroy, Kirkby, Daniels, Menzies, & Montgomery, 2000; Heading et al., 2001; Smith, Kirkby, Montgomery, & Daniels, 1997) and OCD (Clark, Kirkby, Daniels, & Marks, 1998). Another form of treatment, which has been investigated for participants afraid of flying (Bornas, Tortella-Feliu, Llabres, & Fullana, 2001), uses confrontation to pictures of the fearful object on a computer screen in an idiosyncratic hierarchy. This can be seen as exposing participants to a book of pictures of the fearful objects. Another form of computer-assisted treatment is CBT, by means of the Internet, for PTSD or panic disorder (with or without agoraphobia). No face-to-face contacts are given; e-mail is the only form of communication (Lange, van de Ven, Schrieken, & Emmelkamp, 2001; Lange et al., 2003). Research is needed to compare VRET with these other computer-mediated treatments.

3

Treatment of acrophobia in virtual reality: The role of immersion and presence*

In this study the effects of virtual reality exposure therapy (VRET) were investigated in patients with acrophobia. Feelings of presence in VRET were systematically varied by using either a head-mounted display (HMD) (low presence) or a computer automatic virtual environment (CAVE) (high presence). VRET in general was found to be more effective than no treatment. No differences were found in effectiveness between VRET using an HMD or CAVE. Results were maintained at 6-month follow-up. Results of VRET were comparable with those of exposure in vivo (Emmelkamp et al., 2001). In treatment completers no relationship was found between presence and anxiety. Early drop-outs experienced less acrophobic complaints and psychopathology in general at pre-test. They also experienced less presence and anxiety in the virtual environment used in session one as compared to patients that completed VRET.

*Krijn, M., Emmelkamp, P. M. G., Biemond, R., De Wilde de Ligny, C., Schuemie, M. J., & Van der Mast, C. A. P. G. (2004). Treatment of acrophobia in virtual reality: The role of immersion and presence. *Behaviour Research and Therapy, 42*, 229-239.

3.1 Introduction

Over the last few years, research has been done on the effects of virtual reality graded exposure therapy (VRET). Virtual reality (VR) integrates real-time computer graphics, body tracking devices, visual displays, and other sensory inputs to immerse individuals in a computer-generated virtual environment. In VRET patients are exposed to virtual anxiety provoking environments instead of real anxious situations.

Few controlled studies have evaluated the effectiveness of VRET on specific phobias.

Rothbaum et al. (2000) investigated the effectiveness of VRET compared to standard exposure (SE) or a waiting period (WP) for patients fearful of flying. VRET and SE both included four sessions in which the rationale was explained and breathing techniques, cognitive restructuring and thought stopping was learned. The next four sessions differed between conditions: VRET concentrated on virtual exposure to (a) sitting in the airplane, (b) experiencing take-offs and (c) landings and (d) flying in different weather-types. SE concentrated on real exposure to the airport and pre-flight stimuli and exposure to a stationary aircraft. VRET was found to be as effective as SE and both treatments were more effective than a waiting period. Gains maintained during treatment remained stable at 6- and 12-month follow-up (Rothbaum et al., 2000; Rothbaum et al., 2002). No conclusions can be drawn about the effectiveness of the VR exposure component by itself, unfortunately.

Mühlberger et al. (2001) have also conducted a controlled study on the effectiveness of VRET on fear of flying. Four exposures of 16 min to a virtual flight were compared to relaxation training in a between-group design. Before and after treatment questionnaires and a virtual test flight were given to investigate the treatment effectiveness. Results of this study indicate that VRET was able to elicit fear responses in phobics (measured by SUDS, heart rate and skin-conductance), and these responses decreased within exposures and across repeated exposures. The reduction in fear responses induced by four VR exposure flights was comparable to or even greater than achieved with relaxation training. These two studies indicate that VRET can be an effective component in the treatment of flight phobia.

All other studies with multiple subjects have been conducted on acrophobia. The first study was done with students randomly assigned to either VRET or a waiting list control group (Rothbaum et al., 1995b). VRET was found to be more

effective than a waiting period without treatment. In another study on acrophobia (Emmelkamp et al., 2001) 10 patients were first treated with two sessions of VRET and afterwards with two sessions of exposure in vivo, the golden standard of treatment of phobias. VRET was found to be as effective as exposure in vivo. No firm conclusions could be drawn however, because of the order effect (first VRET than exposure in vivo). In the second study by the same research group a between group design was used (Emmelkamp et al., 2002). Acrophobic patients were treated either with VRET or exposure in vivo. The exact same locations used in exposure in vivo were used in virtual reality to create an optimal comparison between the two kinds of treatment. A significant decline in anxiety and (behavioural) avoidance was found for both three-session treatments. There were no differences in effectiveness. The results remained stable at 6-month follow-up. However, in these earlier clinical studies, no-treatment control groups were lacking.

VRET is based on the assumption that people feel 'present' in the virtual environment. Presence is defined as 'a psychological state or subjective perception in which, even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at *some level* and to *some degree*, her/his perceptions overlook that knowledge and objects, events, entities and environments are perceived as if the technology was not involved in the experience' (Lombard, 2000).

It is held that only if a patient has the feeling to be more present in the virtual anxiety-provoking environment than in the real environment, s/he can experience anxiety. Immersion, the objective qualification of the VR-equipment, is of influence on presence (Schubert, Friedmann, & Regenbrecht, 2001).

The aim of the present experimental study was to compare the effectiveness of two kinds of pure virtual reality exposure therapy in a between group design with acrophobic patients. A waiting list control group was added to examine the effect of time on the severity of acrophobia.

Relatively cheap VR-equipment using a normal PC with head-mounted display (HMD) was used for treatment in one condition. This was compared to VRET using a very advanced computer automatic virtual environment (CAVE). It was

predicted that the degree of presence would be significantly higher using the CAVE-type system than by using the HMD. Furthermore, it was investigated if higher presence would lead to more effective treatment.

3.2 Method

3.2.1 Design

Thirty-seven patients were randomly assigned to one of three groups: VRET using (1) an HMD or (2) a CAVE-system or (3) a waiting list control group. After an intake session and a behavioural avoidance test (BAT) patients received a pre-test followed by three weekly 1.5 h sessions of VRET or a waiting period of 4 weeks. One week after the last session or after a waiting period of 4 weeks the post-test was held. After the post-test patients in the waiting list condition were randomly assigned to three weekly 1.5 h sessions of VRET using either an HMD or CAVE and were reassessed after the treatment period. A follow-up was held 6 months after treatment.

3.2.2 Participants

To participate in this project, all subjects had to meet current diagnostic and statistical manual of mental disorders (DSM-IV) criteria for specific phobia, naturalistic type (APA, 1994). Acrophobia had to be the main complaint. Patients who fulfilled the criteria of panic disorder and/or used tranquillizers or anti-depressants and/or wore glasses stronger than 3.5 were declined for treatment. Moreover patients had to be unable to complete the BAT at pre-test.

Thirty-seven patients were included after the intake and BAT. Twelve patients dropped out during the study because of various reasons; two because they could not find the time to participate in treatment and ten because VRET did not arouse anxiety (failures: n(CAVE) = 3; n(HMD) = 7). Five of these 10 subjects for whom VRET did not arouse anxiety, dropped out after the waiting period. However, the data of their pre- and post-tests (during the waiting period) were used for analysis. For ethical reasons VRET was discontinued and these 10 patients were offered treatment outside the experimental trial.

Thirty patients remained in the study (18 males, 12 females). Five patients dropped out after the waiting period. Twenty-two subjects completed the follow-up as well. The average age of these 30 patients was 50.6 years (*SD* = 9.67). The duration of the acrophobia was 33.5 years (*SD* = 13.26).

3.2.3 Treatment

Virtual reality graded exposure therapy with an HMD was given in a dark laboratory room at the department of Clinical Psychology of the University of Amsterdam. The virtual worlds were generated using a Pentium II 450 MHz Intergraph computer with 128 Mb RAM, 4 Gb hard disk, and two Intergraph Intense 3D Pro 2200 graphic cards, with 16 Mb texture memory. The software used was Sense 8 WorldUp R4, a commonly used VR modelling and visualization toolkit. In all the system was able to generate the display at a rate of about 15-20 frames per second. The worlds were displayed using the Cybermind Visette Pro. Projection was stereographic. The field of view was 70.5º diagonally. Tracking was done with Ascension Flock of Birds. Patients could walk around freely on 1 m2. A railing the patient could hold on to bounded this area. Virtual reality graded exposure therapy by means of the CAVE was given in a dark room at the department of Computer Science of the University of Amsterdam. The CAVE is a multiuser projection-based VR system. In the installation the patient and therapist are surrounded by stereoscopic computer generated images on four sides. Three of these 3 by 3 m images are rearprojected on screens, forming the front and sidewalls of the CAVE. The fourth image is projected on the floor from above.

An SGI Onyx2RealityMonster with eight processors generates the stereoscopic images in the CAVE. The InfiniteReality hardware is among the most powerful general-purpose graphics system available. The computer is equipped with four graphic pipes. The computer that serves the CAVE needs 1/60 of a second to generate two projections (left and right eye) for four walls. Patients wore Crystal Eyes LCD Shutterglasses that lightened and darkened in synchronization with the images on the screen. The synchronization signals were given from a number of infrared emitters placed around the CAVE. The CAVE used an Ascension Technologies Flock of Birds electromagnetic tracking system with a sensor attached to the user's shutter glasses to generate the correct perspective view.

Treatment consisted of three sessions of 1.5 h. In each session the patient was exposed to the virtual environment(s) for 1 h (with a 10-min break in the middle to avoid simulator sickness). The rest of the time was used for instructions, loading each virtual environment and filling in questionnaires. At the beginning of session one the rationale of the exposure-program was explained as also the operation of the system. Patients were introduced to virtual reality on ground level of the first virtual environment (VE). Four VEs were created for treatment and used in a gradual order; a shopping mall with four floors (Figure 3.1), a fire escape with six floors in open space (Figure 3.2), a roof garden on a building (Figure 3.3) and a virtual building site with eight floors (Figure 3.4).

Figure 3.2 Fire escape

Figure 3.1 Shopping mall

To give patients a gradual and optimal exposure treatment, patients had to rate their anxiety regularly during the exposure therapy by means of SUDS (0-10). Patients were instructed during treatment to expose themselves to the anxiety provoking situations in a gradual manner. After habituation or a relatively low SUD (usually below two) patients were encouraged to take a next step (for instance move up one floor, or take their hands off the railing). Only exposure techniques were used and encouragement was given during treatment, no cognitive interventions or relaxation was given. Patients were instructed to become as involved as possible and focus on the most frightening stimuli of this particular part of the virtual environment (for example, looking down, describing the situation and their feelings). This was done to avoid dissociation from the VR experience. In order to study the effects of pure VRET, patients did not receive homework instructions, and practising in vivo between sessions at home was not encouraged.

Figure 3.3 Roof garden

Figure 3.4 Building site

3.2.4 Assessment

3.2.4.1 Intake

The section anxiety disorders of the *structured clinical interview for DSM-IV Axis I Disorders* (SCID-I; First et al., 1996) was used in the intake session. The *symptom check list 90 revised* (SCL-90) (Derogatis, 1997) was included as a screening instrument for additional psychopathology. No subject had to be excluded because of severe additional psychopathology.

3.2.4.2 Pre-, post- and follow-up

Questionnaires were used to evaluate the effects of treatment. In addition a *behavioural avoidance test* (BAT) was conducted to measure avoidance behaviour in height situations before and after treatment (or a waiting period). The BAT consisted of walking a fire escape (with a maximum of six floors) as high as a patient was able to, while looking over a railing at ground level continuously. When a patient could not walk any further, because their anxiety became intolerable or the stairs was finished, (s)he was instructed to come down on her/his own. The number of stairs a person had climbed was taken as outcome-measure (range 0-72).

All questionnaires were used before and after treatment (or a 4-week waiting period), at post-test and at follow-up (6 months later). (1) The *acrophobia questionnaire* (AQ; Cohen, 1977) was used, measuring anxiety in height situations

(range 0-20; α = 0.80), and avoidance of height situations (range 0-40); α = 0.70). (2) The *attitude towards height questionnaire* (ATHQ; Abelson & Curtis, 1989) assessed the attitudes from the patients towards height situations (range 0-60; α = 0.81).

3.2.4.3 Within sessions

In each session feelings of presence and state anxiety were measured twice, halfway through the session and after the session.

Presence was measured with the *Igroup presence questionnaire* (IPQ; Schubert, Friedmann and Regenbrecht, 1999). State anxiety was measured in both conditions with the Dutch version of the *state trait anxiety inventory* (STAI; van der Ploeg, 1980).

3.3 Results

3.3.1 Waiting list vs. VRET

To investigate whether VRET was more effective than no-treatment, the HMD and CAVE subjects were pooled. Means and standard deviations are presented in Table 3.1. A 2 (time: pre vs. post) by 2 (condition: VRET vs. WL) MANOVA showed that there was a significant time-effect, $F(4, 23) = 7.302$; $p = 0.001$ and interaction effect between time and condition, $F(4, 23) = 4.040$; $p = 0.01$. Univariate analyses showed that this effect was significant on all main measures, namely the AQ-Anxiety, AQ-Avoidance, the ATHQ and the BAT (see Table 3.1). Thus, VRET was significantly more effective than no treatment. Comparison of the pre-test and the post-test of the waiting condition with paired t-tests, showed that there were no significant differences on any of the measures. The post-test of the waiting group could thus be taken as pre-test for the treatment received afterwards. Habituation effects to the BAT procedure can also be ruled out, because there were no differences whatsoever.

Table 3.1 Means (SD) of VRET and Waiting list-condition and univariate analyses of time-effect and time by condition effect

Measure	Condition	Pre test	Post-test	Time			Time x condition		
				F	df	*p*	*F*	df	*p*
AQ-Anxiety	WL	52.27 (17.95)	55.41 (13.53)	2.559	1, 26	0.122	7.304	1, 26	0.012
	VRET	59.71 (14.12)	47.47 (16.87)						
AQ-Avoidance	WL	14.91 (2.51)	14.00 (4.86)	18.94	1, 26	0.000	10.407	1, 26	0.003
	VRET	16.47 (5.94)	10.35 (4.47)						
ATHQ	WL	46.82 (9.70)	46.45 (10.49)	6.122	1, 26	0.020	5.484	1, 26	0.027
	VRET	47.11 (9.89)	33.88 (10.95)						
BAT	WL	34.64 (11.63)	35.00 (12.50)	13.487	1, 26	0.001	12.499	1, 26	0.002
	VRET	31.00 (14.12)	50.12 (21.50)						

n(WL) = 11; *n*(VRET) = 17. AQ-Anxiety = Acrophobia Questionnaire, Anxiety Scale; AQ-Avoidance = Acrophobia Questionnaire, Avoidance Scale; ATHQ = Attitude Towards Heights Questionnaire.

3.3.2 VRET: HMD vs. CAVE, pre-, post- and follow-up

Subjects who received treatment directly and those who received treatment after the waiting period were pooled into two groups (VRET/CAVE and VRET/HMD).

A 2 (time: pre vs. post) by 2 (VR type: HMD vs. CAVE) MANOVA revealed a significant time-effect, $F(4, 19) = 15.953$; $p < 0.001$, but neither a condition-effect, $F(4, 19) = 1.751$; $p = 0.181$, nor an interaction effect, $F(4, 19) = 0.743$; $p = 0.574$. Means and standard deviations are presented in Table 3.2. Univariate analyses (see Table 3.2), revealed also that VRET was effective in the treatment of acrophobia and the equipment used did not make a difference in treatment effectiveness.

Between post-test and follow-up a significant time effect was found by means of a MANOVA for repeated measures ($F(3, 18) = 3.253$; $p = 0.046$). Univariate ANOVAs for repeated measures however, showed that this significant time effect was not found on any single measure (AQ-Anxiety: $F(1, 20) = 0.346$; $p = 0.563$; AQ-Avoidance: $F(1, 20) = 1.182$; $p = 0.290$; ATHQ: $F(1, 20) = 1.846$; $p = 0.189$). This indicated that the gains made during treatment remained rather stable at 6-month follow up. No significant condition or interaction effects were found.

Table 3.2 Means (SD) of VRET/CAVE and VRET/HMD and univariate analysis of time-effect pre-post

Measure	Condition	Pre test	Post-test	Time		
				F	df	*p*
AQ-Anxiety	CAVE	59.86 (13.72)	46.79 (18.11)	28.630	1, 22	0.000
	HMD	60.35 (13.78)	42.80 (13.07)			
AQ-Avoidance	CAVE	17.14 (6.01)	10.50 (5.10)	53.848	1, 22	0.000
	HMD	14.60 (4.20)	7.30 (3.43)			
ATHQ	CAVE	48.57 (8.83)	34.93 (12.00)	15.299	1, 22	0.001
	HMD	42.30 (11.28)	33.00 (6.75)			
BAT	CAVE	28.00 (11.33)	47.14 (19.92)	38.362	1, 22	0.000
	HMD	37.80 (13.64)	57.60 (17.71)			

n(CAVE) = 14; *n*(HMD) = 10 (missing data of one subject). AQ-Anxiety = Acrophobia Questionnaire, Anxiety Scale; AQ-Avoidance = Acrophobia Questionnaire, Avoidance Scale ATHQ = Attitude Towards Heights Questionnaire.

A univariate repeated measures analysis was done to investigate if there was any time or condition or interaction-effect on the IPQ. The results show that there was a significant condition-effect ($F(1, 20) = 8.024$; $p = 0.010$) which means that therapy given in the CAVE resulted in more presence than therapy given with an HMD. Means and standard deviations are presented in Table 3.3. Finally, no significant correlations were found between state-anxiety and presence in any session.

Because of the relatively large amount of dropouts, these data were used to analyze the differences between drop-outs (failures) and patients that did finish the total VR-treatment (completers). Only those dropouts ($n = 10$) were used that did not complete virtual reality treatment because no anxiety was provoked. On the pre-test data treatment completers scored significantly higher on the AQ-anxiety, $t(34) = 2.151$; $p = 0.04$, and a trend towards significance was found on the AQ-avoidance scale, $t(33) = 1.859$; $p = 0.07$. Completers also experienced more general psychopathology before treatment, measured with the SCL-90, than failures did; $t(25.37) = 2.254$; $p = 0.03$. Failures experienced significantly less presence during the first half of session one as compared to completers, $t(31) = 6.850$; $p < 0.001$). A trend towards significance was found for state anxiety. Patients that completed treatment experienced more anxiety during the first half hour in session one than patients for whom treatment failed, $t(31) = 1.893$; $p = 0.07$.

Table 3.3 Means (SD) of the IPQ-scores in session 1, 2 and 3.

Total IPQ	Session 1	Session 2	Session 3
CAVE	63.79 (10.70)	63.96 (12.25)	62.50 (14.40)
HMD	52.90 (11.54)	48.75 (12.14)	51.35 (8.37)

n(CAVE) = 12; *n*(HMD) = 10. IPQ = Igroup Presence Questionnaire.

3.4 Discussion

This is the first study in which VRET is compared with a no-treatment control group in clinically distressed patients with acrophobia. Only data from patients for whom VRET induced anxiety were used in the analyses comparing HMD vs. CAVE.

VRET was superior to no-treatment on anxiety, (behavioural) avoidance and attitudes towards heights. No differences in effect were found between VRET by means of a CAVE (high presence induction) or an HMD (low presence induction) and results remained stable up to 6-month follow-up. Visual inspection of the means and *SDs* at follow-up reveal that the HMD-condition showed a small decline in treatment effect while the CAVE-condition remained stable.

It must be noted that this study was conducted as an experimental trial to investigate if there were any differences in effectiveness between HMD and CAVE. It cannot be considered as a clinical trail per se. Nevertheless, looking at other studies on treatment of acrophobia, the effectiveness found in this study was in the same range as in the Emmelkamp et al. study (2002) where exposure in vivo was given in three sessions of 1 h each.

The role of presence in moderating successful outcome of VR treatment, so often assumed by different authors (Schubert et al., 1999; Schuemie et al., 2000; Wiederhold & Wiederhold, 2000), did not have any effect on treatment effectiveness in this study. Although the experimental manipulation (HMD vs. CAVE) was successful in creating different levels of presence, this did not lead to enhanced treatment outcome. There were no correlations found between presence and anxiety during the sessions. Some studies did find a linear relationship between presence and anxiety experienced (Schuemie et al., 2000), but others, like this study have not (Regenbrecht et al., 1998).

Failures experienced less acrophobic complaints and psychopathology at pre-test (measured by means of the AQ and SCL-90) than did patients who finished therapy successfully. Further, failures experienced less presence and less anxiety in the first half of the first session. This could suggest that for less severe height-phobic cases VRET is not indicated. Taken together, it might be that some level of presence is necessary to generate anxiety, but a higher level of presence might not enhance the anxiety experienced and hence not lead to a better emotional processing or more effective treatment.

Furthermore, it should be noted that failure rates were different for the CAVE- vs. HMD-condition, but this difference was not significant (X^2 (1) = 1.6, p = 0.21). Perhaps, for less severe acrophobic patients, who have trouble experiencing presence by means of an HMD, VRET in the CAVE can be a more effective option. Based on clinical experience though, the majority of patients with acrophobia can feel present in a height virtual environment using an HMD (e.g. Emmelkamp et al., 2001; 2002).

The results of the present study are in line with the two studies published earlier (Emmelkamp et al., 2001; 2002). In the Emmelkamp et al. study (2002) the same treatment protocol was used when comparing VRET using HMD to exposure in vivo. VRET was found to be as effective as exposure in vivo (Emmelkamp et al., 2002). As to the cost-effectiveness, HMD virtual reality treatment is much cheaper than VRET using a CAVE or the current golden standard exposure in vivo. HMDs are more compatible, much cheaper and easier to use in the therapist's office. The practical use of an HMD is much easier and treatment effectiveness is as good as with the CAVE or treatment outside the therapist's office. The real drawback though is that VR does not elicit anxiety in a substantial number of patients (10 of 35). This is a concern for the validity of the VR treatment in question.

In future research, larger amounts of subjects should be used and more sessions should be given before firm conclusions about VRET's effectiveness on fear of heights and its clinical relevance can be drawn. A BAT was used in order to investigate generalisation to the real world. This assessment, however, might be improved upon in future studies by adding SUD-ratings.

4

Cognitive behaviour therapy versus behaviour therapy of specific phobias in virtual reality

There is a clear need for more detailed analysis of the role of cognitive restructuring in virtual reality exposure therapy (VRET). To date no research on this topic has been done. The primary aim of this study was to investigate the effectiveness of VRET and the possible additional effectiveness of cognitive techniques: coping self-statements. In a randomized crossover design 40 patients with DSM-IV specific phobias (acrophobia or fear of flying) were randomly assigned to two sessions of VRET followed by two sessions of VRET plus coping self-statements or the other way around: first two sessions of VRET plus coping self-statements followed by two sessions of VRET. Results showed that VRET, regardless of addition of cognitive techniques, decreased anxiety and negative phobic cognitions and increased self-efficacy.

4.1 Introduction

Exposure therapy is the golden standard in treating patients with specific phobias (e.g., Craske & Rowe, 1997). Patients are confronted (either graded or by means of flooding) with situations or stimuli they are afraid of. When avoidance of these phobic stimuli is prohibited anxiety will habituate and the situation will progressively being experienced as more neutral (Emmelkamp, 2004).

Some information is available on the effectiveness of cognitive therapy in the treatment of specific phobias and, more specifically, whether cognitive techniques enhance the effects of exposure in vivo. Three studies (de Jongh et al., 1995; Booth & Rachman, 1992; Öst, Alm, Brandberg, & Breitholtz, 2001) showed that cognitive interventions were effective as a treatment for subjects fearful of dental procedures or enclosed spaces, compared to a waiting list group. Moreover, cognitive interventions were found to be as effective as exposure in vivo for claustrophobics (Booth & Rachman, 1992; Öst et al., 2001). In acrophobics, cognitive exposure was found to be superior to exposure in vivo alone on subjective anxiety and cognitions during a behavioural avoidance test. However, cognitive techniques if added to exposure therapy did not enhance actual approach behaviour (Emmelkamp & Felten, 1985). Others showed that cognitive restructuring itself was less effective than guided exposure for subject fearful of heights, elevators or darkness (Biran & Wilson, 1981). Finally, one study showed that cognitive techniques plus exposure was less effective than pure exposure for subjects with animal phobia (Ladouceur, 1983). Taken together, results are mixed and no conclusions with regards to the effectiveness of cognitive therapy or exposure in vivo plus cognitive therapy for specific phobias can be drawn.

A recent development in behaviour therapy of specific phobias is exposure by means of virtual reality (VR). Patients are not confronted with real anxiety-provoking stimuli but with their virtual counterparts. Virtual reality integrates real-time computer graphics, body tracking devices, visual displays and other sensory input devices to immerse patients in a computer-generated virtual environment. There are many advantages of virtual reality exposure therapy (VRET) over exposure in vivo such as cost-effectiveness (for instance in the treatment of fear of flying), the possibility of generating more gradual assignments (sequence and intensity of treatment), creating

idiosyncratic exposure, and ample opportunity of repeating exposure-assignments over and over again. Disadvantages of VRET can be dropout rates (some subject find it impossible to become immersed in the virtual environment), possibility of simulation sickness and prize of equipment (although this declines steadily).

Most research on VRET as standalone treatment is based on case studies. In the last few years more randomised, controlled effectiveness-studies have been conducted, which strengthen the conclusions on the effectiveness of VRET. It has been shown that exposure by means of virtual reality is more effective than a waiting period for (1) fear of flying (Rothbaum et al., 2000; Rothbaum et al., 2002; Krijn et al., chapter 5), (2) acrophobia (Rothbaum et al., 1995b; Krijn et al., 2004) and (3) claustrophobia (Botella et al., 2000), Moreover, VRET was found to be as effective as exposure in vivo for acrophobia (Emmelkamp et al., 2001; 2002). In other research VRET plus cognitive therapy was evaluated and compared to exposure in vivo plus cognitive techniques. There were no differences between those two treatment programs as a package in fear of flying (Rothbaum et al., 2000; Rothbaum et al., 2002). In a study by Mühlberger et al. (2003) VRET plus cognitive treatment was compared to cognitive treatment alone in one long session. Post-treatment and six-month follow-up assessments revealed reduced fear of flying only in the VRET group, not in the pure cognitive therapy group. Finally, in a study by Maltby et al. (2002) VRET plus anxiety management training was compared to a placebo group training, with superior results of the VRET condition compared to the placebo group on four out of five measures at post-test. However, at 6-month follow-up most group differences had disappeared.

Results of cognitive restructuring in the abovementioned studies are difficult to evaluate since an amalgam of different cognitive techniques was used. In the study by Rothbaum et al. (2000) a rich variety of cognitive techniques were taught during session one to four and included a number of anxiety management training components, i.e. information gathering, treatment planning, explanation of the rationale of treatment, breathing retraining, cognitive restructuring, thought-stopping and hyperventilation exposure (if the patient had a history of panic attacks). In the study by Mühlberger et al. (2003) cognitive techniques were taught in one 60-minutes session, in which an information booklet was given, catastrophic thoughts were analyzed, feelings and bodily symptoms were discussed and questions could be asked about the concepts of anxiety and exposure. In the study by Maltby et al. (2002)

anxiety management training consisted of an information booklet, imaginal relaxation, progressive muscle relaxation, the development and use of rational responses to counter anxiety-provoking thoughts and images about flying.

There is a clear need for more detailed analysis of the role of cognitive restructuring in VR exposure. Moreover, a distinction should be made between cognitive restructuring, and anxiety management training, including relaxation techniques. To date no research has been done, in which VRET is compared to VRET plus pure cognitive techniques, which are used during sessions of exposure.

The primary aim of this study is to investigate the effectiveness of VRET and the possible additional effectiveness of cognitive techniques: coping self-statements. In a randomized crossover design patients with DSM-IV specific phobias (acrophobia or fear of flying) were assigned to two sessions of VRET followed by two sessions of VRET plus coping self-statements or the other way around: first two sessions of VRET plus coping self-statements followed by two sessions of VRET. It was expected that VRET, with or without the addition of cognitive techniques, would be effective as treatment of specific phobias. No specific predictions on the possible differences in effectiveness were made, because of inconsistent results of past research on the addition of cognitive techniques to exposure in vivo and scarce information on the addition of pure cognitive techniques to VRET.

4.2 Method

4.2.1 Design

After an intake session by a clinical psychologist, a pre-test followed after which subjects were randomly assigned over two conditions, (1) two sessions of VRET followed by two sessions of VRET plus cognitive techniques or (2) two sessions of VRET plus cognitive techniques followed by two sessions of VRET. All sessions were given weekly and took about 1.5 hour; one hour of exposure, 10 minute break in between and 20 minutes to fill in questionnaires. The first cognitive session took half an hour longer to explore idiosyncratic cognitions and create more neutral self-statements. In between session two and session three an intermediate test was held. In

the week after the last session a post-test was held and six months after treatment a follow-up test was held.

4.2.2 Participants

To participate in this project subjects had to meet current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria for specific phobia, i.e. fear of flying or acrophobia (APA, 1994). Subjects were excluded if they met criteria of posttraumatic stress disorder or acute stress disorder (not related to fear of flying or acrophobia), panic disorder and/ or severe agoraphobia. Subjects were also excluded if they had suicidal tendencies, did not want to stabilise their antidepressant medication during the course of treatment or were unable to discontinue the use of benzodiazepines. For technical reasons, because of the virtual reality equipment, subjects with glasses stronger than 3.5, epilepsy or pacemakers, were also excluded.

4.2.3 Treatment

Virtual reality graded exposure therapy with a head-mounted display was given in a dark laboratory room at the department of Clinical Psychology of the University of Amsterdam. The virtual worlds were generated using a Pentium-II 450 MHz computer with 128Mb RAM, 4 Gb hard disk, and a 3D-Labs Oxygen GVX-420 graphics card with 128Mb video memory and dual-monitor support. The software used was Sense 8 WorldUp R4, a commonly used VR modelling and visualisation toolkit. In all the system was able to generate the display at a rate of about 15 to 20 frames per second. The worlds were displayed using the Cybermind Visette Pro. Projection was stereographic. The field of view was 70.5 degrees diagonally. Tracking was done with Ascension Flock of Birds.

Two virtual environments (VEs) were created for fear of flying: an airport (Schiphol, Amsterdam airport) and an aircraft (Figure 4.1 and Figure 4.2). In the first VE of fear of flying (airport), patients could walk around freely on one square meter. A railing that the patient could hold on to bounded this area. In the second VE patients were seated in an aircraft chair that vibrated during take-off, turbulence and landing.

Three VEs were created for treatment of fear of heights and were used in a gradual order: a fire escape with six floors in open space, a roof garden on a building,

and a virtual building site with eight floors. Patients could walk around freely on one square meter in all height VEs. A railing the patient could hold on to bounded this area.

Figure 4.1 Take off

To give patients a gradual and optimal exposure treatment, patients had to rate their anxiety regularly during the exposure therapy by means of SUDs (0-10). Patients were instructed during treatment to expose themselves to the anxiety-provoking situations in a gradual manner. After habituation as evidenced by a relatively low SUD, patients were encouraged to take a next step (for instance move up one floor or take off by aircraft). In the two sessions of VRET only exposure was used during treatment, no cognitive interventions or relaxation was given. In the two sessions of VRET plus cognitive techniques, the rationale of cognitive therapy was explained briefly and anxiety-provoking cognitions were examined and more neutral self-statements were formulated. During virtual reality exposure questions about cognitions of the subjects were asked and subjects were instructed to use the formulated neutral self-statements during the exposure.

In order to study the effects of pure VRET and/ or VRET plus cognitive techniques, patients did not receive homework-instructions in either condition, and practising in vivo between sessions at home was not encouraged.

Figure 4.2 Cabin

4.2.4 Assessment

4.2.4.1 Intake

The section of anxiety disorders of the Structured Clinical Interview for DSM-IV Axis I disorders (SCID-I; First et al., 1996) was used in the intake session. The Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) was used to screen for depressive symptoms. In the intake session imaginal exposure to the most frightening phobic situation of each subject was used to list cognitions that were anxiety inducing and could be used in cognitive restructuring during VRET plus cognitive techniques. This took a few minutes.

4.2.4.2 Pre-test, intermediate test, post-test and follow-up

Questionnaires were used at pre-test, intermediate test, post-test and follow-up to evaluate the effectiveness of treatment.

The *Flight Anxiety Situations Questionnaire* (FAS; Van Gerwen et al., 1999) was used to measure anxiety related to flying experienced in different situations. The FAS is a 32-item self-report inventory with a 5-point Likert scale ('no anxiety' to 'overwhelming anxiety'). The questionnaire consists of three subscales: 1) Anticipatory Flight Anxiety Scale, measuring anxiety experienced when anticipating

an aircraft flight (14 items); 2) an In-flight Anxiety Scale, measuring anxiety experienced during a flight (11 items); and 3) a Generalised-Flight Anxiety Scale, measuring anxiety experienced in connection to aircraft in general, regardless of personal involvement in a flight situation (7 items). The psychometric properties of the FAS were proven to be good (van Gerwen et al., 1999).

Fear of heights was measured with the *Acrophobia Questionnaire* (AQ) (Cohen, 1977), measuring anxiety in height situations (range: 0-120, α = .80).

A *self-efficacy questionnaire* was constructed. The questionnaire consisted of five items on self-efficacy in a real phobic situation (standing on a fire escape on the sixth floor or sitting in an aircraft to Rome). The items had five themes: the capability to: (1) reduce fear, (2) think clearly, (3) control your actions, (4) control anxious images or thoughts, (5) stay in the situation for two minutes while panicking or with intense fear (range: 0 – 500, α = 0.87 – 0.98).

4.2.4.3 Within VRET-sessions

Questionnaires were also used to measure changes within each treatment session.

The same self-efficacy questionnaire as at pre, intermediate, post-test and follow-up was now used before and after every session.

To measure presence during VRET the *Igroup Presence Questionnaire* (IPQ) was used (Schubert et al., 2001). This questionnaire consisted of 14 items that measured the feeling of being in the virtual environment (α = 0.85-0.87). Each item was scored on a 7-point Likert-type scale ('totally disagree' to 'totally agree').

A *cognition questionnaire* was developed for fear of flying and fear of heights respectively, based on the cognition questionnaire of agoraphobia (Van Hout, Emmelkamp, Koopmans, Bögels, & Bouman, 2001). This questionnaire was filled in after every treatment session. Each item was scored on a 5-point Likert-type scale ('not al all' to 'constantly'). The questionnaires consisted of 24 (fear of heights) and 30 (fear of flying) items with an internal consistency of α = 0.77-0.89 (acrophobia), and α = 0.79 – 0.92 (fear of flying).

Subjective units of discomfort (0-10) were rated every five minutes during a session. The first six SUDs were added to evaluate the subjective anxiety by session (range: 0-60).

4.2.5 Methods of Analysis

Possible differences in anamnestic and dependent variables between orders at baseline were analyzed with Chi-square analysis or ANOVAs, when appropriate.

To be able to create one dependent variable for both groups (acrophobics and participants fearful of flying) a new variable was composed. This variable, measuring anxiety of phobic situations, consisted of the sum of the standardized scores on the FAS and AQ-anxiety scale. This variable was chosen on an a priori basis for testing the hypotheses.

The standardised anxiety scores from the crossover trial were analyzed in two stages. In the first stage, an order effect was tested by a main effect of order. Repeated measures analyses were used for a main effect of time and interaction effects of time by order to test the difference between VRET and VRET plus cognitive techniques. To evaluate the stability of change, a repeated measure analysis was run on the standardized anxiety scores and self-efficacy measure between post-test and 6-month follow-up. The within group effect sizes of the changes on the standardized anxiety score (Z-anxiety) and self-efficacy questionnaire were analysed by computing Cohen's *d* (Cohen, 1988). Cohen's *d* is the difference between the two means being compared, divided with their pooled standard deviations. Cohen (1988) has suggested that $d = 0.20$ can be considered to indicate a small effect, $d = 0.50$ a medium effect and $d = 0.80$ a substantial effect.

To be able to create one dependent variable to assess cognitions within sessions for both groups (patients with acrophobia and fear of flying) a new variable was composed. This variable, measuring cognitions in phobic situations, consisted of the sum of the standardized scores on the acrophobic and fear of flying cognition questionnaire. To evaluate the effects of treatment within sessions the data on the SUDS, cognition questionnaire, self-efficacy questionnaire and IPQ were analyzed in two stages. In the first stage, the potential of an order effect was tested by a main effect of order in a repeated measures analysis. In the second stage repeated measures analyses were used to test for possible changes between sessions on the different questionnaires by means of testing for main effects of time and interaction effects of time by order.

Pearson's correlation coefficients were calculated to investigate whether a relationship existed between SUDs and negative cognitions, SUDs and presence and SUDs and self-efficacy.

4.3 Results

4.3.1 Participants characteristics

In total 57 subjects registered for participation, of which six subjects were rejected, because of a variety of reasons: eye problems (*n* = 2), a diagnosis of panic disorder with agoraphobia (*n* = 2), heart disease (*n* = 1) and unstable antidepressant medication (*n* = 1). 51 subjects were included in the study, 31 subjects with fear of heights and 20 subjects with fear of flying. 11 patients dropped out during the therapy because of various reasons. Of the fear of heights patients seven dropped out, four because VRET did not arouse anxiety (two in cognition first condition, two in exposure first condition) and one dropped out because of simulation sickness during treatment. For ethical reasons VRET was discontinued and these five patients were offered treatment outside the experimental trial. Two subjects dropped out because of personal reasons, unrelated to VRET.

In the fear of flying group four subjects dropped out, three because VRET did not arouse anxiety (two in cognition first condition, one in exposure first condition). For ethical reasons VRET was discontinued. One subject dropped out because of personal reasons unrelated to VRET. Follow-up data is missing of five patients (three acrophobics and two patients fearful of flying). Comparison between dropouts and the completers on background data and pre-treatment scores of the outcome measures revealed no significant differences.

40 patients remained in the study (20 males, 20 females), 26 subjects with acrophobia and 14 subjects with fear of flying. The average age of the patients was 46.93 years (*SD* = 12.68). No significant differences were found on the anamnestic variables and dependent variables at baseline between order (VRET first or cognition first). Descriptive statistics are presented in Table 4.1.

Table 4.1 Descriptive statistics of age, sex, phobia and dependent variables at pre-test by order of completers.

Order	Sex (% male)	Phobia (% acrophobia)	Age	Z-anxiety pre-test	Self-efficacy pre-test
VRET first (*n*= 21)	57	66	47.00 (14.42)	0.69 (1.47)	199.19 (132.66)
Cog first (*n*= 19)	42	63	46.84 (10.84)	0.94 (1.18)	171.84 (121.91)

Cog first = VRET plus cognitive techniques first.

4.3.2 Effectiveness of treatment

A 2 (order) by 3 (time) repeated measure analysis was run to evaluate order effects, treatment effectiveness and differences in treatment effectiveness on the standardized anxiety scores (Z-anxiety). Because of a violation of the sphericity assumption, adjusted degrees of freedom were used for analysis of within subject data. It was found that there was no significant effect of order, $F(1, 38) = 1.06$, $p = 0.31$ and no interaction effect of order by time, $F(2, 76) = 0.55$, $p = 0.58$, indicating no order effect, and no difference in effectiveness of treatment between those who received VRET followed by VRET plus cognitive techniques and those who received VRET plus cognitive techniques followed by VRET. A significant effect of time was found, indicating that treatment reduced anxiety ($F(2, 76) = 56.96$, $p < 0.001$). Post hoc analyses showed that the time effect was significant between pre and intermediate test ($F(1, 38) = 48.09$, $p < 0.001$) and between intermediate and post-test ($F(1, 38) = 33.04$, $p < 0.001$). This indicates that both treatment blocks reduced anxiety.

A 2 (order) by 3 (time) repeated measure analysis was also run to evaluate order effects, treatment effectiveness and differences in treatment effectiveness on the self-efficacy questionnaire. It was found that there was no significant effect of order, $F(1, 38) = 0.36$, $p = 0.55$, and no interaction effect of order by time, $F(2, 37) = 0.021$, $p = 0.81$, indicating no order effect, and no difference in effectiveness of treatment between those who received VRET followed by VRET plus cognitive techniques and those who received VRET plus cognitive techniques followed by VRET on self-efficacy. A significant effect of time was found, indicating that treatment improved self-efficacy ($F(2, 37) = 30.35$, $p < 0.001$. Post hoc analyses showed that the time

effect was significant between pre- and intermediate test ($F(1, 38) = 35.52$, $p < 0.001$) and between intermediate and post-test ($F(1, 38) = 9.28$, $p = 0.004$). This indicates that both treatment blocks increased self-efficacy. Mean, *SD* and Cohen's *d* of Z-anxiety and self-efficacy can be found in Table 4.2.

Separate analysis for each type of phobia (acrophobia or fear of flying) revealed identical results.

Table 4.2 Mean, SD and Cohen's d on the pre-, intermediate and post-test of Z-anxiety and self-efficacy.

Dependent variable	Order	Pre-test	Intermediate test	Post-test	*d* (pre-inter)	*d* (inter-post)	*d* (pre-post)
Z-anxiety	VRET first	0.69 (1.15)	-0.04 (1.26)	-1.10 (0.97)	0.61	0.95	1.69
	Cogn first	0.94 (1.18)	0.16 (1.20)	-0.60 (1.06)	0.66	0.67	1.38
Self-efficacy	VRET first	199.19 (132.66)	296.76 (133.02)	339.19 (140.51)	0.73	0.31	1.03
	Cogn first	171.84 (121.91)	268.16 (117.80)	333.16 (111.27)	0.80	0.57	1.38

n (VRET first) = 21; *n* (cog first) = 19, inter = intermediate, Cog first = VRET plus cognitive techniques first.

4.3.3 Long-term effects

A repeated measures analysis (post-test versus follow-up) showed no significant effect of time, $F(1, 33) = 0.29$, $p = 0.59$ and no interaction effect of time by order, $F(1, 33) = 0.000$, $p = 0.99$ on Z-anxiety. The same pattern was found on the self-efficacy questionnaire, with no significant effect of time, $F(1, 33) = 1.52$, $p = 0.23$ and no interaction effect of time by order, $F(1, 33) = 0.38$, $p = 0.54$. This result indicates that gains made during treatment remained stable at 6-months follow-up. See Table 4.3 for means and *SDs* of Z-anxiety and self-efficacy.

However, results showed a different pattern if analyses were run for each group separately (acrophobia or fear of flying). Between post-test and follow-up patients with fear of flying remained stable on anxiety ($F(1, 10) = 0.72$, $p = 0.42$) and a trend towards significance was found on the self-efficacy questionnaire ($F(1, 10) = 3.96$, $p = 0.075$), indicating further improvement on self-efficacy. However, patients with acrophobia experienced more anxiety, al be it marginally significant ($F(1, 21) = 3.37$, $p = 0.08$), as well as a decline in self-efficacy ($F(1, 21) = 5.37$, $p = 0.03$).

Table 4.3 Mean and SD of Z-anxiety at post-test and follow-up.

Order	Z-anxiety score post-test (*SD*)	Self-efficacy post-test (*SD*)	Z-anxiety score follow-up (*SD*)	Self-efficacy follow-up (*SD*)
VRET first (*n* = 19)	-0.21 (0.86)	354.89 (129.88)	-0.12 (1.02)	330.11 (164.59)
Cog first (*n* = 16)	0.16 (0.94)	331.50 (116.60)	0.24 (1.46)	323.25 (149.12)

Cog first = VRET plus cognitive techniques first.

4.3.4 Within sessions

4.3.4.1 Subjective Units of Discomfort

A 2 (order) by 4 (time) repeated measures analyses on the data of the SUDs showed no significant results. No effect of order, time or an interaction effect of time by order was found. These results indicate a stable pattern of SUD-scores in both conditions. See Table 4.4 for repeated measures analyses and table 5 for means and *SDs* of SUDs by session.

Table 4.4 Repeated measures analysis of the SUD data.

Factors	df	*F*	p
Order	1, 24	0.26	0.62
Time by order	3, 22	0.89	0.46
Time	3, 22	1.62	0.21

n (VRET) = 15, *n* (Cog) = 11, Cog = VRET plus cognitive techniques first.

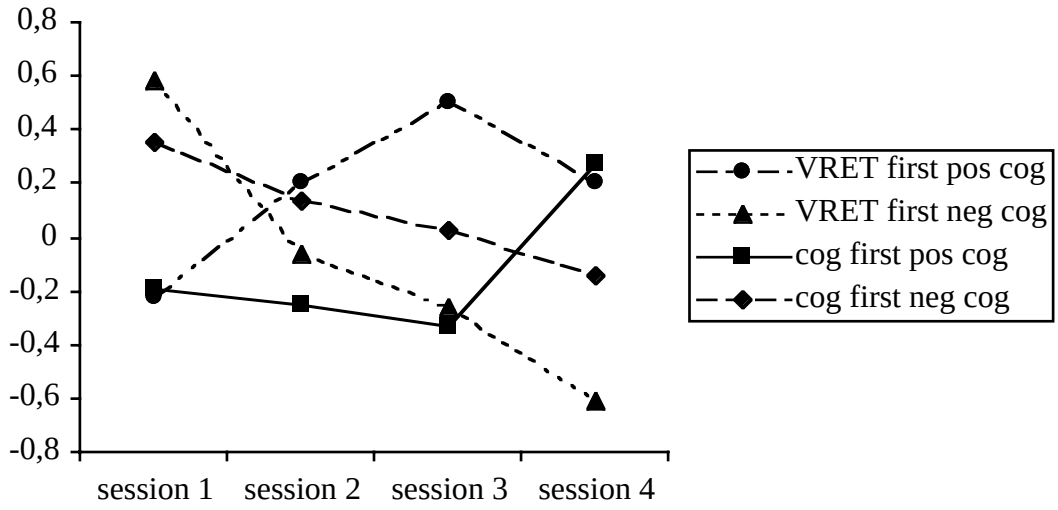
4.3.4.2 Cognition

A 2 (order) by 4 (time) repeated measure analysis was run to investigate the effect of order and time and their interaction effect on the negative and positive cognition scale. Because of a violation of the sphericity assumption, adjusted degrees of freedom were used for analysis of within subject data. No significant effect of order was found on the negative cognition scale, $F(1, 35) = 0.30$, $p = 0.59$ and no interaction effect of time by order was found, $F(3, 105) = 1.36$, $p = 0.26$. However, a significant effect of time was found on this scale, $F(3, 105) = 7.74$, $p < 0.001$, indicating that negative cognitions decreased over sessions. Post hoc analyses showed

a significant effect of time between session 1 and 2, $F(1, 35) = 4.52$, $p = 0.04$ and between session 3 and 4, $F(1, 35) = 4.23$, $p = 0.047$. No significant time-effect was found between session 2 and 3.

On the positive cognition scale, no order effect was found, $F(1, 35) = 1.25$, $p = 0.27$. However, a marginally significant interaction effect between order and time was found, $F(3, 105) = 2.41$, $p = 0.07$. This indicates that the order in which treatment was received, influenced the amount and/ or intensity of positive cognitions reported. Post hoc analysis showed a significant interaction effect between session 3 and 4, $F(1, 35) = 5.20$, $p = 0.029$, indicating a decline in positive cognitions for patients receiving VRET plus cognitive techniques and an increase in positive cognitions for patients receiving VRET. No significant effect of time was found ($F(3, 105) = 1.53$, $p = 0.21$. See Figure 4.1 for means on positive and negative cognitions by order.

Figure 4.1 Mean of the positive and negative cognition questionnaire after every session.



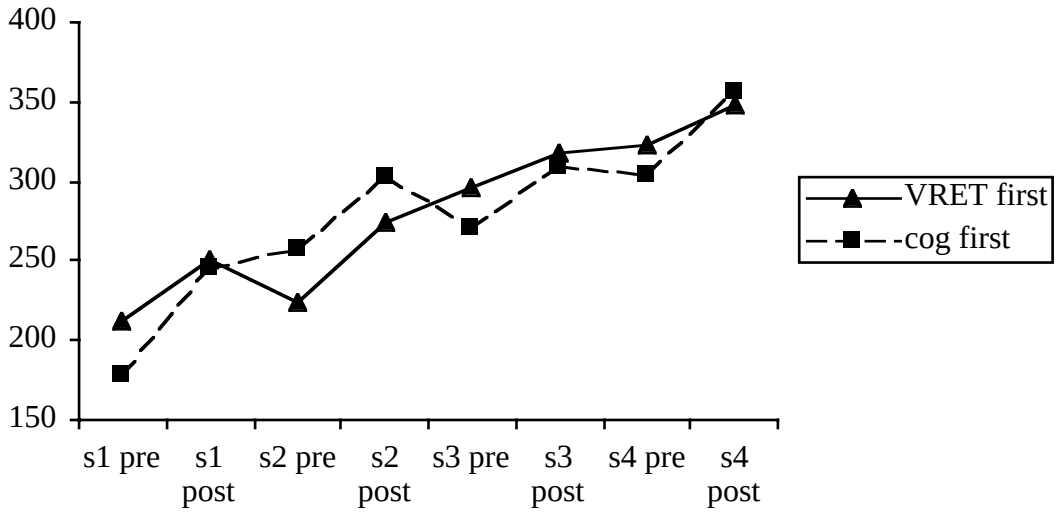
n (VRET) = 19, *n* (cog) = 18.
Cog first = VRET plus cognitive techniques first
Pos cog = positive cognition questionnaire
Neg cog = negative cognition questionnaire

4.3.4.3 Self-efficacy

Every session self-efficacy was measured before and after treatment (pre- and post-test), resulting in eight time-points. To examine the process of therapy on self-efficacy a 2 (condition) by 8 (time) repeated measures analysis was run. Adjusted

degrees of freedom and corrected tests were used for analysis of within subject data, because of a violation of the sphericity assumption. No significant effect of order was found (F (1, 36) = 0.07, p = 0.93) and no interaction effect of order by time (F(7, 252) = 1.44, p = 0.19). A significant time effect was found (F(7, 252) = 24.05, p < 0.001), indicating an increase of self-efficacy during therapy. Post hoc analyses showed that time effects were only found within sessions (s1, F(1, 36) = 34.5, p < 0.001; s2, F(1, 36) = 34.19, p < 0.001; s3, F(1, 36) = 4.31, p = 0.045; s4, F(1, 36) = 17.37, p < 0.001), not across sessions. Self-efficacy increased during a treatment session and remained stable until the beginning of the next session. See Figure 4.2 for means on self-efficacy before and after every session.

Figure 4.2 Mean of the self-efficacy questionnaire before and after every session.



n *(VRET) = 19,* n *(cog) = 19*

4.3.4.4 Presence

A 2 (order) by 4 (time) repeated measure analysis was run to examine the effect of treatment on presence. No significant effect of order (F(1, 35) = 0.094, p = 0.76) and no significant interaction effect of time by order were found (F(3, 33) = 1.08, p = 0.37). Moreover, no significant effect of time was found (F(3, 33) = 0.50, p = 0.69), indicating that patients felt the same amount of presence in each session regardless of order and treatment. See Table 4.5 for means and *SDs* on the IPQ.

Table 4.5 Mean and SD of the IPQ and SUDs by session.

Order	Dependent variable	Session 1	Session 2	Session 3	Session 4
VRET first (*n* = 19)	IPQ	53.37 (9.14)	53.58 (11.83)	52.63 (9.59)	52.84 (10.71)
	SUDs	20.07 (8.75)	16.73 (8.66)	17.00 (7.38)	16.67 (7.20)
Cog first (*n* = 18)	IPQ	51.50 (11.64)	49.28 (15.52)	53.89 (18.05)	53.33 (15.50)
	SUDs	19.27 (5.62)	15.45 (8.41)	20.45 (8.52)	20.09 (7.71)

Cog first = VRET plus cognitive techniques first

4.3.4.5 Correlations

Correlation analysis showed that there was a relationship between SUDs and negative cognitions in every session, session 1; $r = 0.54$, $p = 0.002$, session 2: $r = 0.39$, $p = 0.02$, session 3: $r = 0.52$, $p = 0.002$, session 4: $r = 0.52$, $p = 0.002$. No significant correlations were found between SUD-scores and IPQ scores or SUD-scores and self-efficacy.

4.4 Discussion

This is the first study in which the effectiveness of VRET and VRET plus cognitive techniques is directly compared. Cognitive techniques were pure, only negative cognitions were identified and more neutral self-statements formulated and used during VRET. The findings indicate that the addition of cognitive techniques did not influence the effectiveness of treatment. Both treatments were found effective regardless of order.

Treatment effects (pre-test compared to post-test on Z-anxiety and self-efficacy) were substantial according to Cohen's *d* (Z-anxiety, $d = 1.38 - 1.69$ and self-efficacy, $d = 1.03 - 1.38$). The effect sizes found in this study on anxiety were comparable to treatment effect sizes found in earlier studies on VRET of acrophobia. Emmelkamp et al. (2001) found an effect size of 0.99 after two sessions, Emmelkamp et al. (2002) found an effect size of 1.28 after three sessions and Krijn et al. (2004) found an effect size of 1.31 after three sessions of VRET. Moreover, the effect sizes

found were larger compared to the study by Krijn et al. (chapter 5) after four sessions of VRET (*d* = 0.42-0.43) in patients fearful of flying. Comparable effect sizes were found by Rothbaum et al. (2000) after eights sessions of VRET plus a variety of cognitive techniques (*d* = 0.54 - 1.37) in patients fearful of flying. The effect sizes found by Maltby et al. (2002) in patients fearful of flying were on average larger (*d* = 0.71– 2.55) compared to this study. However, therapy consisted of five sessions, including anxiety management training.

Furthermore, it was found that progress made during treatment remained stable at 6-month follow-up. However, the data of the acrophobics showed a small but only marginally significant increase in anxiety at follow-up and significant decrease of self-efficacy.

Self-efficacy was enhanced within each session and remained stable across sessions. Negative cognitions declined during treatment. Moreover, a linear relationship existed between negative cognitions measured after each session and SUDs. No relationships were found between self-efficacy and SUDs, or IPQ-scores and SUDs. The addition of cognitive techniques during VRET did not influence the amount of presence felt in the virtual environments.

Summarizing, it may be stated that VRET and VRET plus cognitive techniques were effective treatments and cognitive techniques did not enhance treatment effectiveness. From the within session data it can be concluded that negative cognitions decreased during sessions regardless of techniques used (VRET or VRET plus cognitive techniques). The opposite pattern is observed for self-efficacy, which increased during sessions independent of treatment. However, positive cognitions, as measured with a phobia cognition questionnaire, were not more frequently reported during VRET plus cognitive techniques. This could be due to the idiosyncratic nature of the coping statements formulated in therapy and the more general positive cognitions phrased in the phobia specific cognition questionnaire, which fluctuated over sessions.

Other research on effectiveness of exposure for specific phobias showed similar decreases in negative cognitions. Booth and Rachman (1992) as well as Öst et al. (2001) found that negative cognitions decreased during treatment regardless of treatment condition (exposure in vivo or cognitive treatment). De Jongh et al. (1995) found that negative cognitions decreased during cognitive therapy. Maltby et al. (2002) found that negative cognitions with regards to fear of flying decreased after

VRET plus anxiety management training. However, the results of Emmelkamp and Felten (1985) showed that subjects in the exposure plus cognitive therapy condition had more positive cognitions and less negative cognitions compared to subject in the exposure in vivo only condition. It must be emphasized that in the Emmelkamp and Felten study (1985) the procedure used to register cognitions was thought listing, which differed from our study as well as the abovementioned studies that all used questionnaires. It is known that production strategies often generate different results than endorsement measures in cognitive assessment (Chamberlain & Haaga, 1999), which might explain the differences found. In conclusion, negative cognitions seem to decrease during exposure in vivo as well as during VRET, regardless of the addition of cognitive techniques. Unfortunately, no conclusions can be drawn on the process of positive cognitions during and after therapy because the only studies in patients with specific phobia reporting on positive cognitions are the present study and the study by Emmelkamp and Felten (1985), using different measures with mixed results.

This study has some limitations that should be mentioned. First, a waiting list control condition was not present, as a result of which an effect of time or chance cannot be ruled out. However, it must be noted that in another trial with acrophobics of the same research group using the same virtual worlds (Krijn et al., 2004) and a study by van Gerwen, Spinhoven and van Dyck (submitted) on subjects fearful of flying, waiting list control groups showed a stable pattern of anxious complaints. Further, in order to enhance statistical power, two groups with different phobias were pooled. It might be that these specific phobias are not comparable in effectiveness of VRET and cognitive techniques. Nevertheless, analyses for each phobia separately were done to investigate possible differences and were not found between pre-, intermediate and post-test. However, between post-test and follow-up patients with fear of flying remained stable (on anxiety scores) and improved further on self-efficacy while patients with acrophobia experienced a marginally significant increase in anxiety as well as a significant decline of self-efficacy. These results should be considered with caution because of the small sample of the fear of flying group (n = 12). The further improvement in self-efficacy of the fear of flying subjects between post-test and follow-up might be due to practicing in vivo, which was not possible during therapy, but could be done in the 6-months following therapy. Subjects with fear of heights already had ample opportunity to practice in vivo during the therapy period, although this was not encouraged. However, height situations can easily be

found in daily life and could be compared to the virtual situations practiced in treatment.

Future research would profit from the addition of a behavioural avoidance test to analyse the effect of treatment on real anxiety-provoking situations and generalization to the real world. Future research on process variables of VRET, could also measure the use and intensity of the more idiosyncratic self-statements formulated in treatment. This could give a more detailed insight in the cognitive process of subjects during VRET and VRET plus coping self-statements. Moreover, virtual environments and VRET could be used to investigate cognitive biases often found in phobic patients (e.g. Lavy et al., 1993; de Jong & Merckelbach, 2000) and possible changes in these biases during and after treatment. In this study cognitive techniques were taught and used in two sessions, which is relatively short. Future research could expand the amount of treatment-sessions on VRET plus cognitive techniques and could investigate whether this would affect treatment-effectiveness.

Finally, despite the necessary caution in interpreting the results of the present study, they do indicate that the addition of self-statements was not important as a process variable involved in treatment effectiveness for acrophobia and fear of flying. Future studies in the same research field should help to clarify the process of cognitive behaviour treatment by means of virtual reality of specific phobias further.

5

Fear of flying:
A comparative evaluation of virtual reality exposure therapy and cognitive behavioural methods as preparation for cognitive behavioural group training

The aim of this study was to evaluate the effectiveness of a preparation phase of low-budget individually tailored virtual reality exposure therapy (VRET) compared to individually tailored cognitive behaviour therapy (CBT) and bibliotherapy without therapist contact in a between group design in 59 patients suffering from fear of flying. Moreover, after CBT or VRET patients were given a CBT-group training and the effectiveness of CBT or VRET plus group training was investigated as well.

Results showed that treatment by means of VRET or CBT was more effective than bibliotherapy without therapist contact. Both VRET and CBT showed a decline in fear of flying on the two main outcome measures. There was no statistically significant difference in effectiveness between CBT and VRET. However, effect sizes where higher for CBT (medium) than for VRET (between small and medium). Furthermore, it was found that the preparation phase by means of CBT plus the group training was more effective than preparation by means of VRET plus group training. Suggestions for future research are discussed.

5.1 Introduction

Fear of flying, one of the specific phobias, is rather common, affecting 13.2 % of the general population (Curtis et al., 1998). Research to date has shown that the most effective form of treatment for specific phobias, including fear of flying, is (cognitive) behaviour therapy (Craske & Rowe, 1997). As flying has become an integral part of life in industrialised countries, programs have been developed to treat patients who suffer from fear of flying. Different assessment procedures are applied and treatment protocols include various treatment components, e.g. relaxation, stress management, a coping/ distraction component and/ or cognitive techniques. Further, most of the treatment protocols include an information component and exposure in vivo, usually a test flight (Van Gerwen & Diekstra, 2000). Some programs use exposure in flight simulators before the actual flight takes place.

5.1.1 Group training

The effectiveness of a cognitive behaviour therapy (CBT) group program, containing most of the abovementioned components, has been well established (van Gerwen, Spinhoven, Diekstra & van Dyck, 2002). In a study by van Gerwen, Spinhoven and van Dyck (submitted), 150 patients were randomly assigned to one of three conditions; waiting list, a cognitive behaviour group treatment (20 hours) or a behaviour group treatment (12 hours). Both group trainings consisted of a presentation by a pilot, training of coping skills, two flights in a simulator and a return flight of at least one hour one way. In the cognitive behaviour group training, a cognitive skills training was added as well as a presentation of the cognitive model of panic and anxiety. Both training programs were found to be more effective than the waiting list control condition. At 3-month follow-up, the cognitive behaviour training was more effective than the behaviour training, on most specific measures of fear of flying. However, patients in the cognitive behaviour group showed significant improvements before receiving the behaviour component of the treatment, indicating that both cognitive and exposure components of the training accounted for the treatment effects. Because the conditions differed in time spent in therapy, conclusions with respect to the additional effect of cognitive techniques are precluded.

5.1.2 Virtual reality exposure therapy

A recent innovation in the application of CBT for fear of flying is virtual reality exposure therapy (VRET). VRET is an altered form of behaviour therapy and may be a possible alternative to standard in vivo exposure. Virtual reality integrates real-time computer graphics, body tracking devices, visual displays and other sensory input devices to immerse patients in a computer-generated virtual environment. The advantages of VRET over standard exposure therapy can be enormous. In the treatment of fear of flying, VRET is highly cost-effective, components of the flight can be repeated endlessly in the therapist's office, and different weather conditions can be created in milliseconds (e.g. a thunderstorm). Furthermore, treatment of a combination of different phobias can be managed easily. This is important because fear of flying is a heterogeneous problem and not a unitary phenomenon (Van Gerwen, Spinhoven, Diekstra & van Dyck, 1997). For example in some patients fear of flying was associated with fear of losing control, in others with claustrophobia or acrophobia. In VRET different types of phobias associated with fear of flying can be addressed easily (e.g. acrophobia and claustrophobia).

Four case studies and one uncontrolled study have been published in which VRET was used, results being positive in all of them (North et al., 1997; Wiederhold et al., 1998; Rothbaum et al., 1996; Klein, 2000; Kahan et al., 2000).

Mühlberger et al. (2001) reported a study in which VRET was compared to a relaxation training. Subjects were randomly assigned to either VRET or a relaxation training given in one long session of approximately three hours. VRET was found to be more effective than relaxation, but only on specific fear of flying questionnaires. In a study by Rothbaum et al. (2000), 45 subjects were randomly assigned to (1) VRET and anxiety management training (AMT), (2) standard exposure in vivo (SE) and AMT, or (3) a waiting list. The situations used in SE were not the same as in VRET. VRET consisted of virtual flying, taxiing, taking off and landing. The situations in SE, were walking through an airport and sitting in a stationary aircraft. Both treatments were found to be more effective than a waiting list period. Differences between the treatments were not found at post-test, neither at 12-month follow-up (Rothbaum et al., 2002). No information is available on the effectiveness of each treatment component (VRET or SE apart from AMT).

In a study by Maltby et al. (2002), 45 patients were randomly assigned to either five sessions VRET or five sessions attention-placebo group treatment (GT). VRET consisted of psycho-education, AMT, cognitive techniques and graded exposure to flying in a virtual environment. The attention placebo group consisted of education on safety of a flight and mechanics of an aircraft and conversation about subjects fear and fear history. At post-treatment VRET showed more clinically significant decline of fear of flying than GT (on four out of five measures). At six-month follow-up, results remained stable but group differences mostly disappeared with VRET resulting in a superior outcome on only one out of five measures. Again no information is available on the effectiveness of each treatment component by itself.

In a study by Mühlberger et al. (2003), 37 subjects with fear of flying were randomly assigned to one session of either (1) cognitive treatment and VRET or (2) cognitive treatment alone. VRET consisted of one hour of cognitive therapy and four virtual flights of 18 minutes. Cognitive treatment alone consisted of one 60-minutes session of cognitive techniques. Results revealed a reduction in fear of flying (on questionnaires) only in the VRET group. Results suggest that VRET is the most effective treatment component when compared to information about flying, treatment rationale, or cognitive techniques. However, a flaw in this study is the difference in treatment time between conditions.

Finally, in a study by Botella, Osma, Garcia-Palacios, Quero and Baños (2004) nine patients with fear of flying were treated with one session of psycho-education and six sessions of VRET. Results revealed a stable pattern of fear of flying during baseline measurement (one to three weeks) and a significant reduction in fear of flying after treatment (on all questionnaires). Results remained stable at 1-year follow up. All patients flew in vivo after treatment. This study indicates that VRET as the only treatment component can be effective for patients with fear of flying. However, because of the small sample and the design of this study the positive results should be interpreted with caution.

Taken together, results suggest that VRET could be an effective component in the treatment of fear of flying. Especially the controlled studies by Rothbaum et al. (2000), Rothbaum et al. (2002) and Mühlberger et al. (2003) show that VRET is effective.

5.1.3 Self-help guides and bibliotherapy

The effectiveness of bibliotherapy as stand alone treatment has been investigated for specific phobias in general, but has not yet been investigated for fear of flying. Newman, Erickson, Przeworski and Dzus (2003) found that bibliotherapy by reading and practising via a self-help guide can be effective in treating specific phobias. However, the studies reviewed by Newman et al. (2003) differ immensely in the amount of therapist contact(s) and the location where self-help was administered. In three of the four studies that found self-help to be equivalent to therapist-directed therapy, the self-help interventions were conducted in the lab of the investigator. However, self administration at home is much less effective in terms of clinical significant change as compared to lab administered self-help, 10% versus 63% (Hellstrom & Öst, 1995).

Taken together, results suggest that when treating specific phobias in general, bibliotherapy without contact with a therapist after initial assessment could be an effective form of treatment. However, the inclusion of externally imposed structure by means of some therapist contact may be more effective.

The aim of the present study was to compare the effectiveness of VRET to individual CBT, of which the effectiveness has been well established (van Gerwen, et al., 2002) and to bibliotherapy without any contact with a therapist. All treatment forms were used as preparation for the group treatment given afterwards. Moreover, underlying phobias (fear of heights or claustrophobia) were treated as well (in CBT or VRET, not in the bibliotherapy condition). For ethical reasons subjects in the bibliotherapy condition were randomised over the other two individual preparation conditions (CBT or VRET) as it was expected that bibliotherapy without any therapist contact would be less effective than preparation by means of CBT or VRET. In addition, after the initial individual preparation phase all subjects were treated in groups during a two-day training, consisting of cognitive techniques, psycho-education and education about flying, a flight in a simulator and a real flight. Again effects were assessed and compared between groups (preparation by means of VRET or CBT).

5.2 Method

5.2.1 Design

An intake session took place of one hour maximum, after which a pre-test followed. If participants were included in this study random assignment over three preparation conditions took place, (1) individually tailored VRET (4 weekly sessions of 1 h), (2) individually tailored cognitive behaviour therapy (CBT; 2 to 4 weekly sessions of 1 h) or (3) bibliotherapy without any therapist contact (of five weeks). Subjects in all three conditions received a book on fear of flying ("Help I have to fly", van Gerwen and Diekstra, 1996) and were encouraged to read it. Subjects in the bibliotherapy group did not receive any other treatment in the next five weeks. An intermediate test was held. Then, subjects from the bibliotherapy condition were randomly assigned to either VRET or CBT of which they were informed beforehand. A second intermediate test was taken from this group. Hereafter all subjects underwent a two-day training program in groups of five to eight individuals. Training included psycho-education, education about aircraft, flying and safety by a pilot, cognitive therapy, two simulation flights and a real flight. The groups consisted of subjects who participated in this research project as well as patients treated outside the research trial. Directly after the group training a post-test was held.

5.2.2 Participants

To participate in this project subjects had to meet current Diagnostic and Statistical Manual of Mental Disorders criteria for specific phobia, fear of flying (APA, 1994). Subjects were excluded if they met criteria of posttraumatic stress disorder or acute stress disorder (not related to fear of flying), panic disorder and/ or severe agoraphobia. Subjects were also excluded if they had suicidal tendencies, did not want to stabilise their antidepressant medication during the course of treatment or were unable to discontinue the use of benzodiazepines. For technical reasons, due to the VR equipment, subjects with glasses stronger than 3.5, epilepsy or pacemakers, were also excluded.

5.2.3 Treatment

Virtual reality graded exposure therapy with a head-mounted display (HMD) was given in a dark laboratory room at the department of Clinical Psychology of the University of Amsterdam. The virtual worlds were generated using a Pentium-II 450 MHz computer with 128Mb RAM, 4 Gb hard disk, and a 3D-Labs Oxygen GVX-420 graphics card with 128Mb video memory and dual-monitor support. The software used was Sense 8 WorldUp R4, a commonly used VR modelling and visualisation toolkit. In all the system was able to generate the display at a rate of about 15 to 20 frames per second. The worlds were displayed using the Cybermind Visette Pro. Projection was stereographic. The field of view was 70.5 degrees diagonally. Tracking was done with Ascension Flock of Birds.

Patients were introduced to virtual reality in a neutral virtual environment (building ground floor and garden). Two virtual environments (VEs) were created for fear of flying; an airport (Schiphol, Amsterdam airport) and an aircraft. In the first VE of fear of flying (airport), patients could walk around freely on one square meter. A railing that the patient could hold on to bounded this area. In the second VE patients were seated in an aircraft chair that vibrated during take-off, turbulence and landing.

Three VEs were created for treatment of fear of heights and were used if indicated. They were used in a gradual order; a fire escape with six floors in open space, a roof garden on a building, and a virtual building site with eight floors. Patients could walk around freely on one square meter in all height VEs. A railing the patient could hold on to bounded this area.

Three VEs were created for treatment of claustrophobia and were used if indicated. Those VEs were: (1) two elevators (a big one and a smaller one), (2) a hallway, which became narrower while proceeding to the end, and (3) a room with a closet, which could be made smaller to 1 square meter as minimum. Patients could walk around freely on one square meter in all claustrophobic VEs. A railing that the patient could hold on to bounded this area.

If indicated, by means of a score 1.5 *SD* above the mean of a sample of students on the claustrophobia questionnaire (Radomsky, Rachman, Thordarson, McIsaac, & Teachman, 2001) or on the acrophobia questionnaire, (Cohen, 1977) VRET was directed at claustrophobia or fear of heights in the first two sessions. In all other cases all four sessions were used for the exposure to the VEs of flying.

To give patients a gradual and optimal exposure treatment, patients had to rate their anxiety regularly during the exposure therapy by means of SUDs (0-10). Patients were instructed during treatment to expose themselves to the anxiety provoking situations in a gradual manner. After habituation as evidenced by a relatively low SUD, patients were encouraged to take a next step (for instance move up one floor, take off by aircraft, go to the small elevator). Only exposure was used during treatment, no cognitive interventions or relaxation was given. In order to study the effects of pure VRET, patients did not receive homework-instructions, and practising in vivo between sessions at home was not encouraged.

The individual sessions included cognitive therapy and relaxation, and for learning these techniques, two to maximum four sessions were given. Subjects were taught how to relax themselves by means of muscle relaxation techniques. These techniques were also applied while sitting in an aircraft-seat (in the therapist office). Cognitive techniques were used to challenge subject's irrational beliefs. If indicated, by means of a score 1.5 *SD* above the mean of a sample of students on the claustrophobia questionnaire (Radomsky et al., 2001) or on the acrophobia questionnaire, (Cohen, 1977), exposure in vivo was used to treat acrophobia or claustrophobia. This was done in two sessions maximum.

In the bibliotherapy condition, after the intake subjects were given a book on fear of flying and were encouraged to read this book during the five weeks before they were assigned to either CBT or VRET. This book gives information on flying, aircraft, relaxation, cognitive and behavioural coping strategies and self-help.

All patients paid for treatment. An intake session cost 150 euro, an individually tailored CBT session 82,50 euro and a VRET session 41,25 euro. The two-day training, including a return flight, cost 830 euro.

5.2.4 Assessment

5.2.4.1 Intake

All subjects were screened by means of the MINI, a shortened version of the Structured Clinical Interview for DSM-IV Axis I Disorders (Overbeek, Schruers, &

Griez, 1999). The SCL-90 (Derogatis, 1977) was also administered to test for possible baseline differences in psychological symptoms.

5.2.4.2 Pre-test, intermediate test and post-test

Questionnaires were used to evaluate the effects of treatment. At pre-test, intermediate test and post-test two questionnaires were used as main outcome measure; the FAS and the FAM.

Anxiety related to flying experienced in different situations was measured by the *Flight Anxiety Situations Questionnaire* (FAS; van Gerwen et al., 1999). The FAS is a 32-item self-report inventory with a 5-point Likert scale ('no anxiety' to 'overwhelming anxiety'). The questionnaire consists of three subscales: 1) Anticipatory Flight Anxiety Scale, measuring anxiety experienced when anticipating an aircraft flight (14 items); 2) an In-flight Anxiety Scale, measuring anxiety experienced during a flight (11 items); and 3) a Generalised-Flight Anxiety Scale, measuring anxiety experienced in connection to aircraft in general, regardless of personal involvement in a flight situation (7 items). The psychometric properties of the FAS have proven to be good (van Gerwen et al., 1999). Only the total score of the FAS will be used.

Symptom modalities in which anxiety in flight situations is expressed were measured by the *Flight Anxiety Modality Questionnaire* (FAM; van Gerwen et al., 1999). The FAM consists of 18 items with a 5-point Likert format ('not alt all' to 'very intensely'). The questionnaire is divided into two subscales: Somatic Modality measuring physical symptoms (11 items) and Cognitive Modality measuring the presence of distressing cognitions (7 items). Psychometric properties have proven to be good (van Gerwen et al., 1999). Only the total score of the FAM will be used.

The *Cognitive Emotion Regulation Questionnaire-Flying* (CERQ-F) (Kraaij, Garnefski & van Gerwen, 2003) was used in addition to measure cognitive coping strategies to manage the intake of emotionally arousing information, involving thoughts or cognitions that help to manage or regulate emotions. This questionnaire can be used to measure either a more general coping style or a more specific response to a specific event (e.g. flying). The questionnaire consists of 40 items with a 5-point Likert format ('almost never' to 'almost always') divided into a negative cognition scale (range: 20-100, α = 0.86) and a positive cognition scale (range: 20-100, α = 0.83).

Additional outcome measures were used to explore the effectiveness of treatment on acrophobia and claustrophobia. Fear of heights was measured with the *Acrophobia Questionnaire* (AQ; Cohen, 1977), measuring anxiety in height situations (range: 0-120, α = .80). Claustrophobia was measured with the *Claustrophobia Questionnaire* (CLQ; Radomsky, et al., 2001). The questionnaire is divided into two subscales; fear of suffocation (14 items) and fear of restriction (12 items). The psychometric qualities of the questionnaire were proven to be good (Radomsky et al., 2001).

5.2.4.3 Within VRET-sessions

Questionnaires were used to measure changes within each treatment session.

A *self-efficacy questionnaire* was constructed and used every session. The questionnaire consists of 5 items on self-efficacy in a flying situation. The items were designed around 5 themes; the capability to: (1) reduce fear, (2) think clearly, (3) have control over your actions, (4) have control over anxious images or thoughts, (5) stay in the situation for two minutes while panicking or with intense fear. The questionnaire was used after every treatment session (range: 0 – 500, α = 0.90 - 0.98).

To measure presence during VRET the *Igroup Presence Questionnaire* (IPQ) was used (Schubert et al., 2001). This questionnaire consists of 14 items that measure the feeling of being in the virtual environment (α = 0.85-0.87). Each item was scored on a 7-point Likert-type scale ('totally disagree' to 'totally agree').

5.2.5 Methods of analysis

Possible differences in demographic, anamnestic and dependent variables between conditions at baseline were analysed with Chi-square analysis or ANOVAs, when appropriate.

To assess treatment effects paired t-tests were used. ANCOVA's were used with the pre-test as covariate to evaluate possible differences in treatment effectiveness at intermediate test. The same procedure was used to evaluate the effectiveness of the group training plus preparation phase, however, the pre-test was used as covariate to evaluate possible differences at post-test between preparation phase (CBT versus VRET) plus group training. In all cases first completers analysis

were done as well as intention to treat analyses, including the dropouts, by means of last observation carried forward. The within group effect sizes of the changes on the FAS and the FAM were analysed by computing Cohen's *d* (Cohen, 1988). This was done in (1) bibliotherapy versus VRET/ CBT, (2) VRET versus CBT and (3) VRET plus group training versus CBT plus group training. Cohen's *d* is the difference between the two means being compared, divided with their pooled standard deviations. Cohen (1988) has suggested that *d* = 0.20 can be considered to indicate a small effect, *d* = 0.50 a medium effect and *d* = 0.80 a substantial effect.

The scores on the acrophobia questionnaire and the claustrophobia questionnaires were transformed to general standardised anxiety scores (Z-anxiety) with a mean of 0 and *SD* of 1, to examine the effect of treatment of a secondary phobia in general (no difference made between fear of heights or claustrophobia). To assess treatment effects paired t-tests were used. ANCOVA's were used with the pre-test Z-anxiety as covariate to evaluate possible differences in treatment effectiveness at intermediate test.

Process measures during VRET were a self-efficacy questionnaire and the IPQ to measure presence. They were taken after every session. Repeated measure analyses with four time points were done to investigate possible differences between sessions on both questionnaires. If a significant time effect was found post hoc analyses were done to analyse between which sessions the time-effects were significant.

5.3 Results

5.3.1 Participants characteristics

In total 86 subjects were included in the study. No differences were found on demographic, anamnestic or main outcome measures at baseline. See Table 5.1 for means and *SD*s.

Of the 86 subjects included after the intake, 20 patients dropped out during the therapy because of various reasons. In the VRET-condition 13 patients dropped out, 12 because VRET did not arouse anxiety and one because of simulation sickness during treatment. For ethical reasons VRET was discontinued and these patients were offered treatment outside the experimental trial. In the CBT condition two subjects

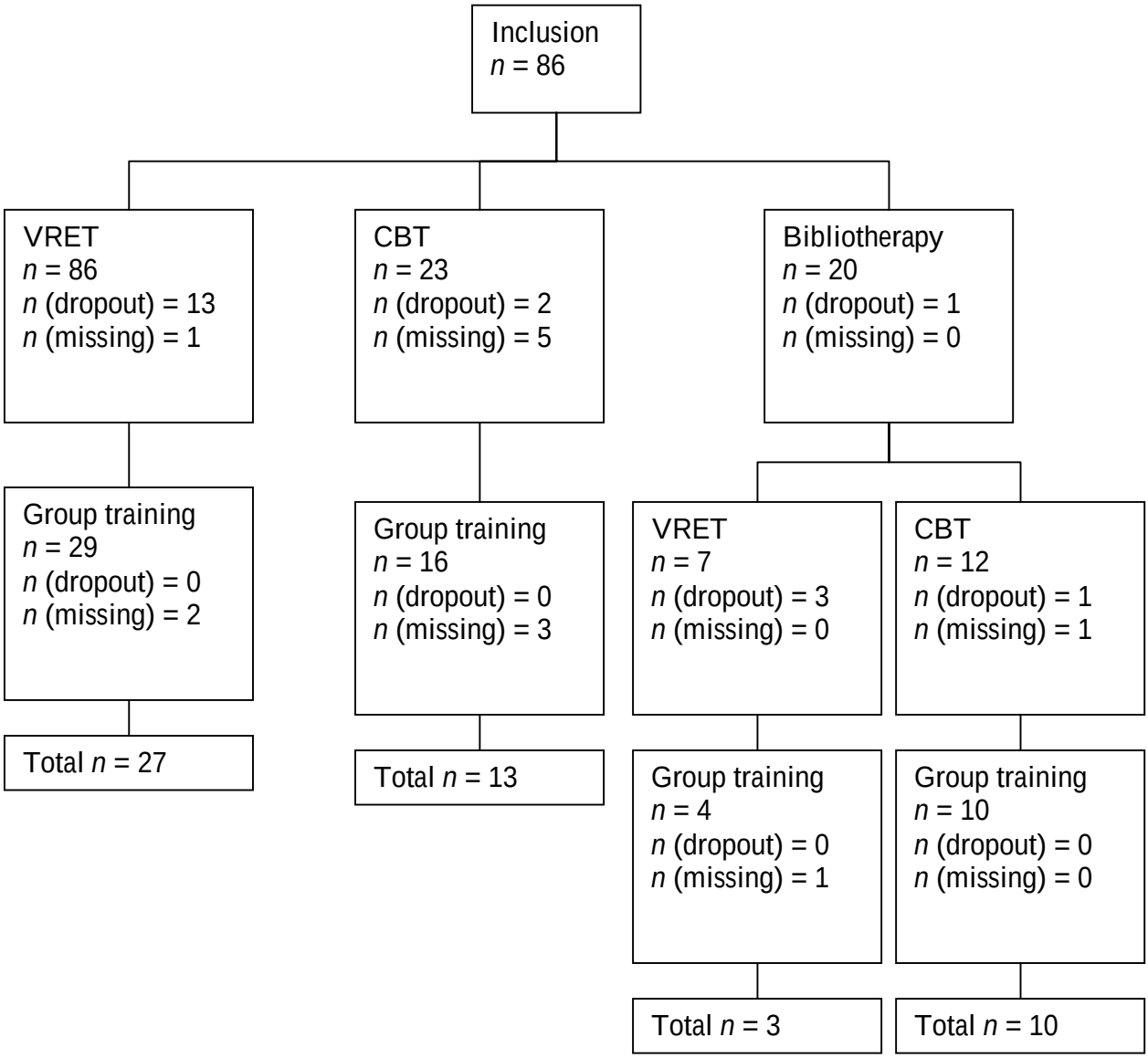
dropped out, one because of other psychological problems that he wanted to deal with first and one because of financial problems. One subject dropped out in the bibliotherapy condition. Five subjects dropped out after the bibliotherapy period, (four in the VRET condition and one in the CBT condition). However, the data of their pre and intermediate tests (during the bibliotherapy period) were used for analysis. From 13 patients, data is partly missing because of logistic reasons. See Figure 5.1 for numbers of subjects in every condition.

59 patients remained in the study (23 males, 36 females) at least until after the CBT or VRET preparation phase. The average age of these patients was 38.58 years (*SD* = 10.91). The duration of the fear of flying was on average 13.27 years (*SD* = 10.12). Two subjects had never flown. 57 patients had flown with an average amount of one-way flights of 20.87 (*SD* = 19.56). The time between their last flight and the intake-interview was on average 5.28 years (*SD* = 7.59). No significant differences were found on demographic, anamnestic or main outcome measures at baseline for this subgroup (see Table 5.1).

Table 5.1 Demographic and anamnestic data and data of main outcome measures at baseline.

Variable		VRET (*n* = 43)	CBT (*n* = 23)	Bibliotherapy (*n* = 20)	*p*
Sex	Male	17 (40%)	11 (48%)	5 (25 %)	n.s.
	Female	26 (60%)	12 (52%)	15 (75%)	
Age		36.60 (11.81)	40.30 (8.99)	37.10 (8.10)	n.s.
Never flown		*n* = 1	*n* = 1	*n* = 1	n.s.
M years since last flight		4.12 (6.19)	6.09 (8.05)	4.42 (7.07)	n.s.
		n = 42	*n* = 22	*n* = 19	
M flights, one way		22.33 (25.01)	15.68 (12.51)	22.89 (23.07)	n.s.
		n = 42	*n* = 22	*n* = 19	
Duration of fear of flying		10.33 (7.98)	15.26 (10.77)	14.00 (10.60)	n.s.
FAS pre-test		68.16 (24.28)	73.05 (19.97)	66.95 (15.38)	n.s.
			n = 22		
FAM pre-test		39.77 (24.87)	45.32 (12.820	46.15 (19.71)	n.s.
			n =22		
SCL-90 total score		123.63 (24.87)	126.43 (19.62)	126.65 (23.07)	n.s.

Figure 5.1 Flowchart of subjects.



5.3.2 Bibliotherapy versus VRET or CBT in the preparation phase

To investigate if VRET or CBT was more effective than bibliotherapy, these two conditions (VRET and CBT) were pooled and compared to the bibliotherapy condition. An ANCOVA with the FAS pre-test as covariate, revealed a significant effect of condition on the FAS intermediate test, $F(2, 61) = 4.66$; $p = 0.035$. An ANCOVA with the FAM pre-test as covariate, revealed a significant effect of condition on the FAM, $F(2, 61) = 5.43$; $p = 0.023$. Paired t-tests revealed a significant effect of time in the VRET/ CBT condition on both the FAS; $t(44) = 2.81$; $p = 0.007$

and the FAM; $t(44) = 3.14$; $p = 0.003$. No significant time effects were found in the bibliotherapy condition, FAS: $t(18) = -0.105$; $p = 0.92$; FAM: $t(18) = 0.79$; $p = 0.44$.

These findings indicate a significant decline on the FAS and FAM in the VRET/ CBT condition but not in the bibliotherapy condition. Means, *SDs* and effect sizes are described in Table 5.2.

Because of the high dropout rate in the VRET/ CBT condition, intent to treat analyses were done as well with last observation carried forward. In case of dropout ($n = 16$), defined as those subjects who did not complete their treatment, their pre-test scores on the FAS en FAM were taken as intermediate test. For means and *SDs* see Table 5.2.

An ANCOVA with the pre-test taken as covariate, revealed neither a significant effect of condition on the FAS, $F(2, 77) = 2.23$; $p = 0.14$, nor on the FAM, $F(2, 77) = 2.824$; $p = 0.097$. Further, paired t-tests revealed a significant effect of time in the VRET/ CBT condition on both the FAS; t (59) = 2.75; p = 0.008 and the FAM; $t(59) = 3.07$; $p = 0.003$. No significant effects of time were found in the bibliotherapy condition, FAS: $t(19) = -0.11$, $p = 0.92$; FAM: $t(19) = 0.79$, $p = 0.44$.

Table 5.2 Means, SDs and effect sizes for the pooled VRET/ CBT group and the bibliotherapy group and VRET/ CBT group dropouts included (di).

Condition	Measure	Pre-test Mean (*SD*)	Intermediate test Mean (*SD*)	*d*
VRET/ CBT	FAS	66.80 (25.22)	56.01 (24.56)	0.43
(*n* = 45)	FAM	39.42 (16.29)	31.08 (17.02)	0.50
Bibliotherapy	FAS	68.53 (14.05)	69.05 (16.95)	-0.034
(*n* = 19)	FAM	45.63 (20.11)	43.54 (16.40)	0.11
VRET/ CBT di	FAS	68.33 (23.39)	60.74 (24.05)	0.32
(*n* = 60)	FAM	41.33 (16.38)	35.08 (17.96)	0.36
bibliotherapy di	FAS	66.95 (15.38)	67.45 (17.99)	-0.030
(*n* = 20)	FAM	46.15 (19.71)	44.16 (16.21)	0.11

5.3.3 CBT versus VRET

In order to enhance power, subjects who received CBT or VRET directly and those who received VRET or CBT after bibliotherapy were pooled into two groups, i.e. cognitive behaviour therapy (CBT) and virtual reality exposure therapy (VRET). The

intermediate test of the bibliotherapy group on the FAS and FAM, which did not differ significantly from the pre-test (see above), was taken as pre-test for CBT or VRET, received afterwards.

An ANCOVA with the pre-test as covariate, revealed no significant effect of condition on the FAS, $F(2, 56) = 0.019$; $p = 0.89$ or on the FAM, $F(2, 56) = 0.023$; $p = 0.63$. Paired t-tests revealed a significant effect of time in the VRET condition on both the FAS; $t(32) = -2.49$; $p = 0.02$ and the FAM; $t(32) = -2.45$; $p = 0.02$. Similar significant time effects were found in the CBT condition; FAS; $t(25) = -2.07$; $p = 0.05$; FAM; $t(25) = -2.95$; $p = 0.007$. Means, *SDs* and effect sizes (Cohen's *d*) are described in Table 5.3.

Table 5.3 Means and SDs for VRET, CBT, VRET dropouts included (di) and CBT dropouts included (di).

Condition	Measure	Pre-test Mean (*SD*)	Intermediate test Mean (*SD*)	*d*
VRET (*n* =33)	FAS	66.09 (26.11)	55.14 (26.23)	0.42
	FAM	39.24 (18.32)	31.28 (18.30)	0.43
VRET di (*n* =49)	FAS	68.53 (23.33)	61.15 (24.74)	0.31
	FAM	40.84 (17.98)	35.49 (18.83)	0.29
CBT (*n* = 26)	FAS	67.42 (19.10)	58.38 (19.25)	0.47
	FAM	42.27 (13.07)	33.38 (16.26)	0.61
CBT di (*n* = 29)	FAS	69.07 (19.97)	60.97 (20.96)	0.40
	FAM	43.73 (13.33)	35.77 (17.12)	0.52

Because of the large amount of dropout intent to treat analyses were done as well, following the same procedure as mentioned above. In all, 16 failures were added to the VRET condition and two to the CBT condition. For means and *SDs* see Table 5.3.

Results showed the same pattern. An ANCOVA with the FAS pre-test as covariate, revealed no significant effect of condition on the FAS, $F(2, 75) = 0.013$; $p = 0.91$. An ANCOVA with the FAM pre-test as covariate, did not reveal a significant effect of condition on the FAM either, $F(2, 75) = 0.24$; $p = 0.62$. However, in the VRET condition paired t-tests revealed a significant effect of time on the FAS; $t(48) = -2.43$; $p = 0.019$, and a significant effect of time was also found on the FAM; $t(48) = -2.39$; $p = 0.021$. In the CBT condition significant effects of time were also found both on the FAS; $t(28) = -2.06$; $p = 0.049$ and FAM, $t(28) = -2.90$; $p = 0.007$.

These results indicate that in the CBT and VRET condition the decline in fear of flying as measured with the FAM en FAS was retained in the intention to treat analyses.

5.3.4 Effects of treatment on acrophobia or claustrophobia

Subjects with a score higher or equal to 42 on the acrophobia anxiety scale were treated for their acrophobia by means of VRET or exposure in vivo (CBT condition) in the first two sessions.

Subjects with a score higher or equal to 52 on the claustrophobia questionnaire were treated for their claustrophobia by means of VRET or exposure in vivo (CBT condition) in the first two sessions. In total 18 subjects were treated for acrophobia (n(VRET) = 10, n(CBT) = 8) and 10 subjects for claustrophobia (n(VRET) = 6, n(CBT) = 4). An ANCOVA with the Z-anxiety pre-test as covariate, revealed no significant effect of condition on the Z-anxiety score post-test, $F(2, 25) = 1.213$; $p = 0.281$. However, in the VRET condition paired t-tests revealed a significant time effect on Z-anxiety; $t(16) = 2.26$; $p = 0.039$. The same effect was found on Z-anxiety in the CBT condition; $t(11) = 6.121$; $p < 0.001$. Means, *SDs* and effect sizes are described in table 5.4.

Table 5.4 Means and Standard Deviations of anxiety Z-scores per condition and effect sizes

Condition	Pre-test Mean (*SD*)	Post-test Mean (*SD*)	*d*
VRET (n =16)	0.48 (1.20)	-0.20 (1.05)	0.60
CBT (n = 12)	0.32 (0.87)	-0.70 (1.24)	0.97

5.3.5 The effectiveness of the group training

To analyse the differences in effectiveness between preparation by VRET or CBT plus the group training, ANCOVAs were conducted. Paired t-tests were used to analyse the effect of time of the treatment package between pre-test and post-test. An ANCOVA, with the pre-test as covariate, showed a significant effect of condition on

the FAS, $F(2, 50) = 4.41$, $p = 0.041$ and a trend towards significance on the FAM, $F(2, 50) = 3.00$; $p = 0.089$.

Using paired t-tests a significant effect of time was found in the VRET preparation condition plus group training on the FAS; $t(29) = -9.301$; $p < 0.001$ and the FAM; $t(29) = -8.48$; $p < 0.001$. The same significant effects of time were found in the CBT preparation condition plus group training, FAS; $t(22) = -17.0$; $p < 0.001$ and FAM; $t(22) = -15.67$; $p < 0.001$. These results indicate that both groups benefited from treatment but the CBT preparation condition plus group training condition benefited more than the VRET preparation condition plus group training. See Table 5.5 for means and *SDs* of the FAS en FAM and the effect sizes per condition

Table 5.5 Means and SDs of the FAS and FAM at pre-test, intermediate test and post-test after the group and effect sizes

Condition	Measure	Pre-test Mean (*SD*)	Intermediate test (*SD*)	Post-test Mean (*SD*)	*d* (pre-intermediate)	*d* (intermediate-post)	*d* (pre-post)
VRET	FAS	65.30 (25.28)	53.28 (25.52)	21.87 (15.50)	0.47	1.53	2.13
(*n* =30)	FAM	38.61 (18.20)	29.51 (16.67)	10.88 (12.44)	0.52	1.28	1.82
CBT	FAS	67.57 (20.24)	57.91 (19.29)	14.96 (11.57)	0.49	2.78	3.31
(*n* = 23)	FAM	42.70 (12.93)	33.42 (15.60)	7.36 (5.85)	0.65	2.43	3.76

5.3.6 Dropouts in the VRET condition

Because of the large amount of dropouts in the VRET condition, participants that dropped out during VRET were compared on pre-test data to the participants that completed VRET. Using a MANOVA, it was found that dropouts did not differ in pre-test scores on the FAS or FAM from participants that continued their VR treatment: $F(2, 46) = 0.58$; $p = 0.56$. Dropouts did not differ from completers on the SCL-90 either, $F(1, 48) = 0.004$, $p = 0.95$. Moreover, dropouts did not differ from

completers on their presence scores after the first virtual reality treatment session; $F(1, 39) = 1.19$; $p = 0.28$. The descriptive statistics can be found in Table 5.6.

Table 5.6 Means and SDs of the FAS en FAM pre-test, SCL-90 and the IPQ scores after the first treatment session of completers and dropout in the VRET condition

Condition	Dependent variable	Mean (*SD*)
VRET completers	FAS (*n* = 33)	66.09 (26.11)
	FAM (*n* = 33)	39.24 (18.32)
	SCL-90 (*n* = 34)	125.50 (25.09)
	IPQ (*n* = 29)	45.31 (11.97)
VRET dropout	FAS (*n* = 16)	73.56 (15.75)
	FAM (*n* = 16)	44.15 (17.35)
	SCL-90 (*n* = 16)	125.00 (26.75)
	IPQ (*n* = 12)	40.75 (12.21)

5.3.7 Changes in self-efficacy and presence between VRET sessions

By means of a repeated measures analysis it was found that self-efficacy with respect to flying increased significantly between sessions; $F(3, 23) = 11.26$, $p < 0.001$. Post hoc analyses showed that a trend towards significant change occurred between session 1 and session 2 ($F(1, 25) = 3.92$; $p = 0.06$) and significant change occurred between session 3 and 4 ($F(1, 25) = 7.22$; $p = 0.01$). There were no significant differences in presence as measured with the IPQ between the sessions. Means and *SDs* are presented in Table 5.7.

Table 5.7 Means and SDs of the Self-efficacy scale and the IPQ total score after session 1, 2, 3 and 4.

Measure	Session 1	Session 2	Session 3	Session 4
Self-efficacy total score (*n* = 26)	169.96 (111.90)	196.84 (131.61)	213.42 (139.54)	242.27 (125.64)
IPQ total score (*n* = 28)	45.32 (12.19)	47.47 (12.44)	47.96 (11.25)	47.57 (10.91)

5.3.8 Cognitive changes

The CERQ-F was used to investigate the change in cognitions of participants with fear of flying. The items were categorised into positive cognitions (sum of scales: acceptance, concentration on other business, refocus planning, positive reappraisal and putting into perspective) and negative cognitions (sum of scales: self-blame, rumination, catastrophizing, other-blame and avoidance).

5.3.8.1 VRET/ CBT pooled versus bibliotherapy

An ANCOVA with the pre-test as covariate, revealed a trend towards significance of condition (VRET/ CBT versus bibliotherapy) on the CERQ-F negative cognitions intermediate test, $F(2, 59) = 3.82$; $p = 0.055$, but no significant effect on the CERQ-F positive, $F(2, 59) = 0.026$, $p = 0.87$. Using paired t-tests a significant effect of time was found in the VRET/ CBT condition on the CERQ-F negative; $t(42) = 2.48$; $p = 0.017$, but no effect was found on the positive scale; $t(42) = -0.95$; $p = 0.35$. No significant effect was found in the bibliotherapy condition, on the CERQ-F negative; $t(18) = -0.46$; $p = 0.652$ and a trend towards significance was found on the CERQ-F positive; $t(18) = -1.8$; $p = 0.09$. Means and *SD*s are presented in Table 5.8.

5.3.8.2 VRET versus CBT

Because of the trend toward significance found on the CERQ-F positive scale in the bibliotherapy condition, the intermediate test of this group was not used as pre-test for the treatment (VRET or CBT) afterwards. Only the data of the subjects who received therapy directly after intake were used to analyse the possible cognitive changes made during CBT or VRET.

An ANCOVA with the pre-test as covariate was done to investigate the effect of CBT or VRET on positive and negative cognitions at intermediate testing. This revealed no significant effect of condition (VRET versus CBT) on the CERQ-F negative cognitions intermediate test, $F(2, 40) = 0.38$; $p = 0.54$. However, a significant effect of condition was found on the CERQ-F positive, $F(2, 40) = 7.26$, $p = 0.010$. Using paired t-tests a significant effect of time was found in the VRET preparation condition on the CERQ-F negative; $t(28) = 2.30$; $p = 0.029$, but no effect of time was found on the CERQ-F positive; $t(28) = 0.51$; $p = 0.61$. However, in the CBT-preparation condition different effects were found. No significant effect of time

was found on the CERQ-F negative; $t(13) = 1.07$; $p = 0.30$, but a significant effect of time was found on the CERQ-F positive; $t(13) = -2.61$; $p = 0.022$. These results indicate that CBT resulted in more positive, coping cognitions towards flying than did VRET. Moreover, VRET resulted in less negative cognitions towards flying than did CBT. Means and *SDs* are presented in Table 5.8.

5.3.8.3 The group training

To investigate the effects of preparation plus the group training ANCOVAs were conducted to analyse the differences in cognitive change between preparation by VRET or CBT plus group training and paired t-tests were used to analyse the effect of time between pre-test and post-test. An ANCOVA, with the pre-test of the CERQ-F as covariate, showed no significant effect of condition on the CERQ-F positive, $F(2, 34) = 0.51$, $p = 0.48$ nor on the CERQ-F negative, $F(2, 34) = 0.62$; $p = 0.44$.

Using paired t-tests a significant effect of time was found in the VRET preparation condition plus group training on the CERQ-F negative; $t(26) = 9.79$; $p < 0.001$, but no effect of time was found on the CERQ-F positive; $t(26) = -0.30$, $p = 0.77$. The same effects of time were found in the CBT preparation condition, CERQ-F negative; $t(9) = 8.04$; $p < 0.001$ and CERQ-F positive; $t(9) = -1.13$; $p = 0.29$. These results indicate that both groups had less negative cognitions on fear of flying after the group training but subjects did not change on positive cognitions. Means and *SDs* are presented in Table 5.8.

Table 5.8 Means and SDs of the CERQ-F positive scales and CERQ-F negative scales at pre-test, intermediate test and post-test

Condition	Measure	Pre-test Mean (*SD*)	Intermediate test Mean (*SD*)	Post-test Mean (*SD*)
Bibliotherapy	CERQ-F positive	40.16 (9.47)	42.68 (11.65)	-
(*n* = 19)	CERQ-F negative	52.58 (12.20)	53.32 (15.42)	-
CBT/ VRET pooled	CERQ-F positive	44.93 (12.25)	46.84 (15.12)	-
(*n* = 43)	CERQ-F negative	49.47 (11.53)	45.16 (13.55)	-
VRET	CERQ-F positive	44.14 (11.03)	42.93 (11.14)	45.11 (13.23)
(*n* = 29)	CERQ-F negative	48.03 (10.94)	43.45 (12.74)	29.33 (8.81)
CBT	CERQ-F positive	46.57 (14.79)	54.93 (19.15)	48.25 (16.52)
(*n* = 14)	CERQ-F negative	52.43 (12.54)	48.71 (14.96)	30.40 (9.28)

* post-test, *n*(VRET) = 27 and *n*(CBT) = 10

Overall, bibliotherapy as well as CBT seem to add to positive cognitions, while VRET and the group training regardless of condition, seem to lessen negative cognitions about flying.

5.4 Discussion

This is the first study in which VRET is directly compared to CBT and bibliotherapy without therapist interventions with patients fearful of flying (DSM-IV diagnosis of specific phobia). Results showed that treatment by means of VRET or CBT as a preparation for CBT group treatment was more effective than bibliotherapy only. However, neither VRET nor individually tailored CBT was superior to the other in terms of effectiveness. Both treatments showed a decline in fear of flying on the two main outcome measures in the group of treatment completers and in the intention to treat analyses. Treatment effects (pre-test compared to post-test on the FAS and FAM) were larger for CBT plus the group training (d = 3.31 and d = 3.76) compared with VRET plus the group training (d = 2.13 and d = 1.87). Effects found in the preparation phase of therapy were between small and medium according to Cohen's d, effect sizes of 0.42-0.61. Decline of fear of flying in the second phase, group training, was substantial, where effect sizes ranged between 1.28 and 2.78.

The effectiveness of the individual phase of treatment on claustrophobia and acrophobia was medium to substantial (VRET, d = 0.60 and CBT, d = 0.97). Both treatment conditions showed decline in anxiety. The effect size of VRET was comparable or slightly smaller to treatment effect sizes found in earlier studies on VRET of acrophobia. Emmelkamp et al. (2001) found an effect size of 0.99 after two sessions, Emmelkamp et al. (2002) found an effect size of 1.28 after three sessions and Krijn et al. (2004) found an effect size of 1.31 after three sessions of VRET. The effect size of CBT was comparable to the effect size found in an earlier study by Emmelkamp et al. (2002) on exposure in vivo of acrophobia, d = 0.98.

The effect size of CBT in this study was comparable to treatment effect sizes found in an earlier study by Öst et al. (2001); d = 1.16 on claustrophobia. The effect size of VRET was smaller. Treatment in the study by Öst et al. (2001) consisted of

one long session of exposure (5 hours), 5 sessions of graded exposure or 5 sessions of cognitive therapy.

It can be concluded that VRET as stand alone treatment was not sufficiently effective in reducing fear of flying in this trial, neither was the individually tailored CBT. Bibliotherapy was not effective on any measure. Other studies on bibliotherapy for specific phobias showed better results (e.g. Öst, Stridh, & Wolf, 1998; Newman et al, 2003). However, it must be emphasised that in those studies, on average, more time with a therapist was spent or self-help was administered in a lab. Furthermore, subjects in the bibliotherapy condition in our study already knew they would receive an individual treatment after five weeks. Whether this influenced the results of the bibliotherapy condition is unknown.

A possible explanation of the small to medium effect sizes of VRET could be the impossibility to check the extinction experienced in the virtual environment. If patients are treated for example for acrophobia, they experience the effects of treatment in their daily life (climbing stairs, going to a shopping mall, etc.). The generalisation effect of fear of flying however can only be found out while flying in a real aircraft. The clinical impression was that patients experienced extinction during VRET but they doubted whether this would also generalise to real life and real flying. The slight to medium effects of CBT and VRET may also be related to expectancy effects. All subjects knew they would get a two-day training program after VRET or CBT suggesting that both therapies would not be effective enough on their own. Moreover, VRET was given in Amsterdam at the university while both CBT in the preparation phase and the CBT group training were given at the VALK foundation in Leiden. Possibly, these practical circumstances concerning VRET influenced the perception of VRET plus group training as two separate treatments instead of a whole treatment package.

In comparison to van Gerwen et al. (submitted) the effect of the individually tailored CBT sessions was smaller (1.69 versus 0.47). However, the timing of the intermediate test was different. According to van Gerwen et al. (submitted) the intermediate test was taken before the exposure component of the group training. In the present study the intermediate test was given after the individual phase before the whole group training that also contained, cognitive therapy, explanation of panic attacks and a presentation by a pilot on aircraft, flying and safety. In case of the study by van Gerwen et al (submitted) these components of treatment were all included

between the pre-test and intermediate test. This difference in timing of the intermediate test was probably responsible for the difference in effect size of the individually tailored CBT treatments mentioned. In concordance with this explanation (timing of intermediate test) is the fact that the effect sizes between intermediate test and post-test on the FAS are much higher in this study compared to the study by van Gerwen et al. (submitted); 2.78 versus 1.28.

In comparison to other studies on VRET as treatment of fear of flying, the effects of VRET as well as CBT in this study were rather small. However, most studies mentioned in the introduction used other techniques, e.g. cognitive therapy and relaxation, next to VRET and used more sessions. In this study VRET and individual CBT were used as preparation and thus smaller effect sizes were expected. It could be suggested that the treatment of fear of flying is more complex than the treatment of other specific phobias and that the treatment of fear of flying should be a combination of techniques (for instance: VRET, cognitive and relaxation techniques). Maltby et al. (2002) concluded that cognitive techniques alone are less effective than cognitive techniques combined with VRET. The conclusion of the present trial is that VRET alone, given in four sessions, is not effective enough. Future research should look into the possibilities of comparing the effectiveness of VRET versus VRET and cognitive techniques or measure the effectiveness of each component of the treatment. Moreover, the CBT condition was a better preparation to the group training than VRET. This could be due to the fact that the group training assumes that subjects know some relaxation methods and cognitive techniques, which are learned during CBT but not during VRET. Maybe another form of group training could be applied when VRET is chosen as first treatment phase with, for instance, more information about cognitions or relaxation in the second phase and less emphasis on the exposure rationale which is already explained during VRET. Treatment of choice at this moment in combination with the well-established group training is individually tailored CBT. Future research should also investigate the effectiveness of the group training as a stand-alone treatment, which might even be superior in cost-effectiveness.

Cognitive changes in negative cognitions were found after the group training regardless of preparation phase and after VRET. Bibliotherapy as well as CBT resulted in more positive and coping cognitions at short term but this change in positive cognitions was not observed after the group training. A possible explanation

is that subjects learn more on coping while reading the book on fear of flying (bibliotherapy) or while learning how to relax and cope during CBT. The group training and VRET on the other hand, focused more on exposure and on fear and fear extinction and therefore possibly on diminishing negative cognitions. Future research should look into the importance of positive and negative cognitions in relation to treatment effectiveness and possible strategies of changing these cognitions.

A drawback of VRET is that in the present study VRET did not elicit anxiety in a substantial number of patients (16 of 50). This is a concern for the validity of the VR treatment in question. Moreover the virtual environments (VEs) used were evaluated by means of testing the worlds with people fearful of flying but this was not done experimentally. New or improved virtual environments should be evaluated more carefully before being used in other clinical trials. Only one flight VE was used with one captain and crew and one destination. In future research more virtual flying environments and more parameters should be created and evaluated (for example a thunderstorm, different forms of turbulence, turning the aircraft, different destinations and voices).

It can be concluded that VRET holds promise as treatment of fear of flying, but to date CBT with an exposure in vivo component showed the largest decrease in subjective anxiety, thus being the treatment of choice.

6

Discussion

The main objective of this thesis was to add empirically based information to the scientific literature on treatment methods that use virtual reality for patients with specific phobias, i.e. fear of heights and/ or fear of flying. In general, the results provide evidence that virtual reality exposure therapy (VRET) produces a medium to substantial decrease in anxiety for specific situations, which persists up to six months. This chapter gives a brief overview of the conclusions from the various studies conducted, after which several strengths and limitations of these investigations are discussed. Moreover, implications for clinical practice and suggestions for future research are presented.

6.1 Intervention outcome studies in the present thesis

First, a review was presented of all studies published to date on virtual reality exposure therapy of anxiety disorders (chapter 2). In short, this review stated that VRET is effective for participants with fear of heights and fear of flying. For other phobias (e.g. agoraphobia and social phobia) mentioned in the review, research to date is inconclusive regarding treatment effectiveness.

Second, three separate studies were presented in this thesis on the effectiveness of VRET (chapter 3 to 5). A study of different levels of presence and of the influence of different levels of presence on the effectiveness of VRET in patients fearful of heights was presented (chapter 3). Either a head-mounted display (HMD; relatively low presence) or a computer automatic virtual environment (CAVE; relatively high presence) was used. No differences were found in effectiveness between VRET using an HMD or a CAVE. These results had remained stable at 6-month follow-up. Moreover, VRET, regardless of the system used, was found to be more effective than a waiting period. The results of the HMD-CAVE study presented in chapter 3 are in line with other studies (Emmelkamp et al., 2001; Emmelkamp et al., 2002; Rothbaum et al., 1995b). Furthermore, the HMD-CAVE study showed that low budget equipment appeared to be as effective as high cost virtual reality hardware, which is most important for clinical practice.

Results of the HMD-CAVE study (chapter 3) are in accordance with two studies, which have recently been published. In a study by Robillard, Bouchard, Fournier and Renaud (2003) was shown that even therapeutic virtual environments

derived from computer games could generate presence and anxiety in phobic patients. Moreover, a study by Baños et al. (2004) has shown that both immersion and emotions elicited in the virtual world had an effect on presence. In this study three immersive systems and two virtual environments, one involving emotional content and one being neutral, were compared on level of presence generated. The three immersive systems used were an HMD, a semi-immersive system video wall and a PC monitor. It was concluded that both immersion and affective content had a positive association with presence; the better the quality of the equipment the higher the level of presence and the more emotion elicited the more presence was experienced. Moreover, immersion was more relevant for non-emotional environments than for emotional ones. Presumably, emotion can mediate feelings of presence in a virtual environment. This gives further support to the notion that relatively cheap equipment can be used in exposure therapy, since eliciting emotions, i.e. anxiety- which is a conditio sine qua non for exposure therapy - can already be achieved by relatively cheap equipment.

The second study described in this thesis was a randomised crossover trial, in which the effectiveness of VRET and the possible additional effectiveness of cognitive techniques were investigated (chapter 4). Both treatments significantly decreased anxiety and increased self-efficacy in patients fearful of heights or flying. Results indicated that VRET was the effective ingredient of treatment, since the addition of cognitive techniques did not enhance treatment effectiveness. Within group effect sizes after two sessions of VRET were medium to substantial. However, long-term effects showed different results for the patients groups. Acrophobic patients experienced a marginally significant increase in anxiety and a significant decrease in self-efficacy both compared to post-test, while patients fearful of flying retained the gains from treatment. However, results should be interpreted with caution because of the small sample size of the fear of flying group (n = 12) and also because a combined measure of anxiety was used for fear of heights and fear of flying.

Third, a comparative evaluation of VRET, cognitive behaviour methods and bibliotherapy as preparation for a cognitive behaviour group training in patients fearful of flying was presented (chapter 5). Both VRET and cognitive behaviour therapy (CBT) were found to be more effective than bibliotherapy. In the preparation phase of treatment no statistical difference between VRET and CBT was found, although effect sizes were higher for CBT (medium) than for VRET (small to

medium). Most importantly, the preparation phase by means of CBT plus the group training was more effective than preparation by means of VRET plus group training. This might be due to the treatment elements of the group training. The idea of the group training is that cognitive techniques and relaxation have been taught individually before entering the group, which was only done in the CBT preparation condition. The most eminent component in the group training is exposure, which was new to the CBT preparation group, but had already been explained to and virtually experienced in the VRET preparation group.

The difference in effect sizes found between the fear of flying study, (chapter 5; small to medium effect sizes, pre-post on anxiety questionnaires) and the cognitive techniques study, (chapter 3; medium to substantial effect sizes after two sessions) cannot be explained by pre-test differences, since no significant differences on FAS en FAM pre-test scores were found. However, expectancy effects can be related to the difference in effect sizes. Prior to the preparation phase of treatment patients in the fear of flying study already knew there would be a two-day training given after this preparation phase. Patients in the cognitive study knew they would only be treated by means of four sessions of VRET. Expectancies like “this is only a preparation for the ‘real’ training” (fear of flying study, chapter 5) or “this is the only treatment given” (cognitive study, chapter 3) might have influenced treatment outcome. Unfortunately, expectancies were not investigated, so no conclusions can be drawn on this subject.

6.2 Strengths and limitations

Several strengths of the research presented in this thesis will be summarized. Randomised clinical trials (RCTs) are a good method of testing the effectiveness of treatments. In the field of VRET RCTs can be counted on one hand, which stresses the value of the three RCTs on VRET presented in this thesis. Before treatment, a standardized psychometric interview was used for DSM-IV Axis-I disorders as a diagnostic tool, indicating that specific phobias were diagnosed before treatment and subjects with mild fears of heights and/ or flying were excluded. This is significant for clinical practice, since only severe cases will apply for treatment. In one study (Krijn et al., 2004) a behavioural avoidance test (BAT) was used to examine generalisation effects to the real world. This is important, since the aim of all treatments is to

influence behaviour and feelings in real life. Also, the authors involved in the research presented in this thesis have no financial interest in the virtual reality equipment investigated. Although there are no indications that conflicts of interest were present in the past, it must be noted that most research published to date is done by authors with financial interest in the virtual reality equipment investigated (Emmelkamp, in press). Studies by independent researchers, like the three RCTs described in this thesis, are essential.

The fear of flying study presented in chapter 5 was conducted at VALK, a treatment centre specifically developed for the treatment of fear of flying. Incorporating research in clinical practice is rather unique and is relevant for expanding the use of VRET from the lab to clinical practice. Components of treatment and their effect on anxiety were studied separately in this thesis. This is important because most studies on VRET studied treatment packages, as a result of which, effectiveness of VRET alone remained unknown. This is particularly relevant with respect to fear of flying. The few studies to date that found VRET effective in fear of flying (Rothbaum et al., 2000; Maltby et al., 2002; Mühlberger et al., 2003) used an amalgam of cognitive behaviour techniques in addition to VRET itself.

One of the main limitations in the research described in this thesis is that no comparison was made between VRET and exposure in vivo, the golden standard to date. However, the effectiveness of VRET in fear of heights is already established by earlier studies by Emmelkamp et al. (2001; 2002), in which VRET was found to be as effective as exposure in vivo in the same amount of sessions, using the exact same situations (Emmelkamp et al., 2002). In fear of flying no direct comparison of exposure in vivo versus VRET (as used in our studies) is available. Nevertheless, exposure in vivo plus anxiety management training (AMT) was found to be as effective as VRET plus AMT in fear of flying (Rothbaum et al., 2000; Rothbaum et al., 2002). However, in the Rothbaum et al. study (2000) different situations were used during exposure in vivo and VRET. Moreover, the effect of AMT as a unique treatment component was not investigated. In case of fear of flying a comparison made between VRET and exposure in vivo using the same environments can be of relevance, but remains fairly complex.

Another limitation of the studies presented in this thesis is the lack of physiological measurements and scarce use of behavioural avoidance tests (BATs). Reliance on retrospective self-reports alone, as a indication of change after treatment

is less thorough compared to adding behavioural or physiological measures. It must be emphasized that in the acrophobia study (chapter 3) a BAT was used and results were in accordance with the subjective measures. Moreover, in the fear of flying study (chapter 5) every subject included in the study actually flew in a real aircraft during treatment, indicating a substantial decrease of anxiety. However, this was done as part of the group training, which was given after preparation by means of VRET or individual CBT.

Clinically significant virtual environments were designed for this study after consulting clinical psychologists, who had much experience in assessing and treating patients with specific phobias and after interviewing fearful subjects. However, in the future, developing virtual environments could be improved by testing them more formally before their use in effectiveness research. During this 'testing-phase', the use of physiological measures, combined with self-report, could be helpful, as indication of the anxiety-provoking qualities of a virtual environment. However, in the studies described in this thesis the majority of patients (75%) found the virtual worlds anxiety-provoking and the clinical impression was that parameters that were of influence to the phobia of patients (e.g. mentioned during intakes) were generally present in the virtual environments.

A last limitation of the studies described is the high amount of dropouts (25%) in the VRET conditions. This influences the external validity of VRET. Several subjects were not able to experience presence during virtual exposure, i.e. they could not feel anxious in the virtual environments, which made exposure therapy impossible. Future research could focus on possible predictors of dropout, especially in the area of participants' characteristics. Preliminary results showed that absorption and dissociation influenced reality judgment in virtual reality (Baños, et al., 1999). This might play an important role in an effective virtual presentation, and may influence treatment effectiveness of VRET. Moreover, the increase in computer speed and technology over the coming years will probably result in virtual environments that are judged as being more realistic, cause less simulator sickness and will create higher levels of presence, leading to a smaller amount of dropouts.

6.3 Clinical implications

There are a number of obstacles to conquer before clinicians will be able to make good use of the virtual reality technology. Randomized controlled trials are a good method to evaluate treatment effectiveness and in the three studies reported in this thesis such methods are used. From these studies, it can be concluded that VRET can be used as treatment (component) in acrophobia and fear of flying. Also, generalisation to the real world was investigated in one study by using a BAT, indicating robust findings of effectiveness of VRET in acrophobic patients. Finally, one study was done in a fear of flying practice, which showed that VRET could be incorporated in a clinical practice. Moreover, large mental health institutes are interested in virtual reality systems and have the intention to use these systems in the next two years, which will result in research on the system's usability and effectiveness in general clinical practices in the Netherlands. To date, several institutes around the world use VRET. In the US several practitioners bought the Virtually Better's system, evaluated by the virtual reality group at the Emory University School of Medicine, Atlanta, Georgia. In Spain the company Previ sells several virtual environments and accompanying hardware and is collaborating with the university of Jaume I, the Polytechnic University of Valencia and the University of Valencia.

However, despite the potential to use virtual reality in the treatment of anxiety disorders in clinical practice, several problems should be mentioned that urge some caution. First, the treatments given in research trials are often poorly described and an amalgam of techniques are generally used in treatment (e.g. VRET plus cognitive techniques, VRET plus anxiety management training). Only some clinical protocols are reported (e.g. Vincelli et al., 2000; Rothbaum, Hodges & Smith, 1999). More detailed information on protocols and therapy given in research conditions should be made available for clinical practice[1]. Second, the effectiveness of virtual reality exposure for other psychiatric disorders than specific phobias, is not yet well established. RCTs for other anxiety disorders than fear of heights and fear of flying are scarce. To date five clinical studies were published, one on fear of spiders, one on

[1] The treatmentprotocols used in the research described in this thesis are available from the author.

agoraphobia, two on social phobia and one on PTSD. The study on fear of spiders (Garcia-Palacios et al., 2002) showed that VRET was more effective than a waiting period. However, the amount of sessions of VRET was flexible. Also, one small study on agoraphobia (Vincelli et al., 2003) was reported with positive results. Experiential cognitive therapy (including VRET) was found to be as effective as CBT. However, the number of subjects in every condition was limited and other techniques, e.g. cognitive techniques, were used in addition to VRET. Two studies with social phobics were reported that showed significant differences between the effectiveness of VRET and a waiting list condition, in favour of VRET (Harris et al., 2002) and no differences in treatment effectiveness between VRET plus cognitive techniques and standard CBT group therapy for social phobia (Klinger et al., 2005). Finally, VRET as treatment of PTSD showed positive results as well (Rothbaum et al., 2001). However, the treatment condition including VRET was not compared to a control condition. In summary, the effectiveness of VRET for more clinically relevant phobias and anxiety disorders, e.g. agoraphobia, social phobia and posttraumatic stress disorder, is unknown, although some studies showed the possibilities of VRET as treatment.

Virtual reality has advanced rapidly in the last years and will probably develop even faster over the coming years, also due to the massive gaming industry and its use of virtual reality. Other clinical applications are being investigated as well, such as the use of virtual reality in distortion of body image in patients with eating disorders (e.g. Riva, Bacchetta, Casa, Conti, & Molinari, 2003; Riva, Bacchetta, Baruffi, & Molinari, 2001), cue exposure for craving in addiction treatment (e.g. Lee et al., 2004), pain reduction in wound care (e.g., Hoffman, Garcia-Palacios, Kapa, Beecher, & Sharar, 2003; Hofmann et al., 2004), cognitive rehabilitation (e.g. Myers & Bierig, 2000; Trepagnier, 1999), assessment of driving capacities (e.g. Wald, Liu & Reil, 2000) and the assessment of the severity of hyperactivity and deficits in attention in children with ADHD (e.g. Rizzo et al., 2000). Research to date showed positive results for the applications mentioned above, although more trials are necessary before firm conclusions can be drawn. However, continuing investigations in the field of mental health and virtual reality will probably lead to useful applications for clinical practice in the near future.

6.4 Future research

In a rapidly growing and developing field of virtual reality applications, ample possibilities and opportunities for research arise. First, randomized controlled trials are needed to investigate the effectiveness of VRET for different more disabling anxiety disorders and other treatment possibilities, such as cue exposure for addictive disorders. Moreover, both behavioural (avoidance) tests should be used and long-term effects should be assessed more often.

Second, controlled creation and investigation of virtual environments is necessary. Virtual reality studies to date have led to the conclusion that realism of the display seems to be far less important for presence than expected (Sanchez-Vives & Slater, 2005). This result has led to the concept of 'minimal cues'; the minimal elements that a virtual environment must include to induce presence (Slater, 2002) and, in virtual reality exposure therapy, anxiety. What makes a virtual environment anxiety-provoking and what parameters are of relevance and could be manipulated? More research into predictor variables is necessary as well, since preliminary results showed that several participant characteristics might influence the amount of presence experienced and indirectly treatment effectiveness (e.g., absorption; Baños et al., 1999).

It is expected that in five years, head-mounted displays will be available at home, which could create possibilities to compare VRET as a home treatment to therapist guided VRET and Internet therapies that have been found effective (e.g., Carlbring et al., in press; Lange et al., 2003).

It was not the aim of the present thesis to test specific theoretical models underlying the effectiveness of VRET. In chapter 1, several models were described that predict the effectiveness of VRET. The confirmation of this effectiveness for patients fearful of heights and/ or flying does not support any one of these models more than the others. However, theoretical underpinnings of exposure can be investigated in a controlled manner in virtual reality in future research. This experimental research is highly relevant because VRET is still considered a black box and more research into the paradigms of learning theory (classical conditioning and operant conditioning) as well as the emotional processing theory and cognitive biases should be done. Virtual reality could be an ideal environment to test theoretically based hypotheses on process variables during treatment, because all parameters

relevant can be controlled and reproduced for each subject. One recent study on fear conditioning in virtual environments showed possibilities of the use of virtual reality to investigate context based conditioning (Baas, Nugent, Lissek, Pine, & Grillon, 2004).

To conclude, the interface between technology and clinical psychology is an interesting field of research, which already created clinical applications, like VRET of fear of flying and fear of heights, and certainly holds promise for the future.

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Samenvatting

(Summary in Dutch)

Virtual Reality en Specifieke Fobieën

Welcome to the real world

Centraal in dit proefschrift staat de vraag of de behandeling van specifieke fobieën, te weten hoogtevrees en vliegangst, door middel van virtual reality exposure therapie (VRET) effectief is. Het is algemeen bekend dat exposure in vivo een effectieve behandelmethode is voor specifieke fobieën (Craske & Rowe, 1997). Patiënten worden bij deze behandelvorm blootgesteld aan situaties waar zij bang voor zijn, zonder dat zij deze situatie direct of indirect kunnen vermijden, zodat de angst kan afnemen en de situatie neutraler wordt ervaren (Emmelkamp, 2004). Minder is bekend over de mogelijkheden van virtual reality bij de exposure-behandeling van fobieën. Exposure in vivo kent enkele nadelen, zoals het vinden van situaties waarin geoefend kan worden, bijvoorbeeld het opstijgen bij vliegen of bergwandelingen bij hoogtevrees, of de motivatie van patiënten om aan behandeling deel te nemen waarbij zij direct worden geconfronteerd met beangstigende situaties. Ook de kosten van exposure in vivo kunnen oplopen (bijvoorbeeld bij de behandeling van vliegangst). Virtual reality zou hierbij een uitkomst kunnen bieden.

In hoofdstuk 1 wordt ingegaan op de diagnose van een fobie, prevalentie van fobieën, meetmethoden, theoretische achtergrond van de etiologie, de instandhoudende factoren van fobieën en de behandeling door middel van exposure van fobieën. Een specifieke fobie is een angst voor een bepaalde situatie of stimulus (spinnen, bloed, hoogte, etc.). Confrontatie met de specifieke stimulus of situatie wordt doorstaan met hevige aanhoudende angst of wordt vermeden. Specifieke fobieën komen veel voor. In Nederland heeft ongeveer 10% van de bevolking tijdens zijn leven last (gehad) van een specifieke fobie (Bijl, Ravelli, & van Zessen, 1998). Met behulp van verschillende meetmethoden kunnen de aanwezigheid en ernst van fobieën en angst bepaald worden. De meest gebruikelijke methoden zijn: vragenlijsten en interviews, gedragstesten en fysiologische metingen. Theoretische modellen die in dit hoofdstuk worden besproken zijn de leertheorie en “emotional processing”. Zij vormen de theoretische basis van exposure in vivo en de ontstaansgeschiedenis van een fobie.

In hoofdstuk 2 wordt uitgelegd wat virtual reality is, welke twee systemen met name gebruikt worden bij VRET en wordt een overzicht gegeven van de onderzoeken naar VRET en angststoornissen tot nu toe.
Virtual reality integreert *real-time* computerbeelden met een systeem dat kan bepalen waar iemand zich in de virtuele wereld bevindt om hierop de beelden die men in de

bril ziet en de geluiden die iemand hoort, aan te passen. Zodra iemand zijn hoofd naar boven beweegt genereert de computer de hierbij passende beelden, bijvoorbeeld van de lucht. Soms worden ook andere zintuigen gestimuleerd onder andere door het toevoegen van geluid of geur. De 'echte' wereld wordt zoveel mogelijk buitengesloten zodat iemand zich zo goed mogelijk kan concentreren op de virtuele omgeving en zich hierin aanwezig kan voelen. Dit gevoel van aanwezigheid wordt *presence* genoemd. VRET kan gezien worden als een vorm van exposure behandeling waarbij patiënten niet worden blootgesteld aan echte angstopwekkende situaties maar de virtuele versies van deze situaties.

Alle gepubliceerde onderzoeken op het gebied van VRET en fobieën samengenomen kan gezegd worden, dat VRET een effectieve behandelmethode is voor mensen die last hebben van vliegangst en/ of hoogtevrees. Over de effectiviteit van VRET voor andere fobieën kan tot op heden geen conclusie getrokken worden, aangezien hier weinig tot geen gedegen onderzoek naar is gedaan. Verder is er in de toekomst meer onderzoek nodig naar VRET als op zichzelf staande behandeling. Momenteel is VRET namelijk vaak onderzocht als deel van een behandelpakket waarin ook andere technieken worden gebruikt, zoals ontspanningsoefeningen of cognitieve technieken, waardoor de unieke bijdrage van VRET aan de effectiviteit van behandeling onduidelijk is gebleven.

In hoofdstuk 3 tot en met 5 worden drie gerandomiseerde klinische studies beschreven naar de effectiviteit van VRET voor hoogtevrees en/ of vliegangst. Hoofdstuk 3 beschrijft een onderzoek waarin de effectiviteit van de behandeling van hoogtevrees door middel van virtual reality exposure therapie wordt bestudeerd. Presence werd gemanipuleerd door patiënten (in totaal 37) willekeurig toe te wijzen aan behandeling door middel van een *head-mounted display* (HMD) of een *computer automatic virtual environment* (CAVE). Het systeem waarbij een HMD (soort virtual reality-bril) werd gebruikt, maakte daarnaast gebruik van reguliere computers en grafische kaarten, terwijl het systeem van de CAVE zeer geavanceerd was. Het bleek dat mensen die werden behandeld met het geavanceerde systeem (CAVE) zich meer in de virtuele wereld aanwezig voelden dan mensen die werden behandeld met behulp van het meer reguliere systeem (HMD). Dit bleek echter niet van invloed op de effectiviteit van de behandeling. Behandeling door middel van VRET, ongeacht het systeem dat werd gebruikt, bleek significant effectiever dan een wachtperiode bij

patiënten met hoogtevrees, gemeten met vragenlijsten en een gedragstest. Er werd geen verschil in effectiviteit gevonden tussen de verschillende systemen (HMD versus CAVE). Zes maanden na behandeling bleek het effect van behandeling nog steeds aanwezig.

In hoofdstuk 4 wordt aandacht besteed aan de rol van cognities bij de behandeling van vliegangst of hoogtevrees door middel van VRET. In dit onderzoek werden 40 patiënten met hoogtevrees of vliegangst behandeld met twee sessies VRET gevolgd door twee sessies VRET plus het gebruik van neutrale coping gedachten of andersom, namelijk twee sessies VRET plus gebruik van neutrale coping gedachten gevolgd door twee sessies VRET. De resultaten van dit onderzoek lieten zien dat VRET effectief was en dat het toevoegen van neutrale coping gedachten niets toevoegde aan de effectiviteit van de behandeling. De behandeling zorgde voor een daling in angst en een toename van zelfvertrouwen, gemeten met behulp van vragenlijsten. Zes maanden na behandeling bleek het effect van behandeling nog steeds aanwezig bij de patiënten met vliegangst. Patiënten met hoogtevrees daarentegen hadden een kleine terugslag, zij voelden zich weer wat angstiger dan direct na de behandeling (marginaal significant) en hadden significant minder vertrouwen in zichzelf in hoogtevrees-situaties dan direct na de behandeling.

In hoofdstuk 5 wordt een onderzoek beschreven naar de effectiviteit van de behandeling van vliegangst. Verschillende behandeltechnieken worden met elkaar vergeleken in twee fasen van behandeling. In de voorbereidende fase werden 86 patiënten willekeurig toegewezen aan, a) vier sessies VRET, b) twee tot vier sessies ontspanningstraining en cognitieve herstructurering (cognitieve gedragstherapie = CGT) of c) vijf weken bibliotherapie. Bibliotherapie bestond uit het lezen van een boek waarin informatie werd gegeven over vliegen, vliegangst en mogelijke coping en zelfhulp. Patiënten moesten dit boek thuis zonder verdere begeleiding doorlezen. VRET en CGT zorgden voor een significante vermindering van vliegangst, maar bibliotherapie liet geen significant behandeleffect zien. Hierna werden de patiënten die bibliotherapie hadden gehad (n = 20) toegewezen aan CGT of VRET zoals hierboven beschreven. In de voorbereidende fase bleek geen verschil in effectiviteit tussen CGT en VRET. Wel bleek dat de effectgrootte van behandeling klein was bij VRET en matig bij CGT. Na de voorbereidende behandelfase werden alle patiënten

door middel van een tweedaagse groepstraining behandeld voor hun (resterende) vliegangst. Deze groepstraining bestond uit: uitleg van een piloot over vliegen, informatie over angst in het algemeen, analyse en verandering van angstopwekkende gedachten, ontspanningsoefeningen, blootstelling aan vliegen in een vliegsimulator op Schiphol en een retourvlucht binnen Europa. De meeste tijd werd besteed aan het vliegen (zowel in de vliegsimulator als de daadwerkelijke vlucht binnen Europa). Uit het onderzoek kwam naar voren dat beide behandelcombinaties (VRET plus de groepstraining en CGT plus de groepstraining) zorgden voor een significante, substantiële daling van vliegangst. Het bleek echter dat VRET plus de groepstraining significant minder effectief was dan CGT plus de groepstraining. Dit verschil in effectiviteit zou verklaard kunnen worden door het feit dat bij VRET plus de groepstraining het essentiële kenmerk van beide behandelfasen exposure was, terwijl het essentiële kenmerk bij CGT plus de groepstraining verschilde per fase, namelijk cognitieve technieken en ontspanning tijdens de voorbereidende fase en exposure tijdens de groepstraining. Helaas konden veel patiënten zich niet inleven in de virtuele omgevingen (± 30%), waardoor behandeling onmogelijk werd en zij uitvielen. Dit was een groot nadeel van VRET.

In hoofdstuk 6 zijn de conclusies van het proefschrift samengevat, worden de sterke en minder sterke kanten van de verschillende onderzoeken belicht en worden de implicaties voor de klinische praktijk en suggesties voor toekomstig onderzoek besproken.

De belangrijkste bevinding is dat VRET als behandelvorm voor patiënten met hoogtevrees en/ of vliegangst effectief is gebleken. Enkele sterke kanten van het beschreven onderzoek uit dit proefschrift waren, (1) de designs van de studies (gerandomiseerde klinische studies), (2) het feit dat in de onderzoeken gebruik gemaakt werd van patiënten met een DSM-IV diagnose voor specifieke fobie (dus niet alleen mensen die bang zijn in een specifieke situatie maar die ook daadwerkelijk last van deze angst hebben in het dagelijks leven), (3) een gedragstest als uitkomstmaat bij één onderzoek (om te kijken naar generalisatie effecten van VRET), en (4) onderzoek binnen een klinische praktijk, te weten stichting VALK (om te kijken of onderzoek vanuit het laboratorium ook toepasbaar is in de klinische praktijk).

Uiteraard zijn er ook wat minder sterke kanten van het onderzoek te noemen. Zo is er geen vergelijking gemaakt tussen de standaard behandeling, exposure in vivo en VRET. Wel blijkt uit vorig onderzoek dat VRET en expsosure in vivo even effectief zijn als behandeling voor hoogtevrees (Emmelkamp et al., 2001; 2002) en VRET plus angst management bleek even effectief te zijn als exposure in vivo plus angstmanagement bij vliegangstigen (Rothbaum et al., 2000; 2002). Ook werd in de onderzoeken beschreven in dit proefschrift geen gebruik gemaakt van fysiologische metingen. Tevens zouden virtuele werelden die voor onderzoek gebruikt worden in de toekomst mogelijk structureler moeten worden getest, voordat ze voor behandeling worden gebruikt dan in de beschreven onderzoeken is gedaan. Als laatste wordt opgemerkt dat er gekeken zal moeten worden naar het hoge aantal uitvallers tijdens behandeling met VRET.

Voor de klinische praktijk is het van belang dat meer gecontroleerd onderzoek naar de mogelijkheden van VRET bij andere angststoornissen en as-I stoornissen, zoals bijvoorbeeld posttraumatische stress stoornis of verslaving, uitgevoerd gaat worden. Nieuw onderzoek naar de behandeling van sociale fobie met behulp van VRET toont positieve resultaten en lijkt veel belovend voor de toekomst (Klinger et al., 2004). Ook zou in het vervolg meer gebruik moeten worden gemaakt van gedragstesten en fysiologische metingen en lange termijn effecten zouden vaker moeten worden onderzocht. Verder zou er kunnen worden gekeken naar voorspellende variabelen om te onderzoeken voor wie VRET een geschikte methode is om zo de uitval bij VRET te kunnen verminderen. Daarnaast lijkt virtual reality een geschikt medium om hypotheses van onderliggende theorieën te kunnen toetsen. In virtual reality kunnen namelijk specifieke parameters worden gemanipuleerd en kan voor iedere proefpersoon de situatie exact worden herhaald.

Samenvattend kan gezegd worden dat het snijvlak tussen klinische psychologie en technologie een boeiend veld van onderzoek is, wat bovendien al geresulteerd heeft in enkele klinische applicaties, zoals VRET voor vliegangst en hoogtevrees en waar in de toekomst nog veel van verwacht mag worden.

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