Evaluation of the effectiveness of Virtual Reality Exposure Therapy (VRET) in the management of anxiety about dental treatment

Raghav, K.

Publication date
2021

Document Version
Other version

License
Other

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Chapter 8. Summary and general discussion

8.1 Introduction

In this chapter a concise overview of the conclusions drawn from individual studies, strengths and limitations of the studies that are part of this thesis that examined the effects of Virtual Reality Exposure (VRET) are presented. This is followed by a discussion about its possible mechanisms of action and the factors that are likely to influence the effectiveness of VRET. Finally the chapter concludes by discussing the impact of VRET in the dental practice, future VRET research avenues and barriers for carrying out VRET in patients with dental phobia.

The primary objective of this thesis was to compare and to evaluate the effectiveness of VRET with an information pamphlet (IP) control condition in terms of dental anxiety reduction using different samples of patients with dental phobia. The secondary objective involved evaluating the real-time physiological heart rate (HR) response of patients with dental phobia during VRET. Therefore, we conducted a series of studies with different study designs to determine the effectiveness of VRET. The next section gives an overview of the chapter-by-chapter summary of the included studies in this thesis.

8.2 Summary drawn from individual studies

8.2.1 Chapter 2

In the second chapter (Gujjar, van Wijk, Kumar, & De Jongh, 2019a), a systematic review of all published studies on technology-based interventions in the treatment of dental anxiety was conducted. The purpose was to review the extant literature regarding the effectiveness of these interventions in the treatment of moderate to severe dental anxiety. Systematic searches of the databases were carried out in two stages. The first literature search was carried out at the start of the Ph.D. study between 1969 and March 2014 which inferred that technology-based interventions in the form of VRET are unexplored in the treatment of dental phobia. This formed the basis to develop a VRET system in a dental context and to test its applicability by conducting series of related studies. The second search was conducted during the mid-Ph.D. period between 1969 to July 2018. After scrutiny, seven randomized controlled trials (RCTs) were included for review. Six studies that evaluated video modelling (n = 3), C-CBT (Computerized-based Cognitive Behavioral Therapy; n = 1), VRET (n = 1) and distraction with audio-visual (n = 1) video material showed
significant greater reductions in dental anxiety compared to inactive controls among both children and adults, suggesting that technology-based behavioral interventions work well in the treatment of dental anxiety. However, the quality of all included studies was generally poor. In addition, the majority of the studies did not evaluate the safety and avoidance of dental treatment following the intervention. This led us to evaluate the efficacy of VRET while also addressing the concerns of the previous published studies on technology-based interventions with a well-designed and high quality RCT.

8.2.2 Chapter 3

The third chapter (Gujjar, Sharma, & De Jongh, 2017) describes the preliminary findings of the first case study that evaluated the applicability of VRET. This study included two female patients aged 24 and 56 years with dental phobia. Following VRET we observed a significant reduction of behavioral avoidance and dental anxiety scores (both state anxiety and dental trait anxiety) at post-VRET and at six months follow-up. Both patients experienced strong presence and realism during VRET and acknowledged that the therapy was useful to them. Within six months, both patients scheduled their dental appointments and underwent dental treatment. Upon evaluation six months later, both patients did not fulfill the diagnostic criteria of dental phobia anymore.

8.2.3 Chapter 4

The fourth chapter of this thesis (Gujjar & De Jongh, 2019) presents the findings of the second case study that evaluated the use of VRET with an adult female patient suffering from severe dental phobia and a case with a pediatric dental phobic patient. VRET was found to be successful in reducing level of state anxiety, dental anxiety and behavioral avoidance in both patients. Further, these patients scheduled an appointment and underwent dental treatment within six months following therapy. That the treatment proved to be successful is illustrated by the fact that both patients did not meet the diagnostic criteria of dental phobia at follow-up.

8.2.4 Chapter 5

The fifth chapter (Gujjar, Wijk, Sharma, & De Jongh, 2018) discusses the results of the first feasibility study that evaluated both the safety of the use of VRET and its efficacy in the treatment of dental phobia by comparing the results of VRET with that of an informational pamphlet control (IP) condition. The study was conducted to identify shortcomings and limitations of VRET prior to commissioning the larger
randomized controlled trial and used a non-concurrent multiple baseline design among ten patients randomized to either VRET or the IP condition. VRET was found to be safe and effective in terms of a significantly greater reduction of state anxiety, dental trait anxiety and behavioral avoidance compared to the IP condition. At six month follow-up, a significantly greater proportion of VRET patients, compared to the IP patients, no longer fulfilled the diagnostic criteria of dental phobia and scheduled a dental appointment with another dentist. VRET patients experienced moderate presence and cybersickness during therapy. We found a significant reduction of HR post-VRET suggestive of physiologic habituation implying successful exposure therapy. However, precise determination of physiologic arousal and physiologic habituation were not evaluated in the feasibility study. Also, patients who underwent VRET experienced moderate cybersickness post-therapy. Hence, a RCT was planned to address the limitations of the feasibility study.

8.2.5 Chapter 6

In the sixth chapter (Raghav et al., 2016), based on the experiences obtained in Chapters 2, 3, 4 and 5, the protocol for a RCT was designed to be conducted in a study with 30 patients suffering from dental phobia. This chapter describes the design of this study that compared the efficacy of VRET against an informational pamphlet (IP) control condition in terms of reductions of state anxiety, dental trait anxiety and behavioral avoidance at one week, three month and six month follow-up. A standard, single VRET session was developed consisting of a baseline phase (no virtual reality display for ten minutes), a training phase (orientation to the virtual reality environment for two minutes), an experimental phase (exposure to the five virtual reality scenarios) and an immediate post-VRET phase for ten minutes. The frequency of breaks within the VRET session was reduced to ten minutes in order to prevent cybersickness. Temporal variations of Virtual Reality (VR) experience parameters such as presence, realism and cybersickness were planned to be determined at different time points following exposure with each VR scenario. In order to precisely measure the physiological arousal and physiological habituation, temporal changes in HR that might occur during VRET session were planned to be analyzed. Also, the number of patients who lost their dental phobia diagnosis and those who scheduled an appointment and underwent dental treatment elsewhere were planned to be evaluated at six month follow-up.

8.2.6 Chapter 7

The seventh chapter (Gujjar, van Wijk, Kumar, & De Jongh, 2019b) addresses, and discusses, the findings of the first randomized controlled study that was conducted
among 30 dental phobia patients who were randomly allocated to either VRET or an IP condition. VRET was found to be effective in terms of a significant reduction of dental anxiety scores (i.e., both state anxiety and dental trait anxiety) and behavioral avoidance compared to IP. There was evidence of physiologic habituation, i.e. a reduction of HR was noted post-VRET (relative to baseline HR). VRET patients experienced consistent strong presence and realism during therapy. However, mild cybersickness was noted in all patients post-VRET. VRET proved to be efficacious in that at six month follow-up, 85% of patients no longer fulfilled the diagnostic criteria of dental phobia compared to only 15% in the IP condition. In addition, within six months following therapy, 77% of the VRET patients scheduled their dental appointment and underwent actual dental treatment compared to 50% in the IP condition.

### 8.2.7 General conclusions

The findings of all included studies suggest that VRET is a safe, well-tolerated, acceptable and effective treatment for dental phobia.

### 8.3 Strengths and limitations

#### 8.3.1 Strengths of this thesis

There are several strengths involving the research projects which were part of my thesis that need to be noted. Firstly, this was the first time a systematic approach to evaluate the efficacy of VRET for dental phobia was carried out. At first, two case studies were conducted to obtain preliminary evidence, whereas next a feasibility study was conducted using a multiple baseline study. Our experiences with, and the findings of, the case studies and feasibility study enabled us to design and conduct a gold standard approach of assessing the relative efficacy of both interventions using a randomized controlled trial (RCT). Secondly, the virtual environment for applying VRET was designed after consulting clinical psychologists, dentists and a software engineer in order for the VR environment to be clinically suitable, realistic and immersive. Thirdly, a multiple validated and reliable instruments was used to evaluate the various therapy outcomes (Chapter 2-7). The studies were conducted only with patients experiencing severe symptoms of dental anxiety, i.e. those fulfilling the diagnostic criteria of dental phobia using the Phobia Checklist criteria (Oosterink, de Jongh, & Hoogstraten, 2009). The use of a variety of valid and reliable self-report measures (MDAS, DFS, and the Phobia Checklist), a physiological measure
(HR) and a behavioral avoidance test (BAT) for assessing treatment outcome, made it possible to examine the external validity of the experiments (McDermott, 2011). Fourthly, the use of a BAT before and after VRET, to examine the behavioral avoidance tendency of patients who had undergone the VRET, was also important, since the objective of any treatment for phobias is to influence patients’ avoidance behavior in real life situations. Taken together, the findings of the included studies in this thesis add empirical evidence to the existing scientific literature on the evidence based treatment of specific phobias.

8.3.2 Limitations of this thesis

One of the main limitations of the studies that were part of the current Ph.D. project is that none of these compared VRET with the gold standard in vivo exposure therapy (IVET). Therefore, in the future it is important to conduct studies that compare the effectiveness of VRET with that of IVET using a similar set of phobic stimuli. Secondly, the included studies had a limited follow-up of six months, which restricts conclusions regarding the empirical support for the long term effectiveness of VRET. Hence, further research is needed to validate the efficacy of VRET in the long term (Maples-Keller, Yasinski, Manjin, & Rothbaum, 2017), and to determine whether or not there is a relapse in patients with dental phobia following successful treatment using VRET. Thirdly, all studies were conducted at a single treatment center. Because we recruited the sample from a dental outpatient clinic, results from this thesis cannot be generalized to patients with extreme avoidance who do not visit the dentist at all. Therefore, to enhance the external validity and generalization of findings, future multi-site randomized controlled studies with a diverse sample are needed. While, given these considerations, on one hand the current findings may overestimate the effectiveness of VRET in the treatment of dental phobia, on the other, the large effect size obtained in the RCT (Gujjar et al., 2019b) suggests that the effects of VRET are robust. Finally, patients in all included studies underwent exposure to only a limited set (i.e., five) of dental VR scenarios (albeit most commonly encountered). Although this was done for reasons of consistency and standardization of the intervention, it may be considered a limitation because the nature and range of the stimuli that have the potential to trigger dental anxiety is much more wide and triggers may strongly vary among individuals (Oosterink, De Jongh, & Aartman, 2008). Regardless of the above limitations, the stability of treatment gains at follow-up and high acceptability of dental treatment among patients (Fernández-Álvarez, Di Lernia, & Riva, 2020) following VRET seem to make it a potentially invaluable treatment option for dental phobia.
8.4 VRET: Possible mechanisms of action

VRET is known to induce fear, emotional responses and physiological symptoms similar to in vivo exposure therapy (IVET; Riva, Bacchetta, Baruffi, & Molinari, 2002). That is, VRET involves exposure to individual’s fear provoking objects and situations (conditioned stimuli) using a computer-generated environment in a well-controlled graded manner in absence of aversive consequence (unconditioned stimuli; Botella, Baños, Rosa, García-Palacios, & Quero, 2017; Craske et al., 2008; Dunsmoor, Niv, Daw, & Phelps, 2015; Lindner et al., 2017). Procedurally, this is equivalent to fear extinction in which the conditioned stimulus that was previously paired with an aversive outcome (i.e., unconditioned stimulus) is repeatedly presented without being followed by unconditioned stimulus (Rothbaum, Hodges, Smith, Lee, & Price, 2000). Hence, it is likely that the resultant new learning (inhibitory learning) of non-threat association between the conditioned stimulus and unconditioned stimulus forms the basis for the effectiveness of VRET.

It has been argued that the success of VRET also depends on its ability to trigger physiological responses that are similar to those induced by phobic stimuli in real-life situations (Jang et al., 2002; Nesse et al., 1985; Roth et al., 1986; Wilhelm & Roth, 1998). That is, similar to IVET, VRET should trigger heightened psychophysiological response (Craske et al., 2008) following confrontation to the phobic stimuli to be successful. However, the RCT (Chapter 7) yielded no evidence of a lack of physiological arousal in that heart rate (HR) showed a downward trend following exposure to the higher anxiety provoking VR scenarios (relative to baseline HR). This is consistent with Fowles’ motivational theory (Fowles & Don 1988) which predicts that VRET specifically activates the behavioral inhibitory system, thereby causing a reduction in HR (Wilhelm et al., 2005). To objectively evaluate treatment outcome, and to better understand the physiological mechanisms (De Carvalho, Freire, & Nardi, 2010) underlying VRET, in future studies, the use of psychophysiological measures that would precisely determine the real-time physiological changes such as HR variability, skin conductance response and functional near infrared scan (fNIRS) would be enlightening. That is, recording physiological measures in real time could enable therapists/researchers (or an automated device or app) to precisely control the exposure, based upon the physiological responses of the patients which might improve treatment outcome.

Factors affecting effectiveness of VRET

As discussed in the introduction (under Section 1.7), for VRET to be effective, the exposure should be designed in such a way that it aims at violating core expectancies and should be administered until this aim is achieved (Craske et al., 2014). Therefore, the purpose of the controlled and realistic exposure to visual, olfactory and auditory
phobic cues (Maples-Keller et al., 2017) without aversive outcomes (Rothbaum, Hodges, Smith, Lee, & Price, 2000) during VRET is to activate the underlying fear structure (Price, Mehta, Tone, & Anderson, 2011). This facilitates learning in patients in that they experience that their irrational predictions are unfounded and as a result of this patients' fear subsides (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). For fear activation to occur, the virtual environment should be captivating for phobic patients (Maples-Keller et al., 2017) so that they interact with their feared virtual environment likewise as they would do in real life situations (Maltby, Kirsch, Mayers, & Allen, 2002). This meaningful interaction between the patient and phobic stimuli is facilitated by rich multi-sensory visual, olfactory and auditory cues (Fernández-Álvarez et al., 2020) that enable patients to perceive the situation as anxiety provoking (Lindner et al., 2017) during therapy (Maples-Keller et al., 2017), to increase the perception that the objects are real (Krijn, Emmelkamp, Biemond, et al., 2004; Krijn, Emmelkamp, Olafsson, & Biemond, 2004), and accordingly, to enhance their experience of 'being there' (Fernández-Álvarez et al., 2020). It is likely that the positive effects of VRET in this thesis were due to the strong presence and realistic VR experience (and thus greater distress) perceived by the patients consistently throughout the therapy (Chapters 3, 4, 5 and 7; Alsina-Jurnet, Gutiérrez-Maldonado, Rangel-Gómez, & María-Virgina, 2011; Ling, Nefs, Morina, Heynderickx, & Brinkman, 2014). This prolonged, focused and controlled confrontations to patients' distressing VR dental situations (Chapters 3, 4, 5 and 7) may have resulted in violation of their core expectancies and therefore led to improved treatment outcomes (Botella, Fernandez-Alvarez, Guillen, Garcia-Palacios, & Banos, 2017; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014; Lindner et al., 2017).

Cybersickness has been considered an important barrier for successful VRET (Rebenitsch, 2015; Shiban, 2018). It refers to bodily discomfort with symptoms including a slight headache, nausea (Gregg & Tarrier, 2007; Krijn, Emmelkamp, Olafsson, et al., 2004), dizziness, disorientation and eye strain (Rebenitsch, 2015) associated with exposure to VR (Davis, Nesbitt, & Nalivaiko, 2014). The most plausible theory for the development of cybersickness is the sensory mismatch theory (Bos, Bles, & Groen, 2008; Davis et al., 2014; Ng, Chan, & Lau, 2019). This account is based on the premise that sensory conflict occurs when there is a difference between the sensory (visual and vestibular) information perceived by the patients in the virtual world, and the one expected by patients based on their experience in the real world (LaViola, 2000) resulting in cybersickness. However, this theory does not account for individual differences in occurrence of cybersickness (Weech, Varghese, & Barnett-Cowan, 2018), and fails to explain why sensory conflict does not cause cybersickness in all individuals (Davis et al., 2014; Davis, Nesbitt, & Nalivaiko, 2015). There is some evidence suggesting that cybersickness commonly occurs in individuals with a history of motion sickness and balance disorders (vertigo; Davis et al., 2014). While,
the underlying mechanism for cybersickness is not completely understood, there has been success in identifying other factors that impact the likelihood of users from developing cybersickness (Davis et al., 2014, 2015). For example, software and hardware factors such as use of high-end VR graphics with reduced lag in the display and sensitive motion tracking cameras that synchronously updates the user's VR view on turning their head are known to reduce cybersickness problems (Davis et al., 2014). Also, cybersickness can be prevented by increasing the level of patients’ sense of control and increasing the number of breaks during VR exposure, following the manufacturers’ safety warnings (Davis et al., 2014; Oculus, n.d.; Porcino, Clua, Trevisan, Vasconcelos, & Valente, 2017). Using brief exposures to VR (rather than continuous long exposures) has been found to be capable of restoring balance, hand-eye coordination, and the ability to multi-task after VR exposure (Oculus, n.d.). However, we were not able to avoid cybersickness completely in our RCT despite excluding patients with no reported history of motion sickness and vertigo, enhancing control by offering patients with a panic button (Levy & Radomsky, 2014), and increasing the number of breaks during VRET intervention (Gujjar et al., 2019b). Therefore, future research aimed to identify other causes of cybersickness with the purpose to reduce its occurrence, thereby increasing the potential effectiveness of VRET, is warranted. To summarise, enhanced presence, realism and distress and low cybersickness experienced by patients might have contributed to the effectiveness of VRET in the present thesis.

### 8.5 Impact of VRET in clinical dental practice

The successful results of VRET as demonstrated in the present thesis, support the notion that incorporating VRET in clinical dental practice is useful. There are several advantages that would make VRET an enticing treatment option for general dental practitioners and patients.

#### 8.5.1 Benefits of VRET for dental health professionals

Firstly, VRET can be specifically tailored to conduct exposure treatments in different simulated environments effectively (Botella, Baños, et al., 2017; Fernández-Álvarez et al., 2020). Secondly, VRET provides a solution for the common perception among therapists that they have very limited control during exposure therapy and that the therapy is distressing to patients resulting in patient drop-outs (Boeldt, McMahon, McFaul, & Greenleaf, 2019). Compared to IVET, VRET is more flexible as the exposure can easily be controlled by the therapist (Lindner et al., 2017; Maples-Keller et al., 2017; Vincelli et al., 2003). Also, VRET allows dentists to precisely control
patient’s exposure to their phobic stimuli enabling gradual, repeatable, engaging and individualized exposure in a safe environment. Also with VRET, the therapist is able to provide constant guidance and encouragement to the patient to confront their phobic stimuli, thereby improving the efficacy of treatment (Boeldt et al., 2019). Thirdly, in individuals who are reluctant to confront the real threat upfront (e.g., in IVET; Garcia-Palacios, Botella, Hoffman, & Fabregat, 2007), VRET could be used as a first step in the exposure hierarchy during IVET (Kampmann et al., 2016). Fourthly, upsurge in the development of economical, user friendly and fast computing software and hardware devices may encourage more therapists/general dental practitioners to use VRET in routine practice (Boeldt et al., 2019; Joda, Gallucci, Wismeijer, & Zitzmann, 2019; Riva, Wiederhold, & Gaggioli, 2016; Shiban, 2018). Finally, versatility of the VR technology could enable dental practitioners to use VR more routinely in their practice. For instance, after alleviation of dental phobia following VRET, patients may undergo VR distraction prior to or during actual dental treatment procedures (Atzori et al., 2018; La Paglia et al., 2019; Lahti, Suominen, Freeman, Lähteenoja, & Humphris, 2020; Tanja-Dijkstra et al., 2014; Tanja-Dijkstra et al., 2018) thereby further assisting the patient to keep their dental anxiety at bay. This combination of VRET and VR distraction could offer all in one solution for the treatment of dental phobia and as well adding to patient comfort and relaxation, thus becoming a useful adjunct for general dental practitioners.

8.5.2 Benefits of VRET for patients

From a patient’s perspective VRET offers several benefits. Firstly, VRET allows controlled, gradual and repeated exposure to patients’ phobic stimuli enabling them to learn to overcome their fears in a safe environment and minimizes distress resulting in better treatment acceptance (Boeldt et al., 2019; Fernández-Álvarez et al., 2020). Secondly, compared to IVET, the sense of security and lack of embarrassment that VRET may offer to the patients helps them to freely express their thoughts and feelings which otherwise could be difficult to express explicitly upon confronting the real-life situations (Baus & Bouchard, 2014; Hartanto et al., 2014). This could reduce chances that a patient with extreme dental fear and avoidance would abandon exposure treatment (Jang, Ku, Shin, Choi, & Kim, 2000). To this end, VRET may improve the relationship between the dentist and patient (Fernández-Álvarez et al., 2020). Finally, VRET could be cost effective because a single exposure scenario can be repeated multiple times as per the needs of the patient (Baus & Bouchard, 2014). Hence, VRET could be an important bridging-step (Pastorino & Doyle-Portillo, 2015) for patients with dental phobia before they undergo treatment in the dentist’s office (Gujjar & De Jongh, 2019) and ideal for use by the general dental practitioners and dental auxiliaries.
8.6 Barriers to using VRET in real world

There are some barriers for adopting VR in general dental practice. Firstly, patients experiencing vertigo, motion sickness, epileptic seizures and those with sensory disabilities such as deafness and blindness may not be the ideal candidates for VRET. Secondly, since VRET research is still in its infancy in the field of dentistry, general dental practitioners may be reluctant (Boeldt et al., 2019; Fernández-Álvarez et al., 2020) to use it in their day to day practice until more concrete evidence is generated. This barrier could be addressed by conducting more VRET research that is relevant to dentistry and addressing the concerns of practitioners by providing them with in-depth VRET training (Boeldt et al., 2019). Offering training to therapists and general dental practitioners via accredited continuing education courses may give confidence and encourage them to practice VRET in their routine practice (Boeldt et al., 2019; Fernández-Álvarez et al., 2020). Finally, not all dental patients (and probably not all dentists) are appropriate candidates for the use of VRET and another treatment might be more appropriate for management of dental phobia. In clinical dental practice, dentists with a cognitive behavioral background, such as those specializing in the treatment of dental fear, may need to gauge the suitability of patients to undergo VRET by carefully screening them, assess the patient to select appropriate fear-eliciting stimuli for the treatment, titrate the exposure to patients’ feared stimuli and monitor and provide support to the patient undergoing the procedure. In addition, non-specific factors, i.e. those factors associated with the relationship with the dentist or therapist may contribute to what is needed for a successful outcome. In line with this, it could be argued that without paying attention to these issues, for instance, if the VR experience is too overwhelming, the treatment may be ineffective or even potentially harmful. However, despite these seemingly important factors it is interesting to note that there is mounting evidence showing that the effectiveness of standard VRET applications have become an effective alternative comparable to the traditional treatments for phobias (Botella, Fernandez-Alvarez, et al., 2017). Yet, in certain more severe cases, dental professionals need to work collaboratively with mental health professionals in using these technologies or to assess whether individuals with, for instance, a psychiatric background and/or a history of childhood trauma may be too vulnerable to undergo VRET and need expert help. In other words, in such instances specialized forms of psychotherapy (e.g., EMDR therapy; Doering, Ohlmeier, de Jongh, Hofmann, & Bisping, 2013) might be a more appropriate option to reduce patients’ burden of phobic fear and comorbid mental health problems.
8.7 Future research on VRET

Research on VR in dentistry so far is predominantly focused on educational teaching and motor skills training (Joda et al., 2019). The present thesis is the first of its kind to explore the successful use of VRET in treatment of dental phobia. Efficacy of VRET as demonstrated in the present thesis holds significant potential in individuals with intellectual disabilities (Rian Dutra da Cunha, 2018). The safe, realistic and controlled exposure (Lindner et al., 2017) may make this therapy specifically suitable for use in individuals with special health care needs who, due to mental and physical disabilities cannot undergo exposure in real life situations (Baus & Bouchard, 2014).

VRET could also be made available widely by making it accessible through the internet in form of online modules, and web and mobile based applications for use by both dentist and patients (as a self-help therapy; Fernández-Álvarez et al., 2020). Use of self-help VRET may be beneficial in remote regions with limited access to psychological treatments and for patients who are reluctant to visit the dentist (Cuijpers & Schuurmans, 2007). Utilization of self-help interventions may possibly allow patients to undergo treatment at their own pace at home with limited or no involvement of therapist (Oing & Prescott, 2018). Also, such automated advances in VR technology might help therapists to manage their caseloads and conserve resources (Boeldt et al., 2019; Marks, Psychiatry, Cavanagh, & Gega, 2007).

VRET may be developed as a serious game (a computer game used for therapeutic purposes), wherein the hierarchal progression system of exposure therapy could be synthesized as a generic game featured with levels, with each level as a gamified exposure task to be completed (Fernández-Álvarez et al., 2020; Lindner et al., 2017). Such gamification could be fascinating, filled with enjoyment, invoking relaxation and more engaging interventions especially for children and for individuals with special health care needs. Also, since confrontation to the phobic stimuli could be highly distressing experience for patients, gamification could possible allay the negative experience of exposure treatment.

An interesting development is the use of gaze or eye trackers in VRET. These may be used in future studies as these tracking devices involve recording the point of gaze by a camera that is integrated into the head mounted device. Eye trackers may not only be a useful diagnostic tool for dentists to assess someone’s level of dental anxiety and dental phobia (Fernández-Álvarez et al., 2020), but also allow them to detect any safety behaviours such as closing of eyes by patients while confronting their phobic VR stimuli. Such detections may help the dentist to optimize exposure by encouraging the patient (when the patient looks away or closes eyes) to stop or avoid using his or her safety behavior during VRET (Lindner et al., 2017).

Although patients in all our studies underwent VRET to only five (albeit most commonly encountered) dental scenarios, conducting future VRET studies with
additional VR sounds and scenarios such as dental aspirator sounds, root canal and dental scaling sounds and instruments would make VRET relevant to more individuals. There is evidence showing that verbal interactions with avatars can influence the emotion and might improve the arousal and efficacy of VRET (Slater et al., 2006). To this end, future VRET studies exploring the role of different race and sex of the dentist avatar with or without verbal and facial cues (Qu, Brinkman, Ling, Wiggers, & Heynderickx, 2014) may lead to solutions that could enhance the effectiveness of VRET.

8.8 Conclusion

To summarize this thesis, administration of VRET in patients with dental phobia resulted in a significant reduction in dental anxiety scores and behavioral avoidance compared to informational pamphlets. In addition, a significantly greater proportion of patients in the VRET group, lost their dental phobia diagnoses, scheduled dental appointments and underwent actual dental treatment at six months follow-up. These promising results along with enhanced presence, realism, distress and lowered cybersickness experienced by patients support using VRET in a general dental practice.

This thesis is supportive of the notion that higher initial fear responses and the enhancement of fear extinction through the modulation of behavioral parameters, owing to limitless possibilities with VR technology (Lindner et al., 2017), are likely to improve treatment outcomes of VRET. There are several behavioral parameters that need to be noted (Chapter 3, 4, 5 and 7) and include a.) prolonged, focused and controlled confrontations to phobic stimuli within the virtual reality environment (Lindner et al., 2017; Maples-Keller et al., 2017), b.) deepened extinction by exposure to multiple VR scenarios or cues (Culver, Vervliet, & Craske, 2015; Fernández-Álvarez et al., 2020; Lindner et al., 2017), and c.) discouraging safety behavior by encouraging patients to open their eyes and to focus on their phobic stimuli (Craske et al., 2014; McInerney, 2019). The effectiveness of employing and manipulating these powerful parameters that potentially influence the enhancement of inhibitory learning, need to be tested further using carefully controlled VRET studies. Clearly, more research remains needed to understand mechanisms underlying behavior change in VRET and to make reliable statements and predictions about use of such therapy in children and in individuals with special health care needs with dental phobia. Also, future application of VRET as a self-therapy to treat remote patients with dental phobia needs to be explored. Hence, there is no doubt that the future applications of VR in dentistry relies on continuous progression of the information technology in coming years.
8.9 References


