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

Raghav, K.

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Chapter 1. General introduction

Some tortures are physical, and some are mental,
But the one that is both, Is dental – Ogden Nash

1.1 Introduction

The physical unpleasantness of dentistry has largely been conquered by developments in dentistry such as minimally invasive techniques and modern anesthetics (Öst & Skaret, 2013). However, the psychological agony manifesting itself in the form of dental anxiety is still a fairly common condition worldwide (Smith & Heaton, 2003), and effective methods to treat the extreme form of dental anxiety, i.e., dental phobia, are still in nascent stages. The core theme of this thesis is to explore the applicability of Virtual Reality Exposure Therapy (VRET) in the treatment of severe dental anxiety and dental phobia. This chapter discusses the relevant background to provide a context to the rest of this thesis. First, I describe the prevalence, etiology, maintenance and consequences of dental anxiety and dental phobia. This is followed by a summary of current treatment strategies for both conditions and their limitations. Next, I will provide a background for the need of investigating VRET for the treatment of dental phobia. Finally, I present the objectives and a brief outline of the studies that form the essential components of this thesis.

1.2 Dental anxiety, dental fear and dental phobia

Constructs like “fear”, “anxiety” and “(specific) phobia” are related and represent the continuum of fear and anxious behavior (De Jongh, Oosterink, Kieffer, Hoogstraten, & Aartman, 2011). Therefore, to develop suitable strategies for the treatment of dental anxiety and dental phobia, identification and proper assessment of the fearful behavior towards dental situations is crucial.

1.2.1 Fear and anxiety

Fear as defined by ethologists is a basic emotional state of motivation triggered by a specific stimulus that causes activation of “fight or fright response” (Cannon, 1915) resulting in defensive behavior or escape (McFarland, 1987). Thus, dental “fear” is an emotional response to specific dental situations. Fears related to dental treatment are heterogeneous in nature, and there is evidence suggesting that these
represent a three-factor structure (van Houtem et al., 2017) consisting of: (a) fear of invasive or pain-associated dental treatment, such as undergoing extraction or root canal treatment of a tooth, dentist drilling a tooth, cutting or tearing soft tissue, undergoing surgery and insufficient anesthetic during dental treatment; (b) feeling of loss of control, such as lying in the dental chair and not knowing what’s happening in the mouth, lack of explanation by dentist and feeling helpless and (c) experiencing unpleasant physical (bodily) sensations such as gagging, vomiting or fainting while undergoing dental treatment (van Houtem et al., 2017).

While dental “fear” refers to the emotional response to real or perceived imminent threat, anxiety is the anticipation of future threat” (American Psychiatric Association, 2013), and is considered to be a normal reaction to stress and a positive adaptive response that can be beneficial for alerting one to potential dangers and aiding in preparation to ward off that danger (American Psychiatric Association, 2018).

1.2.2 Types of anxiety

The construct “anxiety” encompasses two distinct types: state anxiety and trait anxiety. State anxiety refers to a transient, situation-specific emotional response towards a frightening situation that is characterized by feelings of tension and apprehension and an increased activation of the autonomic nervous system (Spielberger, 1966). Conversely, trait anxiety is the general tendency of an individual to respond to perceived threats and is a relatively stable characteristic of an individual (Spielberger, 1966). People with a high level of trait anxiety are more inclined to respond to perceived threats with a greater elevation in state anxiety than individuals with a low degree of trait anxiety (Spielberger, 1966). Thus, dental trait anxiety refers to a general tendency of an individual to experience anxiety towards a variety of dental situations and perceiving them to be threatening or dangerous.

1.2.3 Phobia

“Phobia” is a disproportionate form of anxiety (American Psychiatric Association, 2013). When the elevated level of avoidance towards dental procedures or distress from dental objects interferes an individual’s normal social and occupational functioning, the condition is likely to meet the DSM-5 diagnostic criteria of specific phobia. Dental phobia can be diagnosed by undertaking a structured clinical interview as per the DSM-5 criteria (American Psychiatric Association, 2013). To this end, seven criteria must be satisfied: a) a marked and disproportionate fear within a situational or environmental context to either the presence or anticipation of (dental) objects or situations; b) an immediate anxiety response following
exposure to the phobic (dental) stimulus; c) fear that is out of proportion; d) extreme avoidance towards phobic dental stimuli; e) avoidance behavior, anxious anticipation of pain or distress that interferes with an individual’s daily routine such as social activities or relationships, occupational (or academic) functioning or causes pronounced distress due to phobia; f) the duration of phobia for all ages should be at least 6 months; and g) the symptoms of phobia cannot be attributed to any other mental conditions.

Given that the terms ‘dental anxiety’ and ‘dental fear’ are used interchangeably in the literature (Asl, Shokravi, Jamali, & Shirazi, 2017; Beaton, Freeman, & Humphris, 2014), in this thesis “dental anxiety” denotes all forms of emotional apprehension in anticipation of any dental situation, whereas a pathological form of anxiety that fits the DSM diagnostic criteria of dental phobia is referred to as “dental phobia”.

1.3 Tools for measurement of Dental anxiety and Dental phobia

1.3.1 Dental anxiety

Some of the most popular tools for measuring the severity of dental trait anxiety are the Dental Anxiety Scale (DAS), the Modified Dental Anxiety Scale (MDAS), the Dental Fear Scale (DFS) and the Spielberger Trait Anxiety Scale (STAI-T) (Corah, 1969; Humphris, Morrison, & Lindsay, 1995; Kleinknecht, Klepac, & Alexander, 1973; Kleinknecht, Thorndike, McGlynn, & Harkavy, 1984; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The MDAS consists of five items assessing anticipatory dental anxiety, fear of dental scaling, drills and injection on a five-point Likert scale ranging from 0 (“not anxious”) to 5 (“extremely anxious”) (see Figure 1.1; (Beaton et al., 2014; Humphris, Crawford, Hill, Gilbert, & Freeman, 2013). The cumulative score ranges from 5-25 with greater scores suggestive of a more severe level of dental anxiety. The MDAS has proved to have high level of internal consistency and construct validity (Humphris, Freeman, Campbell, Tuutti, & D’Souza, 2000).

Another internationally widely-used measure for assessing the level of dental trait anxiety is the Dental Fear Scale (DFS). It is a 20-item questionnaire evaluating an individual’s emotional, physiological reactions and avoidance towards dentistry on a 5-point scale ranging from 0 (“not at all”) to 5 (“very much”). The possible cumulative score ranges from 20-100, with scores above 70 being suggestive of dental phobia (Hakeberg & Berggren, 1997). The DFS has been shown to be a sensitive, reliable and valid measure for assessing severity of dental anxiety in research (Davis, Ollendick, & Öst, 2012; Schuurs & Hoogstraten, 1993). In order to comprehensively evaluate an individual’s level of dental anxiety in the clinical setting, and for research, it is recommended to use more than one measure (Schuurs & Hoogstraten, 1993).
Hence, in the present thesis, the severity of dental trait anxiety was indexed using both aforementioned measures (i.e., the MDAS and the DFS).

### 1.3.2 State anxiety

A frequent way to assess the transient anxiety response towards specific dental situations (i.e., state anxiety) used in most of the studies including the present thesis, is the use of the Visual Analogue Scale- Anxiety (VAS-A) (Luyk, Beck, & Weaver, 1988). The patient is requested to select a point (usually by putting a cross mark X) on a 0-100 mm line representing a scale ranging from totally calm and relaxed (0) to the worst fear imaginable (100) as depicted in Figure 1.2. It is considered to be a simple, sensitive, fast, reliable and valid tool for state dental anxiety assessment (Facco et al., 2011).

### 1.3.3 Assessing dental phobia

Although the MDAS and the DFS are both measures of dental anxiety, and are fairly easy and quick to use (Humphris et al., 1995; Newton & Edwards, 2005), these cannot be used for diagnostic purposes in terms of assessing dental phobia (King & Humphris, 2010; Oliveira, Bendo, Paiva, Vale, & Serra-Negra, 2015). As described above in section 1.1.3, a diagnosis of specific (dental) phobia needs to be established by conducting a structured clinical interview as per the DSM-5 criteria performed by a psychiatrist or psychologist.

A simpler tool that has proved to be reliable and valid for screening purposes is the “Phobia Checklist” (Oosterink, de Jongh, & Hoogstraten, 2009) which has initially been adapted from the DSM-4 criteria for specific phobia (American Psychiatric Association, 2000). The Phobia Checklist requires the patients to mark either “Yes” or “No” in response to four questions involving DSM criteria. A 'Yes' response to all four questions of this checklist makes the presence of dental phobia very likely. To this end, the Phobia Checklist has been validated against the Structured Clinical Interview for DSM-4 (First, & Gibbon., 2004) with a sensitivity of 0.95, specificity of 0.99, and an overall hit rate of 97% (Oosterink et al., 2009).

In the present thesis, recruited individuals were assessed for the possible presence of dental phobia using the Phobia Checklist criteria (Oosterink et al., 2009).
1.4 Prevalence

1.4.1 Prevalence of dental anxiety

Estimates of higher dental anxiety and dental avoidance in general population has been found to be ranging from 4-17% (Armfield, 2010; Dou et al., 2018; Eitner, Wichmann, Paulsen, & Holst, 2006; Enkling, Marwinski, & Johren, 2006; Fayad, Elbieh, Baig, & Alruwaili, 2017; Gatchel, Ingersoll, Bowman, Robertson, & Walker, 1983; Hallstrom & Halling, 1984; Halonen, Salo, Hakko, & Rasanen, 2014; Liddell & Locker, 1997; Locker & Liddell, 1991; Nicolas, Collado, Faulks, Bullier, & Hennequin, 2007; Saatchi, Abtahi, Mohammadi, Mirdamadi, & Binandeh, 2015; Sitheeque, Massoud, Yahya, & Humphris, 2015; Stouthard & Hoogstraten, 1990). However, there is considerable variability in the methods, measures and criteria used. The majority of the studies that applied measures of dental trait anxiety have used variable cut-offs to ascertain the severity of dental anxiety (Dou et al., 2018; Fayad et al., 2017; Halonen et al., 2014; Saatchi et al., 2015; Sitheeque et al., 2015). This makes it difficult to estimate through these scales the relative prevalence of individuals with either severe dental anxiety or dental phobia who require immediate attention. An agreed system to address the above concerns is the use of the established standardized DSM-criteria for diagnosing individuals with dental phobia (American Psychiatric Association, 2013).

1.4.2 Prevalence of dental phobia

Only a limited number of studies have used the valid DSM-IV specific phobia criteria for the purpose of either assessing dental phobia or estimating the prevalence of this condition within samples or population groups (Fredrikson, Annas, Fischer, & Wik, 1996; Oosterink et al., 2009; Stinson et al., 2007). Stinson and colleagues estimated that about 2.4% percent of the population fulfills the diagnostic criteria of dental phobia based upon the DSM-IV diagnostic criteria for specific phobia (Stinson et al., 2007). Research from the Netherlands suggests that around 4% of the general population (Oosterink et al., 2009) satisfies the criteria for dental phobia as indexed using the Phobia Checklist. In Sweden Fredrickson et al (1996), used a three item checklist based on DSM IV criteria for specific phobia, and reported that 2.1% and 1.6% of the population may be phobic towards dentists or injections respectively (Fredrickson et al., 1996).
1.5  Etiology and maintenance of dental anxiety and dental phobia

The acquisition of anxiety and phobia is best described by classical conditioning theory (Pavlov & Gantt, 1928). Within this paradigm, a previously neutral stimulus (e.g., the dentist office) can attain the ability to elicit a direct conditioned response (e.g., fear) following pairing of a neutral stimulus with an unconditioned stimulus (e.g., pain from injection). Conditioning models state that the objects and situations to which an individual is irrationally phobic resembles the previous traumatic experiences. A substantial amount of research support the acquisition of dental anxiety due to classical conditioning (De Jongh, Muris, Horst, & Duyx, 1995; Kleinknecht et al., 1973; Moore, Brodsgaard, & Birn, 1991; Öst & Hugdahl, 1985). However, classical conditioning theory faced criticism as only few individuals with anxiety and phobia reported previous conditioning experiences as origins of their phobias (Mineka & Sutton, 2006), indicating that there may be other pathways (other than classical conditioning) that led to development of anxiety and phobias. This was explained by Rachman (1977) who proposed that anxieties and phobias can be acquired and maintained via three major associative pathways in that a neutral stimulus is likely to acquire fearful qualities either directly by means of exposure to (a) a negative event or indirectly by social processes such as (b) vicarious learning or through (c) negative information (Rachman, 1977). However, critics of the Rachman’s model noted that only limited individuals acquire dental anxiety and phobia via associative pathways (Mineka & Sutton, 2006). Additionally, retrospective studies supporting Rachman’s model would rely on individuals’ fallible memories (Merckelbach & Muris, 2001; Mineka & Sutton, 2006; Öst & Hugdahl, 1981). Hence, there could be role of other variables why many individuals following a traumatic (direct or observational) dental event do not develop phobias.

Contemporary views on development of anxiety and phobia argue that mere exposure to a negative event (as needed in classical conditioning), information or observational learning is unlikely to result in clinical phobias (Mineka & Sutton, 2006). Instead, the outcome of direct or observational conditioning may be potentiated by the negative expectancies set up by the negative information (Dadds, Davey, & Field, 2001; Mineka & Sutton, 2006). In addition, differences in individual temperamental and experiential variables (Craske, 1997; Mineka & Sutton, 2006; Muris & Merckelbach, 2001) such as genetic vulnerabilities (van Houtem et al., 2013), individual life experiences, cognitive and personality factors also differentially predispose individuals to develop and maintain dental anxiety and dental phobia (Mineka & Sutton, 2006; Mostofsky & Fortune, 2013). This explains why not all individuals develop dental anxiety or a dental phobia despite of having been exposed to negative conditioning events (direct or observational).
In sum, the etiological mechanisms and maintenance of dental anxiety and dental phobia described above highlight the complex nature of these mental health conditions. Hence, dental professionals, when assessing patients with dental anxiety and dental phobia should be aware that there are a wide array of individual differences that influence the development and maintenance of dental anxiety and dental phobia.

1.6 Consequences of dental anxiety and dental phobia

Following acquisition, individuals with dental anxiety and dental phobia develop aversive memories and negative beliefs and other cognitions about dental treatment (De Jongh et al., 1995; Skaret, Raadal, Berg, & Kvale, 1999) that lead them to avoid dentistry (White, Giblin, & Boyd, 2017). Patients’ memories about their traumatic dental experiences tend to be well remembered and registered as disturbing, lasting and vivid (De Jongh, Eeden, Houtem, & Wijk, 2017; De Jongh, Fransen, Oosterink-Wubbe, & Aartman, 2006; Houtem, Wijk, & Jongh, 2015; McGaugh, 2004; McIntyre 2007; Oosterink et al., 2009; Rubin & Kozin, 1984; Shobe & Kihlstrom, 1997) and can easily be triggered when exposed to dental objects and situations. Frequent recollection of highly intrusive aversive memories and repeated confrontations with the negative dental experiences are likely to play an important role in maintenance and aggravation of symptoms of dental phobia (Houtem et al., 2015) in that reactivations of such disturbing memory could reinforce the aversive memory trace (Davey, 1989; De Jongh et al., 1995; De Quervain & Margraf, 2008). Thus, aversive memories following distressing dental experiences play a pivotal role in the maintenance of dental anxiety and dental phobia (Houtem et al., 2015).

Avoidance of dental care

Repeated activation of intrusive aversive memories is known to result in avoidance in seeking regular dental care in patients with dental anxiety and dental phobia (De Jongh, Aartman, & Brand, 2003; Houtem et al., 2015). Avoidance of dental care is possibly the most detrimental consequence of dental anxiety and dental phobia as it compromises the health and well-being of the patient (De Jongh, Aartman, & Brand, 2003). The relationship between avoidance and dental anxiety has been described by Berggren in 1984 as a “vicious cycle” (Berggren & Meynert, 1984) as shown in Figure 1.3.

Anxious dental patients who avoid regular dental care get easily entrapped in the “Vicious cycle of dental anxiety” (Berggren & Meynert, 1984; De Jongh, Schutjes, & Aartman, 2011). Repeated dental avoidance may yield more dental problems producing symptom-driven treatment patterns thereby necessitating
them to undergo invasive emergency dental treatment that could reinforce their anxiety and further avoidance (Armfield, Stewart, & Spencer, 2007; De Jongh, Oosterink, Kieffer, Hoogstraten, & Aartman, 2011; Oosterink et al., 2009). Also, repeated avoidance towards dental care maintains dental anxiety and dental phobia by inhibiting direct non-fearful learning; that is, avoidance would minimize direct and prolonged contact with the phobic object and hence the phobic individual might not get an opportunity to learn that the conditioned stimulus is harmless (Davis et al., 2012). An additional consequence of dental avoidance is that when patients with dental anxiety and dental phobia do visit the dentist for their appointment, their anxiety/phobia makes their treatment difficult for themselves and for their providers (Armfield & Heaton, 2013; Brahm et al., 2012). To break the avoidance cycle and negative cognitions, appropriate and timely treatment is required (Hakeberg & Wide, 2018; Shahnavaz et al., 2018; Vermaire, de Jongh, & Aartman, 2008).

### 1.7 Current treatment strategies for dental phobia and their limitations

Research and our prevailing experience indicate that general dentists usually refer patients with dental phobia to either specialists or psychologists (e.g. dental fear clinics) wherein they may undergo pharmacological management (e.g. sedation, general anesthesia) or receive psychotherapeutic interventions in the form of cognitive behavioral therapy (CBT) (De Jongh, Adair, & Meijerink-Anderson, 2005).
Unfortunately, there are obstacles for dental care, such as high cost (Öst & Skaret, 2013) and the relative lack or absence of learning in patients with dental phobia who undergo dental treatment under sedation or general anesthesia (De Jongh et al., 2005).

There are a wide range of methods and interventions available to target the fears and anxiety of dental patients, one of these is in vivo exposure therapy (IVET), a method from CBT that is designed to violate negative expectancies and correct underlying maladaptive thoughts and feelings (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). IVET involves controlled gradual presentation of the patients’ feared stimuli (conditioned stimuli) in absence of aversive consequence (unconditioned stimuli; Craske et al., 2008; Dunsmoor, Niv, Daw, & Phelps, 2015). Procedurally, this is equivalent of fear extinction in which the conditioned stimulus (CS) that was previously paired with an aversive outcome (unconditioned stimulus, US) is repeatedly presented without being followed by US. Hence, the resultant learning that CS-No US (no threat) association forms the basis for exposure based therapy. In practice this means that patients with anxiety and phobia are encouraged to confront their real-life anxiety or phobia provoking situations gradually and repeatedly by cognitive behavioural therapists or by dentists trained in using IVET.

However, albeit IVET is considered to be the gold standard for treatment of dental phobia in adults (Wide Boman, Carlsson, Westin, & Hakeberg, 2013), and children (Gomes et al., 2018), not many general dentists are trained to administer IVET, and therefore may refer the patients to psychological services (CBT therapists), which are not widely available. Even if such services are available the patients are usually put on a long waiting list for treatment (Lovell & Richards, 2001). About one-third of the patients who get an opportunity to undergo IVET, express difficulty to face the actual threat due to fear of exposure (Garcia-Palacios, Hoffman, See, Tsai, & Botella, 2001; Kent, 1997; Van der Zijpp, er Horst, de Jongh, & Makkes, 1996) and as a result may not benefit from IVET.

1.8 Virtual Reality Exposure Therapy (VRET)

Considering the limitations of conventional IVET, it has been found useful to apply a technology-based therapeutic intervention that can elicit sufficient feelings of fear, be less mentally demanding in patients with dental anxiety and dental phobia. Recently, technology-based interventions that are easily accessible, tolerable, economical and that are as effective as conventional IVET are being developed (Carlbring, Andersson, Cuijpers, Riper, & Hedman-Lagerlöf, 2018). These interventions are known to reduce the in-patient clinician time (Marks, Cavanagh, & Gega, 2007) and treatment drop-outs (Short, Fuller, Norr, & Schmidt, 2017). It is
conceivable that if IVET is effective, then exposure to virtual counterparts (Botella, Fernandez-Alvarez, Guillen, Garcia-Palacios, & Banos, 2017) of IVET would also be effective as well in patients with dental phobia.

The term Virtual Reality (VR) was first coined by Jaron Lanier in 1980’s (Firth, 2013). It can be defined as “an environment which is produced by a computer and seems very like a reality to the person experiencing it.” In essence, VR applications facilitates new learning (Boeldt, McMahon, McFaul, & Greenleaf, 2019) by enabling the user to interact with controlled immersive three dimensional computer-generated 3-dimensional virtual world (Lindner et al., 2017) inside the head mounted device (HMD) in real time (Bouchard, Côté, & Richard, 2007). HMD comprises of two screens for each eye that are attached in front of the eyes covering the entire visual field of the patient and a head tracking device that detects the head movements (Rothbaum, Hodges, Smith, Lee, & Price, 2000). The simulator computer generates the VR environment which is then seen through the HMD that instantaneously updates the VR environment in real time as per the head movements of the patient (Rothbaum et al., 2000). A user-interface computer is used by the therapist to observe what the patient is seeing through the HMD and control the VR environment. In addition to rich visual stimuli, olfactory, auditory and tactile stimuli are presented to patient to simulate real-world interactive experiences (Lindner et al., 2018). The key aim of the immersive VR system is to perceptually replace the outside world with a VR environment so as to psychologically engage the user with a situation-specific simulated digital content (Rizzo & Shilling, 2017). VR enables objective and consistent format for documenting the sensory stimuli and enables the therapist to control the VR environment as per the needs of the patient.

VR as a mode to conduct exposure therapy was proposed two decades ago (Rothbaum et al., 1995). Recently, virtual reality exposure therapy (VRET) has evolved as the generation next treatment modality for anxiety disorders and specific phobias (Carl et al., 2018). In fact, the American Psychological Association recommends VRET as an alternative to IVET for the treatment of fear of flying (American Psychological Association, 2019). Also, the German clinical practice guidelines for anxiety disorders recommends VRET as an alternative option for treatment of Agoraphobia when IVET is not available or possible (Bandelow et al., 2014; Wechsler, Kümpers, & Mühlberger, 2019). VRET is easy to use by therapists and often more acceptable to patients compared to IVET (Carl et al., 2018). It enables individualized, gradual and controlled, immersive confrontation to the patients’ phobic situations. VRET integrates real time computer graphics, body tracking devices and other sensory inputs (Maples-Keller, Yasinski, Manjin, & Rothbaum, 2017). It allows the therapist to systematically control the type, intensity, duration and repetition of exposure.

(Diemer, Pauli, & Mühlberger, 2015) of the patient to their phobic situation in an highly immersive and interactive computer environment within a meaningful and familiar contextual setting (Parsons & Rizzo, 2008). Results of four meta-analyses have consistently demonstrated that VRET is effective in reducing the symptoms of anxiety-related disorders (Morina, Ijntema, Meyerbroker, & Emmelkamp, 2015; Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). Further, there is evidence suggesting that VRET is equally effective (Carl et al., 2018) or slightly better than IVET in the treatment of specific phobias (Powers & Emmelkamp, 2008). VRET allows better patient-centered care as patients’ undergo exposure treatment at their own pace under controlled conditions and enables therapist to apply strategies consistently to maximize/optimize exposure therapy (covered in Chapter 8 under section 8.4; Lindner et al., 2018). Although, VRET is known to be a powerful alternative for the treatment of specific phobias, it has not been evaluated yet as a potential therapy for dental phobia. Therefore, the purpose of the current thesis is to explore the possibility of using VRET in the treatment of dental phobia. The thesis comprises a series of six related chapters that comprehensively evaluated the applicability of VRET in a dental context.

1.9 Aim and objectives of the thesis

1.9.1 Aim
To determine whether VRET has the potential to reduce dental anxiety and treat phobia among a sample of patients diagnosed with dental phobia.

1.9.2 Objectives of the thesis
a) To evaluate and compare the efficacy of VRET versus an informational pamphlet (IP) control group in terms of anxiety reductions in patients with dental phobia and

b) To evaluate the real-time effect of VRET on the course of participant’s physiological Heart Rate (HR) response on being exposure to a series of dentally related cues during therapy.

1.10 Thesis outline

In this thesis, the rest of the chapters represent the sequential research studies that were conducted to achieve the thesis objectives. Chapter 2 reports on a systematic review that evaluated the effectiveness of technology-based interventions in the treatment of dental anxiety in children.
and adults. Results from this study formed the basis of and informed the need for conducting most of the studies in this thesis.

**Chapters 3 and 4**, describes the initial case studies performed to explore VRET in the treatment of dental phobia. Also, the essential set-up, advantages, and limitations for using VRET in a general dental practice is described and discussed.

**Chapter 5** reports on the findings of a feasibility study on ten randomized patients with dental phobia. The study evaluated the safety and efficacy of VRET compared to the informational pamphlet (IP) control condition in treatment of dental phobia using a multiple baseline study design. Safety was determined by evaluating for any personal adverse events or symptom exacerbation following intervention with both conditions. Efficacy of VRET was evaluated by comparing level of patients’ state anxiety as indexed by a Visual Analogue Scale (VAS-A) and dental anxiety measured with both the Dental Anxiety Scale (MDAS) and the Dental Fear Survey (DFS; 16-times within a 14-week study period, and at six-month follow-up), and its behavioral avoidance, with that of an IP control condition. Also, patients’ heart rate response during VRET, and their experience post-VRET were noted.

**Chapter 6** describes the protocol of the randomized controlled trial designed to evaluate the efficacy of VRET compared to the IP control condition in the treatment of dental phobia. Also, the VRET procedural steps, methods to evaluate physiologic HR response and virtual reality (VR) experience during and after VRET are described.

**Chapter 7** presents the findings of the randomized controlled trial on thirty patients with dental phobia. The effectiveness of VRET in reduction of state anxiety (as indexed by the Visual Analogue Scale (VAS) A, and dental anxiety (as measured by both the Modified Dental Anxiety Scale (MDAS) and the Dental Fear Survey (DFS)) was compared to the IP control condition at baseline, pre-post intervention, 1-week, 3 months and 6-months follow-up. Also, the trial evaluated the pre-post changes in the behavioral avoidance, variations in heart rate and VR experience during and post-VRET. Further, the study determined the acceptability towards dental treatment and number of patients who had no dental phobia in both conditions at 6 months follow-up.

An important note regarding the RCT should be made. At the beginning of the trial, one of the objective was to determine the correlation between the presence, realism, cybersickness and heart rate experienced by the patients during and after VRET. Unfortunately, we could not include this objective as the correlation analysis and its interpretation was found to be too complicated. Therefore, it was not feasible to include this objective in the thesis.

**Chapter 8** includes a global synthesis of the presented studies, mechanism of VRET, factors that affect the effectiveness of VRET and the strengths and limitations of included studies. The thesis is concluded with future directions for conducting VRET research in the treatment of dental phobia.
Chapters 2, 3, 4, 5, 6 and 7 have been published in international peer-reviewed journals. There are overlaps in the information provided in the publications. Hence, the abstracts of all articles are removed and the texts in articles are adjusted to enable the thesis coherent.

1.11 References


EVALUATION OF THE EFFECTIVENESS OF VIRTUAL REALITY EXPOSURE THERAPY


