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Commentary

Virtual Reality distraction during pediatric medical procedures

Belinda Lange, Marie Williams and Ian Fulton

Pediatric medical interventions are often associated with high levels of anticipatory fear and anxiety and procedural pain. Management of procedure-related distress commonly includes the use of distraction techniques which aim to divert attention away from the procedure and focus attention on an activity or task (Piira et al., 2002; Vessey et al., 1994). Distraction techniques can be provided in many forms (e.g. conversation, books, movies, computer games) which range from passive to active interventions. It has been suggested that the more active/interactive and interesting a distraction technique, the greater the potential for distraction, but this suggestion remains to be adequately tested (Dahlquist et al., 2002; MacLaren & Cohen, 2005; Mason et al., 1999). Virtual reality (VR) has become popular through the entertainment industries and the technology has only recently been applied in simulated and remote surgical techniques, rehabilitation and health applications. While research exploring the therapeutic use of VR as a distraction intervention for children and adults is sparse (Gold et al., 2005), theoretically this intervention has the potential to be an effective form of management for distress associated with medical procedures.

What is Virtual Reality?

Virtual Reality is an interactive computer-based system that immerses the user in a virtual environment (VE) (Heim, 1998). Commonly, VR systems used for distraction include a head mounted display (HMD) and 3-D tracking device connected to a computer. The HMD consists of an enclosed headset or helmet through which a VE can be viewed and manipulated using a mouse, joystick or dataglove. A tracking device, connected to the HMD, monitors the user's head movements, giving the user a first person, 360 degree view of the VE. The VE can be abstract or realistic with cartoon based images of fantasy creatures or realistic human avatars (graphic representations of persons). Some pictures of VR equipment and VE images can be seen on the web pages referred to in endnote 1. The cost of a VR system (HMD, tracking device and VE) varies from US$400 to US$5000 (plus laptop/PC), depending on the quality of the hardware and complexity of the VR. VR systems are similar in many ways to computer games in that both systems allow the user to provide input into the VE using a mouse/joystick. However, VR differs from standard computer game applications due to the degree of interactivity and immersion provided. The interactivity of VR results from the tracking device attached to the HMD which tracks the user's head movements and alters the first person view of the VE in real-time. This visual synchronicity permits the user to feel engaged or immersed in the VE, providing a sense of presence (the subjective experience of being in the VE, even when the user is physically situated outside the VE) (Burdea & Coiffet, 2003). The level of presence is dictated by the ability of the "outside world" to be blocked from providing sensory input and the degree of engagement with the VE. Within medical situations, patients still need information about what is

happening during the procedure and although the HMD provides a barrier between the real and virtual worlds, the procedure can be viewed by removing the HMD if necessary. (The child can ask a parent or staff member to lift the HMD, or can use the hand holding the input device to raise the HMD to his/her forehead.) In studies of adults immersed in VR, a small percentage experience nausea or motion sickness-like symptoms (Cobb et al., 1999; Regan & Price, 1994). Two studies have demonstrated that children experience little to no nausea following immersion VR (Hoffman et al., 2000a,b; Lange, 2006). Children with a history of epilepsy, migraines or vestibular disturbances are generally considered more susceptible to adverse responses to VR and as such are generally excluded from participating in VR studies. Since reports of VR side effects in children are limited, all children should be monitored for side effects during VR distraction.

Virtual Reality distraction

Distraction is proposed to work using the fixed capacity theory of attention processing, whereby there is only a limited capacity of attention available on which pain and cognitive tasks can draw (Piira et al., 2002; Veldhuijzen et al., 2006). Distraction strategies aim to draw attention away from thoughts associated with the procedure and dedicate the limited capacity for attention to the distraction task (McCaul & Mallet, 1984). Virtual reality has qualities that should provide successful distraction in that well designed systems are interactive, immersive, interesting, novel and provide a high level of presence. Variation in VEs used within VR distraction (Gorilla game, SnowWorld, ARQuake, SpiderWorld) can affect the level of interest and immersion of the user and therefore alter the level of distraction provided. Using fMRI, Hoffman and colleagues (2004) demonstrated that VR significantly reduced subjective pain intensity ratings and pain-related brain activity. Virtual reality has been shown to be effective in decreasing pain intensity and anxiety in the treatment of burns (Das et al., 2004; Hoffman et al., 2000a,b, 2001a). The use of VR for dental procedures, venipuncture, chemotherapy and lumbar punctures has provided mixed results (Bentsen et al., 2001, 2003; Gershon et al., 2004; Gold et al., in press; Hoffman et al., 2001b; Lange, 2006; Sander Wint et al., 2002; Schneider & Workman, 2000; Schneider et al., 2004; Steele et al., 2003). A number of these studies have used the term VR to describe watching a video/movie through a HMD without the use of tracking or interactive devices (Bentsen et al., 2001, 2003; Sander Wint et al., 2002; Schneider & Workman, 2000; Schneider et al., 2004). Although these so-called 'VR' systems provide some degree of immersion, they do not fit the technical definition of VR as an immersive and interactive system that provides real-time feedback.

Virtual Reality distraction for burns and postoperative procedures

Hoffman and colleagues were among the first researchers to explore the use of VR as a distraction technique. Their initial study focused on two adolescent patients (aged 16 and 17 years) undergoing wound care for severe burns (Hoffman et al., 2000a). In addition to receiving pharmacological management, the patients were propelled through a VR ice fantasy world (SnowWorld). Using a series of visual analogue scales after both VR and game interventions, the scores for pain and distress were lower for both subjects during VR. With a similar within-subjects design, Das et al. (2004) used VR for nine children (aged 5-18) undergoing dressing changes for burns. The VE (ARQuake game) transported the child on a journey through a building where creatures could be found and hit with confetti for points. Children reported lower pain scores when using VR and interviews with staff and parents indicated that VR was thought to be effective. Similarly, work from the same laboratory by Steele et al. (2003) reported lower pain scores when using VR (ARQuake game) with pharmacological management compared to standard pharmacological treatment alone in a single case study of a 16-year-old child with cerebral palsy, undergoing postoperative physiotherapy.

Virtual Reality distraction for minor procedures

Recently, researchers investigated the effect of VR distraction for children undergoing needle procedures (port access, intravenous cannula insertion

(IV), venipuncture, suturing) (Gershon et al., 2004; Gold et al., in press; Lange, 2006). Gershon et al. (2004) compared the use of VR (Gorilla VE), playing a computer game or receiving standard care in 59 children (aged 7-19) undergoing IV port access. No significant difference was reported between the three groups for subjective pain, anxiety or behavioral distress for child or parent; however, staff rated pain significantly lower during VR. Lange (2006) compared VR (ARQuake) with watching a movie in 88 children undergoing venipuncture, IV insertion and suturing in a Pediatric Emergency Department. No significant differences between distraction strategies were noted for ratings of pain or anxiety by children, parents or staff. Behavioral distress scores were significantly lower in children receiving VR and parents and staff reported the VR intervention significantly higher in effectiveness.

Does Virtual Reality decrease pain and anxiety during medical procedures?

The necessity of distraction techniques alone or in conjunction with pharmacological management for minor medical procedures is difficult to confirm. Clinically, the pain experienced during such procedures may be perceived as minor and transient and the time and cost involved in applying interventions such as VR may not justify small benefits to patients, parents and staff. Alternatively, while pain may be unavoidable, strategies which lower the degree of suffering for both patients and parents may justify their application, especially as primary experiences of pain and anxiety lay the foundation for future experiences (Schechter et al., 1993). Studies of VR distraction during minor and major medical procedures present conflicting results. These differences are likely to reflect differences in technologies, degree of immersion, magnitude of pain experienced, coping styles of the patients, or outcome measures, but may also be a result of the differences in study design and sample size. Studies reporting a reduction in pain and distress using VR for major medical procedures (burn and postoperative care) involve within-subjects case studies (1-2 patients) or small samples (N = 9). Studies investigating VR for minor procedures (needle, IV insertion) have used larger samples (N = 59-88) and between group comparisons. In general, these group design studies have found that while VR reduces behavioral distress, pain and anxiety are not altered significantly. In essence, studies in which VR is reported to be effective consider the individual response. On the other hand, studies reporting little or no overall change are calculated on average responses between groups, though individual responses are likely to include both positive and negative experiences. Research design, outcome measures and sample size should be given careful consideration in the design of future studies. Predicting which patients, regardless of age or procedures, will benefit from VR based interventions requires further research.

Future directions

Research investigating the use of VR distraction during medical procedures in children is in its infancy; however, results suggest that VR has the potential to be effective as an adjunctive analgesia. Primary issues associated with VR distraction requiring further exploration include establishing which patients will conclusively benefit or suffer adverse effects, calculating the cost benefits, confirming whether a minimal pain or anxiety threshold exists for effective distraction, and determining whether procedure type (minor or major) or frequency (repeated or single) impact upon effectiveness. Given the rapid rate of technological innovation associated with computer applications, it is conceivable that future VR applications will evolve which rely upon mobile, portable interfaces (mobile phones and personal organizers) and incorporate VEs individually tailored for age, gender, local environment, and personal attributes such as coping style or recreational preference.

Belinda Lange, BSc, B Physio (Hons)
PhD candidate, Division of Health Sciences, University of South Australia, Adelaide, Australia
email: belinda.lange@postgrads.unisa.edu.au

Marie Williams, PhD
Associate Professor, Division of Health Sciences, University of South Australia, Adelaide, Australia

Ian Fulton, MAppSc (Manip Physio)
Lecturer, Division of Health Sciences, University of South Australia, Adelaide, Australia

Endnote

1. Pictures of VR equipment and VE images can be seen on the following web sites (available 3 March 2006):

http://www.hitl.washington.edu/projects/burn/

http://www.unisa.edu.au/researcher/issue/2004Nov/virtualpain.asp

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