VIRTUAL REALITY FOR BRAIN INJURY REHABILITATION: AN EVALUATION OF CLINICAL PRACTICE, THERAPISTS' ADOPTION AND KNOWLEDGE TRANSLATION

by

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Abstract

Background: Acquired brain injury (ABI) affects considerable numbers of Canadians every year, resulting in a range of functional impairments requiring rehabilitation. Virtual reality (VR) is a relatively new treatment approach being used increasingly for this purpose. A lack of research documents current practice in VR use, along with the barriers, facilitators and support needs of therapists expected to adopt the technology.

Purpose: This research aimed to describe how the GestureTek VR system was being used clinically in ABI rehabilitation, to outline preliminary work addressing the resource needs of clinicians, to examine factors influencing therapists' adoption of VR and to evaluate the impact of a multi-faceted knowledge translation (KT) intervention at mediating these factors to facilitate VR implementation.

Hypotheses: The KT intervention will be associated with improvements in therapists' perceived ease of use and self efficacy in using the technology, and an associated increase in their intentions to use VR.

Methods: A single group pretest-posttest design was used to examine the determinants of VR adoption as proposed by the Decomposed Theory of Planned Behaviour and to evaluate change following KT. The intervention included interactive education, the provision of clinical protocols and technical and clinical support. Forty-two therapists from two health centres completed the ADOPT-VR outcome measure. Descriptive measures recorded the nature of therapists' use of VR with 29 clients. Related-samples Wilcoxon signed ranks tests were used to evaluate pretest-posttest changes in hypothesis variables. Descriptive statistics and content analysis were used to analyse nominal and qualitative data, respectively.

Results: Differences existed between clinical application and existing research in both treatment and client characteristics. Overall, therapists had positive attitudes and intentions to use VR. Increases in perceived ease of use and self efficacy, but not behavioural intention, were observed following KT. The most significant barriers to VR use included time and client factors, while primary facilitators included peer influence and organisational-level supports.

Conclusion: Preliminary knowledge of current VR practice trends can assist in the design of clinically relevant ABI research. Barriers and facilitators can be targeted by management to support VR implementation. Therapists' identified knowledge and support needs can inform future KT strategies.

Preface

Chapters 6-11 are based on collaboration with my research committee and with Barb Ansley, Diana Velikonja, Christine Brum, Denise Sartor and John Zsofcsin at Hamilton Health Sciences, to conduct a multi-site study that formed the basis for this research project. My role included conceiving the research question and study design, developing the intervention and measures, eliciting feedback to refine the design and measures, coordinating the project, completing the Ethics application and data collection at the Vancouver site, conducting data analysis and drafting any written work.

A version of Chapter 8 is to be submitted for publication. [Glegg, S. M. N., Holsti, L., Velikonja, D., Ansley, B., Sartor, D., & Brum, C. (n.d., to be submitted). Documenting clinical practice in virtual rehabilitation for brain injury]. I was responsible for developing the descriptive measure and field testing it in preparation for the study. I also acted as the study coordinator at the Vancouver site, and completed all data analysis. I drafted the manuscript and made minor revisions based on co-author feedback. All co-authors contributed to elements of the study design.

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Check the first pages of these chapters to see footnotes and prefaces with similar information.

The University of British Columbia/Children's & Women's Research Ethics Board approved this research at the Vancouver site, as per Ethics Certificate numbers H09-01107 and H09-01174. The Hamilton Health Science/Faculty of Health Sciences Research Ethics Board approved this research at the Hamilton site, as per Ethics Certificate number 09-612.

This research was carried out as an independent study. The researchers and the members of the graduate committee had no affiliation with or funding support from Xperiential Learning Systems/GestureTek, and report no conflict of interest.

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List of Abbreviations

A = attitude
ABI = acquired brain injury
ADL = activities of daily living
ADOPT-VR = Assessing Determinants of Prospective Take-up of Virtual Reality
AGREE = Appraisal of Guidelines for Research & Evaluation
AVM = arteriovascular malformation
B = Bachelor Degree
BI = behavioural intention
CAOT = Canadian Association of Occupational Therapists
CIHI = Canadian Institute for Health Information
CNS = central nervous system
CO = compatibility
COTBC = College of Occupational Therapists of British Columbia
CPG = clinical practice guideline
C&W = Children's & Women's Health Centre of British Columbia
Dip = diploma
DST = Dynamic Systems Theory
DTPB = Decomposed Theory of Planned Behaviour
E = experience
FCB = facilitating conditions & barriers
GCS = Glascow Coma Scale
HHS = Hamilton Health Sciences
HMD = head-mounted display
IADL = instrumental activities of daily living
ICP = intracranial pressure
KT = knowledge translation
KTA = Knowledge-to-Action
LOC = level of consciousness
M = mean
MANOVA = multivariate analysis of variance
MClin = clinical entry-level Masters degree
MD = medical doctor
MRes = research Masters degree
MVA = motor vehicle accident
n = sample size
NDT = Neurodevelopmental Treatment Approach
NTBI = non-traumatic brain injury
n.d.= no date
OT = occupational therapist
PASW = Predictive Analysis Software
PBC = perceived behavioural control
PEOU = perceived ease of use
PI = peer influence
PT = physiotherapist
PU = perceived usefulness
RCT = randomised controlled trial

Rec = recreation therapist
RT = rehabilitation therapist
r^2 = coefficient of determination (effect size)
SD = standard deviation
SE = self efficacy
SI = superior influence
SN = social norms
t = paired t-test statistic
TAM = Technology Acceptance Model
TBI = traumatic brain injury
TPB = Theory of Planned Behaviour
VE = virtual environment
VR = virtual reality
WHO = World Health Organization

Glossary

Acquired brain injury: A damaging insult to the brain occurring after birth that is not related to a congenital disorder, developmental disability or progressive damage process; the mechanism of injury may be traumatic in nature (e.g. motor vehicle accident, fall, etc.) or non-traumatic (e.g. stroke, lack of oxygen, encephalitis, tumour, etc.) (Bayley et al., 2007)

Activities of daily living: daily self-care activities (e.g. bathing, dressing, grooming toileting, eating, transferring)

Apoptosis: a programmed sequence of cell death

Ataxia: impaired voluntary control of muscle movements

Autophagocytosis: a process of cell destruction generated by enzymes within the cell

Clinical practice guidelines: "systematically developed statements designed to assist clinician and client decisions about appropriate health care for specific clinical situations" (Field & Lohr, 1992 as cited in CAOT, 2007).

Dystonia: A neurological movement disorder in which sustained muscle contractions cause twisting and repetitive movements or abnormal postures (Bayley et al, 2007, p. 37)

Edema: a collection of fluid that leads to swelling

Encephalitis: inflammation of the brain

GestureTek system: A virtual reality system developed by Vivid Group Inc. in Toronto that employs minimally-invasive video-capture technology to generate a real-time image of the participant that is projected onto a viewing screen within a virtual environment, where he or she interacts with "virtual" objects through body movement (Weiss, Rand, Katz & Kizony, 2004; Sveistrup, 2004). The system includes five primary software platforms: the Gesture Xtreme (GX) games suite, the Interactive Rehabilitation Exercise System (IREX) games suite, Meal-Maker (MM), Emotional Meal-Maker (EMM) and the Virtual Mall (VMall)

Hematoma: pooling of blood outside of the blood vessels

Hypotonia: low muscle tone

Hypoxia: restricted oxygen supply

Ischemia: restricted blood supply resulting in decreased oxygen supply

Instrumental activities of daily living: daily activities a person performs that contribute to independent living in the community

Knowledge translation: “a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically-sound application of knowledge to improve health, provide more effective health services and products and strengthen the healthcare system” (Straus, Tetroe & Graham, 2009a, pp. 4)

Meningitis: inflammation of the membranes surrounding the central nervous system

Metastases: the spread of disease from one organ to another

Necrosis: cell death

Presence: the sensation that the virtual reality participant is actually in the simulated environment, and as a result demonstrates behaviours consistent with the context of that environment (Slater, 2003)

Rehabilitation: A progressive, dynamic, goal-oriented and usually time-limited process, that aims to enable an individual with impairment(s) to identify and reach his/her optimal mental, physical, cognitive and/or social functional level. Rehabilitation also provides opportunities for the individual, the family and the community to accommodate a limitation or loss of function and aims to facilitate social integration and independence (Bayley et al, 2007, p. 38)

Spasticity: Velocity-dependent increase in muscle tone (i.e. an increase in muscle stiffness above the normal level in response to movement) (Bayley et al, 2007, p. 39)

Tone: Muscle tone is evaluated as the amount of resistance of a limb where resistance arises from passive and active forces. OR: Muscle tone (aka residual muscle tension or tonus) is the continuous and passive partial contraction of the muscles (Bayley et al, 2007, p. 39)

Vasodilation: the relaxation of blood vessel walls leading to their widening

Visuospatial (unilateral) neglect: an impairment in attention or awareness of one side of the visual field

Virtual environment: computer simulations of real or imagined environments (Rand et al., 2005)

Virtual reality: a computer hardware and software system used to create virtual environments with which clients interact using their own movements (Weiss, Rand, Katz & Kizony, 2004)

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Dedication

This work is dedicated to my late father, Robert G. Smith, who instilled in me a love of learning, a passion for writing and the motivation to seek out new ways to improve health services delivery for Canadians.

CHAPTER 1: Introduction

Acquired brain injury (ABI) is one of the most prevalent causes of death and disability in Canada (Greenwald, Burnett & Miller, 2003; Rose, Brooks & Rizzo, 2005; Teasell, Cullen & Bayley, 2009). Rehabilitation can help to reduce the impact of these injuries by facilitating functional gains and by fostering independence (Bayley et al., 2007; Cullen et al., 2009). Among the variety of treatment approaches available to therapists is the use of virtual reality (VR) technology, which produces computer-simulated environments in which treatment activities can be presented (Rand et al., 2005). These virtual environments (VE) can afford therapists a greater degree of control over the manner in which they grade therapeutic activities, and provide increased variety in a treatment programme, which can enhance client motivation to engage in the rehabilitation process (Galvin & Levac, 2011; Kim, Jang, Kim, Jung & You, 2009; Thornton et al., 2005; Weiss, Rand, Katz, & Kizony, 2004). Although the state of the evidence about this intervention is at a developmental stage, emerging research lends support for VR as a promising tool.

With the popularity of game-based rehabilitation, therapists are increasingly being asked to implement the technology into practice. However, a lack of research exists to document the way in which VR is being used clinically for ABI rehabilitation. The implication of this disconnect is that the generalisability of current VR research to the clinical setting, and the feasibility of the intervention protocols under study have not been determined. Exploring the nature of any disparities can inform the design of clinically applicable VR research, thereby providing therapists with more relevant information on which to base their clinical decision-making. Furthermore, little is known about the factors influencing therapists' decisions to use the technology with their ABI clients. This knowledge is of value to those charged with facilitating its implementation in the health care setting. Finally, information about therapists' support and learning needs in adopting this relatively new treatment approach is also unavailable. A corresponding dearth of clinical tools and evidence based professional supports is available to support the development of clinical competencies in applying the technology. Similarly, evidence substantiating the value of targeted interventions to facilitate VR adoption has not yet been generated.

Accordingly, the objectives of this thesis were (1) to document the manner in which VR is being used clinically by therapists in ABI rehabilitation, (2) to apply a well-known theory of behaviour change to examine the specific barriers and facilitators to VR use from the perspective of therapists, (3) to describe preliminary work carried out to address the resource gap faced by clinicians, and (4) to evaluate change in the determinants of VR use following a multi-faceted knowledge translation (KT) strategy that incorporated this preliminary work.

CHAPTER 2: Acquired Brain Injury (ABI) Rehabilitation and Virtual Reality (VR)

2.1 The Incidence & Cost of Brain Injury in Canada

ABI is one of the most common causes of death and long-term disability in North America (Greenwald et al., 2003). Every year in Canada over 80,000 people are diagnosed with ABI at emergency and acute care clinics; up to 45% of these are children (Canadian Institute for Health Information [CIHI], 2007). The incidence of traumatic brain injury (TBI) (the most prevalent type of ABI) is highest in adolescents and children under five (Greenwald et al., 2003). ABI can involve injuries to the brain as the result of trauma, as seen most commonly in motor vehicle accidents (CIHI, 2007); also predominant in children are cases of abuse, falls and other accidents (Teasell et al., 2009). In addition, ABI includes non-traumatic injuries to the brain related to strokes, encephalitis, meningitis, blood vessel malformations, tumours and lack of oxygen secondary to incidents, such as near-drowning, smoke inhalation and cardiac events (Bayley et al., 2007).

The economic and psychosocial costs to families and society that stem from ABI are very high (Rose et al., 2005; Teasell et al., 2009). Some of the primary economic costs associated with recovery include emergency and acute hospital care, physician care and drug therapy, with estimates for the fiscal year 2000-2001 surpassing 900 million dollars for all ABI admissions (CIHI, 2007). In addition, post-acute recovery costs for those with moderate to severe ABI frequently involve intensive rehabilitative therapy, equipment and additional supports to promote community reintegration, development, emotional adjustment and increased independence (Lippert et al., 2009; McCormick, Curiale, Aubut, Weiser, & Marshall, 2009; Teasell et al., 2009; Wilkins et al., 2000). Support for families in relation to stress management, family functioning, social support and adjustment to living with ABI are also important aspects that must be provided during the rehabilitation process (Bayley et al., 2007), as caring for an ABI survivor increases stress and the risk of depression (Lippert et al., 2009). These costs and the related caregiver burden are ongoing, and often increase over time, particularly in the case of children, as they continue to develop during their recovery and face new challenges associated with increasing demands of school, social and family life, access to different environments and participation in activities of daily living (Lippert et al., 2009; McCormick et al., 2009).

2.2 Mechanisms of ABI

2.2.1 Primary Injury

Primary injury occurs at the time of the initial mechanism of injury; it destroys or damages brain tissue and affects the functions of cells, though not necessarily in a permanent way (Greve & Zink, 2009). In the case of TBI, primary injury is the result of physical forces acting on the brain (Greve & Zink, 2009) and includes wounds, skull fractures, hemorrhages, brain contusions, tissue tearing, interference with cellular processes, and damage to blood vessels (Gharahbaghian, Schroeder, Mittendorff & Wang, 2010). Localised contusions and hemorrhaging commonly result from linear forces (Greve & Zink, 2009); however, more diffuse injury can also result because of the shearing force of the brain accelerating and decelerating within the skull (Gharahbaghian et al., 2010), which damages neurons and ruptures blood vessels causing hematomas (Greve & Zink, 2009). Other mechanisms of primary injury can be observed in cases of hypoxia, for example, from incidents of near drowning or airway obstruction (Bayley et al., 2007), which lead to increased cerebral blood flow and the consequent swelling of glial cells; global encephalitis can ensue (Busl & Greer, 2010).

Anoxic injury from smoke inhalation occurs when carbon monoxide displaces oxygen on hemoglobin in the bloodstream, leading to cardiac ischemia that intensifies hypoxic encephalitis by also eliciting systemic vasodilation (Busl & Greer, 2010). In cases of prolonged hypoxia, delayed post-anoxic encephalopathy can manifest days after the initial injury, in which demyelination within the cerebral cortex is expressed clinically in sudden motor control, cognitive and behavioural difficulties (Busl & Greer, 2010). The mechanism of this demyelination is unknown (Busl & Greer, 2010). The rupture of blood vessels seen in TBI, strokes, arteriovascular malformation (AVM) and some tumours represents an additional mechanism of primary injury that results in hemorrhaging (Gharahbaghian et al., 2010; Riva et al., 2001). Primary brain injury can also result from infection, as in the cases of viral encephalitis or bacterial meningitis, or from cancer, in which a disease process results in gene mutations and damage to the mitochondria (Seyfried, Kiebish, Marsh, Shelton, Huysentruyt, & Mukherjee, 2011).

2.2.2 Secondary Injury

Secondary injury involves further injury to the brain that occurs over time, and is caused by physiological and biological changes resulting from the initial injury (Enriquez & Bullock, 2004; Greve & Zink, 2009). One cause of secondary injury is a prolonged decrease in oxygen supply to the brain (Enriquez & Bullock, 2004). Edema is a second mechanism of secondary injury (Enriquez & Bullock, 2004). The presence of edema or of a hematoma compresses brain tissue, altering function; it can also lead to increased intracranial pressure (ICP), decreased cerebral blood flow, and ischemia (Gharahbaghian et al., 2010; Greve & Zink, 2009), which can trigger cell destruction (Enriquez & Bullock, 2004). The risk of subsequent hemorrhage or herniation also increases, producing further increases in ICP and potentially death (Busl & Greer, 2010;

Gharahbaghian et al., 2010). Hyperthermia can also contribute to brain edema (Yokota et al., 2000). This build-up of pressure, however, is preventable through acute medical intervention (Gharahbaghian et al., 2010). Pooled blood is additionally damaging because it facilitates the formation of free radicals (Greve & Zink, 2009) that can have devastating effects on the integrity of small blood vessels, thereby exacerbating the bleeding (Busl & Greer, 2010).

Secondary injury can also originate at the biological level from the calcium homeostasis disruption that resulted from the primary injury mechanism; this process also produces free radicals that decrease cell membrane integrity, leading to cell death (Greve & Zink, 2009). Furthermore, the calcium imbalance triggers destructive enzymes that compromise cell function (Greve & Zink, 2009). The intracellular environment created by the calcium influx and the presence of free radicals also stimulates increased glutamate and nitric oxide levels (Greve & Zink, 2009), which directly cause the breakdown of neural tissue by necrosis, apoptosis and autophagocytosis (Busl & Greer, 2010). Each of these three stimulatory mechanisms can accentuate the action of the others, thereby proliferating a cascade of further destruction if protective responses of the body are inadequate (Greve & Zink, 2009).

Acute care aims to prevent or reverse the unfavourable environment created by the disrupted calcium homeostasis cascade initiated by the primary injury (Greve & Zink, 2009), and in the case of cancer, to halt the proliferation of metastases (Riva et al., 2001). Medical management also includes controlling bleeding, removing mass occupying lesions and regulating ICP, in order to minimise the extent of secondary injury (Gharahbaghian et al., 2010), as this dictates morbidity and mortality for survivors (Greve & Zink, 2009).

2.3 Outcomes of ABI

For children, ABI disrupts the typical path of growth and development, and as such, results in difficulty not only with previously learned skills, but also with functional abilities in domains that have yet to develop (McCormick et al., 2009). The consequence is that the gap between ABI survivors and their same-aged peers can continue to expand over time as developmental demands increase (McCormick et al., 2009), while the capacity to achieve functional improvements in rehabilitation decreases over time (Jaffe, Polissar, Fay & Liao, 1995). Those individuals with moderate to severe ABI face permanent disabilities (Teasell et al., 2009; Teplicky et al., 2005), which typically involve impairments across a wide spectrum of functioning. While different mechanisms of injury, brain areas injured and severities of injury invariably lead to different presentations (Teasell et al., 2009), several resulting sequellae are fairly widespread amongst ABI survivors (CIHI, 2007; McCormick et al., 2009).

Level of consciousness (LOC) relates to one's post-injury cognitive functioning, and is a key area that is impacted by an ABI (Wilkins et al., 2000); as such, it is used as a marker of brain injury severity (Greenwald et al., 2003). Related behavioural and cognitive characteristics, such as orientation to person, place and time, the consistency of responses to external stimuli, and the nature of those responses (e.g. generalised versus localised), are assessed during the acute rehabilitation phase (Rancho Los Amigos National Rehabilitation Center [RLA], 2011a). For those clients with higher LOC, the degree of distractibility, delay in responses, ability to initiate tasks and level of support or structure required for participation in goal-directed activities are several of the aspects monitored through such measures as the Rancho Los Amigos LOC scales (Hagen, 1998). LOC of an individual with ABI can fall anywhere on a continuum from non-responsive, to minimally conscious, through fully aware, and can progressively change over the course of the admission, acute care and rehabilitation phases of recovery (Wilkins et al., 2000). This level of awareness plays a significant role in one's capacity to participate in the rehabilitation process (RLA, 2011b) and is therefore a critical component of the acute rehabilitation assessment process (Bayley et al., 2007).

Cognitive impairments as the result of ABI often also involve difficulty with visual perception, attention, learning, organisation, judgment, memory and problem-solving (Bayley et al., 2007; CIHI, 2007) as well as slowed information processing (McCormick et al., 2009). Behavioural sequellae often include impaired self-regulation, mood, motivation and impulsivity (Bayley et al., 2007). In particular, individuals sustaining a TBI can have no physical sequellae, but instead may present with cognitive and behavioural difficulties (Marshall et al., 2009a). Each of these domains must be considered in the provision of therapy since they influence a client's ability to engage and cooperate in the rehabilitation process, as well as to transfer skills and learning to other aspects of daily life (Bayley et al., 2007).

Motor impairments following ABI commonly include deficits in postural control, balance, mobility and upper extremity function (Dumas & Carey, 2002; McCormick et al., 2009). Also prevalent is ataxia, as well as dysfunctions in tone, such as dystonia, spasticity and less commonly, hypotonia (Kanyer, 1992). These impairments impact motor abilities and in many cases necessitate mobility aids including wheelchairs with specialised seating systems (Bayley et al., 2007). Decreased fine motor skills, speed of movement, dexterity and coordination are also prominent in moderate to severe ABI (Kuhtz-Buschbeck et al., 2003). ABI survivors vary tremendously in the extent to which they experience motor deficits, with the most severely affected individuals facing complete dependence, while others are challenged primarily by speed-related tasks, and others still effectively participate in active pursuits at physical levels comparable to their peers (Dumas & Carey, 2002). This range in functioning highlights the important role therapists play in tailoring therapeutic interventions to meet the specific needs and abilities of their clients (Bayley et al., 2007).

While tremendous variability exists in the constellation and severity of impairments in body structure and function, these deficits ultimately translate into limitations in a person's ability to participate in meaningful activities. Post-acute rehabilitation provides an intensive goal-directed process by which these areas can be addressed to promote greater independence (Bayley et al., 2007). While return to pre-injury levels is uncommon following a significant ABI, rehabilitation has been shown to be effective at improving functional outcomes for these individuals (Cullen et al., 2009).

2.4 Current Treatment Strategies

2.4.1 Common Theories in Neurorehabilitation

Rehabilitation is a dynamic goal-directed process by which health care professionals facilitate the optimal functional recovery of their clients over the course of treatment (Bayley et al., 2007). More global objectives of rehabilitation also include community integration and increased independence, as well as aiding with the adjustment to any residual limitations (Bayley et al., 2007; Lippert et al., 2009). The use of theory to inform clinical decision-making can assist health care professionals to organise and justify their treatment choices and to evaluate client outcomes as they work towards these goals (Levac & DeMatteo, 2009). Five commonly used theoretical approaches to rehabilitation, used alone or in combination by therapists, include neuroplasticity theory, motor learning principles, the Neurodevelopmental Treatment approach, Dynamic Systems Theory and compensatory strategies.

Neuronal plasticity theory suggests that therapy challenges the nervous system during treatment activities to promote recovery of the brain and its neural pathways through compensatory and regenerative mechanisms (Rose et al., 2005). Experience of successful task performance has the potential to modify the brain through four identified means: the removal of inhibitory signals to an unutilised neural pathway, the strengthening of existing synapses, a change in excitability at the neuronal membrane, and the generation of new neural connections (DeFina et al., 2009). Furthermore, research suggests that uninjured areas of the motor cortex and associated motor and sensory areas demonstrate anatomical and neurochemical modifications proportional to the size of the injured cortical area (Frost, Barbay, Friel, Plautz & Nudo, 2003). These structures may be assuming the functions of the damaged area through functional re-organisation (Nudo, Plautz & Frost, 2001). Significant overlap exists in the electromyographic representation of motor movements in multiple areas of the brain, and a complex network of horizontal neural connections links local and remote functional regions; this may explain the potential of the brain to demonstrate neuroplastic re-organisation in the face of injury (Nudo et al., 2001). Sensory input, such as visual feedback, can also assist with the internalisation of the movement pattern to be learned (You et al., 2005b).

Motor learning principles purport that repetition, feedback and motivation are fundamental to motor learning (Holden, 2005). The provision of adequate task practice that allows for progressive successes is paramount to this approach to treatment (Holden, 2005). The theory also purports that transfer of learning may be greater if task rehearsal involves whole tasks rather than parts of tasks (Zwicker & Harris, 2009). Furthermore, feedback about one’s performance in executing those tasks improves the efficiency of motor learning (Zwicker & Harris, 2009). Motivation must also be high in order to maintain compliance to achieve functional gains (Holden, 2005). For this reason, the capacity to grade the degree of difficulty of the task is a key feature in providing a “just-right challenge” to promote success while pushing the limits of performance to obtain optimal gains (Sveistrup, 2004). In order to achieve functional improvements, therapists typically provide gradually increasing levels of difficulty in task presentation, while also grading the amount of physical or verbal support offered over the course of learning (Sveistrup, 2004; Zwicker & Harris, 2009). Since their inception in the 1980s, theories of motor learning have been well studied and are considered clinically relevant for the rehabilitation of clients across the life span (Zwicker & Harris, 2009).

The Neurodevelopmental Treatment Approach (NDT) is based on a hierarchical model of central nervous system (CNS) development that relies on a belief that neuromaturation follows a stepwise series of progressions leading to the emergence of motor skills (Keshner, 1981; Levac & DeMatteo, 2009). A feedback loop involving sensory input, resulting motor movement and subsequent feedback about one’s performance provides the mechanism for motor learning (Miles Breslin, 1996). The tendency of CNS impairment to interfere with normal motor development because of dysfunctions in muscle tone, reflexes, movement patterns, posture and sensation led NDT developers to design interventions to address these components of body function (Butler & Darrah, 2001). One of the primary assumptions of NDT is that motor control develops in a proximal to distal fashion, with postural control development being a prerequisite to functional use of the limbs (Miles Breslin, 1996). Also fundamental is the belief that maturational dissociation of reflexive movement for those with CNS disorders will lead to the development of voluntary control (Levac & DeMatteo, 2009). Under this therapeutic approach, active movement was avoided until reflexive and tone patterns were normalised, because of the ensuing compensatory movement patterns that were thought to be dysfunctional (Miles Breslin, 1996). In response to growing knowledge about neurorehabilitation, NDT gradually evolved to address some of the failed assumptions of its maturational theory principles and its lack of carry-over into functional volitional movement control (Butler & Darrah, 2001). More recent representations of the theory in practice involve the use of preparatory activities aimed at improving joint range of motion and postural alignment, followed by facilitative activities in which the therapist provides hands-on guidance and grades sensory input to promote active movement (Miles Breslin, 1996). NDT has been a prevalent approach to neurorehabilitation in recent decades despite an absence of conclusive evidence supporting its efficacy (Brown & Burns, 2001; Butler & Darrah, 2001) and long-standing findings indicating that the CNS does not mediate functional movement strictly hierarchically, nor in isolation (Keshner, 1981; Levac & DeMatteo, 2009). Contemporary theories linking the interplay of CNS impairments with the influence of other systems on functional improvement are thus gaining popularity (Levac & DeMatteo, 2009).

According to Dynamic Systems Theory (DST), the development of motor behaviour is determined by multiple systems that interact to coordinate function (Kamm, Thelen & Jensen, 1990). In contrast to hierarchical development theories, DST appreciates that while CNS damage does restrict the system, other subsystems also shape behaviour, including features of the task and of the physical and social environments, as well as other subsystems of the body (Kamm, Thelen & Jensen, 1990; Thelen, 2005). This shaping is a dynamic process that is not predetermined, but rather evolves based on the multiple inputs of the inter-related subsystems (Thelen, 1995). The status of each variable changes over time, leading to self-organisation of the movement pattern, in which preferred patterns are generated that represent the most efficient means of achieving a given task (Kamm et al., 1990). Exploration, practice and problem solving are the proposed mechanisms by which children learn functional tasks, with quality of movement peripheral to the accomplishment of the desired outcome (Levac & DeMatteo, 2009). Development is seen as a process involving an alternating and overlapping series of stable and unstable transition phases in which the system is self-organising to generate more adaptive patterns (Smith & Thelen, 2003). Transition periods describe times of relative instability, during which new patterns of behaviour are more likely to develop (Kamm et al., 1990). Some dynamic factor within the system (either internal or external to the body) must cause instability in order to allow the system to develop new and more adaptive patterns (Thelen, 1995). From a therapy perspective, dysfunctional patterns must be disrupted in favour of a transition in which adaptive change can be realised (Kamm et al., 1990). Therapeutic intervention, then, seeks to promote the exploration of new movement patterns during times of transition in order to facilitate the adaptation to person, task and environmental constraints (Kamm et al., 1990). By providing a range of experiences as well as flexibility by which the client can problem solve, new functional patterns can emerge (Kamm et al., 1990). Any of the subsystems coordinating the behaviour would be a fair target for therapeutic intervention (Kamm et al., 1990). This holistic approach considers a wide spectrum of influences in structuring therapeutic intervention to facilitate recovery, and is becoming more prevalent in the rehabilitation literature (Levac & DeMatteo, 2009).

When function has not returned to pre-injury levels, an adaptive, or compensatory approach can help to minimise the impact of impairment on functioning by optimising the use of residual skills to make up for deficits (Landa-Gonzalez, 2001). The compensatory approach provides interventions to facilitate higher levels of independence in daily activities (Koh, Hoffmann, Bennett & McKenna, 2009), including cognitive strategies and modifications to the environment (Tsaousides & Gordon, 2009).

Additionally, treatment can incorporate the provision of assistive technology to enhance performance, such as a wheelchair for mobility (Hoenig, Ganesh, Taylor, Pieper, Guralnik & Fried, 2006), a portable electronic device to cue memory (Hart, Buchhofer & Vaccaro, 2004), or a long-handled reacher to compensate for restrictions in upper extremity function while getting dressed (Shelton, Volpe & Reding, 2001). Support levels can also be graded throughout recovery to promote functional gains (Shelton et al., 2001).

2.4.2 ABI Rehabilitation

During rehabilitation, health professionals, such as occupational and physical therapists, are expected to select treatment interventions that meet the needs and goals of their clients based on best evidence from clinical experience and research literature (Teplicky et al., 2005). These therapists address impairments in body structures and functions related to the ABI and their consequent impact on successful execution of purposeful activities and involvement in life situations (World Health Organization [WHO], 2007). Physical, social and psychological aspects of functioning are incorporated into the treatment approach in order to enable optimal participation in life roles and activities (WHO, 2007). While continued improvements can be made during the first three years post-injury and beyond, the rate of improvement slows significantly after the first year, designating this early phase as the critical period in which to provide access to rehabilitation services for optimal recovery (Jaffe et al., 1995). Inpatient rehabilitation has been shown to improve functional outcomes, including mobility and self-care skills, and the ability to process social information; treatment continuing within the community after discharge can further improve independence, social participation and the level of care required (Cullen et al., 2009).

LOC can be used by therapists as a framework for selecting appropriate rehabilitation goals to meet the client's needs (Flannery, 1995; RLA, 2011a). Early interventions or interventions for those with lower LOC usually focus on comfort, tone management, positioning and the monitoring of awareness (Sellars & Vegter, 2003). At higher levels, the re-learning of tasks, motor skill practice, cognitive rehabilitation and participation in meaningful activities are among the foci of therapy (Sellars & Vegter, 2003). Typical rehabilitation activities for the client with ABI may include strength, balance and motor skills retraining, cognitive and social skills training, and the teaching of compensatory strategies (McCormick et al., 2009). Best practice indicates that motor rehabilitation should involve functional strength training, task-specific training, cardiorespiratory fitness, gait re-education and specialised wheelchair seating if indicated (Bayley et al., 2007). Support provided to enable participation in activities of daily living (ADLs) may range from physical assistance to verbal or physical cueing, set-up assistance or minimal supervision, depending on the degree of help required (Bayley et al., 2007). Tasks of increasing difficulty are typically presented, with graded physical and/or verbal support in order to enhance function (Sveistrup, 2004). As compared to single discipline care, coordinated interprofessional rehabilitation has been found to result in greater functional gains and independence levels while reducing the burden on caregivers (Semlyen, Summers & Barnes, 1998).

Effective rehabilitation should be provided "within a functional, purposeful and motivating context" in a way that can be "readily graded and documented" (Sveistrup et al., 2004, p. 4856). Activity grading in ABI rehabilitation can help to provide a "just-right challenge" that promotes successful participation and improved self efficacy, while encouraging the development or recovery of skills and awareness (Toglia & Kirk, 2000).

In addition, feedback about one's performance and the repetition required for motor learning are also important to successful rehabilitation in this domain (Holden, 2005).

2.4.3 VR in ABI Rehabilitation

VR is a new technology that can be used to provide therapy according to these principles (Holden, 2005; Sveistrup, 2004). VR uses computer software to create simulated environments in which clients can work towards their rehabilitation goals (Rand et al., 2005). This innovative approach provides a suitable medium through which to address a number of motor and cognitive recovery goals, and is beginning to be implemented as an adjunct to conventional therapy approaches (Weiss, Sveistrup, Rand & Kizony, 2009). Preliminary work has established the GestureTek VR system as a feasible and motivating rehabilitation tool for use with clients across a wide range of diagnostic and age groups, including ABI populations (Bart et al., 2010; Harris & Reid, 2005; Kizony, Katz & Weiss, 2003; Reid & Hirji, 2003; Thornton et al., 2005; Weiss et al., 2009). Both enjoyment and presence levels have been reported to be relatively high across a range of different VEs (Lotan, Yalon-Chamovitz & Weiss, 2009), and an absence of cybersickeness has been reported (Glegg, Tatla & Holsti, n.d., submitted).

Of the 23 studies with levels of evidence high enough to justify causal inferences about this intervention, nearly half have involved post-stroke patients (Glegg et al., n.d., submitted). This research provides moderate to strong quality level II evidence in support of the system for functional balance, mobility and upper extremity functional outcomes, and weak level II evidence related to unilateral spatial neglect and ADL outcomes (Glegg et al., n.d., submitted). Nevertheless, while this evidence is valuable, little information is available for therapists treating the many other ABI clients equally deserving of evidence based therapy. This limitation is particularly problematic in paediatrics, as the incidence of stroke in children in Canada is estimated to be less than 300 per year, while paediatric TBI estimates exceed 35,000 (Agrawal, Claiborne Johnston, Wu, Sidney & Fullerton, 2009; CIHI, 2007; Statistics Canada, 2011). With respect to the adult TBI population, weak to moderate level II evidence has been identified in relation to balance and mobility outcomes, while moderate quality level II evidence exists in support of executive functioning improvements and instrumental activities of daily living (IADLs) (Glegg et al., n.d., submitted). Although insufficient evidence is available for the paediatric ABI population, research in paediatrics with other neurological populations demonstrates strong quality level III evidence for functional balance and mobility improvements, and moderate quality level I evidence related to functional reach gains, based on single subject research designs (Glegg et al., n.d., submitted). Nonetheless, the transferability of skills to real life participation, and the long-term sustainability of functional gains have yet to be adequately examined (Glegg et al., n.d., submitted).

The primary limitations in this body of research are the smaller randomised controlled trial (RCT) as the highest level of available evidence, the limited recruitment of non-stroke ABI participants, and the lack of common outcome measures, which makes comparison across studies difficult (Glegg et al., n.d., submitted). In general, the level and quality of VR research appears to be consistent with that available in the field of ABI rehabilitation. If anything, as a relatively new clinical tool, VR may be receiving more attention from researchers than many conventional treatment approaches that are commonly in use, yet poorly studied. Overall, the research evidence examining motor rehabilitation in ABI is sparse, thereby offering limited guidance for clinical decision-making by therapists (Bland, Zampieri & Damiano, 2011; Marshall et al., 2007). Relatively low levels of evidence in ABI research are the result of small and often heterogeneous samples, and of the frequent lack of control groups, random assignment, quality outcome measures used, quality of reporting and long-term follow-up evaluations (Bland et al., 2011; Galvin, McDonald, Catroppa & Anderson, 2011; Marshall et al., 2007; Sandlund, McDonough & Hager-Ross, 2009).

As the result of the scarcity of research and the inherent difficulties in designing appropriate and high-quality studies to address such a heterogeneous population, Marshall et al. (2007) support the idea that a particular intervention may still produce benefits at the level of the client despite a lack of research evidence supporting its effectiveness. Until more research emerges, Levac & Missiuna (2009) recommend that therapists become familiar with the motor requirements of the VR system, monitor clients' performance in the VE and apply clinical judgment and experience in evaluating the applicability of VR-based therapy to address rehabilitation goals.

CHAPTER 3: Theoretical Framework of VR Adoption

3.1 The Role of Theory in Research

Theory provides a framework by which to explore the factors influencing therapists' adoption of VR. The advancement of science is dependent upon the creation, testing and revision of theories to produce objective accounts and sound predictions of observable fact (Siegert, McPherson & Dean, 2005; Whyte, 2007). Both its explanatory and predictive functions centre on a theory's capacity to demonstrate the link between theoretical constructs of interest (Kerlinger & Lee, 2000). The observed interactions between variables within a controlled environment provide scientific evidence about the relationships of those variables, which can then be used to predict outcomes (Whyte, 2007). Theory testing allows investigators to describe a particular phenomenon of interest more precisely by building on previous learning, while forestalling earlier pitfalls, which improves the efficiency of advances in knowledge (Brawley & Culos-Reed, 2000; Siegert et al., 2005). Whether a study aims to improve one's understanding of the natural world or to empirically test a proposed hypothesis regarding the relationships between different variables, theory is a necessary foundation for research (Siegert et al., 2005; Whyte, 2007).

3.2 The Decomposed Theory of Planned Behaviour (DTPB)

The Decomposed Theory of Planned Behaviour (DTPB) (Taylor & Todd, 1995a) provided the theoretical foundation for this research. The Theory of Planned Behaviour (TPB) aims to predict and to explain future behaviour based on one's intention to perform the behaviour and on one's beliefs about a number of influences on these intentions (Ajzen, 1991). The TPB grew from the Theory of Reasoned Action, which posits that one's intention to engage in a particular behaviour is dependent on one's attitude toward the behaviour and on subjective norms, or the reasons for carrying out that behaviour (Fishbein & Ajzen, 1975). The TPB builds on this interaction by incorporating additional complexity to account for situations in which individuals may not have total control over their behaviours (Ajzen, 1991).

According to the TPB, the three primary determinants of one's intention to carry out a behaviour are attitude, social (or subjective) norms and perceived behavioural control (PBC) (Ajzen, 1991). Attitude is defined as “the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behavior in question” (Ajzen, 1991, p. 188). Social norms represents the perceived influence of relevant others on carrying out a behaviour (Ajzen, 1991). PBC is “the perceived ease or difficulty of performing the behavior” (Ajzen, 1991, p. 188), and incorporates both past experience and perceived barriers (Ajzen, 1991). By evaluating these three constructs, the relative influence of each can be determined as a means of establishing an intervention aimed at increasing or decreasing intention to perform a behaviour, and consequently, actual behaviour (Perkins et al., 2007). Various researchers have “decomposed” or extended these primary constructs into sub-constructs to produce versions of the DTPB, to afford a greater depth of understanding about the determinants of behavioural intention (Chau & Hu, 2001; Hsu & Chiu, 2004; Jackson, Smith & Conner, 2003; Lin, 2006; Taylor & Todd, 1995a).

3.3 Operational Definitions of the DTPB Constructs

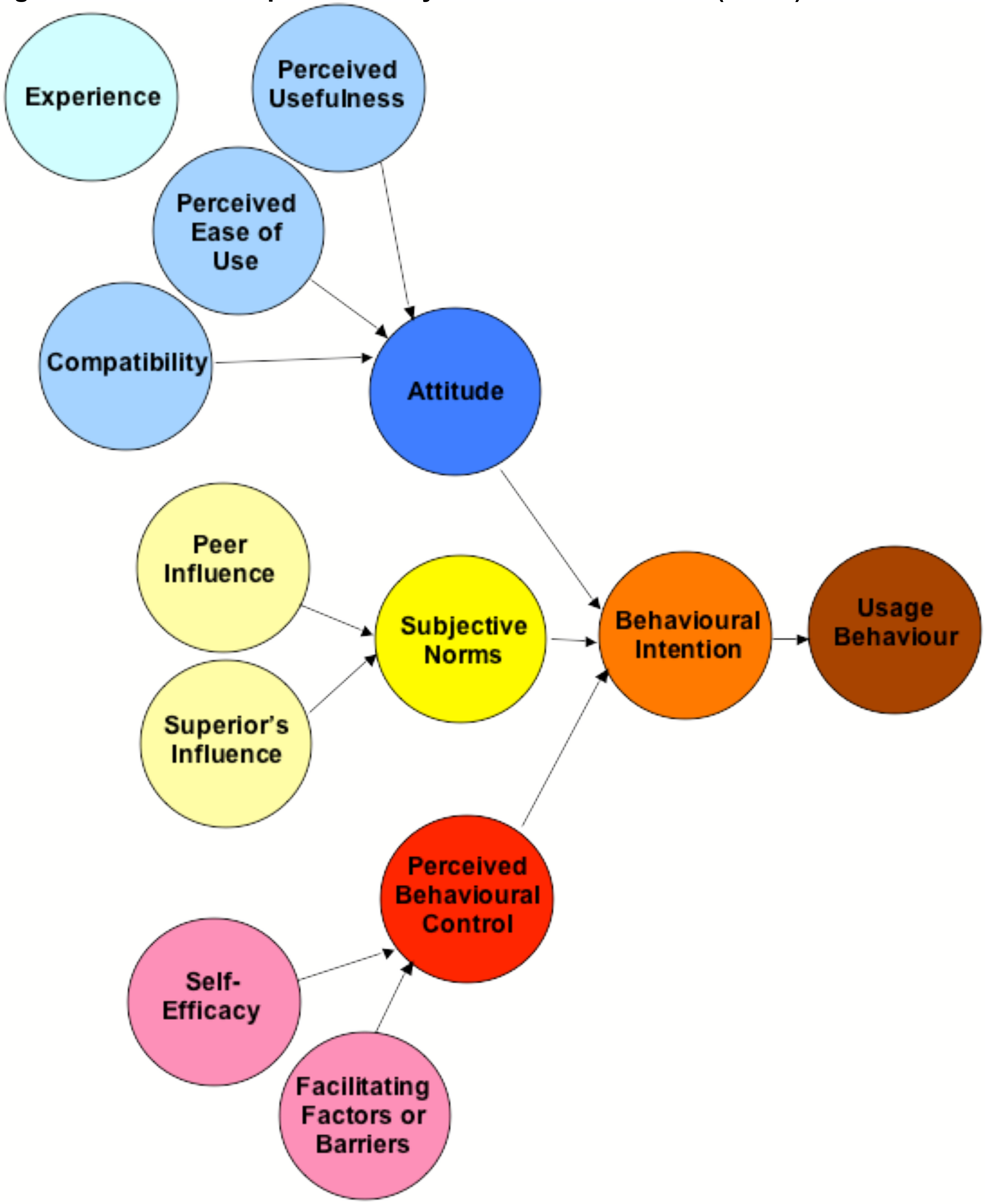
The DTPB as applied to this research came from the technology adoption literature and combined elements of three theories in identifying the determinants of behaviour: the TPB (Ajzen, 1991), the Technology Acceptance Model (TAM) (Davis, 1989), the Diffusion of Innovations Theory (Rogers, 1983). The specific behaviour of interest that the DTPB aimed to predict and explain in this study was the therapeutic use of VR technology by therapists. Three primary constructs are proposed by the DTPB as determinants of intention to use the technology: a) attitude, which is influenced by perceived usefulness, ease of use and compatibility of the technology, b) the social influence of peers and superiors, and c) an individual's perceived ability, which includes self efficacy and perceptions of external conditions that may help or hinder one's ability to use the technology (Taylor & Todd, 1995a). Refer to Figure 3.1 for a visual representation of the relationships of these constructs to one another. Table 3.1 provides operational definitions for each of the DTPB constructs from the literature, with research context-specific definitions generated by the author. Experience has been added as a sub-construct based on research by Taylor & Todd (1995b) that revealed how experience altered the relative influence of these determinants on behavioural intention.

Table 3.1: Theoretical Constructs of the DTPB

Construct	Operational Definition	Research Context-Specific Definition
Attitude (A)	"An individual's positive or negative evaluative affect about performing a particular behaviour." (Chau & Hu, 2001, p. 701).	Therapists' general feelings about using virtual reality as a treatment tool with their clients.
Perceived Usefulness (PU)	"The degree to which a person believes that using a particular system would enhance his or her job performance." (Davis, 1989, p. 320).	Therapists' beliefs that virtual reality is a valuable therapy tool that will enhance the treatment process for them and/or their clients and will result in improved client outcomes.
Perceived Ease of Use (PEOU)	"The degree to which a person believes that using a particular system would be free of effort." (Davis, 1989, p. 320).	Therapists' beliefs that using virtual reality in their clinical practice will be free of effort for them.
Compatibility (CO)	"The degree to which the use of technology is perceived to be consistent with the individual's work practices" (Chau & Hu, 2001, p. 704).	The extent to which therapists believe that the use of virtual reality as a therapy tool fits with their current treatment approaches and meets their clients' needs.
Social Norms (SN)	"The perceived social pressure to perform or not to perform the behavior." (Ajzen & Madden, 1986, p. 454).	Therapists' beliefs about whether or not others think they should be using virtual reality-based therapy.
Peer Influence (PI)	An individual's perception of the expectations of those from a relevant shared social group (consisting of people who are neither superiors nor subordinates) on them to perform a specific behaviour (Taylor & Todd, 1995a).	Therapists' beliefs about whether their colleagues think they should be using virtual reality in their clinical practice.
Superior Influence (SI)	An individual's perception of their superior's expectations of them to perform a specific behaviour (Taylor & Todd, 1995a).	Therapists' beliefs that their clinical supervisors expect them to use virtual reality in clinical practice.

Construct	Operational Definition	Research Context-Specific Definition
Perceived Behavioural Control (PBC)	“Beliefs regarding access to the resources and opportunities needed to perform a behaviour, or alternatively, to the internal and external factors that may impede performance of the behaviour.” (Taylor & Todd, 1995a, p. 150).	Therapists’ perceptions of internal (e.g. knowledge and skills) and external factors (e.g. resources and supports) affecting their ability to use virtual reality in their practice.
Facilitating Conditions & Barriers (FCB)	“The availability of resources needed to engage in a behaviour, such as time, money or other specialised resources.” (Taylor & Todd, 1995a, p. 150).	Therapists’ beliefs about the influence of factors perceived to assist and/or limit or prevent them from using virtual reality in their clinical practice. Examples may include access to the technology, adequate training and technology support.
Self Efficacy (SE)	“The conviction that one can successfully execute the behavior required to produce [certain] outcomes.” (Bandura, 1977, p. 193).	Therapists’ beliefs that they have the personal ability to use virtual reality as a treatment tool with their clients.
Behavioural Intention (BI)	“Motivation to perform a behaviour” which reflects “an indication of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour.” (Ajzen, 1991, p. 181-182).	Therapists’ intentions to use virtual reality during treatment sessions with their clients in the future.

Figure 3.1: The Decomposed Theory of Planned Behaviour (DTBP)



Adapted from Taylor & Todd, 1995a

3.4 The Utility and Theoretical Status of the DTPB

Across a vast range of disciplines, which include psychology, education, health care and information technology, among others, the TPB and its derivatives have been accepted in the literature as being useful in explaining and predicting behaviour (Perkins et al., 2007). Within health care contexts, the TPB has been accurate at predicting behaviours related to smoking, drinking and exercise, the prescribing behaviours of physicians, patient education and ethical decision-making (Ajzen, Joyce, Sheikh & Gilbert Cote, 2011; Bonetti et al., 2005; Courneya & McAuley, 1995; Limbert & Lamb, 2002; Moan & Rise, 2005; Randall & Gibson, 1991). The theory is also prevalent in the study of practice change in health care, including aspects, such as clinical guideline adoption (e.g. McGinty & Anderson, 2008; Rashidian, Eccles & Russell, 2008), continuing education (Archer, Elder, Hustedde, Milam & Joyce, 2008; Casper, 2007), treatment decision-making (Van der Geer & Kangis, 2002) and technology use (Chau & Hu, 2001; Shoham & Gonen, 2008). Although the theory does not appear to have been applied to occupational therapists' practice behaviours, and has only been applied to physical therapists in the context of choosing to work for a specific employer (Arnold et al., 2006), the demographic profile of the health care professionals studied previously, as well as the range of other populations represented in TPB studies in the literature, demonstrate the feasibility of the theory's use as applied to occupational therapists as well.

Within health care settings, DTPB-based research on technology adoption has explored physicians' use of telemedicine technology (Chau & Hu, 2001), social workers' use of information technology (Zhang & Gutierrez, 2007), and nurses' use of computers (Shoham & Gonen, 2008). As such, the theory can provide insight into the challenges faced by health care professionals in attempting to adopt a new innovation into their practice. The extended scope of the DTPB in addressing the nature of the technology, the different social influences and the internal and external factors affecting an individual's behavioural control provides a richer and more detailed explanation of important influences of behaviour than does the TPB. This added structure allows for an in-depth investigation of context-specific factors that may be targeted through interventions aimed at promoting practice change.

Specific measurement tools based on the TPB can be developed or modified to meet the contextual features of the population, practice setting and behaviour under study (Ajzen, 1991). Construct validity and internal consistency of DTPB-based measures used to evaluate the theory in a number of different contexts have been found to be high, with alpha coefficients for each construct ranging from 0.61 to 0.97, and factor loadings ranging from 0.65 to 0.99 (Feng & Wu, 2005; Hsu & Chiu, 2004; Lin, 2006; Shiue, 2007). These findings indicate that the items relating to a specific construct measure that construct and not others, and that the constructs are independent of one another (Portney & Watkins, 2000). Consistent with the theory's broad-ranging history in the literature, the TPB clearly has an appeal to researchers as a reasonable representation of behaviour and its determinants.

Although the DTPB has not yet been applied to VR adoption by therapists, the factors identified by existing research as being influential to VR implementation for other health professionals and settings can easily be categorised within the theory's framework, with each of its sub-constructs represented when the literature is considered as a whole. For example, attitudes toward VR were found to be important in two published studies (Kramer et al., 2010; Lotan, Yalon-Chamovitz & Weiss, 2011). Additionally, aspects of the technology itself, such as control over software parameters, ease of set-up and the ability to incorporate physical and cognitive supports for clients (Annema, Verstraete, Abeele, Desmet & Geerts, 2010), relate to perceived usefulness, perceived ease of use and compatibility. In a mental health setting, the social norms construct was identified in the positive influence of organisational leadership and of peers on clinicians' use of the technology (Kramer et al., 2010). With respect to perceived behavioural control and its sub-constructs, high self efficacy (Lotan et al., 2011) and technology support have been cited as facilitators (Lotan et al., 2011), while lower levels of experience, knowledge and skill in using the technology, client compliance, the availability and accessibility of evidence to guide practice, and organisational factors, such as high caseloads and the need for equipment and technical support, were presented as limiting factors (Kramer et al., 2010; Lotan et al., 2011; Markus et al., 2009). Further analysis of these factors as they relate to the DTPB and VR adoption, along with a summary of the gaps in the VR implementation literature is provided in Chapter 9.

3.5 Limitations of the DTPB

The primary assumption of the TPB is that behavioural intention can be used to predict future behaviour (Ajzen, 1991). This assumption has been challenged as a weakness of TPB research when actual behaviour is not observed or measured (Perkins et al, 2007). In clinical practice guideline (CPG) implementation research, both intention to use CPGs and actual use have been measured in only a few studies (Bonetti et al, 2005; McGinty & Anderson, 2008). In the technology adoption literature, accurate predictions of behaviour over time, for example, with internet banking behaviour, demonstrate the predictive potential of the TPB's behavioural intention construct (Yousafzai, Foxall & Pallister, 2010), although these findings are not consistent across all contexts (Armitage & Connor, 2001). Nonetheless, in a meta-analysis of the TPB literature, a modest correlation of 0.47, ($p<.001$) was found between intention and behaviour, with perceived behavioural control contributing significantly to the variability (Armitage & Connor, 2001). Clearly, including a measure of actual behaviour, as well as an analysis of the relative influence of PBC would represent the most optimal application of the theory.

Additional assumptions of the theory are associated with the relationships of the constructs to one another. Research in the field of health care has shown that populations with varying experience levels, such as students and professionals, may differ in their reactions to social influence (Chau & Hu, 2001; Limbert & Lamb, 2002), and that in certain contexts, some constructs, such as perceived ease of use or social norms, may not appear to affect behavioural intention (Chau & Hu, 2001; Puffer & Rashidian, 2004). Ajzen (1991) recommends that the measurement of the TPB constructs be done in such a way as to account for this context-specific variability. This accommodation may add to the complexity of measurement, but improves the specificity of the information gained and thus the richness of understanding. As such, application and testing of the theory in different contexts and with different populations is valuable in understanding this variability.

CHAPTER 4: Facilitating VR Adoption Through Knowledge Translation

4.1 The Science of Knowledge Translation (KT)

KT is defined by the Canadian Institutes of Health Research (CIHR) as “a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically-sound application of knowledge to improve health, provide more effective health services and products and strengthen the healthcare system” (Straus, Tetroe & Graham, 2009a, pp. 4). KT extends beyond the simple transfer of knowledge, to include the implementation of that knowledge to practice (Graham et al., 2006). Through this practice change, applied knowledge can affect health outcomes. Both system- and individual-level barriers and facilitators contribute to the process of behavioural change in health care (Legare, 2009; Wensing, Bosch & Grol, 2009). The assessment of these specific factors within the local context, along with the corresponding adaptation of implementation methods to address stakeholders’ needs, is required in order to promote the successful application of new knowledge (Wensing et al., 2009).

Two of the primary means of translating research into practice have traditionally been the publication of evidence in peer-reviewed journals and the presentation of findings at conferences. However, this type of passive dissemination has been shown to have little effect on practice change (Wensing, Bosch & Grol, 2010). In addition to an awareness and understanding of clinically relevant evidence supporting specific interventions, and positive attitudes toward the adoption of the interventions themselves, health professionals also require the knowledge and skills to be able to implement new approaches into daily practice (Hutchinson & Estabrooks, 2009). As such, educational interventions may play a valuable role in knowledge implementation for a clinical audience (Straus et al., 2009a).

Research suggests that most single strategies for influencing practice change are relatively ineffective, resulting in, at most, up to ten percent adoption by health professionals (Hakkennes & Dodd, 2008). In circumstances where the baseline practice behaviour is already low, larger improvements are more probable (Hakkennes & Dodd, 2008). While no intervention has been identified to successfully effect practice change in all situations (Hakkennes & Dodd, 2008), a number of interventions have demonstrated more success than others, with additive effects in some cases when interventions are applied in combination (Simpson & Doig, 2007). These strategies include site initiation visits, interactive education sessions and meetings with clinicians in their own practice settings, the provision of in-services by a clinician who is an on-site investigator, training using a resource book, and ongoing support (Richens, Rycroft-Malone & Morrell, 2004; Simpson & Doig, 2007; Sprague, Oppenheimer, McCabe, Graham & Davies, 2008). Generally, multiple methods are considered to be more effective than a single intervention (Richens et al., 2004; Simpson & Doig, 2007), particularly when different aspects of the intervention address different barriers to change; active interventions are more likely to demonstrate results than passive methods (Wensing et al., 2009).

By including therapists in the research process, certain shortcomings related to implementation can be minimised. Research carried out from the perspective of clinicians is likely to better match their practice needs and to fill information gaps that are relevant to daily practice (Pentland et al., 2011). Involving health care professionals in research has also been shown to improve the uptake of research findings (Lizarondo, Gimmer-Somers & Kumar, 2011). A shortage of VR research has been conducted from the perspective of therapists. As these professionals are the stakeholders expected to carry out the intervention, it would be prudent to find ways to meet their knowledge needs and to support them in order to facilitate VR implementation.

4.2 A Model of KT: The Knowledge-to-Action Process

The Knowledge-to-Action (KTA) Process (Graham et al., 2006) is a useful framework for guiding the application of knowledge about VR to clinical practice. The KTA model describes the steps involved in the process of knowledge translation and involves two components: *Knowledge Creation* and the *Action Cycle* (Graham et al., 2006). According to its authors, relationships amongst the model's constructs are not necessarily unidirectional; each step in the action phase can be influenced by neighbouring steps, while the *Knowledge Creation* and *Action Cycle* phases can influence each other throughout the process. This interactivity results in a dynamic system that allows for adaptation in the KTA plan based on observations and outcomes discovered throughout the process; this flexibility has the potential to improve the utility, uptake and application of knowledge (Graham et al., 2006).

The steps in the KTA process can be carried out by different stakeholders including knowledge producers, such as researchers, working either independently of or in collaboration with knowledge implementers and users (Graham et al., 2006). The key element in bringing knowledge to action is the knowledge exchange that takes place between the different stakeholders in order to tailor knowledge to meet the local context of its end users and to develop effective methods of enabling the application of that knowledge (Graham et al., 2006). This framework has been applied previously in clinical guideline and practice change implementation (Straus & Holroyd-Leduc, 2008), in the development of a health care professional mentorship strategy for KT (Straus, Graham, Taylor & Lockyer, 2008) and in translating knowledge to clients to enable them to effectively direct their own care (Tugwell, Santesso, O'Connor, Wilson & Effective Consumer Investigative Group, 2007).

4.2.1 Knowledge Creation

Knowledge Creation begins with the phase of *Knowledge Inquiry*, in which evidence is investigated in response to a clinical question or issue (Graham et al., 2006). This evidence can include primary research, expert opinion, clinical and client experience (Egan, Dubouloz, von Zwek & Vallerand, 1998). In the field of VR, the sources of this knowledge are quite diverse, and include information from the domains of software engineering and technology, which employ language with which many therapists may be unfamiliar. In an emerging field, the restricted state of knowledge necessitates an appraisal of the quality and applicability of new developments, which can be slow to become available, and difficult to find. Thus, knowledge inquiry for therapists exploring VR for rehabilitation may be a challenge. The *Knowledge Synthesis* stage, therefore, must incorporate the compilation and summarisation of this knowledge in a way that makes sense and demonstrates the relevance and utility of the knowledge for its target audience (Graham et al., 2006).

Through this process of tailoring knowledge, the end result is the generation of *Knowledge Tools or Products* that are useful for the end user, and are more easily accessible than the vast array of knowledge inputs that are scattered throughout the literature and in clinical and research settings (Graham et al., 2006). In the design of *Knowledge Tools*, specific recommendations intended to influence the behaviour of stakeholders, and an accessible format that addresses the knowledge needs of users, are two features that are thought to better enable the transfer of that knowledge to action (Graham et al., 2006). The *Tailoring of Knowledge* around the clinical use of VR for therapists will be described in Chapter 5, section 5.1, through an account of the development of clinical protocols to support the knowledge needs of therapists.

4.2.2 The Action Cycle

The *Action Cycle* provides the framework for the research process by outlining the steps involved in facilitating knowledge uptake through the deployment of specific KT activities. The initial step in the cycle is to *Identify the Problem*, which can be initiated by an individual or a group who then searches for knowledge to address the problem (Graham et al., 2006). Alternately, the second step in the cycle, *Identify, Review & Select Knowledge,* can be initiated first, triggering a query into whether there exists a problem that would benefit from the application of this knowledge (Graham et al., 2006).

Adapting Knowledge to the Local Context is the third step in the cycle (Graham et al., 2006). When planning knowledge transfer to target a particular population, it is important to tailor the format, content and dissemination methods to both meet the needs of the end user as well as to optimise the uptake of that information (Graham et al., 2006). Decision-making about the clinical applicability and relevance of evidence (Graham et al., 2006) related to VR would be an activity example carried out during this step.

Planned action theories can be used to drive the next step in the KTA process, *Assessing Barriers to Knowledge Use* (Graham et al., 2006). A comprehensive approach examines aspects of the innovation itself, along with those of the local context and those of stakeholders (Graham et al., 2006). Facilitators of adoption can also be important influences of the KTA process and should be identified during this phase (Legare, 2009). Applying the information gained through this assessment can inform the

Selection, Tailoring, & Implementation of Interventions, in order to identify or improve upon appropriate strategies (Graham et al., 2006) targeted at facilitating knowledge use in practice. Although little substantive evidence links specific interventions to explicit barrier reduction, the use of both theory and exploratory methods is recommended to structure this process (Wensing et al., 2010).

The ensuing *Action Cycle* phase, *Monitoring Knowledge Use*, involves an evaluation of the extent to which knowledge has changed the way users conceptualise issues, and to which they engage in behaviour change in response to that knowledge (Straus, Tetroe, Graham, Zwarenstein & Bhattacharyya, 2009). This first dimension of knowledge use can thus be measured by examining changes in knowledge, understanding and attitudes (Straus & Holroyd-Leduc, 2008); the latter relies on the assessment of either self-reported or actual practice change. The *Evaluating Outcomes* stage follows as a mechanism of determining the impact of knowledge uptake on client outcomes (Graham et al., 2006).

Sustaining Knowledge Use necessitates a similar process of evaluation to that just described. Specifically, it involves the assessment of the barriers to sustainability, and the corresponding tailoring of interventions to address these barriers. Ongoing monitoring and evaluation through a revisiting of the KTA cycle will provide information about the effectiveness of this process (Graham et al., 2006). A reassessment of the knowledge needs of stakeholders connects the KTA cycle, which may trigger a new knowledge inquiry or the identification of different aspects of the KT process that require further exploration and attention. Subsequent chapters of this thesis present the KT research on VR adoption that was stimulated by this model.

4.3 The Use of Clinical Practice Guidelines (CPG) in Rehabilitation

Clinical guidelines, or protocols, are one tool that can assist therapists to incorporate new treatment approaches into their practice, by providing information about clinical decision-making related to specific treatments with which therapists may be less familiar, and by synthesising the existing evidence which supports those decisions (Jackson & Feder, 1998). According to depictions in the medical literature, CPG implementation appears to be perceived as compulsory in nature by physicians (McGinty & Anderson, 2008). In contrast, the incorporation of clinical judgment, which preserves the value of client-centered practice, is important in the field of occupational therapy, where CPGs are perceived as “advisory” rather than as regulatory (Canadian Association of Occupational Therapists [CAOT], 2007, p. 2130). This belief is also evident in the physiotherapy literature, as patient individuality, and therapist intuition and creativity are taken into account in applying CPGs as a “framework with…freedom of choice” (Harting, Rutten, Rutten & Kremers, 2009, p. 238). This distinction suggests that therapists may perceive more autonomy over the implementation of CPGs than do other health care professionals (Harting et al., 2009). Employing a holistic view that incorporates the influence of the person, the task and the environment on clinical outcomes, as well as maintaining a client-centered approach to treatment, are values that contribute to the complexity of clinical decision-making for therapists (College of Occupational Therapists of British Columbia [COTBC], 2003; Cusick & McCluskey, 2000; Smith, Higgs & Ellis, 2008). As such, CPG development for rehabilitation professionals may require the incorporation of these elements into a flexible package that still meets best practice standards based on the available evidence.

While clinical guidelines for interprofessional ABI rehabilitation have been compiled based on an appraisal of the existing ABI rehabilitation guidelines (Bayley et al., 2007), they address few specific treatment approaches supported by evidence, and require that therapists subsequently access the literature to inform themselves of the evidence and its relevance and feasibility within their clinical setting, in addition to the manner in which to carry out the treatment. While sensorimotor and cognitive rehabilitation are addressed in the guidelines, no recommendations are offered with respect to the use of VR. Moreover, no clinical VR guidelines or protocols have been published for any rehabilitation context or clinical population. In response to this gap, clinical protocols for VR use in ABI rehabilitation specific to the GestureTek VR system were developed recently (Smith[1] & Jordan, 2008) to assist therapists by increasing their knowledge, skills and efficiency in using the technology for rehabilitation. This development process is outlined in the next chapter, along with other foundational work carried out in preparation for the thesis research described in subsequent chapters.

[1] Note: This work was published under the thesis author's maiden name

CHAPTER 5: Foundations for This Research

This chapter provides an overview of the foundational work that was carried out before the thesis research began. The outcome of this work included a knowledge product for therapists, called the clinical protocols manual, which was provided as a component of the study's KT intervention. The measures used for data collection were also developed and field tested in preparation for the research. These measures allowed for the documentation of current VR practice in ABI, the examination of the determinants of VR use by therapists, and the evaluation of change following the KT intervention. The development of each of these products is described below.

5.1 Development of Clinical Protocols for VR in ABI Rehabilitation

In considering the clinical application of VR, a knowledge gap was identified with respect to the resources available to therapists considering adopting the technology. A preliminary search of the literature yielded little scaffolding by which therapists could implement VR into practice. With clinical experience, the need for knowledge products to support therapists in this endeavor became apparent. While the GestureTek VR system comes with a user manual, it was written by software developers and fails to meet the information needs of therapists. For example, while it presents a description of each game, it does not describe different ways in which the games can be used therapeutically, nor does it provide guidelines related to appropriate software settings to use with clients with varying skills and abilities.

Clinical protocols can assist therapists to gain knowledge and skills about a practice or treatment area, and provide recommendations based on evidence and expert opinion (Jackson & Feder, 1998). The development of clinical protocols for VR use in ABI rehabilitation was selected as the method of addressing the existing resource gap for clinicians. The term ‘protocol’ was chosen over ‘practice guideline’ in order to reflect more accurately the freedom of choice therapists had in implementing the recommendations and tools provided. This nomenclature decision was made in part because of the culture of CPG adoption for the target therapist population, but also because of the level of evidence available to inform the design of the protocols. Indeed, evidence-based CPGs require a comprehensive body of research findings from high quality studies in order to support their generalisability (Butler & Darrah, 2001). In the absence of this knowledge, current best evidence must be used to inform clinical decision-making by therapists (Butler & Darrah, 2001).

The purposes of the clinical protocols manual were (1) to provide an evidence based resource that synthesised clinically relevant information from both the literature and clinical experience, (2) to reduce the amount of time required by therapists to explore the system through trial-and-error such that they would be familiar enough with the technology to use it with ABI clients, and (3) to offer a framework that supported clinical decision-making with respect to assessing VR rehabilitation readiness, selecting and grading activities, developing treatment programmes and evaluating outcomes.

Protocol development work began in 2005 following the introduction of the GestureTek VR system into clinical practice at Sunny Hill Health Centre for Children (Smith & Jordan, 2008). The AGREE Tool (AGREE Collaboration, 2001) was used to help guide the initial development of the protocols. The specificity and strength with which recommendations could be made about VR use post-ABI was limited by the level and quality of existing evidence. As a result, both clinical experience and research evidence were considered in developing flexible protocols, and emphasis was placed on the educational materials and the clinical tools needed to facilitate therapists’ use of VR. Inclusions from the literature related to rehabilitation applications of the technology, activity and goal selection, therapy intensity and outcome measurement, while knowledge gained through clinical experience in applying the VR technology in ABI rehabilitation practice related primarily to strategies for activity grading and appropriate software parameter settings. A thorough assessment of the client, and clinical knowledge about ABI sequellae and their impact on function were prerequisites for applying the tool to practice.

5.1.1 Content of the Clinical Protocols Manual

The outcome of the development process was a manual entitled “Clinical Protocols for Virtual Rehabilitation: Using the Vivid GX Learning Suite by GestureTek Health in Brain Injury Rehabilitation” (Smith & Jordan, 2008). The manual included a summary of the literature on the use of VR for rehabilitation, with specific reference to ABI, paediatrics and the GestureTek VR system. Reference material also included an overview of the GestureTek system, its set-up and how it works, guidelines for the development of VR-based treatment goals, and sample scripts for therapists introducing this novel treatment to clients and families. Resources to assist with the clinical decision-making process included a model for assessing client characteristics proposed to contribute towards VR rehabilitation readiness, a structure for developing client programmes, suggestions for measuring client performance, and specific recommendations for the grading of VR activities based on client abilities and treatment goals. A programme tracking sheet template was also developed on which to record relevant aspects of the client programme throughout the course of treatment. As recommended by Levac & Missiuna (2009), a task analysis of the games in relation to the specific movement skills required, and suggestions for modifications to improve the rehabilitation value of the games were also included. The final appendix described these features, including specific software setting ranges for each game that had been tested as being suitable for different client skill and ability sets. This diverse collection of tools and resources addressed the recommendation of the AGREE Next Steps Consortium [AGREE] (2009) to provide tools to support the implementation of the intervention.

While the clinical protocols manual was developed with previously identified general barriers to practice change and technology adoption in health care in mind, little is known about the specific perceived barriers and facilitators that exist for therapists considering adopting VR-based treatment for their clients. Research was required not only to identify these factors, but also to evaluate the extent to which the protocols could address barriers that influence VR adoption by therapists.

5.2 Measure Development

5.2.1 Outcome Measure: The ADOPT-VR Survey

The Assessing Determinants of Prospective Uptake of Virtual Reality (ADOPT-VR) survey was developed for this study as an outcome measure to examine change in the determinants of VR adoption as outlined by the DTPB. The methodology used to develop and to field test the measure, along with the outcomes of that process, including preliminary psychometric properties of the survey, are described in Chapter 9 (Glegg et al., n.d., under review). The final posttest version of the survey was identical to the pretest version described in Chapter 9, but included a final page with questions requesting feedback from therapists about the utility of and their use of the clinical protocols. The posttest took 15-20 minutes to complete, and can be found in Appendix A.

5.2.2 Descriptive Measure: The Client Tracking Sheet

The Client Tracking Sheet was developed for this study as a descriptive measure to collect information about client and VR programme characteristics. A detailed description of the Client Tracking Sheet is provided in Chapter 8 (Glegg et al., n.d., to be submitted). Field testing of the measure was carried out with the same sample and structured feedback methods used to field test the ADOPT-VR survey. This process resulted in minor refinements in the wording and changes to the formatting of the measure to reduce visual clutter. The Client Tracking Sheet was initially divided into three portions; the first page was used to describe the client characteristics and the VR programme at the onset of VR-based therapy. The second page highlighted changes in client abilities and subsequent changes to the VR-based therapy programme at any point that client goals had changed. The final page summarised the client's status at the end of the programme and described reasons for termination of VR-based treatment.

Based on structured feedback, the format was modified so that client characteristics at each phase of the VR programme (represented by goal changes) were presented on the first page. This modification allowed for ease of comparison between phases in order to identify changes in client characteristics and abilities over time. Corresponding client goals and VR programme characteristics for each treatment phase and the reasons for terminating the VR programme (if applicable) were presented on subsequent pages, with space for up to four goal change phases. The different phases of treatment were colour-coded for ease of use. The document was also reformatted using a landscape orientation. These changes resulted in more efficient formatting of the client characteristics section such that it required less space and was easier to read, allowed for additional white space on the document, and more space in which to record client goals. The goal setting section was restructured to allow therapists to indicate whether the goals had been achieved and whether they thought that VR facilitated this improvement. In addition, the goal setting section and the behaviour section were modified to allow open-ended responses rather than requiring forced choice answers that categorised clinical observations or goal areas. A new section was added to enable therapists to document the client's response to treatment in order to improve the clinical utility of the tool. Suggestions to increase the specificity of items describing client characteristics, such as integrating standardised measures or increasing the level of detail requested with respect to the nature of supports required, were not incorporated in order to avoid the need for additional pages and to limit the research participation burden on therapist subjects. This form is provided in Appendix B.

CHAPTER 6: Research Aims

As an emerging intervention tool, it is crucial to ascertain how VR is being used in ABI rehabilitation currently in order to inform clinically relevant VR efficacy research on which therapists can make evidence-informed decisions. While the literature describes some of the barriers and facilitators to VR implementation in other practice settings, a comprehensive theoretically based assessment of the extent to which these factors influence therapists' motivation to ultilise VR for ABI rehabilitation is lacking. Furthermore, no research has examined the effectiveness of interventions aimed at mediating these factors to promote VR use. Although a clinical protocols manual has been developed to assist therapists in using VR for ABI rehabilitation, this instrument has yet to be pilot tested to establish and subsequently improve its utility and methodological quality.

6.1 Study Purposes

The purposes of this research were:

1. To describe the manner in which therapists are currently using VR with clients in their ABI practice
2. To examine factors influencing therapists' adoption of VR for ABI rehabilitation, as described by the DTPB
3. To explore the impact of a KT strategy[2], which included the provision of clinical protocols, at mediating these factors
4. To inform the refinement of the clinical protocols manual to produce a more effective tool for therapists

[2] Specific goals of each component of the KT intervention are described in Section 7.5

6.2 Hypotheses

Hypotheses were generated for outcomes related to the intervention phase of the study as described in Study Purpose #3 (above):

Primary hypothesis: The KT intervention will be associated with improvements in therapists' perceived ease of use of the technology at posttest.

Secondary hypothesis: The KT intervention will be associated with therapists' improved self efficacy, and an associated increase in behavioural intention to use the technology at posttest.

These hypotheses were selected because of the nature of the intervention and its goals of increasing therapists' knowledge and skills in using VR, as well as their efficiency in being able to apply it to practice. The variables of perceived ease of use and self-efficacy were identified as the variables most amenable to change following KT, and thus the target of the intervention, as described in section 7.5. Furthermore, as highlighted in section 9.1, the most commonly referenced barriers to VR use as identified in the literature relate to this lack of knowledge, skill and self efficacy (Kramer et al., 2010; Lotan et al., 2011; Markus et al., 2009), as well as aspects of the technology contributing to perceived ease of use (Thornton et al., n.d., as cited by Weiss et al., 2009; Annema et al., 2010; Markus et al., 2009.

6.3 Clinical Implications

Descriptive information about how VR is presently being used clinically will be valuable for researchers involved in outcomes research using VR, in informing the design of future research to target clinically relevant populations using interventions that are feasible and specific to clinical therapists' VR use habits. Findings of this research will identify barriers and facilitators to VR use that can be targeted to improve the accessibility of the technology to therapists. Furthermore, results may inform future KT interventions aimed at promoting practice change in this context. In addition, feedback from therapists will be incorporated in revisions to the clinical protocols manual to yield a more effective tool to support their learning needs.

CHAPTER 7: Research Methodology

This chapter provides an overview of the research methods used for the study. Some of this information is repeated in Chapters 8 and 9 of the thesis, which are manuscripts prepared for publication. These manuscript chapters also contain more specific details about the methodology used for pretest survey administration to therapists, client recruitment and data analysis.

7.1 Study Design

Because of the small population of therapists using the GestureTek VR system in practice, a single group pretest-posttest design was selected to enable subjects to act as their own controls, and to increase the power of the study in identifying statistically significant changes in the variables of interest.

7.2 Recruitment & Sampling

Three health centres from different provinces across Canada were selected to provide approximately equal recruitment numbers of therapists working with children and adults to increase the size of the population of therapists from which to sample, and to increase the generalisability of results. Inclusion criteria for site selection included an ABI rehabilitation programme with occupational and/or physical therapists on staff, and access to the GestureTek VR system. Participating sites were also required to provide a study coordinator to execute the study protocol, including managing the ethics application process.

To test the effect of the KT intervention, a sample size of up to 25 therapists was thought to be feasible based on the population size across the three study sites. G*Power 3.1.2 software (Faul, Erfelder, Lang & Buchner, 2007) was used to calculate a required effect size of 0.58 based on an alpha level of 0.05 and 80% power for a two-tailed test. This required value reflects a large effect, meaning that a large change in posttest over pretest mean scores would be required in order to increase the likelihood of detecting a statistically significant difference. The predicted standard deviation in item scores for the primary variable (perceived ease of use) at baseline was based on previous research exploring technology adoption by health professionals and was estimated to be 1.36 for a 7-point scale (Chau & Hu, 2001). As a result, for this repeated-measures design using a 9-point scale, the smallest effect size that would be significant based on 80% power would be a pretest-posttest mean change of 1.02 points.

During the ethics application process, one site dropped out, citing as a reason that the study coordinator was unable to continue in the role. The study was thus limited to two sites in order to preserve the study timeline and to avoid the logistical complexity of establishing new contacts and recruiting at an additional site. However, recruitment rates were higher than expected, at 89%, and despite losing one site, the recruited sample size of n=42 exceeded original estimates. Further to the recruitment details described in Chapter 8 (Glegg et al., n.d. under review), therapists were invited to participate by means of a letter of introduction circulated within the therapy department at each site. Informed consent for all participating therapists and clients, and university and agency Research Ethics Board approval for the study were obtained at each remaining site.

7.2.1 Inclusion Criteria

Therapists were required to have clients with ABI on their caseloads, and be occupational, physical, recreation or rehabilitation therapists. Because of differing terminology across provinces, the latter therapists are also referred to as rehabilitation assistants and rehabilitation aides. The term rehabilitation therapist will be used throughout this thesis. Rehabilitation and recreation therapists were included to represent typical practice across the research sites and to increase the size of the population from which to sample. According to professional governing body regulations, occupational, physical and recreation therapists are autonomous primary health care professionals who are able to prescribe and carry out treatment programmes, whereas rehabilitation therapists cannot prescribe treatment but can carry out supervised treatment programmes developed by occupational, physical and recreation therapists (CAOT, 2009; COTBC, 2003; College of Physical Therapists of British Columbia, 2008; Canadian Therapeutic Recreation Association, 2006). These differing roles will be discussed further in the Outcomes section (7.3) as they pertain to the different measurement tools used with therapists from the different professions.

7.2.2 Exclusion Criteria

Therapists were excluded if, during the study period, they would not be providing direct therapy to ABI clients as part of the rehabilitation process. This exclusion criterion applied to therapists whose role was solely to provide specialised consultation services, such as wheelchair seating prescription or dysphagia assessment, but who were not responsible for other ongoing direct therapy of which VR would be one potential intervention.

7.3 Outcomes

The development and field testing of the ADOPT-VR survey and the Client Tracking Sheet were described in Chapter 5. The ADOPT-VR survey was administered to therapists following informed consent, and at the completion of the study requirements to allow for the evaluation of change in the determinants of VR use as described by the DTPB.

The Client Tracking Sheet was completed by prescribing therapists (e.g. occupational, physical and recreation therapists) over the course of the study period for at least three of their eligible clients. The Therapist Log Sheet was completed by rehabilitation therapists or prescribing therapists covering other colleagues' caseloads to track the number of clients seen by each therapist. This documentation was completed in order to ensure that each therapist had used the VR system with this required minimum number of clients during the study period, and to assist the researchers in timing the administration of the ADOPT-VR posttest survey for these therapists. The Therapist Log Sheet documented therapist and client codes, dates and durations of treatment sessions, and the client's response to treatment.

7.4 Study Procedures

Subsequent to obtaining informed consent from therapist subjects, the following steps were performed:

1. Pretest surveys were administered in print form to therapists by the study coordinators at each site. Print form was selected to allow more flexibility in terms of providing a quiet environment in which therapists could complete the survey at a time that was convenient for them, given that they did not all have access to a dedicated personal computer workstation. The study coordinators were Stephanie Glegg at Sunny Hill Health Centre, and Christine Brum and Denise Sartor at Hamilton Health Sciences.
2. Stephanie Glegg provided an interactive education session to subjects at each site to afford therapists the opportunity to see the technology being applied, to

learn about its therapeutic utility and to ask questions. This session was designed to ensure that therapists had the same baseline level of knowledge about the VR system and its application to practice at the onset of the study. The session also allowed participants the opportunity to ask questions about the clinical protocols manual and other study processes. An overview of the content provided during this education session is provided in Appendix C. The average time between pretest administration and the education session was 28 days, during which time recruitment of therapists was ongoing. More specific details about the intervention are described in section 7.5.

3. The clinical protocols manual and the Client Tracking Sheets were provided to therapists by the study coordinators at each site; study coordinators were available to provide or to coordinate technical or clinical support for therapists on request.
4. The study coordinators collected Client Tracking Sheets as therapists completed them. Therapists identified clients with whom they would like to use VR and completed the Client Tracking Sheets for their first available ABI clients consenting to participate. The target was to collect tracking sheets for a minimum of 3 and a maximum of 6 clients per therapist to account for any learning effects based on experience using the VR system during the course of the study period. Each full-time therapist typically treats approximately 14 clients with ABI per year, so an eight-month data collection period was provided to allow all therapists to complete the data collection process. Because of the pace of client recruitment and the lower than anticipated number of admissions of appropriate clients, the minimum number of clients in the target range (e.g. three) was set as the cut-off point for terminating data collection.

5. Posttest surveys were distributed in print form to each therapist by study coordinators once that therapist had submitted all Client Tracking Sheets or had completed the Therapist Log Sheet requirements. The average time between the education session and posttest administration was 32 weeks.

7.5 Details of the Intervention

The independent variable was a multi-faceted KT intervention that included an interactive education session, the provision of the clinical protocols manual to therapists, and clinical and technical support provided on request. This intervention was designed to enhance therapists' knowledge and skills in using the VR technology for ABI rehabilitation, and to address some of the primary barriers to implementation as identified in the literature. Based on pretest findings as presented in Chapter 9, additional support with respect to enabling improved access to the VR system (e.g. dedicated space) as well as assistance with set-up and take-down of equipment for treatment sessions was provided. Other barriers and facilitators amenable to the planned KT intervention were consistent with those identified in the literature.

7.5.1 Clinical Protocols Manual

As part of the KT intervention, each participating therapist received a copy of the clinical protocols manual described in Chapter 5. The manual was provided on completion of the pretest survey as an information primer at the start of the study, and was available as a reference during the course of client treatment. The intention of the manual was to improve the efficiency by which therapists could apply the technology to practice by decreasing the time required of them to gain knowledge about its use. Evidence suggests that knowledge alone may not change behaviours; as such, providing "practice-enablers", such as protocols or clinical tools, during an education session may help to facilitate subsequent application of the knowledge to practice (Davis & Davis, 2010; Marinopoulos et al., 2007).

7.5.2 Interactive Education Session

An interactive education session at each site was thus used to introduce therapists to the content of the clinical protocols manual. Interactive education sessions have been demonstrated to be more successful than passive lecture-style education at improving clinicians' knowledge, skills and attitudes (Richens et al., 2004). The session provided an overview of the GestureTek system as applied to ABI rehabilitation, and included case-based scenarios in which the technology was used to demonstrate intervention strategies. The inclusion of video-based vignettes of ABI clients participating in VR-based rehabilitation highlighted the clinical application of the technology to target identified client goals, while demonstrating ways in which activities and software parameters could be graded to vary the degree of challenge. Additional live demonstrations of these aspects of VR use were provided, along with the opportunity for therapists to request additional demonstrations or to ask questions to address their learning needs. Such use of media during group education sessions can increase the clinical relevance of the content and improve the learning potential for clinicians (Marinopoulos et al., 2007).

For consistency, a single clinician investigator (the author), who was a therapist with experience using the VR system, led the session for each research site, either live or by videoconference. Logistical problems related to scheduling constraints necessitated the use of a videotaped version of the education session for those therapists who were unable to attend the live session. For these therapists, the opportunity to ask questions and interact was limited to contacting the education session provider by email after viewing the session, if desired (an option available to all participating therapists), and engaging in within-site discussion amongst colleagues. No formal forum for this latter process was provided.

7.5.3 Clinical & Technical Support

To address previously identified barriers to technology adoption by health care professionals, such as confidence in using the technology, and technical assistance (Chau & Hu, 2011; Markus et al., 2009), both clinical and technical support was provided on therapist request. One individual at each site acted as a clinical technologist, addressing computer-based technical issues related to equipment and software set-up and troubleshooting that arose during clinical VR use. This individual also acted as a liaison between the site's clinicians and the software company when difficulties could not be resolved locally. In addition, an on-site clinical expert provided one-to-one or group support to therapists with respect to the clinical application of the technology. This assistance took the form of a review of the VR games and their potential applicability to client goals, guidance on how to set software parameters to grade the challenge of activities, and assistance with the development of client goals and/or programmes. Ongoing support was offered in order to individually target the changing support needs of clinicians as they became more familiar with the technology.

7.6 Data Management

All therapist and client data was identified by a numerical code that was known only to the investigators and the study coordinators at each site. Data was collected by study coordinators at each site and sent to the author in Vancouver by courier for analysis. Raw data was stored according to confidentiality requirements of the Ethics

Review Board, which included password-protecting electronic data and securing hard copy data in a locked filing cabinet.

7.7 Data Analysis

Data analysis methods for the ADOPT-VR data are described in Chapter 9 (Glegg et al., n.d. under review) in relation to pretest findings. To allow for pretest-posttest comparisons, relevant analyses were re-run using the data set that excluded therapist dropouts (n=37). Posttest data was also plotted to evaluate the normality of the distributions; all but the Superior Influence construct were negatively skewed and demonstrated non-normal distributions. Consequently, non-parametric statistical methods were used to analyse the data. The related-samples Wilcoxon signed ranks test was used to test the primary and secondary hypotheses. An alpha level of .05 for a two-tailed test was used to assess the significance of findings. Statistical analysis was carried out using Predictive Analysis Software (PASW) version 18. Frequency counts were used to evaluate reported use of the different sections of the clinical protocols manual. Open-ended feedback responses about the utility of the clinical protocols were truncated into main points for summary purposes. Client Tracking Sheet data analysis methods are described in Chapter 8 (Glegg et al., n.d. to be submitted).

CHAPTER 8: Documenting Clinical VR Use in ABI Rehabilitation[3]

This chapter is a manuscript submitted for publication. As such, some of the information contained within it duplicates information presented in earlier chapters of this thesis.

8.1 Introduction

Virtual rehabilitation employs computer hardware and software to generate VEs in which clients use their own body movements to interact while working towards their treatment goals (Weiss et al., 2004). The technology's ability to give augmented feedback in a motivating medium that provides variety for rehabilitation across a range of ages and populations has been a driving force in its clinical adoption as an adjunct to conventional treatment approaches (Holden, 2005; Kim et al., 2009; Sveistrup, 2004; Weiss et al., 2009). VividGroup's GestureTek VR system by Xperiential Learning Systems is one such VR platform that is currently in use at several rehabilitation centres across Canada. While research supporting its use in ABI rehabilitation is relatively scarce, weak to strong quality evidence exits from smaller RCTs showing the system improves outcomes related to balance, mobility, upper extremity function, activities of daily living and unilateral spatial neglect in adult stroke populations, and for instrumental activities of daily living (IADLs) in adults following TBI (Glegg et al., n.d., submitted).

A number of challenges exist in ABI research, including limited use of control groups related to ethical issues associated with denying treatment (Whyte, 2009), the rate of and potential for spontaneous recovery during acute rehabilitation (Jaffe et al., 1995), which can bias results in favour of a treatment effect (Whyte, 2009), and small and often heterogeneous samples recruited primarily during the post-acute

[3] A version of this chapter will be submitted for publication.

rehabilitation phase (Bland et al., 2011; Marshall et al., 2009a). Limitations also exist in the availability or use of sensitive, valid and reliable outcome measures for the ABI population (Bland et al., 2011; Galvin et al., 2011; Sandlund et al., 2009). These shortcomings have contributed to the paucity of knowledge about the effectiveness of specific interventions, such as VR, during inpatient rehabilitation. Furthermore, the majority of ABI research focuses on the stroke population; consequently, little evidence exists for therapists treating the many other ABI clients who are equally deserving of evidence-based therapy.

Because of these difficulties, Marshall et al. (2007) support the idea that a particular intervention may still produce benefits for clients despite a lack of research evidence supporting its effectiveness. Given the emerging state of the evidence on VR, understanding the idiosyncrasies of and barriers to its clinical implementation in ABI rehabilitation at this early stage is crucial to informing clinically relevant research. This knowledge will help to ensure that study samples resemble real-world clinical populations, that the intervention programmes being evaluated are feasible in practice, and that outcomes are relevant to clients and therapists, thus increasing the likelihood of research utilisation by clinicians (Pentland et al., 2011). No research describes the manner in which therapists are currently using VR with which to inform the research process. The purpose of this study was thus to document current practice in virtual rehabilitation for an adult and paediatric inpatient ABI population in order to provide a point of reference for clinicians integrating this relatively new treatment approach into their practices, and to inform future research design to improve its clinical applicability.

8.2 Methods

8.2.1 Participants & Recruitment

Over an eight-month period, four occupational therapists, five physical therapists and two recreation therapists participating in a larger multi-site study examining factors influencing VR adoption (as described in Glegg et al., n.d., under review) identified clients over the age of five in their ABI rehabilitation practices for whom they would be providing VR-based therapy, and connected them with the study coordinators with permission from clients and/or families as appropriate. Recruitment was carried out at two rehabilitation centres providing interprofessional inpatient ABI rehabilitation services. As the only tertiary centre in the province, the paediatric centre provides rehabilitation services to all children in British Columbia and the Yukon referred with moderate to severe ABI. The adult centre also acts as a provincial referral centre, providing services for individuals with physical, cognitive, severe behavioural and/or psychiatric difficulties following ABI throughout the province of Ontario. Informed consent was obtained for all participating therapists and clients and/or families as appropriate, and the Research Ethics Board at each site approved the study. No clients dropped out of the study. This method of recruitment was meant to capture actual practice in ABI rehabilitation, in that therapists' decision-making with respect to identifying appropriate clients for VR-based therapy was maintained, and obtaining clients' permission participate reflected existing shared decision-making practices in terms of consent to treatment.

8.2.2 Measurement

A Client Tracking Sheet was developed and field tested with a sample of 15 occupational and physical therapists with experience in neurorehabilitation who were not involved in the larger study in order to establish face and content validity. Therapists involved in the current study then completed the form for each of their participating clients over a period of eight months. The information collected included client characteristics, such as physical and cognitive abilities and the nature and timing of the ABI, as well as details about the VR-based treatment programme, including treatment characteristics, rehabilitation goals and reasons for ending the programme. Glascow Coma Scale (GCS) ratings from the medical chart were collected as an index of brain injury severity to describe the sample. Ratings from the Rancho Los Amigos adult (eight-level) and paediatric (five-level) Levels of Cognitive Functioning scales were used to quantify clients' behavioural characteristics and cognitive deficits following ABI (Hagen, 1998; Sellars & Vegter, 1999). These latter scales are used to gather information related to orientation to person, place and time, the consistency of responses to external stimuli, and the nature of those responses (e.g. generalised versus localised) during the rehabilitation phase (RLA, 2011a). The degree of distractibility, delay in responses, ability to initiate tasks and level of support or structure required for participation in goal-directed activities are several of the aspects monitored by therapists than can have an impact on the client's ability to engage in the rehabilitation process (Hagen, 1998). In the rehabilitation setting, the adult scale was found to have an inter-rater reliability of .87 to .94, with a test-retest reliability of .82 (Gouvier, Blanton, LaPorte & Nepomuceno, 1987). The psychometric properties for the paediatric scale are not yet available.

8.2.3 Data Analysis

Descriptive statistics including frequency counts were tabulated for nominal data. Interval data was plotted to evaluate the normality of its distribution; accordingly, medians and interquartile ranges were selected to describe central tendencies. Content analysis of goal descriptions provided by therapists allowed for the categorisation of goals by rehabilitation outcome area in order to allow for comparisons of frequencies with those of the research literature.

8.3 Results

8.3.1 Sample Characteristics

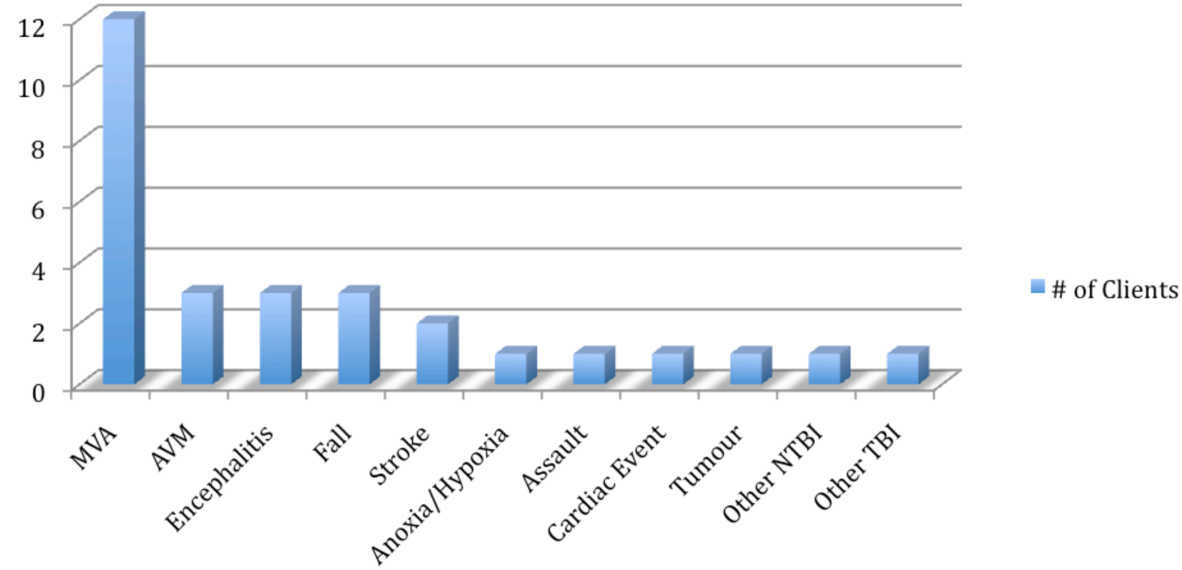
Characteristics of the sample of 29 individual clients, including functional status and time since injury and admission, are provided in Table 8.1. 41% had VR programmes developed by occupational therapists, 38% by physiotherapists and 21% by recreation therapists. Nine clients were seen for VR-based treatment by both occupational therapists and physiotherapists. For these latter cases, the timing of onset of VR-based treatment was calculated using dates provided by the therapist with the earlier onset of treatment. There were no incongruencies in the data for other client characteristics. Thirty-four percent of clients were paediatric; 38% had a GCS of eight or less, indicating a severe injury, and 14% had scores within the range of 13 to 15, indicating a mild injury (Centers for Disease Control and Prevention, 2009). Because of incomplete medical records, the severity of injury of the remaining 11 adult and three paediatric clients (48% of the sample) was unavailable. Figure 8.1 presents the number of clients recruited by mechanism of injury; 41% of clients had suffered a non-traumatic ABI, of which only 17% represented stroke. Rancho Los Amigos paediatric scale ratings ranged from one (oriented to time and place; recording ongoing events) to two (responsive to the environment), with a median and a mode of two, while adult ratings ranged from emerging level five (confused-inappropriate, non-agitated) to level eight (purposeful-appropriate), with a median of emerging level seven (automatic, appropriate), and a bimodal distribution with modes at emerging level seven and emerging level eight. Note that for the adult scale, higher scores represent higher levels of functioning, whereas the reverse is true for the paediatric scale.

Table 8.1: Client Characteristics at Onset of VR Treatment

Demographic	Median	Range	Interquartile Range	% of Clients				
Right upper extremity function				86.2 Independent	6.9 Support required	6.9 Unable		
Left upper extremity function				85.7 Independent	7.1 Support required	7.1 Unable		
Support needed for sitting				76.0 Independent (dynamic)	4.0 Independent (static)	12.0 At pelvis	4.0 From trunk down	4.0 From head down
Transferring ability				62.1 Independent	13.8 Standby assist	10.3 One-person assist	13.8 Total support	
Ambulation status				48.3 Independent	3.4 Standby assist	10.3 One-person assist	13.8 Walking aide	24.1 Unable
Weeks since injury	24.0 132.0* 8.0**	1779.0 1775.0* 37.0**	168.0 379.0* 8.0**	100.0				
Weeks since admission	5.0	18.0	5.0	100.0				

*Adult subjects only
**Paediatric subjects only

Figure 8.1: Client Mechanisms of Injury



Abbreviations: MVA=Motor vehicle accident; AVM=atriovenous malformation; NTBI=non-traumatic brain injury; TBI=traumatic brain injury

8.3.2 Treatment Programme Characteristics

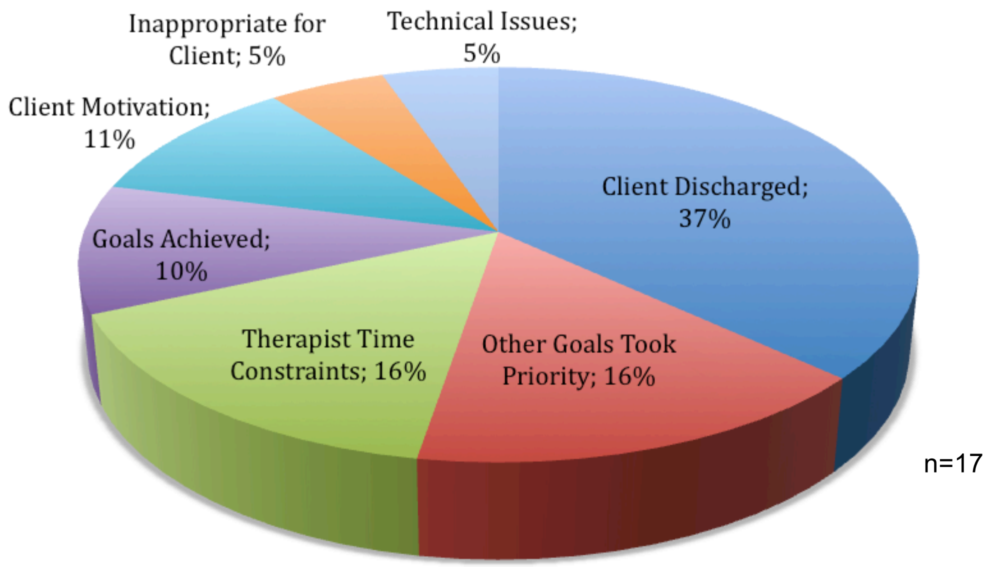
Information about treatment frequency, intensity and duration used by each therapist and the position used by the client during treatment is provided in Table 8.2. Of more than 30 games available in the Gesture Xtreme games suite, therapists reported incorporating between one and seven into client programmes at the onset of treatment, with the average being three. Of the 18 games used at programme onset, the most frequently used ones included Soccer (67% of programmes), Sharkbait (39%), Orbosity (36%), Drums (36%) and Snowboarding (33%). The proportion of clients discharged from VR-based treatment by reason, as reported by the therapist, is shown in Figure 8.2. Results concerning discharge from VR are limited to those for clients who had completed their VR programmes prior to the end of the study period (59%), and were based on the frequency of multiple-choice answer selection by therapists (see Appendix B for answer options).

Table 8.2: VR Treatment Programme Characteristics

Demographic	Median	Range	Interquartile Range	% of Clients			
Position used for treatment				51.7 Standing independently	13.8 Standing with support	3.4 Sitting on chair/bench	31.0 Sitting in wheelchair
Programme duration (weeks)	2.0 5.0* 0.5**	24.0 23.0* 5.0**	9.5 10.00* 3.5**	100.0			
Treatment frequency (# sessions per week)	2.3 2.5* 1.0**	5.0 5.0* 0.5**	1.9 1.1* 0.00**	96.6 94.7* 100.0**			
Treatment intensity (# minutes per session)	18.8 17.5* 27.5**	35.0 15.0* 35.0**	11.3 6.9* 16.3**	89.7 84.2* 100.0**			

*Adult subjects only
**Paediatric subjects only

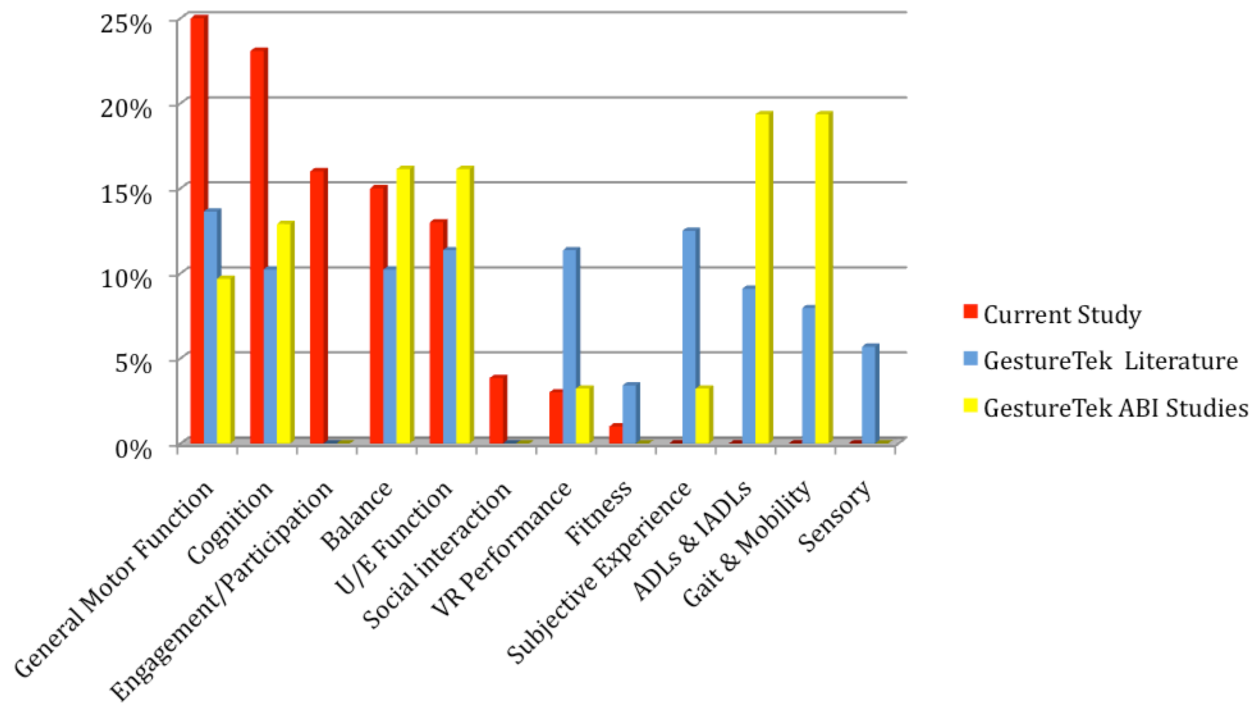
Figure 8.2: Reasons for Discontinuing VR Programme



8.3.3. Goal Areas

Therapists recorded a total of 95 VR-specific goals for their clients during the study period; only five clients had a second round of goals initiated following attainment of their first set. Figure 8.3 illustrates the frequency of goal setting by goal area during this study, as compared to outcomes evaluated in both the GestureTek rehabilitation literature and ABI-specific GestureTek research. Of the general motor goals, outcomes of primary interest were endurance (38%), motor planning/coordination and response time (19% each). Range of motion (38%), increased use of the upper extremity (38%) and reaching/targeting (23%) were priority areas for the upper body. Cognitive goals focused mainly on attention (54%) and visuospatial neglect (21%). Both sitting and standing balance were included in balance goals. Novel goal areas identified during this study, which are not represented in the GestureTek research literature, included engagement in meaningful activities (which was the most frequently reported goal area), increased social interaction with peers or family, initiating cause-and-effect activities, demonstrating new learning, following directions, and participating in choice-making.

Figure 8.3: Proportion of Outcomes Evaluated by Clinicians Versus Researchers (By Outcome Category)



8.4 Discussion

8.4.1 Sample Characteristics

In keeping with Canadian health statistics, the largest proportion of clients in the sample had sustained their injuries during a motor vehicle accident (CIHI, 2007). Surprisingly, only 2 clients were admitted following stroke. The range in Rancho Los Amigos scale ratings of participating clients suggest that the VR system may be suitable for an inpatient ABI population at different stages of recovery. Characteristics, such as the degree of motor ability required to participate, the level motor challenge provided, the degree to which therapists have control over software parameters, including the number and speed of stimuli and game duration, and the ability to grade the level of physical challenge independent of cognitive requirements (Galvin & Levac, 2011; Weiss et al., 2004), lend support to this idea. Even so, a number of therapists reported that some of their clients were inappropriate for VR-based treatment (see Chapter 9 and 10, related to barriers to VR use), citing behaviours, such as agitation, or cognitive factors, such as an inability to comprehend the VE or to make cause and effect associations. Hence, a descriptive measure of LOC or other cognitive and behavioural characteristics may prove useful in describing research samples used in outcome studies so as to inform clinicians about the generalisability of the results and the applicability of the intervention to their clinical populations. Of the available high-level evidence on ABI for this VR system, only two studies identified a measure used to screen cognitive status (Jacoby et al., 2011; Kim, Chun, Yun, Song & Young, 2011).

While severity of injury appeared to be high for this sample, data on more than half of the clients for this demographic was missing from the acute care medical chart; therefore, it is not possible to ascertain the true nature of the sample's injury severity without more accurate documentation during this phase of the hospital admission. Nonetheless, therapists made VR accessible for clients with a range of mobility impairments, including those dependent on wheelchairs. Although the vast majority of clients were independent with sitting and with the use of their upper extremities, a range of skills and abilities was represented in the sample, suggesting that the GestureTek system may be perceived as a useful rehabilitation tool for clients across this functional spectrum. Accordingly, therapy was provided in a range of functional positions including supported sitting and standing; this ability to vary the position of the client may be a valuable feature of VR for this rehabilitation context.

For therapists involved in the current study, a disproportionate amount of research focused on the adult stroke population limits the availability of clinically relevant evidence on which to base their treatment decisions. In addition, specific functional abilities that these therapists addressed in clinical practice with the system, such as unilateral spatial neglect, limited dynamic balance in sitting, and poor mobility skills, have often been stated as exclusion criteria by researchers (Jacoby et al., 2011; Jang et al., 2005; Kim et al., 2009; Kim et al., 2011), further limiting the external validity of their findings to these clinical settings. As described earlier, little research evidence exists to inform therapists using VR in ABI rehabilitation in general, and given the current findings, even less examines the types of ABI clients with whom these therapists are actually working. In order to make VR research more clinically relevant, recruitment strategies should engage both adult and paediatric populations, include severe injuries of both traumatic and non-traumatic mechanisms with a range of functional sequellae, and extend beyond the diagnostic category of stroke.

8.4.2 Treatment Characteristics

While little guidance exists in the GestureTek literature with respect to establishing optimal treatment durations, frequencies or intensities, available research appears to favour programmes of shorter duration (one to five weeks) but of moderate to high intensity (two to five sessions per week) (Glegg et al., n.d., submitted). Both the median programme duration and frequency of intervention obtained during this study were congruent with medians from research protocols in the GestureTek literature (Glegg et al., n.d., submitted). In the context of the present study, given a mean length of stay of ten weeks at the paediatric centre and 16 weeks at the adult centre, and the trend towards beginning VR-based treatment at approximately five weeks post-admission, shorter programme durations may more feasible in this clinical context, although the range in both characteristics suggests that variability may be possible. However, the documented time constraints of therapists, staffing issues, competing treatments and multiple goals being addressed during the inpatient rehabilitation phase may be influential in limiting practical treatment frequencies, particularly in the absence of support from rehabilitation therapists to whom various aspects of treatment can be delegated (Glegg et al., n.d., submitted). Furthermore, important ABI client factors, such as endurance or tolerance to treatment, motivation to participate and impaired physical or cognitive abilities (Bayley et al., 2007; Dumas & Carey, 2002; McCormick et al., 2009), may also play a role in therapists' decisions regarding treatment intensity at this stage of recovery, which may not be accounted for in research with different populations or at different recovery phases. These factors may explain the relatively low median intensities used by these therapists in comparison to a median and mode of 60 minutes documented in other research protocols in the GestureTek literature (Glegg et al., n.d., submitted). Consequently, research needs to be designed to study what is currently being done in practice, and to generate more evidence about optimal treatment characteristics by which clinicians can inform their practice for this population during the inpatient rehabilitation phase. Information about the timing of VR-based treatment onset can also be applied in the recruitment of clinically relevant populations in order to increase the external validity of research findings for clinicians.

Therapists' reasons for ending VR-based treatment programmes were in keeping with many of the documented barriers to VR use in this context, including lack of time, competing goals, poor client motivation, technical issues and the lack of appropriateness of the treatment to meet the client's needs (Glegg et al., n.d., submitted). While more than a third of clients were still working on VR-based treatment goals at the time of discharge, more than half had their programmes discontinued in favour of other treatments in response to these barriers. Virtual rehabilitation in this clinical context may represent a selectively used treatment approach to address particular outcomes targeted at specific times during the inpatient rehabilitation stay. Further research to explore the reasons underlying the timing of VR-based treatment initiation would provide more insight into its clinical use with this population.

8.4.3 Goal Areas

Common themes emerged within the wide range of goals documented by therapists; this information may be useful for therapists integrating VR into practice by allowing them to compare their decision-making about goal selection against those of other therapists, to explore additional goal areas being used by others as potential rehabilitation applications for VR, and to efficiently access a range of general and specific goal suggestions within a particular outcome area. Although data about the specific outcome measures used by therapists was not collected during this study, the grouping of the available data by goal area has allowed an approximation of current practices to compare with the frequency of study of particular outcomes within the GestureTek literature. Seemingly, therapists' primary uses of the technology were fairly congruent with the outcomes examined by researchers, although the evaluation of the transfer of VR-based training to activity and participation-level outcomes, such as ADLs, does not appear to have been embraced by therapists in the current study. In addition, several additional goal areas were identified here that have not been cultivated by researchers to date. These insights have exposed a new array of potential research questions that have yet to be examined in a systematic way. Although there exists a lack of commonality in the outcome measures used in the GestureTek rehabilitation literature (Glegg et al., n.d., submitted), given the current state of the evidence for this intervention approach, clinicians may wish explore this body of knowledge to assist them in identifying valid and reliable outcome measures to monitor client progress in relation to their clients' rehabilitation goals.

8.4.4 Limitations & Future Directions

This study was conducted at two rehabilitation centres over an eight-month period. A larger client sample and recruitment base would increase the generalisability of findings, and allow for more in-depth analyses of the differences between paediatric and adult rehabilitation settings, as well as acute versus post-acute rehabilitation applications for VR. Furthermore, a more detailed descriptive measure would have provided additional information about the frequency of use of specific games within the VR system over the course of VR programmes, which would allow researchers to target the full range of utilised games in their research interventions. Finally, client outcomes as the result of VR-based treatment were not monitored in the current study; as such, no information is available about the effectiveness of the treatment approaches taken by therapists participating in the study. As a result, clinicians should be cautious in inferring the appropriateness of the programme characteristics presented here.

Future directions for research and for facilitating implementation include the application of Goal Attainment Scale methodology (Joyce, Rockwood & Mate-Kole, 1994) to refine the VR goals identified by therapists into a collection of structured outcome measurement tools. Access to this resource has the capacity to improve the efficiency, sensitivity and reliability with which therapists develop VR programmes and evaluate client progress (Hurn, Kneebone & Cropley, 2006; Joyce et al., 1994; Steenbeek, Ketelaar, Galama & Gorter, 2007). In addition, collaboration is underway to design clinically relevant outcomes research using the GestureTek VR system for inpatient ABI rehabilitation. As described earlier, research recommendations include evaluating relevant client outcomes using intervention characteristics that are both feasible and congruent with typical practice in these settings, and providing more specific guidance to therapists about the characteristics of effective client programmes to promote optimal outcomes.

8.5 Conclusions

This study is the first to document the manner in which VR is currently being used for inpatient ABI rehabilitation. This data provides preliminary information for researchers designing studies to explore the impact of VR-based rehabilitation specific to these use habits and types of clients. Further research with a broader sample can explore the generalisability of the current findings. By recruiting clinically relevant samples and matching interventions and outcomes of interest to those that are important to practising therapists, the clinical relevance of the developing knowledge base in the field of VR will provide clinicians with access to readily applicable evidence by which to inform their decision-making.

CHAPTER 9: Factors Influencing Therapists' Adoption of VR for ABI Rehabilitation[4]

This chapter is a manuscript submitted for publication. As such, some of the information contained within it duplicates information presented in earlier chapters of this thesis.

9.1 Introduction

VR is a computer hardware and software system that generates simulations of real or imagined environments with which participants interact using their own movements (Weiss et al., 2004). The GestureTek VR system by Xperiential Learning Systems (www.gesturetek.com) employs video-capture technology to generate an image of the participant that is projected onto a viewing screen such that it appears within a simulated or 'virtual' environment (Sveistrup, 2004). Several advantages of the GestureTek system include (a) the provision of real-time feedback about motor performance to participants as they see themselves moving within the VE; (b) the ability to focus on whole body or isolated movements while controlling the quality of movement; (c) the flexibility of the system in terms of the positions in which patients can participate as well as the range of therapist-modifiable software parameters available; and (d) the lack of need for peripheral devices, such as HMDs (Galvin & Levac, 2011; Sveistrup et al., 2004; Weiss et al., 2004).

VR has been praised for its potential as a rehabilitation tool because of its ability to provide augmented feedback during repetitive practice opportunities within a controlled but motivating environment, which can enhance the efficiency of motor learning (Holden, 2005) as well as patient compliance with therapy (Thornton et al., 2005). Fatigue, and lack of interest and motivation can affect engagement in ABI

[4] A version of this chapter has been submitted for publication

rehabilitation (Johnson et al., 1998). To counteract these factors, VR can be used as an adjunct to traditional therapy approaches to increase variety in a treatment programme, and to enhance motivation (Kim et al., 2009; Sveistrup, 2004; Weiss et al., 2009). Furthermore, therapists often have the ability to grade the level of challenge presented within VR activities for their patients by modifying the characteristics of the VE, thus enabling gradual increases in difficulty while promoting safe and successful participation (Galvin & Levac, 2011; Sveistrup, 2004; Weiss et al., 2004). This flexibility may be especially important after brain injury, as physical, cognitive and behavioural impairments may all contribute to a patient's ability to engage in the rehabilitation process (Bayley et al., 2007). As research supporting the benefits of VR for ABI rehabilitation continues to emerge (e.g. Bart et al., 2010; Jang et al., 2005; Kim et al., 2009; Kim et al., 2011; Rand, Katz & Weiss, 2007; Thornton et al., 2005; You et al., 2005a), a number of health centres have purchased the technology for clinical use; therapists are being asked more frequently to incorporate this new intervention approach into practice.

Theory can provide a framework for examining the factors influencing the adoption of VR by therapists. Scientific progress relies upon the development, testing and reworking of theories to yield objective explanations and accurate predictions of observable phenomena (Siegert et al., 2005; Whyte, 2007). The DTPB (Taylor & Todd, 1995a) formed the theoretical basis for this research. The DTPB is an extension of the Theory of Planned Behaviour (TPB), which aims to predict an individual's future behaviour based on his or her intention to carry out that behaviour (Ajzen, 1991). The theory also aims to explain the behaviour based on the individual's beliefs about various factors or determinants influencing his or her intentions (Ajzen, 1991). According to the

TPB, the three primary determinants of behavioural intention are attitude, social (or subjective) norms and perceived behavioural control (PBC) (Ajzen, 1991).

Extensions of the TPB by various researchers have "decomposed" the three primary constructs into additional sub-constructs purported to act as further determinants of behaviour, with the goal of providing a richer understanding of behaviour (Chau & Hu, 2001; Hsu & Chiu, 2004; Jackson et al., 2003; Lin, 2006; Taylor & Todd, 1995a). For example, perceived usefulness and perceived ease of use of the technology, which are the primary determinants of technology use according to the TAM, (Davis, 1989), have been incorporated into the DTPB as sub-constructs of attitude because of their established inter-relationships within the context of technology adoption (Chau & Hu, 2001; Lin, 2006; Shiue, 2007). Compatibility, a construct from the Diffusion of Innovations Theory (Rogers, 1983), has been integrated into the expanded theory as well (Taylor & Todd, 1995a). The social norms construct has been separated to reflect the relative influence of peers and superiors on behaviour in the workplace (Taylor & Todd, 1995a; Shiue, 2007). Previous researchers have deconstructed PBC by dividing internal factors, such as self efficacy (Bandura, 1977), and external factors, such as facilitating conditions and barriers (Taylor & Todd, 1995a), into separate categories. The DTPB distinguishes a greater range of determinants of behaviour than any one of these models alone, thereby allowing more specific targeting of strategies to influence behaviour change (Mathieson, 1991; Taylor & Todd, 1995a). For this reason, many researchers have found the DTPB to be more useful than its founding theories for explaining or predicting the use of technologies by individuals (Choudrie & Dwivedi, 2006; Lin, 2006; Taylor & Todd, 1995a; Zhang & Gutierrez, 2007).

VR implementation research is at an early stage. Clinicians are direct mediators of their patients' access to VR; hence, the factors influencing therapists' intentions to use the technology are paramount to the implementation process. Eight studies have explored the VR adoption from the perspective of clinicians to some degree (Annema et al., 2010; Bertrand & Bouchard, 2008; Di Loreto et al., 2011; Hanif, Niaz & Khan, 2011; Kramer et al., 2010; Lotan et al., 2011; Markus et al., 2009; Thornton et al., n.d., as cited in Weiss et al., 2009). However, only three of these research groups described a theoretical framework informing its design, data collection or analysis methodologies (Bertrand & Bouchard, 2008; Di Loreto et al., 2011; Hanif et al., 2011). Accordingly, the use of the TAM in two instances and Shackel's Usability framework in the other, limited results to aspects of the technology while overlooking social, personal and external factors of potential importance that would have been better evaluated within the context of the DTPB (Mathieson, 1991). Nevertheless, Bertrand & Bouchard's (2008) and Hanif et al.'s (2011) studies were the only ones to examine the relationship between perceived barriers or facilitators and behavioural intention, a link critical for developing effective interventions that have the potential to influence VR use. Furthermore, only one published and one unpublished study surveyed occupational and physical therapists (Di Loreto et al., 2011; Thornton et al., n.d., as cited in Weiss et al., 2009), which leaves the generalisability of the other studies' findings to this particular population in question. Of significance is that the majority of these studies employed qualitative methods, which aim to seek depth of meaning and understanding of an issue from the perspective of those experiencing the issue (Portney & Watkins, 2000). Once this insight has been gained, the use of quantitative methods can provide a means of empirically testing the relationships amongst theoretical constructs, as well as the precise measurement of specific variables allowing for comparisons between groups or points in time (Portney & Watkins, 2000).

While the DTPB has yet to be used to explain and predict specific health care professionals' use of VR, a review of the literature has revealed that each of the DTPB constructs has been represented in the findings of at least one of these aforementioned studies. Facilitating conditions and barriers appear to be the most commonly discussed construct, while less frequent but recurring factors in the literature included the need for training and experience to enhance self efficacy and perceived ease of use, and the call for technical support and the design of the technology to enhance perceived ease of use. Social norms have been the least researched construct in this context. Operational definitions for each of the 11 DTPB constructs employed in this research were provided in Table 3.1.

While these previous studies identified some specific barriers and facilitators to VR implementation, the extent to which these factors apply to occupational and physical therapists as well as other therapists facilitating rehabilitation has not been adequately tested. The small convenience samples recruited from single health centres in the majority of these studies may limit the external validity of the results (Kramer et al., 2010). The use of theory to structure the data collection process can ensure that each identified factor is examined systematically in order to determine its relative importance to therapists. Likewise, an understanding of the extent to which these factors influence the intention to use VR by therapists who differ in their experience levels or other important demographic characteristics is essential for the cost-effective planning of barrier-reducing interventions for different clinical contexts. The DTPB may have predictive value in facilitating the process of VR implementation. Moreover, additional empirical research can provide further validation of the DTPB as applied to VR adoption by occupational, physical, recreation and rehabilitation therapists, as well as explain the context-specific relationships amongst the theory's constructs in the ABI rehabilitation setting. Furthermore, each study explored a different VR system; as a result, the generalisability of findings may be limited. For instance, the primary barrier to VR implementation identified in the study by Markus et al. (2009) was the time required for set-up and equipment cleaning between patients. In contrast, with the video capture-based GestureTek system, cleaning time between patients is negligible because of the lack of need for peripheral devices, such as HMDs or force feedback gloves.

Overall, research exploring factors influencing the implementation of the GestureTek VR system by therapists in ABI rehabilitation settings has yet to be conducted. Therefore, the purpose of this study was threefold: (1) to develop and to establish the face and content validity of a DTPB-based tool to measure the theoretical determinants of GestureTek VR adoption, (2) to use this tool to examine the relative importance of and extent to which these factors were associated with therapists' intentions to use the VR system for ABI rehabilitation, and (3) to identify specific perceived barriers and facilitators to VR use from the perspective of occupational, physical, recreation and rehabilitation therapists. Because of the potential risk of type I error associated with multiple-hypothesis testing, given the sample size, hypotheses were generated only for the single most pertinent variable and relationship of interest. We hypothesised that (1) therapists would have positive attitudes toward the GestureTek VR technology as a treatment tool, in keeping with the literature on attitudes toward technology adoption in health care by other professionals, and (2) perceived ease of use of the technology would be the most highly correlated variable to behavioural intention. This latter hypothesis was generated because perceived ease of use appears to be related to many of the cited barriers to VR use as reported in the literature, which, if addressed, could have strong potential for influencing therapists' intentions to use the technology in practice.

9.2 Part 1: Development of the ADOPT-VR Survey: Face, Content Validity

9.2.1 Materials

The outcome measure used was a self-report survey developed specifically for this study, called the ADOPT-VR survey. The underlying model upon which the scale was developed was the DTPB (Taylor & Todd, 1995a). The measure was developed in accordance with the guidelines presented by Ajzen and Fishbein (1980) and Ajzen (1991), employing a process that paralleled that used by Todd & Taylor (1995a). The survey was customised for use with therapists with access to the GestureTek VR system. To structure the survey, a starting pool of 79 items was selected or adapted from existing DTPB measures in the literature, as per recommendations by Ajzen and Fishbein (1980). Specifically, survey items were customised for therapists, with the behaviour of interest being the clinical use of the GestureTek VR system with clients with ABI. Additional questions requesting demographic information and information about experience levels from study participants were added. The items were intended to measure each of the DTPB constructs (with the exception of actual use) using a nine-interval scale with anchors on strongly agree (9) and strongly disagree (1). Seven to ten point rating scales produce the most reliable scores with the highest interclass correlations, and are also preferred by respondents because of their ease of use, quickness to complete and improved ability to express respondents' feelings (Preston & Colman, 2000). A nine-point scale was chosen for its superior discriminating power (Preston & Colman, 2000). By providing anchors only on the extremes of the scale, respondents are better able to select the position on the scale that best fits their feelings without being influenced by the interpretation provided by scale descriptions supplied for each point on the scale (Wildt & Mazis, 1978).

9.2.2 Methods

Face and content validity of the measure were established through field testing with a convenience sample of 15 therapists recruited from Children's & Women's Health Centre of British Columbia. Subject inclusion criteria included being an occupational or physical therapist, and having experience in neurorehabilitation. These criteria were chosen in order to obtain subjects who would closely resemble the subjects to be recruited in the follow-up study that would be using the measures being refined during this phase. Subjects were excluded if they were working in clinical areas in which the GestureTek VR system was currently in use, in order to preserve the small population from which to draw subjects for the follow-up study. Informed consent and Research Ethics Board approval were obtained before field testing began. The first activity administered to subjects during field testing was a card-sorting task intended to improve the content validity of the original 79-item ADOPT-VR outcome measure, which required subjects to match each DTPB outcome measure item with its theoretical construct definition as presented in Table 3.1. An acceptability cut-off of 0.65 or greater for level of agreement (Moore & Bensabat, 1991) was used to refine the original 79-item measure; this process resulted in the removal of 39 of the 60 DTPB items because of poor agreement across therapists. Three items meeting a 0.60 level of agreement and two items falling below this cut-off were modified according to structured feedback responses from subjects to improve clarity. These items were retained in order to ensure representation of all constructs on the final survey by at least two items each, as well as to include questions concerning the primary barriers to VR implementation as described in the literature. Table 9.1 reports the agreement level across items.

Table 9.1: Level of Agreement for the Initial ADOPT-VR Items

Item	DTPB Construct	% Agreement	Retained	Wording Modified	Reason for Retaining/ Discarding	Construct & Final ADOPT-VR Item #
1	A	80	Yes	No	High % Agreement	A – 1
2	A	87	Yes	No	High % Agreement	A – 2
3	A	93	Yes	No	High % Agreement	A – 3
4	PU	60	No	N/A	Poor % Agreement	
5	PU	13	No	N/A	Poor % Agreement	
6	PU	47	No	N/A	Poor % Agreement	
7	PU	47	No	N/A	Poor % Agreement	
8	PU	27	No	N/A	Poor % Agreement	
9	PU	33	No	N/A	Poor % Agreement	
10	PU	93	Yes	No	High % Agreement	PU – 4
11	PU	73	Yes	Yes	High % Agreement	PU – 5
12	PU	27	No	N/A	Poor % Agreement	
13	PU	80	Yes	Yes	High % Agreement	PU – 6
14	PU	73	No	N/A	Duplication	
15	PU	27	No	N/A	Poor % Agreement	
16	PEOU	60	No	N/A	Poor % Agreement	
17	PEOU	100	Yes	Yes	High % Agreement	PEOU – 7
18	PEOU	53	No	N/A	Poor % Agreement	
19	PEOU	73	Yes	No	High % Agreement	PEOU – 8
20	PEOU	33	No	N/A	Poor % Agreement	
21	PEOU	73	Yes	No	High % Agreement	PEOU – 9
22	CO	87	Yes	No	High % Agreement	CO – 10
23	CO	87	Yes	No	High % Agreement	CO – 11
24	CO	53	No	N/A	Poor % Agreement	
25	E	80	Yes	Yes	High % Agreement	E – 13
26	E	40	Yes	Yes	Important demographic information	E – 12
27	E	40	No	N/A	Poor % Agreement	
28	E	N/A	No	N/A	Unclear to respondents	
29	E	40	No	N/A	Poor % Agreement	
30	E	N/A	No	N/A	Unclear to respondents	
31	E	40	No	N/A	Poor % Agreement	
32	E	67	Yes	Yes	High % Agreement	E – 14

Item	DTPB Construct	% Agreement	Retained	Wording Modified	Reason for Retaining/ Discarding	Construct & Final ADOPT-VR Item #
33	E	60	Yes	No	Important demographic information	E – 15
34	SN	60	No	N/A	Poor % Agreement	
35	SN	73	Yes	No	High % Agreement	SN – 16
36	PI	93	Yes	Yes	High % Agreement	PI – 17
37	PI	80	Yes	No	High % Agreement	PI – 18
38	SI	93	Yes	Yes	High % Agreement	SI – 19
39	SI	100	Yes	No	High % Agreement	SI – 20
40	SI	100	No	N/A	Duplication	
41	PBC	20	No	N/A	Poor % Agreement	
42	PBC	60	Yes	Yes	To retain 2 items per construct	PBC – 22
43	PBC	7	No	N/A	Poor % Agreement	
44	PBC	60	Yes	Yes	To retain 2 items per construct	PBC – 21
45	PBC	27	No	N/A	Poor % Agreement	
46	SE	27	No	N/A	Poor % Agreement	
47	SE	33	No	N/A	Poor % Agreement	
48	SE	73	Yes	No	High % Agreement	SE – 23
49	SE	33	No	N/A	Poor % Agreement	
50	SE	40	No	N/A	Poor % Agreement	
51	SE	20	No	N/A	Poor % Agreement	
52	SE	40	No	N/A	Poor % Agreement	
53	SE	33	No	N/A	Poor % Agreement	
54	SE	33	No	N/A	Poor % Agreement	
55	SE	27	No	N/A	Poor % Agreement	
56	SE	7	No	N/A	Poor % Agreement	
57	SE	20	No	N/A	Poor % Agreement	
58	SE	13	No	N/A	Poor % Agreement	
59	SE	27	No	N/A	Poor % Agreement	
60	SE	13	No	N/A	Poor % Agreement	
61	FCB	60	No	N/A	Poor % Agreement	
62	FCB	33	Yes	Yes	To reflect barriers to VR implementation from the literature	FCB – 25
63	FCB	53	No	N/A	Poor % Agreement	
64	FCB	60	No	N/A	Poor % Agreement	

Item	DTPB Construct	% Agreement	Retained	Wording Modified	Reason for Retaining/ Discarding	Construct & Final ADOPT-VR Item #
65	FCB	67	Yes	No	High % Agreement	FCB – 26
66	FCB	47	No	N/A	Poor % Agreement	
67	FCB	53	No	N/A	Poor % Agreement	
68	BI	93	Yes	No	High % Agreement	BI – 30
69	BI	40	No	N/A	Poor % Agreement	
70	BI	73	Yes	No	High % Agreement	BI – 31
71	BI	87	Yes	No	High % Agreement	BI – 32
72	Demographic	N/A	Yes	No	No negative feedback	Demographic
73	Demographic	N/A	Yes	Yes	To more accurately reflect the population	Demographic
74	Demographic	N/A	Yes	No	No negative feedback	Demographic
75	Demographic	N/A	Yes	Yes	To allow open-ended responses for improved precision	Demographic
76	Demographic	N/A	No	N/A	To decrease the length of the survey	
77	Demographic	N/A	Yes	Yes	To allow open-ended responses for improved precision	Demographic
78	Demographic	N/A	Yes	Yes	To allow open-ended responses for improved precision	Demographic
79	Demographic	N/A	Yes	Yes	To allow open-ended responses for improved precision	Demographic

Abbreviations: A = attitude; PU = perceived usefulness; PEOU = perceived ease of use; CO = compatibility; E = experience; SN = social norms; PI = peer influence; SI = superior influence; PBC = perceived behavioural control; SE = self efficacy; FCB = facilitating conditions & barriers; BI = behavioural intention

The second field testing task required of subjects involved obtaining structured feedback from subjects about the ADOPT-VR survey. This feedback was used to improve the measure's content validity, face validity and sensibility for use in the follow-up study. An open-ended questionnaire comprised of five questions helped to structure subjects' feedback regarding the clarity of wording, the relevance of content, any perceived content gaps, duplication of questions and general feedback.

Structured feedback from respondents resulted in small refinements to the wording of a few items and in the re-ordering of questions to improve clarity, as well as in the removal of two DTPB items because of perceived duplication by respondents. Demographic questions requesting information about experience levels and caseload characteristics were modified from forced-choice to open-ended format, and three items were removed from this section in order to decrease the length of the survey based on feedback. Five additional questions were added to the ADOPT-VR survey based on subject feedback; these items requested brief open-ended responses of respondents following relevant forced-choice questions, in order to obtain more specific information about therapists' personal experiences in using VR in practice and to allow for inclusion of items relating to the common barriers and facilitators to VR implementation as described in the literature. The final version of the ADOPT-VR consisted of 40 questions measuring the ten DTPB constructs and took 10-15 minutes to complete. Construct validity and internal consistency have been found to be high in similar DTPB-based measures specific to health care and technology adoption, from which the ADOPT-VR items were drawn; alpha coefficients for each construct in these measures ranged from 0.61 to 0.97, and factor loadings ranged from 0.65 to 0.99; only the occasional construct fell below the acceptability cut-off of 0.7 (Feng & Wu, 2005; Hsu & Chiu, 2004; Lin, 2006; Shiue, 2007; Taylor & Todd, 1995). Internal consistency of the ADOPT-VR scale was found to be 0.876 using Cronbach's alpha; values are presented for each construct in Table 9.2. Further details on the scale's psychometrics will be examined in a subsequent publication but have not been explored as part of this thesis.

Table 9.2: Construct Reliability for the DTBP Composites

Construct	Cronbach's Alpha
Attitude	0.939
Perceived Usefulness	0.927
Perceived Ease of Use	0.868
Compatibility	0.903
Social Norms	0.869
Peer Influence	0.641
Superior Influence	0.824
Perceived Behavioural Control	0.772
Self Efficacy	0.713
Facilitating Conditions & Barriers	0.831
Behavioural Intention	0.923

9.3 Part 2: Examining Factors Influencing VR Adoption

9.3.1 Participants

Purposive sampling was used to recruit therapists at two Canadian rehabilitation centres. Inclusion criteria for site selection included the presence of an ABI rehabilitation programme staffing occupational, physical and/or rehabilitation therapists, and access to the GestureTek VR system. Participating sites were also required to provide a study coordinator to execute the study protocol including managing the ethics application and data collection processes. Research Ethics Board approval was obtained at each site.

For inclusion, subjects were required to be occupational, physical, recreation or rehabilitation therapists who provided rehabilitation to clients with ABI, and to have access to the GestureTek VR system for clinical use. Because of differing terminology across provinces, the rehabilitation therapists are also referred to as rehabilitation assistants, or occupational therapy, physical therapy or rehabilitation aides. For simplicity, the term rehabilitation therapist will be used here. Those therapists not participating in the larger research study were excluded. Therapists were provided with an overview of the research study at a departmental meeting by the study coordinator at their respective site. Forty-two therapists were recruited from a total population of 47 eligible therapists (89%).

9.3.2 Methods

This study was part of a larger ongoing study exploring the impact of KT interventions on therapists' attitudes toward VR. A single group pretest-posttest design was used to examine changes in factors influencing therapists' adoption of VR. The ADOPT-VR survey was used to identify perceived barriers to and facilitators of VR use. Results presented here include the pretest findings collected in 2011 as a baseline measure before the interventions were implemented during the larger study. These initial findings are important as they provide insight into therapists' perceived barriers to VR adoption prior to a structured implementation process, which can inform the development of targeted interventions and supports for therapists prior to VR implementation at other health care centres.

Following informed consent, therapists completed the ADOPT-VR survey in a quiet office; data was compiled and analysed using Predictive Analysis Software (PASW) version 18. All interval data was plotted to determine normality of the distributions. DTPB items were converted into composite scores by aggregating item data according to its corresponding construct. Mean scores and standard deviations were calculated for all normally distributed interval data and medians, ranges and standard deviations were calculated for non-normally distributed interval data. These measures of central tendency were calculated in order to identify an average or representative score for the sample on each construct at baseline, and to allow for the exploration of relationships between constructs. Descriptive statistics including frequency counts were tabulated for nominal data. Pearson correlations were obtained for the DTPB composite scores as the majority of these yielded normal distributions, and when compared to Spearman correlations the difference was minimal for only two composites.

9.4 Results

Demographic information describing the sample is shown in Table 9.3. The proportions of female therapists and of therapists working in adult rehabilitation were both 78.6%. Twelve therapists had used the VR system clinically before participating in the study, reporting familiarity with two (median) of the 30 games offered by the system. Only five therapists had had the opportunity to explore the system during work hours outside of treatment sessions.

Table 9.3: Therapist Demographics (n=42)

Demographic	Mean	Median	Range	Standard Deviation	% of Therapists				
Profession					64.3 RT	16.7 PT	14.3 OT	4.8 Rec	
Education					45.2 B	35.7 Dip	11.9 MClin	4.8 MRes	2.4 Other
Years clinical experience	10.86		23.00	6.38	100				
Years ABI experience		8.5	31.83	6.68	100				
Annual ABI caseload (# patients)		14	93.00	21.91	100				
Months using VR		0.00 *1.00	42.00 *0.00	10.03 *0.00	*28.57				
Familiarity with VR (# of games) (n=12)		0.00 *2.00	30.00 *4.50	5.21 *1.38	*28.57				
Hours explored VR during work (n=5)		0.00 **30.00	5.00 **41.90	1.16 **16.17	**11.9 0				
Mentored others in VR use					11.9				

*= values calculated for responses >0 (n=12)
** = values calculated for responses >0 (n=5)
RT = Rehabilitation Therapist; PT = Physiotherapist; OT = Occupational Therapist; Rec = Recreation Therapist; B = Bachelor Degree; Dip = Diploma; MClin = Clinical Entry-Level Master’s; MRes = Research Master’s; Other = Master of Business Administration; Medical Doctor; ABI = Acquired brain injury; VR = Virtual reality

Composite mean or median scores as appropriate, as well as ranges and standard deviations can be found in Figure 9.1 and Table 9.4. All composite scores demonstrated normal distributions except for attitude and behavioural intention. Table 9.5 presents the correlation matrix for DTPB composite scores. The attitude and behavioural intention composites yielded the highest central tendencies, the former of which confirmed the first hypothesis, while self efficacy was the lowest. The social norms construct was found to be the most significant correlate of behavioural intention, which was contrary to the second hypothesis. Pretest-posttest data analysis demonstrated that the ADOPT-VR was sensitive enough to detect changes in multiple variables following intervention, although high correlations amongst the measure's constructs limits the strength of this finding. Details of change scores at posttest are described elsewhere (see Chapter 10).

Table 9.4: Descriptive Statistics for DTPB Pretest Composites

Pretest Composite	Mean	Median	Standard Deviation	Range	Interquartile Range	95% Confidence Interval (CI)
Attitude		7.00		7.00	2.00	
Perceived Usefulness	6.76	7.00	1.45	5.00		6.32, 7.20
Perceived Ease of Use	5.39	5.00	1.73	8.00		4.87, 5.91
Compatibility	5.58	5.00	1.63	7.00		5.09, 6.07
Social Norms	5.48	5.00	1.69	7.00		4.97, 5.99
Peer Influence	5.37	5.00	1.88	8.00		4.80, 5.94
Superior Influence	5.29	5.00	2.21	8.00		4.62, 5.96
Perceived Behavioural Control	5.10	5.50	2.61	8.00		4.31, 5.89
Self Efficacy	4.33	5.00	2.58	8.00		3.55, 5.11
Facilitating Conditions & Barriers	5.26	5.00	2.25	8.00		4.58, 5.94
Behavioural Intention		7.00		8.00	3.00	

Figure 9.1: Central Tendencies: DTPB Composites

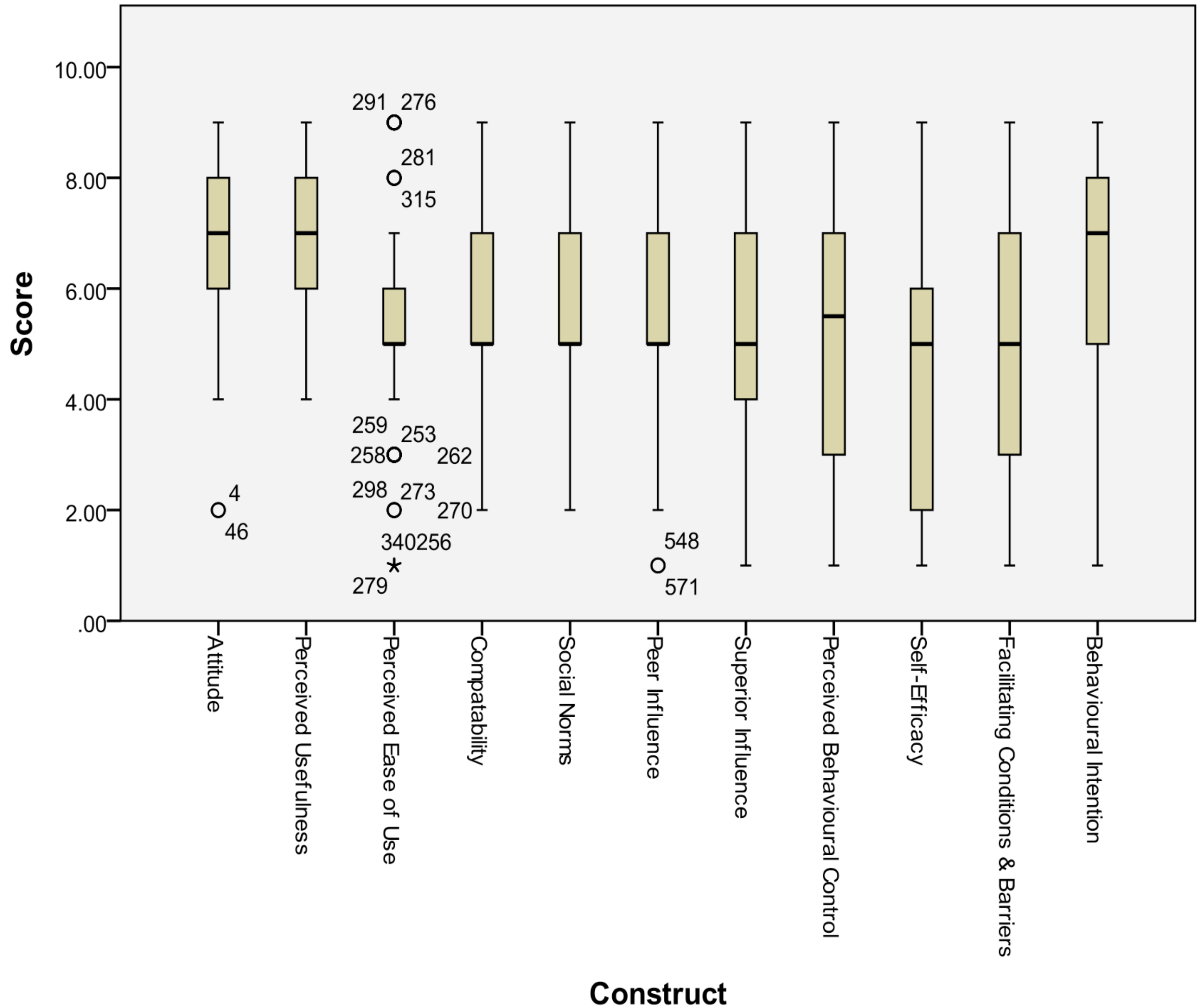


Table 9.5: Construct Correlations for the DTPB Variables

Pearson Correlations		A	PU	PEOU	CO	SN	PI	SI	PBC	SE	FCB	BI
Attitude (A)	Correlation	1	.757**	.499**	.562**	.628**	.502**	.295**	.428**	.561**	.307**	.547**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.008	.000	.000	.004	.000
	N	126	126	126	84	42	84	80	84	42	84	126
Perceived Usefulness (PU)	Correlation	.757**	1	.449**	.523**	.592**	.553**	.331**	.381**	.398**	.243*	.504**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.003	.000	.009	.026	.000
	N	126	126	126	84	42	84	80	84	42	84	126
Perceived Ease of Use (PEOU)	Correlation	.499**	.449**	1	.481**	.351*	.351**	.110	.284**	.177	.164	.345**
	Sig. (2-tailed)	.000	.000		.000	.023	.001	.333	.009	.262	.136	.000
	N	126	126	126	84	42	84	80	84	42	84	126
Compatibility (CO)	Correlation	.562**	.523**	.481**	1	.558**	.503**	.309**	.293**	.308*	.148	.551**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.005	.007	.047	.178	.000
	N	84	84	84	84	42	84	80	84	42	84	84
Social Norms (SN)	Correlation	.628**	.592**	.351*	.558**	1	.855**	.775**	.407**	.383*	.121	.562**
	Sig. (2-tailed)	.000	.000	.023	.000		.000	.000	.007	.012	.447	.000
	N	42	42	42	42	42	42	40	42	42	42	42
Peer Influence (PI)	Correlation	.502**	.553**	.351**	.503**	.855**	1	.546**	.268*	.447**	.042	.406**
	Sig. (2-tailed)	.000	.000	.001	.000	.000		.000	.014	.003	.702	.000
	N	84	84	84	84	42	84	80	84	42	84	84

Pearson Correlations		A	PU	PEOU	CO	SN	PI	SI	PBC	SE	FCB	BI
Superior Influence (SI)	Correlation	.295**	.331**	.110	.309**	.775**	.546**	1	.268*	.457**	.058	.385**
	Sig. (2-tailed)	.008	.003	.333	.005	.000	.000		.016	.003	.606	.000
	N	80	80	80	80	40	80	80	80	40	80	80
Perceived Behavioural Control (PBC)	Correlation	.428**	.381**	.284**	.293**	.407**	.268*	.268*	1	.615**	.497**	.377**
	Sig. (2-tailed)	.000	.000	.009	.007	.007	.014	.016		.000	.000	.000
	N	84	84	84	84	42	84	80	84	42	84	84
Self Efficacy (SE)	Correlation	.561**	.398**	.177	.308*	.383*	.447**	.457**	.615**	1	.370*	.327*
	Sig. (2-tailed)	.000	.009	.262	.047	.012	.003	.003	.000		.016	.034
	N	42	42	42	42	42	42	40	42	42	42	42
Facilitating Conditions & Barriers (FCB)	Correlation	.307**	.243*	.164	.148	.121	.042	.058	.497**	.370*	1	.458**
	Sig. (2-tailed)	.004	.026	.136	.178	.447	.702	.606	.000	.016		.000
	N	84	84	84	84	42	84	80	84	42	84	84
Behavioural Intention (BI)	Correlation	.547**	.504**	.345**	.551**	.562**	.406**	.385**	.377**	.327*	.458**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.034	.000	
	N	126	126	126	84	42	84	80	84	42	84	126

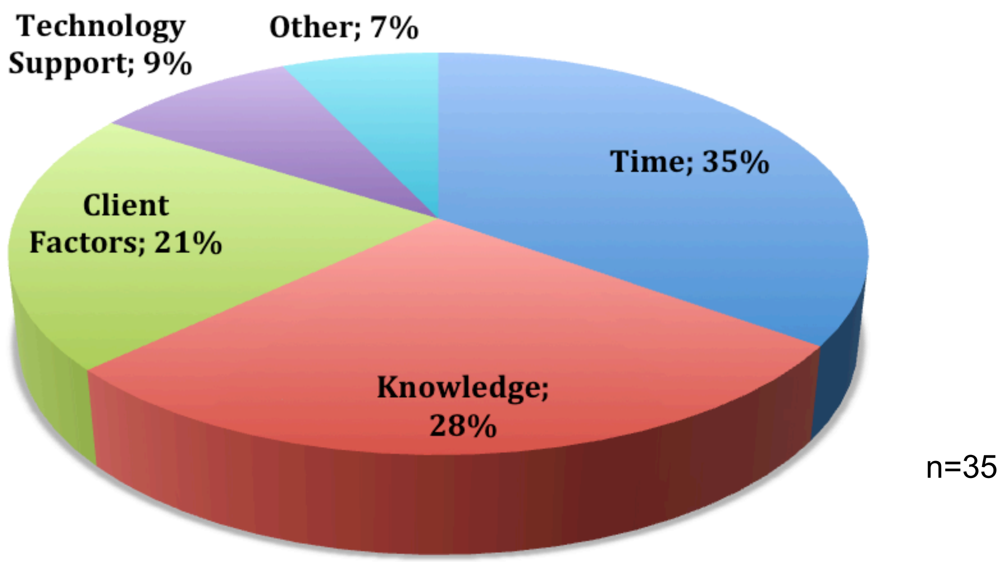
Additional descriptive data was gathered for the facilitating conditions and barriers, self efficacy and behavioural intention constructs. Therapists' perceived barriers of and facilitators to VR use, as well as the most significant perceived barriers are presented in Table 9.6 and Figure 9.2, respectively. Information about barriers and facilitators was collected through multiple choice questions, with an option for reporting "other" responses not provided as choices. The ADOPT-VR survey questions addressing self efficacy, reasons for behavioural intention and most significant barriers requested open-ended responses. The number of respondents providing answers to these questions is reported in the respective table and figure. The most prevalent perceived barriers to VR use were poor client motivation and time constraints, while the most frequently cited facilitators were educational opportunities and social influences. Time to learn and to use the system, and knowledge about how to use the system clinically were considered by therapists to be the two most significant barriers to VR adoption.

Table 9.6: Perceived Barriers & Facilitators of VR Use

Factor	Perceived Barriers to VR Use*		Perceived Facilitators of VR Use∆	
	Frequency	%	Frequency	%
Time to learn	22	55		
Time to use	18	45		
Lack of appropriate clients	15	37.5		
Other	2	5		
Quality of evidence	2	5		
Education/training opportunities	13	32.5	4	19
Client motivation, enjoyment or interest	24	60	3	14
Access/availability of the VR system	12	30	2	10
Access to evidence	13	32.5	1	5
Support or expectation of management			4	19
Colleagues with interest or expertise			4	18
Personal factors (e.g. positive attitude toward VR; familiarity with technology)			2	10
Nature of VR-based intervention as a task that can be delegated to support personnel			1	5

Abbreviations: VR = virtual reality
* - 40 of the 42 subjects provided responses to this question
∆ - 21 of the 42 subjects provided responses to this question

Figure 9.2: Most Significant Barriers to VR Use



In keeping with therapists' limited reported experience with VR in general, the area identified as contributing most frequently to lower self efficacy (n=32) was lack of general knowledge about how to use the system (52%). More specific skills in which therapists reported lacking confidence included modifying software parameters (16%), developing VR-based client programmes (14%), equipment set-up (9%) and identifying appropriate clients (9%).

Reported reasons for therapists' intentions to use VR more in the future (n=35) included the perceived benefits to clients (40%), and VR's perceived motivational utility (29%). Factors influencing behavioural intention in a negative direction included lack of knowledge about VR and its clinical use (23%), lack of time (17%), access to the system (11%), competing treatments (9%), lack of appropriate clients with which to use the technology (9%), and technical issues (6%).

9.5 Discussion

This study is the first to establish the initial face and content validity of a VR adoption measure developed for therapists working in ABI rehabilitation, and the first to employ theory to empirically measure system-specific, social and personal factors influencing therapists' adoption of the GestureTek VR system in this practice setting. Specific barriers and facilitators to VR adoption have been identified from the perspective of therapists, which can be addressed to support therapists in adopting this technology in their practice. The DTPB proved to be a useful theory in identifying these factors for examination.

9.5.1 DTPB Constructs

Overall, therapists had positive attitudes toward VR, which is promising for those involved in facilitating its implementation. This construct demonstrated one of the highest correlations with behavioural intention. Descriptive data also linked positive attitudes toward VR or to technology in general with respondents' positive intentions to use VR in the future. This finding is consistent with the DTPB technology adoption literature with respect to health care professionals (e.g. Chau & Hu, 2001; Shoham & Gonen, 2008; Zhang & Gutierrez, 2007) and supports the first hypothesis.

Generally, therapists perceived VR to be useful as a treatment tool, with its benefit to clients identified as an incentive for its use. With increased clinical experience using the technology as an intervention approach, therapists may better understand the system and its capabilities, as well as make observations about its impact on patient outcomes. Furthermore, the provision of knowledge products, such as evidence synopses, and other KT strategies, could play a role in promoting VR uptake as new efficacy research emerges, by addressing identified barriers in the availability and accessibility (Kramer et al., 2010), as well as the quality of evidence supporting VR use for ABI rehabilitation. With a greater awareness of the breadth of the VR literature through the transfer of knowledge in a pre-appraised and synthesised format, therapists may perceive the technology to be more useful for effecting positive functional outcomes for their clients.

The compatibility composite mean score fell in the mid-range of the scale, although it was one of the strongest correlates of behavioural intention. The perception of one therapist that VR-based treatment may not be amenable enough to hands-on support by the therapist is an example of incompatibility between the system and preferred treatment approaches. Further to compatibility is the nature of the intervention as a task that can be delegated to support personnel, which may fit with the daily practice preferences of busy prescribing therapists who are wary of the time required to use VR with their clients when faced with competing interventions and technologies. KT strategies may also have the potential to contribute to therapists' perceptions of VR as being more compatible with their typical treatment philosophy as an evidence based intervention, should the research support the therapist's clinical application of the technology.

The accessibility and availability of the VR equipment were factors identified by therapists that could logically affect perceived ease of use. Strategies to improve the availability of the equipment for clinical use may include ensuring close proximity of VR to regular treatment areas (Thornton et al., n.d., as cited by Weiss et al., 2009), as well as providing dedicated VR treatment space to minimise the time required for therapists, purchasing multiple VR systems to reduce scheduling conflicts, and establishing a permanent or standardised set-up configuration of the equipment to reduce the likelihood of technical issues. Additionally, lack of knowledge and familiarity in the use of VR were raised as barriers, while knowledge and education opportunities were cited as facilitators for therapists. Increased learning opportunities about how to use VR in clinical practice may positively influence therapists' perceived ease of use of the technology as they gain knowledge and skills in applying this new treatment approach. In terms of the second hypothesis, the restricted range and the significant variability of scores obtained for the perceived ease of use construct likely contributed to its lower correlation with behavioural intention. The relationship between these two variables may be different in a sample of more experienced VR users, or in environments in which these barriers have been adequately addressed.

While qualitative support exists for the facilitating role of social norms on therapists' adoption of VR (Kramer et al., 2010), these factors had not previously been measured in quantitative terms with this population. Notably, in the current study, social norms held the strongest correlation with behavioural intention, while superior and peer influence together accounted for 37% of subjects' responses in relation to facilitators of their VR use. While the other top facilitator, education or training in VR use was also represented in the barriers category, subjects perceived social influences solely as facilitators of their use of VR. These results may indicate that the involvement of colleagues as clinical experts or knowledge brokers in a mentoring or promotional capacity, as well as the demonstrated support or expectation of management regarding the use of VR, could have a positive impact on therapists' adoption of the technology. Although the medical DTPB literature suggests that social norms have little impact on physicians' behavioural intentions to adopt technology (e.g. Chau & Hu, 2001), this study indicates that therapists may differ in this respect in the context of clinical VR adoption.

The positively skewed distribution of the perceived behavioural control composite score may reflect therapists' beliefs that they may be lacking access to some of the resources or opportunities required to apply VR to practice. According to descriptive data, therapists cited a lack of resources including technical support, clinical tools, general knowledge in applying the technology to treat patients with ABI, and training opportunities.

The self efficacy composite yielded the lowest median score of the DTPB composites, as well as a positive skew in its distribution, suggesting a relative area of weakness for therapists. Interestingly, a minority of therapists reported having had the opportunity to explore the VR system outside of clinical sessions, which, along with variable experience and limited training, likely influenced self efficacy. Education or training was also perceived as a significant facilitator of VR use by the therapists sampled, which is in keeping with previous research (Kramer et al., 2010; Lotan et al., 2011). The established link between knowledge, self efficacy and behavioural change (Bandura, 1977; Cervone & Scott, 1995) supports further the provision of educational and practice opportunities, as well as tools to assist therapists in feeling proficient in the use of VR with their clinical populations as a means of facilitating its use.

Knowledge regarding the most significant barriers to VR use affecting therapists allows clinical leaders, administrators and management to target resources and implementation efforts to effect maximal impact. Time was the most frequently cited factor by therapists, with knowledge of VR use and client factors following in popularity. As two therapists indicated, the delegation of VR interventions to support personnel, such as rehabilitation therapists, may be one strategy to enable VR use within time constraints. Additional steps including involving non-therapist support staff to assist with equipment set-up and take-down, and providing educational support to improve the efficiency of learning and clinical implementation may be other useful strategies emerging from this research.

Low perceived motivation of patients to participate in VR-based therapy was the most frequently cited barrier to VR use; this finding was surprising given the consistent research support (which included both TBI and stroke populations) for VR as an interesting, enjoyable and motivating rehabilitation tool as described by patients themselves (Holden, 2005; Sveistrup, 2004; Thornton et al., 2005; Weiss et al., 2009). Our contradictory findings may be related to the relatively low levels of VR experience of the therapists in our sample, which were associated with lower self efficacy and knowledge about the clinical use of the technology. Greater clinical exposure may influence these views over time if previous research findings supporting VR as a motivating intervention hold true for the inpatient ABI population. Future research exploring the possible link between expertise, self efficacy, and therapists' perceptions of client motivation may provide more insight into the VR adoption process.

9.5.2 Study Strengths & Limitations

Purposive sampling of ABI therapists from health centres with access to the GestureTek system allowed for more clinically applicable results to inform VR implementation in other health centres. The sample in this study varied in terms of both clinical and ABI experience. Conversely, the majority of therapists had minimal exposure or familiarity with the VR system before participating in the study, with only five reporting the opportunity to explore the VR system outside of clinical use. Based on previous findings by Taylor & Todd (1995b) demonstrating differences in the relative influences of the determinants of behaviour on behavioural intention between novice and experienced technology users, longitudinal follow-up may be warranted to examine the impact of experience on behavioural intention and its determinants within this demographic and clinical context.

Given the recruitment rate, selection bias was likely minimised. Because of the small sample size, subject data across the two sites was pooled for analysis; a larger number of both paediatric and prescribing therapists would have enabled separate data analyses, which may have provided a better understanding of the local context, including differences that may exist between therapists in paediatric versus adult settings and those of different professions or genders. Furthermore, different experiences with technology support, one-to-one clinical support, superior influences, client motivation and demographics, as well as exposure to VR as a treatment tool may also have influenced subjects differently across sites. Future research with a larger sample would also allow for confirmatory factor analysis to further assess the construct validity of the measure.

Previous work by Bertrand & Bouchard (2008) suggests that the relationship between self efficacy and both behavioural intention and perceived usefulness may be stronger with increased experience using VR. As mentioned, the sample in this study was comprised mainly of therapists with limited exposure to the GestureTek VR system as a clinical tool. Generalisability of the results of this study to clinicians with more experience using the system should be done with caution until further research can confirm the relationship between experience and the determinants of VR use by therapists.

More comprehensive qualitative methods may have had the potential to generate a greater depth of understanding about the factors influencing therapists' adoption of VR without introducing bias through the content or design of the questionnaire; however, the DTPB provided a useful framework for exploring the extent to which its theoretical constructs influence therapists' motivation to use VR. Additional sub-constructs may be added to the DTPB model based on qualitative data from other studies (such as safety, clinician or patient preferences); the relationships within this more extensive set of variables could then be tested in the context of VR use by therapists in a sample with more experience using the VR system. Administrative barriers, such as cost of the equipment, have also been identified in the literature (Kramer et al., 2010), but were not evaluated here since the VR system had already been purchased at participating sites.

The use of a self-report measure resulted in information about therapists' perceptions of potential influences on their VR use, although actual use was not measured. Because the measure gathered information about respondents' beliefs at a single point in time, the current data may reflect biased responses resulting from intentional misrepresentation, under- or overestimation of one's skills or of the utility of the VR system, or lack of knowledge about the VR system; additionally, responses could be subject to change as the result of subsequent influences, mood at the time of survey completion or altered interpretation of the questions (Borgatti & Carboni, 2007; Casper, 2007; Jimmieson, Peach & White, 2008). Confirming the predictive utility of behavioural intention on actual use of VR would require longitudinal follow-up and explicit measurement. In terms of capturing self-report data about therapists' perceptions, the measurement process was very efficient, requiring 10-15 minutes of therapists' time in completing the ADOPT-VR survey. Data collection at additional sites would be feasible with the support of management, therapists and a research investigator who is able to complete the ethics application process. Refinement of the ADOPT-VR survey based on psychometric testing results will allow for an even more concise instrument with enhanced internal consistency. Further reporting of the psychometric testing carried out for the measure will also increase confidence in its reliability and validity, thus enhancing its utility for others seeking to explore therapists' adoption of VR or other technologies.

9.5.3 Future Directions

Of value would be to explore therapists' intention to use VR at sites in which the VR system is not yet in place, as a means of assisting management with decision-making regarding targeting supports and interventions to facilitate its use by therapists should it be introduced. Additional sampling of therapists with greater levels of experience with the VR system would allow for comparisons between groups. The current longitudinal study aims to provide some insight into changes in the determinants of VR use and therapists' intentions to use it following increased exposure to the technology as a rehabilitation tool. Future research is also needed to confirm the predictive link between behavioural intention and actual use of VR in practice, as the latter was not measured during the current study. Further psychometric testing of the ADOPT-VR survey will also be carried out to inform refinement of the measure to remove duplication in items and/or constructs as appropriate, and to improve the confidence with which it can be used by researchers in the field.

The question of whether or not clients' motivation to use VR differs between the inpatient ABI population and populations studied in the literature has yet to be answered. Ongoing research by these authors will explore changes in the perceptions of low client motivation to participate in VR by therapists in this sample following more experience using the system with the inpatient acute rehabilitation ABI population.

Based on the current findings, our ongoing research will involve the provision of a multi-method KT strategy aimed at mediating the determinants of behavioural intention with the aim of increasing VR adoption by therapists. By addressing perceived barriers to VR use as identified by therapists, such as lack of knowledge and skills in using VR, and by enhancing facilitators, such as colleague endorsement or support for VR use, we hypothesised that therapists' intentions to use VR will increase in response to improvements in the mediators of behavioural intention. Longitudinal research will allow for repeated measures of these determinants in order to detect change following the KT intervention. Results will inform future VR implementation efforts at other health centres.

9.6 Conclusions

Overall, therapists had positive attitudes towards VR, perceived it as being useful, and had positive intentions to use the technology more in the future. The lowest scores were related to self efficacy in using the technology. The most significant barriers to VR use included lack of time, lack of knowledge and specific client factors, while the primary facilitators included peer and superior influences as well as opportunities to increase knowledge and skills in using VR. Future research will evaluate the impact of KT interventions targeted towards these factors on therapists' adoption of VR.

CHAPTER 10: Evaluating Change in the Determinants of VR Use Following KT

This chapter describes the findings of the final phase of this research, which involved the evaluation of change in the determinants of VR use following the KT intervention. As described in Chapter 7, this intervention included an interactive education session, the provision of the clinical protocols manual and both technology and clinical support. After the posttest administration of the ADOPT-VR outcome measure to therapists, data was plotted to evaluate normality of the distributions and non-parametric tests were used to test the primary and secondary hypotheses outlined in Chapter 6. Data on therapists' reported use and perceived utility of the clinical protocols manual was also collected using the ADOPT-VR posttest.

10.1 Results

10.1.1 Sample Demographics

Therapist demographics at pretest for the original sample (n=42) were described in Chapter 9 (Glegg et al., n.d., under review). The participant flow diagram provided in Figure 10.1 provides information about therapist dropouts (12%) and the reasons for failure to complete the participation requirements of the study. Therapist demographics for the final sample with dropouts excluded are provided in Table 10.1. Twenty-four percent of therapists were male, and 84% were working with adult populations.

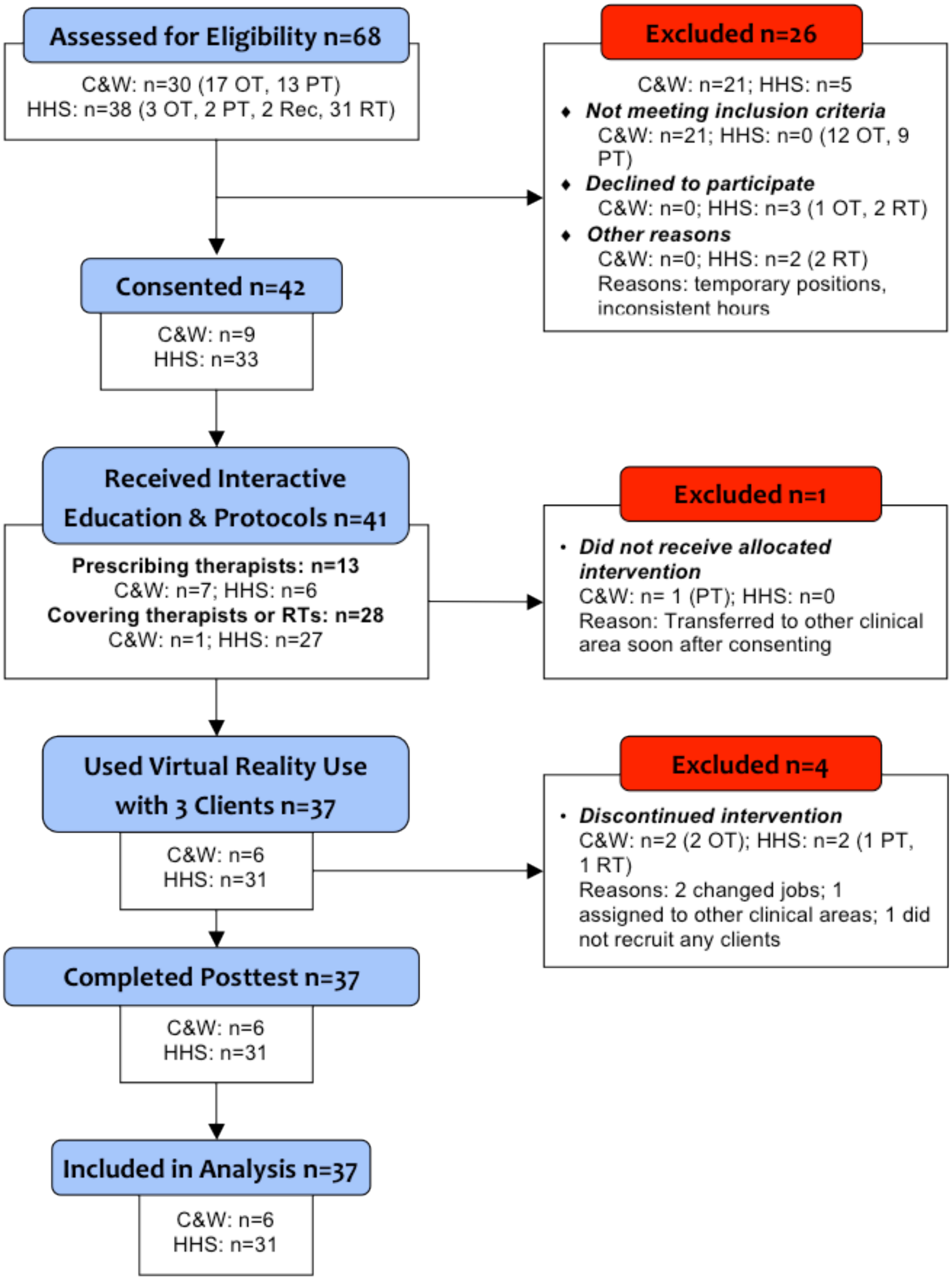
Table 10.1: Therapist Demographics (n=37)

Demographic	Mean (Standard Deviation)	Median	Range	Interquartile Range	% of Therapists				
Profession					70.3 RT	13.5 PT	10.8 OT	5.4 Rec	70.3 RT
Education					45.9 Bach	37.8 Dip	16.2 MClin		
Years clinical experience	11.0 (6.4)	10.0	23.0		100.0				
Years ABI experience		9.0	31.8	9.5	100.0				
Annual ABI caseload (# patients) (n=32)		13.5	93.0	14.8	86.5				
Months using VR		0.0 30.0∞	42.0 41.9∞	0.0 27.0∞	100.0 13.5∞				
Familiarity with VR (# of games)		0.0 5.0*	30.0 28.0*	1.0 8.5*	100.0 31.0*				
Hours explored VR during work		0.0 2.0**	3.5 3.0**	0.8 1.0**	100.0 37.9**				

∞=values calculated for responses >0 (n=5)
*= values calculated for responses >0 (n=9)
** = values calculated for responses >0 (n=11)
RT=rehabilitation therapist; PT=physiotherapist; OT=occupational therapist; Rec=recreation therapist; Bach=bachelor degree; Dip=diploma; MClin=clinical entry-level masters; ABI=acquired brain injury; VR=virtual reality

At posttest, a 22% increase was observed in the number of therapists reporting having provided mentoring on VR use to other therapists. In addition, the median number of games with which therapists reported familiarity increased from 1.97 to 7.59 at posttest. A 46% increase in the number of therapists who had had the opportunity to explore the VR system at work outside of clinical treatment sessions was also observed; the median time of exploration increased from .51 to 2.14 hours at the end of the study period (range: pretest 0-3.5 hours; posttest 0-15 hours). Client characteristics are provided elsewhere (see Chapter 8, e.g. Glegg et al., n.d., to be submitted).

Figure 10.1: Participant Flow Diagram (Therapists)



Abbreviations: C&W = Children's & Women's Health Centre of British Columbia; OT = occupational therapist; PT = physiotherapist; HHS = Hamilton Health Sciences; Rec = recreation therapist; RT = rehabilitation therapist

10.1.2 DTPB Constructs and Hypotheses

Table 10.2 presents findings from the analysis of the normality of the distributions for the primary and secondary hypothesis variables. Results from the Shapiro-Wilk test of normality suggest that non-parametric tests would be appropriate for analysis of pretest-posttest change, given that the only variable of interest meeting a significance level of >.05 was perceived ease of use (PEOU) at pretest, although self efficacy (SE) at posttest approached this threshold. Subsequent analysis of skewness and kurtosis revealed that PEOU at posttest demonstrated a distinct non-normal distribution, whereas both secondary hypothesis variables met (or approximated, in the case of pretest SE) these normal distribution criteria at both time points.

Table 10.2: Normality Distribution Test Results for Primary & Secondary Hypothesis Variables

Pretest	Shapiro-Wilk Significance Level	Skewness Statistic	Kurtosis Statistic
PEOU	.166	-.121	.649
SE	.016	.058	-1.074
BI	.033	-.360	-.592
Posttest	**Shapiro-Wilk Significance Level**	**Skewness Statistic**	**Kurtosis Statistic**
PEOU	.000	-1.459	2.644
SE	.046	-.323	-.822
BI	.003	-.562	-.666

In the case of PEOU and behavioural intention (BI), the p-values for Levene's statistic (p=.849 and p=.524, respectively) were greater than alpha=.05, indicating that the homogeneity of variances assumption may be reasonably satisfied. Conversely, for SE, the p-value was .003, leading to a rejection of the null hypothesis that the variances were equal. Based on these findings, non-parametric tests were selected to evaluate change in these three variables. Wilcoxon T analysis results for the three hypothesis variables are shown in Table 10.3 These findings are in support of the primary hypothesis and the first part of the secondary hypothesis. Given the obtained sample size and an alpha level of .05 for a two-tailed test at 80% power, the required effect size was re-calculated to be 0.47.

Table 10.3: Pretest-Posttest Change Findings for Hypothesis Variables

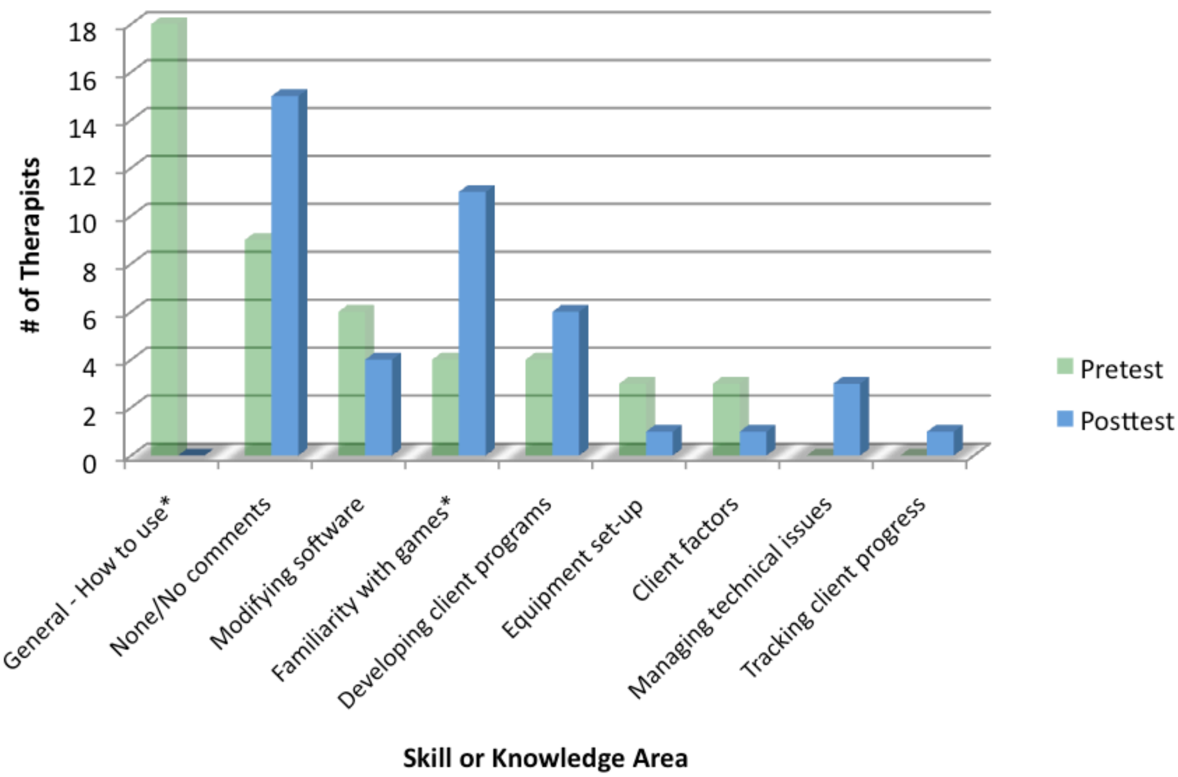
Variable	Pretest (Median)	Posttest (Median)	Wilcoxon T	Total Ranks for Increases	Total Ranks for Decreases	Significance Level	Effect Size
Perceived Ease of Use	5.00	8.00	T=68	595	68	p=.000	1.01
Self Efficacy	5.00	7.00	T=45	618	45	p=.001	1.30
Behavioural Intention	7.00	7.00	T=294.5	406.5	294.5	p=.158	0.12

Note: Critical value for T for a two-tailed test with alpha of .05 at n=37 is 221.

10.1.3 Self Efficacy

Figure 10.2 outlines areas in which therapists reported lack of confidence, based on open-ended responses at pretest and posttest. Significant differences between pretest and posttest frequencies are denoted by a * in the figure. Managing technical issues and tracking client progress emerged as new areas of low self efficacy at posttest.

Figure 10.2: Areas in Which Therapists Lacked Confidence in VR Use

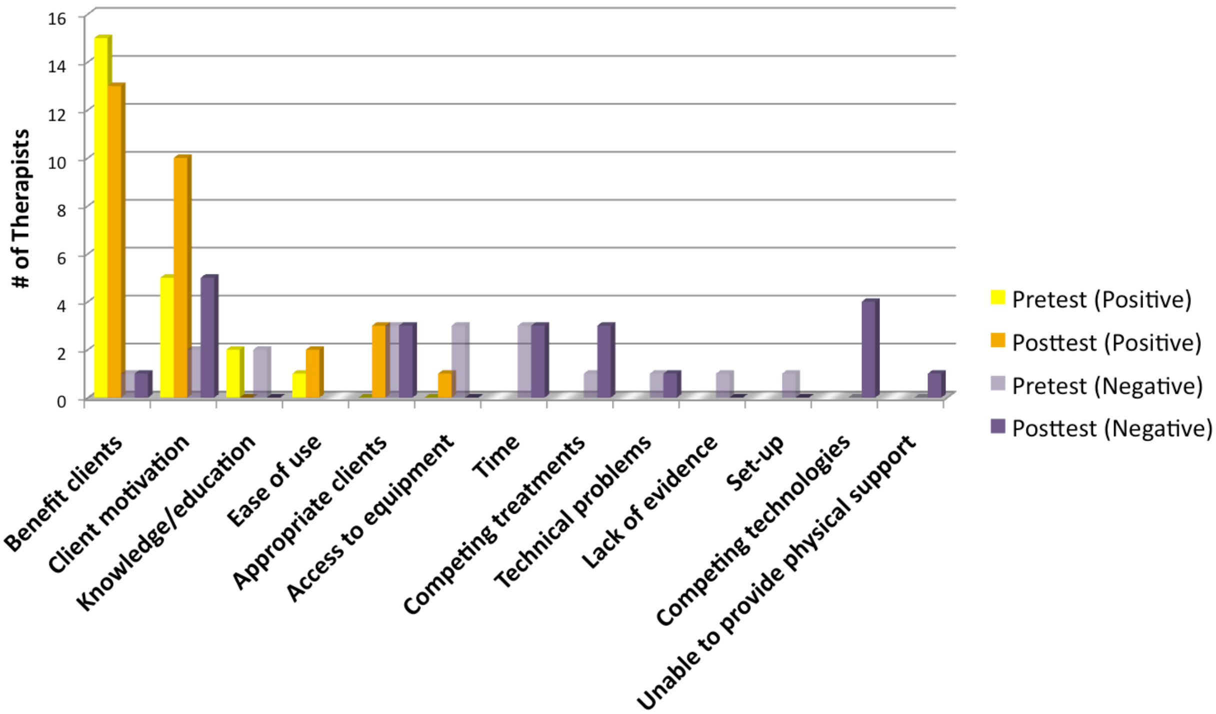


Note: Significant differences based on a 95% CI are marked by *

10.1.4 Reasons for Behavioural Intention

The primary reason for positive intentions to use VR more in the future was perceived benefits to clients, including increased motivation. Therapists providing reasons related to positive intentions to use VR perceived the system to be a useful therapeutic tool in its capacity to provide a meaningful activity for pursuing therapy goals, to allow for assessment of the client’s movements in a non-over-learned environment, to increase mobility and promote physical activity, to provide challenge and stimulation, to keep the client busy, and to enable participation in activities the client may have enjoyed pre-injury. Conversely, no single repeatedly reported reason for therapists' negative intentions to use VR was identified. Competing technologies, which emerged as a new reason for negative intentions at posttest, was the only difference to reach significance. Refer to Figure 10.3 for details about the reasons behind therapists' behavioural intentions with respect to VR use.

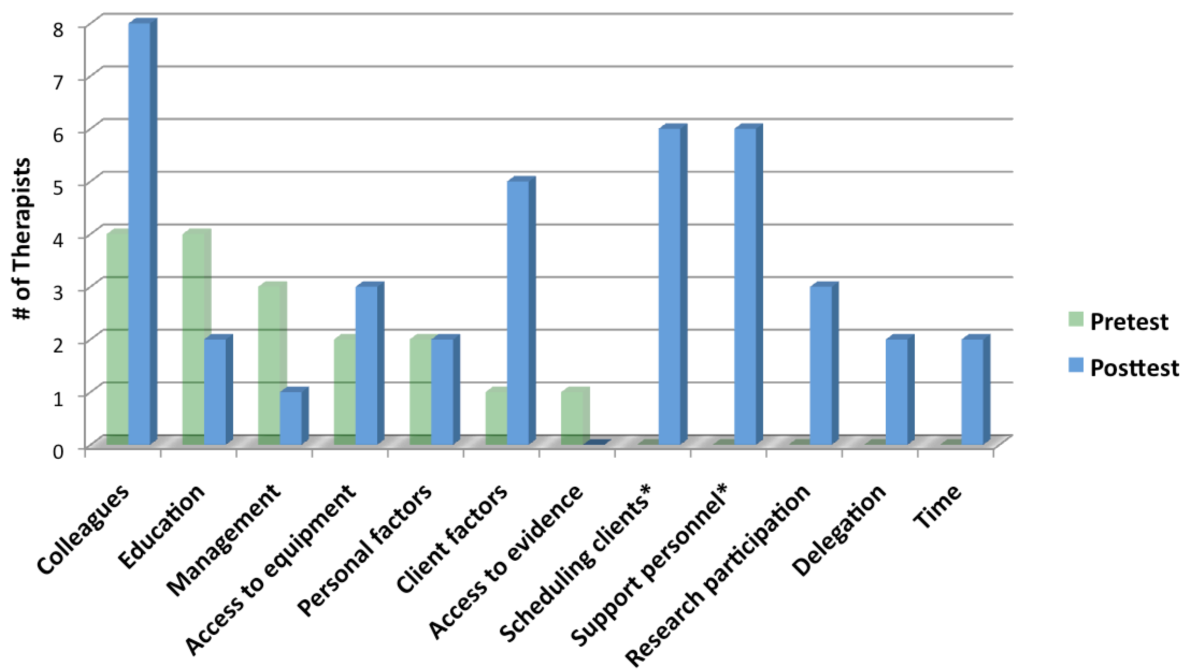
Figure 10.3: Reasons for Behavioural Intentions



10.1.5 Facilitators of VR Use

A visual comparison of therapists' perceived facilitators of VR use at pretest and posttest is provided in Figure 10.4. While the frequency of therapists' reporting of facilitators identified at pretest did not change significantly at posttest, a significant increase of 58% in the number of reported facilitators was observed at posttest. Colleagues with an interest or expertise in VR were a positive influence on VR use was the most frequently reported facilitator at posttest, while four novel facilitators also emerged, three of which fell within the top five facilitators at posttest. These factors were involvement in research, the assistance of support staff for equipment set-up and takedown, the scheduling of VR into the weekly routines of clients, the delegation of VR-based treatment to rehabilitation therapists and time.

Figure 10.4: Perceived Facilitators of VR Use

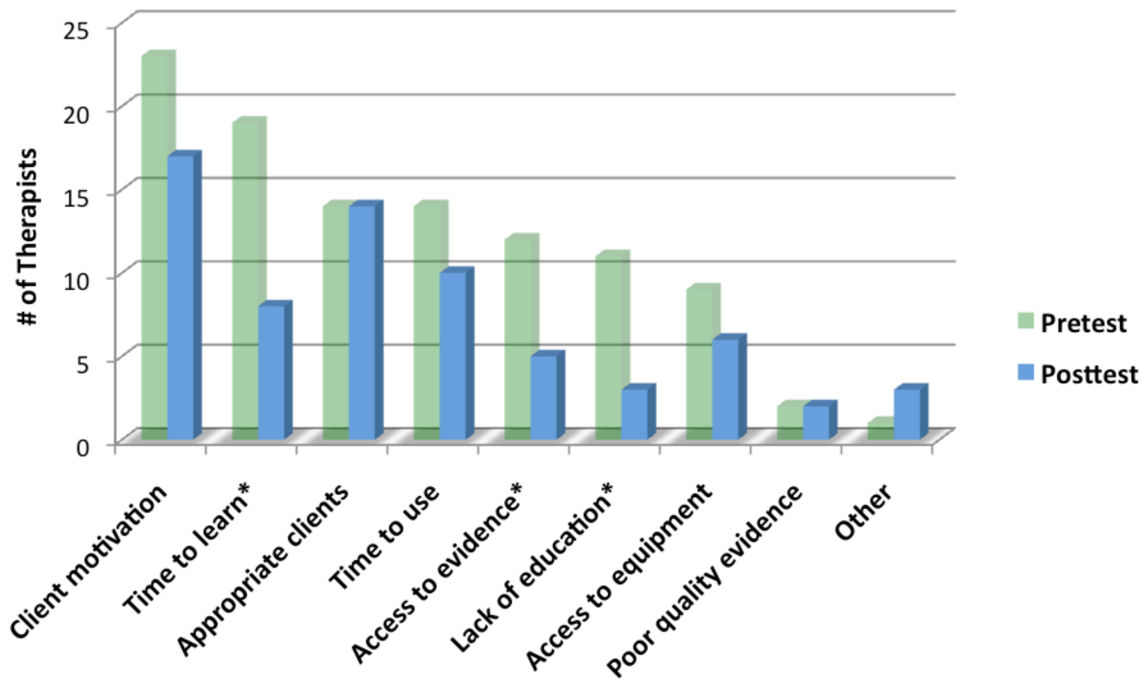


Note: Significant differences based on a 95% CI are marked by *

10.1.6 Barriers to VR Use

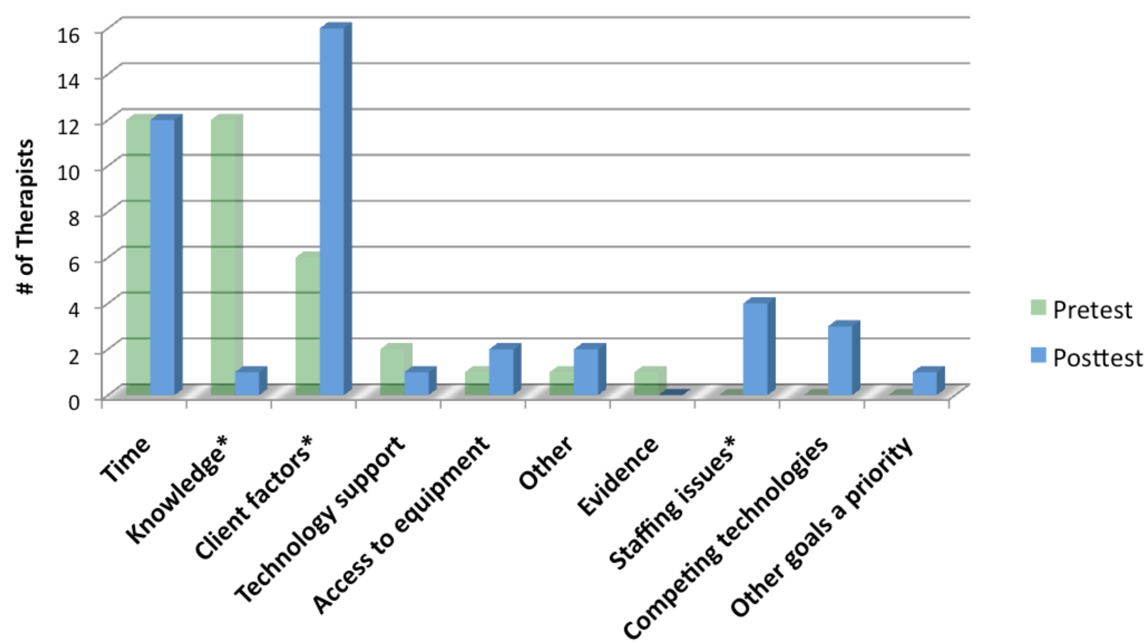
A statistically significant decrease of 32% in the number of perceived barriers reported by therapists was observed at posttest. Figure 10.5 illustrates the change in frequency of reporting of these specific barriers between pretest and posttest. At pretest, the “Other” reported barrier as indicated in this figure was technology support, while at posttest these barriers included technical issues, working the night shift, and determining the appropriate timing of VR introduction relative to recovery and when to use VR as opposed to other technology or treatment approaches, respectively. A graphical representation showing the frequency of reporting of barriers therapists’ perceived as being the most significant to their use of VR at both time points can be found in Figure 10.6. "Other" most significant barriers reported at posttest included technical issues, explaining use of the system to clients, and compatibility challenges with the system for wheelchair users.

Figure 10.5: Perceived Barriers to VR Use



Note: Significant differences based on a 95% CI are marked by *

Figure 10.6: Most Significant Barriers to VR Use



Note: Significant differences based on a 95% CI are marked by *

10.1.7 Clinical Protocol Feedback

Fifty-nine percent of therapists reported using the clinical protocols manual in some capacity over the course of the study, although the average number of sections used was two, of the available ten. The most frequently accessed sections of the manual were those describing set-up of the equipment (35% of therapists), goal setting (30%), the client programme tracking form (27%), developing client programmes (24%) and measuring client progress (22%). The least accessed section was the evidence summary (5%). No therapists reported making use of the entire manual.

Open-ended responses by therapists described helpful aspects of the manual, which included its thoroughness, organisation and ease of understanding, the forms provided, the overview of games and how to select appropriate ones for client programmes, information on isolating desired skills or grading the activities for use in therapy, the provision of sample goals, and the evidence synthesis. Content some therapists reported as not being helpful included the evidence synthesis and the client programme tracking form because it duplicated aspects of medical charting. Suggestions for improvement included adding more information about identifying client appropriateness for VR, setting measurable goals (particularly using the Goal Attainment Scale format), how to support clients with multiple impairments and varying levels of consciousness in using the system, support with decision-making around selecting the GestureTek VR system versus competing technologies for particular clients or phases of recovery, relating information about game grading and outcome measurement more directly to functional goals, and how to manage technical issues associated with using the system, particularly with clients in wheelchairs.

10.2 Discussion

10.2.1 Sample Demographics

At posttest, more than a third of therapists had answered yes when asked if they had offered spontaneous support to colleagues to assist them in learning about or in using the technology in a clinical capacity. This finding may be associated with therapists' overall positive attitudes and perceived usefulness of the technology, while implying not only that therapists needed more support to use the technology, but also that they likely saw mentoring as an acceptable means of transferring knowledge about VR use. Although there were no statistically significant differences between mentors and non-mentors with respect to self efficacy and behavioural intention, these subgroups represent small samples; future studies may explore the nature of any differences between these groups on a larger scale. Nevertheless, mentoring can contribute towards improved skill levels, self-confidence and knowledge exchange, a greater sense connectedness with others and with the organisation, and the ability to manage change (Horner et al., 2008; Singh, Bains & Vinnicombe, 2002). Further research exploring mentoring as a KT intervention in this context may provide a greater depth of understanding about the acceptability and utility of the strategy, as well as the mechanisms by which it may effect change in behaviours or knowledge that support the implementation process.

While therapists' familiarity with VR games increased over the course of the study, not one therapist reported familiarity with the entire games suite, and the median familiarity of the group represented a mere 25% of available games. An increase in therapist familiarity with the full range of activities has the capacity to optimise the variety and rehabilitation potential of the GestureTek system as a rehabilitation tool; limited experience with the technology may therefore have the potential to influence the degree of client engagement in the rehabilitation process, the extent to which activities are provided or graded to meet the client's needs, and ultimately, rehabilitation outcomes. Despite an eight-month study period during which therapists had the opportunity to gain experience with the system, it appears as though therapists may need additional resources to support them in expanding their familiarity with VR. While more than three quarters of therapists had explored the system outside of treatment sessions, the median length of time spent on this activity was just over two hours. Ongoing opportunity for exploration time to expand the range of VR rehabilitation activities therapists are able to offer their clients as they gain experience with the system would be a valuable starting point to supplement the information contained in the clinical protocols manual. An assessment of familiarity and competencies in clinically applying specific games is recommended to determine the specific needs for additional support. Whether these needs would be best addressed in the form of additional education, one-to-one clinical expert support, peer mentoring, and/or a refinement in the way the information about the games was presented during the intervention remains unanswered. The amount of exploration time needed to address this issue is not known; nonetheless, future implementation processes may consider the inclusion of a series of scheduled dedicated practice opportunities if feasible, to address organisational-level barriers related to workload or time management demands. Research suggests that affording such exploration of technology can lead to greater levels of adoption and promote the incorporation of innovations into practice (Greenhalgh et al., 2005).

10.2.2 DTPB Constructs and Hypotheses

The large effect sizes demonstrated in PEOU and SE change scores were greater than anticipated. While the design of the study does not allow for causal inferences with respect to the reasons behind the observed improvements in these two variables, several potential influences have been described (Glegg et al., n.d., under review). These influences include intervention components, such as making the VR equipment more accessible, supporting therapists with technical issues, the provision of information designed to increase knowledge and skills in procedural and clinical use of the technology through group and one-to-one education, as well as the clinical protocols manual. Nevertheless, basic experience gained from using the system with clients over the course of the study period is an obvious confound to the influence of the study intervention that realistically affected both PEOU and SE. A sample of therapists with more experience using the system may have diminished the potential bias of this aspect of study participation, because a higher level of general knowledge about the system would have left less room for experiential learning. However, a more robust design with random allocation to the intervention or no intervention would allow for more convincing evidence regarding the effectiveness of the intervention in improving therapists' confidence and ease of use of the VR system.

10.2.3 Self Efficacy

Open-ended responses about areas in which therapists lacked confidence at pretest and posttest provide some insight into the types of supports required to address their learning needs at different stages of VR adoption. Through participation in the study, all therapists appear to have gained general knowledge about how to use the VR system clinically, as demonstrated by an absence of reported low confidence in this area at posttest. Although it is not possible to identify the sources of this gained skill as perceived by therapists, this information was introduced during the education session, and reinforced in more detail in the clinical protocols manual. At posttest, 41% of therapists failed to identify an area in which they were lacking confidence; of those who did, areas involved higher-level skills, such as modifying software parameters to meet the client's skills and abilities, grading the degree of challenge, managing technical issues, and developing client programmes. As expected, with increasing experience using the system over several months, therapists were able to more precisely identify their learning needs, resulting in increases in reporting of more specific skill gaps related to clinical VR use. As a result, therapist education about VR could use a multi-stage approach to address general knowledge needs at the onset of implementation, followed by more specific clinical and software-related competencies as therapists' familiarity and comfort levels with the technology increase. In addition to the learning needs emerging from feedback about the clinical protocols manual content as discussed in the results section, recommended topics for these education sessions based on therapist feedback include general information about the VR system (e.g. how it works, an overview of software capabilities, set-up and an introduction to the games), followed by information about how to modify software parameters, develop client programmes, track client progress and manage technical issues.

10.2.4 Reasons for Behavioural Intention

The finding that increases in behavioural intention at posttest did not reach statistical significance may be explained by the composite's relatively high scoring at baseline. Still, a greater variability in change scores for behavioural intention in comparison with the other constructs tested by the study hypotheses suggests that experience using the system during the study may have increased therapists' awareness of important positive and negative considerations for the clinical use of VR. For those therapists with positive intentions to use VR more in the future, the system was perceived to be useful, motivating and of benefit to clients for a variety of reasons that have been reiterated in the literature (e.g. Farrow & Reid, 2004; Galvin & Levac, 2011; Holden, 2005; Miller & Reid, 2003; Sveistrup et al., 2004; Weiss et al., 2004).

The lack of consensus on the reasons behind therapists' negative intentions to use VR points to the need for a multi-faceted approach to addressing barriers and augmenting facilitators to VR use. Nonetheless, several factors identified by therapists are less amenable to direct interventions aimed at promoting VR adoption. Of note was the emergence of competing technologies as a reason not to use the GestureTek system. New technologies for rehabilitation are constantly being developed, and reasons, such as client or therapist familiarity with other systems, the ability to continue VR-based rehabilitation programmes at home, the variety of games available and the superior graphics afforded by other systems, were cited by therapists as considerations for their decisions about which technologies to use in practice. Furthermore, competing treatment approaches not involving technology, time and caseload constraints, as well as the need to prioritise other rehabilitation goals during recovery will continue to influence the frequency of VR use by therapists in the inpatient setting. Therapist feedback about specific facilitators and barriers to VR use can further enrich our understanding of the determinants of VR adoption, thereby informing the selection of potential supports that might be used to augment or diminish the relative impacts of these determinants.

10.2.5 Facilitators of VR Use

The most frequently reported facilitator of VR use at posttest was the support of colleagues with an interest or expertise in using the technology. This finding is in accordance with work by Rappolt & Tassone (2002) maintaining that physical and occupational therapists value the opinions and experience of their peers in incorporating new knowledge into practice. The spontaneous increase in mentorship amongst colleagues, and the availability of an on-site clinical expert to provide support on request as part of the intervention likely played roles in the frequency of this reported facilitator more than doubling at posttest. While involvement in the research study was cited as a facilitator, interestingly, the role of education decreased in importance, despite being a component of the research participation itself. Without more depth of understanding, it is not possible to determine which aspects of research participation, such as access to a clinical expert or peer group using the technology, education or resource provision, encouragement to recruit clients with whom to use VR, general experience or other elements, represented its key ingredients in facilitating VR use. However, a review by Lizarondo and colleagues (2011) identified a consistent association in the literature between involvement in research activities at work and engagement in information seeking, as well as in the reported use of research findings amongst allied health professionals. Qualitative research involving longitudinal follow-up to identify the important elements of research participation and their impact on sustainability of VR use would provide more insight into the role of research involvement on technology uptake in this context.

Client factors were also among the most frequently reported facilitators at posttest. Therapists reported that if they had appropriate clients on their caseloads, and that if clients were motivated to participate, their use of VR for treatment purposes would increase. As identified by therapists, access to rehabilitation therapists to carry out VR-based treatment programmes developed by prescribing therapists (e.g. occupational, physical, recreation therapists) may also facilitate VR adoption by reducing the time required to use it. Additional operational strategies to promote VR use may include the routine scheduling of clients, and the use of support personnel to assist with equipment set-up and takedown. Each of these identified facilitators may be considered by administrators and management as a means of providing organisational and resource support to facilitate VR uptake.

10.2.6 Barriers to VR Use

The significant decreases in the frequencies of therapists' reporting of time to learn, access to evidence and educational opportunities as barriers to VR use observed at posttest had the potential to be influenced by the KT intervention provided during the study. For instance, the interactive education session afforded participating therapists an educational opportunity, and was intended to decrease the time required to learn how to use VR, as was the clinical protocols manual. The evidence synthesis provided in the manual was created as a means of providing easy access to relevant evidence on the GestureTek system and on VR in general. Support with equipment set-up and take-down, and the technical troubleshooting that was carried out to improve the efficiency of these processes, as well as access to the clinical protocols manual in which to look up software parameters without having to rely on trial-and-error, were also provided to decrease the time required to use VR in practice. Although limitations in the study design do not permit causal inferences about these outcomes, the design of interventions to specifically target identified barriers and facilitators, which are selected based on theory, is the recommended approach to improving uptake (Wensing et al., 2009). The intervention components identified here may be a useful starting point on which to build the KT knowledge base, by applying a methodologically stronger study design in order to systematically evaluate their relative impacts on knowledge uptake and VR implementation.

Interestingly, client motivation remained the most frequently cited barrier at posttest. This finding is in contrast with the literature, which presents consistent findings across a range of diagnostic and age groups, including ABI (e.g. Bart et al., 2010; Rand et al., 2007; Rand, Weiss & Katz, 2009; Reid & Hirji, 2003; Thornton et al., 2005), demonstrating that VR is a motivating, satisfying and enjoyable therapeutic medium from the client's perspective. Because the current study did not examine motivation from the perspective of ABI clients undergoing inpatient rehabilitation, further research would be required to confirm with them this perception held by the therapists. A greater depth of understanding from therapists about which characteristics determine client appropriateness, and the potential reasons behind poor client motivation in this setting would also be beneficial. An awareness of both points of view can help to foster a client-centred approach by cultivating collaboration in the selection of motivating and useful treatments and in the design of VR-based therapy programs. Focus group research conducted by Thornton et al. (2005) with adults post-TBI who were no longer receiving inpatient rehabilitation and their family members provides some insight into the incongruence between therapist perceptions documented in the current study, and those of clients from the literature. While Thornton's reported qualitative themes were overwhelmingly positive in nature, some participants did indicate that certain activities were boring, and that enhanced variety and progressive increases in the degree of challenge were important in mediating this problem (Thornton et al., 2005). It may be interesting to compare client motivation to use VR during treatment when administered by novice versus more expert therapists, as confidence, skill, and the range of activities and specificity of grading could feasibly play a role in the client experience. Work by King et al (2007) supports this idea; they found that expert therapists possessed more competencies than novice therapists in their abilities to engage clients, to strategise about effective ways to facilitate change, and to customise interventions to make therapy manageable.

Knowledge about therapists' perceptions of the most significant barriers can help organisations efficiently target the most pertinent issues to help promote treatment implementation. Time constraints within the clinical setting remained a substantial barrier to VR use, although client factors (e.g. lack of appropriate clients and poor client motivation) surpassed time in frequency of reporting at posttest. These factors may have played a role in the recruitment of clients by therapists, and consequently, therapists' frequency of VR use. Staffing issues, other goals taking priority, compatibility of the system for clients using wheelchairs, and difficulty explaining the system to clients also emerged as significant barriers. Staffing issues specifically related to the inability of rehabilitation therapists to leave the unit to use the VR equipment with clients; adjustments to make the system physically more accessible, and to allow more flexibility for VR use by staff during work shifts may help to address this barrier. Although wheelchair compatibility of the technology has been identified as an issue, strategies, such as laying a smock of green fabric over the wheelchair, providing physical support behind the client while both sit on a bench, or limiting the range of games or the physical requirements to those that do not necessitate moving outside the outer borders of the wheelchair (e.g. shoulder abduction instead of lateral trunk leaning), have been used when feasible to ameliorate frustrations.

Lack of knowledge was the second most significant barrier in terms of frequency of reporting at pretest, but had minimal presence at posttest. The single therapist reporting lack of knowledge as her most significant barrier at posttest referred to higher-level technology-specific knowledge required to address technical issues that arose with the system during treatment sessions. This finding is promising as it suggests that overall, therapists gained the knowledge they perceived to be required to provide VR-based treatment over the course of the study, whether this learning occurred through experience using the system or as the result of the KT intervention. However, ongoing technical support is likely still required as therapists continue to gain knowledge about technical troubleshooting in the course of using the system.

10.2.7 Clinical Protocol Feedback

The provision of the clinical protocols manual and an orientation to its contents appear to have been insufficient in disseminating the aforementioned recommended learning content to all therapists involved in the study. Despite the positive initial response to the clinical protocols manual during its overview at the interactive education session, more than 40% of therapists did not refer to it during the study period, but rather relied on colleagues, the study coordinator or personal experience to gain information about clinical VR use. This finding suggests that its content played little role in affecting these therapists' perceived barriers, facilitators, self efficacy and knowledge levels at posttest, but rather that other elements of the intervention or of research involvement, such as the education session, access to clinical support from the study coordinators, peer mentoring or general VR experience, likely played a more significant role in the changes observed in these factors. Limited feedback was available from therapists about ways to improve the content and delivery of the clinical protocols as a result of the breadth of open-ended responses to survey questions about the utility of the manual. Nonetheless, positive feedback about the manual's ease of use suggests that it was written in a way that was understandable to those who did access it. Given the range in VR experience levels of therapists and the time constraints identified as a barrier to VR adoption, it is not surprising that individual therapists opted to access only specific sections of the manual to meet their immediate learning or clinical needs. A more structured feedback method, such as a Delphi process, is one potential strategy that could be used to extract opinion and obtain consensus from stakeholders to improve the content and delivery of knowledge products for future studies (Nworie, 2011). This strategy would enable a broader range of experts to contribute to the content and recommendations, allowing for a more representative and objective knowledge product that more effectively acknowledges contextual factors in different clinical settings (Matteo Hamilton & Breslawski, 1996; Rolls & Elliott, 2008). Furthermore, the AGREE II Instrument (AGREE, 2009) can be used to conduct a thorough appraisal of the manual and assist with the incorporation of findings gleaned from this research to improve the quality of the tool. A review of the literature is recommended at least every two years in order to integrate current research.

To increase the rate of access to the educational content provided in the manual, alternate methods of KT that more actively engage therapists in applying the content will be explored in future projects. These methods include an e-Learning module, a more comprehensive series of interactive education sessions involving practical application of VR to clinical scenarios with increasing complexity and skills, and mentoring support. These strategies have the potential to better engage therapists, and to facilitate their learning through more clinically relevant application of the information provided in the manual in order to address some of the corresponding gaps in knowledge they reported at posttest (Marinopoulos et al., 2007; Wensing et al., 2010). Furthermore, research suggests that therapists are generally accepting of web-based learning, which can increase the accessibility of learning opportunities while providing a more flexible self-paced learning experience (Bates, 1995; Stanton, 2001). Information gained from those who did use the manual will be used to refine its content and to inform the content and delivery of any associated knowledge tools or transfer mechanisms.

CHAPTER 11: Conclusions & Clinical Implications

11.1 Overall Conclusions

This theory-driven research represents the first study to quantitatively examine the social, personal, external and technology-specific barriers to VR use from the perspective of occupational, physical, recreation and rehabilitation therapists, and provides important insights into the use of VR within an ABI rehabilitation context. Based on data from this sample, important differences exist in the types of clients and the feasibility of VR treatment programmes that are being used in these rehabilitation settings as compared to those in published ABI research studies. Given the small sample size recruited from two health centres, the generalisability of these findings warrants further examination. However, the information gathered here from both paediatric and adult inpatient ABI rehabilitation settings serving province-wide populations has highlighted some important gaps that have not adequately been addressed in the research literature. Equipped with information about the usage trends, barriers and clinical populations that exist in current practice, researchers will be better positioned to design more clinically relevant outcomes research that can enhance the applicability of the evidence base from which therapists inform their practice.

The DTPB provided a useful theoretical framework by which to examine the determinants of VR use, and the ADOPT-VR survey developed for the study demonstrates potential as a responsive outcome measure for this purpose. While the most prominent and consistent barriers to therapists' use of VR over the course of the study remained client factors, including poor motivation or lack of appropriateness of the treatment approach, a number of perceived barriers are amenable to mediation. These include lack of time to learn and to use the system, lack of knowledge or educational opportunities, limited access to the system and to quality evidence supporting its effectiveness, and inadequate staffing support. Principal facilitators included peer influence or support from colleagues, the weekly scheduling of clients, assistance from support personnel, and involvement in research. These barriers and facilitators may be further explored within the local context to inform implementation efforts at other health centres.

Despite increases in therapists' self efficacy and perceived ease of use of the technology over the study period, and their overall positive intentions to use the technology more in the future at both evaluation points, additional research is needed to confirm the link between behavioural intention and actual use of VR, as well as to distinguish the relative impact of the different components of the KT intervention in relation to experience using the system. This latter research could inform future implementation efforts by improving the efficiency with which KT is provided. For example, identifying the most effective methods of KT could decrease the amount of time spent developing or refining written materials, or the time required of therapists to meet as a group if one-to-one methods proved to be most successful.

Although aspects of the clinical protocols manual were used by many therapists, a multi-method KT strategy that includes a series of clinically relevant educational opportunities of increasing information complexity may better meet the learning needs of novice VR users as they gain experience with the technology. Given the positive response of therapists to peer support, a mentoring model may also be of benefit. Feedback provided by therapists will contribute to the refinement of the content and delivery of future training initiatives.

11.2 Study Strengths & Limitations

11.2.1 Study Design

The primary limitation of this research was the study design used; while subjects were able to act as their own controls, the lack of randomisation did not allow causal inferences to be drawn about the intervention, because potential confounding influences, such as increasing experience using VR over the course of the study, were not controlled. The reasons for selecting a single group pretest-posttest design over a RCT related to the small population of ABI therapists using the GestureTek system from which to sample, and the logistics of recruiting a study coordinator and supporting the ethics application and data collection processes at a fourth rehabilitation centre, given the scope of the research as a Masters level project. As a result, this study provides preliminary evidence that may inform the design of subsequent more robust KT research. In particular, mixed-methods follow-up research would provide more opportunity for exploration about the perceived value of different aspects of the KT intervention from the perspective of therapists. While the use of qualitative data from therapists in the current study has added to the depth of understanding about their support and learning needs with respect to VR implementation, their involvement as stakeholders in shaping the nature of the KT intervention to meet their priority concerns, and their feedback about its effectiveness would have the potential to augment our understanding of the key ingredients in individual KT processes. Furthermore, such qualitative input may also help to identify the extent to which such interventions or supports might be useful to facilitate the adoption of other technologies or innovations in rehabilitation.

11.2.2 Sampling

The small sample represents another limitation to the study, particularly with respect to the range of analyses that could be conducted for the ADOPT-VR data, but also in terms of the generalisability of findings regarding the nature of clinical VR use. Progress had been made to recruit subjects from rehabilitation centres in three provinces across Canada in order to improve both the sample size and the external validity of results, although factors beyond the control of the researchers altered these plans. A larger project scope, or subsequent duplication research involving a broader range of ABI rehabilitation programmes would add strength to the findings. Nonetheless, as an emerging treatment approach, limited information exists in the literature on this topic; providing an indication of the nature of current practice in these settings, including an overview of relevant barriers, forms a foundation on which future research can be developed.

11.2.3 Outcomes

As described in Chapter 8, the use of self-report measures has the potential to introduce measurement bias in the form of misrepresentation, under- or overestimation, misinterpretation or transient beliefs (Borgatti & Carboni, 2007; Casper, 2007; Jimmieson et al., 2008). In addition, research from the field of psychology suggests that people are more likely to recall positive versus negative experiences (Berntsen, Rubin & Siegler, 2011). Despite these drawbacks, this evaluation method was felt to be the most efficient and feasible way of gathering empirical data about the perspective of therapists from a behavioural point of view. The use of a survey served to standardise the questions being asked, to maintain the anonymity of responses, and to allow respondents time to consider their answers, while eliminating the potential for bias as the result of interviewer interaction (Portney & Watkins, 2000).

The feasibility of measuring actual use (especially longitudinally) led to a study design in which measures of therapists' behavioural intention to use VR were assumed to approximate actual use, in keeping with the theoretical underpinnings of the DTPB. Follow-up research would be valuable to explore the frequency of VR use by therapists following completion of the study to test this prediction. In the absence of this data, medium to strong effect sizes found in correlational research in health care suggest that the predictability of the relationship between intention and behaviour is on par with that demonstrated for non-health professionals; this lends support for the predictive utility of intention, at least in circumstances in which external influences on behaviour are not substantial (Eccles et al., 2006). Consequently, one important consideration of any such extrapolation must be that therapists have access to appropriate and motivated clients, given the magnitude of this perceived barrier to VR use as reported by therapists.

This study was designed to examine actual practice in order to enhance its external validity. In this regard, co-intervention was not considered to be a negative factor, in that therapists in a clinical setting are typically able to collaborate with their colleagues when learning about and incorporating new treatment strategies into their practice. It was felt that discouraging or attempting to restrict this informal shared learning might have a negative impact on therapists' attitudes toward VR, which would represent an artificial negative effect on the outcomes under study, while misrepresenting actual clinical practice. In order to better understand the role of peer influence and mentoring on VR adoption, questions were included on the outcome measure to explore the extent to which these factors were relevant for therapists. Correspondingly, the pretest-posttest design functioned to eliminate contamination that could have been a significant threat in a RCT.

The sites of intervention were the therapists' own familiar clinical environments. These environments may have differed on a number of characteristics (e.g. the level of technology support provided, the availability of support staff, or the extent of organisational supports). Such characteristics may have influenced therapists' perceptions of their experiences with VR, and should be evaluated in future implementation efforts in order to determine their impacts on behavioural intentions and to identify the need for additional supports where feasible.

Based on the structure of the DTPB framework, an inherent assumption that other factors not represented by the theory are not significant influences on practice behaviour exists. Authors who have extended the TPB through the addition of relevant sub-constructs have challenged this assumption. The use of this theory was somewhat limiting in that it presented bias in the measurement of data that was confined to the theoretical constructs. Further research may identify additional factors of relevance to rehabilitation professionals and evaluate their relative influences on practice change and technology adoption. One limitation of the ADOPT-VR was that it did not include factors at the system level for which therapists may perceive little control, such as the cost of the equipment, which is reported in the literature as a valid drawback of VR incorporation in the clinical setting (Kramer et al., 2010). However, the measure did allow for the comprehensive measurement of the important barriers and facilitators to VR use from the perspective of therapists, as identified in the literature, and demonstrated the ability to detect change. The measure was modeled after existing technology adoption measures through the selection of accessible items with established psychometric properties that were published in the academic literature. Items were adapted to the research context in keeping with the theory developers' recommendations. The inclusion of open-ended questions on the outcome measure allowed for additional depth of understanding about the nature and significance of the barriers and facilitators to VR use in this clinical context.

Finally, it was not feasible to assess the responsiveness of the DTPB measure through pilot research prior to this study, given the small population of therapists from which to sample. As a result, the detection of pretest-posttest change during the study itself demonstrated support for the responsiveness of the ADOPT-VR and thus its validity for use as an outcome measure in the context of this study. This preliminary support is promising given the lack of research on the responsiveness of similar DTPB-based measures in the technology adoption literature. Further evaluation of the measure's psychometric properties will provide researchers with more confidence in it as a valid and reliable tool.

11.2.4 Data Analysis

Non-parametric statistical analysis methods were selected to evaluate change in the DTPB constructs of interest at posttest because of the non-normal distributions observed in the data. As a result, the range of statistical analyses available was smaller. For instance, the use of multivariate analysis of variance (MANOVA) to compare the interactions among the determinants of behavioural intention was precluded. However, a statistically significant difference was detected between pretest and posttest on the variables of interest despite the reduced power of non-parametric statistics. Given the smaller sample size, the research question was restricted so as to test a primary and secondary hypothesis, in order to reduce the likelihood of type I error resulting from multiple analyses. The small sample size also prevented separate analysis and comparison of data across groups, such as between therapists or clients in paediatric versus adult settings, novice versus more experienced VR users, and therapists who differed in their demographic characteristics, such as education level, profession or gender. Information about the extent of any differences across these groups may offer more detailed direction for those targeting the determinants of VR use to promote its uptake.

11.2.5 Dropouts

The therapist dropout rate for the study was 12%, while no client dropouts were observed. The reasons for therapist dropouts were changing jobs, being assigned to other clinical areas prior to completion of the study, or holding part-time positions resulting in an inability to recruit the required number of clients during the study period. Only one full-time therapist dropout failed to meet the client recruitment threshold. Consequently, dropouts were unlikely a significant threat to internal validity.

11.3 Clinical Implications

This research aimed to make VR more accessible as an intervention tool for therapists. The overall positive attitudes of therapists towards the technology are promising for those considering introducing VR in a similar rehabilitation setting. A holistic account of the barriers and facilitators to VR use identified through this research provides a preliminary means by which health services managers or clinical leaders can develop targeted supports or interventions to promote the use of VR. An awareness of these factors may help to endorse a multifaceted approach to facilitating supported practice change that encompasses personal, social, organisational, environmental and technology-specific considerations. An inventory of the learning needs of novice clinical VR users is also valuable in informing the development of KT initiatives to address these needs. Refinement of the protocols based on therapist feedback is one method by which this information can be applied to yield a more effective tool to assist therapists in applying VR in practice. In addition, the development of an interactive and clinically applied multi-stage training programme of increasing complexity should be considered for this purpose. Finally, researchers can ultilise the knowledge provided about current clinical use of the technology in the design of more clinically relevant evidence for therapists.

11.4 Future Research Directions

A wealth of opportunity exists for high-quality clinical research in the field of virtual rehabilitation, particularly during the acute phase of ABI rehabilitation. In particular, this study has identified a gap in the literature with respect to the recruitment of clinically relevant clients, which challenges the external validity of much of the available evidence for clinicians. Furthermore, the feasibility of research-based intervention protocols comes into question in light of the barriers identified by therapists in this study. Collaboration is currently underway to design ABI outcomes research in the inpatient rehabilitation setting with typical clients to contribute to the knowledge base.

This study has stimulated a number of additional research questions that merit further study. These directions include identifying client characteristics that cause therapists to perceive particular clients as being inappropriate for VR-based therapy, and exploring the influence of therapists' VR expertise on both client motivation and on the determinants of VR use in a sample with a broader range of experience using the system. In addition, comparing therapists' perceptions of low client motivation in this population with the perspectives of clients would provide valuable information about the congruency between these perspectives in the inpatient setting, as well as highlight ways to make VR more accessible to clients by enabling their further engagement in the rehabilitation process through a client-centred approach to treatment. Furthermore, a more thorough understanding of the nature and influence of time constraints on therapists' willingness to use VR may highlight ways in which organisational supports can be structured to reduce the impact of this barrier.

Additional theory testing would involve longitudinal research to monitor frequency of VR use to investigate the extent to which behavioural intention predicts actual use of VR. While further psychometric evaluation of the ADOPT-VR is underway to further verify its reliability and validity, a larger sample would allow for more complete evaluation, including confirmatory factor analysis. Refinement of the measure based on these evaluations will follow, with the aim of increasing its utility for researchers.

A working group of clinicians and researchers has been formed, with the task of converting therapist-identified rehabilitation goals for VR-based therapy into the Goal Attainment Scale format. This project will afford therapists with more efficient access to a compilation of specific, measureable goals that may be adapted for individual clients, and may be used as outcome measures in both the clinical and research settings. This information may also assist therapists in identifying clients who might best benefit from VR, by allowing them to match their targeted rehabilitation goals to the intervention. A KT plan will be developed to disseminate this goal bank to relevant stakeholders.

Based on therapist feedback, it is recommended that future research examining the effectiveness of KT initiatives to support VR use incorporate a multi-stage approach to training with increasing complexity, using practical applications of knowledge and skills to clinical scenarios. Collaboration with another research team is currently underway to further investigate the role of KT interventions, including the use of e-Learning modules, interactive education and mentoring on VR usage and clinical competencies.

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Appendix A: ADOPT-VR Posttest Survey

Therapist Survey

This survey should take approximately 15-20 minutes to complete.

Please circle the appropriate number for each question, and do not skip any questions.

Code: Date:

Virtual Reality – Gesturetek Health's Vivid GX/IREX Software

This survey relates specifically to the Gesturetek virtual reality system developed by Gesturetek Health. This system has been used as a rehabilitation tool by therapists for a range of client populations. The system consists of a computer, a viewing screen, a camera, a green background screen, and the Vivid GX/IREX software. Please answer the survey questions with this virtual reality system in mind. The first 3 questions ask about your general feelings toward the Gesturetek virtual reality system.

1. Using virtual reality in treatment sessions with my clients is a good idea.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

2. I would have fun using virtual reality in my practice.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

3. I like the idea of using virtual reality with my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Perceived Usefulness

The next questions ask you about the usefulness of the Gesturetek virtual reality system as a treatment tool.

4. Using virtual reality will result in improved functional outcomes for my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

5. Virtual reality provides variety for my clients in working towards their therapy goals.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Therapist Survey
Please circle the appropriate number for each question, and do not skip any questions.

6. Virtual reality adds something beyond what my conventional treatment approach could offer my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Perceived Ease of Use
The following questions relate to how easy you feel the Gesturetek virtual reality system is to use.

7. Using virtual reality with my clients requires minimal mental effort on my part.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

8. It is easy for me to become skillful in using virtual reality.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

9. I would find virtual reality easy to use.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Compatibility
The next 2 questions are about the virtual reality system and how compatible it is with your typical treatment approaches when working with clients.

10. Using virtual reality fits with the way I work.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

11. Using virtual reality fits with my practice preferences.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Therapist Survey
Please circle the appropriate number for each question, and do not skip any questions.

Experience
Please answer the following questions about your experience using virtual reality to date.

12. I have explored the Gesturetek IREX/Vivid GX software during work hours.
Yes No

12a. If Yes, please estimate the number of hours spent exploring, in total, without clients present: ____________________

13. How long have you been using the Gesturetek VR system with your clients? ________________________________

14. There are typically over 30 games in the Vivid GX software package. The number of these games with which I feel I am familiar enough to use in therapy sessions is: _______________

15. I have provided mentoring to others who are using/wanting to use virtual reality with their clients.
☐ Yes ☐ No ☐ Unsure

Social Norms
The following questions ask about social influences related to your work.

16. Those whose opinions I value would prefer that I use virtual reality with my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

17. My colleagues think I should use virtual reality with my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

18. I feel I am keeping up with my colleagues in my use of virtual reality with clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Therapist Survey
Please circle the appropriate number for each question, and do not skip any questions.

19. My supervisor thinks I should use virtual reality with my clients.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

20. I will have to use virtual reality in my practice because my supervisor requires it.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Perceived Behavioural Control

The next few questions ask you about your beliefs about both internal (e.g. knowledge, skills) and external factors (e.g. supports) that may or may not affect your ability to use virtual reality with your clients.

21. I have the knowledge to make use of virtual reality in my therapy sessions.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

22. I have access to the resources and opportunities I need to use virtual reality.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Self-Efficacy

This section asks you to think about your confidence in using the virtual reality system with your clients to address their rehabilitation goals.

23. I feel confident in my ability to create client programs using virtual reality.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

24. Please describe any areas in which you may be lacking confidence with respect to using virtual reality with your clients: ________

____

____

Therapist Survey

Please circle the appropriate number for each question, and do not skip any questions.

Facilitating Conditions or Barriers

The next set of questions asks about external factors that may or may not affect your use of virtual reality.

25. I have the time to use virtual reality.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

26. I feel that I have the technology support I need to use virtual reality in my practice.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

27. I see the following as barriers to my use of virtual reality in my practice (**check all that apply**):

- ☐ lack of time to learn how to use the virtual reality system
- ☐ the time required to use virtual reality in a treatment session
- ☐ lack of access to evidence on virtual reality's effectiveness
- ☐ poor quality of evidence to support the use of virtual reality
- ☐ lack of educational opportunities related to virtual reality
- ☐ lack of appropriate clients with which to use virtual reality
- ☐ treatment space issues (e.g. lack of dedicated space for virtual reality equipment, room scheduling conflicts)
- ☐ poor motivation of clients to participate
- ☐ Other: ____________________

28. The most significant barrier to my use of virtual reality is: ____________________

____

29. What has helped you to incorporate virtual reality into your practice? ____________________

____

Intention to Use Virtual Reality

The next questions relate to your motivation to use virtual reality in your daily practice in the future.

30. I intend to use virtual reality for therapy as often as needed.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

31. To the extent possible, I would use virtual reality in therapy frequently.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

Therapist Survey
Please circle the appropriate number for each question, and do not skip any questions.

32. I plan to increase the amount that I use virtual reality in my practice.

1	2	3	4	5	6	7	8	9
Strongly Disagree								Strongly Agree

33. What are the reasons behind your intention to use/not use virtual reality in the future? ________________________________
____
____
____

Demographic Information
The next questions ask for information about you and your clinical experience.
Please check the appropriate box(es) for each question.

34. Gender: M F

35. Profession:
Occupational Therapist Physiotherapist Behavioural Therapist Speech-Language Pathologist
Recreation Therapist Rehabilitation Therapist, OT or PT Aide, or Rehabilitation Assistant
Other: ____________________

36. My highest academic degree or diploma is:
Certificate/Diploma Bachelor's Degree (e.g. BSc) Research Masters (e.g. MSc)
Clinical Masters (e.g. MOT, MPT, MRSC) PhD Other: ____________________

37. # years of experience as a therapist/aide/RA: ____________

38. My clients range in age from (**check all that apply**):
Birth to 2 years 2-5 years 5-13 years 13-19 years 19-65 years 65+ years

39. # clients on my caseload per year with acquired brain injury: _____________

40. # years experience working with clients with acquired brain injury:_____________

Therapist Survey

Feedback on the Clinical Protocols
The last series of questions asks for your input regarding the clinical protocols provided to you at the start of the study.

1. Which aspects of the clinical protocols did you use **(check all that apply)?**
   Evidence summary on VR   Assessing Virtual Rehab Readiness   Setting Appropriate Rehab Goals
   Developing Client Programs   Grading for Participation & Progress   Measuring Client Performance
   Appendix 1: Tips for setting up the system   Appendix 2: Sample Scripts for Therapists
   Appendix 3: Activity Tracking Sheet   Appendix 4: Software Parameter Grading
2. What about the protocols did you find helpful? ____
   ____
   ____
   ____
   ____
3. What was not helpful? ____
   ____
   ____
   ____
   ____
4. What was missing? ____
   ____
   ____
   ____
   ____
5. Other recommendations for improvement: ____
   ____
   ____
   ____
   ____

Thank you for your time and participation!
Please return your completed survey to the study coordinator.

Appendix B: Client Tracking Sheet

Assessment Sheet for Virtual Rehabilitation (VR)

Therapist Code: ____________________ Profession: __________________

Client Subject Code:
Birth Month:
Birth Year:

Mechanism of Brain Injury[1]: ____________ GCS at Time of Injury: ____ (Glascow Coma Scale) Date of Injury: _____________ Date of Admission: _________

CLIENT ASSESSMENT	At Onset of VR Therapy	At Goal Change #1 (if applicable)	At Goal Change #2 (if applicable)	At Goal Change #3 (if applicable)	At End of VR Program
Date					
LEVEL OF CONSCIOUSNESS (LOC)[2] Select scale used (see over): Rancho Pediatric Scale Rancho Adult Scale					
Rancho Level					
BEHAVIOUR					
Briefly describe current behaviour					
PHYSICAL SKILLS					
Upper Extremity Functional Use	**Left Right** Independent Support req'd Unable	**Left Right** Independent Support req'd Unable	**Left Right** Independent Support req'd Unable	**Left Right** Independent Support req'd Unable	**Left Right** Independent Support req'd Unable
Support Required to Sit	from head down from trunk down at pelvis none (static) none (dynamic)	from head down from trunk down at pelvis none (static) none (dynamic)	from head down from trunk down at pelvis none (static) none (dynamic)	from head down from trunk down at pelvis none (static) none (dynamic)	from head down from trunk down at pelvis none (static) none (dynamic)
Transfers (e.g. bed to chair or wheelchair)	Independent Standby assist 1 person assist Total support	Independent Standby assist 1 person assist Total support	Independent Standby assist 1 person assist Total support	Independent Standby assist 1 person assist Total support	Independent Standby assist 1 person assist Total support
Ambulation	Independent Standby assist 1 person assist Walking aide Unable Other: _________	Independent Standby assist 1 person assist Walking aide Unable Other: _________	Independent Standby assist 1 person assist Walking aide Unable Other: _________	Independent Standby assist 1 person assist Walking aide Unable Other: _________	Independent Standby assist 1 person assist Walking aide Unable Other: _________

Therapist Code: ____________ Thank you for your time!
Version 2 June 3, 2011 **Please return your completed forms to the study coordinator.**

Assessment Sheet for VR: SCALES & DESCRIPTORS

Mechanism of Brain Injury[1]:

Non-Traumatic:	Traumatic:
Encephalitis	Motor Vehicle Accident
Tumor	►Passenger
Meningitis	►Pedestrian
Metabolic	►Cyclist
Stroke	►Driver
Cardiac Event	Assault
Toxicity	Fall
Anoxic/hypoxic e.g. near drowning	Other: ___________
Arterio-venous malformation (AVM)	
Other: ___________	

Current Level of Consciousness (LOC)[2]:

PEDIATRIC Rancho Los Amigos LOC Scale (birth to 12 years)		
Level	**Response**	**Description**
5	None	No response to stimuli
4	Generalized response to sensory stimuli	Startles to loud sound, generalized reflex response to painful stimuli.
3	Localized response to sensory stimuli	Blinks when strong light crosses field of vision, follows moving object passed within visual field, turns towards or away from loud sound, localized response to painful stimuli.
2	Responsive to environment	Follows simple verbal or gestured requests, initiates purposeful activity, actively participates in therapy, imitates examiners facial expressions.
1	Orientated to time & place; is recording ongoing events	Can provide accurate, detailed information about self and present situation, knows way to and from daily activities, knows sequence of daily routine, bowel and bladder trained.

ADULT Rancho Los Amigos LOC Scale (mature 12 years and older)		
Level	**Response**	**Description**
1	None	Patient does not respond to external stimuli and appears asleep.
2	Generalized	Patient reacts to external stimuli in nonspecific, inconsistent, and non-purposeful manner with stereotypic and limited responses.
3	Localized	Patient responds specifically and inconsistently with delays to stimuli, but may follow simple commands for motor action.
4	Confused, Agitated	Patient exhibits bizarre, non-purposeful, incoherent or inappropriate behaviours, has no short-term recall, attention is short and nonselective.
5	Confused, Inappropriate Non-agitated	Patient gives random, fragmented, and non-purposeful responses to complex or unstructured stimuli. Simple commands are followed consistently, memory and selective attention are impaired, and new information is not retained.
6	Confused, Appropriate	Patient gives context appropriate, goal-directed responses, dependent upon external input for direction. There is carry-over for relearned, but not for new tasks, and recent memory problems persist.
7	Automatic, Appropriate	Patient behaves appropriately in familiar settings, performs daily routines automatically, and shows carry-over for new learning at lower than normal rates. Patient initiates social interactions, but judgment remains impaired.
8	Purposeful, Appropriate	Patient oriented and responds to the environment but abstract reasoning abilities are decreased relative to pre-injury levels.

Client Program Tracking Sheet for Virtual Rehabilitation (VR)

Client Subject Code:
Birth Month:
Birth Year:

Therapist Code: ____________________ Profession: ________________

Client Goals At Onset of VR Therapy (list up to 4 goals)		Date Achieved	Did VR facilitate meeting goal?
1.			Yes No
2.			Yes No
3.			Yes No
4.			Yes No

Client Program At Onset of VR Therapy	Date:			
# therapists for client's sessions:	Primary position used for VR sessions: Sits in wheelchair Sits on chair/bench Stands with support Stands independently	Games used at onset:	Avg frequency of VR sessions (per week):	Avg session length (in minutes):
Client Response to VR:				

Date VR therapy discontinued (if applicable): ____________________

Reason(s) VR therapy discontinued: (check all that apply):

Client discharged
Goals achieved
Inappropriate for client
Therapist comfort with VR
Other goals took priority
Therapists' time constraints

Other: ____

Therapist Code: __________
Version 2 June 3, 2011

Thank you for your time!
Please return your completed forms to the study coordinator.

Client Program Tracking Sheet for Virtual Rehabilitation (VR)

Client Subject Code:
Birth Month:
Birth Year:

Therapist Code: ____________________ Profession: ____________________

Client Goals At Goal Change #1 (if applicable - list up to 4 goals)		Date Achieved	Did VR facilitate meeting goal?
1.			Yes No
2.			Yes No
3.			Yes No
4.			Yes No

Client Program At Goal Change #1 (if applicable)	**Date:**			
# therapists for client's sessions:	Primary position used for VR sessions: Sits in wheelchair Sits on chair/bench Stands with support Stands independently	Games used at onset:	Avg frequency of VR sessions (per week):	Avg session length (in minutes):
Client Response to VR:				

Date VR therapy discontinued (if applicable): ____________________
Reason(s) VR therapy discontinued: (check all that apply):

Client discharged
Goals achieved
Inappropriate for client
Therapist comfort with VR
Other goals took priority
Therapists' time constraints

Other: ____________________

Therapist Code: ____________
Version 2 June 3, 2011

Thank you for your time!
Please return your completed forms to the study coordinator.

Client Program Tracking Sheet for Virtual Rehabilitation (VR)

Client Subject Code:
Birth Month:
Birth Year:

Therapist Code: ____________________ Profession: ____________________

Client Goals At Goal Change #2 (if applicable - list up to 4 goals)		Date Achieved	Did VR facilitate meeting goal?
1.			Yes No
2.			Yes No
3.			Yes No
4.			Yes No

Client Program At Goal Change #2 (if applicable) **Date:**				
# therapists for client's sessions:	Primary position used for VR sessions: Sits in wheelchair Sits on chair/bench Stands with support Stands independently	Games used at onset:	Avg frequency of VR sessions (per week):	Avg session length (in minutes):
Client Response to VR:				

Date VR therapy discontinued (if applicable): ____________________
Reason(s) VR therapy discontinued: (check all that apply):

Client discharged
Goals achieved
Inappropriate for client
Therapist comfort with VR
Other goals took priority
Therapists' time constraints

Other: ____

Therapist Code: ____________	Thank you for your time!
Version 2 June 3, 2011	**Please return your completed forms to the study coordinator.**

Client Program Tracking Sheet for Virtual Rehabilitation (VR)

Client Subject Code:
Birth Month:
Birth Year:

Therapist Code: ____________________ Profession: ________________

Client Goals At Goal Change #3 (if applicable - list up to 4 goals)		Date Achieved	Did VR facilitate meeting goal?
1.			Yes No
2.			Yes No
3.			Yes No
4.			Yes No

Client Program At Goal Change #3 (if applicable)	**Date:**			
# therapists for client's sessions:	Primary position used for VR sessions: Sits in wheelchair Sits on chair/bench Stands with support Stands independently	Games used at onset:	Avg frequency of VR sessions (per week):	Avg session length (in minutes):
Client Response to VR:				

Date VR therapy discontinued: ____________________
Reason(s) VR therapy discontinued: (check all that apply):

Client discharged
Goals achieved
Inappropriate for client
Therapist comfort with VR
Other goals took priority
Therapists' time constraints

Other: ____

Therapist Code: ____________ Thank you for your time!
Version 2 June 3, 2011 **Please return your completed forms to the study coordinator.**

Appendix C: Education Session Outline

1. Introduction to the GestureTek virtual reality (VR) system
    a. Set-up tips
    b. Features
    c. Available activities
2. Applications of the system for acquired brain injury rehabilitation (including clinical vignettes)
3. Overview of the Clinical Protocols Manual
    a. Setting appropriate rehabilitation goals for VR-based therapy
    b. Developing client programs
    c. Grading activities to meet clients' needs
    d. Tracking client progress
4. Questions, discussion and demonstration requests