The influence of virtual reality play on children's motivation

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Key words

▪ Paediatric occupational therapy ▪ Virtual reality ▪ Cerebral palsy

Abstract

***Purpose**. This study explored the degree of motivation children exhibit during virtual reality (VR) play sessions. **Method**. Sixteen children with cerebral palsy aged 8 to 12 years participated. They were observed during a variety of VR environments that were video recorded. The Pediatric Volitional Questionnaire (PVQ) was used to measure children's motivation. The PVQ provides insights into children's inner motives as well as how the virtual environment enhances or attenuates children's motives. Nine VR environments were randomly selected to score with the PVQ. **Results**. Data were analyzed and descriptive statistics were calculated for modes and medians of total volition scores for each VR environment. Different environments produced varying levels of volitional behaviour. The features of environments that produced higher levels of volition included challenge, variability and competition. **Practice Implications**. The overall volitional scores of children with cerebral palsy in the current study indicate that VR play is a motivating activity and thus has potential as a successful intervention tool.*

Résumé

***But**. Cette étude examinait le degré de motivation manifesté par des enfants pendant des séances de jeux en réalité virtuelle. **Méthodologie**. Seize enfants atteints de paralysie cérébrale et âgés de 8 à 12 ans ont participé à l'étude. On a observé et enregistré ces enfants sur bande vidéo pendant qu'ils jouaient dans divers environnements de réalité virtuelle. Le Pediatric Volitional Questionnaire (PVQ) a été utilisé pour mesurer la motivation des enfants. Le PVQ jette une lumière sur les motivations intérieures des enfants, de même que sur les façons dont l'environnement virtuel rehausse ou atténue les motivations des enfants. Neuf environnements virtuels ont été choisis au hasard et cotés au moyen du PVQ. **Résultats**. Les données ont été analysées et des statistiques descriptives ont été calculées afin de déterminer les modes et les médianes des scores de volition, pour chaque environnement virtuel. Les différents environnements ont produit des degrés divers de comportement volitif. Les caractéristiques des environnements ayant produit les plus haut degrés de volition étaient, notamment, le degré de difficulté, la variabilité et la compétition. **Conséquences pour la pratique**. Dans cette étude, l'ensemble des scores de volition des enfants atteints de paralysie cérébrale indique que le jeu en réalité virtuelle est une activité motivante qui pourrait s'avérer un outil d'intervention efficace.*

The Model of Human Occupation (MOHO) conceptualizes the individual as three subsystems comprised of volition, habituation, and performance (Kielhofner, 1995). These subsystems along with the environment influence occupational performance. Volition is often referred to as being the most important subsystem in determining an individual's engagement in occupation (Haglund & Kjellberg, 1999). Volition is defined as "a collection of dispositions and self-knowledge that predisposes and enables persons to anticipate, choose, experience, and interpret their occupational behaviour" (Kielhofner, 1995, p. 30).

Volition is a key element in determining the level of participation an individual will have in an occupation. In Kielhofner's model, the purpose of the volition subsystem is to guide one's choice of occupational behaviour and their motives behind that behaviour. An individual usually chooses an activity they find enjoyable, challenging and engaging. Since participation in therapy is highly dependent on motivation and play is the major occupational behaviour of children, it is important to explore the characteristics in therapeutic play environments that are motivating and that engage children with cerebral palsy as active participants.

The current study used VR as the therapeutic play environment because of its accessibility to children with physical disabilities. This study examines a virtual play environment to determine if it supports the expression of volitional or

motivational behaviours in children with cerebral palsy, to provide insight into the clinical utility and value of virtual play as an intervention strategy.

Literature review

Play is often described as both the earliest occupational behaviour and as the primary occupation of children (Reilly, 1974; Vandenberg & Kielhofner, 1982). It is regarded as the most effective setting in which to assess motivational characteristics and behaviours in children (Basu, Kafkes, Geist & Kielhofner, 2002). In order for an activity to be defined as play, it must contain these five essential characteristics: intrinsic motivation, free choice, pleasure, non-literal and active engagement (Rubin, Fein & Vandenberg, 1983).

Several different theories have proposed the contributions of play to the developing child. Piaget's theory of cognitive development regards play as a tool for intellectual growth (Piaget, 1962). Play may also have an ego-building function; through the facilitation of physical and social development, play can enhance a child's self-esteem (Bjorklund & Brown, 1998; Eppright, Sanfacon, Beck & Bradley, 1997; Erikson, 1963). Vygotsky (1976) added a new dimension on play emphasizing that the effects of play on a child's development cannot be fully understood without considering the context of the play experience.

Children with disabilities have a more restricted play experience than able-bodied children (Howard, 1996). In a study conducted by Okimoto, Bundy and Hanzlik (2000) there were significant differences in playfulness of young children with cerebral palsy or developmental delays when compared to young children with no disabilities. Howard (1996) found that accessibility was a barrier for children with disabilities that led to decreased participation in leisure activities.

Virtual reality play potentially offers children with disabilities the opportunity to participate in games otherwise inaccessible. Virtual reality (VR) is defined as an immersive and interactive three-dimensional computer experience that responds to user's movements occurring in real time (Pimentel & Teixeira, 1994). In its finest form, VR produces computer-generated real life experiences. With computers becoming more readily available, usage has increased within households, schools and health care facilities. Virtual reality offers a variety of people an interactive environment in which they can play, learn and develop skills.

The effectiveness of VR use with children of all abilities is currently being explored. McComas, MacKay and Pivik (2002) examined the efficacy of a desktop VR program on the education and training of children to safely cross intersections. The sample consisted of 48 fourth- to sixth-grade students. Participants learned safe street-crossing within a virtual environment by learning to stay on the sidewalk, stop at the curb, look left-right-left, and remain vigilant while crossing the road. Results showed significant changes in performance after three trials with the VR intervention and some generalization to actual street-crossing behaviour.

Another study illustrates that VR is effective in teaching children with and without disabilities about accessibility and attitudinal barriers. Pivik, McComas, Macfarlane and Laflamme (2002) conducted a controlled pretest/post-test study where 60 children were required to manipulate a virtual wheelchair through a virtual environment where they were exposed to both environmental and attitudinal barriers. This experience resulted in increasing children's knowledge of accessibility barriers. Although gains were made in both studies, skills were not generalized successfully across all study participants. This may indicate that desktop VR lacks the realism of more sophisticated VR systems such as immersive reality.

The following two studies used immersive VR systems with an accompanying head-mounted tracking device. Cho et al. (2002) found that VR-enhanced cognitive training was more effective than standard cognitive training or no training at all for teenagers with attention and behaviour difficulties. This was determined by an increased level of attention demonstrated during the post-test of a continuous performance task in the VR-enhanced cognitive training group. Immersive VR with head-mounted devices has also been used with children of lower cognitive functioning. Strickland, Marcus, Mesibov and Hogan (1996) wrote two case studies showing that children with moderate autism tolerated a head-mounted immersive VR system and that these two children displayed indications of engagement by verbally labeling objects and colours in the virtual environments. In addition, the children tracked moving objects in the environment with eyes, head and body turning. However, these two cases were taken from a larger study sample of children with autism who may not have tolerated the head-mounted device. Invasive tracking devices used with VR limit those with physical disabilities or severe sensory dysfunction from participating. For individuals to get the most out of a VR interaction they cannot be restricted by the equipment of the system itself. There have been reported problems with using head mounted displays such as motion sickness and dizziness.

The current study described in this paper is innovative in two ways. First, motivation to participate in VR has not been explored for children with disabilities. Second, the VR system is fully immersive which overcomes many of the problems with other systems. The current study used a VR intervention to explore if with the provision of virtual environments, children with cerebral palsy expressed more volitional behaviours and how this expression of volitional behaviours changed with the different environmental contexts.

The purpose of the current investigation is, therefore, to explore if VR play is a good motivator to use as a form of intervention for children with cerebral palsy. Further, the

study will examine: a) whether certain virtual environments are more motivating than others; b) the characteristics of motivating virtual environments; and c) the behavioural indicators of volition most elicited by virtual reality.

Method

Participants

Children were recruited from a database of children who were attending a large rehabilitation centre in the Greater Toronto Area. Families of children diagnosed with cerebral palsy between the ages of 8 and 12 were contacted to participate in a larger randomized control trial examining the impact of virtual reality on children with cerebral palsy. Thirty-two families agreed to participate and the children were randomly assigned to either a control group or a treatment group. A total of 16 participants made up the treatment group and they were included in the sample for the current study. All the participants had normal or corrected vision and average intellectual functioning. Children were receiving occupational or physical therapy an average of 1 or 2 times a month in addition to receiving the VR. All children were assessed for gross motor function using the model of gross motor function for children with cerebral palsy (Palisano et al., 2000). Consent was obtained from the parents and verbal assent was obtained from the children prior to the commencement of the study (see Table 1).

TABLE 1
Demographic Data (N=16).

Characteristics		Male N=10	Female N=6
Age		M = 9.6 SD = 1.07	M =10.6 SD = 1.97
Diagnoses	Spastic	4	2
	Quadriplegic	4	1
	Spastic Diplegic	0	1
	Hemiplegic	1	0
	Athetoid	1	2
Grade level	2	1	0
	3	3	2
	4	2	1
	5	3	1
	6	1	0
	7	0	2
Gross motor level score (Palisano et al., 2000)	1	3	3
	2	0	0
	3	4	1
	4	1	0
	5	2	2
Mobility status	Wheelchair user	7	2
	Walker	0	1
	No aid	3	3

Instruments

Virtual reality apparatus

In order to provide the most realistic computer interaction, a projected virtual reality system was chosen for the current study. This system allows the children to watch themselves being projected into a virtual world. The projected virtual reality system used in the current study is the 1996 patented Mandala R Gesture Xtreme Virtual Reality™ system developed by Vivid Group Inc. A video camera is used to capture and track the user placing them within a VR environment. The user is free from any devices they might have to wear, touch or hold. When the children reach with their arm or bend at the waist, they are able to score points or manipulate animations (e.g. playing soccer, making a painting) through the system's video gesture capability (see Figures 1 and 2).

Observational assessment tool

The occupational behaviour that the current study explores is play. The Pediatric Volitional Questionnaire (PVQ) examines how a child engages in various occupational behaviours (Basu et al., 2002). The PVQ was used to assess volition. The questionnaire is an observational tool designed for young children engaged in free play. Research indicates that aspects of volition are developed as young as 18 months and that by 2 years children begin to derive pleasure from producing outcomes, and are more systematic in problem-solving tasks (Bullock & Lutkenhaus, 1989; Basu et al., 2002). As volition cannot be directly observed, the questionnaire is broken down into indicators. This allows individuals to make inferences about volition through observation. Examples of some of the behavioural indicators of volition include: tries to solve problems, expresses pleasure and seeks challenges.

Preliminary results using the PVQ indicate that the questionnaire demonstrates good construct validity (Anderson, 1998; Basu, 2002). The PVQ has been Rasch analyzed (Andersen, 1998; Basu et al., 2002). The PVQ is designed to provide insight into a child's inner motives as well as information about how the environment enhances or attenuates the child's volition. The PVQ is most appropriately used for school-aged children and the intended population encompasses a continuum of physical and cognitive abilities.

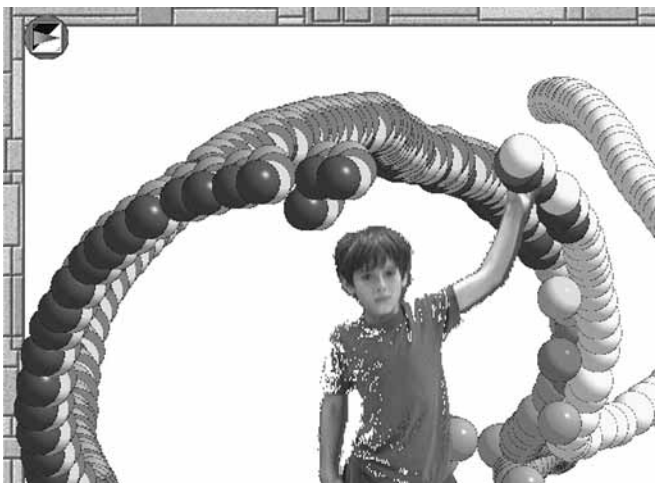
It is recommended that a child's volition be observed in many different environments and that the activities include an opportunity for social interaction. There are 14 behavioural indicators of volition within the PVQ rated on a 4-point scale. The highest score of four points indicates *spontaneous* for which the child must have shown the behaviour without support, structure or stimulation. A score of 3 or *involved* indicates that the child demonstrated the behaviour with a minimal amount of support, structure or

FIGURE 1
Soccer application.

stimulation. A score of 2 or *hesitant* indicates that the child demonstrates the behaviour with maximal amount of support, structure or stimulation. A *passive* response receives a score of 1 point and indicates that the child does not demonstrate the behaviour even with support, structure or stimulation. As the PVQ is primarily used for observing children in free play environments, some modifications were made to the behavioural indicators of the instrument so that it could be used accurately in a virtual environment.

The PVQ defines the behavioural indicator item 12, organizes/modifies environment, as the child makes changes within his or her environment to meet a need and/or increase the interaction with the environment, such as removing barriers/toys/materials that interfere with the activity. This item was relevant if the child asked the research assistant (RA) to restart a game on the computer. Because the VR intervention was not self-administered (the RA operates the computer system), and it was inappropriate for the children to remove barriers/toys/materials (as there were none in the vicinity), a participant was given a score of spontaneous if they independently asked the RA to modify the VR environment for them. Examples of typical questions include: can you move me closer to the net, or birds and balls is stuck, can you restart the game? Even though the RA made the physical change in the environment, it was the participant who independently identified the need for change.

FIGURE 2
Paint application.



The items in the PVQ can be found in Table 2. A copy of the ratings is in Appendix A.

Procedure

The participants individually completed eight one-hour sessions of virtual reality play intervention. Each intervention session began with the game Birds and Balls. After this play intervention, the participants were free to select the games they wanted to play. As each game offered a new environment, the number of environments a participant engaged in during a typical treatment session ranged from 5 to 10. All 128 VR sessions were videotaped. The author and another RA controlled the computer system and facilitated the VR sessions. During the intervention sessions, the role of the RA was to encourage the participant, give appropriate cues to facilitate expression of the behavioural indictors of volition in the virtual environment and at times be the participant's opponent or partner.

Data analysis

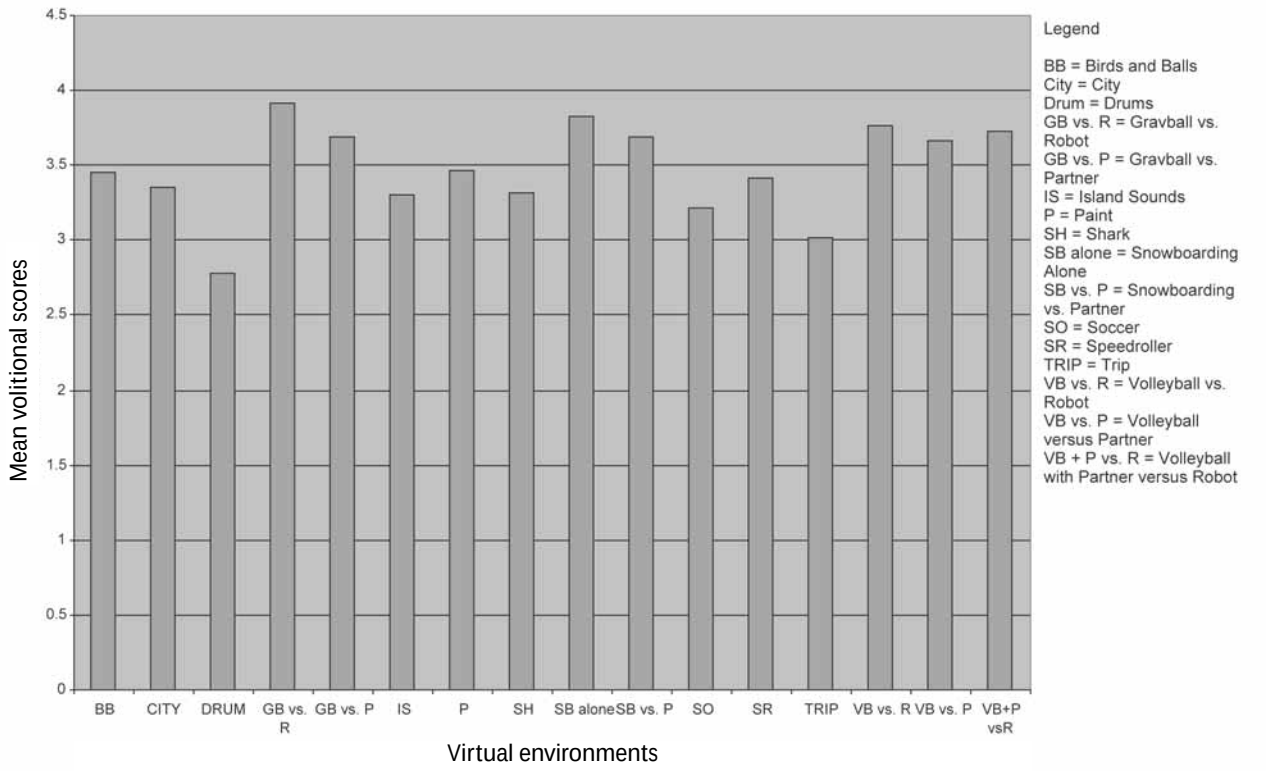
Treatment sessions and trials within each session were randomly selected for analysis using a random numbers table. For the purposes of clarity, VR environments will be referred to as virtual reality trials (VRT). For each participant, nine VRTs were chosen for data analysis. The types of VRTs therefore varied across participants. The VRTs ranged in duration from 2 minutes, 30 seconds to 17 minutes, 30 seconds (mean = 7 minutes).

The first author independently coded 16 participants using the PVQ. Since we did not re-Rasch the item scores, we did not calculate means and use them in the analysis. Instead we computed the mode and median scores for each item and for the overall PVQ.

Results

Children with cerebral palsy in the current study achieved volition item ratings ranging from 1.89 to 4.00 with over 50% of the items scoring 3 or above. The mode and median overall were 4 and 3.63 indicating a high level of volition. Table 2 presents the item mode and median scores. Figure 3, 4, 5 and 6 show the volitional scores of all the PVQ items.

FIGURE 3
Scores of PVQ items.



Discussion

There are some common elements found in the VR environments that yielded volition. The first element was variation in the game. Games that offered more variety appeared to produce volition. The item "tries new things" typically scored 4, reflecting that children were willing to play new activities. Variation resulted in an unpredictable environment that required continuous concentration and readiness on the part of the child. For example, in the game Gravball, children were required to stop balls from coming into their net. The balls however, come from various parts of the screen and were fast moving. There is no predictable pattern of movement of the balls and this produces a game that was constantly changing. Variable environments are also challenging, which led to the fulfillment of the second element.

When a child engages in an activity that is slightly above his or her skill level there is a higher degree of challenge. The item "stays engaged" typically scored over 3 reflecting that children were engaged in the VR play. The item "is task directed" also indicated the ability of the children to remain focused on the activity. Aspects of the VR environment can also increase the challenge, such as when a child cannot predict their next move or when a child has to develop a strategy to better interact with the environment. When a child is challenged they are required to use a higher level of concentration in order for the game to be satisfying. If the game is either too challenging or too easy they may become frustrated. This can explain why some of the VR games may have been too difficult for the children and yielded lower volitional scores. City was a game where the children were required to fly a plane through a virtual city. The graphics in the game were very realistic and complex, and the music was appealing, however, the plane was too difficult to control and land on targets.

The third characteristic of VR games yielding higher volitional scores was competition. The virtual environments where the children were able to play against a robot or another player such as volleyball or snowboarding appeared to be more motivating. Playing a game that was competitive encouraged children to establish concrete goals (e.g. beating the robot), which also increased the level of challenge.

Other behavioural indicators that were observed to have high scores of over 3 were "initiates actions" and "pursues activity to completion", "tries to produce effects" and organizes/modifies the environment. "Pursues activity to completion" is of particular interest because it indicated that VR play appears to be motivating enough for a child to persevere through to the end of a game regardless of the VR environment. We observed that the children were actively and intentionally engaged with the VR system. Children were capable of making changes to the VR by simply asking the research assistant to modify the game, for example having

FIGURE 4
Scores of PVQ items.

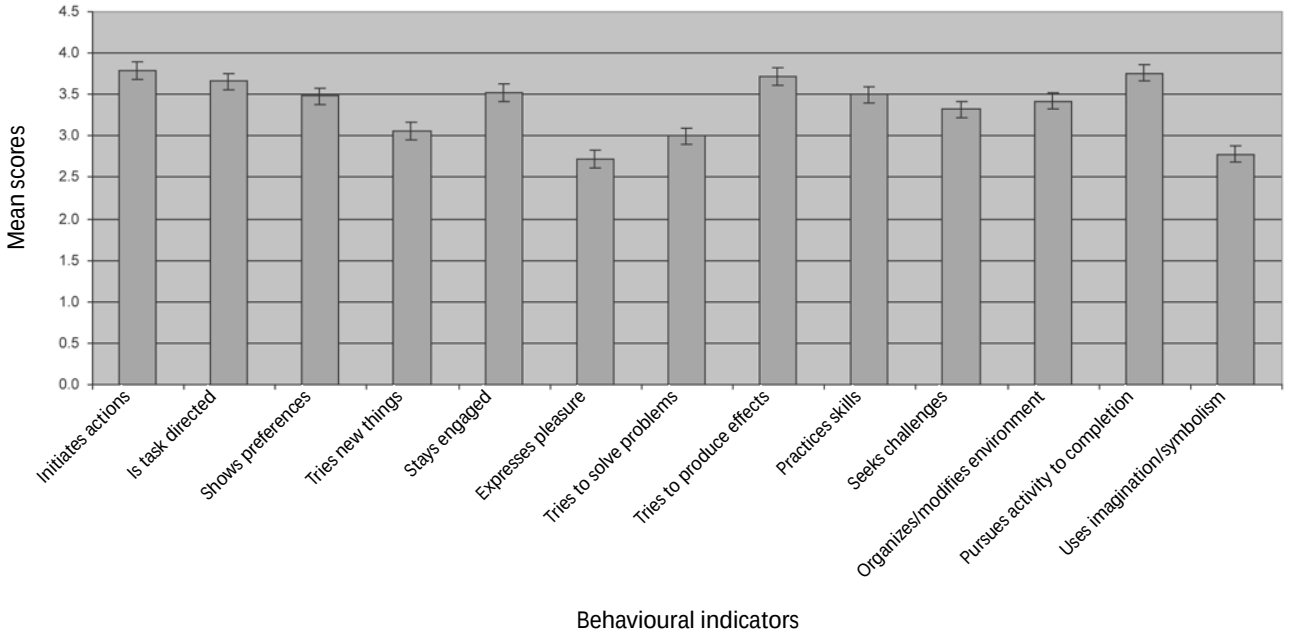


FIGURE 5
Scores of PVQ items.

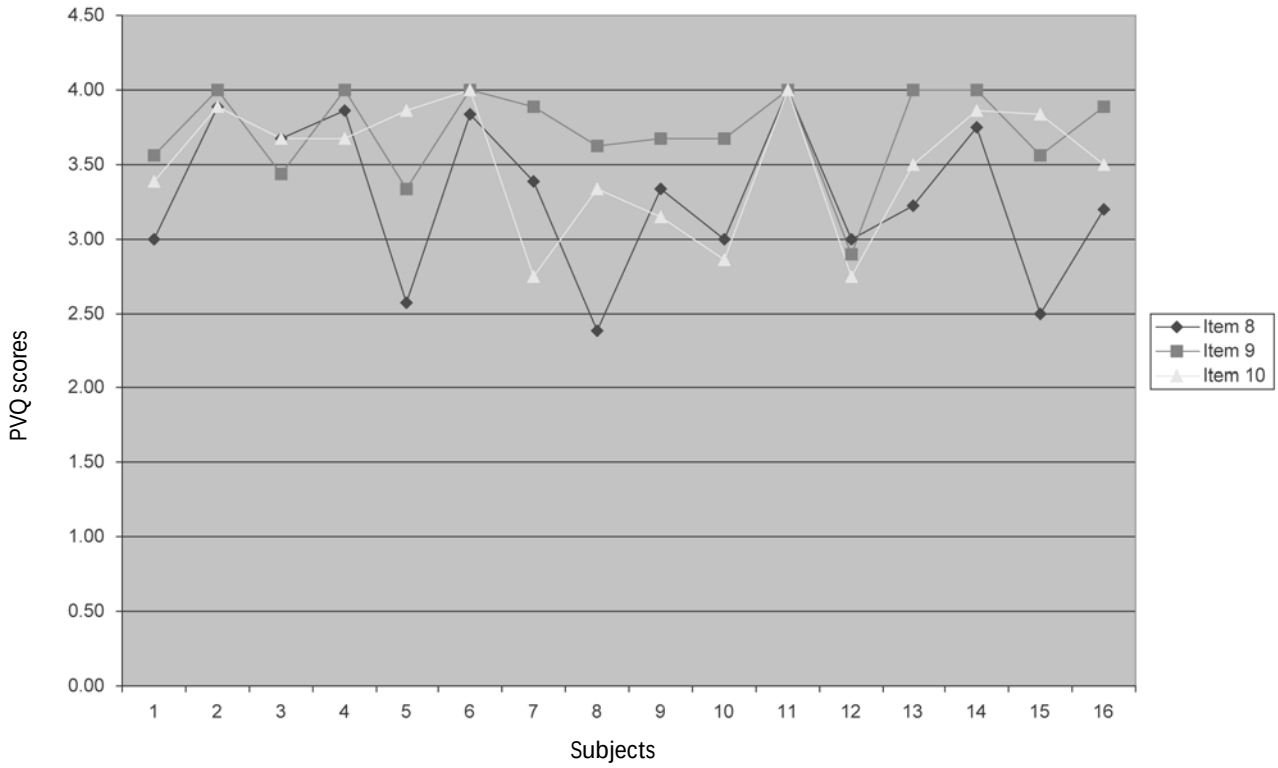
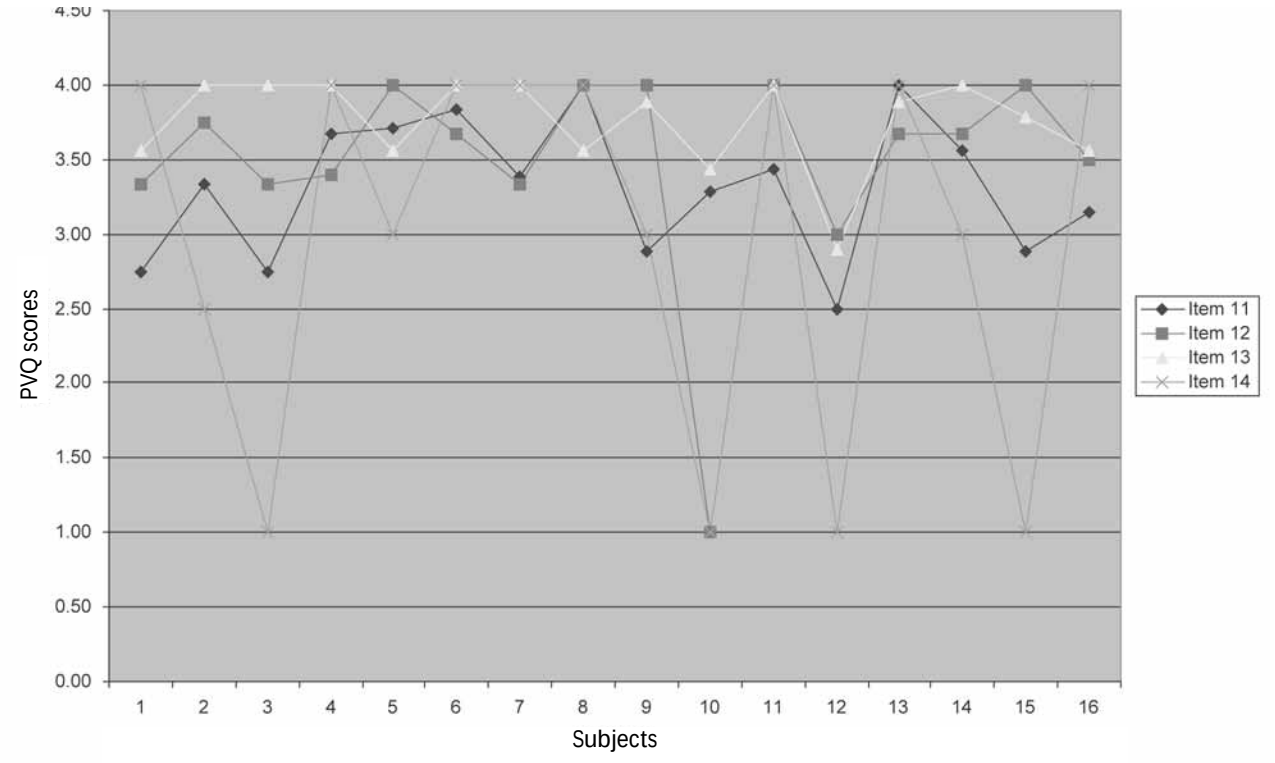


FIGURE 6
Scores of PVQ items.



more balls, increasing the speed, etc. When they were playing they were able to have an effect on the activity, for example in volleyball, if they wanted to score a point they had to aim the ball over the net to the opponent's side. There are several examples of ways that they produced effects.

The behavioural indicator "expresses pleasure" was scored lower than a 3 indicating a hesitant level. The lower score for "expresses pleasure" may be related to the strict scoring criteria of this behavioural indicator. When participants were engaged in a virtual environment they often displayed serious expressions (likely reflecting concentration) and did not express observable indicators of pleasure (e.g. smiling, laughing) until the end of the VRT. However, since it appeared that the participants were not expressing pleasure for at least 75% of the session they could not be given a score of spontaneous regardless of whether or not they were feeling pleasure throughout the session. The item "shows preference" was scored high, but there were three people who scored a passive rating of 1 meaning that the behaviour was not displayed. These participants did not explicitly indicate their preferred activities. The behavioural indicator "uses imagination/symbolism" was not demonstrated at all in 4 participants. According to Bundy (1997) these participants may have been less playful from the perspective of not being able to pretend or assume different make-believe roles.

TABLE 2
Median and Mode of PVQ behavioural indicators score.

PVQ indicators for item	Median	Mode
1. Explores Novelty	3.69	3.78
2. Initiates Action	3.95	4
3. Is Task Directed	3.73	4
4. Shows Preference	3.50	4
5. Tries New Things	4.00	4
6. Stays Engaged	3.56	3.56
7. Expresses Mastery Pleasure	2.78	2.89
8. Tries to solve Problems	3.28	3
9. Tries to Produce Effects	3.78	4
10. Practices Skills	3.59	3.67
11. Seeks Challenges	3.36	2.75
12. Organizes/modifies environment	3.67	4
13. Pursues Activity to Completion	3.89	4
14. Uses Imagination/Symbolism	3.50	4

The overall mode and median volitional score for VR play of the study sample was 4 and 3.63. This indicates that virtual reality play provides a good environment for fostering volition for this sample of children with cerebral palsy. According to Basu et al. (2002) this indicates an involvement to spontaneous level of behaviour. These results are also important when considering current research on the body-environment experience (Reid, 2002). This model draws on the concept that optimal occupational performance requires the ability to balance occupation with views of the self and environment, in addition to encompassing changing priori-

ties. Virtual reality relates to the two sub-components of body-environment experience: environmental centralization and entexturement. As VR is highly motivating, it facilitates active engagement of children with disabilities in the occupation of play. Because the child is interacting in a space that offers relevant and optimal environment conditions, the environment is centralized to increase the child's ability to produce results and thus increase the child's motivation to engage in the VR activities. In addition, some VR applications offer the concept of entexturement in that they allow the child to regulate the aural or visual stimuli of the environment (e.g. rhythm, sound, light and colour) in order to do the activity as if it were meant to be done. When the child was able to take the features of the environment and make them unique, their level of motivation increased as did their overall personal experience.

Limitations

A few limitations exist in the current study. One limitation of the study was the data analysis strategy. We sampled a random number of VR environments, not all of them. We also did not reanalyze the data using Rasch analysis therefore our data are presented in a descriptive fashion. Another limitation is that programmed computer games offer semi-structured environments making certain elements of the activity unable to be changed. Since the PVQ was designed to be used in a free play environment some of the items were not observed in a virtual environment readily. Future research should explore semi-structured play environments of children without disabilities as a comparison group to expand on the knowledge of volition in this type of environment.

Conclusion

Measuring volition enables clinicians to determine the value of a virtual play environment as a therapeutic tool for children with cerebral palsy. Virtual reality appears to be a promising medium for the delivery of a motivating rehabilitation program for children with cerebral palsy. As not all VR environments are equally motivating, it is important to explore the elements of different environments that foster motivation in children.

This information will be useful in selecting a virtual play intervention activity for children with cerebral palsy. In the current study VR environments offering variability, challenge, and competition derived the highest scores of volition. An important future direction is to determine if VR play yields different volitional scores than other forms of therapeutic play for children with cerebral palsy. This has implications for the field of occupational therapy and other professionals concerned with children's motivation and play behaviours. As occupation is the focus of intervention it is vital for children with disabilities to have the opportunity to experience therapy in a play environment. Virtual reality creates accessible environments for children with disabilities to engage in their primary occupation. An accessible environment that is motivating will empower children with disabilities to take an active role in their rehabilitation.

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APPENDIX A
PVQ scoring system.

(S=4) SPONTANEOUS: shows behaviour without support, structure, or stimulation.
Given throughout his/her performance beyond what is allowed for some of the indicators. This rating implies that this behaviour comes from within and is independent of any identified external factors (i.e. therapist or teacher assistance, structure, or stimulation).

(I=3) INVOLVED: shows behaviour with a minimal amount of support, structure, or stimulation.
The child needs some attention, encouragement, verbal cues, or structuring of the environment from the therapist or teacher. This rating implies support that might be necessary for a person with adequate volition.

(H=2) HESITANT: Shows behaviour with maximal amount of support, or structure, or stimulation.
The child needs verbal or visual cues to be repeated several times, and/or frequent intervention, such as repeat demonstrations in order to initiate the desired behaviours. This rating implies the obvious volitional difficulty in interacting with the environment. This rating implies some concern about the child's self-confidence, attention to the environment, ability to employ cognition, etc.

(P=1) PASSIVE: Does NOT show behaviour even with support, structure, or stimulation.
The child does not show the behaviour and/or may show a brief orientation to the activity given maximum input. This rating implies the judgment that there is a volitional deficit—for example, very low self-esteem, high anxiety with novelty or very low interest in environment. With no support, structure, or stimulation given, the child remains passive and does not show the behaviour.

NA: Indicates item is not applicable.

Item was not observed due to: a) child was not given cues, b) item is irrelevant to the game