An evaluation of the use of a computer game in improving the choice reaction time of adults with intellectual disabilities.

PJ Standen BSc, PhD C Psychol is Professor in Health Psychology and Learning Disabilities. Division of Rehabilitation and Ageing, University of Nottingham. Her primary research interest is in evaluating ways of promoting the independence and quality of life of people with learning disabilities and her main area of research is developing and evaluating virtual environments and interactive software for people with learning disabilities.

Raj B Karsandas B Med Sci, BMBS is a trainee doctor at York Hospital currently on a research secondment in primary care. He carried out this project as part of his B Med Sci degree

Nicola Anderton BA C Psychol, is at Leicester University training to be a Clinical Psychologist and worked on this project while employed as a research assistant in the Division of Rehabilitation and Ageing, University of Nottingham

Steven Battersby MSc is a researcher in the School of Computing & Mathematics, Nottingham Trent University

David J Brown M.Eng, PhD is Professor of Interactive Systems for Social Inclusion at NTU. He is EU Project Coordinator for the Game On and GOAL projects to develop Serious Games for offenders learning basic skills; and people with learning disabilities and sensory impairments learning work based skills.

Correspondence to Professor PJ Standen, Head of School of Community Health Sciences
University of Nottingham, Division of Rehabilitation and Ageing, B Floor Medical School, QMC , Clifton Boulevard, Nottingham NG7 2UH

Tel: 0044 (0) 115 823 0233
p.standen@nottingham.ac.uk,

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ABSTRACT

An increasing body of work explores the effects of computer software on cognition but little focuses on people with intellectual disabilities. To test whether interactive software may reduce choice reaction time (CRT), 16 people with severe intellectual disabilities were randomly allocated to either an intervention or a control group. The intervention group spent eight sessions playing a switch controlled computer game that required a timed response while the control group spent the same amount of time playing a computer based matching game that did not require a timed response. Both groups completed a test of CRT before and after the intervention. The intervention group also showed a significant reduction in their CRT from baseline while the control group did not

Keywords

intellectual disabilities, choice reaction time, interactive software, computer games, controlled trial

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INTRODUCTION

There is now an increasing body of work exploring the effects of interactive computer software on cognition. Green and Bavelier (2003) found that computer games requiring frequent switches of attention had a beneficial effect on visual attention that generalised to a different task in non-disabled young people. In their more recent study (2007) they found that playing action video games altered fundamental characteristics of the visual system in terms of the ability to resolve increasingly smaller spatial differences. In a review of both the positive and negative effects of playing videogames, Griffiths (2004) describes how videogames may have a role in cognitive rehabilitation for example in perceptual disorders, conceptual thinking, attention, concentration and memory in patients with brain damage following stroke or trauma. Claims have also been made for the beneficial effects on cognitive skills of virtual environments. These are three dimensional, interactive computer generated environments commonly displayed on a normal computer monitor. Preliminary work suggests they have a role in improving memory (Rose et al, 1999) and attention (Rizzo et al, 2000) in those recovering from brain injury and other neurological disorders.

However, while computer technology has been employed to teach skills (Standen, Cromby & Brown, 1998; Ayres & Langone, 2002) it has not been fully exploited to improve cognitive functioning in people with intellectual disabilities. Moreno and Saldaña (2005) engaged 21 adolescents and young adults whom they described as having “severe intellectual abilities” in repeated sessions using a modified version of a computer assisted thinking skills program *Comprehending and Transforming* (Mora, 1997). Ratings of their metacognitive abilities were made on their initial and final sessions and showed a significantly greater improvement than did the ratings made on a control group who experienced normal schooling between the two sessions. Improvements in performance on a computer based task with repeated sessions were also found in a study by Standen and Low (1996). In initial sessions school aged students with severe and profound intellectual disabilities needed much assistance and prompting from a tutor to use desk top virtual environments. After repeated sessions, however, the amount of self directed interaction with the computer increased and the amount of help they required from the tutor decreased.

Both these studies used performance on the intervention task itself as an outcome measure and while this in itself is obviously informative, an obvious question is whether the improvements in the targeted behaviour would be shown in a different test.

Standen and Ip (2002) investigated the impact of making choices in a Virtual Environment on choice reaction time in people with severe intellectual disabilities. The software was the Virtual City (Brown et al., 1999) which consisted of a series of scenarios such as a virtual café, supermarket and factory in which the user had to choose from options such as a place to sit, items from a menu, items from supermarket shelves and the correct protective clothing to enter a factory. In an attempt to devise ecologically valid outcome measures, they used two tests to measure choice reaction time at baseline and post intervention. The first consisted of 10 cards depicting a familiar object on one side that were shuffled and placed face down before the participant was asked to pick one depicting a particular object eg apple. Time taken to do each of 10 trials was recorded. The second task involved the participant choosing two items from each of 10 pictorial shopping lists displayed on a computer monitor. Again, time taken was recorded. To avoid habitual responses, on three trials, after the time for the second choice had been recorded, participants were told that one of the items was no longer available and they had to choose something else. Data from 9 individuals who had six sessions using virtual environments (the active group) indicated a significant ($p<0.003$) reduction from baseline in their time to make a choice in the card game and the shopping list. Although there was some improvement when they were forced to make an alternative choice in the shopping list this reduction did not reach significance. A control group of 6 individuals who sat alongside a matched active partner during the intervention showed no improvement on all three measures.

Although these results are encouraging, the outcome measures for this study can be criticised. The shopping list task was computer based and any improvement on this task may have merely demonstrated increasing familiarity with using a computer. For the non-computer based outcome measure (the card game) timing was dependent on the reaction time of the research assistant who used a stopwatch to record time to make a choice. In addition, members of the control group were reluctant to continue with the study even though they were promised sessions using the VE after the study had finished. Using reaction time as an outcome measure may not reflect the experience of making choices in the virtual environment as these choices were not made within any time limits.

The current study was designed to avoid these drawbacks by using a non-computer based outcome measure with accurate electronic timing and by giving the control group a task to complete. In order to involve participants who had difficulty controlling the interfaces for the three dimensional VE, the intervention was a game that could be controlled by a switch. As a more disabled group was taking part the first aim of the study was to see whether they could learn to play the game. The second aim was to see whether repeated sessions playing the game resulted in a decrease in choice reaction time (CRT).

METHODS

Design

To test the first aim, for the intervention group the change over repeated sessions in the proportion of switch presses made that were made at the right time (correct switch presses) was compared with chance level. The proportion of correct switch presses was correlated with help received to determine whether switch pressing was made independently. To test the second aim, baseline CRT was compared with post intervention CRT in the intervention group and a matched control group.

Participants

24 people from a day centre for adults with intellectual disabilities were nominated by their specialist carers at the centre if they matched the inclusion criteria below:

1. Severe intellectual disabilities indicated by their scores on the Adaptive Behaviour Scale (ABS) (Nihira, Leyland & Lambert, 1993).
2. No visual impairment which prevented viewing the screen
3. Sufficient motor and cognitive ability to operate a simple microswitch
4. No previous exposure to microswitches or similar software

Only 16 of those nominated could be included in the study as 8 were unable to react within the recording limit of 1750 milliseconds on a minimum of 5 of the 20 baseline choice reaction trials. The remaining participants were grouped into pairs matched in terms of their age, ABS score and mean baseline CRT and members of each pair were randomly allocated to either the intervention or the control group. Their characteristics are shown in Table 1. Although the mean CRT is longer for the control group this difference is not statistically significant.

	Intervention Group n=8	Control Group n=8
Mean (SD) Age in Years	37.5 (15)	35.5 (8)
Mean (SD) ABS scores	37.1 (8.6)	37.0 (7.7)
Mean (SD) baseline CRT in milliseconds	1272.7 (247.3)	1352.9 (231.7)
Male: Female Ratio	5:3	4:4
Ethnicity	7 Caucasian:1 Asian	7 Caucasian:1 Asian

Table 1 - Characteristics of participants

Interventions

The computer game was designed specifically for people with severe to profound intellectual disabilities by the fourth author. It involved a man jogging across the screen and encountering several obstacles such as a log or a large rock. The aim was to jump over these hurdles and to make it to the finish line when audio (a cheering sound) as well as visual (a rotating trophy) signals appeared as a reward. The man was made to jump by a single press of a 'jelly bean' microswitch which if made at the appropriate time would allow the man to clear the obstacle. However if the switch was continuously pressed, there was no observed effect within the game. The game recorded the number of switch presses that resulted in the running man clearing the obstacle and the total number of switch presses made.

The control task involved the participant trying to match pictures of familiar animals or objects from a series of cards to those displayed on a computer monitor. The participant sat in front of the monitor and ten cards faced down were placed on the table in front of her. On the other side of each card was a different picture depicting an object familiar to the participant (eg animals, items of food). When a picture appeared on the monitor the participant had to find the card with the matching picture. The rate at which the pictures appeared on the computer monitor was controlled by the participant assisted by the researcher and a new picture only appeared once the participant had found the card with the matching picture.

Outcome measures

Choice reaction time This device, designed by Piercy Adams Ltd. Cambridge, involved a series of 6 outer red LEDs as well as a central green LED, all of which were placed

within a close proximity to their respective light sensitive diodes. The device measured choice reaction time by assessing how quickly a user could shift his/her hand from the central green LED to the appropriate outer red LED which became illuminated at random. A new light was only illuminated once the participant had responded to the previous one. However the timer would only record choice reaction times with a maximum duration of 1750 milliseconds and therefore any reaction time above this was not recorded but noted as the maximum.

Help received All sessions with the intervention group were videotaped and analysed using OBSWIN (Oliver et al, 2000) to measure amount of tutor assistance (measured as an event variable). The definition of assistance given was taken from a methodology previously established by Standen et al (2002). It referred to any help given to the participant to carry out a correct switch press or to direct the participant's hand closer to the switch.

Procedure

Data collection took place in the day centre attended by the participants. And all data collection was carried out by the same member of the research team (RK).

Before baseline measures of CRT were recorded the test was demonstrated to the participant and a verbal explanation given if they could understand it. They were then encouraged to complete 20 trials and if they could manage at least 5 they went on to be included in the study. At post intervention, they received another demonstration from the researcher if it was required before being asked to complete another 20 trials.

Each participant spent 8, twice weekly sessions that lasted up to a maximum of 10 minutes but could be terminated earlier if the participant did not wish to continue.. This session length was kept the same for intervention and control participants of each matched pair. One of the research team (RK) sat alongside the participant to give them assistance and encouragement.

Analysis

As the upper limit for a reaction time was set at 1750 milliseconds, for each participant the median of their CRTs for each 20 trial block was calculated. As these values were normally distributed the comparison between their baseline and post intervention median CRT was made using a paired t-test. To take account of any variation in time playing the game and a strategy of high levels of switch pressing,

the number of correct switch presses from the computer game was converted to a proportion of the total number of switch presses made. All videotapes were analysed by the same researcher who had collected the data so in an attempt to minimise bias resulting from knowledge of how many sessions the participant had completed, the order of the tapes for analysis was scrambled. Video collected data were expressed as a percentage of session duration. Comparisons between first and last sessions for both correct switch presses and help received were made using a paired t-test. The relationship between these two variables was examined using Pearson's correlation coefficient. The comparison of the change in the proportion of correct switch presses with chance level was made using regression analysis.

RESULTS

Change in the proportion of accurate switch presses with increasing sessions

The proportions of accurate switch presses by the intervention group increased significantly ($p<0.0001$) from first to last session. Regression analysis produced a significant ($p<0.00003$) adjusted R squared value of 0.956 indicating that over 95% of the increase in proportion of accurate switch presses was explained by session number (i.e. increased exposure to the game). A beta value of 0.038 ($p<0.00002$), indicates that with each session, the proportion of accurate switch presses increases by approximately 0.038. Figure 1 shows the group means for each of the eight sessions.

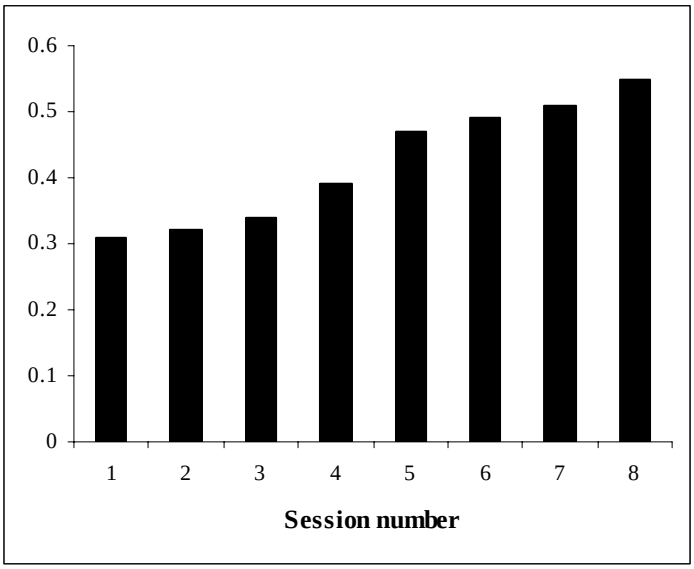

Figure 1 - Mean proportions of accurate switch presses by session

The increase in the proportion of accurate switch presses was not dependent on help from the tutor as the percentage of the session in which participants received help from the tutor decreased significantly ($p<0.0002$) from sessions 1 to 8 and was significantly ($p<0.00007$) negatively correlated with the proportion of accurate switch presses made. Figure 2 shows the group means for each of the eight sessions.

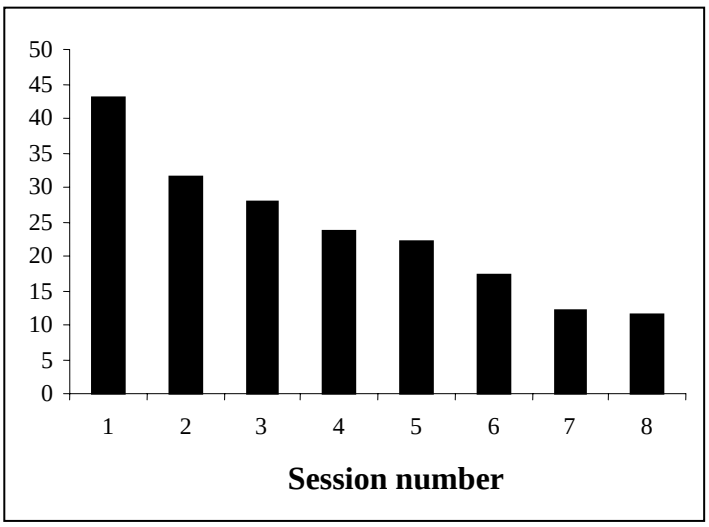

Figure 2 - Mean percentage of sessions spent receiving physical assistance

Change in CRT from baseline to post intervention

Mean choice reaction times are shown in Table 2. The intervention group showed a significant ($p<0.003$) decrease from baseline to post intervention in mean choice reaction time whereas the decrease observed in the control group failed to reach significance.

	Intervention Group		**Control group**	
	Baseline	Post intervention	Baseline	Post intervention
Mean CRT (msec) (SD)	1273 (247)	990 (170)	1353 (232)	1302 (229)

Table 2 - Baseline and Post intervention mean Choice Reaction Times in milliseconds

DISCUSSION

Even with the limited time playing the switch controlled game, the intervention group learnt how to play as evidenced by the increase in successful switch presses expressed as a proportion of the total number of switch presses. From this we can conclude that the design of the game matched their level of ability and that their interest and attention could be sustained over eight sessions. As with all of our research, someone sat alongside the participant and there is always the possibility that the researcher or tutor can cross the fine line between facilitating the participant's performance and controlling it. In initial sessions the participants will

inevitably require high levels of help from the tutor but as they become more familiar with the game and more skilled the level of help from the tutor should diminish. The results indicate that this was happening so it can be concluded that the increasing proportions of correct switch pressing are evidence of learning or increased ability in the participant. For a group of people who may experience very low levels of stimulation or social interaction such an activity can have a range of benefits. According to Lancioni et al. (2001) who reviewed several studies on the use of microswitches “the establishment of successful responding may have immediate benefit in terms of increased alertness and positive interaction with the surrounding world”.

The intention of this study was to explore whether any other benefits could be detected from the continued use of a switch in order to play a computer game. When compared to the control group who spent the same amount of time playing a game without a time limited response, the intervention group showed a significant decrease in choice reaction time after eight sessions playing the game and this in spite of small sample sizes. Both groups had equal lengths of time sitting in front of the computer screen and similar rates of tutor contact, suggesting that the time pressured nature of the task faced by the intervention group was the influential element.

There are obvious limitations in this study in addition to the small sample size. The equipment to measure CRT limited the type of participants we could involve so these findings may not generalise to other groups. The participants only received a limited exposure time to the intervention and we have no information on how long the effects of the intervention would last before needing to be repeated. Although measures were taken to avoid researcher bias there is always the possibility that knowledge of which group the participant belonged to might have subtly influenced the encouragement given by the researcher when CRT was measured post intervention. Unlike non-disabled groups, these participants cannot be left alone in a separate room to minimise extraneous influence when using such equipment.

Even if these findings are robust and would be repeated with a larger sample size, questions still remain. Unlike the studies reviewed above on cognitive rehabilitation where participants all suffered from a similar cognitive deficit such as an attention disorder, there is no evidence that for people with intellectual disabilities a slow choice reaction time is a problem. However, baseline readings from the participants were quite high: Sternberg (1969) estimated CRT for 6 stimuli to be 630 msec. Of more importance is the significance of the reduction that was found in the intervention

group, in other words does an improve CRT have any benefit in the real world? Maintaining information processing speed is necessary for a whole range of daily life activities such as crossing roads or restoring balance after a near fall (Lupinaci et al., 1993). It may also underlie the ability to make choices or decisions which people with intellectual disabilities are thought to find difficult. For example, Jenkinson and Nelms (1994) found that they were less likely to produce responses that reflected a systematic evaluation of possible alternatives than were people without intellectual disabilities. Cooper and Browder (2001) see their inability to make choices as resulting from a constant denial of choice and their study demonstrated how embedding choice opportunities in a trip to a fast food outlet can enhance choice making. The implications of this are that carers of those with intellectual disabilities need to present them with options on as many occasions as possible. Options presented by carers in day to day activities may well be the most ecologically valid way of increasing the opportunities for making decisions. However, they are often pressed for time, wary of letting their charges take risks and may also find it difficult to suppress their natural inclination to take over before allowing the person sufficient prompts for them to perform the selection independently. While using interactive software in the form of computer games may well improve alertness and responsiveness, the facilitation of the selection from among options or decision making may require more complex games or virtual environments. By depicting more complex every day situations such software might be used to facilitate other components of the decision making process such as the understanding of an issue and the identification and informed evaluation of options which Jenkinson and Nelms (1994) consider essential parts of the process. This software could also be used to depict situations in which participants can practice these skills.

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