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Virtual Reality in the Rehabilitation of People with Intellectual Disabilities: Review

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ABSTRACT

Virtual reality (VR) possesses many qualities that give it rehabilitative potential for people with intellectual disabilities, both as an intervention and an assessment. It can provide a safe setting in which to practice skills that might carry too many risks in the real world. Unlike human tutors, computers are infinitely patient and consistent. Virtual worlds can be manipulated in ways the real world cannot be and can convey concepts without the use of language or other symbol systems. Published applications for this client group have all been as rehabilitative interventions. These are described in three groups: promoting skills for independent living, enhancing cognitive performance, and improving social skills. Five groups of studies are reviewed that utilize virtual technology to promote skills for independent living: grocery shopping, preparing food, orientation, road safety, and manufacturing skills. Fears that skills or habits learnt in a virtual setting would not transfer to the real world setting have not been supported by the available evidence, apart from those studies with people with autistic spectrum disorders. Future directions are in the development of more applications for independent living skills, exploring interventions for promoting motor and cognitive skills, and the developments of ecologically valid forms of assessment.

INTRODUCTION

In the United Kingdom, around 25 people in every thousand have mild or moderate intellectual disabilities, and about four or five per thousand have severe intellectual disabilities.[1] For the most disabled of these, help will always be needed with almost every aspect of daily living, yet even those who are more able will still need a degree of support to achieve the things the rest of society takes for granted. According to the 2001 White Paper,[1] people with intellectual disabilities are amongst the most socially excluded and vulnerable groups in Britain, and this is unlikely to differ in other countries. Very few have jobs, live in their own homes, or have real choice over who cares for them. Today, the majority no longer live in institutions but in the family home, and although their individual needs will differ, there is an expectation that they will achieve greater independence and greater inclusion in society.[1] The intention of current policy is to enable them to have as much choice and control as possible over their lives, be involved in their communities, and make a valued contribution to the world at work.

However, in order to achieve these aims, interventions are needed. The Tomlinson Report[2] highlighted the need to provide courses that teach independent living and communication skills, and this need has been reiterated by others.[3] Current conceptions of rehabilitation no longer focus on the restoration of a previously well-established func-

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tion but encompass interventions that are aimed at those who may never have developed the function in the first place. For example, Wade[4] describes rehabilitation as "a problem-solving and educational process aimed at reducing the disability and handicap experienced by someone . . . always within the limitations imposed both by available resources and by the underlying disease." For people with intellectual disabilities, virtual environments can contribute to this process in two ways. First, they can act as a therapeutic or rehabilitative intervention, and second, they can serve as a means of assessment. A review of existing research indicates that practically all developments published so far fall into the first of these two categories.

ADVANTAGES OF VIRTUAL REALITY FOR REHABILITATION IN INTELLECTUAL DISABILITIES

The earliest work with virtual reality (VR) saw its main contribution lying in the educational field. Yet the very characteristics that appealed to educationalists also give it a role in rehabilitation, especially for the acquisition and maintenance of skills necessary for independent living. Children with intellectual disabilities are often denied real world experiences, which for the non-disabled child provide the opportunity to acquire skills that will later allow them to become independent of their parents. As adults, acquiring or maintaining these skills through practice is difficult for the same set of reasons. Their carers may be scared of the consequences of allowing them to do things on their own,[5] they may fear the reaction of others to appearance or challenging behavior, and scarce resources may mean that accompanied visits to a real environment sufficient to learn a skill may be impossible to arrange. However, in the virtual environment, the person with intellectual disabilities can go where they like, even if they have a mobility problem. They can make as many mistakes as they wish without suffering the real, humiliating, or dangerous consequences of their errors.[6,7] Unlike even the most patient of human tutors, the computer will not express irritation at repeated mistakes nor tire of the learner attempting the same task over and over again, nor get impatient because they are slow or engrossed in particular details.[8]

When attempting a skill or activity for the first time, the complexity of the environment can be overwhelming. However, virtual worlds can be manipulated in ways the real world cannot. In the real world, the beginner can be provided with scaffolding in the form of add-ons such as self-help manuals because the world cannot be changed. As she becomes familiar with elements of the task, the scaffolding or training support is removed little by little until finally, when the task is completely learned, all scaffolding has been removed and the apprentice is on her own doing the job.[9] Virtual environments can be constructed in any way the builder requires. A simple world can be constructed within which the task could be performed, and as the user becomes more familiar with the task, the world can become more complex. Features to which the learner needs to pay attention can be made more prominent.[10] Additionally, virtual worlds can be manipulated in ways the real world cannot be, perhaps providing less challenging versions of a task for the beginner. Cues can be provided in terms of enhanced features to which the learner needs to pay attention,[10] or help can be given by a virtual tutor. Some of these qualities have been exploited in a virtual travel training environment,[11] to be described below.

The ease with which virtual environments can be manipulated has another advantage for their use in rehabilitation for people with intellectual disabilities. As a group, they are considered to be poor at generalizing skills learnt in one setting to another.[6] This is particularly so for people with intellectual disabilities who also have an autistic spectrum disorder.[12] More work with this particular group will be described later, but Strickland[13] and Parsons and Mitchell[14] recommend using VR as an intervention for autism, seeing an advantage in the possibility it allows for producing a variety of versions of a learning environment, each with minimal modification of a similar scene. To encourage flexibility and generalization, differences between different versions of the learning environment could be gradually increased.

For a group that includes many with little or no grasp of language, virtual environments can convey rules and abstract concepts without the use of language or other symbol systems. They have been described as having their own "natural semantics"[15]: the qualities of objects can be discovered by direct interaction with them. They can thus be used to facilitate concept attainment through practical activity, by-passing the need for disembodied thinking,[16] which people with intellectual disabilities often find difficult to acquire and use.

These characteristics of virtual technology have led to its use assisting with the acquisition of skills necessary for independent living, improving cognition, and practicing social skills.

SKILLS TO SUPPORT INDEPENDENT LIVING

Studies exploring virtual environments as an aid to the acquisition of skills to support inclusion in society and independent living have looked at grocery shopping, preparing food, orientation, crossing the road, and vocational training.

Grocery shopping

One of the first attempts to use a virtual environment as an aid to acquiring an everyday skill was a randomized controlled study to examine whether practicing grocery shopping in a virtual supermarket would have a beneficial effect on shopping in a real supermarket.[17] As a baseline measure of their shopping ability, 19 young people aged 14–19 years with severe intellectual disabilities were taken to a supermarket to find four items on the shelves and take them to the checkout. Then nine of the students, the intervention group, spent twice weekly sessions carrying out a similar task in a virtual supermarket displayed on a desktop computer. The remaining students, the control group, had the same number of sessions using other educational virtual environments. Although there was no difference between the two groups at baseline, on repeating the task in the real supermarket the intervention group was significantly faster than the control group and had significantly more correct items in their shopping cart. This latter finding cannot have resulted from the intervention group having improved their chances of a correct choice by selecting more items. On the second visit, there was no difference between the two groups in the number of items they picked up, whether correct or not. Additionally, the intervention group had significantly fewer items overall in their carts at the checkout.

The virtual supermarket used in this study was very simple in design and bore limited resemblance to the real supermarket. Recommendations to promote transfer of skills learning include selecting teaching examples that sample the range of stimulus and response variation that the learner can expect to encounter.[18] The success of the virtual environment in this study may have been attributable to the fact that its simplicity abstracted the essential features of supermarkets in general (aisle, shelves, checkout desk), and these features could be recognized in the real supermarket. The question remains as to how much detail should be built into the environment to increase the likelihood that learning will generalize to other settings. Virtual environments would need to have sufficient detail for the learner to be able to practice skills needed in the real world (visual search, navigation) and to be recognizable as a representation of the real world. On the other hand, too much detail may prevent the learner from extracting the salient features necessary for the task to be learnt. Design guidelines for designing environments for teaching purposes have been described by Brown et al.[19]

Food preparation

The virtual environment used by Brooks et al.[20] to teach food preparation was based on an actual kitchen in which half of the participants were already undergoing training. These were 24 students aged 15–43 years currently undertaking a college catering course. All participants first underwent a baseline assessment on four food preparation tasks, and the identification of 12 hazards in the kitchen in which they normally trained. They then received training on one food preparation task and identifying three hazards in the same kitchen, one food preparation task, and three hazards in the virtual kitchen, and one food preparation task and three hazards in specially designed workbooks. After training, they repeated the baseline assessments on all preparation tasks and hazards in their own kitchen. For all measures, there was no difference according to whether the students were familiar or unfamiliar with the kitchen on which the virtual one was based.

Students showed significantly greater improvement on the tasks they had learnt in the virtual kitchen than they did on those learnt using the workbook and those on which they had no training. However, there was no difference between tasks learnt in the virtual or the real kitchen. For the hazard detection task, there was no difference between all three training methods, but they were all better than no training. To explain the difference between the two tasks, the authors point out that virtual and real training on the food preparation tasks involves learning a sequence of actions. The virtual kitchen, unlike the workbook, provided the opportunity to utilize procedural memory by allowing them to perform this sequence. In contrast, training on the hazard recognition task simply involved an association between an item and whether it was unsafe or harmful, and for this no overt performance of actions was necessary.

Orientation

Brooks et al.[20] found no difference in improvement between virtual and real training, which is exactly the result needed to recommend adoption of this type of intervention. Virtual training does not have to be better than the real world analogue, as although the real version may be more motivating, it does have other drawbacks when compared with its virtual analogue as described above. A similar conclusion applies to a study[7] describing the use of virtual environments in teaching spatial skills. 22 students with severe intellectual disabilities aged 7–19 years starting at a special school, familiarized themselves with their new building by exploring either a virtual model of it (intervention group) or experiencing the normal "orientation" course (control group). This consisted of seven sessions learning to find 16 markers in the real school. The virtual course consisted of the same number of sessions finding the markers in the virtual school. On the eighth session, a teacher who did not know to which group the participants belonged tested all the students in the real school in their attempt to find a random selection of the markers. There was no difference between the two groups in the total time spent with the tutor over the seven training sessions, so neither group had the advantage of more of the tutor's time nor was the intervention group more expensive in teaching time. However, the intervention group had found significantly more markers by the end of the seventh session than had the control group. In the eighth session, although the intervention group took less time to reach each marker than the control group, this difference did not reach significance. Neither was there any difference between the groups in the number and types of clues given once these figures were adjusted for the number of markers found. However, the fact that the intervention group was no worse than the control group is evidence that the learning they experienced in the virtual environment transfers to the real world analogue. While in this application there was no saving in terms of the tutor's time, there were obvious advantages in using virtual training. It saved some of the physical effort expended by the learners, many of whom had mobility problems, and avoided the problems involved in enabling students to keep moving around the narrow corridors of a busy school.

Rose et al.[21] also report a study that examined the role of virtual environments in spatial recognition, although their environment was not modeled on a real world analogue. It depicted four interconnected rooms in a bungalow that contained 20 items such as a piano or bottle of wine. Fifteen college students (the active group) with intellectual disabilities aged 17–46 years were asked to find a route through the virtual bungalow and look for a toy car which was placed in the last room they could visit. The route they took was recorded by the computer. After each one had completed this task, the recorded route was played back to another participant (passive group) who did not determine their own route through the bungalow but was still instructed to look for the toy car.

After exploring the virtual bungalow, all participants then carried out tests of spatial and object recognition. The spatial recognition test consisted of two-dimensional cardboard cut-outs representing the shapes of the bungalow rooms as viewed from the doorway. Participants had to identify the shapes that represented the rooms they had entered and where they had exited from them in the right order. The object recognition test involved identifying the 20 objects they had seen on their route from 40 color photographs of objects. Active participants were significantly better than passive participants at both the spatial and object recognition task.

Road safety

The virtual environments described so far have been rather limited in the degree to which they have exploited the flexibility of the medium. Most have been models of actual environments or of generic versions of recognizable environments. Few have taken advantage of the quality described by McLellan[10] whereby virtual worlds, unlike real worlds, can be manipulated to make a task easier for the user. In order to inform the design of such an environment, Standen et al.[22] documented the assistance learners needed when using an environment that contained minimal cues to help the user. This information was used to modify an existing virtual travel training package.[11]

For people with intellectual disabilities and some degree of independent mobility, being able to negotiate traffic and cross the road would give them access to a wide range of activities and resources that they can usually only achieve with the help of others. However, road crossing is a complex skill that involves, for example, the identification of safe places to cross, and the accurate judgment of the speed and proximity of advancing vehicles. Few training packages can simulate all of the environmental aspects to which the learner must pay attention. The Virtual City[23] includes a procedure to teach the use of a pelican crossing and catching a bus, and initial evaluations of this showed some transfer of learning from the virtual to the real world. An unpublished master's thesis[24] describes the evaluation of the virtual environment to teach road crossing and route finding built by Brown et al.[11] This study was not designed to look at the transfer of learnt skills to the real world but to evaluate the addition of an intelligent agent to the software. The training package consisted of three tutorials—zebra crossing, pelican crossing, and way finding—and exploited some of the characteristics of the virtual environment described above.

First, it incorporated an intelligent traffic system whereby cars randomly appeared outside the virtual world and drove into the virtual city according to traffic rules. The use of invisible "plane" models helped the cars to detect corners, zebra crossings, pelican crossings, and traffic lights. They could then turn the corner of a street, and slow down and stop in front of a crossing and at traffic light. Secondly, features to which the learner had to attend were visually enhanced. Thirdly, they could watch an avatar performing the actions and lastly traffic density could be varied. The authors point out that varying the learning situation each time the learner attempts a task can help to maintain interest and motivation.

The evaluation was carried out with the help of two groups of nine adults with intellectual disabilities attending a charity-run day center. All of them spent three sessions with a non-disabled human tutor working through the tutorials. These sessions were recorded on videotape, and analyzed for the frequency and type of assistance given by the tutor using the methodology described in Standen et al.[12] Learners completed simple rating scales to assess their opinions on the environment, and any other comments they made were recorded. One group of nine participants worked through the original version of the three tutorials which included no additional cues to help the learner and depended on the help of a human tutor to achieve the learning outcomes. The second group of nine worked with a modified version of this software which included a tutorial agent who appeared in the introduction to explain the control functions and give the user an initial training period in its use. The agent appeared on the screen throughout the tutorials to give task instructions or suggestions about safety issues.

Analysis of the videotapes showed that, when the tutor was working with the learners using the intelligent agent, they spent significantly less time giving both general and task-specific advice and also less instruction about the control devices, in this case, the mouse and joystick. With the intelligent agent, users also asked significantly fewer questions and made fewer errors, such as stepping into the road when it was unsafe and forgetting to look both ways before crossing. Enhancing the software in this way would replace some of the functions of the human tutor, for example, marking relevant features of the task and interpreting discrepancies between the learner's productions and correct solutions. This would enable a less experienced person, even a peer, to carry out the function of maintaining the learner's interest and motivation.[22]

Vocational training

Only one study so far has investigated the contribution that virtual environments might make to increase the employment opportunities for people with intellectual disabilities.[25] Taking place in two European centers, it evaluated the effectiveness of a virtual workshop designed to simulate the assembly of a torch from its basic components. The study reports results from 20 trainees who met local criteria for employability in a sheltered workshop. Two of the trainees were described as having severe disabilities (no reading and counting ability); five had moderate disability (no reading but some counting ability); and were 13 mildly disabled (able to read and count up to 100).

Some aspects of the assembly task were as simple as checking the charge of batteries or as complex as carrying out the whole assembly which involved up to as many as 39 different actions to be performed in the right sequence. Tasks were organized into different incremental levels of difficulty, each one with several variants. Training was preceded and followed by assessment on the completion of real tasks that mimicked those that could be performed in the virtual workshop. After training in the virtual workshop, participants were faster and put together more parts correctly, but the difference did not reach significance. The study did not employ a control group to control for increasing practice and familiarity. Additionally, the authors admit that the improvement on the real task could have been influenced by the positive attitude of the raters, who were also the same people who acted as tutors for the virtual workshop training. Nevertheless, the study is encouraging as even the most severely impaired of the participants were able to tackle the easier tasks and learn from practice.

ENHANCING COGNITIVE SKILLS

Using VR for cognitive rehabilitation is relatively rare with people with intellectual disabilities. Work has been carried out with people recovering from traumatic[26] and vascular brain injury,[27] and other neurological disorders.[28] Pantelidis,[29] talking about their role in education, claimed that virtual environments encourage active involvement: if the user remains passive, nothing will happen. In common with other interactive software, the user is constantly faced with making choices or decisions about what action to take next, for example, whether to move or remain stationary, which direction to go, which object to select. This characteristic is especially important for people with intellectual disabilities who have a tendency to passive behavior.[30] To investigate whether interacting with virtual environments increased activity, Standen and Low[31] recorded the behavior of 18 school-aged students with severe and profound intellectual disabilities over repeated sessions working through a desk top virtual environment alongside their teacher. In initial sessions, the students needed much assistance and prompting from the teacher to use the software. 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.

A common perception of people with intellectual disabilities is that they are unable to make choices. This inability prevents them from playing a fuller role in society and maintains their dependence on staff or other care givers.[32] It has also been cited as a barrier to making informed decisions about the health care they wish to receive[33] and their ability to give eye witness testimony.[34] Cooper and Browder[32] see this characteristic as resulting from a constant denial of choice which underlies their inability to respond to stimuli in the community, and as a result, they may never acquire skills that lead to enhancing their independence. Additionally, they believe limited opportunities to make choices may result in the expression of frustration in the form of aggressive behavior or withdrawal. Reduced intellectual capacity need not necessarily lead to the inability to make choices as even people with severe and complex disabilities can express stable preferences when provided with choices.[35]

The rationale for replacing traditional forms of institutional provision with small community-based residential support, as well as being financial, included a belief that this move would facilitate both inclusion and self-determination.[36] However, while there is considerable evidence to suggest that people in smaller community-based residential settings may experience greater choice than people in larger, more institutional settings, opportunities are still highly restricted.[36] Cooper and Browder[32] demonstrated how embedding choice opportunities in a trip to a fast food outlet can enhance choice making. They set out to increase the opportunities for choice making in a group of eight people with severe learning disabilities with a staff-training package. They trained staff to offer a series of two options (e.g., which of two doors through which to enter; two photos of food or drink options) when using fast food restaurants. Compared with baseline, the people with intellectual disabilities increased the number of choice responses they made both prompted and independently. They also required a much lower level of prompting to make these choices after the intervention.

The implications of this study are that carers of those with intellectual disabilities need to present them with options on as many occasions as possible. Options presented by staff and carers in day-to-day activities may well be the most ecologically valid way of increasing the opportunities for choice making. However, staffs are often pressed for time, are 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. If the user's activity in a virtual environment takes the form of making choices or selection from options, would this improve the ability of people with intellectual disabilities to make decisions or choices in other situations?

To investigate this possibility, Standen and Ip[37] devised two tests to measure choice making 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, for example, apple. The time taken to do each of the 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, the 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. After completing the baseline measures of choice making, nine individuals (the active group) spent six sessions working through some of the sections of the Virtual City[23] before they repeated the measures of choice making. After the intervention, there was a significant reduction from baseline in their average 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 did not reach significance.

A control group of six individuals who sat alongside a matched active partner showed no improvement on all three measures.

Although encouraging, this pilot study had several drawbacks. The sample size was small, participants may have benefited from more exposure to the software, and the outcome measures were based only on reaction time with no analysis of the choices made for the shopping list task. The shopping list task was computer based, and any improvement on this task may have merely demonstrated increasing familiarity with viewing the computer monitor. Although not using virtual environments, a recent study[38] found that computer games requiring frequent switches of attention had a beneficial effect on visual attention that generalized to a different task in non-disabled young people. This finding, together with the results from Standen and Ip,[37] suggest that this application of VR should be further investigated.

IMPROVING SOCIAL SKILLS

An area of application still in its infancy is the use of virtual environments in social skills training. The client group for whom this intervention is being developed is people with Asperger's syndrome (AS) and autistic spectrum disorders (ASD), all of whom experience deficits in communication and social understanding. Whereas people with AS have intellectual ability within the normal range, 70–75% of people with autism have some associated intellectual disabilities and 50% have an IQ below 50.[12] Autism is also characterized by impairments in cognitive flexibility,[39] failure to generalize, and a tendency to over-selective responding. This latter characteristic describes the individual's response to an irrelevant cue of a compound stimulus. An example would be when a learner will attend to the teacher's shirt rather than the teaching material.[40]

Early studies suggested that using interactive computer software could encourage language use in children[41,42] and responsivity,[43,44] and some suggested that social skills acquired in this way generalized to other areas.[45] Children with autism were reported as being more enthusiastic when working with computers than in a "regular toy situation,"[46] probably because the computer may appear to make fewer demands on them than a human tutor[47] and reduce stimulation to a level of input tolerable to the individual.[13]

These characteristics together with those described earlier suggest that VR is worth exploring as an intervention for people with ASD. One of the first reports[13] on its application described two case studies to investigate the use of VR as an aid to learning in children with autism. Neither child was classified as high functioning, and neither spoke nor understood many normal sentence structures. The two children were given an initial test involving recognizing and tracking a moving car in a street scene. Neither had previously been able to learn to recognize and track a common object when taught in the conventional way. Both children were happy to practice this task in a virtual street scene on a head-mounted display, and the explanation given for their improvement on the task after the intervention was the controlled nature of the learning environment, which limited the stimulus load on the learners. It may also have helped that the children were not exposed to social stimulation while learning the task in the virtual environment.

The controlled nature of the learning environment was one of the reasons behind the creation of "Returning Home,"[48] which presents autistic children with possible everyday activities that may take place when they return home. The house consists of five rooms, for example, a bathroom and kitchen, on two stories, and before attempting a task such as washing hands, the child has the option of watching an avatar perform the tasks. As yet, no findings have been reported using this application.

The social difficulties experienced by people with ASD are attributed to their lack of a theory of mind. This refers to their inability to recognize or think about the mental states or the self of others. This leads them to make literal interpretations of speech, for example, a child being told "Go and ask your mum if she wants a cup of tea" and failing to reappear. The child will carry out the command without realizing that the speaker wants the answer to be reported back.[49]

Parsons and Mitchell[14] make a strong case for utilizing virtual environments in social skills training for people with ASD in spite of the inherent contradiction involved in using a training medium that reduces the need for social interaction. People with ASD have little aptitude for pretense so cannot role play, but virtual environments would provide an opportunity to learn rules and basic skills which could be repeatedly practiced before entering the real setting in which they were required.[50] They could also help with the lack of a theory of mind by helping them to consider the implications of thought and consider how their own behavior may be seen by others. For example, thought bubbles could be used to represent thoughts.[51] Scenarios could be created to represent a mental state, thus

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creating a tangible counterpart for a belief or feeling and enabling a demonstration of the situation from the other person's point of view.

Their failure to generalize learnt skills to untrained settings poses a challenge for any rehabilitative intervention, leading to the suggestion that social skills training is best conducted in each and every situation to which the child is exposed.[49] However, in spite of the obvious drawbacks, in terms of the complexity of social situations, teaching rules is proffered as the best option for people with autism because they lack an innate understanding of how to behave in different contexts.[49]

This approach was tested in a study with a group of six teenagers with ASD, some of whom had an IQ in the intellectually disabled range.[52] As a baseline assessment, they were shown a video of a real café and bus interior, and were asked to choose where they would sit and why. They then underwent an intervention in a virtual environment depicting a café similar to that shown in the video. They had to learn two rules about finding a seat: "when there is an empty table, you should sit there rather than with strangers;" and "when there are no empty tables, you should ask if an empty seat is available or whether you can sit down."

They were then reassessed on the video task, and the remaining participants learnt the rules in the virtual café before repeating the video task. After training in the virtual café, the participants showed a significant improvement in ideal behavior and in the social appropriateness of the reasons given. However, they could not generalize the rules from the café to the bus.

This application of rehabilitative virtual environments could be criticized for exactly the same reasons that computer-based instruction for people with ASD has been criticized. Chen and Bernard-Opitz[40] raised the possibility that computer-assisted instruction might be a hindrance to the development of social skills. To counteract this, software could be used with a teacher sitting alongside.[6] Howlin[12] speculated that an overreliance on computer interaction could lead to obsessive behavior and a decline in real world interaction. The predictability of the software and the sense of control this may give could become appealing. Latash,[53] talking about a variety of users, warned that, if the rehabilitative virtual environment is too safe and attractive, the patient may be reluctant to re-enter the real world. Parsons and Mitchell[14] advise that, to counteract this, the virtual environments could be made more flexible, with more interaction being demanded so that the virtual environment was less predictable.

FUTURE DIRECTIONS

VR should not be seen as a solution that would suit all users, and currently there are limited applications that are designed for those with visual impairments. However, the studies reviewed all indicated the acceptability of this medium for many users, and potential applications are continually being proposed. To illustrate future directions, three of these are described below.

Preparation for court appearances

People with intellectual disabilities are often denied the right to appear as a witness or even as a defendant. However, if they are offered this opportunity, they are often ill-prepared. The Home Office document "Speaking up for Justice"[54] recommended that more should be done to assist vulnerable witnesses prepare for their attendance at court. With this end in mind, a virtual courtroom has been developed in conjunction with a group of young people with intellectual disabilities, to enable witnesses to familiarize themselves with the environment and procedures they will encounter during their court appearance.[55] At the time of writing, a systematic evaluation of this application had not yet been completed.

Motor rehabilitation

Many people with intellectual disabilities have fine motor difficulties, as they suffer from conditions where damage has been caused to the central nervous system, such as cerebral palsy. This causes them to experience difficulties controlling the input devices needed to navigate round and interact with virtual environments.[22] In order to reduce these difficulties, Standen et al.[56] set out to design devices that were both easier to understand and control. However, with repeated practice, users do improve in their ability to handle the input devices,[22] and this suggests that using virtual environments may have a role to play in improving motor control and hand eye coordination.

Support for this proposal comes from a second study reported by Rose et al.,[21] who gave virtual training for a task that relies heavily on hand–eye coordination. They produced a virtual version of the steadiness tester for which, in its real world version, the individual has to move a metal hoop along a length of curving wire without the hoop coming into contact with the wire. The virtual version was controlled with a wooden handed device similar to the real one. Forty-five college-attending students aged 16–46 were randomly allocated to one of three groups: real training, virtual training, and no training. Although real training was better than virtual training, virtual training was still significantly better than no training.

Assessment

As mentioned above, the developments of virtual technology as a rehabilitative intervention have not been matched by its use as a method of assessment. Its lack of reliance on language and its ability to present models of everyday environments that are risk free indicate that virtual technology has an untapped potential in the assessment of ability, mood, and personal preferences.

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