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Virtual Reality for Putting People with Disabilities in Control

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ABSTRACT

Virtual reality technology offers a number of useful possibilities for people with disabilities. An obvious application is for those who face mobility problems to navigate around a virtual environment with minimal physical movement, allowing someone with limited motor ability the opportunity to explore virtual spaces with the same freedom of someone without physical impairments. This has implications for educational and entertainment systems, but also opens up possibilities for therapeutic systems, where the effects of a small amount of movement might be exaggerated in a virtual representation. We have been investigating some less obvious applications of virtual reality for people with disabilities. The development of graphical interfaces with metaphorical representations which the user manipulates suggests that a three-dimensional, realistic representation may be helpful as an interface in some situations. Work on improving complex computer-based communication systems for non-speaking people has involved investigating new ways to present conversational material to the user. A system has been developed which presents the material in terms of realistic scenes through which the user can navigate. In another project a virtual reality scene has been used to attempt to capture the interest and then channel the attention of children with attention deficit hyperactivity disorder. In both cases the approach seems to offer advantages. One feature of both projects is giving the disabled user more and better control - over the interface, and also in their interactions with others.

A PICTORIAL INTERFACE DESIGN FOR A COMMUNICATION SYSTEM

An obvious application of virtual reality is for people with disabilities who face mobility problems. Potentially, they could navigate around a virtual environment with minimal physical movement, allowing them the opportunity to explore virtual spaces with the same freedom of someone without physical impairments. This has implications for educational and entertainment systems, but also opens up possibilities for therapeutic systems, where the effects of a small amount of movement might be exaggerated in a virtual representation.

We have been investigating some less obvious applications of virtual reality for people with disabilities, specifically its application in computer-based communication systems for non-speaking people. People who are severely physically disabled and are nonspeaking have formidable challenges in communicating with others. Their physical capabilities can vary widely, many have very limited muscle control, and some can only interact with the world through the operation of a switch. In order to communicate, these people usually rely on some form of communication aid or system to interact with others. Depending on literacy ability (approximately 60% have some literacy problem) these communication aids may be text- or symbol-based. Speed of communication through a communication system can be very low, however, particularly when the physical disability is severe. Word rates which can be achieved with existing technology usually lie in the range 2-10 words per minute [l]. Conversations can thus be difficult to conduct and prone to breakdown. This is especially the case when the conversation partner is unfamiliar with this method of communication, and is a big obstacle to non-speaking people when they wish to meet people and interact with them.

A basic form of communication device consists of a word board or display panel on which a number of language items are arranged in a grid layout, and the user communicates by pointing to the language item he or she wishes to communicate. The communication partner then reads the language item directly from the word board or display panel. With the advent of microcomputers and speech synthesisers, it became possible for these word boards to become dynamic and for the user to be able to "speak" with a synthetic voice. The resulting systems were still far from ideal, however. It takes considerable time and effort for a user of a communication device to produce each speech act. This is because the speech acts usually have to be constructed word by word. The result can be dysfunctional communication caused by long pauses and low communication rate.

It is possible to have systems hold a large amount of pre-stored phrases, sentences and larger text units (such as commonly told stories), but there remains a major problem of remembering what is stored and how to access it when needed. We have been experimenting with a new method of organising pre-stored utterances to attempt to overcome this memory load problem. It is proposed that users' memory load can be reduced by making use of their existing long term memory to help them locate and select appropriate utterances from the system. Schank and Abelson [2] proposed that people remember frequently encountered situations in structures in long term memory which they called "Scripts". A script captures the essence of a stereotypical situation, and allows people to make sense of what is happening in a particular situation, and to predict what will happen next.

As a way of completely modelling the outside world, scripts obviously have significant limitations. However the potential application of the scripts concept to communication systems for non-speakers has been recognised for some time. The proposal is that if pre-stored utterances are stored within script type structures inside a communication system, then this would aid the user's memory by finding utterances through appropriate scripts. Scripts are most likely to be useful in transactional type conversations, where the speaker is trying to accomplish a particular task, as these tend to be very structured, and predictable in content and flow. Many users of communication systems find this type of conversation particularly difficult as it very often involves them talking with strangers who are not familiar with their particular method of communicating.

After consultation with a group of non-speaking users of communication systems [3] it was decided to develop initially a set of seven scripts. These scripts were chosen because they represented situations that users thought important, but found great difficulty communicating. The seven scripts were: "Activities of daily living", "Restaurant", "Doctor", "Shopping", "Meeting someone new", "Talking about emotions" and "On the telephone". The scripts were developed by considering all the conversation tasks or goals a user would wish to achieve in any given situation. These conversation tasks were further broken down until each sub-task could be performed with a single phrase. A suitable phrase was then composed for each of these conversation sub-tasks. These phrases were grouped into sequences and scenes, and then mapped onto suitable props. The complexity of each scene was carefully controlled to make the scenes easy to use, and easy to learn to use. Wherever possible the number of props within a scene was restricted to nine, as this is approximately the limit of human short-term memory [4].

A scene based user interface to the scripts was devised. In this interface, scripts are presented to the user as a sequence of cartoon style scenes. Each scene is populated with objects chosen to represent the conversation tasks that can be performed. Research into picture recognition and memory structures has indicated that groups of objects organised into realistic scenes corresponding to stereotypical situations assist recognition and memory, compared to groups of arbitrarily placed objects [5]. The scene approach gives users a pictorial indication of subject matter, and allows for users with varying levels of literacy skills.

Figure 1 shows a scene within the restaurant script. Several types of object exist, some allow the user to switch between scenes and others allow the user to speak useful utterances. Special objects allow the user to speak detailed information regarding times, dates and numbers.

Access to all the Scripts is provided through the town plan scene. To move from one script to another requires the users to navigate through the town plan. In order to make it easy to locate the town plan, a special control, the overview button, was provided.

The development of a practical device has been completed. It has been shown, throughout its development, to an advisory group of nine non-speaking people. Their ideas were instrumental in the design of the system, the first set of scripts produced, and the interface design. This group thought the new type of interface would be an advance on existing systems, and was particularly suitable for providing access to scripts. Extended evaluation with disabled non-speaking people is taking place at the moment. From the first set of preliminary evaluations it emerged that users liked the interface style, and it offered them an improved ability to interact effectively in the script settings. The commercial companies involved in the project consortium will be producing a commercial communication system, called ScripTalker, based on this research. It will be available initially in Dutch and German versions, and soon in English, with other languages to follow. One advantage of working at the level of entire phrases is that customising the system for new languages is just a matter of replacing the set of phrases.

A VIRTUAL ENVIRONMENT FOR CHILDREN WITH BEHAVIOUR PROBLEMS

In another project a virtual reality environment has been used to hold the attention and involvement of children with problems in concentration and impulsive behaviour. In both cases the key issue has been one of control. The script interface is an attempt to give the user improved control at a glance over a system while they attend to the primary task, which is interacting with other people. The attention-holding abilities of the virtual environment for difficult children may be due to its affording a high degree of control to the child over an environment which is sufficiently rich as to be interesting to them.

Although there are differing opinions as to the prevalence of the condition, depending on the professional viewpoint of the observer, Attention Deficit Hyperactivity Disorder (ADHD) is a growing problem and challenge for health care and education services [6]. Children who have this condition are currently treated in the UK by a strategy involving both drug and behavioural therapies, including social skills training. The combination of these treatments can be effective in bringing about long-term improvements in the affected children's behaviour.

The challenge faced by carers involved with these children is that there is an increasing number of referrals for treatment, and a shortage of therapists qualified to deliver appropriate therapy, particularly social skills training. This has resulted in significant numbers of children being treated mainly with drug therapy and receiving minimal or no behavioural treatment. The use of computers to assist in the delivery of social skills training to children with ADHD and related behavioural disorders offers a potential opportunity to address this in the longer term. However, more immediately it may complement and enhance the existing work of the therapist.

It was proposed that by exploring a virtual environment under the direction of the therapist a child with these difficulties would be able to experiment safely with the potential consequences of their behaviour. In collaboration with a group of clinical colleagues from community psychiatric nursing, a number of potential scenarios suitable for creation as a virtual environment were discussed. These needed to be pertinent to the client group's state of development and relevant to their behavioural needs.

The virtual environment allowed role-playing to take place within the safe parameters of a computer-based therapy session. Its purpose was to allow the child to enter and move about an environment which had potential for difficulties whilst under supervision of the therapist. The intention is that the child would have access to everyday objects within the environment and that they would be able to approach them, pick them up and move with them. The system was designed to run under relatively low specification machines and there was no expectation of high levels of computer skills amongst the therapist users. The presentation was in the form of 'desk-top' virtual reality, with no need for a special viewing mechanism.

A virtual kitchen was created, which the child was invited to enter and move around. The room was free standing, located in a virtual field, effectively a plane with a never ending horizon, which could be accessed through one of three doors. The interior consisted of a typical modern kitchen, including floor, wall units and large electric appliances; cooker, refrigerator, and dishwasher. The cupboard doors opened when activated as did the doors of the ovens, refrigerator and dish washer. Apart from a number of bottles in the fridge, there were no small objects included in the first version. The cooker hob could be turned on by activating the control knobs; this caused the hob ring to turn red.

During a demonstration of this initial version to therapists, several development suggestions were made. Could the kitchen be populated with more objects that one may typically expect to find in a kitchen? Was it possible to pick up objects and to move around the kitchen with them? They also felt that being able to pass through solid objects would not be a problem for them and felt that it may add interest for the children. As the child would be supervised during therapy sessions and required to navigate around the kitchen under direction of the therapist, it could also be a useful method of monitoring compliance with instruction. Effectively the temptation to deliberately pass through solid objects would have to be overcome and success could be determined by their ability to achieve this.

Potential therapy scenarios incorporating the types of behaviour typically displayed by children with ADHD were discussed. The main area of interest to the therapists was the impulse control difficulties exhibited by this group, one of the manifestations of which is a potentially fatal attraction to electricity and electrical appliances. It was felt that it would be useful, if as well as being able to pick up objects and move around with them in the world offering the capacity to insert them into electrical appliances or a mains electricity socket. It was decided to attempt to incorporate as many of these suggestions into the application as possible given the time constraints.

The software was tested with three separate groups of subjects: computing postgraduate students, children not diagnosed as suffering from ADHD and children diagnosed as suffering from ADHD.

From the responses of the subjects in the student test the joystick and mouse activation methods were optimised.

Of the twenty primary school children (ten girls and ten boys), not diagnosed as suffering from ADHD, only one girl reported never having used a computer before. All boys and eight of the girls had used a mouse before. Ten of the boys and four of the girls had used a joystick before. Responses to the question: *How realistic was the kitchen?* were overwhelmingly positive with 18 (90%) finding it very realistic or quite realistic, two responded neither. To the question: *How frustrating was the experience?* eight (40%) found it a little frustrating, 2 found it neither and 10 (50%) found it either not frustrating or not at all frustrating. In response to the question: *How involved did you feel?* five (25%) responded very involved, 11 (55%) felt involved, 2 reported neither and one not involved. All of the subjects reported the experience as very interesting or interesting and very enjoyable or enjoyable. Also all said that they would be willing or very willing to do this again.

The third test involved a group of five boys diagnosed as having ADHD and attending a therapy group. All had used a computer, mouse and joystick previously and they produced the following results. Four subjects reported the kitchen as being very realistic and one as being quite realistic. Responses to the question: *How frustrating was the experience?* produced one not at all frustrating, one not frustrating and two neither. Four subjects felt very involved and one felt involved. All of the subjects found the experience very interesting with four finding it very enjoyable and one quite enjoyable. All would be very willing to do it again.

Because the numbers in each of the two child subject groups varied dramatically it is not possible to draw firm conclusions from the results, however as a preliminary and exploratory exercise some useful observations were made. There can be little doubt about the computer and the application's ability to captivate the user's attention. All of the subjects showed an intense interest in what they were doing. It must be remembered that this application was not a game, instead it was on the face of it a relatively unstimulating virtual environment. On the other hand, what it was able to do was to provide an active experience where the children were able to explore and activate real-life objects.

Perhaps the most interesting results were the comments of the clinical staff. All of the clinical therapists thought that the kitchen world was providing the children with much more control over their environment than they would experience within a game. If this turns out to be true then it may be a very important feature indeed, as many of the children with ADHD have many external controls placed upon them over which they have little power of direction. The fact that objects within the world were not jumping out producing noise and high impact visual stimulation on the face of it should have reduced enthusiasm. However this was not a feature observed and the children seemed to gain a great deal of pleasure from exploring this unanimated world.

Thus the machine and application were able to hold the attention of the user, potentially offering the opportunity for therapy to be given, either by the computer or by a human therapist. This effect will be investigated further. More work needs to be done on developing appropriate virtual worlds and therapeutic scenarios in which they can be used. It is also important that any studies into the use of virtual reality should demonstrate a measurable and transferable positive result. It is not good enough to show that behaviour is learned or changed within the virtual world if it cannot be translated into positive benefits in the real world.

CONCLUSIONS

The work described here is in its early stages, but it does seem that these two rather unusual applications of virtual reality may be of benefit. Having a realistic scene as an interface is particularly appropriate when the user is trying to control a system which is accessing scripts. A very quiet virtual scene seemed to draw the interest of children with attention holding problems even without dramatic special effects. It is possible that this lack of activity was in itself helpful, in that it allowed the children to gain control over the environment easily and did not distract them with too much activity.

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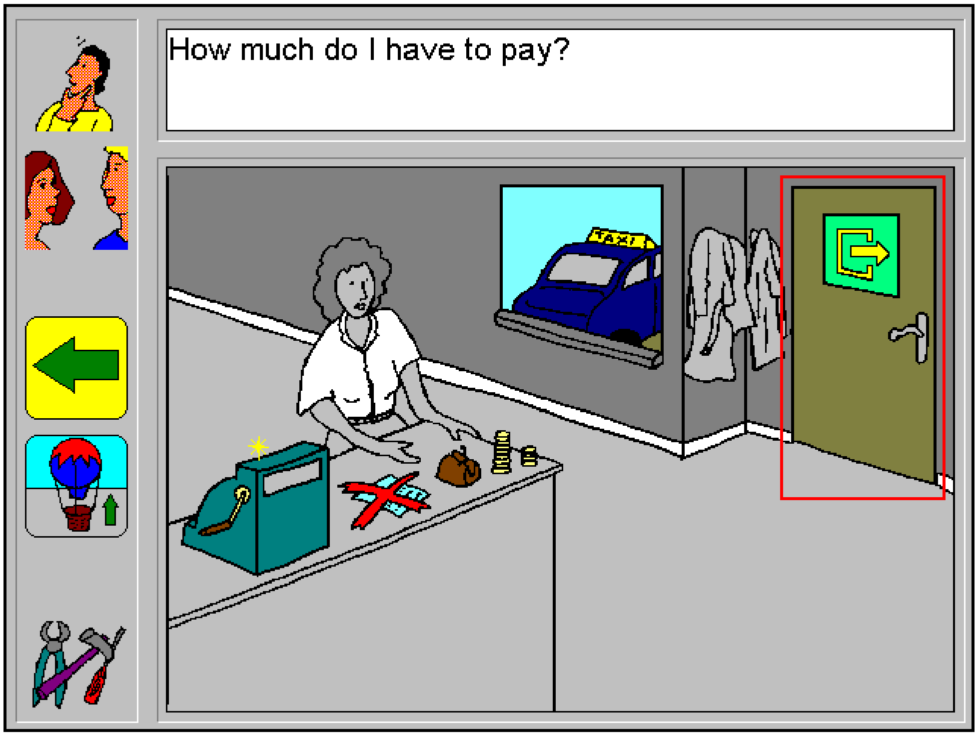

Figure 1: The paying and leaving the restaurant scene from the restaurant script. In the main picture phrases are associated with the objects pictured. The user is speaking the phrase associated with the cash register object. In the left margin are buttons for quick comments (top two), extra navigation aids (middle two) and a toolkit (at the bottom).