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Virtual reality stroke rehabilitation – hype or hope?

Background

People who have had a stroke frequently experience difficulty performing activities of daily living (ADL's) due to a combination of physical, cognitive and perceptual problems (Mayo, et al., 1999). Occupational therapists commonly retrain stroke survivors in personal ADL's (for example feeding, dressing, bathing) and instrumental ADL's (for example meal preparation, housework, shopping) (Latham, et al., 2006; Richards, et al., 2005). A recent systematic review found that stroke survivors who received occupational therapy became significantly more independent in personal and instrumental ADL's than those receiving no occupational therapy or usual care (Legg, Drummond, & Langhorne, 2006). However, the intervention approaches used varied between studies and at present it is not clear which treatment approaches and techniques are most beneficial (Legg et al., 2006). Common approaches to the retraining of ADL's after stroke include; practise of the desired activity, prescription of aids/equipment and teaching of compensatory strategies (Walker, Drummond, Gatt, & Sackley, 2000).

Virtual reality is a relatively recent approach in stroke rehabilitation. Virtual reality is described as the 'use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear and feel similar to real world objects and events' (Weiss, Kizony, Feintuch, & Katz, 2006). While virtual reality interventions to date have predominantly targeted motor rehabilitation of the upper and lower limb (Henderson, Korner-Bitensky, & Levin, 2007), researchers have also designed interventions to retrain ADL's. Retraining of the target ADL (for example, making a hot drink) is achieved as the user interacts with life-like objects (such as a kettle and teaspoon) in the virtual environment (the virtual kitchen). Virtual reality programs have been designed to retrain supermarket shopping, automobile driving, scooter driving and making a hot drink; details of these studies are included in the appendix (Akinwuntan et al., 2005; Edmans et al., 2009; Jannink, Erren-Wolters, de Kort, & van der Kooij, 2008; Lee et al., 2003; Rand, Katz, & Weiss, 2009).

There is a beginning body of literature upon which occupational therapists can evaluate the application of virtual reality into the clinical environment. Published literature to date has tended to describe the development of virtual reality programs and assessment of their usability. Small evaluation studies have reported positive effects of virtual reality intervention however most of the studies have had small sample sizes and only two of the studies are randomised controlled trials (Akinwuntan et al., 2005; Jannink et al., 2008).

In this viewpoint article we describe some of the attributes that we believe makes virtual reality a potentially influential tool for occupational therapists; however we also highlight issues that need to be addressed in further research before widespread clinical use can be recommended.

A powerful tool for therapy….

The programs detailed in the appendix capture the imagination and illustrate how practise of ADL's is possible in a virtual environment. Virtual reality intervention has

many desirable attributes, and offers many of the features thought to be important in stroke rehabilitation programs. There are a number of reasons why using virtual reality, either as an assessment or intervention tool, may potentially be advantageous when compared to traditional therapy approaches.

Firstly, virtual reality allows the therapist to exercise more control over the environment compared to real life settings (Rizzo & Kim, 2005). This enables the therapist to grade the task to the appropriate level of challenge. Driving simulators may one day be so well designed that the client can practice a virtual driving trip prior to an on-road test. The therapist can grade the task, so that the client could start the virtual driving task on quiet roads in good weather conditions, and progress to busier roads in the rain or dark. This would provide more comprehensive information about the driver's ability to perform in a variety of situations than current assessment methods. Furthermore, tasks that are performed with an element of risk can be practised safely and with control. Meal preparation tasks can be performed without the therapist worrying the patient will burn their hand on the hotplate; the client can practise virtual Automatic Teller Machine use and make multiple mistakes without the therapist being concerned about potential negative consequences of incorrect pin entry. Many of the most difficult issues confronting occupational therapists who work with people after stroke are concerned with how to balance safety issues with respect for a patient's autonomy and desire for independence. Virtual reality approaches appear to offer opportunities to directly address risk by providing a safe and supported environment for practice.

Secondly, the use of virtual reality allows a broader range of activities to be offered in hospital and rehabilitation settings. Occupational therapists value the importance of the context or environment in which occupations are performed (Dunn, Brown, & McGuigan, 1994). This may raise questions as to the usefulness of practising tasks in a virtual reality environment; however we believe the tasks may provide more ecological validity than traditional rehabilitation tasks (meaning they better represent real-world tasks). This may be particularly true for tasks performed in an acute or sub-acute setting where often limited opportunities for practise of real world tasks are available. For example, clients could reach for virtual items in a wardrobe rather than reaching for quoits held out by the therapist in a therapy gym; or practise scanning for items on a supermarket shelf, rather than using traditional pen and paper tasks for the remediation of neglect.

Thirdly, virtual reality may be a more cost effective way of providing assessment and intervention, for example it could be more cost effective than an on-road driving assessment. Additionally, stroke survivors could be trained to practise virtual tasks independently. The addition of independent practice to traditional face-to-face therapy would result in an increased amount of time the patient spends in therapeutic activities, which may result in better ADL outcomes, without the associated increased staffing costs (Kwakkel et al., 2004). We believe this approach may also be useful in rural settings or nursing homes where clients have reduced access to therapy and for clients where transport is not available. Furthermore, increasing demand for rehabilitation and the pressure for shorter hospital stays has identified the need to challenge conventional therapy approaches in stroke rehabilitation where the predominant form of therapy is one to one.

Virtual reality offers additional characteristics that are thought to be important in stroke rehabilitation such as providing an enriched environment (where there is opportunity to engage in challenging therapeutic tasks), and multimodal feedback on performance (for example visual, tactile and audio feedback) (Dobkin, 2004). In this way, virtual reality shares similarities with computer games which have also recently been used with some success by health professionals. While there are few high quality studies, there is some evidence that computer games are more appealing than, and at least as effective as traditional methods in enhancing health related knowledge and improving health related behaviours in children and adolescents (Papastergiou, 2009). We imagine that this type of enriched environment and feedback will be appealing to stroke survivors who will be able to gain detailed information about their performance and be able to measure their progress more objectively.

…..or not all it is hyped up to be

While virtual reality appears to hold great promise as a therapy tool, there are currently significant barriers to it's implementation in terms of application, education and research.

While there has been an increase in the development of specially designed virtual environments (Crosbie, Lennon, Basford, & McDonough, 2007), these environments have only been evaluated in research studies and it is difficult to be sure of their clinical utility. While there are some commercially available programs ("GestureTek Health," 2010; Riva et al., 2010), these programs are often unaffordable. Clinicians interested in developing their own programs will find the cost prohibitive due to the amount of time and expertise required in development (Burdea, 2003) and clinical settings may also lack the space required for virtual reality systems. Given that future virtual reality programs are likely to become more versatile and affordable over time and provide an increased dose of therapy they may be a wise investment however, further research into their clinical and cost effectiveness will indicate whether this investment is justified.

While some studies have demonstrated that virtual environments are user friendly (Rand et al., 2009), it appears that older people in particular are not as confident using this technology (Lee et al., 2003) Creating a user friendly program appears to be one of the greatest challenges at present and researchers have described varied success in creating user friendly ADL interventions. Lee (2003) reported that participants had difficulty using a joystick to navigate through a virtual supermarket, though participants adjusted to the task over time. In comparison, Rand (2009) reported that using a video capture system (in which the person's image is captured by a small camera and projected on a screen in front of them) to retrain shopping was well received by participants, some of whom described the task as more active and challenging than traditional rehabilitation tasks. The use of virtual reality programs may be more successful with younger stroke survivors who are generally more technologically savvy and willing to try new technologies. Evaluation needs to occur on both the type of patient who will most benefit from virtual reality and also the appropriate time in their rehabilitation program (for example acute or subacute).

As with all interventions, we need to be aware of possible side effects of virtual reality. Studies have shown that some users report motion sickness, however this has

not been rigorously evaluated (Rizzo & Kim, 2005).This needs to be considered when designing programs and monitoring the user's physiological response.

As therapists it is difficult to keep abreast of the rapidly altering technological advances. We are unlikely to introduce technology that is difficult to use, takes time to set up, or frequently needs repair. Educating occupational therapists to develop technical expertise will be required for the successful application of virtual reality in the clinical setting of stroke rehabilitation. It is also useful for clinicians to be aware of developments in the commercial gaming industry (for example the Nintendo Wii), as these systems are more sophisticated and will further drive developments in specially designed rehabilitation environments. Additionally access to support staff with a high level of technical skill is required to maximise the chance of the success of virtual reality in rehabilitation by occupational therapists.

Researchers need to further explore the relationship between performance in the real world and the virtual world. Some studies have found correlations between performance suggesting validity (Matheis et al., 2007; Zhang et al., 2003) however another study found inconsistencies (Edmans et al., 2006). We believe that this is likely to be related to the design of the hardware and software, and that programs that have more naturalistic methods of interacting with the virtual environment and more life-like visual display are more likely to correlate with real world performance.

Clinical trials in this are have had small numbers of participants and a recent systematic review examining the effect of virtual reality in stroke rehabilitation identified only three randomised controlled trials. Subsequently they concluded that while results of the intervention were generally positive, the evidence base is too limited at present to guide practice (Crosbie et al., 2007). Additionally, Edmans (2009) commented on the difficulty they had recruiting participants to their trial; only 9% of those participating in stroke rehabilitation could be recruited. This raises questions concerning how many stroke survivors may benefit clinically from virtual reality intervention.

While occupational therapists may be concerned that virtual reality programs will replace the role of the therapist it is unlikely this will occur in the foreseeable future due to abovementioned limitations. Virtual reality is a tool that may revolutionalise rehabilitation, but the tool needs to be provided in a therapeutic way. Occupational therapy involves holistic assessment and individualised treatment. Therapists using virtual reality as part of rehabilitation will need to assess the suitability of virtual tasks for the client, grade the task and evaluate it's effectiveness as part of a holistic and goal oriented rehabilitation plan.

Conclusion

Virtual environments show promise as a future tool in the rehabilitation of ADL's after stroke, particularly in the subacute phase. They can be motivating and have the potential to be used in a range of settings such as in the home or in nursing homes allowing additional practise outside of formal therapy sessions. Clinical use is currently limited by cost, availability and technical expertise. Even if these factors were not an issue, there is not enough evidence yet to support routine use (Crosbie et al., 2007). Occupational therapists need more information from researchers about accessibility, useability, and the relationship between performance in the real world

and in the virtual world. Similarly, at this time a number of aspects of the application of virtual reality technology by occupational therapists remain unclear including: which patients at which stage of rehabilitation are most likely to benefit from the use of virtual reality; and which issues this approach is most useful for (for example the assessment of risky activities versus offering additional practice). If occupational therapists are able to engage with research teams early in the process of developing virtual environments their skills in activity analysis, grading of meaningful occupations and their understanding of the needs and functional abilities of the user will improve the utility and effectiveness of the approach.

It seems likely that virtual reality will be important in the future for occupational therapists and with the increasing demand for rehabilitation services it is vital that we explore innovative new ways of service delivery. Without partnerships between clinicians, game designers and researchers the area will advance slowly. We urge therapists to engage with engineering and gaming groups to explore innovative approaches to the delivery of rehabilitation programs.

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