Arcada Working Papers 8/2017
ISSN 2342-3064
ISBN 978-952-5260-86-1

Virtual Reality in rehabilitation: a user perspective

Laura Pesonen[i], Linah Otieno[ii], Loveth Ezema[ii], Daisy Benewaa Kusi[ii], Thomas Hellstén[iii]

Abstract

In rehabilitation stroke and Multiple sclerosis (MS) are two very common causes of motor disability in adults. Traditional rehabilitation is very time-consuming and expensive. Therefore, rehabilitation professionals are looking to Virtual Reality (VR) technology in order to assist patients on their path to function better in their daily lives. Recent studies have mostly investigated the end results of VR therapy, but the user experience has been less studied. This working paper presents a thematic review of recent studies to highlight the advantages and disadvantages of VR solutions in motor rehabilitation from the user perspective. Our findings suggest that VR rehabilitation can be more motivating for the patient than traditional rehabilitation, but current VR interventions are often overly simplistic and not customized for the user. This presents opportunities for innovative service design.

Keywords: e-health, rehabilitation, Multiple Sclerosis, stroke, Virtual Reality

1 INTRODUCTION

Several factors have contributed to the demand for and rise of e-health solutions in developed countries. These include the rapidly aging population coupled with the diminishing budgets for public healthcare. E-health is a young field still seeking a definite definition. Eysenbach (2001) summarizes e-health as *"the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies."*

At the same time, demand for alternative rehabilitation resources in motor (re)learning is highlighted, as traditional forms of rehabilitation are often time-consuming and expensive. (Lohse et al., 2013; Sisto et al., 2002; Saposnik and Levin, 2011; Langhorne, Coupar and Pollock, 2009).

[i] Student at Metropolia University of Applied Sciences, Finland, Department of Health Care and Social Services, [laura.pesonen@metropolia.fi]
[ii] Student at Arcada University of Applied Sciences, Finland, Department of Health and Welfare
[iii] Senior lecturer at Arcada University of Applied Sciences, Finland, Department of Health and Welfare, [thomas.hellsten@arcada.fi]

One of the most intriguing e-health solutions is Virtual Reality (VR), which can be defined as a computing technology that generates a simulated or artificial three dimensional environment, which imitates reality (Sisto et al., 2002). VR technology has been successfully used over several decades in psychotherapy for example in the treatment of phobias and post traumatic stress disorder (PTSD) (Keshner, 2004). Promising results have been reported by studies regarding the benefits of VR treatment for motor learning or relearning after stroke (Saposnik and Levin, 2011; Langhorne, Coupar and Pollock, 2009).

The aforementioned stroke and Multiple sclerosis (MS), are increasingly prevalent conditions. For example, stroke is the leading cause of disability in adults with 4.8 million survivors worldwide (Wüest et al., 2014). On the other hand, more than 2.3 million people are diagnosed with MS worldwide not counting the undiagnosed cases (MS International Federation). This means that millions of people yearly acquire the need for motor rehabilitation in order to function in their daily lives.

Studies about VR in rehabilitation have generally only assessed the deployment effect (i.e. the effect that using or not using VR has on engagement) instead of addressing the design characteristics that VR exercises should contain, in order to optimally enhance engagement (Matijevic et al., 2013).

The aim of this working paper is to inspect, assess and discuss VR solutions in motor rehabilitation from the user perspective. As an example of patient groups requiring motor rehabilitation, we discuss the needs of MS and post-stroke patients. This Arcada working paper is co-authored by students attending the e-health course at Arcada University of Applied Sciences in 2017 with supervising teachers. The purpose of the course was to explore the current state and future visions of the ongoing digitalization in the field of health and welfare. Co-writing as a process can be seen as a pedagogical model for enhancing students' deep evidence-based learning.

2 THEORETICAL FRAMEWORK

Since the push for VR technologies began, different theories have been proposed to describe the underlying mechanisms involved in maximizing learning. One key learning theory is the motor learning theory (MLT), which is a series of internal processes that lead to relatively permanent changes in the capability to perform certain tasks as a direct result of practice or experience. The MLT processes are broken down into three phases: acquisition, retention, and transfer. For example, in a VR therapy that aims to retrain clients to walk safely, the client would practice how to walk safely in a laboratory environment (acquisition), be able to reproduce the task later (retention), and eventually be able to walk in the community (transfer). (Jarus and Ratzon, 2005)

2.1 VR rehabilitation for post-stroke and MS patients

Treatments such as VR rehabilitation are performed to control the symptoms and aftermath that come with MS and stroke. In both MS and post-stroke, arm and leg move-

ments are affected in one way or another, and most commonly on gait movements. (Girone et al., 2001; Cho and Lee, 2013)

Motor (re)learning is possible only if a patient experiences some forms of movement especially post-stroke as compared to showing no motion signs at all post-stroke and persistent practice (Girone et al., 2001; Cho and Lee, 2013).

Challenges may arise while rehabilitating stroke patients, as some experience lack of interest towards repetitive training. The use of VR-based programs will act as an alternative to traditional motor training programs. These technologies aim at increasing engagement and willingness to participate in rehabilitation. (Shin et al., 2014)

VR interventions that have been used for motor rehabilitation in the stroke patients include for example Rutgers systems for ankle rehabilitation and for improving finger range of motion, GestureTek's Interactive Rehabilitation and Exercise System (IREX), VR treadmill training and off-the-shelf commercially available gaming systems including Nintendo Wii Fit and Wii Sport, EyeToy Play 2 and Kinect (Girone et al., 2001). Of these, Nintendo Wii appears to be the most common, or at least the most studied, perhaps due to the accessibility, affordability and variety offered by the system.

3 METHOD AND RESULTS

Using VR technologies for motor rehabilitation is an extensive branch of medicine but still subject to further research, especially on the aspects of patient motivation and patient engagement.

A thematic review was used to collect information on motor rehabilitation using VR technologies from different scientific databases, including PubMed and MetCat. The search terms "virtual reality", "rehabilitation", "stroke" and "MS" were used. In order to narrow the search down to articles focusing on the user experience, the terms "experience" and "engagement" were used in addition. Eleven studies were chosen, which briefly discussed the user experience. Additionally, other articles were chosen with the aim of getting general information relating to this topic. This perspective was also chosen because few studies have been done relating to the user experience of using VR technology in motor relearning for stroke and MS.

3.1 VR interventions based on stroke and MS patients

Service design uses information from market research by testing products with the help of customers, while monitoring customer experience to improve the product after understanding patient needs (Stickdorn et al., 2011). Understanding the needs of stroke and MS patients with matters relating to their rehabilitation is key in order to design usable and engaging VR technologies for them. These patients have specific requirements for motor learning, which we highlighted in section 2.1. In addition to needs presented by the specific conditions of the patients, each user has their own unique qualities and interests which determine what motivates them for rehabilitation (Kielhofner, 2008; Wüest et al., 2014).

The results of services are not only visible during the service period, but are extended way after the service has been used (Stickdorn et al., 2011). Therefore, developers should not end their focus on finished products but continue to monitor the user experience to find faults and achievements of the service for future development.

Producing usable VR technologies for MS and stroke patients should ultimately provide the patient with environments, occupations (activities) and goals, which are relevant and motivating for them individually. Specifically, experiences they can relate to and bonds that affect them positively emotionally. Such technologies set themselves apart from others while offering pleasant experiences as well as helping patients to express themselves and unveil their identities to be known to others (Stickdorn et al., 2011).

3.2 Results

As follow we will present the results. According to Faria et al. (2016), VR and interactive technologies have emerged as a valuable approach in stroke rehabilitation, by providing the opportunity to practice cognitive and motor activities that are not or can´t be usually practiced within the clinical environment. These include as training attention abilities in street crossing situations, executive functions by visiting a supermarket or performing simulations of real-life scenarios and activities in urban virtual environments. Yet the advantages of VR to address stroke impairments go beyond ecological validity of training, with a growing body of evidence especially in the motor rehabilitation domain.

Wüest et al. (2014) claim that stroke rehabilitation programs lack a theory-driven basis, especially for motor learning. Commercial games do not work optimally to support motor learning, and they may not work in optimally engaging the individual in question. Lohse et al. (2013) have noted that well-designed video and virtual reality games can increase patient engagement and motivation in rehabilitation and therefore time spent in rehabilitation.

Studies examining the user experiences of VR are in the minority. Many of these concern the use of Nintendo Wii. For example, Glännfjord et al. (2016) examined the use of Wii Sports Bowling in a group of elderly people. They found that the use of the game resulted in experiences of being immersed in the activity and even in a state of "flow". The game was deemed easy to use and an enjoyable way of participating in activities socially. It was also noted that the presence and support of a peer group can help in engaging in an active life.

According to Glännfjord et al. (2016), virtual activities result in similar types of feelings as real life activities. Allaire et al. (2013) found that those elderly persons who engaged in some kind of digital game (including Wii), were in better health and exhibited less signs of ageing than those who didn't. Anderson et al. (2010) found that "Wii rehabilitation" has been successful in increasing patients' motivation and encouraging full body movement. Al-Darraji (2014) found that Wii therapy's benefits are evident especially in the subacute phase of stroke patients.

In a study by Zimmerli et al. (2013) control subjects without any neurologic movement disorders were compared with subjects with spinal cord injury. Different VR exercises

were used to measure e.g. mobility and lower extremity functions. They found that in order for VR interventions to promote active participation, VR exercises have to be interactive, and user preferences and expectations need to be taken into consideration.

4 DISCUSSION

In this section we will discuss the advantages and disadvantages of using VR in motor rehabilitation from the user's perspective.

4.1 Advantages of VR rehabilitation from the user perspective

The aim of this paper was to discuss advantages and disadvantages of VR rehabilitation from a client perspective. One of the most cited advantages of VR in rehabilitation is the ability to motivate the user to persist in practicing the required movements and occupations. Increasing the time spent in rehabilitation is the best way to improve the results of therapy. The motivating effect of VR has been documented by e.g., Matijevic et al. (2013), Anderson et al. (2010), and Keshner and Fung (2017). The motivational effect of VR is of course dependent on the fact that the VR games are well-designed (Lohse et al., 2013).

Other key advantages of VR from the user perspective is that it allows independent practice and stimulus control, it is flexible, safe and easily documented and it provides the user feedback. VR allows the patient to practice in his/her own home. (Lohse et al., 2013) This provides the patient a safe and comfortable environment, which in itself can improve motivation and engagement. At the same time, this decreases the costs of rehabilitation.

Flexibility means that the level of difficulty can be increased based on the user's progress (Faria et al., 2016), and the user's attention can be distracted or augmented (Keshner, 2004). In addition, advances can easily be graded and documented (Matijevic et al., 2013; Lewis and Rosie, 2012).VR also provides real-time feedback about the individual's current level and quality of movement (Zimmerli et al., 2013; Keshner, 2004).

4.2 Disadvantages of VR rehabilitation from the user perspective

Among the main disadvantages of VR from the user's point of view is that VR interventions are often overly simplistic and not customized for the specific user and his/her unique needs. The interventions are often not properly analyzed regarding their effectiveness for motor learning during therapy. (Zimmerli et al., 2013)

Anderson et al. (2010) noted that WII applications were not designed with the rehabilitative focus in mind, and this presents a number of problems: games are too difficult for patients, they mainly target upper-body gross motor functions and they lack support for task customization, grading and quantitative measurements.

In order for the patient to become engaged and motivated, activities used in rehabilitation need to be meaningful for the individual (Kielhofner, 2008). In a similar way, it is also important that the VR activity is executed in a believable way in order for it to be meaningful for the patient (Glännfjord et al., 2016).

Common consensus is that virtual environment interventions are likely beneficial if used as an adjunct to conventional therapy. In fact, using VR without proper orientation and guidance by the therapist is a risk for the success of rehabilitation. According to Keshner and Fung (2017), many clinicians use it to motivate clients without identifying or controlling for the actual cognitive and neuromuscular parameters that could be modified by these activities.

5 CONCLUSION AND IDEAS FOR FURTHER STUDIES

VR offers new possibilities for activating and engaging MS and stroke patients in motor rehabilitation. In order for these activities to optimally support the rehabilitation process, they need to be meaningful to the individual and customized to the individual's specific rehabilitation needs. This requires innovative service design.

Further studies should highlight characteristics of VR solutions that promote both optimal motor learning, as well as active participation, in patients with MS or post-stroke rehabilitation needs. Studies should also examine the most effective treatment frequency and intensity. Another interesting topic for study would be the risks associated with VR motor rehabilitation, as very few studies highlighted these.

REFERENCES

Al-Darraji S.J., 2015. Virtual reality Wii therapy: An efficacious, safe, feasible, alternative approach to post stroke rehabilitation. *School of Physician Assistant Studies.*

Allaire, J.C., McLaughlin, A.C., Trujillo, A., Whitlock, L.A., LaPorte, L. and Gandy, M., 2013. Successful aging through digital games: Socioemotional differences between older adult gamers and non-gamers. *Computers in Human Behavior*, 29(4), pp.1302-1306.

Anderson, F., Annett, M. and Bischof, W.F., 2010. Lean on Wii: physical rehabilitation with virtual reality Wii peripherals. *Stud Health Technol Inform*, 154(154), pp.229-34.

Brahnam, S. and Jain, L.C., 2011. Virtual Reality in Psychotherapy, Rehabilitation, and Neurological Assessment. In Advanced Computational *Intelligence Paradigms in Healthcare 6. Virtual Reality in Psychotherapy, Rehabilitation, and Assessment* (pp. 1-9). Springer Berlin Heidelberg.

Cho, K.H. and Lee, W.H., 2013. Virtual walking training program using a real-world video recording for patients with chronic stroke: a pilot study. *American journal of physical medicine & rehabilitation*, 92(5), pp.371-384.

Eysenbach, G., 2001. What is e-health?. *Journal of medical Internet research*, 3(2).

Faria, A.L., Andrade, A., Soares, L. and i Badia, S.B., 2016. Benefits of virtual reality based cognitive rehabilitation through simulated activities of daily living: a randomized controlled trial with stroke patients. *Journal of neuroengineering and rehabilitation*, 13(1), pp.96.

Glännfjord, F., Hemmingsson, H. and Larsson Ranada, Å., 2017. Elderly people's perceptions of using Wii sports bowling–A qualitative study. *Scandinavian journal of occupational therapy*, 24(5), pp.329-338.

Girone, M., Burdea, G., Bouzit, M., Popescu, V., Deutsch, J.L. 2001. A stewart platform-based system for ankle telerehabilitation, *Autonomous Robots*, 10(2), pp. 203-212.

Jarus, T. and Ratzon, N.Z., 2005. The implementation of motor learning principles in designing prevention programs at work. *Work*, 24(2), pp.171-182.

Keshner, E.A., 2004. Virtual reality and physical rehabilitation: a new toy or a new research and rehabilitation tool?. *Journal of NeuroEngineering and Rehabilitation*, 1(1), pp.8.

Keshner, E.A. and Fung, J., 2017. The quest to apply VR technology to rehabilitation: tribulations and treasures. *Journal of Vestibular Research*, 27(1), pp.1-5.

Kielhofner, G., 2002. *A model of human occupation: Theory and application*. Lippincott Williams & Wilkins.

Langhorne, P., Coupar, F. and Pollock, A., 2009. Motor recovery after stroke: a systematic review. *The Lancet Neurology*, 8(8), pp.741-754.

Lewis, G.N. and Rosie, J.A., 2012. Virtual reality games for movement rehabilitation in neurological conditions: how do we meet the needs and expectations of the users?. *Disability and rehabilitation*, 34(22), pp.1880-1886.

Lohse, K., Shirzad, N., Verster, A., Hodges, N. and Van der Loos, H.M., 2013. Video games and rehabilitation: using design principles to enhance engagement in physical therapy. *Journal of Neurologic Physical Therapy*, 37(4), pp.166-175.

Ma, M. and Zheng, H., 2011. Virtual reality and serious games in healthcare. *Advanced Computational Intelligence Paradigms in Healthcare 6. Virtual Reality in Psychotherapy, Rehabilitation, and Assessmen*t, pp.169-192.

Matijevic V., Secic A., Masic V., Sunic M., Kolak Z., Znika M., 2013. Virtual Reality in Rehabilitation and Therapy. *Acta clinica Croatica*, 52(4), pp. 453-457.

Mittman, R. and Cain, M., 1999. The Future of the Internet. *Institute for the Future*.

MS International Federation. https://worldmsday.org. Accessed on June 15, 2017.

Moore C. MS from the inside out uses virtual reality to share what life for patients is like. https://multiplesclerosisnewstoday.com. Accessed on June 15, 2017

Saposnik, G., Levin, M. and Stroke Outcome Research Canada (SORCan) Working Group, 2011. Virtual reality in stroke rehabilitation. *Stroke*, 42(5), pp.1380-1386.

Shin, J.H., Ryu, H., Jang, S.H. and Kim, S., 2013. Task-specific interactive game-based virtual reality rehabilitation system for stroke patients: A usability test and two clinical experiments. *Journal of the Neurological Sciences*, 333, pp.e569.

Sisto, S.A., Forrest, G.F. and Glendinning, D., 2002. Virtual reality applications for motor rehabilitation after stroke. *Topics in stroke rehabilitation*, 8(4), pp.11-23.

Wüest, S., Langenberg, R. and Bruin, E.D., 2013. Design considerations for a theory-driven exergame-based rehabilitation program to improve walking of persons with stroke. *European Review of Aging and Physical Activity*, 11(2), pp.119.

Zimmerli, L., Jacky, M., Lünenburger, L., Riener, R. and Bolliger, M., 2013. Increasing patient engagement during virtual reality-based motor rehabilitation. *Archives of physical medicine and rehabilitation*, 94(9), pp.1737-1746.