

The contribution of a VR-based programme in cognitive rehabilitation following stroke

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Abstract— The main purpose of this study was to test a VR training programme to promote cognitive recovery of memory and attention deficits in patients that suffered from an acute ischemic stroke episode. Our sample consisted of two patients with memory and attention deficits resulting from stroke. The patients were submitted to a 10 training virtual reality (VR) sessions where they performed memory and attention exercises. These patients were assessed before, during and after the VR training programme with WMS and TP scales. Descriptive analysis showed an increase in memory and attention mean scores from the initial sessions to the final sessions.

Keywords- Stroke; VR; Memory; Attention

I. INTRODUCTION

The consequences of stroke can be very diverse and can affect all human domains, such as cognitive, emotional, behavioral and social functioning resulting in deficits that range from motor disability to cognitive impairment or attention/concentration deficits. Neuropsychological rehabilitation is related with the improvement of cognitive and motor deficits caused by brain injury. The major goal of neuropsychological rehabilitation is to enable patients to overtake cognitive and emotional deficits and to achieve social adjustment and better quality of life (1). In this context, several studies are in development in order to assess the role of neuropsychological rehabilitation in cognitive and motor recovery. According to (2) the repetitive practice or stimulation can help to recover the impaired functions. The most widely use exercises for cognitive rehabilitation are based in this assumption. They are function-based approaches for neuro-rehabilitation as they are focused on a specific cognitive or motor domain. The contribution of the new information technologies by means of using the virtual reality (VR) environments for neuro-rehabilitation could offer a more controlled environment for function based training. VR, for training purposes, can provide an application where repetition, visual and auditory feedback can be systematically manipulated according to each individual differences. Another important issue with rehabilitation is patient's motivation to perform the preselected exercises. Mainly because VR is usually presented on a multimodal platform with several sorts of immersive cues, such as images and sounds, patients may be more willing to engage and pursue with the exercise (3). On a virtual environment, training is perceived more as a game and less than a task and can be considered as more engaging and more stimulating than the conventional methods (4). Other

studies (5) found that when compared to conventional exercise, children with cerebral palsy had more fun and tended to repeat more often the VR exercises. Motor aspects of using VR environments were also studied by (6). They developed a VR application for stroke patients aimed at training a specific function (making a hot drink) and studied the performance of these patients when making this task in a real and virtual world. Data suggested that virtual applications can be used for rehabilitation of stroke, but the neural mechanisms underlying performance in a virtual world can be different than real life situations. According to these conclusions, it is reasonable to assume that larger and more rigorous studies are needed in order to endorse all these different areas that are involved in cognitive and motor rehabilitation. Moreover, and to our best knowledge there are lack of studies regarding the role of VR-based approaches in cognitive rehabilitation. In light of this, our main purpose was to test a VR training programme to promote cognitive recovery of memory and attention deficits in patients that suffered from an acute ischemic stroke episode.

II. METHOD

A. Participants

The sample consisted of two patients from the rehabilitation hospital Centro de Medicina da Reabilitação do Alcoitão with memory and attention deficits as a consequence of stroke. Both patients were female with 18 and 37 years old, respectively for patient A and B. Both suffered an acute ischemic stroke in the anterior cerebral artery territory from the left hemisphere (3 months before the study). None of the patients had family antecedents of stroke, but the latter had several risk factors of vascular disease such as hypertension, obesity and smoking behavior. Along with memory and attention deficits, the patient B was diagnosed with Broca aphasia and right hemiparesis.

B. Measures

Each patient was assessed in three different moments (before, during and after training) with the Wechsler Memory Scale - WMS (7) for neuropsychological evaluation of memory and the Toulouse Piéron - TP (8) for attention/concentration. In order to control possible effects of VR exposure, VR related variables, such as, Presence (Presence Questionnaire - PQ (9)), Immersion (Immersion Tendencies Questionnaire (10)) and Cybersickness (Simulator Sickness Questionnaire (11)) were also assessed, Task performance was monitored during each

VR session through the completion time of each task. An indicator of task performance speed was also used.

C. Procedure

The patients interacted with the VR worlds through an eMagin Z800 HMD (Head Mounted Display), moving around by pressing the left mouse button. The platform was developed using Unity 2.5. The VR-based tasks consisted of 10 weekly VR sessions (one session per week). More specifically, session number 1 was a practice session dedicated to training the interaction with the VR scenario. Afterwards, activities of daily living such as morning hygiene, taking the breakfast, finding the way to the minimarket and buying several items from a shopping list were gradually and systematically manipulated. For example, demands on working memory and attention were manipulated in several ways: (a) by adding more grocery items to the shopping list; (b) finding a different way to the minimarket; (c) finding a pre-determined door number; (d) retention of information in the outdoor advertisements; (e) calculation and digit retention tasks from the Mini-Mental State Examination along the way to the mini-market. An example of these tasks can be found below (Fig. 1).



III. RESULTS

Descriptive analysis was performed for the comparison between the three different assessments in each test score. The analysis started with an inspection of VR related variables, namely for presence, immersion and cybersickness scores. Mean values for each dimension of the PQ, ITQ and SSQ are presented below in Table 1. Overall data for presence, immersion can suggest an increase in these scores during the rehabilitation programme. Motion sickness symptoms were similar between the three different assessments. Regarding to memory domain, the WMS data showed an increase of memory capabilities in both patients, but that was more pronounced in patient B (i.e. from an initial score of 20 to 35 at the final assessment). The other domain estimated by attention/concentration scores from the TP, revealed an increase in sustained attention to these tasks. Task performance was also assessed during each VR session, revealing a decrease in mean completion time until working memory sessions. During these sessions the completion time increased, probably, because the participants had to perform more cognitive demanding visuo-spatial orientation tasks.

	Before	During	After
WMS (mean scores)	37	40	45
TP (mean scores)	65	79	107
PQ (mean scores)	17	21	20
ITQ (mean scores)	16	17	15
SSQ (mean scores)	72	72	72

Conclusions

The main purpose of this study was to test a VR training programme to promote neuro recovery resulting from an ischemic stroke condition. Our results revealed an increase in memory and attention/concentration skills, which, in turn, can suggest a higher level of executive functioning in these patients after the VR training programme. Patient B had a more pronounced recovery in working memory skills, which is somewhat intriguing given that patient B was diagnosed with a higher level of cognitive impairment with co-morbidity of language and motor disorders. Even though, language and motor domains are considered as crucial skills for the conventional stimulation/rehabilitation programmes, here, with the use of fully immersive VR applications designed with several sorts of stimulus (visual and auditory), training can be more specific of a pre-determined function neglecting other cognitive processes. Nevertheless, our study consisted only on two patients, which has not allowed a more comprehensive statistical analysis. Although stroke etiology was similar between these patients, the level of cognitive impairment was very dissimilar and could have biased our results. Also, controlled trials should be carried out in further studies to enable the comparison of VR based interventions with other conventional approaches or even with a waiting list group.

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