

The effect of social gaming in virtual reality based rehabilitation of stroke patients

A pilot study with the Rehabilitation Gaming System

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Abstract— Therapy for motor recovery in stroke patients is strongly related to motivation and social factors [1, 2]. In this study, we evaluate the effects of social interaction in stroke rehabilitation.

Our hypothesis is that social interaction in form of a multiplayer competitive context has a positive effect on motor rehabilitation. We test this hypothesis using the Rehabilitation Gaming System (RGS), an ICT Virtual Reality (VR) tool for upper extremities motor rehabilitation. Stroke patients participated in a memory card game, playing in a single player mode during one session and in a multiplayer mode during another session.

Assessing the range of movement shows that patients performed wider elbow flexion/extension movements of the upper limbs in the multiplayer mode than in the single player mode ($p = 0.036$). These findings suggest that using social interaction such as a multiplayer environment positively affects the performance of the patients during the treatment.

Motor rehabilitation; stroke; virtual reality; rehabilitation gaming system

I. INTRODUCTION

Stroke is the leading cause of long-term disability in modern societies [3]. Recent studies have shown that high levels of social interaction and motivation are significantly related to faster and more extensive recovery of functional state [1, 2]. Thus, adaptive training systems sustaining the patients' performance and motivation become promising tools for stroke neurorehabilitation.

The Rehabilitation Gaming System (RGS) is a novel ICT VR tool for the rehabilitation of motor deficits of the upper extremities [4-6]. Based on the mirror neurons theory, RGS combines movement execution with the observation of correlated action by virtual limbs that are displayed in a first-person perspective (Fig. 1a). In order to maintain the participants' motivation and arousal during the therapy, RGS includes the, so called, Personalized Training Module (PTM),

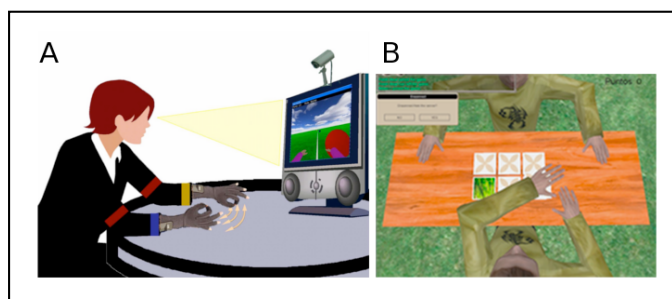


Figure 1. A. The Rehabilitation Gaming System. A subject sits on a chair with his/her arms on a table, facing a screen. Arm movements are tracked by the camera mounted on top of the display and mapped onto a 3D character's arms. B. Memory Game. Participants have to match up pairs of cards with the same image.

which adapts the task to the specific performance level of the user. In addition, the system acquires qualitative and quantitative information of the performance of the subject/player during the tasks. Recent studies have been conducted testing the usability of the RGS, analyzing its psychometrics and demonstrating its effectivity in a clinical context [7, 8].

In this study we include a multiplayer mode in RGS in order to test the effect of social interaction on the involvement of the patients in the therapy and thus also on the rehabilitation process.

II. METHODS

The prototype presented in this pilot study is an extension of the Rehabilitation Gaming System (RGS) including two low cost key-gloves. We developed a new game scenario based on a multiplayer platform (Torque Game Engine) that allows the patients to compete with another user in a memory card game. The game consists in matching pairs of cards from a set of cards (Fig. 1b). In the multiplayer mode the game was played by turns and players were able to talk during the session, where

in the single player mode participants solved the whole game alone. The game involves memory and attention training as well as reaching and grasping movements. An autonomous game controller maximized the difficulty level while maintaining the appropriate exercise intensity for each user.

In order to test the impact of social interaction on motivation we compared the performance of six patients affected by disorders of the central nervous system (CNS) in a multiplayer versus a single player virtual scenario. The patients participated in two randomized sessions lasting 10 minutes, one using the single player mode and the other using the multiplayer mode.

III. RESULTS

To compare the patients' performance while playing in the multiplayer and the single-player mode, we collected data corresponding to reaching movements for each patient during the game. Two variables determined the hand position of the player describing frontal and lateral movements. The data revealed that the maximum y-axis values reached during the patients' performance, describing the flexion/extension movement of the elbow and a slight frontal shoulder abduction/adduction, were significantly higher in the multiplayer mode group (M = 42.240, SD = 3.2), than in the single-player mode group (M= 41.416, SD = 3.0, Students Test for independent groups $p = 0.036$) (Fig. 2). These differences indicate a superior extension of the elbow during the multiplayer game. After each session, a subjective questionnaire on intrinsic motivation was conducted in order to evaluate and compare the patients' enjoyment, effort, tension and perceived competence during each session. The answers obtained from this questionnaire show remarkable differences between groups in the perceived enjoyment.

IV. CONCLUSIONS AND DISCUSSION

This study evaluates the influence of including social factors in the motor neurorehabilitation therapy of stroke patients, focusing on the participants' motivation and performance. To the best of our knowledge, the Rehabilitation Gaming System is the first multiplayer platform specifically oriented to motor rehabilitation and tested with stroke patients. We have carried out a wide preliminary analysis about the impact of including multiplayer functionalities in the training session. For this experiment we obtained both qualitative and quantitative results. On the one hand, we studied the perceived motivation of the patient in each of the game modes (single-player and multiplayer). On the other hand, we analyzed the quantitative data collected automatically by the system during the patients' performance. Based on quantitative data, the results obtained indicate that harder motor exercise was performed during the multiplayer sessions.

We found that the upper limbs exercises performed by the patients in multiplayer mode reached wider elbow flexion/extension movements than those performed in the single-player mode. Considering the serious deterioration in skeletal muscle performance suffered by patients that acquired brain injury, the presented results suggest that patients affected

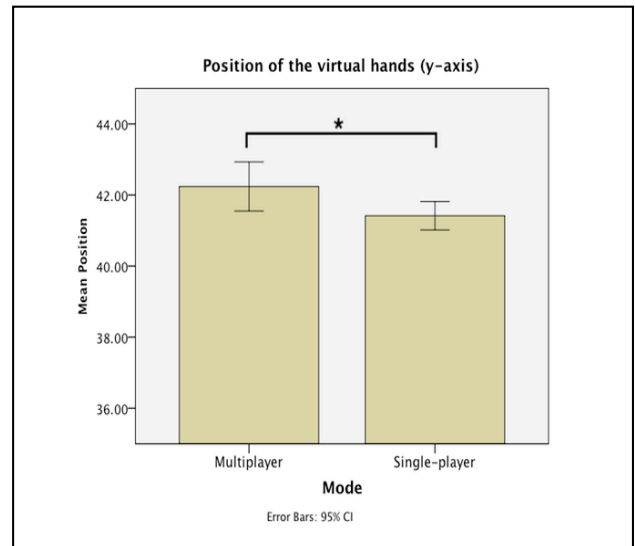


Figure 2. Mean position reached by both hands in the frontal movement (paretic and non-paretic) during multiplayer and single-player session. $p=0.036$, between group comparison.

by a stroke or presenting other disorders of the CNS put forth a greater effort when practicing the reaching task in a competitive environment than when playing alone.

This study is the first step towards a better understanding of the potential of social platforms in the medical context. The results suggest that combining the new therapy technologies and social networks will constitute an effective tool to raise the standard of living of patients affected by CNS disorders and to significantly reduce the amount of elderly patients suffering from depression.

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