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Including Social Interaction in Stroke VR-Based Motor Rehabilitation Enhances Performance: A Pilot Study

Abstract

Social factors and motivation are key factors for recovery in stroke patients (Glass, Matchar, Belyea, & Feussner, 1993). The goal of this study is to enhance accessibility and evaluate the effects of including social interaction in a virtual reality (VR) -based system for stroke rehabilitation. We hypothesize that a multiplayer competitive context will have a positive effect on the involvement of the patients in the therapy and thus on the rehabilitation process. We test this hypothesis using the Rehabilitation Gaming System (RGS), an ICT virtual reality tool for upper extremities motor rehabilitation. First, we implemented and evaluated a new interface based on a low-cost key-glove. Then, we developed a dedicated RGS scenario where the player has to match pairs of cards from a stack of playing cards. This task trains cognitive (memory) and motor tasks (grasping and reaching). Eight stroke patients participated in two sessions lasting 20 min, one using a single-player VR environment and another using a multiplayer version of the same game. A usability test showed that participants interact with the system much faster when using the new key-glove–based interface ($p = .02$) in comparison to a mouse and keyboard. In addition, our results showed that upper limb exercises performed by the patients in multiplayer mode reached wider elbow flexion/extension movements than the ones performed during the single-player game session ($p = .04$). Considering that the presence of spasticity is very common in patients affected by an ictus and that it causes an ongoing level of contraction, these results suggest that the patients affected displayed more effort in reaching if engaged in a social task. Our study shows that accessibility and social engagement in multiplayer environments positively affects the patients' performance and enjoyment during the task. Although the long-term impact of this enhanced motivation needs to be further assessed, our results do suggest that the inclusion of social factors such as multiplayer capabilities is an important factor for the rehabilitation process in VR-based therapy and might have an impact on both performance and mood of stroke patients.

1 Introduction

1.1 Rehabilitation Approaches

Stroke is the third largest cause of death and the leading cause of serious long-term disability in modern societies (Mathers & Loncar, 2006). Together with pure motor deficits, stroke can cause cognitive impairments that range

Presence, *Vol. 21, No. 4, Fall 2012,* 490–501

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from disturbance of attention, to abnormal communication and emotional state, as well as visuospatial and sensorimotor perception deficits.

There is a considerable variety of treatment concepts and therapies addressing stroke without a clear consensus (Dombovy, 2004); however, most of them share some fundamental principles: on the one hand, the effectiveness of stroke therapy has been shown to depend on treatment frequency and intensity (Kwakkel, Kollen, & Lindeman, 2004; Sonoda, Saitoh, Nagai, Kawakita, & Kanada, 2004; Van Peppen et al., 2004); on the other hand, the specificity of rehabilitation training with respect to the deficits and required functional outcomes has an impact on recovery (Krakauer, 2006).

Occupational therapy (OT) focuses on self-care activities and improvement of fine motor coordination of muscles and joints. It is based on task-oriented training, designing, and assessing physical activities of daily living (ADLs). Reaching and grasping are two of the most basic fine motor patterns used in our daily lives; therefore, the recovery of upper-limb function is crucial for the patient to recover self-sufficiency. A number of approaches to motor rehabilitation have emerged in the last decades and a wide spectrum of them are based on OT, particularly focusing on the upper extremities. Recently, standard rehabilitation methods have been augmented with new technologies such as virtual reality. Clinical studies have begun to demonstrate the effectiveness of virtual reality (VR) as an intervention tool for OT-based rehabilitation programs in patients affected by stroke (Gaggioli, Mantovani, Castelnuovo, Wiederhold, & Riva, 2003; Merians et al., 2002; Schultheis & Rizzo, 2001; Weiss, Rand, Katz, & Kizony, 2004). These systems allow for an objective evaluation of the patient's progress, which makes possible the automated collection of data and their corresponding analysis for a more accurate short-term/long-term diagnosis. They also permit the manipulation of the structure of social interaction using transformed social interaction (Bailenson, Beall, Loomis, Blascovich, & Turk, 2004), and allow for the delivery of complex stimuli while maintaining full experimental control (Bernardet et al., 2010). There remain, however, a number of important issues that must be addressed in order to determine how widely VR-based intervention could be implemented, and how specific patient populations can benefit from its unique attributes.

1.2 The Rehabilitation Gaming System

The Rehabilitation Gaming System (RGS) is a novel VR tool for the rehabilitation of motor deficits that occur after stroke (Cameirao, Badia, Oller, & Verschure, 2010; Cameirao, Bermúdez i Badia, & Verschure, 2008; Cameirao, Bermúdez i Badia, Duarte, & Verschure, 2009; Cameirao, Zimmerli, Oller, & Verschure, 2007; da Silva Cameirao, Bermúdez i Badia, Duarte, & Verschure, 2011). The RGS is based on the assumption that the brain maintains a level of plasticity throughout life (Disterhoft & Oh, 2006) that can be stimulated to help functional recovery after stroke, that is, via the stimulation of the mirror neurons system. The mirror neurons system might represent a flexible system that encodes action observation and could be strongly related to the development, control, and recovery of motor functions and social cognition (Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Small, Buccino, & Solodkin, 2010). Based on this theory, RGS combines movement execution with the observation of correlated action by virtual limbs that are displayed in a first-person perspective (see Figure 1).

RGS collects qualitative data (i.e., paretic side) and quantitative information (i.e., shoulder angle, elbow angle, time, and finger flexion) of the performance of the subject/player during the training tasks, which allows for a detailed assessment of the deficits of the patient/player and the dynamics of his or her recovery. In order to maintain the user/patient motivation and arousal during the therapy, RGS includes the so-called personalized training module (PTM), which adapts the task to the specific performance level of the user. To test the usability of the RGS, a previous study was conducted to analyze its psychometrics, and its validation in the clinic (Cameirao et al., 2010). However, RGS still presents several limitations that could be crucial factors for the therapy: on the one hand, the standard interfaces integrated in RGS, such as the mouse and the keyboard, have limited accessibility for the physically disabled; on

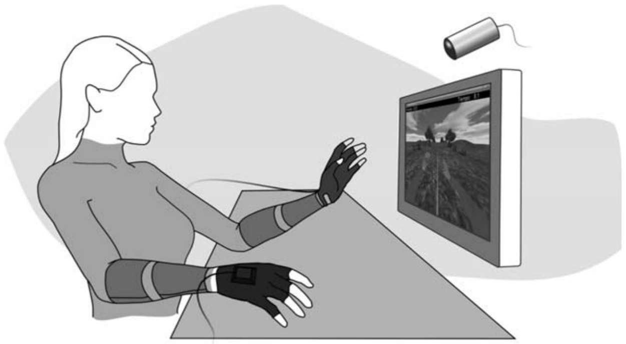

Figure 1. *The Rehabilitation Gaming System. A subject sits on a chair with his or her arms on a table, facing a screen. On the display, two virtual arms mimic the continuous movements of the subject's arms, hands, and fingers. Adapted from Cameirao, Bermúdez i Badia, et al., 2009.*

the other hand, the system does not aim at providing an environment for social interaction for patients and therapists. The main contribution of this work is to address the aforementioned limitations of RGS.

1.3 Social Isolation in Stroke Patients

Most post-stroke patients suffer from depression, isolation, communication problems, loss of social influence, and many other social aspects. Recent studies have shown that one-third of stroke patients suffer from depression (Hackett, Yapa, Parag, & Anderson, 2005). Social factors and motivation are strongly linked to the development of depression, and influence whether patients participate in activities that promote functional recovery (Maclean, Pound, Wolfe, & Rudd, 2000). Especially interesting for this work is the psychosocial impact of stroke. After stroke, most patients will depend on their relatives and/or therapists to meet their daily needs, they may suffer from isolation, and even experience the loss of social status. All these factors have an important role on the patients' emotional state and thus on the recovery process. Recent studies have shown that strong social support is significantly related to faster and more extensive recovery of functional status in post-stroke patients (Glass et al., 1993). Therefore, social support could be considered as an important prognostic factor in the recovery process, whereas socially isolated patients may be at particular risk for a poor recovery outcome. On this basis, we consider that accessibility to communication technologies and social interaction become key factors while designing novel rehabilitation approaches.

1.4 Multiplayer Online Games (MOGs) Applied to Rehabilitation

Internet, voice conference, text chat, and e-mail are becoming new communication tools for patients and therapists. From this trend, a new approach called e-therapy has emerged, also known as cybertherapy or net therapy. These terms refer to the provision of psychological therapy and consultation over the internet. Nowadays, these novel methods are being applied in many healthcare services, allowing patients to attend therapy sessions from their homes and offering several advantages for both therapists and patients, such as the possibility to deliver feedback and services across geographical distance or the possibility to provide an environment for social interaction (Manhal-Baugus, 2001; Riva, 2004; B. K. Wiederhold & M. D. Wiederhold, 2004). MOGs have become useful platforms for experimentation and application of new psychological therapies. MOGs provide shared virtual scenarios where users are allowed to interact in multiple manners: local chat, voice conference, instant messaging, gestures, and movements. It has been suggested that MOGs applied to psychological treatments can be useful to improve the user's motivation for change and influence psychological recovery (Gaggioli, Gorini, & Riva, 2007). However, to the best of our knowledge, no previous study has tested whether these online social platforms can induce motor improvement in patients affected by stroke or presenting other disorders of the central nervous system (CNS).

We hypothesize that extending the RGS in terms of accessibility and social interaction will have a positive effect on the involvement of patients in the therapy and thus also on the rehabilitation process. To improve the RGS interface in terms of accessibility, we propose a new graphical user interface (GUI) controlled by a low-cost key-glove. Regarding the social interaction, we develop a multiplayer scenario and evaluate its effects on the patients' motivation and performance. Our main objec-

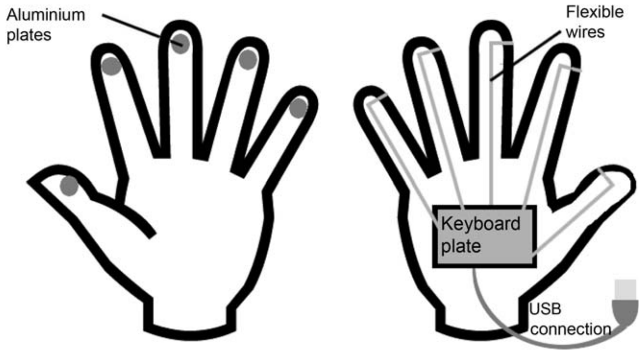

Figure 2. *Components of a low-cost key-glove.*

tive is not just to evaluate the presented hypothesis, but also to provide an efficient tool to assess the impact of online multiplayer functionalities in motor rehabilitation technologies.

2 Methods

The RGS consists of different elements: a PC with graphics accelerator; a 19-in LCD display; speakers; a color CCD camera positioned on top of the display; and a vision-based motion capture system called AnTS (Bermúdez i Badia, 2003–2011). This vision-based tracking system detects color patches located on the wrists and elbows of the patients. A biomechanical model of the upper body allows the reconstruction of the patient's movements. These movements are mapped to a 3D avatar in real time, which allows the user to observe the avatar's own arm movements in the virtual environment.

The prototype described in this paper is an extension of the RGS including two low-cost key-gloves developed for this study and adapted for finger motor rehabilitation.

Each of these key-gloves was built from a keyboard plate connected to five 6-mm diameter aluminum plates fixed on the glove's fingertips (see Figure 2). This new interface is totally compatible with any kind of computer, quick to set up, easy to handle, flexible, and portable.

In this paper, we present an extended version of the RGS based on a multiplayer platform (the Torque Gaming Engine) that allows the patients to start/join a game and play against another user. Arm movements of each

Figure 3. *The RGS application interface adapted to be used with a key-glove.*

patient are mapped onto the virtual 3D character's arms. Both players and therapists can observe the whole arms of the players in real time.

2.1 Graphic User Interface (GUI)

In previous versions of RGS, the gaming scenario was accessed and personalized from a main menu controlled with a mouse and a keyboard. However, these input devices turned out to be not optimally used by most patients due to reduced mobility and their inexperience with computer interfaces. To avoid physical discomfort and improve usability, we built a new main-menu GUI controlled with a key-glove (see Figure 3). The main requirements for the design of this interface were as follows.

- Present information and options in a logical order that is easy to follow.
- Provide clear and unambiguous instructions.
- Guide the patients through all processes.
- Use simple, easy to read letter styles.
- Use big pictures and schematic objects, without using childish design.
- Use prominent and bright colors to draw attention to salient information.
- Make the interaction intuitive.

Patients controlled the main menu of the system using a key-glove. When the user's finger (index, ring, or middle) comes in contact with the thumb, an action is executed: select option, move to the next option, or move

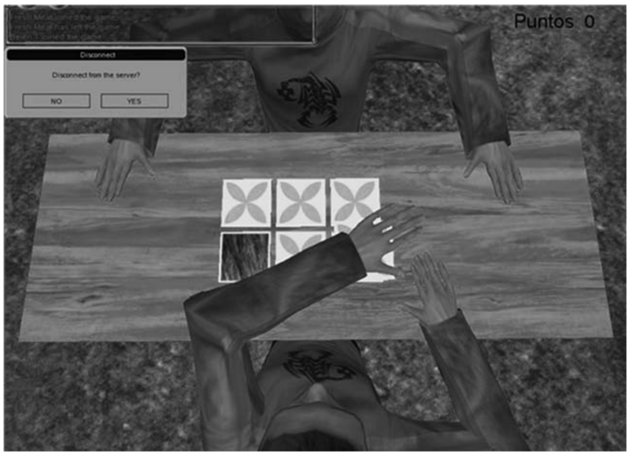

Figure 4. *Memory Game scenario in multiplayer mode.*

to the previous option. Always after 10 s of inactivity, an animation and voice present three possible actions that the user could choose to navigate through the menu.

2.2 Game Training Scenario

We developed a dedicated RGS scenario where the player has to match pairs of cards from a stack of playing cards. The Memory Game scenario consists on a set of a paired number of cards initially presented upside-down on the surface of a table. The player appears at one side of the table, and the point of view of the game is determined by a camera situated above the player's head, offering to the user a third-person zenith point of view (see Figure 4). The cards appearing on the center of the table can be selected with both hands, while the cards appearing closer to the right and left side borders of the table must be reached and grasped by the corresponding hand. At the start of the session, two rows of a variable number of cards appear face down over the table.

The game is divided into four stages.

Step 1. At the beginning of each movement, the player has to move the arm to reach the position of one of the cards. In order to reach a card, the center of the virtual hand must be inside the area covered by the card irrespective of the vertical position of the hand. The position of the virtual hand depends on the patient's shoulder horizontal flexion/extension and elbow flexion/extension, rather than the actual position of the hand in the real world. Once this reaching movement is achieved, the corresponding card levitates on the table, indicating that the card can be grasped.

Step 2. The grasping task consists of touching the thumb with the index or the middle finger of the same hand. This movement simulates the pick-up gesture and is recognized by the key-glove to execute the "turning the card" command. The image contained by the selected card is then shown to the player. If this is the first movement of the player's turn, the card will remain turned face up over the table and the patient will repeat Step 1 and Step 2 using another card.

Step 3. When the patient grasps two different cards consecutively, the program evaluates whether both cards have the same image on them. If the selected pair of cards has the same image, the cards will lie on the table face up and the player will receive 10 points. If the images do not match, the cards will be turned face down.

Step 4. When the player matches every card of the set with its pair, all the playing cards will be face up and the game will finish, showing the final scores.

The difficulty level of each game in the Memory Game scenario is determined by two parameters: the number of cards per row, and the maximum time to complete the game. The minimum number of cards presented in a game was four, and the maximum number of cards was limited to 16 per game. The variation of these parameters provides a range of different difficulty levels defined by the following formula:

$$t = 420(n^2), \quad (1)$$

where t is the time in tenths of a second that a patient needs to complete a game, and n is the number of cards per row.

The game can be played either individually (i.e., in single-player mode) or in pairs (i.e., in multiplayer mode). When played in multiplayer mode, the Memory Game is a competitive concurrent game. The rules of the concurrent games state that the players play alternately (Zagal, Nussbaum, & Rosas, 2000). In the Memory Game, the

Table 1. *Participants in the Experiment*

	Profile				
Patient	Age	Gender	Disease	Weeks since disease	Affected arm
1	54	M	Stroke	12	Right
2	28	M	Stroke	3	Right
3	26	F	Aneurysm	4	None
4	24	M	Tumor	3	None
5	55	M	Stroke (chronic)	3	Right
6	58	F	Guillain-Barré	2	Right
7	54	F	Guillain-Barré	8	Right
8	60	F	Stroke	23	Left

screen displayed a text indication when it was a player's turn; and both participants were able to talk during the session. Note that, in addition to the memory task, there are two different motor tasks also involved in this training game: reaching and grasping. Reaching movements involve elbow horizontal flexion/extension, shoulder vertical flexion/extension, and shoulder horizontal flexion/extension. Grasping movements involve pinch grip movements (i.e., finger flexion/extension).

2.3 Inclusion Criteria and Demographics

The inclusion criteria for this study were set to guarantee that the participants would be able to perform the task. Based on this indication, a therapist from the Occupational Therapy Unit at Hospital Esperança, Barcelona, selected inpatients who were presenting mild cognitive and motor impairments in the upper extremities, and were able to perform elbow flexion/extension, shoulder vertical flexion/extension, shoulder horizontal flexion/extension, and finger flexion/extension. In total, four men and five women affected by disorders of the central nervous system (CNS) were recruited for the experiment. All participants gave their signed informed consent. One participant experienced sickness during the first session and therefore was excluded from the study. The rest of participants (see Table 1) completed all stages of the experiment.

2.4 Experimental Design

All the experiments were conducted at the Occupational Therapy Unit from Hospital Esperança, Barcelona. The hospital's ethics committee approved the experimental protocol.

In order to assess some of the presented features, we defined three different sets of evaluation: a usability test to evaluate the new GUI and key-gloves, a psychometric analysis of the game, and the evaluation of the patients' performance with the single-player mode and the multiplayer mode.

2.4.1 GUI Usability Test. A first run of experiments was addressed to compare the old version of the main menu (controlled with a mouse) with the new version (controlled by a key-glove). The experiment was divided into two randomized sessions, each one using each interface device. The patients were asked to complete four different tasks: start a game, exit the system, load a profile, and modify a parameter of the game. The chosen performance indicators were: task completion rates, satisfaction ratings, and time on task.

2.4.2 Study of the System as a Monitoring Tool. To test the training scenario, each patient attended a minimum of one session and a maximum of four sessions, each one consisting of 10 min of continuous play. This set of experiments was designed to obtain the proper empirical data to evaluate the coherence of the system as a monitoring tool. In order to evaluate this aspect, several variables were measured during the gaming session: the distance covered by each hand, the mean grasping time, the mean reaching time, and finger flexion. In addition, this set of experiments also provided information about the global performance of the patients. These data were used to identify the right difficulty level for each participant.

2.4.3 Single-Player / Multiplayer Comparison.

In order to test the impact of multiplayer functionalities, additional experiments were conducted. These experiments were divided into two randomized sessions lasting 20 min, one using a single-player VR environment and the other using a multiplayer version of the same game. After each session, the users' intrinsic motivation (i.e., motivation that comes from inside an individual rather than from external rewards) was assessed using a 22-item Spanish version of the Intrinsic Motivation Inventory (IMI; Tsigilis & Theodosiou, 2003; as shown in Appendix 1). This questionnaire assesses the users' intrinsic motivation by asking them to evaluate 22 statements on a 7-point Likert scale (from 1, "strongly disagree," to 7, "strongly agree"), and measures four factors: enjoyment, effort, tension, and perceived competence. The answers to the questionnaire are combined to form a four-factor score per participant. At the end of the questionnaire, the patient answered three additional questions about his or her attribution of value to each game mode (single-player and multiplayer; see Appendix 1).

3 Results

3.1 GUI Usability Test

A first run of experiments was conducted to evaluate the impact of an interface adapted to stroke patients. The new main menu of the system was designed to provide accessibility to additional functionalities. In order to evaluate its efficiency, each patient performed four different tasks using two different devices: mouse/keyboard and key-glove. Only three out of eight patients reported having previous experience with the mouse and the keyboard. Those three participants were excluded from the analysis. A Student's paired t-test showed significant differences between multiplayer and single-player groups in terms of time ($p = .02$), which shows that participants interact with the system much faster when using the key-glove (see Figure 5).

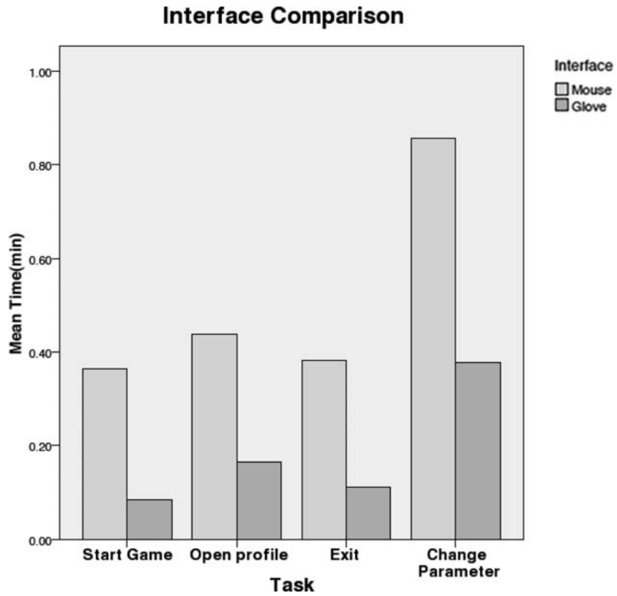

Figure 5. *Mean time (minutes) needed by the participants to complete four tasks using two different interfaces (mouse/keyboard and key-glove).*

3.2 Psychometric Analysis

A second run of experiments confirmed that the Memory Game scenario diagnoses and monitors functional motor rehabilitation based on two different aspects: time needed to perform pinch grasp, and space covered by reaching movements. A Student's t-test for independent groups shows significant differences between the movements performed with the paretic and with the nonparetic limbs in terms of time needed to execute the fine grasping movement ($p = .01$; see Figure 6) and in terms of distance covered during the reaching task ($p = .01$; see Figure 7).

3.3 Multiplayer/Single-Player Comparison

We hypothesized that a multiplayer scenario would have a measurable effect on behavior and user perform-

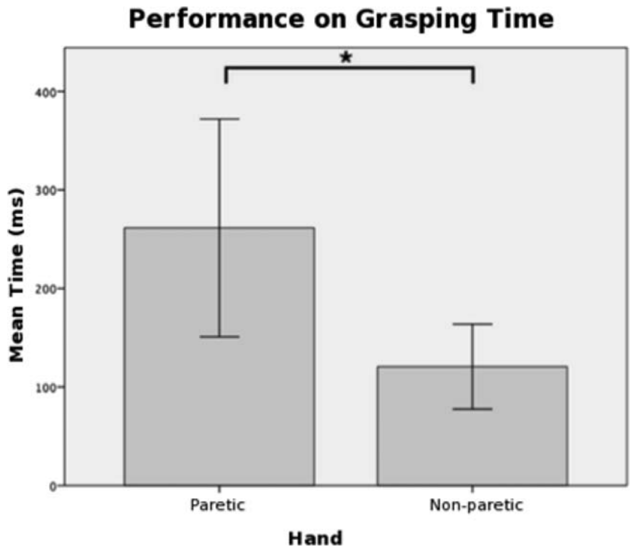

Figure 6. *Patients' performance in terms of time needed to execute the grasping movement.*

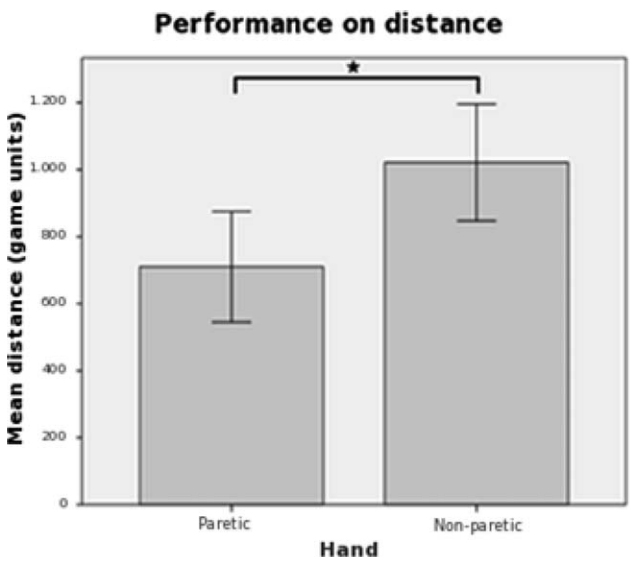

Figure 7. *Mean distances covered by the paretic and nonparetic hand of the patients. Distance measurements are expressed in Torque Game Engine space units.*

ance. Thus, to study the patients' performance while using the multiplayer and the single-player system, we compared the collected data corresponding to the reaching movements for each patient during the game. Two of the eight patients were excluded from the analysis due to incomplete data. Two variables determined the hand

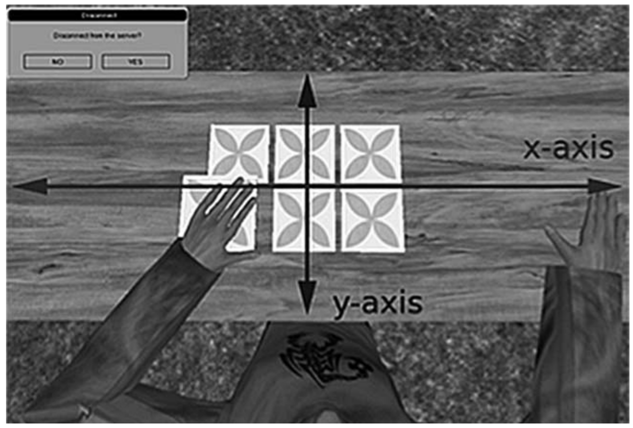

Figure 8. *Mean positions reached by both virtual hands (paretic and nonparetic) during multiplayer and single-player session. Positions are expressed in Torque Game Engine space units.*

position of the player: a value for the horizontal axis and a value for the vertical axis (see Figure 8). The values in the horizontal axis are mostly determined by the shoulder horizontal flexion/extension, while the *y* axis values are generally related to flexion/extension of the elbow and a slight vertical shoulder flexion/extension. The maximum values reached in the vertical axis during the patients' performance were significantly higher in the multiplayer mode group ($M = 42.2$, $SD = 3.2$) than in the single-player mode group, $M = 41.416$, $SD = 3.0$, Student's test for independent groups, $p = 0.04$; see Figure 9. These differences would point to a larger extension of the elbow during the game.

With the intrinsic motivation questionnaire we evaluated the patients' enjoyment, effort, tension, and perceived competence during the single-player session and during the multiplayer session. As a result, patients showed a slightly higher satisfaction with the multiplayer version of the game (see Figure 10). Six out of the eight patients answered they would prefer to invest their time training with the multiplayer game, while the remaining two participants chose to play half of the time in each mode (single-player and multiplayer). Four out of six patients considered the multiplayer version of the game to be more expensive in comparison to the single-player version. Two of them reported that the price of the multiplayer game should cost twice as much as the single-

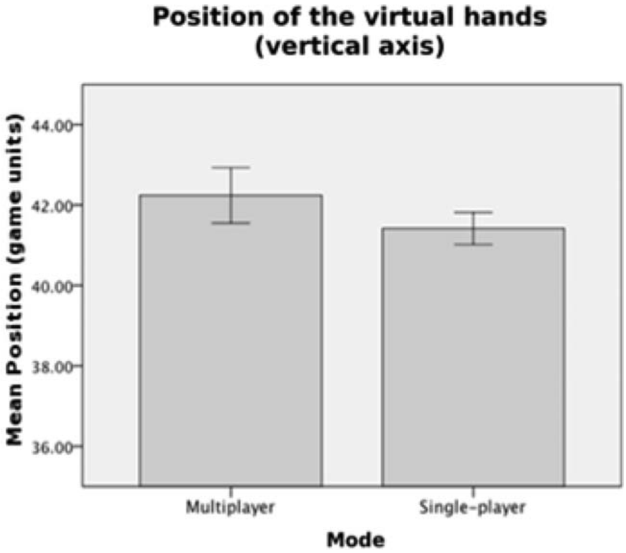

Figure 9. *Game coordinates considered for the position measurements.*

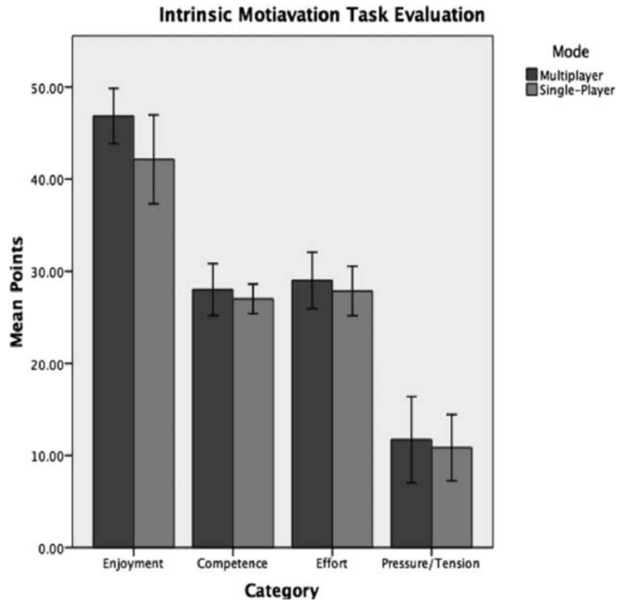

Figure 10. *Results obtained from the Intrinsic Motivation Task evaluation questionnaire.*

player version. Surprisingly, one of them answered that the multiplayer game should be eight times more expensive than the single-player version. Finally, all the participants answered that they would recommend the game to other patients.

4 Conclusions and Discussion

Over the last decade, several studies have suggested the efficacy of VR systems for motor and cognitive rehabilitation (da Silva Cameirao et al., 2011; Merians et al., 2002; Saposnik et al., 2010). Nevertheless, various aspects about its efficacy and application remain unclear. In this study we have carried out a preliminary analysis of the capability of VR systems to provide accessible solutions to patients affected by a stroke. We contributed, with the application of a new low-cost key-glove device, (less than six euro), to improve the control of the system interface. In addition, we evaluated a multiplayer platform version of RGS and its inherent social implications related to the recovery process.

The first stage of analysis focused on the GUI and a low-cost key-glove device that extends the hardware specifications of the system. The data obtained from this set of experiments have shown that the key-gloves were more efficient in controlling the main menu in patients with no previous mouse experience. Moreover, all patients were able to use the new interface, whereas one of the participants was not able to control the mouse; thus, it can be suggested that the key-glove interface could allow patients to be more self-sufficient during routine treatment with the RGS. These findings underline our leading motivation for this stage of the study, which is to provide an accessible solution for motor and cognitive rehabilitation while reducing the total cost of the system employing low-cost key-gloves instead of standard data gloves.

In a second set of experiments, we evaluated a new scenario to train memory, attention, reaching, and grasping movements. We showed that this scenario diagnoses and monitors functional motor rehabilitation in terms of grasping time and hand position. The new game scenario was configured to adapt the difficulty level of the task to the user's capabilities. The number of cards per row presented in the scenario is dynamically defined by the patients' performance and determines the difficulty of the game. Identifying the difficulty level of a player is important both to allow him or her to play a rehabilitation game tailored to movement capacities, and to provide him or her with motivating challenges in single-player and in multiplayer modes.

In a third set of experiments, we assessed the impact of including multiplayer functionalities in the training session. In this experiment we obtained results of two different natures. On one hand, we analyzed quantitative data collected automatically by the system during the patients' performance. On the other hand, we studied the perceived motivation of the patient in each of the game modes (single-player and multiplayer). Based on quantitative data, the results obtained reflected significantly higher elbow flexion movements performed during the multiplayer game session than during the single-player game session. These findings suggest that patients affected by stroke or presenting other disorders of the central nervous system (CNS) use great effort while developing the reaching task in a competitive environment.

After the sessions with RGS, each patient was asked to answer 25 questions to evaluate motivation. The answers to the questionnaire showed remarkable differences between groups in terms of perceived enjoyment, showing that the patients perceived the multiplayer version of the game to be more enjoyable than the single-player version. In addition, most of the patients reported a preference for the multiplayer game and conferred a more elevated economic value to the multiplayer version of the game, compared to the single-player version.

In this work, we evaluated and extended the accessibility characteristics of RGS, we provided a multiplayer platform for rehabilitation, and we studied its inherent social implications related to the recovery process.

5 Future Work

Subject matter for future research includes: increasing the number of participants, focusing on stroke patients only and not other disorders of the central nervous system, and assessing the effects of the multiplayer version of RGS on functional gains using standardized clinical scales. Moreover, it is still an open question how different modes of multiplayer scenarios influence the effectiveness of rehabilitation. Previous studies suggest that cooperation promotes a higher quality of individual problem solving (R. T. Johnson, D. W. Johnson, & Stanne, 1986) and increases self-esteem (Slavin, 1980) than does competition. Further, we want to investigate more precisely the effect of VR-based collaborative scenarios on the recovery process.

Finally, there are a variety of social-oriented technologies, such as videoconferencing, portable communications devices, and GPS, that could be explored in combination with VR technology such as RGS. The integration of these technologies could significantly enhance the effectiveness of VR when applied to cognitive and motor rehabilitation programs.

Acknowledgments

This work was supported by the European Commission through the project Rehabilitation Gaming System1—RGS [EC- FP7 Ambient Assisted Living Joint Programme, AAL-2008-1-119] and the Fundação para a Ciência e Tecnologia (FCT, Portugal).

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Appendix 1: Motivation questionnaire

ID:

Age:

Gender:

1. Mientras jugaba pensaba en lo bien que me lo estaba pasando. *(During the game I was thinking I was having a good time.)*
2. No me he sentido nervioso durante la tarea. *(I didn't feel nervous during the task.)*
3. Me he esforzado. *(I put effort into doing the task.)*
4. Creo que soy bueno en esta tarea. *(I think I'm good at this task.)*
5. La tarea me ha parecido interesante. *(The task was interesting.)*
6. Me he sentido tenso durante la tarea. *(I felt tense during the task.)*
7. Creo que he hecho bien la actividad, en comparación a cómo lo harían otros pacientes. *(I think I did well in this activity in comparison to other patients.)*
8. Hacer esta tarea ha sido divertido. *(Doing this task was funny.)*
9. Me he sentido relajado realizando esta tarea. *(I felt relaxed while doing this task.)*
10. He disfrutado mucho la tarea. *(I enjoyed the task a lot.)*
11. No he puesto demasiada energía en la actividad. *(I didn't put much energy into the task.)*
12. Estoy contento de cómo lo he hecho. *(I'm happy with my performance.)*
13. Me sentía ansioso durante la tarea. *(I was feeling anxious during the task.)*
14. La actividad me ha parecido muy aburrida. *(The activity was boring.)*
15. Me he esforzado al máximo con esta tarea. *(I put a maximum effort into this task.)*
16. Me he sentido muy capaz de hacer esta actividad. *(I felt I wasn't capable of doing this activity.)*
17. La actividad me ha parecido interesante. *(I think the activity was interesting.)*
18. Me he sentido presionado durante la tarea. *(I felt pressure during the task.)*
19. No he intentado hacerlo lo mejor posible. *(I didn't try to do it the best I could.)*
20. Esta tarea es muy agradable. *(This activity was very nice.)*
21. Era muy importante para mi realizar bien esta tarea. *(It's very important to me to do well on this task.)*
22. Después de entrenar un poco con esta actividad, he sentido que era capaz de hacerla. *(After training I felt I was able to do this task.)*
23. Si el juego individual cuesta 10 euros, ¿cuánto crees que costaría el juego de dobles? *(If the single-player game cost 10 euros, how much would the multiplayer version of the game cost?)*
    __________€
24. Si dispones de 15 minutos al día para jugar a este juego, ¿qué preferirías? *(If you had 15 minutes a day to play this game, what would you prefer to do?)*
    a. Jugar los 15 minutos al juego individual. *(To play 15 minutes in single-player mode.)*
    b. Jugar los 15 minutos al juego en pareja. (To play 15 minutes in multiplayer mode.)
    c. Jugar la mitad del tiempo al juego individual y la otra mitad al juego en pareja. (To play half of the time in single-player mode and half of the time in multiplayer mode.)
25. ¿Recomendarías este juego a otros pacientes? *(Would you recommend this game to other patients?)*
    No *(No)* Sí *(Yes)*