Use of Novel Virtual Reality System for the Assessment and Treatment of Unilateral Spatial Neglect: A Feasibility Study

Heidi Sugarman, PT, PhD, Aviva Weisel-Eichler, PhD
Research Center for the Health Professions
Ono Academic College, Kiryat Ono, Israel
hsugarman@ono.ac.il

Arie Burstin BPT, Riki Brown PT, MSc
Beit Rivka Geriatric Rehabilitation Center
Petach Tikva, Israel

Abstract—**This paper reports the outcome and feasibility of using a novel virtual reality system, SeeMe, for the assessment and treatment of unilateral spatial neglect following stroke in a recovered post-stroke subject with residual symptoms of unilateral spatial neglect (USN). The subject received 8 weekly treatment sessions. Outcome measures included the Short Feedback Questionnaire, standard paper and pencil tests and the assessment procedure of the SeeMe system itself. The tests were done on the first and last treatment days. The paper and pencil tests were normal while the SeeMe system showed a clear difference between movement times in the right and left hemispace. Following treatment, the subject showed improved movement times to the left hemispace and also showed functional gains. The subject did not experience any discomfort such as nausea or dizziness while using the system. This initial pilot study indicates that the SeeMe virtual reality system has the potential to be used in clinical settings in order to assess and treat USN. A full clinical trial is necessary in order to examine this premise.**

Keywords: unlateral spatial neglect; stroke; virtual reality; rehabilitation, SeeMe

I. INTRODUCTION

Unilateral spatial neglect (USN) is a neurological disorder characterized by impairment of the ability to perceive or adequately respond to stimuli in the contralesional space. USN affects the ability to perform many of the activities of daily living and is well known to have an adverse effect on the likelihood of successful rehabilitation. A variety of treatment methods for USN have been used, with no consensus as to what method is the most effective. In the clinic, assessment of USN is usually performed using traditional paper-and-pencil tests. However, this method has several serious drawbacks and there is a need to develop different methods of assessment for USN. One approach to solving this problem is to include behavioral assessment in the evaluation of neglect [1]. Other approaches include the use of computer-based tests [e.g., 2, 3] and virtual reality [e.g., 4,5]. These latter methods have been used in treatment as well as in assessment.

Virtual reality technologies hold great opportunities for the development of effective assessment and treatment techniques for neglect because they can provide multimodal and highly controllable environments. In a virtual world, the patient not only reacts to the stimuli, as occurs in computerized tests, but can actually interact with the computer generated 3D, lifelike environment, providing an entire new realm of possibility for evaluation and treatment.

We present here a novel virtual reality system *SeeMe*. Unlike other virtual reality systems that require a head mounted display, or other specialized equipment, SeeMe does not require any equipment beyond a webcam camera and a standard computer with a good video card. A further advantage is that unlike other virtual reality systems that have been used for the assessment and treatment of neglect, SeeMe is designed to be used while standing and moving about, in addition to sitting. This confers a dimension of immersion and ecological validity lacking in systems that are used only in sitting. This article is a report of the feasibility and outcome of using the SeeMe system for the assessment and treatment of USN in a recovered post-stroke person with residual symptoms of USN. We show that the SeeMe system has the potential to be a useful addition to available techniques for the assessment and treatment of USN following stroke.

II. METHODS

SeeMe is a projected video capture, virtual reality system with novel algorithms for movement and position recognition and analysis (www.rehabtech.co.il). Two of the authors, RB and AB, served as advisors in the development of the system. Participants stand or sit in a demarcated area viewing a large monitor that displays functional tasks such as touching virtual balls. The subject sees himself on the screen interacting with the virtual story in real time, using trunk and limb movements, so that it appears as though the user is part of the virtual environment, leading to engagement in the simulated task. A single screen-mounted camera and vision-based tracking system capture and convert the user's movements for processing. SeeMe differs from most video capture systems in several ways: 1) No markers, wires or monochromatic background are required. 2) The system uses movement recognition and not just color recognition, eliminating the need for special colored gloves. 3) The system does not need to be calibrated before each session. 4) A unique feature of the system of SeeMe is that the performance of the client can be monitored “on-line” and the parameters of the virtual tasks can be modified, even in the middle of a game. Thus the task can immediately be made easier or harder in accordance with the performance of the subject. Outcome measures, including movement time, success rate and the parameters of the virtual game, are stored and can be easily retrieved. Movement time is defined as the time elapsed between the appearance of the target and virtual contact with the target by the subject.

The subject was a 66-year old woman who had suffered a massive right hemisphere stroke 15 months previously. At the time of the study, she had no obvious disability remaining from the stroke, aside from some functional signs of left USN. The subject was living at home and was not undergoing any rehabilitation treatments. She was independent in activities of daily living, and oriented in place and time. The subject attended 8 weekly one-hour treatment sessions using the SeeMe system. Three of the SeeMe tasks/games were used for treatment and a fourth task was used for evaluation. She was assessed on the first and last days of treatment with SeeMe, along with the standard paper and pencil tests. The Short Feedback Questionnaire (SFQ) was filled out on the last day of treatment, along with an open ended interview. The SFQ, in Hebrew, from Rand et al [6] is based in part on a translated version of Witmer and Singer's [7] Presence Questionnaire.

III. RESULTS

At the time of the study, the subject had no obvious disability remaining from the stroke. However, she showed functional signs of USN. For example, she complained of bumping into the left side of doorposts when going through a doorway, and did not pay attention to people and objects on the left side of her visual field. In addition, she complained of feeling disoriented and said that she was unable to follow any route that required consecutive turns to right and left and therefore never left her home without a companion. She tested normal on the standard paper and pencil cancellation tasks which she completed quickly and easily.

The VR evaluation was done using the React task of the SeeMe system. In this task, virtual balls appear randomly on both sides of the screen. The task of the subject is to touch the virtual ball within a set amount of time. The system records both the number of misses and the movement time necessary in order to reach the target. The average movement time to targets on the left hand side of the screen was 1282 msecs as compared with 1040 msecs for targets on the right hand side of the screen. That is to say, movement time for the left hand targets was 23% greater than for the right hand targets. In the first evaluation, she missed 50% of the balls on the left side and none on the right side. In the final evaluation, movement times had decreased to 968 and 861 msecs for left and right sides respectively and the difference between left and right hand movement times decreased from 243 msecs to 106 msec. Accordingly, by the last treatment, left hand movement time was only 12% greater than right hand movement time. She did not miss any balls in the final evaluation.

About half way through the treatment sessions, we asked the subject to please keep a diary and record the number of times that she bumped into doorposts and other objects. She replied that there was no need since she hardly bumped into anything anymore. On the last day of treatment, the subject reaffirmed that there was a great improvement in the collision rate with various objects in her environment. She also claimed that she was less disoriented than previously and could now follow simple routes that required consecutive turns and was venturing alone out of her home for short excursions.

In the SFQ, the subject gave a score of 5 out of 5, for the items of enjoyment, feeling of control and success in the virtual tasks. However, she gave a score of only 2 to the question 'How real does the environment seem to you?' This did not interfere with her feeling of immersion in the virtual task. With the intention of establishing how VR treatment is perceived in the eyes of a patient, the subject was also asked if she felt VR was a "real "treatment. "Absolutely not," she replied, "it was too much fun." On the other hand, she wanted to know if she could refer other people suffering from neglect for the VR treatment, thus indicating that she did perceive the VR treatment as valuable.

IV. SUMMARY AND CONCLUSIONS

The SeeMe system indicated a clear difference between movement times in the right and left hemispace, even though paper and pencil tests were normal. Following treatment, the subject showed improved movement times to both the left and right hemispace, indicating that there was some learning in the system. However, it is worth noting that the difference between left and right sided movement times decreased considerably between the first and last treatment sessions. In addition to decreased movement time towards the left side, the subject also showed functional gains, colliding less with objects in the environment and feeling less disoriented. The treatment was well received by the subject who very much enjoyed the experience and was highly motivated to participate in the treatment. The subject did not experience any discomfort such as nausea or dizziness while using the system.

We have shown the feasibility of using the SeeMe virtual reality system for the assessment and treatment of USN. There were no technical problems in setting up and using the system. The system was sensitive enough to detect evidence of USN that was not detected by standard paper and pencil tests. This initial pilot study indicates that the SeeMe virtual reality system has the potential to be used in clinical settings in order to assess and treat USN. Clearly, a full clinical trial is necessary in order to examine the accuracy and effectiveness of the SeeMe system.

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