

Virtual Environment Training System for Rehabilitation Of Stroke Patients with Unilateral Neglect

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Abstract

In this paper, we propose a system for rehabilitation of stroke patients with unilateral neglect by using technology of virtual reality and evaluate this system in two ways: to be suitable and be effective to unilateral neglect.

The proposed system is designed to compensate contralateral visual site by training patients to pay attention to the contralateral visual site. This system contains the assessment of unilateral neglect and the training of this disease. The assessment procedure is implemented by using the calibration of the object in subjective middle line. The training procedure is implemented by completing the missions that are to keep being the virtual avatar safe during crossing the street in virtual environment.

The results of this study show that the proposed system is suitable to assess unilateral neglect and is effective to train unilateral neglect. The parameters extracted from this system are correlated with those of traditional unilateral neglect assessment methods such as the line bisection test and the cancellation test. And the parameter to assess unilateral neglect in this system is gradually decreasing as the number of training is increasing. Also it is proved by the line bisection test and cancellation test.

Key words : Virtual Reality, Rehabilitation, Unilateral Neglect

Introduction

In recent years, virtual environment or virtual reality applications have been great interest in using VEs for training of various types of motor and cognitive deficits.

Unilateral neglect is referred to by a variety of names including hemi-inattention, hemispatial neglect, and unilateral spatial agnosia. It is manifested by a failure to respond or orient to stimuli presented contralateral to a

brain lesion [1]. Neglect denotes the impaired or lost ability to react to or process sensory stimuli (visual, auditory, tactile, and olfactory) presented in the hemispace contralateral to a lesion of the human right or left cerebral hemisphere without merely elementary sensory, motor or cognitive/emotional deficits.

The treatment of unilateral neglect can be approached in several ways. Visual scanning training is the most common treatment. This training includes paper-and-pencil tasks, cancellation tasks and tracking a series of lights across a panel. And a recent study reports the effect of computer based training for unilateral neglect patients. A trial was performed to confirm the merit of a newly-developed computer system that detects gaze in diagnosing unilateral visual neglect syndrome [2]. Another trial was performed to study laterally directed arm movements using the traffic light paradigm [3]. A trial was performed to train stroke patients with unilateral spatial neglect to cross a street safely by using virtual reality technology [4].

In this study, we propose the VR system for training of unilateral neglect patients and the proposed system employed a concept of compensation to rehabilitate unilateral neglect. This system induced patients to pay attention to contralateral visual site by giving them cuing in contralateral visual site. And we show that the proposed VR System is suitable and effective for training of unilateral neglect patients.

Methods

Virtual Environment Contents & VE Training System

The virtual environment contents were programmed using virtual rendering engine based on Direct 7.0a SDK. The virtual street crossing environment consisted of a segment of a typical Korean Seoul street. An avatar was initially located in the middle of crossing.

The implemented Virtual Environment system consisted of three main parts: subject information part, calibration part, training part and the system's difficulty was controlled by two components: level and stage. In subject information part as shown Figure 1, a medical trainer could store the subject's information such as name, age, neglect direction (right or left), and setting values determining which level and how many trials a subject was trained.



Fig. 1. Visual cue (left) and auditory cue (right) to give an attention to the patient

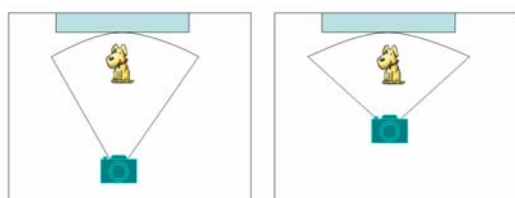


Fig. 2. Screen shot of the different stages. Left one is easier stage than right one.

Subjects

The training system had been administered to normal individuals and to patients with unilateral brain lesion including visual neglect. Total fifty subjects, aged 13 to 68 years, participated in this study. Subjects were divided into three groups. First group was the patient group. The last of subjects except patient group was divided into two normal groups because it may be possible that the computer-friendly subject would well response in virtual. The normal group 1 (not computer-friendly group) and normal group 2 (computer-friendly group)

Parameters

Seven parameters during the training were examined: the deviation angle, the reaction time (in detail, reaction time to the right stimuli and to the left stimuli), visual cue frequency, auditory cue frequency, and failure rate of mission.

In addition to the seven parameters, left to right ratio scores are calculated to measure asymmetries of reaction time between right side response and left side one.

$$\text{left to right ratio} = \frac{\text{left side RT}}{\text{right side RT}}$$

One advantage of this score is that it provides a quantitative estimate of bias.

Result

The data extracted from this experiment are shown in Table 2. To study the influence of computer experience on this experiment, normal group 1 and 2 are investigated by statistical t-test method. As shown in result, there is significant difference between patients group and normal group 1 at $p < 0.05$.

	Patients group	Normal group I	Normal group II
Deviation angle	$-9.17 \pm 4.37^\circ$	-0.36 ± 1.18	0.15 ± 0.07
Reaction time (s)	7.77 ± 1.84	4.94 ± 1.07	4.49 ± 0.57
Visual cue (%)	45.28 ± 27.81	2.70 ± 5.29	1.56 ± 3.90
Auditory cue (%)	31.65 ± 34.12	0.00 ± 0.00	0.00 ± 0.00
Failure rate of mission (%)	8.65 ± 10.12	0.00 ± 0.00	0.00 ± 0.00
Line bisection test	23.22 ± 15.89		
Letter cancellation test	17.00 ± 19.61		

* $p < 0.05$ (between patients group and control group I, II)

Table 2. The experiment data shows significant difference in each factor between patients group and the normal group 1.

The reaction time was analyzed in detail to study the difference between right and left performance. As shown in Table 3. There is a significant difference between the left and right reaction time in the patient group at $p < 0.05$.

Suitability of VR system & Effectiveness of VR System

The proposed system was evaluated in the face of assessment of unilateral neglect. We could evaluate this system by the comparing the traditional methods and proposed one.

Also, the proposed system was evaluated in the view of training of unilateral neglect. The most important factor to evaluate a system is the system's performance: How much a system has an influence on the desired result in positive ways.

This system was effective to training of unilateral neglect. The result of this analysis was shown in Figure 3. for deviation angel and for left to right ratio score. The patient had a follow-up study in 3 weeks later.

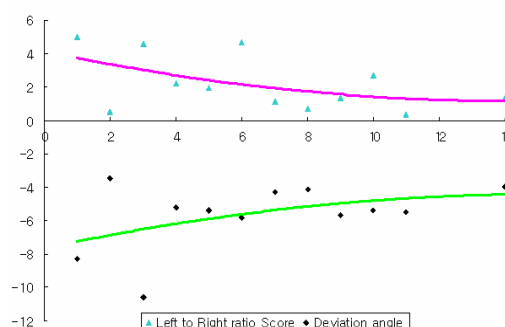


Fig. 3. The training result for left to right ratio score and deviation angle.

Discussion

In this paper, virtual environment system for rehabilitation of unilateral neglect patients was proposed. Virtual environments consisted of virtual avatar, virtual vehicle, and virtual city. The subjects performed the mission, which was to make the virtual avatar keep being safe during crossing the street. The proposed virtual environment system was studied in two points of views. In the assessment, the results showed that the proposed virtual environment system was validated by comparing the experimental parameters and traditional assessment parameters. To study the effectiveness of the proposed training system, patient's deviation angle and the traditional methods such as line bisection test, cancellation test were examined. These two results showed that the proposed virtual environment system was proper to the rehabilitation of unilateral neglect patients and had an effect to train the patients.

In some aspects, the proposed system is more sensitive or accurate than traditional methods. Cooke(1992) pointed out that when practicing scanning using cancellation tasks, a structured array (symbols arranged in neat, straight rows across the page) could be made increasingly more complex as the patient progresses [5]. Scanning tasks must be practiced in a variety of settings, because patients can improve on a task without an improvement in neglect. This system is more robust than traditional methods which provide limited setting.

Left to right ratio which was measured in this experiment had a same meaning with the laterality scores used as well-known parameter. Laterality scores are measured to compare asymmetries of performance [6]. For the line bisection test, one can calculate the cumulated percentage of deviation from the true centre for all the lines. Rightward deviation assumes a positive sign, whereas leftward deviation carries a negative sign. One advantage of this score is that it provides a quantitative estimate of bias. The score can range from -1 (all the items reported or cancelled on the left side, none on the right side) to +1 (the opposite situation). However, in this study, left to right ratio is preferable rather than laterality score to measure the bias since items such as visual cue, auditory cue didn't have to be always happened. The laterality score ranging from -1 to +1 is not proper to this experiment. Instead of laterality score, the left to right ration is more meaningful in this study since the right side items are normalized by the left side items. The left to right score can be +1 (the bias is not measured, that is the events such as visual cue, auditory cue, failure is equal to the left events). The less bias is measured, the more left to right score is close to +1, whereas the more bias is measured, the more this score is away from +1.

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References

1. Trombly, Catherine Anne, Radomski, Mary Vining. Remediating Perceptual Impairments: Occupational therapy for physical dysfunction. Lippincott Williams & Wilkins, c2002: pp. 531.
2. Min-Young Kim, Sae-Il chun (2001). A trail of diagnostic program using a computer for unilateral visual neglect. J. of Korean Acad. Of Rehb. Med. Vol. 25, No. 1, February, 2001:pp. 39-50.
3. Paolo Bartolomeo (2002). The traffic light paradigm: a reaction time task to study laterally directed arm movements. Brain Research Protocols 9: pp. 32-40
4. Patrice L., Yuval Naveh (2003). Design and testing of a virtual environment to train stroke patients with unilateral spatial neglect to cross a street safely. Occupational Therapy International, 10(1): pp. 39-55.
5. Trombly, Catherine Anne, Radomski, Mary Vining. Section IV. Treatment Principles and Practices: Occupational therapy for physical dysfunction. Lippincott Williams & Wilkins, c2002: pp. 532.
6. P. Bartolomeo, S. Chokron, Egocentric frame of reference: Its role in spatial bias after right hemisphere lesions, Neuropsychologia 37(1999) 881-894.

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