Therapeutic Games to Address Left Neglect Symptoms in Stroke Patients: Some Preliminary Studies

Nuratiqah Mohd Zahari¹, Riaza Mohd Rias², Fazah Akhtar Hanapiah³

¹Faculty of Computer and Mathematical Sciences, Universiti Teknologi Mara, Malaysia, eqa.atiqah01@gmail.com
²Faculty of Computer and Mathematical Sciences, Universiti Teknologi Mara, Malaysia, riaza@salam.uitm.edu.my
³Faculty of Medicine, Universiti Teknologi Mara, Malaysia, fazah@salam.uitm.edu.my

ABSTRACT

Visual neglect is one of the various symptom causes of stroke which patient cannot respond at their side opposite the brain hemisphere lesions. Among the symptoms, left neglect following right brain damage is more occurred. In recent years, the popularity of serious game in healthcare has given opportunity for therapists to assists them in therapeutic and diagnose session. Therefore, this paper reports on some early investigation done on this topic and a proposed methodology for design and development for this study. The preliminary results indicate a desideratum for future outcome for game development and a pilot study for stroke patients.

Keywords: Stroke, visual neglect, left neglect, serious game, therapeutic, diagnose

I INTRODUCTION

About 15 million people become worse caused of stroke. Based on (Driver J & Vuilleumier, P, 2001), stroke patient with neglect may unaware of sights, sounds, touches and body parts on the contralateral side even though they are not blind, deaf or insensitive on that side (Jani Kettunen, 2013). (Sunderland et al.,1987) found that the neglect symptom has varied from 90% to 8%. (Fullerton et al.,1986) found that 74% of patients from 205 subjects showed symptom of neglect within 48 hours of a stroke. Patients with neglect also have longer hospital stays and more difficulty resuming activities of daily living.

Increased age has been shown to be associated with a higher incidence and severity of neglect (Ringman et al.,2004; Linden,2005; Gottesman et al.,2008; Jani Kettunen, 2013). (Ringman et al.,2004) reported that only 5% of patients aged 18-50 exhibited neglect, whereas 18% of patients aged over 80 had neglect one week post-stroke.

The literature uses various terms to describe neglect, such as unilateral neglect, hemineglect, and hemispatial neglect. In this research, the term visual neglect is used because the focus of this study is on problems in the visual modality. Visual neglect is a common neurological disorder in which patients fail to attend to, report or represent information appearing in contralesional hemispace, despite intact sensory processing and visual acuity (J.J. Marotta et al.,2003). Visual neglect occurs more commonly after right hemisphere than left hemisphere stroke (Vanier M et al.,1990; Stone SP et al.,1993; Bowen et al.,1999; Ringman et al.,2004; Anna M. Barrett et al.,2006; Metehan Çiçek et al.,2009; Jani Kettunen, 2013), suggesting a specialized role for the right hemisphere in directed attention (Vallar, G,1993).

Rehabilitation treatment can overcome the degree of neglect symptom in stroke patients in term of the training process which can strengthen the neural networks of user brain (Raz, A & Buhle J, 2006). However, there is still no consent among clinicians regarding the methods of rehabilitation, monitoring changes after treatment, and identifying left visual neglect in peripersonal space which a reaching space around the patient (Jani Kettunen, 2013). Therefore, it is highly important to provide an efficient treatment service in reducing the number of people suffering with left neglect symptom in stroke patients.

With rapid diffusion of information technology nowadays, therapist should take the opportunity to use technology into the treatments. Due to the popularity and comprehensive benefits can be obtained from using game, this has increased the interest of researchers and health professionals to use a serious game in the treatment (Lavender T.J. & D.Gromala, 2012).

To gain more insight on the current situation and problems faced by therapist during therapeutic session, an initial study was carried out in this paper. Some observations on related works in neglect symptoms for stroke patients were also presented. Based on the findings from this study, a methodology for design and development with this project was proposed.
II PRELIMINARY STUDY

In order to understand and identify issues of therapeutic environment and game design methodology, a therapy used to identify and overcome the left neglect symptom in stroke patients. It is critical to understand both techniques before producing the design model for therapeutic game. The findings from this initial study also will be used as guideline to develop an appropriate model of design methodology for therapeutic games.

A. Findings from a series of interviews with experts:

Systems. There are no current systems that can recover the neglect stroke patients 100%.

Ability. Although patients can play the game that focus on attention, they can play those games at the right side of the screen computer only.

Test. Test is conducted using paper and pencil which clinicians need to guide the patient during the session in term of motivation and the outcomes. Table 1 show the standard type of paper and pencil task used by clinicians to identify the visual type of neglect in peripersonal space.

<table>
<thead>
<tr>
<th>TASK</th>
<th>FUNCTION</th>
<th>LEFT NEGLECT PATIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancellation task (Albert, 1972).</td>
<td>Cross out and search for a target symbols</td>
<td>Patient fail to cancel stimuli on the left side of the sheet</td>
</tr>
<tr>
<td>Line Bisection task (T. Schenkenberg et al.,1980).</td>
<td>Patients are required to place a mark in the exact midpoint of a line drawn on a sheet of paper</td>
<td>Tend to show a rightward deviation or inappropriate marking of the mid-points of lines skewed to their right ends</td>
</tr>
<tr>
<td>Landmark task (Binder JR et al.,1992; Harvey M et al.,1995).</td>
<td>Judge whether pre-marked lines are correctly bisected or not</td>
<td>Impairment of perceptual judgement</td>
</tr>
<tr>
<td>Figure and Shape Copying (G. Gainotti et al.,1972; J.A. Ogden, 1985).</td>
<td>Copy a drawing from the left to the right side</td>
<td>Incomplete copying or drawing with gross distortions or omissions on their left side</td>
</tr>
<tr>
<td>Overlapping Figures test (G. Gainotti et al.,1991).</td>
<td>Patients are asked to name four overlapping figures, two on the right and two on the left of a fifth centrally located figure</td>
<td>Patient make left sided omissions of figures</td>
</tr>
</tbody>
</table>

However, the static displays of those paper-and-pencil tasks make unspeeded performance which become mundane and boring for patient. These efficacies of clinical tests also are still controversial for left neglect symptom in stroke patients (Dick Y et al.,2013). For example, (Samuelsson et al.,1996; Jani Kettunen,2013) proposed that the star cancellation task which the most sensitive tasks among paper-and-pencil tasks (Philippe Azouvi et al.,2006), does not present distinct clues that force the patient to start on the left or the right side of space.

Based on Feber findings in cancellation tasks, stroke patient was unable to obtain the second target accurately when the target for the first saccade was in the left visual space and the second saccade was towards a target in right visual space. Thus, final eye position of patient were demonstrated a larger error if the second saccade is

III BACKGROUND AND RELATED WORK

A. Traditional Neglect Assessment

There have a paper and pencil task such as Line Bisection, Cancellation task, Landmark Task, Figure and Shape Copying, and Overlapping Figures Test which to measure the symptom of left neglect in peripersonal space. Clinicians are allowed to guide the patient during the session in...
from a right visual field to a left visual field target (Heide et al., 1995). This could mean that the measures available for assessing visual neglect are not sensitive enough to detect residual attention bias (Jani Kettunen, 2013).

B. Technology Neglect Assessment

Based on (Anna-Sofia, 2009), the concept of using games for purposes other than entertainment is referred to as Serious Games. To date, the use of serious games has already been utilized as an assistive tool in several stroke patients, during physical therapy and cognitive therapy. Table 2 showed some related work in neglect assessment for stroke patients using technology.

Technologies such as virtual reality, video games, computer games and touch screen devices are capable to engage patients into the treatments. Among these technologies, the efficacies of computer game were to be eminently effective to improve the treatments for neglect symptom in peripersonal space. (Robertson, I. H. & Murre, 2011) identified that attention and motivation are two factors in computer games, which are significant for ability of brain to adapt and reorganize the training and experience. Due to the right hemisphere brain lesions in neglect symptom among the stroke patients, these factors are possible to strengthen the assessment of left neglect visualisation in stroke patients which (Cohen et al., 1988; Coslett & Heilman, 1989; Samuelsson et al., 1998; Duncan J et al., 1999; Pardo et al., 1991; Anna M. Barrett et al., 2006) indicate that a sustained attention is most important element to overcome the right hemisphere lesion.

(Bonato & Deouell, 2013; Jani Kettunen, 2013) also conclude that computer-based assessment has several advantages over the commonly used paper-and-pencil tasks, which they suggest suffer from various limitations and they are typically summarized into a single score. Computerized tasks may have the advantage of being less susceptible to test-retest bias, making them suitable for recovery tracking (Korte & Hillis, 2011; Jani Kettunen 2013).

IV METHODOLOGY

In this paper, we propose a method using a computer technique which can facilitate clinicians in term of quantitative significance and their systematic procedures. Apart from the neglect measurement assessment, this study applies computer game techniques or therapeutic games for patient motivation to overcome the left neglect symptom.

<table>
<thead>
<tr>
<th>METHOD NAME</th>
<th>TECHNOLOGY</th>
<th>TECHNIQUES</th>
<th>TECHNIQUES MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Environment for Spatial Neglect Assessment (VESNA) (Assaf Y Dworkin et al., 2008)</td>
<td>-Virtual Reality -Robotics Machine</td>
<td>-Targets appear on the right, left, below and eye level in close per personal and extra-personal space -Response by pressing a button</td>
<td>-Position and orientation of the head -Reaction time to initiate button press -Success rate -Mean reaction times -Percent of correct detection collapsed</td>
</tr>
<tr>
<td>Virtual Wheelchair Navigation Test (VWNT) (Laurel J. Buxbaum et al., 2006).</td>
<td>-Virtual Reality -Motorized wheelchair navigated via joystick</td>
<td>-Name all of the objects appearing on the left and right of the path(“coming” and “going”)</td>
<td>-Score for objects named on the left -Number of objects collided on the left -Category and color error -Response Time</td>
</tr>
<tr>
<td>Vertical-horizontal Illusion in hemi-spatial neglect (M. de Montalembert, 2010).</td>
<td>Computer</td>
<td>-Detect whether a vertical or a horizontal line was longer</td>
<td>-Percentage of times -Point of subjective equality (PSE) for a comparison stimulus</td>
</tr>
<tr>
<td>Tonic and Pasic Alertness Training (TAPAT) (DeGutis et al., 2013).</td>
<td>LCD panel of a laptop computer</td>
<td>-Respond via a button press when the tone was a non-target tone</td>
<td>Reaction time to responding to non-target</td>
</tr>
<tr>
<td>Modified Landmark and Line Bisection task (Metehan Çiçek et al., 2009).</td>
<td>-Computer -Infrared Video graphic camera</td>
<td>-Subjects viewed the screen from a mirror mounted on the head coil away from their eyes and press a mouse button for the target</td>
<td>-Eye-movement length of scan path -Region of interest of hemisphere cluster</td>
</tr>
<tr>
<td>Prissm (Styimir Saevarsson et al., 2009).</td>
<td>-Laptop computer -Video camera</td>
<td>-Respond by a different colour mouse button for target and non-target -Pointing movements</td>
<td>-Scores -Response times -Region of interest of hemisphere cluster</td>
</tr>
<tr>
<td>Assessment of Visuo-spatial neglect (Michiel J.A et al., 2009).</td>
<td>Virtual reality</td>
<td>Pushed a mouse button for the target balls that coming in different patterns</td>
<td>-Scores -Scanning time</td>
</tr>
</tbody>
</table>

Table 2. Neglect Assessment using Technology.
This game therapy is combination of left neglect measurement and left neglect rehabilitation technique to addressing neglect. Figure 1 showed the framework tasks illustrated in this study.

Patients are able to continue to the next level after their score has reached the desired level which indicates that patients are able to look at the most left side of computer screen.

![Figure 1. Task Framework.](image)

A. Neglect measurement

This neglect measurement function is to identify every part of left neglect visualisation in peripersonal space. The game score is based on the left neglect measurement. Patients can get higher score if they able to look at the most left side of the computer screen and otherwise for low score. The measurement is hidden from patient view to make them enjoyable during the game session without feel it as a task assessment. Clinicians can identify the left neglect visualisation of patient stage such as low, intermediate or chronic at the game database.

B. Game technique

This game design will be able to access by both patients and clinicians. It used left bias orientation technique which allow patient to look at the most left side of the computer screen. (Samuelsson et al.,1996) also suggested including cues that force patients to start the task from the left side. The concept is fundamental to most theories of neglect that refers to a bias in the direction in which attention is oriented in space (Jani Kettunen, 2013).

The level difficulties and motivation element such as simple and easily interpretable animation, high degree of contrast colour and short of sounds which suitable with elderly attentiveness (Aurelie, 2011) will improve the sustained attention element and engaging (Sebastian Deterding et al.,2011) as well among the neglect patient.

C. Database

The score and other information such as total of target and non-target achieved, time log in and time log out, left neglect percentage, and patient profile will be saving at the game database and can only be seen by clinicians. By using this database also, they are able to evaluate the patient progress without patient presence which it can help clinicians in term of time constraint and give the patient space to do the task alone.

V CONCLUSION

Left neglect symptom is one of the great percentages among the stroke patients in this world. Based on this study, we would investigate whether this technique is able to overcome and diagnose the symptom in term of therapeutic game and neglect measurement. Future outcome for
game development and a pilot study for stroke patients will come out in this study.

ACKNOWLEDGMENT

The authors would like to thank the Research Acculturation Grant Scheme (RAGS), The Ministry of Education & Universiti Teknologi MARA (UiTM) for sponsoring a part of this research.

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