Cortical Neural Response to Visual Navigation through a Virtual Environment

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Abstract

This poster reports the preliminary results of an on-going near infrared spectroscopy (NIRS) study conducted to examine cortical response to visual motion typically found in Virtual Reality (VR) applications. Comparing to watching a grey background, navigating through a virtual tunnel increased levels of oxygenated haemoglobin in visual cortex (around area V3). Potential benefits of the finding for reducing cybersickness are discussed.

Keywords: Visual cortex, Near Infra-Red Spectroscopy, visual motion, cybersickness and oxygenated haemoglobin.

Index Terms: simulation and behavior; psychology; immersion

1 Introduction

Near infrared spectroscopy (NIRS) can measure the changes of oxygenated and deoxygenated haemoglobin in localized cortical areas of human brain [24]. The main strength of NIRS measurement lies in its continuous fine temporal resolution (100ms). This makes it ideal for studying functional changes in respond of treatment or stimuli that varies with time. In this study, NIRS response to optical flow stimuli when navigating through a virtual environment (VE) is examined. Such visual motion has been associated with symptoms of motion sickness [2, 6, 9, 20, 21, 25, 26]. The effect has been referred to as cybersickness or visually induced motion sickness (VIMS) [11, 12, 13, 18, 19, 22]. VIMS has been studied for many years but the neural mechanism is not fully known [8, 10, 14, 15, 28]. On average, 1/3 of the population is affected [6, 23]. A review of literature indicates that there is no study measuring NIRS responses associated with changes in symptoms of VIMS and / or vection sensation. Coutts and Wilkins (2008) reported significant increases in oxygenated haemoglobin and decreases in deoxygenated haemoglobin in the visual cortex of viewers watching a checkerboard pattern (similar to that shown in Figure 1) alternated with a grey background as compared to watching a grey background [4, 5]. Although no NIRS studies have investigated vection, positron emission tomography (PET) studies have reported that watching roll axis circular vection-provoking stimuli will activate the medial parietal-occipital area and V6 as well as deactivate the deep posterior insular area [1].

2 Methods

Eight participants were exposed to visual oscillation along the fore-and-aft axis of a virtual tunnel (Figure 1). The visual stimulus was presented on a binocular display system (Figure 2). Same images were shown to both eyes to avoid potential convergence and accommodation mismatch [27]. Viewers' heads were fixed to avoid effects of perceived response lags [16,17]. An oscillation frequency of 0.05 Hz was used because a previous study showed that viewing fore-and-aft visual motion at this frequency caused the highest level of vection (illusion of self-motion) [3]. Participants were exposed to a sequence of visual stimuli with 5, 7, 13 or 17 second duration in random order. Each exposure was separated by a resting period of 4, 6, 12 or 16 seconds. This made up an 80 second data session and each participant exposed to 10 repeated sessions. During the resting period, a grey background was shown (Figure 3). The 32 channel Imagent function brain imaging system (ISS, Champaign, IL, USA) was used to measure the NIRS responses. Two transmitters and two receivers were placed near V3 area of the visual cortex areas on both hemispheres (about 35 mm vertically above the inion and about 30cm from the mid-line symmetrically on each side).

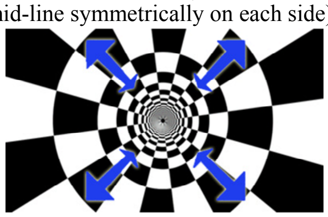

Figure 1. An illustration of the back and fore navigation motion through a virtual tunnel (the 4 blue arrows are not part of the stimulus, they illustrates the directions of expansion and contraction of the radial patterns).

Figure 2. The binocular display system used to present the visual stimuli to the participants.

Figure 3. An illustration of baseline stimulus.

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3 RESULTS

The experiment is still on-going and the preliminary results of the first two participants indicated that the oxygenated haemoglobin levels increased shortly after the visual stimulus was shown and reduced shortly after the baseline grey background was shown (Figure 4). More data will be reported in the poster.

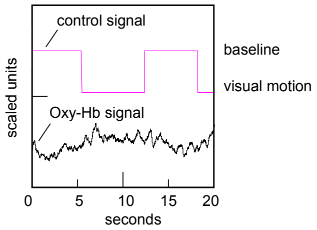

Figure 4. An illustration of the oxygenated haemoglobin signal verses the control signal.

4 DISCUSSIONS

This study demonstrated that navigating along fore-and-aft axis in a virtual tunnel can cause an increase in levels of oxygenated haemoglobin in the visual cortex area. The preliminary finding is important because it opens up the possibility to study how the brain responds to dynamic visual motion. Cybersickness has been agreed to be a major usability barrier of VR systems in ISO International Workshop Agreement 3 (IWA 3: [7]). Currently, both the Commission Internationale de L'eclairage (CIE) Technical Committee TC1-67 and ISO working group on dynamic image safety are developing guidelines for game industries [19]. If we could understand the neural mechanism of cybersickness, effective solutions to reduce visual stress associated with VR games can be developed.

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