ELSEVIER

Biomed Pharmacother 56 (2002) 367s–369s

& BIOMEDICINE PHARMACOTHERAPY

www.elsevier.com/locate/biopha

Original paper

Non-linear dynamic analysis of hemodynamic behavior during virtual reality immersion

Tomoyuki Yambe [a,*], Makoto Yoshizawa [b], Akira Tanaka [c], Ken-ichi Abe [c], Kouichi Tabayashi [d], Shin-ichi Nitta [a]

[a] *Department of Medical Engineering and Cardiology, Institute of Development, Aging and Cancer, Tohoku University, Sendai, Japan*
[b] *Information Synergy Center, Tohoku University, Sendai, Japan*
[c] *Graduate School of Engineering, Tohoku University, Sendai, Japan*
[d] *Tohoku University Graduate School of Medicine, Sendai, Japan*

Abstract

Several years ago, a famous accident occurred in Japan. Hundreds of children, who were watching a cartoon on television, suddenly complained of spasms and vertigo, and were taken to hospital. In this study, the autonomic nervous system was evaluated during audiovisual stimulation with three dimensional Virtual Reality (VR) imaging. In our previous studies, we designed the diagnosis machine for an autonomic function using multi-parameters, including electrocardiography, arterial blood pressure, respiration and stroke volume as detected by ultrasonic cardiography. Healthy adult volunteers were used in this experiment with their satisfactory informed consent. The three-dimensional content for VR included dinosaur images in a pre-historic scene. The content was projected on a wide screen and volunteers watched an audiovisual screen for about 20 minutes and the 3-D and 2-D images were compared. There was no significant arrhythmia during experiments in both images. No significant alteration was observed in the quantified hemodynamic data during the experiment. Spectral analysis was performed to evaluate the heart rate variability (HRV) during the experiment. LF, HF and LF/HF of HRV were calculated. However, there were no significant changes during the experiment. Significant change was observed in the fractal dimension of the stroke volume during 2-D and 3-D image VR immersion. Our results suggest that a significant response was observed in the autonomic function according to the 2-D or 3-D images. Our study, which aims at safe audiovisual stimulating equipment, must be developed.

Keywords: Heart rate variability (HRV); Virtual reality (VR); Fractal; Chaos; Autonomic nervous system

1. Introduction

Several years ago, an unfortunate accident occurred in Japan. Hundreds of children watching a cartoon on TV suddenly complained of spasm and vertigo and were taken to hospital [1]. Approximately four million children had watched this program and about three to four hundred of them felt ill and went to hospital. It was the biggest incident concerning a TV program in Japan. As a result, the Japanese government has sponsored the research work which sets out to evaluate responses to audiovisual stimulation, such as TV, game machines, and newly developed Virtual Reality (VR) machines. In Tohoku University, autonomic nervous system responses to VR was evaluated [2]; new diagnostic equipment for evaluating autonomic function and audiovisual machines was constructed, and responses of autonomic function to VR were evaluated.

2. Material and methods

Several researchers have already carried out various studies on responses to VR immersion [2-4]. Various

* Corresponding author.
E-mail address: yambe@idac.tohoku.ac.jp (T. Yambe).

PII: S0753-3322(02)00319-0