Subjective Evaluation of Peripheral Viewing during Exposure to a 2D/3D Video Clip

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Abstract—**Symptoms of three-dimensional (3D) sickness, such as intoxication and eye fatigue, have been observed in subjects viewing 3D films and vary according to the image quality and visual environment. In addition, the influence of stereoscopic vision on the incidence of 3D sickness has not been explored sufficiently. Therefore, it is important to examine the safety of viewing virtual 3D content. The present study examines the effects of peripheral vision on reported motion sickness during exposure to 2D/3D video clips for 1 minute and for 1 minute afterwards in human subjects. The Simulator Sickness Questionnaire was administered after exposure to the video clips with or without visual pursuit of a 3D object and compared. The questionnaire findings significantly changed after the subjects viewed the video clips peripherally. This influence may result when subjects view a poorly depicted background element peripherally, which generates depth perception that contradicts daily experience.**

I. Introduction

In recent times, the familiarity towards three-dimensional (3D) images has increased greatly because 3D movie contents providing binocular parallax are loaded onto different sources of amusement, such as cinema, home television, and game machines. Although the visual presence has been enhanced by the progress in 3D technology, which enables portrayal of movie scenes more realistically, each merit has its demerit. In this case, motion sickness is induced while viewing stereoscopic video clips [1].

Watching 3D movies, though, can produce certain adverse effects such as asthenopia and motion sickness [2]. It has been considered that this visually induced motion sickness (VIMS) is caused by the sensory conflict that results from the disagreement between convergence and visual accommodation while viewing 3D images [3]. Thus, stereoscopic images have been devised to reduce this disagreement [4, 5]. In this paper, we also examine whether the VIMS is caused by this kind of the sensory conflict.

VIMS can be measured by psychological and physiological methods, and the Simulator Sickness Questionnaire (SSQ) is a well-known psychological method for measuring the extent of motion sickness [6]. The SSQ has been used in the present study to verify the occurrence of VIMS. In addition, the following parameters of autonomic nervous activity are considered appropriate for the physiological method: heart rate variability, blood pressure, electrogastrography, and galvanic skin reaction [7-9]. It has been reported that a wide stance (with the midlines of the heels from 17 to 30 cm apart) significantly increases the total locus length in the stabilograms of individuals with high SSQ scores, while the length for individuals with low scores is less affected by such a stance [10]. We reported that VIMS could be detected by the total locus length and SPD, which were used as the analytical indices of stabilograms [11].

The recent widespread use of stereoscopic vision facilitates provision of virtual reality and sensation; however, as discussed, since long, there has been concern over the symptoms caused by stereoscopic vision. Accordingly, in the present study, we have examined whether our visual and equilibrium systems are affected by an hour-long session of stereoscopic viewing [12]. In an earlier study by Yoshikawa et al. [12], the sway values measured after visual pursuit of the stereoscopic sphere in a video clip tended to become smaller than those after (peripheral) viewing without purposeful pursuit of the object. In addition, when the subjects were not allowed to fix the point of gaze as they wished, they looked at the objects with different virtual depth. Each time subjects change their point of gaze, interaction occurs between systems to control accommodation and convergence. A state of non-equilibrium in the control system for visual information processing imposes additional load on the human body. Further, the intermittent inconsistency between accommodation and convergence is considered to cause imbalance in our autonomic nervous system. In order to examine this hypothesis, we measured the severity of the influence of peripheral viewing, which is expected to cause uncomfortable symptoms of motion sickness, and compare it with the influence of the visual pursuit of a virtual object on the equilibrium function.

II. Material & Method

Eleven healthy men (mean ± standard deviation, 22.6 ± 0.7 yrs.), who may have had any otorhinolaryngologic or neurological diseases in the past, participated in this study. The experiment was sufficiently explained to the subjects, following which written consent was obtained from them. The research was approved by the Ethics Committee, Graduate School of Information Science, Nagoya University.

In this experiment, the body sway was measured while viewing 2D/3D video clips. The subjects stood for 30 s before

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the exposure to the following video clips. The subjects were instructed to maintain the Romberg posture during the trials. For the first 60 s, the subjects were asked to do the following:

I. Gaze at a static circle with a diameter of 3 cm (Control).
II. Follow a sphere which complexly ambulated.
III. Peripherally view the same video clip as shown in (II) on the 40-inch display KDL 40HX80R (Sony, Tokyo). Subjects were ask to gaze blankly at the entire screen without pursuing the sphere.

That is, we categorized the visual sighting method as pursuit (II) and peripheral viewing (III). Subjects gazed at a point of fixation (I) or video clips (II)/(III) with their eyes open for the first 60 s, after which they closed their eyes for 60 s. Subjective evaluation of symptoms caused by the motion sickness was then examined using the SSQ and Visual Analog Scale (VAS).

The circle (I) was placed before the subjects, 2 m away, at their eye level. Stereoscopic video clips (II)/(III) and their monocular (2D) vision were shown to subjects on the binocular parallax 3D display. The content in the "SkyCrystal" (Olympus Memory Works Ltd. Co., Tokyo) was modified, with permission from the company, and used as the visual stimulus in this experiment. The stimulus includes spheres fixed in four corners, which supplies perspective. We measured the body sway and the subjective evaluation for each vision (I) Control, (II)-2D, (II)-3D, (III)-2D, and (III)-3D situation randomly, according to the abovementioned protocol.

Subjective evaluation was conducted by filling out the questionnaires before and after the stabilometry. In addition to the SSQ, the VAS was utilized to evaluate their eye strain. Finally, a two-way ANOVA on the abovementioned factors was conducted for each sub-score, specifically, the N, OD, D, TS, and VAS.

III. Results

The SSQ confirmed that the subjects did not complain of discomfort before the stabilometry and after the control stabilometry. Any sub-scores of the SSQ filled out after the exposure to the 3D video clip were greater than those filled after the exposure to the 2D one. Moreover, any sub-scores of the SSQ after peripheral viewing of the video clips were also greater than those measured after exposure to the visual pursuit ones.

According to the two-way ANOVA, with reference to the subjective indices, interaction was not found between the abovementioned factors. In the sub-scores for N, OD, and TS, the main effect of the vision method was observed ($p < 0.05$). While the main effect of the vision method also tended to be seen in the sub-score D ($p < 0.1$), the main effect of solidity of the vision was observed in this sub-score ($p < 0.05$). With reference to the VAS, the subjects complained of eye strain after peripheral viewing of the video clips (Fig. 1), which was indicated by the main effect of the vision method in this subjective evaluation (**$p < 0.01$).

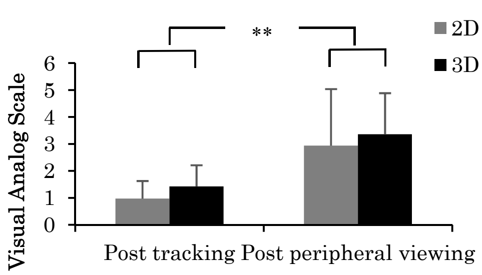

Fig.1 Results of two-way ANOVA for subjective evaluation using the VAS.

IV. Discussion

The change was obtained from the statistical results of subjective evaluation after peripherally viewing the video clips. According to the analysis of the SSQ subscore N, OD, TS, and VAS, we could found increase in severity of the symptoms such as uncomfortable and eye strain that were induced by the VIMS.

Subjective acute exacerbation was observed after peripheral viewing of the video clips, in comparison with that after viewing clips involving visual pursuit of the sphere. This is regarded as persistent influence, which might be caused by peripheral viewing in an unskillful background element, depth perception in which differs from our experience in daily life. In future research, we will examine whether the severity of the VIMS depends upon exposure time, differential rate of backgrounds, and the vestibular input, and discuss limits of our ability in visual information and the mechanism of the VIMS.

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