

HUMAN IMPACT ASSESSMENT OF WATCHING 3D TELEVISION BY ELECTROCARDIOGRAM AND SUBJECTIVE EVALUATION

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Abstract: Some health problems such as photo sensitive epilepsy, motion sickness, and visual fatigue might be caused by 3D TV. This study evaluated the effects of watching 3D TV in elderly ($=75.39 \pm 4.16$ years) and young subjects ($=26.25 \pm 2.53$ years) using electrocardiography (ECG) and a subjective evaluation. As a result, the r-r interval changes of the old showed significant difference ($p < 0.05$) comparing to that of the younger. This result supports the subjective evaluation; the old felt more visual fatigue and showed stronger desire of stop watching 3D TV. As a conclusion, new guides for making 3D TV contents are needed.

Keywords: 3D TV, ECG, Subjective Evaluation, Motion Sickness, Visual Fatigue.

1. INTRODUCTION

By recent advance in the multimedia processing fields, 3D TV is expected to become one of the most dominant markets in the next generation broadcasting system [1]. The 3D visual technology based on rapid progress in digital electronics has been greatly improved in recent years. However, 3D display devices are still possible to cause eye strain due to unnatural artificial stereopsis. As information and communication technologies advance, the image media industries have achieved an outstanding growth, while biological impacts of screen image are being brought into questions worldwide. Through this recent technological development, the opportunity to experience 3D TV or 3D visuals by the general audience increases. In addition, 3D TV broadcasting has already started or begun on a trial basis in USA, Japan, Korea and Europe [2]. Besides this development, it has been widely whispered that some specific movies tend to cause motion sickness, and that eye fatigue occurs very often while watching 3D screen images. Not only 3D vision but also visually induced motion sickness caused by wide displays has become an issue to be

taken into account [2]. It is recommended to stop watching 3D visuals, when experiencing symptoms such as: altered vision; light-headedness; dizziness; involuntary movements such as eye or muscle twitching; confusion; nausea; loss of awareness; convulsions; cramps; and/or disorientation. Viewing in 3D mode may also cause motion sickness, perceptual after effects, disorientation, eye strain, and decreased postural stability. One of the biggest issues at the moment from the audience, who is watching 3D visuals, is the visual fatigue.

Visual fatigue is a very important issue of 2D and 3D display market to implementing more comfortable display devices in terms of human factor. Many studies have been performed in order to measure the visual fatigue using objective evaluation method such as, electroencephalogram (EEG) in 3D display environment. Notably, Kim and Lee [3] performed the study to measure the visual fatigue. They performed the difference of visual fatigue using a subjective method and compared it to an objective measure. As a result, the 3D content affected the power of brain wave in the beta frequency. Beta power was more strong at the viewing the 3D contents. Also, subjective result also showed more strong visual fatigue in the 3D condition than in the 2D condition. Another study was to develop a paradigm to measure 3D visual fatigue using background EEG and event-related potential (ERP) signals [4]. They have developed 3D oddball paradigm, which revealed the effect of binocular parallax and presentation duration on 3D visual fatigue. Also subjective 3D visual fatigue was also measured. Kim et al [5] investigated the relationship between the visual fatigue and the amount of binocular disparity by using functional magnetic resonance imaging (fMRI). Kim et al [6] proposed a visual fatigue monitoring system based on eye-movement and eye-blink direction, which analyses the eye-movement of blinks, based on the assumption that saccade movement of the eye decreases and the number of

eye blink increases when visual fatigue of viewer was accumulated.

Emoto et al [7] assessed visual fatigue associated with stereoscopic TV viewing and compared it with conventional 2D TV. They measured viewers' fusional amplitude and the interaction between vergence and the accommodation system after viewing conventional 2D TV and stereoscopic viewing 3D TV, and assessed subjective visual fatigue, changes in fusional amplitude and accommodation ratio. No et al [8] compared visual fatigue caused by HDTV and stereoscopic HDTV. They measured the degree of visual fatigue using a subjective test method and compared it to an objective measure, namely the change in accommodation before and after viewing images. And also detected discomfort image scenes from the best program using the single stimulus continuous quality method. Lee et al [9] measured the frequency of blinking using a near-infrared pupil detection device to quantitatively compare the amount of eyestrain caused when watching the 2D and 3D displays, on the basis that more frequent blinking indicates greater eyestrain. In terms of 3D visuals making, different methods are available namely: One Source One Device (OSOD) and One Source Multi Device (OSMD). At present, the OSOD approach is employed. When comparing with OSOD, the OSMD is expensive and difficult to produce, but the quality of visual is good and reproduces the actual. In regard to photosensitive epilepsy (PSE), physiological data such as EEG have been collected for examination in view of image safety. However, the motion sickness and 3D image-induced eye fatigue involve much of viewers' subjective aspects, and hence, the measurement of both psychological factors and physiological parameters such as heart rate (ECG), blood pressure and pupillary response is required for understanding the safety with higher accuracy.

In this study, we have considered different age group viewers (elderly and younger), and different image dimensions (2D, 3D, OSOD, and OSMD), to measure visual fatigue. We have analyzed the viewer's visual fatigue through the subjective evaluation and ECG experiment.

2. MATERIALS AND METHODS

This study evaluated the effects of watching 3D TV in elderly ($=75.39 \pm 4.16$ years) and young subjects ($=26.25 \pm 2.53$ years) using ECG and a subjective evaluation. A total of 40 subjects (20 elder and 20 younger) were considered. The day before the experiment, subjects were asked to avoid excessive exercise and excessive intake of alcohol. On the day of experiment, to avoid the central nervous system and smell receptors impact, subjects were asked to avoid smoke, drink and drugs, eating chewing gun.

To determine the optimal viewing distance and duration of viewing the 3D visuals, preliminary experiments were performed. From the preliminary experiments, the viewing distance was set as six times the height of the display and the duration of viewing the 3D visuals was set as 45 minutes. The ECG signals were measured with bipolar leads (Fig. 1). Biopac system's Acqknowledge program (BIOPAC System

Inc., USA) was used as a physiological workstation. Sampling rate for measuring the physiological signals was set as 512 Hz. Each measurements cross-resistance was less than 10 k Ω . The Biopac MP100 System ECG amplifier was used to measure the ECG signals and to calibrate the system Oscilloscope was used. The both system measured the same frequency. The expanded uncertainty of the equipment was 0.02 Hz with 95% confidence level.

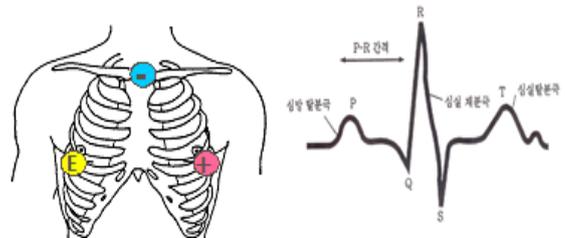


Figure 1. ECG Bipolar Leads

From the ECG experimental results, the average R-R interval was obtained. The low frequency (LF) and high frequency (HF) of each frequency bands were calculated using FFT and power spectrum analysis tools. For the normalized sensitivity the measured signals were compared with steady state (1). The results were statistically analysed in SPSS program with ANOVA and t-test.

$$NS(\%) = (\text{signals} + \text{steady state}) / \text{steady state} \quad (1)$$

3. RESULTS AND DISCUSSION

Subjective Evaluation: Subjective assessment was performed, when watching 2D and 3D visuals. The survey score was evaluated as percentage. Survey items included factors such as: eye sickness, desire for stopping watching, nausea, body pain, image not clear or blurred vision or hazy vision. From the subjective evaluation score, it was clear that: both elderly and younger's overall sickness score was high while watching 3D visuals than 2D. The blurred vision score was higher than other factors with younger's 40.19% and elderly 49.60%. The factor desire for stooping watching was also high with 26.44% for elderly.

Electrocardiography (ECG): Initially, watching 2D and 3D visuals were compared. The variation of R-R interval was decreased significantly (p -value=0.007) for watching 3D visuals than 2D (Fig. 2).

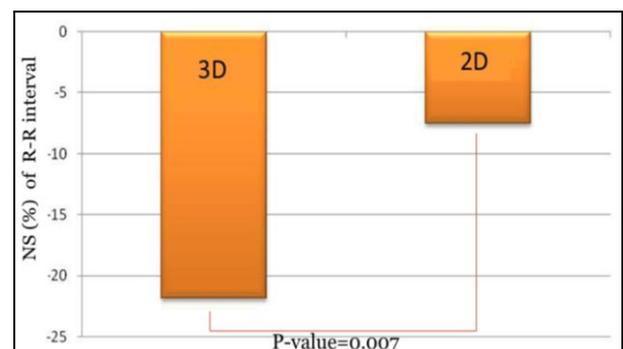


Figure 2. R-R interval after watching 3D and 2D visuals

The younger's R-R interval value was comparatively similar, before and after watching 3D visuals. Whereas elder's, R-R interval value was decreased significantly with 93% (p-value = 0.016) (Fig. 3.), before and after watching 3D visuals.

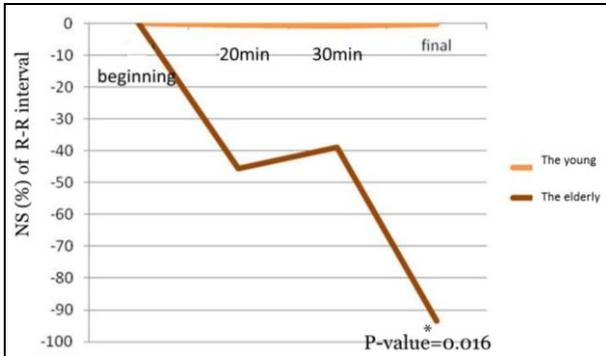


Figure 3. R-R interval after watching 3D visuals in the younger and elderly

The LF/HF ratio was compared after watching 2D and 3D visuals. The variation of LF/HF ratio was increased significantly for watching 3D visuals than 2D (p-value=0.013) (Fig. 4.).

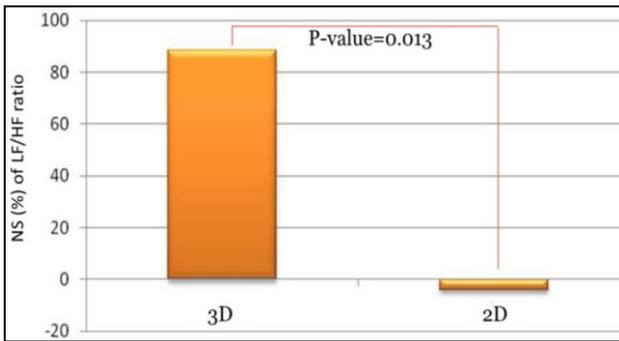


Figure 4. LF/HF after watching 3D and 2D visuals

While comparing before and after watching 3D visuals, 57% increase in younger's LF/HF ratio and 125% increase in elder's were found. When comparing age groups, the LF/HF ratio difference was 68% (p-value=0.049) (Fig. 5).

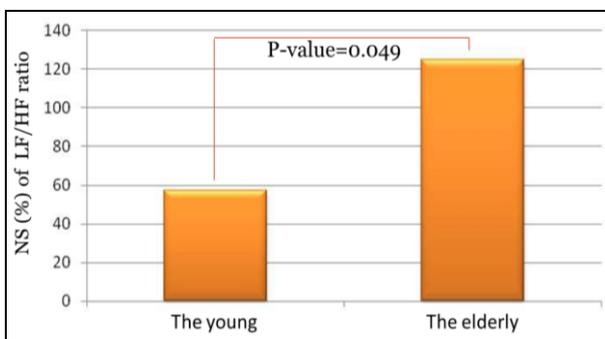


Figure 5. LF/HF after watching 3D visuals in the younger and elderly

Second, watching 3D visuals with different in making such as OSOD and OSMD were compared. After watching

3D visuals, the R-R interval were decreased for both OSOD and OSMD. In comparing OSOD and OSMD, the variation of R-R interval was decreased more for OSOD (p-value=0.042). In comparing OSMD and 2D, both showed a similar trend of decrease in R-R interval (Fig. 6).



Figure 6. R-R interval after watching 2D, OSMD, OSOD

When comparing R-R intervals of 2D visuals, OSMD and OSOD, after watching them for same duration. Similar reduction were found in the younger's R-R intervals. For the elder's, drastic reduction were found (Fig. 7).

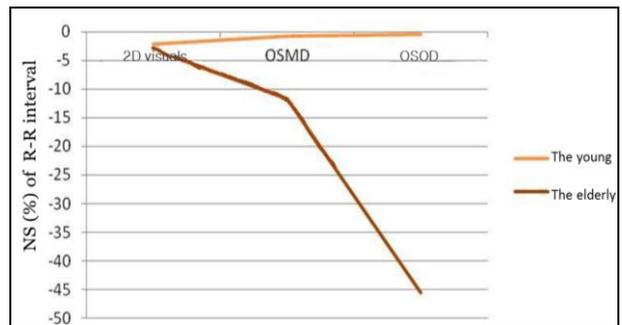


Figure 7. R-R interval after watching 2D visuals, OSMD, OSOD in the younger and elderly

When comparing OSOD and OSMD's LF/HF ratio, after watching. The OSMD's ratio was decreased (Fig. 8).

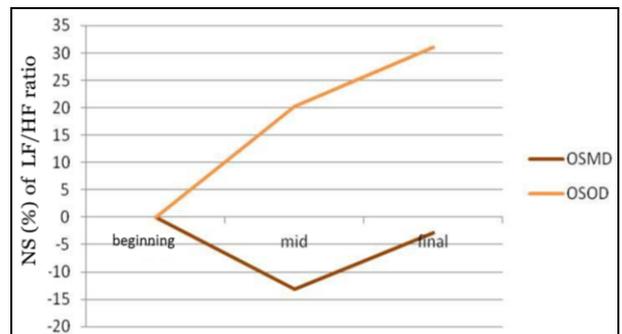


Figure 8. LF/HF after watching OSMD and OSOD

When comparing OSMD's LF/HF ratio, after watching. The elder's LF/HF ratio was 58% increased then younger's (p-value=0.027) (Fig. 9).

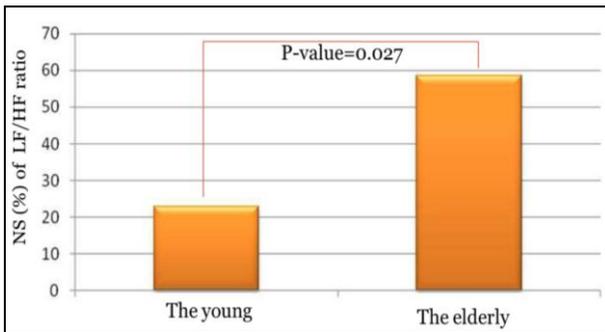


Figure 9. LF/HF after watching OSMD in the younger and elderly

4. CONCLUSION

In this study, through the subjective evaluation and ECG experiment the eye fatigue while watching 3D TV was measured and compared. Watching 3D visuals generates more eye fatigue than 2D. The 3D visuals generate higher fatigue and stress to the elder's than younger. OSMD generates less eye fatigue than OSOD, and both OSMD & 2D showed a similar eye fatigue trend. Comparing to all, the OSMD visuals showed the lesser fatigue. At present, the approach of making 3D visuals only follows OSOD method. And also, only single guideline is available to watch 3D visuals. In future, OSMD method should be employed to make 3D visuals, to reduce eye fatigue. And also, new guidelines of watching 3D visuals are necessary for vulnerable groups for example older people.

5. REFERENCES

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