The Evaluation of Visual Fatigue in 3D Televisions

Po-Hung Lin(✉)

Department of Industrial Engineering and Management Information,
Huafan University, New Taipei City, Taiwan
phlin@cc.hfu.edu.tw

Abstract. This study explores the effects of 3D film types, watching time and ambient illumination on users' visual fatigue through experimental design. A three way mixed factorial design was used to investigate the effect of ambient illumination, the film type and the watching time on the change of critical fusion frequency (CFF) and simulator sickness questionnaire (SSQ). The ANOVA results indicated that watching time was significant on change of CFF and SSQ, where watching 15 min has more visual fatigue than 5 min and 10 min for subjects. In addition, the interactions between watching time and film type were also found on change of CFF and SSQ.

Keywords: Visual fatigue · 3D television · Film type · Watching time

1 Introduction

With the advancement of technology and maturing of techniques, 3D displays have been the mainstream of the market. The 3D technology is applied in many areas, such as 3D televisions and notebooks. Compared to traditional 2D displays, 3D displays contain better image qualities. Kalich et al. [1] pointed out that three-dimensional displays provide a wider field of vision. Kooi and Toet [2] proposed that binocular viewers may pass uncorrelated noises easily to see relevant signals which represent the objects in the scene. Therefore, the issue of 3D displays is an interesting topic.

Ambient illumination is a critical factor affecting participants' visual fatigue when watching 3D TVs. For smaller size displays, Jeng et al. [3] found that the legibility of electronic paper increased with the illumination level in the range of 200–1500 lx, but decreased at a higher illumination level. In addition, dark room is also an alternative for watching 3D TVs since people currently consider TVs with large screens as home theaters. In addition, Obrist et al. [4] had investigated the four types of movies including skiing, space jumping, breakdance, and body painting on 3D screens. Actually, video types with different visual effects may bring the impacts on participants' visual fatigue and it's also worthy to be investigated. Finally, duration time for participants' watching was also an important consideration. Obrist et al. [4] set about 3 min for people watching the four types of movies. Lambooij et al. [5] conducted the questionnaire survey after participants' watching 3D movies for 15 min. Based on above arguments, ambient illumination, video type and watching time were the three independent factors with corresponding levels considered in this study.

© Springer International Publishing Switzerland 2016
C. Stephanidis (Ed.): HCII 2016 Posters, Part I, CCIS 617, pp. 216–219, 2016.
DOI: 10.1007/978-3-319-40548-3_36

2 Method

Forty college students took part in this experiment. All had corrected visual acuity better than 0.8 and passed the Stereo Fly Test (Stereo Optical Co., Inc., U.S.A). A three way mixed factorial design was used to investigate the effect of video type (sport and travel), watching time (5, 10, and 15 min), and ambient illumination (dark room, 200, 1500 and 3000 lx) on subjective visual fatigue and change of critical fusion frequency (CFF). Analysis of variance (ANOVA) was conducted with repeated measures on subjective visual fatigue and change of CFF. The Least Significant Difference (LSD) test was used to find the significance among the levels of independent variables. All statistical analyses were calculated with the Statistical Products Services Solution (SPSS).

3 Results and Discussion

The ANOVA results for subjective visual fatigue indicated that watching time ($F = 7.737$, $P < 0.05$) and the interaction between watching time and video type ($F = 7.635$, $P < 0.05$) were the significant factors. The significant interaction was needed to test the simple main effect (see Fig. 1). Therefore we focused on each video type, investigating its effect on watching time. The results indicated that sport video was significant in watching time ($F = 7.562$, $P < 0.01$), where significant differences ($P < 0.01$) were found among 5, 10, 15 min through LSD test. The results also indicated that travel video was significant in watching time ($F = 8.915$, $P < 0.01$), where significant differences were found between 5 and 10 min ($P < 0.01$), and between 5 and 15 min ($P < 0.01$). We then studied the effect of each watching time on video type. The results indicated that no matter in which level of watching time, the results were not significant ($P > 0.05$).

The ANOVA results for change of CFF indicated that watching time ($F = 9.384$, $p < 0.01$) and the interaction between video type and watching time ($F = 6.906$, $p < 0.05$) were the significant factors. The significant interaction was needed to test the simple main effect (see Fig. 2). Therefore we focused on each video type, investigating its effect on watching time. The results indicated that sport video was significant ($F = 11.322$, $P < 0.01$), where the significant differences were found between 5 and 15 min ($P < 0.01$) and between 10 and 15 min ($P < 0.01$). The results also indicated that travel video was significant in watching time ($F = 6.5$, $P < 0.05$), where significant differences were found between 5 and 10 min ($P < 0.05$), and between 5 and 15 min ($P < 0.01$). We then studied the effect of each watching time on video type. The results indicated that no matter in which level of watching time, the results were not significant ($P > 0.05$).

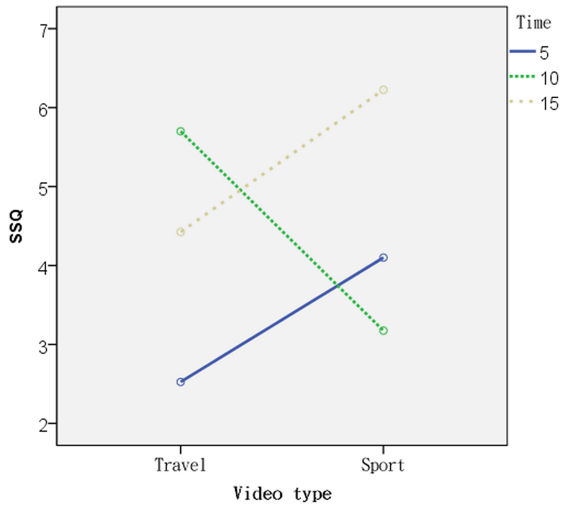

Fig. 1. The interaction between video type and watching time for SSQ (Color figure online)

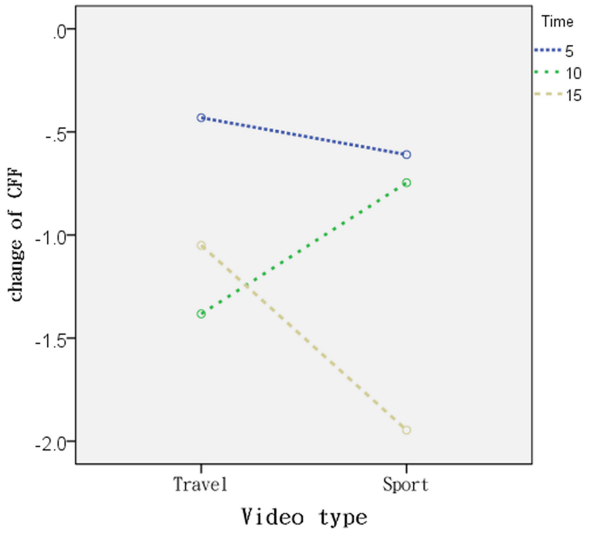

Fig. 2. The interaction between video type and watching time for change of CFF (Color figure online)

4 Conclusion

This study explores the effect of file type, watching time and ambient illumination on subjective visual fatigue and change of CFF. The results for the interactions between watching time and video type on change of CFF and subjective visual fatigue indicated

that for travel video, the difference between 10 and 15 min can't be distinguished. The reason may be that travel videos may bring less visual fatigue than sport videos, especially for long time watching.

References

1. Kalich, M.E., Rash, C.E., van de Pol, C., Rowe, T. L., Lont, L.M., Peterson, R.D.: Biocular image misalignment tolerance. In: Rash, C.E., Reese, C.E. pp. 284–295. (2003)
2. Kooi, F., Toet, A.: Visual comfort of binocular and 3D displays. Displays **25**, 99–108 (2004)
3. Jeng, S.-C., Lin, Y.-R., Liao, C.-C., Wen, C.-H., Chao, C.-Y., Lee, D.-S., Shieh, K.-K.: Effect of character size and lighting on legibility of electronic papers. In: SID 06 Digest, pp. 1316–1319 (2006)
4. Obrist, M., Wurhofer, D., Meneweger, T., Grill, T., Tscheligi, M.: Viewing experience of 3DTV: An exploration of the feeling of sickness and presence in a shopping mall. Entertain. Comput. **4**, 71–81 (2013)
5. Lambooij, M., Murdoch, M.J., IJsselsteijn, W.A., Heynderickx, I.: The impact of video characteristics and subtitles on visual comfort of 3D TV. Displays **34**, 8–16 (2013)