A Quantitative EEG Study of Video Games

Eric He, *Student Member, IEEE***, Wenjing Ye,** *Member, IEEE***, and Bin He,** *Fellow, IEEE*

In the past 20 years, video games have reached hundreds of millions of people through a wide variety of mediums. Audiences now include people from all ages and both genders. Consumption ranges from recreational usage for a couple minutes to professional play for hours on end. People play games on mobile devices, computers, and consoles specifically designed for games as well. Given the increasing prevalence of video games, studies have been conducted to assess their impacts on the consumers, showing mixed results. There has been evidence of both positive and negative effects on the brain of the player of a video game, depending on various criteria.

The potential negative effect of video games that receives perhaps the most attention is an increase in violence. However, this project would instead focus on effects that happen after an order of time on the scale of hours rather than days or weeks. The largest negative effect on this scale is a potential buildup in stress. As players continue to play video games, frustration and elation can occur. Combined with the games' constant utilization of the players' mental capabilities, this can cause stress to build up. Video games have also been shown to have benefits in its players as well. Playing video games can potentially help improve attention allocation, memory, and other executive skills [1]. Real time strategy games, for example, require a multitude of executive skills such as task switching, mental flexibility, planning, and problem solving. First person shooters have been shown to potentially improve spatial selective attention [2]. Investigating neurological signs of increased activity in these areas using EEG would help signal users that they are practicing these skills and could potentially quantify improvements in these areas.

EEG was used to assess and quantify the effects of video games on players [3]. Two types of video games - fast paced reaction time based games, and slower more strategically based games – were used. Four healthy young humans were recruited to be the subjects and participated in the study according to a protocol approved by the IRB of the University of Minnesota. 64- or 128-channel EEG signals were recorded in 3 minute segments periodically over the course of an hour of gameplay. Power spectral analysis was performed and relative power changes in reference to the baseline (prior to game play) were computed and visualized over the scalp. In subjects studied, it was found that the strategy based games resulted in a larger frontal midline theta-wave power increase as gameplay continued, as compared with fast paced reaction time based games. The theta wave of EEG has been found to correlate with cognitive loads over the frontal lobe. Other power bands were not found to produce statistically significant differences. The EEG based results suggest a higher cognitive load associated with strategy based games, as compared with fast paced reaction time based games, which may be related to stress.

Parallel to the use of EEG as a quantitative tool to assess effects of video games on players, EEG may be used as a means of helping players to enhance its mental strength through an interactive mode. Brain computer interface (BCI) has been used to extract users' intentions for the control of an external device or computer [4]. In a BCI set-up, a player may play video games using their mental signals instead of their hands. Such mental signals based video games may control the flight of a virtual helicopter [5]. Use of such mind controlled video games may help improve the cognitive ability of its players, although much work still need to be done.

REFERENCES

[1] W. Boot, A. Kramer, D. Simons, M. Fabiani, and G. Gratton, "The effects of video game playing on attention, memory, and executive control," *Acta psychological*, vol. 129, no. 3, pp. 387-398, 2008.

[2] S. Wu, C. Cheng, J. Feng, L. D'Angelo, C. Alain, and I. Spence, "Playing a first-person shooter video game induces neuroplastic change," *J. of cog. neuroscience*, vol. 24, no. 6, pp. 1286-1293, 2012.

[3] E. He, H. Yuan, L. Yang, C. Sheikholeslami, and B. He, "EEG Spatio-spectral Mapping during Video Game Play," Proc. of *ITAB,* 2008, pp. 346-348.

[4] Gevins A, Smith ME, McEvoy L, and Yu D. "High-resolution EEG mapping of cortical activation related to working memory: effects of task difficulty, type of processing, and practice." Cereb Cortex. 1997 Jun; 7(4):374-85.

[5] B. He, S. Gao, H. Yuan, and J. R. Wolpaw, "Brain-Computer Interface," In: Neural Engineering, B. He, Ed. Springer, 2013, pp. 87–151.

[6] A. Doud, J. Lucas, M. Pisansky, and B. He, "Continuous three-dimensional control of a virtual helicopter using a motor imagery based brain-computer interface." PloS One, vol. 6, no. 10, 2011.