User Research for 3D Display Settings with EEG Frontal Alpha Asymmetry

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Abstract

The effectiveness of stereoscopic 3D displays in games is currently debated for creating immersive player experiences. In this project, we investigate how stereoscopic 3D can work in games that make use of depth information in 2D overlays and how this affects physiological brain responses (EEG) indicating player arousal. We conducted a pilot study to determine whether stereoscopic 3D is more arousing than other depth techniques such as shadow cues and heads-up displays (HUD). Participants played a game with multiple game maps in different display conditions: stereoscopic 3D (S3D), heads-up display (HUD), shadow (S), or none (N). The physiological results showed no hemispheric activity difference by condition.

Author Keywords

Electroencephalography, Games; Stereoscopic 3D; Games User Research; Hemispheric Alpha Asymmetry, Heads-up Display (HUD)

ACM Classification Keywords

H.5.2 [Information Systems]: User Interfaces; K.8.0 [General]: Games – Personal Computing

Introduction

Engaging video games rely on real-time feedback, often displayed to the player via a heads-up display (HUD) or a graphical user interface (GUI). A HUD is a 2D layer (usually semi-transparent) on top of the main game world view. GUIs and HUDs display player critical information, such as health, items, or ammunition. Developers often rely on monoscopic display methods (i.e., information that can be viewed with only one eye) to convey this information to players. Some additional information (e.g., depth perception), however, is difficult for players to comprehend in monoscopic views. Static and dynamic shadows can be used to convey spatial relationships between objects [7] with low accuracy. In some cases, shadows may not be of any help (e.g., no scene object receives the shadow). HUDs can be distracting because users must divide their attention across information on limited screen space [8].

Stereoscopic 3D gives the illusion of depth. Objects can appear either in front of the screen or behind the screen. The stereoscopic effect is created by presenting each eye with a slightly different image [1]. The difference in these images is known as parallax settings [2]. The projection of an object directly on the screen has zero parallax. S3D may cause an immersive user experience or cause discomfort through eyewear (e.g., shutter glasses) and exaggerated S3D effects, where the disparity between the displayed images is high [3].

We currently do not know how excited players are when using display settings such as S3D. Therefore, we study arousal measured using electroencephalography (EEG, inter-hemispheric alpha level) during monoscopic and stereoscopic 3D gameplay based on prior research [2,5,6] in this study. Prior research supports the notion that an increase in arousal could translate to a better overall player experience in S3D gaming [6].

Related Works

Some users feel an increase in simulator sickness because of the nature of stereoscopic 3D displays. This may be caused by the difference between the human body's ability to understand images and the unnatural focus point of the stereoscopic object [3]. Feelings of discomfort, similar to those experienced in car sickness, are known as simulator sickness [4]. Stereoscopic 3D settings and user experience were studied by Takatalo et al. [2]. In a detailed study using questionnaires, the researchers reviewed the degree of parallax settings and their effect on user experience. They found that the parallax settings affected enjoyment of the game. The highest parallax settings often show higher levels of simulator sickness. In contrast, a lack of stereoscopic 3D settings was found to be less enjoyable. The authors concluded that medium parallax settings were most effective [2].

Schild et al. conducted several studies related to stereoscopic 3D and user experience where they reached a similar conclusion. The researchers used questionnaires and EEG recordings to understand the relationship between the display settings and user experience. The study concluded that stereoscopic 3D was preferred over other measures according to the questionnaires. The EEG results were not as conclusive, possibly because of the measures used and the methodology applied [5].

Salminen et al. [6] used the Hemispheric Frontal Alpha Asymmetry technique to look at player arousal during game events such as scoring points or player deaths. The conclusion of the paper is that higher arousal is an indicator of user experience because more arousing games are more exciting.

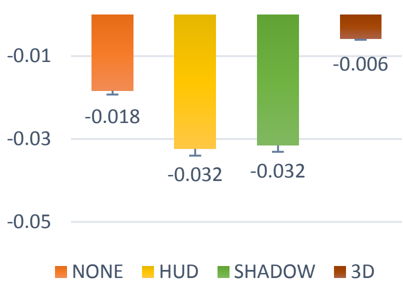

Figure 1: The Average Difference by Condition

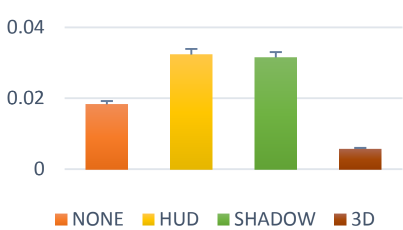

Figure 2: The Absolute Value of the Average Difference by Condition

All of this research informs our study, driven by the questions: Will Hemispheric Frontal Alpha Asymmetry show that stereoscopic 3D games are more arousing? What if it were compared to other display settings such as shadows (with limited depth information) [7]? How do the above settings compare with the addition of a HUD [8]? In our study, we compare arousal based on the differences between display settings.

Methodology

We used a within-subjects design, meaning that the participants played the levels of the game in each condition: with a HUD, using shadow information and using S3D. Order of presentation was randomized.

Participants

Five participants were recruited, all male and all expert gamers. Participants ranged in age from 21-26.

Game

We used a Top-Down Shooter S3D game [9]. The participants were faced with puzzles as they navigated through the level in an animated ship. Participants experienced minimal cartoon violence. Due to spatial orientation differences between genders, only males were recruited for this study [10].

Questionnaire

The GEQ was used to test for differences in gameplay experience by condition. Players were also allowed to add additional comments.

Electroencephalography

The EPOC Emotiv was used to collect data at a sampling rate of 128Hz. The electrodes of interest to the study are FC5, FC6, F7, F8, F3, F4, AF3 and AF4. Data was automatically Nyquist-filtered. Bandpass filtering was used to narrow the frequency range to 8-12Hz [11]. No further filtration techniques were applied to avoid distortion of data [12]. Hemispheric Frontal Alpha Asymmetry is a technique that is used to measure arousal by comparing opposing lobes of the brain [13]. A Fast Fourier Transform (FFT) was applied to the data [11]. Each lobe was analyzed for alpha activity separately and then compared. The value of each lobe (left and right) was calculated after subtracting the baseline value. Both the value and the absolute value are presented below. These values were then compared to each other (left and right). In this case, the absolute difference was taken before subtracting the difference of the baseline.

Results

A comparison of the results of each group shows no significant difference between groups.

Hemispheric Frontal Alpha Asymmetry

The absolute value of the differences are displayed in Figure 1 and Figure 2. To check for significance, several t-tests were performed between the two lobes per condition. Figure 3 shows the calculated value of frontal alpha for both the left lobe and the right lobe and groups them by condition. Table 1 shows the results of the t-tests and their significance per condition.
The study had limitations associated with the analysis that will need to be fixed before conducting a full study.

Discussion

In this paper EEG was used to understand the level of arousal between conditions. No differences were found between lobes for any of the display settings. Thus, one would question the preference for stereoscopic 3D

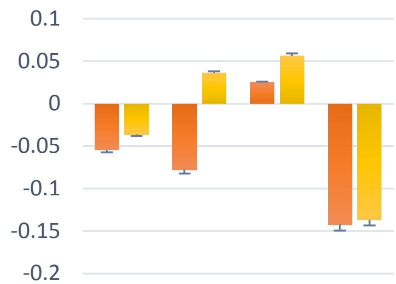

Figure 3: Alpha per Lobe by Condition

Table 1: t-test Between Left and Right Lobe*

	None	HUD	Shadow	S3D
t-test	-0.678	-0.218	-0.759	-0.118
Signifi-cance	0.535	0.095	0.490	0.912

*α = 0.05

established by studies using questionnaires. It may be possible that stereoscopic 3D is not more arousing but provides a different part of user experience. Players may expect to enjoy 3D more (considering its novelty), which is then reflected in the questionnaire. Due to the learning curve associated with the game the study may have been affected by the within-subjects design. A secondary pilot should be run to test for the significance between display conditions using a between-subjects design. A within-subjects design will shorten the experiment length, reducing fatigue experienced by participants which could affect recorded alpha activity [11]. Valence of the arousal cannot be verified without comparing the EEG results to a secondary measure [6, 14]. Possibly to galvanic skin response [15] or to a questionnaire [2].

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