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Lab Report #1

# Video Game Effects on Beta Wave Concentration and Brain Activity

## Abstract

Beta waves in the brain are associated with active attention and concentration. Increased levels of beta wave concentration can be induced when playing video games. This study investigates three different genres of mobile video games to identify which genre would activate more beta waves. In this experiment, EEG data was measured of the subject playing a horror game (*Granny*), an arcade game (*Subway Surfers*), and a first-person shooter game (*Call of Duty*) to provide an analysis of the amplitude and frequency of accompanying beta waves. Results proved that the horror game contained the highest beta wave concentration compared to the other two genres with amplitudes 14 times larger than the relaxed data and 20 times more powerful beta waves around 13.5 Hz. Playing video games can increase the frequency of beta waves and stimulate brain activity in the frontal lobe which would generate higher cognitive functions. Additional studies can provide an answer to the relationship between video games and beta waves leading to higher cognitive functions in the frontal lobe of the brain.

## Introduction

Brainwaves are an indication of electrical activity coming from the brain. The five primary categories of brain waves that are measured by an electroencephalogram (EEG) are delta, theta, alpha, beta, and gamma waves. Beta waves are associated with high levels of mental and physical activity and are found between 12.5 and 30 Hz (Abhang, 2023). The prefrontal cortex of the brain produces the most beta waves, which are produced in the frontal lobe of the

brain. The prefrontal cortex is responsible for cognitive functions such as memory, problem-solving, and motor skills (Siddiqui 2008).

Video gaming is generally considered a cognitively demanding form of leisure activity. User engagement has varying effects on brain activity depending on the alertness the game requires. The player is required to pay close attention to details and react quickly, this requires greater attention and focus from the user. Beta waves sit on a range of different frequencies, with higher beta wave frequency being associated with greater cognitive function (Hendryana, 2020). Different levels of engagement for games can be recorded by looking at the frequency range of beta waves produced while playing.

To discover which genre of video game would create the most brain activity, different genres of video games effect on the brain's cognitive function needs to be investigated. This study examines how the genre of a video game influences the number of beta waves produced in the brain by measuring the EEG data of a subject playing three different genres of mobile video games. This study will prove that the horror genre produces the highest concentration of beta waves due to its increased user interface and complexities.

**Materials and Methods**

Gold cup electrodes (6) were placed on the subject's skull at the O1, O2, Fp1, Fp2, FpZ, and A1 positions. The BioRadio (Great Lakes Neurotechnologies, Cleveland, OH) was connected to the LabCourse software (Great Lakes Neurotechnologies, Cleveland, OH) and configured. A sampling rate of 500 Hz and a bandpass filter was turned on with a highpass cutoff of 30 Hz, a lowpass filter of 0.05 Hz, and a filter order of 4 for all trials. Wired headphones were used to hear audio from the mobile games. The subject was asked to relax with their eyes closed

while thirty seconds of EEG data was recorded in triplicate. *Subway Surfers* (SBYO, Copenhagen, Denmark) was played for three to five minutes and data was collected for thirty seconds in triplicate. This process was repeated for *Call of Duty Mobile* (Activision, Santa Monica, California) and *Granny* (Dvloper, Sweden). During data collection, the time of each point of interest was noted by hand. These points noted jumping in Subway Surfers, kills in Call of Duty, and jump scares in Granny. Data analysis and a Fast Fourier Transform were performed in Microsoft Excel.

**Results**

Filtered EEG channel data of each trial was plotted with respect to time in Figure 1. Points of interest were marked in the graph for each genre. The horror game contained EEG waves with amplitudes 14 times larger than the relaxed data at the point when the subject was startled. The first-person shooter had EEG waves 3 times larger than the relaxed data when the subject killed another player. The arcade game had EEG waves 4 times larger than the relaxed data when the subject jumped in the game. Some points of interest did not align with a corresponding spike in EEG data seen in Figure 2d.

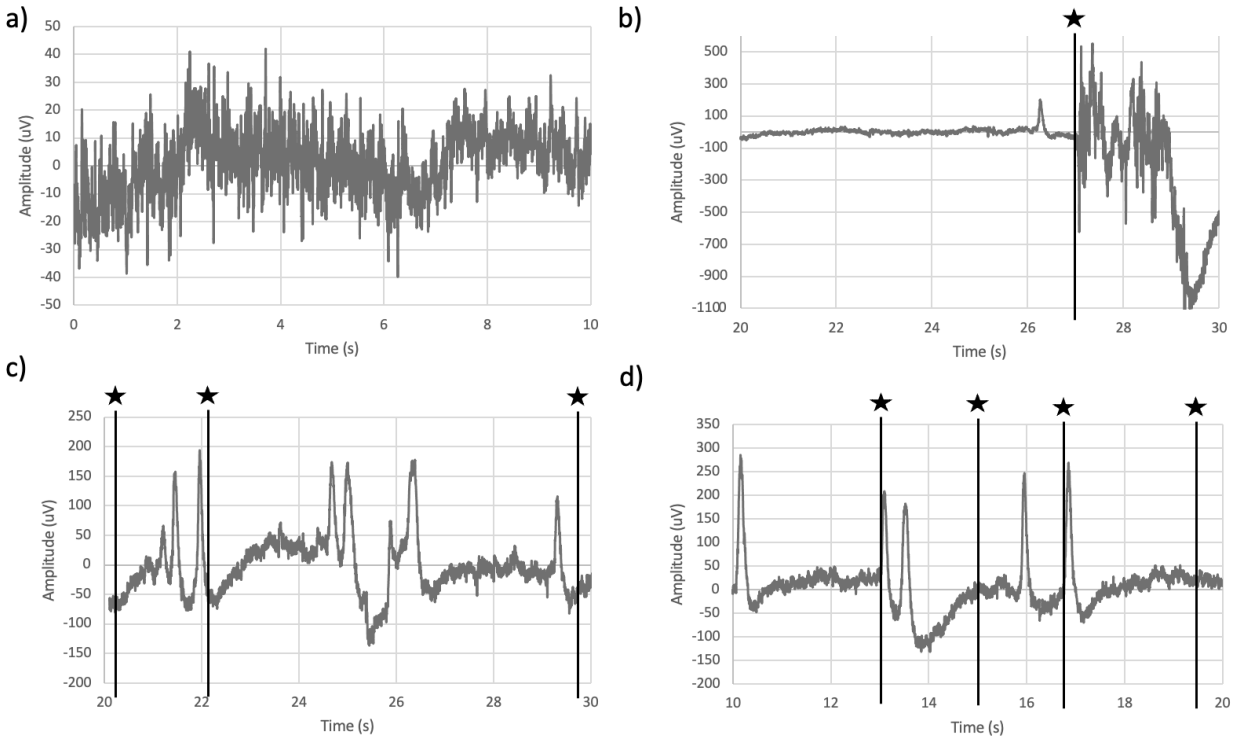


**Figure 1. EEG data of four genres of video games.** Graphs a, b, c, and d represent the filtered EEG channel data of the subject at rest, playing a horror, first-person shooter, and arcade game, respectively. Starred lines in graphs b, c, and d represent jumpscares, kills, and jumping, respectively.

Spectral analysis was conducted on the EEG data using a Fast Fourier Transformation (FFT) for one-second surrounding points of interest and plotted in Figure 2. Beta wave concentration for each graph was determined through the qualitative analysis of the area under the curve and the comparison of the most powerful beta waves. The horror game had the most beta wave concentration, especially around 13.5 Hz with a power reading of 1.2 $\mu V^2/Hz$. The first-person shooter game had the second most beta wave concentration which peaked at around 16.5 Hz with a power of 0.27 $\mu V^2/Hz$. The arcade game showed slightly greater beta wave concentration with a power of 0.12 $\mu V^2/Hz$ at 12.5Hz.

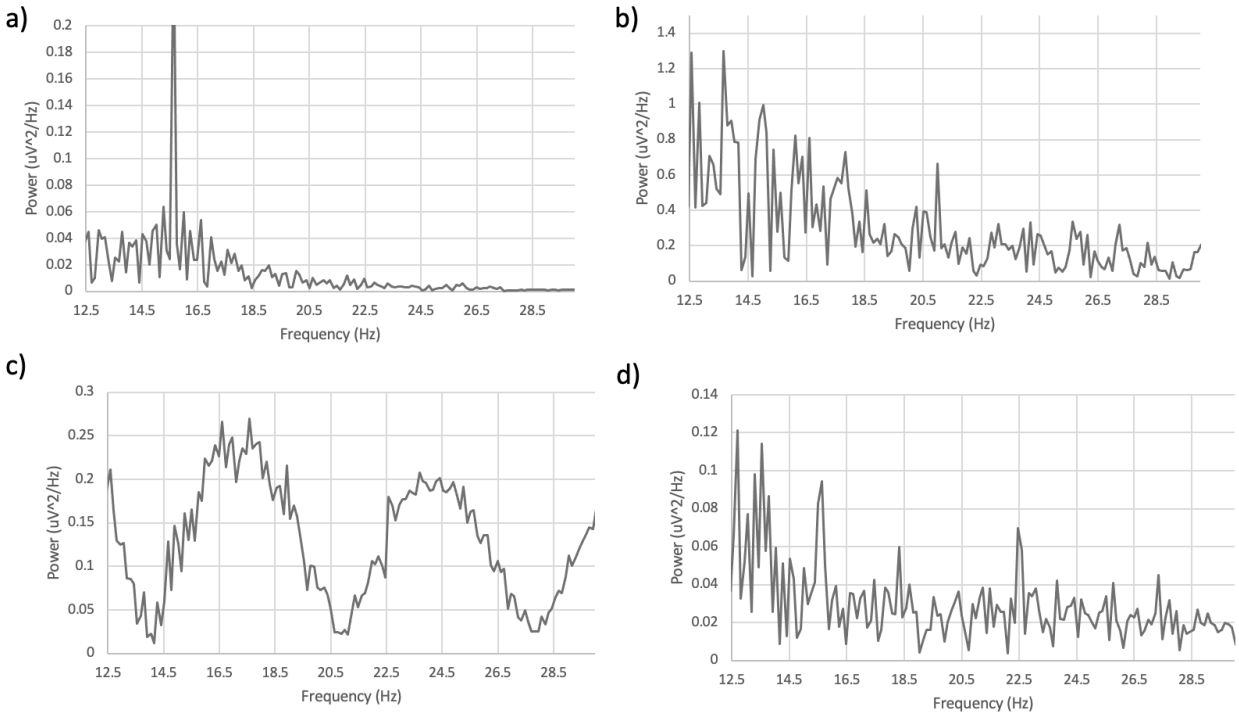


**Figure 2. Beta wave concentration of filtered EEG channel data.** Graphs a, b, c, and d represent the spectral analysis, in the beta wave range, of the subject at rest, playing a horror, first-person shooter, and arcade game, respectively. The spike in graph a at 15.5 Hz was an anomaly and not considered in the analysis.

**Conclusion**

Points of interest in Figure 1 associated with spikes in the amplitude should not be present since beta waves show lower amplitudes than relaxed alpha waves. These spikes are likely exaggerated motion artifacts that occurred whenever the subject made quick movements at these points such as being startled, seen in Figure 2b at the 27-second mark. Though these spikes in amplitude are not expected, they do not discredit the spectral analysis data but could be a possible source of error (Figure 2). It is noteworthy that points of interest did not always align with spikes of EEG data in Figure 1. Noise sources such as sniffling, blinking, and electrical

noise could be responsible for this amplitude increase. The slight misalignment of points of interest and EEG spikes may be due to human error because points of interest were manually noted as they happened.

The spectral analysis of the EEG data in Figure 2 shows that the horror genre produced the most beta waves in the subject's brain followed by the first-person shooter and the arcade genre. These beta waves were 20 times more powerful than the relaxed state. The horror genre most likely demonstrated the most beta wave concentration due to the higher stress associated with being in a state of fear. The increased state of fear and stress while playing the horror mobile game (Granny) results in higher focus and therefore more brain stimulation. The first-person shooter game showed 4 times more powerful beta waves than the relaxed state due to the visual stimulation and engaging controls of the game, especially at the moments when the subject killed another online player. The arcade-type game showed 2 times more powerful beta waves when compared to the relaxed data. The arcade-type game also had the least area under the curve compared to the relaxed data which suggests that the game requires the least amount of focus of the three genres in this study. This low concentration of beta waves could be explained due to the game's simple and monotonous motions, which could be relaxing to the subject.

This study determined which genre of video games, horror, first-person shooter, or arcade produces the most beta wave production in brain activity. As expected, results showed that horror games created the highest concentration and the most powerful beta waves and therefore the most brain stimulation in a subject, followed by first-person shooters, and arcade games. Since this study was only performed on three games, one of each genre, the strength of the results is limited and therefore does not indicate that this trend is the same for all games in a genre. Future studies could investigate more games and genres to obtain conclusive results on which type of

video game produces the most beta waves. The optimal time of video game consumption could also be investigated since prolonged beta wave stimulation may not be beneficial.

## References

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