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Mapping EEG Alpha Activity: Assessing Concentration Levels during Player Experience in Virtual Reality Video Games

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Abstract: This work presents a study in which the cognitive concentration levels of participants were evaluated using electroencephalogram (EEG) measures while they were playing three different categories of virtual reality (VR) video games: Challenging Puzzlers, Casual Games, and Exergames. Thirty-one voluntary participants between the ages of 17 and 35 were recruited. EEG data were processed to analyze the brain's electrical activity in the alpha band. The values of power spectral density (PSD) and individual alpha frequency (IAF) of each participant were compared to detect changes that could indicate a state of concentration. Additionally, frontal alpha asymmetry (FAA) between the left and right hemispheres of the brain was compared. The results showed that the Exergame category of video games elicited higher average cognitive concentration in players, as indicated by the IAF and FAA values. These findings contribute to understanding the cognitive effects of VR video games and their implications for designing and developing VR experiences to enhance cognitive abilities.

Keywords: alpha band; brain waves; electroencephalogram; frontal alpha asymmetry; individual alpha frequency; power spectral density; video games; virtual reality

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1. Introduction

Currently, video games are an application focused principally on entertainment, in which one or more persons can play using some controllers and, with this, have an experience through electronic devices, such as displays, television, computer, or console. Video games are almost everywhere and are important in our lives. They are used in hospital waiting rooms, waiting for the bus, on a plane, in the home, playing with friends, or with kids in a car.

The impact of video games and technology on human health, particularly in relation to calming emotions and improving concentration skills, has become an increasingly significant area of research [1]. This study, cited in [2], explores the potential benefits and drawbacks of video games and technological interventions in managing emotions and enhancing concentration abilities.

With many platforms to play and enjoy video games, the type of gamers also starts to differ. Some games only require a mobile device, console, or PC. With every single platform comes different types of games and gameplay. Moreover, it is imperative not to overlook an essential aspect inherent in any game—the playful element. This playful essence is engaged when a player competes and either wins or loses against another player or even the computer. Cooperative games have emerged as a novel way to play video games, where players form teams and compete against other teams or computer opponents [3–5]. This phenomenon has garnered widespread interest as it fosters connections among individuals, allowing the formation of gaming communities around the shared experience.

Worldwide, there are approximately 2.7 billion video gamers, as reported in 2020 [6]. Considering this, the game industry is bigger than the movie industry. As was already mentioned, games have a great community that conducts conferences and tournaments worldwide, including, of course, some online events. For years, video games have taken an important role in different areas, like education, health, cognition [7], memory treatments, and depression and anxiety treatments. In addition, a very important line of investigation is all the knowledge about the application of video games to health, knowledge, and some illnesses in which video games have had a good impact. Video games, often incorporating immersive virtual environments and interactive gameplay, have been found to have the potential to calm emotions and alleviate stress, as in work cited in [8]. Incorporating calming elements, such as soothing visuals, tranquil soundscapes, and gameplay mechanics that promote relaxation, can create a conducive environment for individuals to unwind and experience emotional relief [9].

Although video games and technological interventions hold potential benefits for human health, it is vital to acknowledge potential drawbacks, such as increased sedentary behavior, social isolation, and addiction-like behaviors, with excessive use [10]. Setting healthy boundaries and considering individual differences, like age and personality traits, is crucial for ensuring the effectiveness and suitability of technology-based interventions [11].

Virtual reality has an essential role in that it can be measured and compared, and proposed alternatives can be suggested to use this technology to see the results of some illnesses and cognitive problems [12]. Virtual reality is an image generated by a computer and shown through a helmet where any user can interact with the environment [13]. As with any device, it is also possible to interact with controls. One of the main characteristics of virtual reality is the immersive environment that the user can experience. Some studies [14–16] have demonstrated how people find activities in VR more fascinating than outdoor activities. This finding suggests that VR video games have the potential to positively influence people's mood and various cognitive abilities, such as reducing rumination and enhancing cognitive and attentional parameters. This enables developers to propose video games that offer both enjoyment and well-being during gameplay. However, the implications of the cognitive processes that occur while playing VR video games have been relatively under explored. Further research in this area could provide valuable insights into how VR gaming impacts cognitive functions, attention, and other psychological aspects. Understanding these effects will not only contribute to the development of more engaging and effective VR games but also help to harness the full potential of this technology for cognitive enhancement and well-being.

Various studies link cognitive activity to the power of electroencephalogram (EEG) [17–19]. In [18], brain activity during a working memory task in humans was investigated. The researchers found that gamma waves are associated with the maintenance of visual representations, whereas alpha waves reflect functional inhibition. Gamma activity was linked to the retention of facial orientation (dorsal stream), whereas alpha waves were observed during the retention of facial identities (ventral stream). In [19], alpha oscillations in EEG were explored, along with their relevance to cognitive, psychomotor, psychoemotional, and physiological aspects of human life. According to [20], alpha oscillations (8–12 Hz) play a critical role in selective attention, suppressing irrelevant information in different sensory systems. As reviewed in [21], studies on event-related potentials (ERPs) in attention-deficit/hyperactivity disorder (AD/HD) are examined. Additionally, the review recommends further research on temporal processing and integrating EEG and ERP measures in future studies.

The work in [22] investigates how video gaming experience affects the modulation of brain activity through brain–computer interfaces (BCIs). It was found that experienced gamers may exhibit enhanced sensorimotor learning and improved BCI control. However, the video gaming experience did not necessarily lead to a significant performance increase, but it resulted in faster learning for "hardcore" players.

Two exploratory studies exposed the effects of the MUSE neurofeedback device based on EEG in mindfulness-based relaxation activities [23]. No significant differences were found in heart rate variability (HRV) between the group that used the device and the unassisted relaxation group.

Study [24] investigated the effect of cognitive training on young and older adults using EEG. Although there were significant cognitive improvements, the individual alpha frequency (IAF) of the EEG did not change in either of the groups. The IAF is shown as a stable and relevant neurophysiological marker in [24,25]. Frontal alpha asymmetry (FAA) was addressed in [26,27]. The studies suggested that greater left frontal activity is related to sensitivity to behavioral activation, whereas the relationship with behavioral inhibition is complex and not fully explained by right frontal activity.

In this research, we analyze the level of cognitive concentration induced by three categories of VR video games. However, a direct comparison with previous studies is not possible due to various factors, such as limited access to EEG databases, different cognitive stimulation (as they do not study VR video games), distinct video game categories (non-VR), and the use of different EEG-based neurofeedback devices, among other reasons. Three representative metrics used in the state of the art were selected to address this. Specifically, the power spectral density (PSD) of alpha waves in the 8 to 12 Hz frequency range is utilized to analyze the state of relaxation and focused cognitive attention. The degree of cognitive concentration is derived by calculating the individual alpha frequency (IAF) and frontal alpha asymmetry (FAA). Based on the conducted experiments and obtained results, it is demonstrated that exergames within the VR video game category stimulate a higher level of cognitive concentration in players.

1.1. Motivation

Since the appearance of video games, there has always been good acceptance by those who play them. However, it is difficult to be well-accepted when studying video games as an alternative to concentration. This is usually because many video games are currently played with the aim of entertaining, compared to what is done in attention issues and cognitive skills.

We propose a list of different video games and their genres that people enjoy playing. With this, we seek to have evidence of the positive impact that video games generate in people who suffer from depression. A comprehensive series of tests was conducted using an electroencephalogram to thoroughly compare the various genres of video games and their acceptance in experiments. Through this process, we hope to understand better how these different video game genres impact people's concentration. By analyzing the data collected from these tests, we can better understand how video games can positively impact people.

For our experiment, we have chosen to exemplify the three types of video game genres: Challenging Puzzlers, Casual Games, and Exergames. We have selected one representative game from each category to showcase the unique characteristics of each genre. This will allow us to examine how each genre impacts a person's concentration. By analyzing and comparing the effects of these three genres, we hope to quantify the impact of video games on a person's concentration level.

1.2. Contribution and Article Structure

The realizations of the proposed algorithms and experiments mainly demonstrate that the described methodology is suitable for EEG data analysis. The contributions of this work can be summarized as follows:

(i) An appropriate methodology has been developed to collect EEG data while a player, whether experienced or inexperienced, participates in a virtual reality experience.
(ii) Modified IAF and FAA algorithms are proposed for obtaining average values based on EEG data.

These contributions highlight the effectiveness of the methodology and algorithms in studying the impact of VR experiences on brain activity.

The remaining sections of the article are organized as follows. Section 2 outlines the methodology employed in the study, including the choice of three categories of video games and the modified IAF and FAA algorithms used for EEG data analysis. Section 3 presents the realizations of the proposed algorithms and the corresponding statistical results for each evaluated experiment. In Section 4, the implications of the findings are discussed. Finally, Section 5 summarizes the key conclusions derived from this research.

2. Methodology

The research question aims to explore the impact of video games on human concentration and how video games can positively affect human mood conditions, focusing on concentration. The study involved 31 cases of young people who played three types of video games: Challenging Puzzlers, Casual Games, and Exergames. The research seeks to generalize the findings from these 31 cases to demonstrate the broader impact of video games on concentration among people.

The context establishes that video games are primarily intended for entertainment and provide interactive experiences through electronic devices. The origin of video games was in solving puzzles and challenges, and their application initially focused on studying and programming to play against machines. However, video games have become part of people's lives, used in various settings and with diverse gaming platforms.

Recent studies have shown an increasing interest in understanding the impact of video games on human health, particularly in relation to calming emotions and enhancing concentration skills. Researchers have explored the potential benefits and drawbacks of video games and technological interventions in managing emotions and cognitive abilities. Studies suggest [28] that video games, with their immersive virtual environments and interactive gameplay, can provide a form of relaxation and diversion from daily life stressors, contributing to emotional well-being and concentration.

Individual differences play a significant role in the impact of video games on human health. Factors such as age, personality traits, and pre-existing conditions can influence how individuals benefit from video games. Considering these factors when designing and implementing technology-based interventions is essential to ensure their effectiveness and suitability for different populations.

Virtual reality (VR) has emerged as an essential tool in measuring and comparing the results of illnesses and cognitive problems. VR offers an immersive environment that allows users to interact with the virtual world, making it a valuable instrument for studying human capabilities. Exergaming, a concept combining gameplay and exercise within a virtual environment, has shown promising results in enhancing mood and cognitive abilities. The support of technologies like computational electroencephalograms and brain-computer interfaces integrated into video games provides convincing feedback and opens up opportunities for developing games that promote a sense of well-being during gameplay.

In this research, our primary objective is to clarify the differential impact of specific video game genres, as assessed by existing classifications, on individual concentration levels. Video games have garnered attention for their potential to influence mood regulation and attitude and even foster physical activity, making them an intriguing subject of scientific inquiry with broad implications for human well-being [29,30]. The investigation's central focus lies in understanding how these interactive digital experiences can serve as powerful enhancers of concentration, offering valuable insights for potential therapeutic or educational applications.

The research proposes analyzing the degree of cognitive concentration produced by the three categories of video games using EEG data analysis. Specifically, the power spectral density (PSD) of alpha waves in the frequency range of 8–12 Hz is used to assess the state of relaxation and focused cognitive attention. The individual alpha frequency (IAF) and frontal alpha asymmetry (FAA) are calculated to quantify the degree of cognitive concentration. Based on the experiments and results obtained, it is shown that exergames stimulate a higher cognitive concentration process in players compared to other game genres.

Therefore, our research sheds light on the potential positive impact of video games on human mood conditions, particularly in enhancing cognitive concentration. By analyzing the EEG data from participants engaged in gameplay, the study provides valuable insights into the role of video games in promoting emotional well-being and cognitive engagement. The findings can be generalized to demonstrate the broader impact of video games on human concentration, and the research opens up opportunities for further exploration of video game applications in various areas, such as education, health, and cognitive treatments.

The methodology consisted of two phases: the first phase involved explaining different video games, providing a video tutorial, and making necessary adjustments to use the VR headset. Brainwave data were recorded using electroencephalography while participants played video games during this phase. The second phase focused on analyzing the brainwave data to determine the concentration level exhibited during different categories of VR video games.

The first phase can be seen in Figure 1, where different video games are explained, along with a video tutorial for making all the adjustments needed to use the virtual reality headset. After all the necessary adjustments are made, the person starts playing the video games while their brainwave data are simultaneously recorded using an EEG (MUSE 2), as shown in Figure 2. The MUSE 2 is a headband designed for measuring EEG signals. These brain activity readings are transmitted wirelessly to a tablet through Bluetooth, enabling the data to be analyzed online or offline. The MUSE 2 headband has proven effective in capturing EEG data for activities like neurofeedback and brain-computer interfacing (BCI) sessions [23,31]. Participants try on the Meta Quest 2 and remove it to fit the EEG to their heads. Once the EEG signal is transmitted to the tablet, users put on the Meta Quest 2 again to begin the video game testing, as shown in Figure 3.

In this investigation, we focus on determining which category of virtual reality video games people exhibit higher concentration levels.

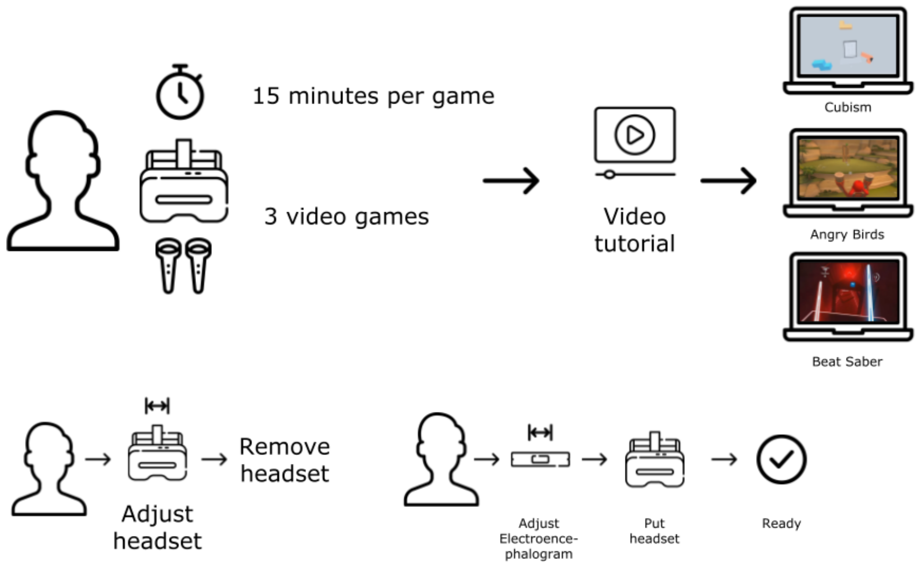

Figure 1. Preparation and adjustments to play video games in virtual reality.

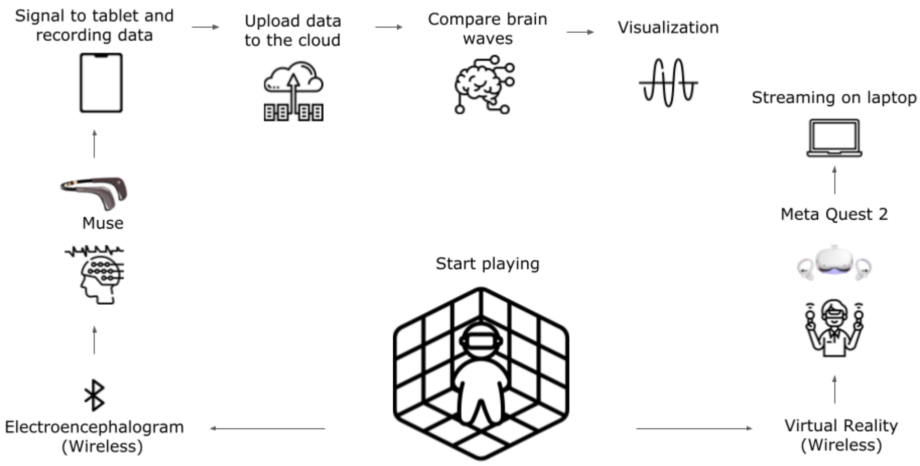

Figure 2. Analysis of brain waves during the gaming experience with videogames in virtual reality.

Figure 3. A user with the MUSE 2 and the Meta Quest 2 playing a VR video game.

2.1. Experimental Design

The aim is to conduct this experiment with male and female participants aged 17 to 35 who play three virtual reality video games: Cubism, Angry Birds, and Beat Saber. It does not matter if any user has had the chance to use a virtual reality headset. These three different video games are from three different genres. Cubism corresponds to Challenging Puzzlers, Angry Birds to Casual Games, and Beat Saber to Exergames. In the case of Challenging Puzzlers, as shown in Table 1, video games are designed to be difficult and require advanced problem-solving skills. These games often contain complex puzzles that require players to use their creativity to solve them. Casual Games are characterized by simple rules, short sessions, and a low learning curve. People of all ages and skill levels can enjoy those types of games. Finally, Exergames are video games that require physical activity. These games typically use motion sensors to track and translate player movement into gameplay.

Table 1. Characteristics and objectives.

	Classification		
	Challenging Puzzlers	**Casual Games**	**Exergames**
Characteristics	Challenging activities Enjoyable Playful work	Easy to play Attractive design Enjoyable	Physical activity Challenges Motivation
Objective	Education Training Concentration Absorption	Distraction Quick hitch	Calories burning Increase heart rate Coordination Attention

The video game Cubism is a virtual reality game developed by Thomas Van Bouwel and released on 17 September 2020 [32]. In this case, this game is a puzzle game where you assemble blocks in shapes that the game gives you. This video game is not open-source. Angry Birds is a game that first appeared on mobile platforms and now has a version in virtual reality. Resolution Games developed it, and the release date was 21 May 2019 [33]. In this video game, the user throws birds with a flinging slingshot with the hands to accomplish the game's objectives. The third video game, Beat Saber, is a virtual reality game that was developed by Beat Games and released on 21 May 2019 [34]. The players have to cut cubes following the line to cut them using two lightsabers as tools. It is important to note that this video game is not open-source and has some updates that cost money.

A total of 31 participants were recruited and informed for participation (18 females and 13 males, with an overall average age of 25.7 years). It was not necessary to have any experience using VR. Although eight of them have some experience in VR, none of the participants had played any of the experiment's video games before. All participants were typically recruited from the Universidad Panamericana Campus student population in Guadalajara, and all of them participated in the experiment voluntarily. Each video game has a 15-min session per participant. Each game has some particularities, as shown in Table 2. Cubism has calm music, the blocks have pastel color, and the video gamers can interact with the control or hands. The video game Angry Birds is a casual game where the player has to hit the pigs and destroy the platforms that appear. Beat saber has rhythmical music, and the video gamer interacts with the control as a saber with neon color and cuts cubes depending on the saber's color.

Table 2. Properties of video games.

	Video Games		
	1: Cubism	**2: Angry Birds**	**3: Beat Saber**
Properties of the game	Calm music Pastel color Use of control or hands Interaction with objects	Upbeat music Saturated color Use of control or hands Interaction with objects	Rhythmical music Neon colors Use of control Interaction with objects

2.2. Data Preparation and Evaluation

The EEG data are collected after each participant has completed a concentration test, as described in Figure 2, while playing each of the three virtual reality (VR) video games listed in Table 2. To measure the level of cognitive concentration elicited in each volunteer (player), based on the spectral power density (PSD) of the EEG, individual alpha frequency (IAF), and frontal alpha asymmetry (FAA), the following EEG data processing was conducted:

- Participants were outfitted with an EEG device during the games to measure the brain's electrical activity in different frequency bands, including the alpha band. EEG data were recorded at a sampling rate of 500 Hz for a period of 15 min. Each of the three games lasted 15 min, with a brief 5-min break between each. The games were chosen to provide a variety of difficulty levels, as well as different genres of games, to assess cognitive skills while playing.
- EEG data were processed to analyze the brain's electrical activity in different frequency bands, including the alpha band (8–12 Hz). PSD in the alpha band was compared to activity in the other frequency bands to measure concentration. PSD in the alpha band was calculated using the Welch method:

$$S_{xx}(f) = \frac{1}{N_{FFT} \cdot \Delta} \cdot \sum_{i=0}^{M-1} \frac{|X_i(f)|^2}{N_{avg}} \tag{1}$$

  where $S_{xx}(f)$ is the power spectral density at frequency f, N_{FFT} is the number of points used in the FFT, Δ is the time interval between overlapping signal segments, M is the total number of signal segments, $X_i(f)$ is the Fourier transform of the ith EEG signal segment, and N_{avg} is the number of segments averaged in the Welch method.
- The IAF of each participant was measured using a custom algorithm to detect the individual frequency of the alpha wave in the frequency spectrum of each participant. The computation of these average IAF values is described in detail in Algorithm 1. Alpha wave activity was analyzed at each participant's frequency to determine if any activity change could indicate a state of concentration.

Algorithm 1: Individual alpha frequency (IAF) algorithm

```
Input: Electroencephalogram (EEG) data;
Output: IAF
n_people = 31;
n_games = 3;
for person = 0 to n_people − 1 do
    for game = 0 to n_games − 1 do
        Load EEG data from file;
        eeg_data = "game[person][game].csv";
        Compute PSD using Welch's method;
        [freq, psd] = welch(eeg_data);
        Store PSD values in psd_data;
        psd_data[person][game] = psd;
        Define alpha frequency band;
        if (freq ≥ 8) and (freq ≤ 12) then
            Store individual alpha frequency (IAF);
            iaf_data[person][game] = argmax(psd_data[person][game]) ;
        end
    end
end
Compute mean IAF values across all persons for each game;
iaf_means = mean(iaf_data, axis = 0);
Find game index with highest average concentration according to IAF;
best_iaf_game = argmax(mean(iaf_means));
```

- To measure FAA, the alpha wave activity was recorded in electrodes in the left and right hemispheres of the brain, and the activity in both hemispheres was compared. The difference in alpha wave activity between the electrodes of the left and right hemispheres was calculated, and this difference was compared with the activity in the alpha band. More significant activity in the left hemisphere than in the right could indicate a concentration state. Algorithm 2 describes calculating the average FAA values for each video game using EEG data.

Algorithm 2: Frontal alpha asymmetry (FAA) algorithm

```
Input: Electroencephalogram (EEG) data;
Output: IAF
n_people = 31;
n_games = 3;
for person = 0 to n_people − 1 do
    for game = 0 to n_games − 1 do
        Load EEG data from file;
        eeg_data = "game[person][game].csv";
        Compute PSD using Welch's method;
        [freq, psd] = welch(eeg_data);
        Store PSD values in psd_data;
        psd_data[person][game] = psd;
        Define alpha frequency band;
        if (freq ≥ 8) and (freq ≤ 12) then
            Store Frontal Alpha Asymmetry (FAA);
            faa_l = mean (psd_data[1:end/2]);
            faa_r= mean(psd_data[end/2 + 1: end]);
            faa[person][game] = faa_l − faa_r ;
        end
    end
end
Compute mean FAA values across all persons for each game;
faa_means = mean(faa_data, axis = 0)
Find game index with highest average concentration according to FAA;
best_faa_game = argmax(mean(faa_means))
```

3. Results

The PSD was computed using the pwelch function in Python 3.11 to analyze the alpha waves of the EEG signals. Specifically, 4-s Hamming windows with a 50% overlap were employed. Subsequently, the PSD values within the frequency range of 8–12 Hz (commonly referred to as the alpha band) were extracted.

3.1. Experiment One

The resulting average PSDs for each video game are depicted in Figure 4. Notably, within the alpha band, it becomes evident that video games 1 and 3 exhibit a greater concentration of energy than video game 2. This finding suggests that video games 1 and 3 elicit higher levels of cognitive engagement among players. The average power of each PSD within the alpha band was calculated to obtain a more accurate metric than PSD. The results of the average power for each video game are shown in Figure 5. As expected from the data shown in the PSDs of the video games, the average power of video game 1 and 3 are very close. However, the highest recorded average power was for video game 1 at 30.78 mW/Hz. It is important to note that this metric takes into account the energy values of the PSD. Therefore, it cannot be solely concluded from this metric that video game 1 stimulates cognitive concentration more in players.

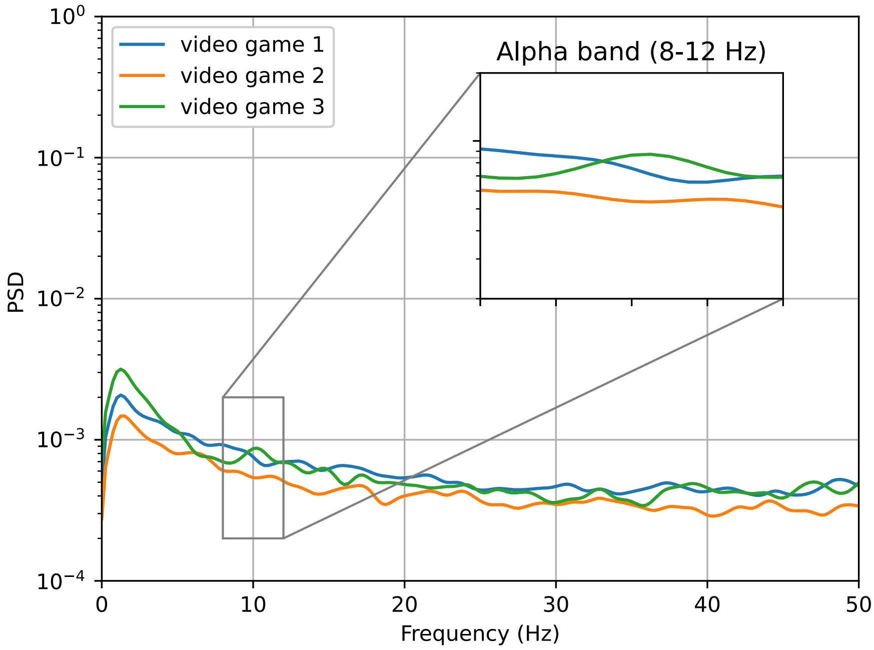

Figure 4. Comparison of the average PSDs per player for each video game.

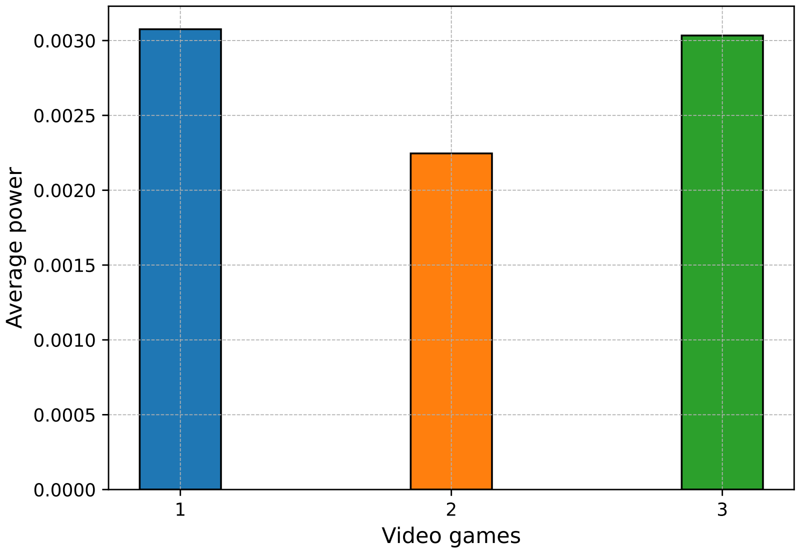

Figure 5. Comparison of the average power per player for each video game within the alpha band.

3.2. Experiment Two

Figure 6 presents a box and whisker plot that visually represents the average individual attention frontal (IAF) activity within the alpha band for players across each analyzed video game. Each video game is associated with a dataset consisting of the average IAF values of the players. The computation of these average IAF values is described in detail in Algorithm 1.

The whiskers in the plot, which are the vertical lines extending from the boxes, symbolize the minimum and maximum values of the IAF data. Any values beyond these whiskers are considered outliers and are depicted as individual data points in Figure 6. The red lines inside the boxes indicate the medians of each set of IAF values, representing the middle values in the distribution.

Upon examination of the plot, it becomes apparent that video game 3 exhibits a higher median than the other two games. This signifies a higher average concentration level within that specific game. The discrepancy in median values suggests that video game 3 potentially elicits a more pronounced impact on cognitive focus and attention when compared to the other video games analyzed.

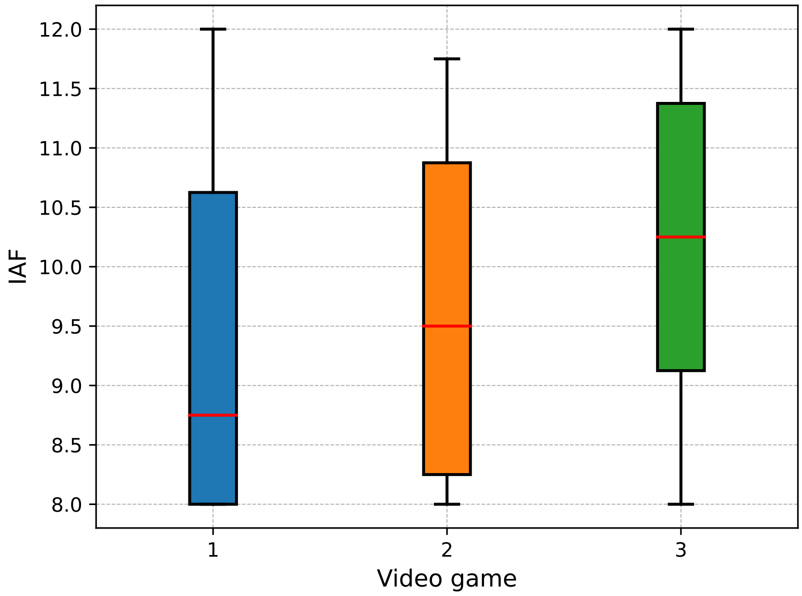

Figure 6. Box and whisker plot of the average individual attention frontal (IAF) per player for each video game within the alpha band.

3.3. Experiment Three

The box and whisker plot depicted in Figure 7 provides an overview of the distribution of average frontal alpha asymmetry (FAA) values for each video game under analysis. FAA is a metric for assessing the asymmetry of alpha band activity within the brain's frontal regions. By employing Algorithm 2, the average FAA values were calculated for each video game utilizing EEG data.

Notably, video game 3 exhibits the highest median FAA value of 4.29×10^{-3}, signifying a greater degree of average frontal alpha asymmetry than the other video games. This observation suggests that video game 3 fosters a heightened level of cognitive concentration among the players. By yielding an elevated average FAA among the players, video game 3 demonstrates its potential to engender a more profound impact on cognitive concentration.

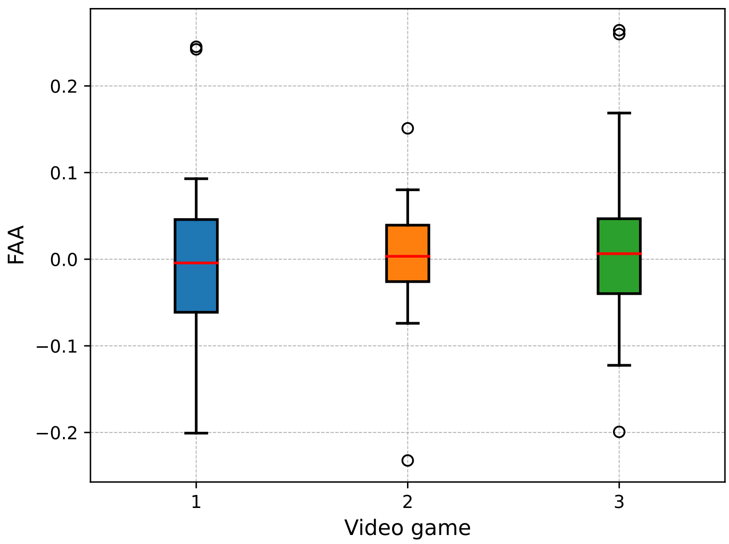

Figure 7. Box and whisker plot of the average frontal alpha asymmetry (FAA) per player for each video game within the alpha band.

4. Discussion

The collected EEG data were processed and analyzed. PSD in the alpha band was calculated using the Welch method, allowing for a comparison of alpha band activity with activity in other frequency bands. Additionally, the IAF of each participant was measured using a custom algorithm to detect their individual alpha wave frequency. The IAF values were used to assess changes in alpha wave activity, indicating concentration levels. The proposed IAF and FAA algorithms only process information from the alpha EEG waves. Although alpha waves are associated with certain mental states, such as relaxation or focused attention, the brain is a highly integrated system, and limiting the analysis solely to alpha waves may restrict a comprehensive understanding of cognitive functions and their relationship with other brain areas. For future work, if one desires to explore cognitive processes different from concentration, our proposed algorithms would not be able to provide results due to the lack of information from other EEG waves. Therefore, it is essential to consider incorporating data from other EEG waves or using more comprehensive algorithms to investigate a broader range of cognitive processes effectively.

Our observations during this research revealed that the Exergames category elicited the most significant level of participant concentration during the gaming session. This information acquisition holds significant value, demonstrating participants' ability to sustain focus and highlighting the simultaneous engagement in physical activity while playing. The convergence of attention and physical exertion within video games presents a substantial advantage, extending its potential benefits even to emotional aspects.

The experimental results have demonstrated a strong focus on the gameplay of Beat Saber. This finding holds significant implications for future research work. Furthermore, it is worth noting that the video game Beat Saber has earned widespread acclaim as one of the best virtual reality games ever released. It has received prestigious awards, including the Best Virtual Reality Game of 2019 and the Fan Favorite Virtual Reality Game of 2018, among others [34]. These accolades underscore the remarkable reception of Beat Saber among users, which correlates with our results as the Exergames category exhibits high levels of user concentration during gameplay.

5. Conclusions

Video games and technology have the potential to positively impact human health by calming emotions and improving concentration skills. By providing immersive and interactive experiences, video games offer a means of relaxation and emotional relief. Technological interventions, such as smartphone apps and VR experiences, provide platforms for enhancing concentration abilities. However, it is crucial to maintain a balanced approach to technology use and consider individual differences to maximize the benefits while minimizing potential drawbacks. Further research is warranted to explore the long-term effects, optimal usage patterns, and individual factors that contribute to the effectiveness of video games and technological interventions in promoting emotional well-being and concentration skills.

The results of this study provide valuable information about the relationship between concentration and electrical activity of the brain during the performance of cognitive tasks in a virtual reality environment. These findings may have important implications for developing VR technologies to enhance concentration and cognitive performance in work and educational environments. This research study provided valuable insights into the impact of VR video games on concentration levels. By recording and analyzing brainwave data, the study aimed to identify the category of VR video games that elicits higher concentration levels. Based on the average evaluated results from IAF and FAA, it was determined that the video game Beat Saber, belonging to the category of Exergames, produced the highest levels of concentration among players within the alpha band. The findings from this study can contribute to understanding how video games and VR technology can be utilized to enhance concentration skills and promote cognitive engagement.

6. Ethics Approval

Integrity Code of the Universidad Panamericana, validated by the Social Affairs Committee and approved by the Governing Council through resolution CR 98-22, on 15 November 2022.

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