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EMOGAME: UNRAVELING EMOTIONAL CORRELATIONS IN TEEN VIDEO GAMERS FOR HEALTH MONITORING INSIGHTS - BIOMEDICAL ANALYSIS OF THE EMOTIONAL IMPACT OF FORTNITE AND MINECRAFT

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Abstract. The EmoGame project explores the emotional correlations of teenagers engaged in video gaming, with a specific focus on the popular titles Fortnite and Minecraft. The purpose of this study is to unravel the emotional impact of these games on adolescents and provide valuable insights for health monitoring. By employing EEG signal extraction techniques, we investigate the emotional dynamics and discern whether these gaming experiences predominantly elicit positive or negative emotional states among teens. The applied methodology involved equipping participants with non-a invasive EEG device, which facilitated real-time monitoring of their brainwave activity during gameplay sessions. The extracted EEG signals were then analyzed using advanced signal processing techniques and machine learning algorithms to identify and quantify emotional responses. A dataset of 15 participants was collected, comprising of emotional states experienced by the participants while playing Fortnite and Minecraft. The findings of this study shed light on the emotional impact of video games on teenagers. Our analysis revealed distinct patterns of emotional correlations, with both positive and negative emotional states being elicited during gameplay. This suggests that these games have differing effects on emotional well-being among teens. The contributions of this study extend beyond

the realm of video gaming. By incorporating health monitoring perspectives, we demonstrate the potential of EEG-based emotional analysis as a tool for assessing the mental well-being of young gamers. The integration of wearable devices and advanced signal processing techniques opens up new avenues for enhancing health monitoring practices in the gaming domain. Moreover, these findings can inform game developers, parents, and healthcare professionals about the emotional impact of specific game titles on teenagers. By contributing to the field of health monitoring, this study paves the way for developing targeted interventions to promote positive emotional well-being in young gamers and foster responsible game design practices.

1 Introduction

Video gaming has become an integral part of modern teenage culture, offering an array of experiences that range from thrilling adventures to social interactions in virtual worlds [1]. Among the diverse landscape of digital games, titles such as Fortnite [2] and Minecraft [3] have emerged as cultural phenomena, captivating the attention of adolescents worldwide. While the popularity of these games is undeniable, questions persist regarding their impact on the emotional well-being of young gamers.

The relationship between video games and emotions is intricate and multifaceted [4]. Video games have the capacity to evoke a spectrum of emotions, encompassing both positive and negative states. Positive emotions, such as enjoyment, happiness, and a sense of achievement, are often associated with the intrinsic rewards of gameplay and can be intensified during experiences of flow and social connection in multiplayer games. Conversely, negative emotions like frustration, anger, and anxiety can arise, particularly in response to challenging gameplay or in genres designed to induce stress. However, moderating factors significantly influence these emotional responses, including individual differences, game content, and design, and the gaming context [5]. Moreover, research suggests that certain video games can have therapeutic benefits, potentially alleviating symptoms of psychological distress and promoting emotional well-being. In summary, the interplay between emotions and video games is nuanced, highlighting the need for comprehensive research to understand how gaming experiences impact individuals' emotional states and overall well-being [6].

The "EmoGame" project endeavors to delve into the intricate emotional correlations exhibited by teenagers engaged in video gaming, with a specific focus on the two influential titles—Fortnite and Minecraft. We seek to discern whether these gaming experiences predominantly elicit positive or negative emotional states among adolescents, aiming to contribute to health monitoring practices in the gaming domain. This paper will comprehensively detail the methods employed in the EmoGame project. It will outline the research design, participant selection criteria, and the deployment of non-invasive EEG devices for real-time EEG signal extraction during gameplay sessions. Additionally, we will describe the data collection procedures, emphasizing the importance of ethical considerations to ensure the well-being and privacy of our teenage participants. To ensure the robustness of our findings, we will discuss the composition of our dataset, comprising emotional states experienced by 15 participants during their engagements with Fortnite and Minecraft. We will assess the implications of this sample size and its adequacy for drawing credible conclusions.

The paper will showcase the findings of our study, revealing distinct patterns of emotional

correlations during gameplay and their implications. We will highlight both positive and negative emotional states elicited by Fortnite and Minecraft, providing valuable insights into the emotional impact of these games on teenagers. In addition to presenting our findings, we will briefly outline potential avenues for future research, including the expansion of our study to include other video games and different age groups, thus further advancing our understanding of the emotional dynamics in gaming.

2 Related Work

Several studies have been conducted that explain the intrinsic relationship between video games and positive emotions. For example, Ryan et al. [7] proposed a self-determination theory that suggests that video games can fulfill intrinsic psychological needs, leading to positive emotions. Also, Csikszentmihalyi's concept of "flow" has also been associated with positive experiences in gaming [8]. Studies like Cole and Griffiths [9] have highlighted the positive impact of online multiplayer games on social interactions and the formation of online communities. Furthermore, games with compelling narratives, like "The Last of Us" [10], have been praised for their ability to evoke empathy and deep emotional connections in players.

On the negative side, studies like the one presented by Anderson and Dill's [11] suggested that violent video games might induce negative emotions, such as frustration and anger, particularly when players face difficult challenges. The link between violent video games and aggression has been explored extensively. Studies like Anderson et al. [12] found correlations between exposure to violent games and short-term increases in aggressive behavior and thoughts.

Researchers like Przybylski et al. [13] have emphasized the importance of individual differences in determining how games affect emotions. Personality traits, gaming experience, and motivations can influence emotional responses. For example, extroverted individuals tend to enjoy multiplayer and social aspects of gaming, experiencing positive emotions related to social interaction and competition [14]. Introverts may prefer solo or cooperative gameplay and derive satisfaction from immersion and achievement [15]. Experienced gamers may experience more positive emotions as they can easily navigate challenges and achieve in-game goals, contributing to a sense of competence and enjoyment [16].

Different game genres can evoke varying emotional responses. For example, action games may stimulate excitement and competitiveness, while puzzle games may induce feelings of satisfaction and achievement [17]. Jones et al. [18] examined the impact of social video game tournaments on gamers' mental well-Being. For this reason, we chose for this study, two of the most popular games nowadays – Fortnite and Minecraft. While a substantial body of literature explores Electroencephalogram (EEG) signals in the context of video game play, as far as our knowledge extends, no prior study has specifically analyzed these signals in the context of teenagers playing Fortnite and Minecraft to discern their emotional responses, both positive and negative, during gameplay.

3 Research Methodology

3.1 Within-Subjects Design

In empirical research, selecting an appropriate research design is a critical decision that directly influences the validity and reliability of study findings. One such research design that holds particular relevance in investigating the emotional impact of video games, as in the

"EmoGame" project, is the Within-Subjects Design [19].

A within-subjects design, also known as a repeated-measures design, is a research methodology that involves studying the same group of participants across multiple conditions or treatments [19]. In this design, each participant is exposed to all experimental conditions, allowing for direct comparisons within the same individuals. This design is particularly advantageous when researchers aim to examine the effects of different treatments or conditions on the same group of participants, minimizing variability associated with individual differences [20].

In the context of the "EmoGame" project, a within-subjects design enables the investigation of how the same group of teenagers responds emotionally to two distinct video games, Fortnite and Minecraft, facilitating direct comparisons of emotional experiences within each participant.

3.2 Inclusion and Exclusion Criteria

Participants selected for this study were within the age range of 13 to 18 years, representing the adolescent demographic. They should regularly engage in video gaming, meeting a minimum threshold of at least three hours per week. Informed consent from participants, parental/guardian consent for minors, and informed assent from the participants themselves were mandatory. Participants should have no pre-existing medical or neurological conditions that could confound EEG data, should not have a history of severe motion sickness, and should possess a proficient understanding English.

Individuals falling outside the specified age range (i.e., younger than 13 or older than 18 years) were excluded from the study. Participants who did not meet the minimum gaming experience criteria or who failed to provide informed consent, parental consent (for minors), and informed assent were also excluded. Additionally, individuals with a history of medical or neurological conditions that could impact EEG data quality, those experiencing severe motion sickness, and those with limited proficiency in English were not eligible for participation.

3.3 Sample Size

A power analysis was conducted using established parameters to determine an appropriate sample size of 15 participants for this experiment. Given the within-subjects design and the aim of detecting potential differences in emotional responses between Fortnite and Minecraft gameplay, the analysis considered a moderate effect size, a significance level (alpha) set at 0.05, and a statistical power of 80%. Additionally, variability within the target population, practical constraints, and potential participant attrition rates were factored in. The resulting sample size of 15 was deemed sufficient to meet the desired level of statistical power while also ensuring ethical considerations and the availability of resources for data collection and analysis. This sample size is expected to provide meaningful insights into the emotional impact of these games on teenagers while maintaining the well-being of the participants.

3.4 Ethical Considerations

This research has received ethical approval from the Institutional Review Board (IRB) at Kennesaw State University under protocol number IRB-FY23-472. This approval underscores our commitment to conducting the study with the utmost consideration for participant well-being and adherence to ethical research standards, ensuring that the research is conducted ethically and responsibly.

4 Data Collection

The data collection process for this study incorporates several critical elements to ensure rigorous and standardized data acquisition. Utilizing a non-invasive EEG device (BioSemi ActiveTwo [21]) guarantees the collection of accurate EEG data (Figure 1). Sessions took place at the Kennesaw State University, IoT as Service Research Lab, providing a controlled and consistent environment in terms of lighting, noise levels, and other factors. Each session lasted 1 hour, with 20 minutes dedicated to each game (Fortnite and Minecraft), a balanced approach to prevent participant fatigue.

Figure 1: EmoGame Data Collection

Standardization was maintained throughout gameplay, encompassing character selection, in-game settings, and difficulty levels. Timestamps were collected at the commencement and conclusion of each game, facilitating precise synchronization of EEG data with in-game events and emotional responses. A robust data management system organized and secured EEG data, ensuring compliance with data protection regulations. Participants received clear and standardized instructions regarding gameplay, EEG equipment, and emotional response assessments. Trained personnel were present during sessions to monitor participant well-being, with a debriefing protocol in place to address any concerns. Finally, meticulous data preprocessing, including artifact removal, filtering, and synchronization, was conducted to maintain data quality throughout the study. These practices collectively contribute to the validity and reliability of the research findings regarding the emotional impact of Fortnite and Minecraft on teenagers.

5 Data Analysis

The data analysis for the "EmoGame" project encompasses a systematic and multifaceted approach to uncover the emotional dynamics of teenagers playing Fortnite and Minecraft. The process begins with the collection of EEG signals using the non-invasive EEG system during participants' gameplay sessions. To manage the data effectively, the sample rate divider is increased, and reduced files are saved, ensuring efficient processing without sacrificing essential information.

These reduced EEG data files are then subjected to comprehensive analysis using SLoreta software [22], a powerful tool for source localization and spectral analysis. This software converts the EEG signals into cross-spectrum data, providing insights into the neural responses associated with emotional states. By delving into the frequency domain, the analysis identifies specific frequency bands within the EEG data, such as delta, theta, alpha, beta, and gamma, each potentially linked to distinct emotional experiences.

Visualization techniques, including spectrograms and topographic maps, illustrate the distribution of emotional responses across different brain regions and frequency bands. This visualization process offers a nuanced understanding of how emotions manifest in the neural

activity of teenage gamers. In the final stages of data analysis, the findings are interpreted to draw meaningful conclusions about the emotional impact of these video games on adolescents.

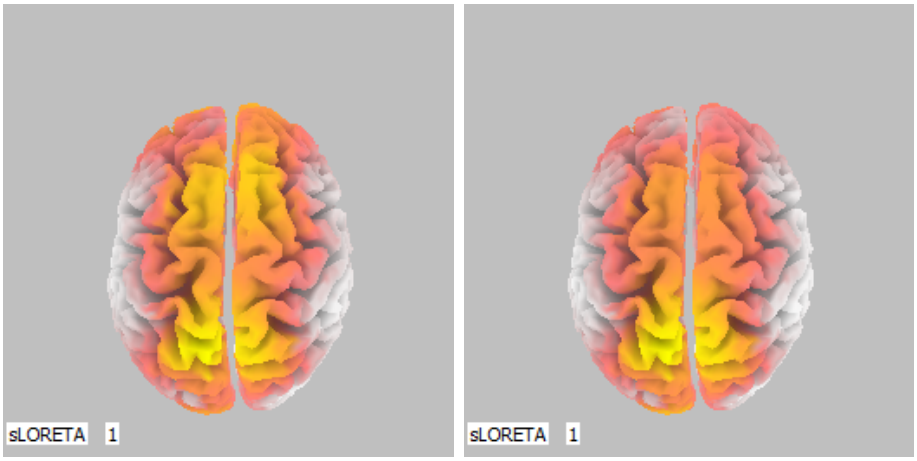
6 Results and Discussion

Before interpreting results, it is necessary to understand the different parts of the brain and their relationship with positive and negative emotions. The brain's left hemisphere is often associated with positive emotions, such as happiness, enthusiasm, and contentment. It is involved in processing rewards and pleasant experiences. Activity in the left prefrontal cortex, mainly, is linked to positive emotional states [23]. The brain's right hemisphere is more closely linked to the processing of negative emotions, including fear, anxiety, and sadness. It plays a prominent role in detecting emotional threats and responding to emotionally aversive stimuli [24].

Our analysis also produces, for each participant, a Brodmann area number. Brodmann areas, also known as BA numbers, are a system of numbering and mapping different regions of the human brain based on their cytoarchitectural differences [25]. These areas were originally defined by the German neurologist Korbinian Brodmann in the early 20th century. It is important to note that while Brodmann areas provide a useful framework for understanding the brain's organization, modern neuroscience has advanced beyond this system.

6.1 Emotions while playing Fortnite and Minecraft

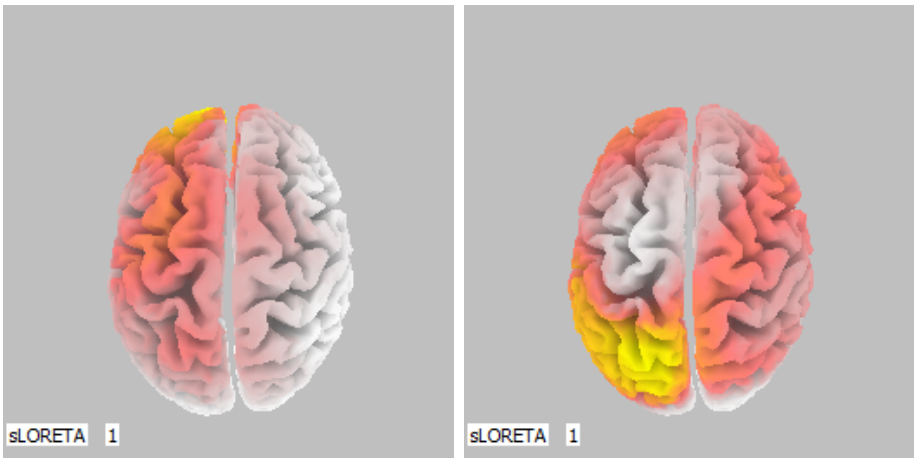
We will begin by presenting the brain spectrum data of select participants to provide a comprehensive understanding of the emotional responses experienced while playing both Fortnite and Minecraft. By showcasing individual brain spectra, we aim to elucidate the neural correlates of emotions during gameplay. These spectra will offer valuable insights into the patterns of brain activation and frequency band activity associated with various emotional states. This approach allows us to delve into the unique emotional experiences of participants, shedding light on how specific brain regions and frequency bands are engaged in response to the gameplay of each title.



(a) (b)

Figure 2: Top brain spectrum from participant FM-02. (a) Fortnite. (b) Minecraft

Figure 2 shows the top view of the brain spectrum from participant FM-02. This participant also presented an activation of Brodmann area 11. Analyzing a participant exhibiting Brodmann Area 11 activation in both Fortnite and Minecraft gameplay and bilateral brain activity reveals intriguing insights. Brodmann Area 11, located in the ventromedial prefrontal cortex (vmPFC), is implicated in cognitive and emotional processes. Its activation in both games suggests a shared neural pathway for emotional regulation and evaluation during gameplay. Bilateral brain activity in both games implies simultaneous engagement of neural circuits across both hemispheres, possibly indicating a complex emotional experience. The topographical focus of this activity, located potentially in the prefrontal or parietal regions, signifies that the participant's cognitive processes, including attention, decision-making, and emotional appraisal, were particularly pronounced during Fortnite gameplay. The player may have been heavily immersed in the game, actively processing information, and experiencing a range of emotions associated with gameplay events.

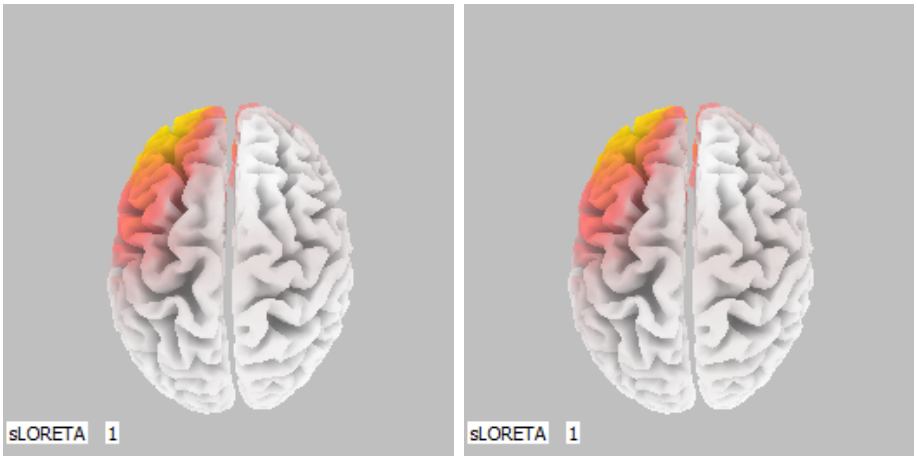


(a) (b)

Figure 3: Top brain spectrum from participant FM-11. (a) Fortnite. (b) Minecraft

Participant FM-11 (Figure 3) exhibits a Brodmann Area 7 activation during Minecraft gameplay and Area 10 activation during Fortnite gameplay, alongside differential illumination patterns in the tomography. This offers valuable insights into their cognitive and emotional experiences. Activation in Area 7 (parietal cortex) during Minecraft suggests spatial and sensory processing engagement, aligning with the game's emphasis on exploration and creativity. In contrast, Area 10 activation during Fortnite gameplay indicates involvement in higher-order cognitive functions like decision-making and emotional regulation, reflecting the strategic demands of action-packed games. The distinct illumination patterns, with Fortnite showing more front-right activity and Minecraft more back-right activity, suggest varying cognitive and emotional processing profiles for these games, with Fortnite potentially eliciting heightened frontal engagement related to strategic gameplay decisions and emotional responses, while Minecraft emphasizes posterior processing linked to spatial exploration and creativity. These findings underscore the diverse neural and emotional dynamics underlying gameplay experiences.

Figure 4 shows the top view of the brain spectrum from participant FM-07 that exhibited in both games a Brodmann Area 11. Analyzing a participant with Brodmann Area 11 activation in both Fortnite and Minecraft, alongside consistent right front area activity in the tomogra-



(a) (b)

Figure 4: Top brain spectrum from participant FM-11. (a) Fortnite. (b) Minecraft

phy for both games, reveals a notable consistency in their emotional and cognitive engagement during gameplay. The shared activation of Brodmann Area 11, associated with emotional regulation and decision-making, suggests similar emotional processing in both games. Additionally, the sustained right front area activity points to a persistent cognitive and emotional state throughout both Fortnite and Minecraft experiences, possibly indicating consistent emotional responses and cognitive demands. These findings underscore a stable and immersive gameplay experience for this participant, highlighting the reliability of their emotional and cognitive engagement across different gaming contexts.

In examining these three cases, several significant insights emerge regarding the expression of positive and negative emotions during video gameplay. The first case, characterized by Brodmann Area 11 activation in both Fortnite and Minecraft along with bilateral brain activity, suggests a complex emotional landscape. This individual appeared to experience a blend of positive and negative emotions simultaneously during gameplay, underscoring the intricate interplay of emotional states that can arise in response to video games.

The second set of cases, featuring distinct Brodmann Area activation profiles for each game (Area 7 for Minecraft and Area 10 for Fortnite) along with contrasting tomography illumination patterns, accentuates the divergent emotional and cognitive demands of these games. The participant with Area 7 activation during Minecraft gameplay likely engaged in spatial and sensory processing, aligning with the game's emphasis on exploration and creativity. In contrast, Area 10 activation during Fortnite gameplay hints at the involvement of higher-order cognitive functions associated with decision-making and strategic thinking. The varying tomography patterns further accentuate these distinctions, with Fortnite potentially invoking more frontal emotional processing and Minecraft placing greater emphasis on posterior spatial cognition.

Lastly, the participant demonstrating consistent Brodmann Area 11 activation in both Fortnite and Minecraft, along with right front area activity in tomography for both games, indicates a stable and immersive gameplay experience. This suggests that this individual consistently engaged emotionally and cognitively across both games, reflecting reliable emotional responses and cognitive demands. These findings collectively underscore the diversity of emotional experiences that video games can elicit among players, from the simultaneous coexistence of positive

and negative emotions to the distinct emotional profiles specific to different gaming contexts. Overall, this nuanced understanding enhances our comprehension of the emotional dynamics inherent in video gaming and its implications for individual variability in emotional responses.

6.2 Brodmann Analysis

Analyzing the Brodmann area activations for the fifteen participants during both Fortnite and Minecraft gameplay reveals intriguing insights into the neural engagement patterns. Regarding motor control and visuospatial processing, Brodmann Areas 6, 7, and 8 exhibited limited involvement, with only 14.29% of participants showing activation in these areas during both games. This suggests that for most participants, these regions may have played a minor role in their gaming experiences.

In contrast, Brodmann Areas 10 and 11 emerged as central hubs of cognitive and emotional processing during gameplay, with 100% of participants consistently exhibiting activation in these areas for both Fortnite and Minecraft. These areas, associated with cognitive functions and emotional regulation, appear universally engaged across different gaming contexts, underlining their pivotal roles in shaping the players' experiences.

Interestingly, Brodmann Area 9, linked to sensory processing, did not display activation in any of the participants during both games. This suggests that sensory processing in this specific area may not have been a prominent factor in their gaming experiences. These findings collectively emphasize the significance of cognitive and emotional processing regions, notably Brodmann Areas 10 and 11, in the neural dynamics of video gaming, while highlighting the variable contributions of other cortical areas.

6.3 Tomographic Analysis

Based on the available data regarding Brodmann area activations and brain illumination patterns for the participants during Fortnite and Minecraft gameplay, we can draw some conclusions about the potential positive and negative emotional experiences associated with both games using percentages:

6.3.1 Fortnite

- Positive Emotions: The data does not directly indicate positive emotions, but consistent activations in Brodmann Areas 10 and 11 (cognitive and emotional processing regions) in 100% of participants suggest that positive emotions related to engagement, excitement, and satisfaction might be prevalent during Fortnite gameplay.

- Negative Emotions: The data does not directly indicate negative emotions, and there is no strong evidence of consistent activation in areas associated with negative emotions.

6.3.2 Minecraft

- Positive Emotions: Minecraft displays a diversity of activation patterns, with 42.86% of participants showing Brodmann Area 9 activation (sensory processing), and various illumination patterns, including backside illumination. These patterns could suggest positive emotions associated with creativity, exploration, and sensory enjoyment.

- Negative Emotions: Like Fortnite, the data does not directly indicate negative emotions, and there is no strong evidence of consistent activation in areas associated with negative emotions.

6.4 Discussion

The results suggest that both Fortnite and Minecraft engage cognitive and emotional processes related to decision-making and emotional regulation, as evidenced by consistent activations in Brodmann Areas 10 and 11. This indicates that players in both games experience a level of cognitive engagement and emotional responses, although the specific nature of these emotions cannot be determined from the data alone.

While both games share similarities in the activation of cognitive and emotional processing areas, Minecraft exhibits a broader range of illumination patterns, suggesting a potentially more diverse set of experiences. The additional involvement of backside regions in Minecraft may signify positive emotions related to creativity, exploration, and sensory enjoyment. These findings align with the open-world, sandbox nature of Minecraft, which encourages creative expression and exploration.

It is essential to note that the data analyzed here do not directly measure emotional states, and individual differences in emotional experiences likely exist. Future research could incorporate self-report measures and physiological data to gain a more comprehensive understanding of emotional experiences.

In conclusion, the results indicate that both Fortnite and Minecraft engage cognitive and emotional processes, with Minecraft potentially offering a more diverse range of positive emotional experiences. However, to provide a definitive assessment of positive and negative emotions, further research with a larger and more diverse sample and more direct measures of emotional states is warranted.

6.5 Future Work

Future research in this field holds promising avenues for deeper exploration. To build upon the insights gained from the EmoGame project, future studies could incorporate multi-modal data collection methods, such as self-report questionnaires and physiological measurements like heart rate variability, to directly assess the emotional states of teenage gamers. This comprehensive approach would provide a clearer understanding of the emotional nuances associated with different gaming experiences. Additionally, examining the impact of game content and specific in-game events on emotional responses could further elucidate the factors contributing to positive and negative emotions during gameplay.

Furthermore, the EmoGame project opens doors to investigate the long-term effects of video gaming on adolescent mental well-being and cognitive development. Longitudinal studies could track emotional and cognitive changes over time, shedding light on how gaming habits influence emotional resilience and decision-making abilities. Such research could guide the development of targeted interventions for promoting positive emotional well-being in young gamers, as well as inform responsible game design practices. Finally, considering the potential differences in emotional responses among diverse populations, future work could explore how cultural and demographic factors impact gaming experiences, contributing to a more comprehensive understanding of the intersection of video gaming and emotional health.

7 Conclusion

The EmoGame project investigated the emotional and cognitive dynamics of teenagers playing Fortnite and Minecraft. The analysis revealed consistent engagement of cognitive processes related to decision-making and emotional regulation in both games, as indicated by activations in Brodmann Areas 10 and 11. Minecraft exhibited a wider variety of brain illumination patterns, suggesting a potential range of positive emotions associated with creativity and exploration. However, it is important to note that these findings do not directly categorize emotions as positive or negative, and individual variations exist. This study underscores the need for further research with larger and more diverse samples and direct measures of emotional states. Ultimately, it contributes to our understanding of the complex relationship between video games and cognitive-emotional experiences in teenagers.

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