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Exploring the Link Between Emotional Arousal and Player Skill in Video Gaming Using Electrodermal Activity

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ABSTRACT

Video games provide a high-octane competitive sports platform where players with diverse skills engage in tasks that require precise control of cognitive skills and emotional responses. Electrodermal activity (EDA) is a portable, non-invasive, and wearable physiological activity sensing modality that captures correlates of emotional responses. In this exploratory study, we analyzed the EDA skin conductance data that we collected from healthy adult participants over their left index and middle fingers, while they were playing a first-person shooter video game. Participants played solo against easy and hard AI opponents, where the objective was to either escort a truck to its destination or prevent the truck from being escorted to win the game. The in-game behavioral performance results showed that, as expected, novice players struggled with the game more than experienced players: novices had fewer kills, died more, and finished the scenarios slower. Furthermore, EDA skin conductance results showed that experienced players showed significantly higher electrodermal activity than novice players while playing the game, both in the context of the phasic and tonic activity.

Keywords: Electrodermal activity, Emotional arousal, E-sports, Video gaming, Player skill

INTRODUCTION

Emotions play an influential role in our everyday lives, as it guides people's thoughts and behaviors, affecting cases such as social behavior, decision-making, and hand-eye coordination (Andrade and Ariely, 2009, Trampe et al., 2015, Sin and Prasetia, 2021). This also applies in interactive and competitive environments such as e-sports, where competitors' cognitive decisions and in-game execution throughout the game have a drastic impact on the game's outcome (Jerčić et al., 2012). Since emotions can affect gamers' decision-making and in-game performance, gaming research has begun to examine the effects of emotion on performance via self-reported questionnaires or physiological measures (Hughes and Jorda, 2021, Kou and Gui, 2020, Behnke et al., 2020, Poulus et al., 2020, Holm et al., 2021, Passalacqua et al., 2020). Even then, additional empirical work needs to be conducted to expand our understanding regarding the emotional behavior of players of different skill levels in video gaming environments.

As a method to expand this knowledge, electrodermal activity (EDA) can be utilized. EDA is a portable, non-invasive method that measures the electrical properties of the skin, commonly in the form of skin resistance or skin conductance (Topoglu et al., 2020). EDA shifts occur due to the activity over the eccrine sweat glands, which are regulated by the autonomic nervous system (ANS) (Boucsein, 2012). Because of its relationship with the ANS, EDA is utilized as an indicator for emotional responses such as arousal, nervousness, or fear (Dawson et al., 2017). In our recent studies EDA, we have also demonstrated the integration of EDA with electroencephalogram (EEG) (Sargent et al., 2020b) and functional near-infrared spectroscopy (fNIRS) wearable neuroimaging (Watson et al., 2019, Sargent et al., 2020a).

In this study, we aim to assess the relationship between player skill and their emotional arousal. We have utilized participants' EDA data recorded while playing the first-person shooter video game 'Overwatch' in short, controlled scenarios of easy and difficult conditions. We hypothesized that novice players will show worse in-game performance than experienced players since they have less knowledge about how to play the game. Also, from the perspective of EDA, experienced players will have more electrodermal activity than novices, as previous literature shows that people with expertise in a task try to anticipate and react to "hazards" more than novices (Chirles et al., 2021, Kinnear et al., 2013).

METHODS

Participants

A total of 10 healthy adult participants (5 novices, mean age = 22.44) volunteered for this study, and data collection is still ongoing. All participants had the requirements of being right-handed with vision correctable to 20/20. Before the study, participants filled and signed the consent form approved by the Institutional Review Board of Drexel University.

Experiment Protocol

The study was performed over a single session, and participants sat in front of a computer, played Overwatch, a first-person shooter (FPS) game made by Activision-Blizzard (Santa Monica, CA, www.activisionblizzard.com). Before the session, participants filled out background forms to classify whether they were a novice or experienced regarding playing the video game.

In the experiment, participants played Overwatch individually in 'Escort Mode' (shown in Figure 1a and 1b), which is a game mode consisting of two

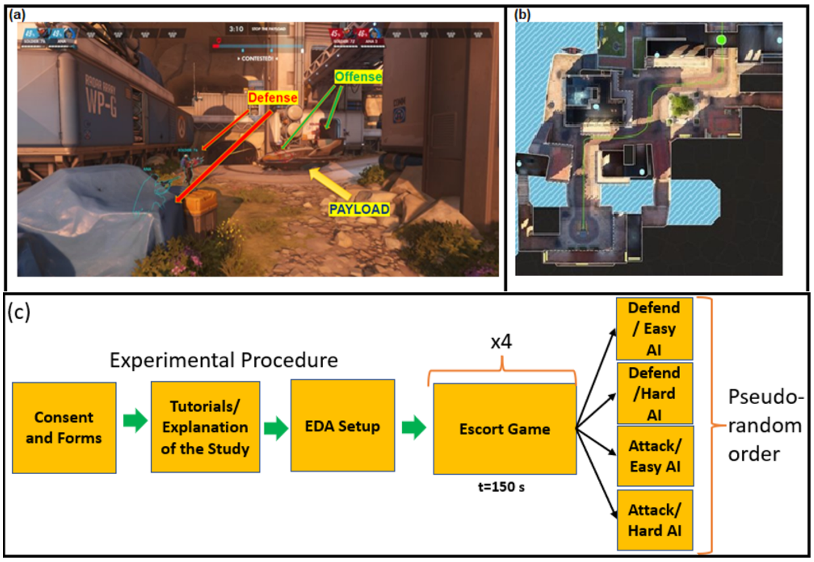

Figure 1: (a) An example snapshot of the Escort Mode, where the attacking team transports the 'payload' by standing close to it while defending team tries to prevent the attacking team escort the 'payload'. (b) The map for the game scenarios. The green line represents the payload's path, green dot represents the destination. (c) Overall experimental procedure in order.

teams where the attacking team needed to escort a 'payload truck' from a specific point to another to win the game, while the defending team tried to prevent the truck from being escorted to its destination within a time limit. Each trial had a time limit of 150 seconds, the game ended either when the timer expired, or the payload had been successfully escorted to the final point. As seen in Figure 1c, after form completions, the explanation of the study with tutorials, and setting up the EDA sensor, participants played the 'Escort' scenario singly in either attacking or defending scenario twice each in a pseudorandomized order, either playing against 2 easy or 2 hard AI opponents. Hard AI dealt more damage to the players compared to easy AI while taking less damage from them.

Data Acquisition, Signal Processing, and Analysis

Throughout the experiment, participants' skin conductance was recorded at a sampling rate of 128 Hz in the unit of microSiemens via the Shimmer GSR+ Unit (Shimmer Sensing, www.shimmersensing.com), a portable and wireless EDA sensor by being placed on the participants' left index and middle fingers. The time blocks where the participants played the game in different scenarios were synchronized using custom MATLAB scripts. Using these synchronized blocks, EDA data was processed via Ledalab, an open-source MATLAB toolbox designed for EDA analysis (Benedek and Kaernbach, 2010a). As for the pre-processing procedure, EDA data was filtered with a zero-phase 2nd order Butterworth low-pass filter with 0.5 Hz cut-off frequency for pre-processing to reduce the high-frequency noise. After low-pass filtering, the continuous

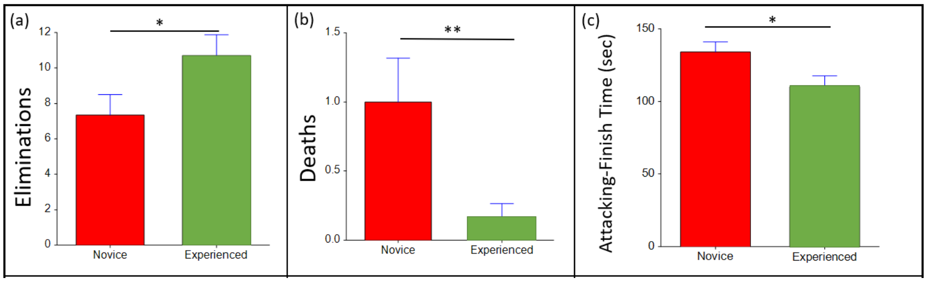

Figure 2: Overall results for the in-game performance stats. Experts have significantly (a) more eliminations and (b) fewer deaths than novices. (c) Experts finish the Attacking scenario in less time than novices. *p<0.05, **p<0.01. Whiskers are SEM.

decomposition analysis method, which uses nonnegative deconvolution to separate the components of EDA data designed by Benedek and Kaernbach (Benedek and Kaernbach, 2010b), was applied to separate EDA data into two different components: phasic and tonic activity. Average event-related phasic component (a.k.a. skin conductance response (SCR), which is the small but fast fluctuations as a reaction to an event) and tonic component (a.k.a. skin conductance level (SCL), slower but bigger changes) of EDA data over the time blocks where the participants played each scenario were extracted as a feature. For statistical analysis, linear mixed models are used via NCSS software, with the player skill and scenario difficulty fixed factors.

RESULTS

In-Game Performance Measures

For the behavioral results, we examined the in-game performance measures such as the number of eliminations (kills and assists combined) and deaths for each participant in each scenario, alongside finishing time while participants played the Attacking scenario. In the case of in-game performance measures, as shown in Figure 2a, our results show that experienced players had significantly more eliminations ($F_{(1,42)} = 4.10$, $p = 0.049^{*}$) than novice players. Experts also died significantly fewer than novices across all trials ($F_{(1,42)} = 7.34$, $p < 0.01^{**}$), shown in Figure 2b. Furthermore, experts finished the Attacking scenarios in significantly less time than novices ($F_{(1,42)} = 5.40$, $p = 0.03^{*}$) (Figure 2c).

EDA Results

For EDA data, we have compared the average event-related skin conductance responses and skin conductance levels for experienced and novice players across all trials. The game difficulty was not a significant factor in neither the average SCR nor SCL, along with the main interaction between game difficulty and player skill. However, seen in Figure 3a, there was a significant difference between the Novice and Experienced group across all scenarios, experienced group having significantly more electrodermal activity than the novice players ($F_{(1,42)} = 10.33$, $p < 0.01^{**}$). In terms of tonic activity, the

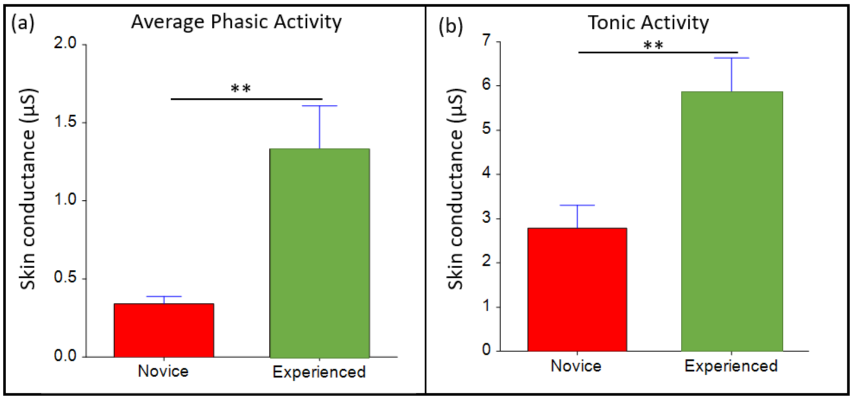

Figure 3: Average event-related skin conductance response of the participants when they played the game. Experienced players have significantly higher EDA (a) phasic activity and (b) tonic activity than novices across all trials. **p<0.01, Whiskers are SEM.

trend in phasic activity also followed the skin conductance levels, experienced players having significantly more tonic activity than novice players ($F_{(1,42)}$ $=8.96$, $p < 0.01$**), as shown in Figure 3b.

DISCUSSION

In this study, our goal was to demonstrate EDA as a tool to assess the relationship between player skill and their emotional response. We hypothesized that novice players would have worse in-game performance than the expert players, and experts' EDA activity would be higher than novice players due to being more attentive in-game. Our first hypothesis was consistent with our results since experts killed more opponents, died fewer times, and finished the scenarios in a shorter amount of time than novice players. This shows that novice participants struggled more while playing the game compared to experienced players. In the case of electrodermal activity, our EDA results also show consistency with our second hypothesis. Our EDA results showed that experienced players showed significantly more electrodermal activity than novices, showing more emotional arousal. The reasons could be that experienced players are more likely to be prepared for different scenarios and situations in the video game than novices, hence they are more prone to anticipate and perceive hazardous situations to appropriately react to them, similar to other cognitive tasks such as driving (Chirles et al., 2021, Kinnear et al., 2013) and air traffic control tasks (Lanini-Maggi and Fabrikant, 2014). In addition, we did not find any significant difference between easy and hard difficulties in EDA, which is also similar to the results in previous literature (Drachen et al., 2010, Kneer et al., 2016).

There are a couple of limitations to this study. The first limitation is that we only used Overwatch, a first-person shooter, as the video game for the assessment. Games from diverse genres (MOBAs, fighting games, real-time strategy games, etc.) may have different impacts on the features examined in this study. The second limitation is that we had a relatively small sample size (10 participants). Future studies with larger participant cohorts could investigate the effect between group conditions with better precision.

In summary, we used EDA alongside behavioral measures to evaluate the connection between player's skill and their emotional arousal in a video gaming environment. As expected, the findings show that experienced players performed better and faster in-game than novice players behaviorally. In the context of EDA, experts also show more emotional arousal than novices, due to the "anticipatory period" for dangerous situations. Despite the limitations, this preliminary study is a promising step towards demonstrating EDA as an objective measurement tool to provide valuable information about gamers' emotional arousal, which can be beneficial in understanding gamers' emotional responses in video gaming environments. A better understanding of the biomarkers related to emotional responses during video gameplay can be used in the training of e-sports athletes and optimization of new game development.

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