# The role of game preferences on arousal state when playing first-person shooters

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**Abstract.** Several player typologies have emerged as a result of needing to understand the role of personal preferences when selecting and playing games. However, experimental investigations into whether these preferences affect psychophysiological responses when playing have been scarce. In this study, two groups of active gamers (N=24) played and watched a gameplay video of a first-person shooter game. The two groups consisted of players who either preferred or disliked game dynamics prominent in first-person shooter games, such as killing and shooting. While playing and watching, the participants' electrodermal activity and heart rate were monitored as indexes of autonomic arousal. The results suggest that playing preferences and autonomic arousal are related. Those who preferred the content showed a stable arousal state across time when playing, whereas those who disliked the content showed a rising tendency in autonomic arousal state. The effects were similar when participants were watching a video of gameplay.

**Keywords:** Player Types, Preferences, Arousal.

## 1 Introduction

Changes in electrodermal activity (EDA) and heart rate (HR) indicate arousal of the nervous system [1, 2]. Because EDA and HR are relatively easy to measure while participants are playing without interrupting them, there is a growing body of research about electrodermal activity and heart rate during playing [3, 4, 5, 6]. So far, however, there are no studies on the differences in EDA and HR activity between player groups with differing preferences for game dynamics.

Players are known to have preferences for game contents: several player typologies and player trait models that use game dynamics as their components have been identified [7, 8, 9]. Game dynamics, that is player-game interactions such as dancing, killing, or taking care of pets, seem to divide people [9, 10] and may therefore influence how a game is experienced.

Even though player typologies have been formed, there have been hardly any attempts to experimentally validate any of these player types. Instead, the most ambitious validation efforts have so far focused on whether there are overlaps between different player categorizations [11] or whether gaming preferences predict game choice [12].

Tondello, Mora, and Nacke [13] have also explored whether different player types have particular preferences for certain gameful design elements. To our knowledge, no studies have focused on whether player typologies are in line with emotional responses during actual playing, i.e. whether players react accordingly to their player type when confronted with game material that is in line or discordant with their preferences. In other words, it is unclear whether self-reported likes and dislikes for certain game contents actually make a difference when playing, or whether they are just abstract self-conceptualizations.

In this study, we focus on first-person shooter games. These types of games are filled with "assault dynamics" [9] such as wrecking, crushing, destroying, and blowing things up; killing and murdering; shooting enemies and avoiding enemy fire; surprising an opponent or enemy by sneaking, et cetera [9]. According to Vahlo et al. [9], assault dynamics tended to divide participants quite strongly. First-person shooter games corporate mostly assault dynamics and little else, which makes them a preferable choice for a game for this purpose compared to other types of games that tend to have a mix of several types of dynamics. These types of games are also particularly suitable to study psychophysiological effects because they are likely to be visceral enough to generate strong emotions [14]. Arousal related to emotional reactions can be detected with electrophysiological evaluation methods, such as heart rate and electrodermal activity.

The present aim was to further explore the association between gaming preferences and physiological arousal in terms of EDA and HR measurements. We formed the following research questions: RQ1. Does physiological arousal to a violent videogame and a gameplay video depend on game dynamics preferences? RQ2. Are there differences between videos and gameplay in how different individuals respond to them?

## 2 Method

### 2.1 Participants

Participants were recruited from an internet survey that focused on their preferred game dynamics, i.e. player-game interaction modes. The final dataset consisted of 24 participants (20 men, 4 women, Mage = 28.67, SDage = 6.18) who were all active videogamers.

Participants were invited to the laboratory experiment based on their preference for violent gaming dynamics. In order to create two matched groups, we created pairs of players with similar experience of playing but opposite preferences for violent dynamics: those who particularly preferred them and those who disliked them. For this division, we used an updated 50-item version of the Gameplay Activity Inventory (GAIN) [10] scale. More specifically, we used only items pertaining to dynamics associated with what could be termed as violent. The items included, for example: "Firing enemies and avoiding enemy fire in a high speed" and "Close-combat by using fighting techniques and by performing combo attacks". There were altogether 12 of these items. Participants were to rate how much their level of satisfaction depended on these game dynamics either based on their earlier experiences or on their experiences in trying a new game. Ratings were given on a 5-point Likert scale (1= Very Dissatisfying, 2 = Dissatisfying, 3 = Neither, 4 = Satisfying, 5 = Very Satisfying).

Based on the responses to the 12 items, the participants were divided into two groups: those who had a high preference for violent dynamics (n = 12, 3 women, $M_{age}$ = 28.58 years, $SD_{age}$ = 9.22 years) and those who had a low preference for violent dynamics (n = 12, 1 woman, $M_{age}$ = 28.75 years, $SD_{age}$ = 10.1 years). Those with a preference for violent dynamics played on average 15.67 hours weekly (SD = 9.2), and those with a low preference for violent dynamics played an average of 18.75 hours weekly (SD = 10.1).

### 2.2 Apparatus

The PlayStation 3 gaming console (Sony Computer Entertainment) attached to a 24” and 144 Hz screen (Benq XL2420Z) was used for gaming. The participants sat at a distance of 90 cm from the screen and the volume was kept on the same comfortable level for all the participants.

Biopac® MP150 (Biopac Systems, Inc., Santa Barbara, CA) with added EMG100C, GSR100C and PPG100C modules were used for data collection. The data was recorded using AcqKnowledge 4.4.0 software (Biopac Systems, Inc., Santa Barbara, CA).

Two different sets of electrodes were used for measuring electrodermal activity (EDA). For the first 14 participants, we used two 8 mm Ag/Ag-Cl electrodes that were attached to the participants’ right foot’s index and middle toe using wrap-around bands (Biopac TSD203). For the rest of the participants, recordings were made using two 4 mm electrodes that were attached to the participants’ right foot’s sole using tape. The electrodes were filled with isotonic gel (Biopac GEL 101). They were attached to the participants’ feet in order to keep their hands free for using a gaming pad and to decrease artefacts that might have resulted from pressure to the electrodes if they were attached to fingers. The EDA signal was relayed to the Biopac GSR100C module. The raw signal was amplified (gain = 5 $\mu\Omega$/V) and bandwith filtering was set between 0.5 to 1 Hz.

For recording heart rate, we used a photoplethysmogram (PPG) transducer (Biopac TSD200C) that was attached to the earlobe using a clip. The signal from the transducer was relayed to the PPG100C module and amplified (gain = 100). A bandwith filter was set between 0.5 and 10 Hz.

### 2.3 Materials

Call of Duty: Modern Warfare 2 (Activision, 2009) was chosen to represent a violent dynamics game. As a first person shooter (FPS) game it contains all of the game dynamics included in the participant selection criteria. Therefore we had reason to assume that the participants would react differently to the game based on their self-reported preferences for such game dynamics.

### 2.4 Design

The experiment followed a 2x2 design, in which there were 2 preference groups and 2 conditions (video watching and playing). The conditions of playing and watching were chosen because we wanted to make sure that it was the content instead of, for example, difficulty of the playing that generated the particular responses in the participants. Furthermore, we wanted to compare the overall effects of playing and video watching.

We used two different levels for both the video watching and the playing condition. For the video condition, we recorded two videos from the campaign mode of the game (levels A and B) of a player playing the same levels with the same frame rates and volume as in the playing condition. Level A was the mission “Team Player” and Level B the mission “Wolverines!”. Both videos were 6 minutes long and taken from the beginning of the mission without the intros. The playing and watching conditions were counterbalanced so that every other participant played level A and every other played level B. Likewise, every other participant watched a gameplay video of level A, and every other watched a video of level B. This was done to ensure that everyone was exposed to the same levels, either by playing or by watching. Every other player started by playing the level A and every other started by watching the video of level A. The same screen was used for both watching and playing conditions.

### 2.5 Procedure

Every participant completed a practice level before moving onto playing/watching. The practice level did not end before it was successfully completed, ensuring that the participant had enough practice of using the controls. After completing the practice level, the game automatically set a difficulty level appropriate for the participant. This difficulty level was used during the playing condition. This was done because half of the participants did not like assault dynamics and therefore were more likely to be inexperienced in playing first-person shooter games. We therefore had reason to assume that these players might get frustrated if the perceived difficulty was too high, and this frustration might affect the psychophysiological measures instead of the actual content.

The participants had a chance to play for 15 minutes, or less if they completed the level before that. However, data was only collected from the first six minutes of the playing condition, which was in accordance with the length of the video condition.

**Data preparation and processing.** The recorded data was processed using the AcqKnowledge 4.4.0 software (Biopac Systems, Inc., Santa Barbara, CA).

For EDA, we resampled the signal to 62.5 samples per second and then used median smoothing, with a median of 50 samples per second. A low pass filter of 1 Hz was utilized.

For the PPG signal, we removed the comb band stop frequency of 50 Hz and used the waveforms created by the PPG signal to measure heartbeat. For this, we used the “find rate” option of the software and inspected the data manually for artefacts. We then converted the signal to the “beats per minute” form provided by the software.

After processing the raw data, it was divided into one second epochs, each containing the mean values for the signals.

# 3 Results

## 3.1 Statistical analyses

Analyses were carried out with linear mixed-effects models (LMM) using the lme4 package [15] in the R statistical software (Version 3.3.2; R Core Team, 2016). Time, condition and preference group were entered as fixed effects. Time was centered, and condition (video vs. playing) as well as preference (liking or disliking violent dynamics) were contrast coded. Playing was coded as 1 and video watching as -1. The group with no preference for violent dynamics was coded as 1 and the violent dynamics preference group as -1. Participants and random slopes for condition were included in the models as random effects. Three-way interactions of time, condition and preference were further examined by computing model estimates at different levels of preference group.

Measures for both EDA and heart rate (HR) were log-transformed to normalize the data. The percentage of outliers removed from the data after using a criterion of 2.5 SD was .95% for EDA and .66% for HR. Descriptive statistics for both measures as a function of condition (playing vs. video) and preference group (preference for vs. dislike of violent dynamics) can be found in Table 1. Both models are reported in Tables 2 and 3. A threshold value of $t > 1.96$ was used for statistical significance.

**Table 1.** Means and Standard Deviations for each variable in each preference group.

| | Condition | | | |
|---|---|---|---|---|
| | Watching | | Playing | |
| | *M* | *SD* | *M* | *SD* |
| EDA (in μS) | | | | |
| Non-Violent Preference Group | 10.21 | 7.82 | 10.77 | 8.10 |
| Violent Preference Group | 11.43 | 6.46 | 11.69 | 6.12 |
| HR (in beats per minute) | | | | |
| Non-Violent Preference Group | 81.57 | 10.41 | 84.48 | 12.99 |
| Violent Preference Group | 80.25 | 15.58 | 80.31 | 16.23 |

## 3.2 Electrodermal activity (EDA)

For EDA, there was a main effect of time ($b = 4.79 \times 10\text{-}5$, 95% CI [$3.90 \times 10\text{-}5$, $5.67 \times 10\text{-}5$], $t = 10.55$), indicating that participants had an overall rising tendency in electrodermal activity – i.e. as the watching or playing progressed, their electrodermal activity increased. There was also a main effect of condition ($b = 2.42 \times 10\text{-}2$, 95% CI [$6.92 \times 10\text{-}3$, 0.04], $t = 2.75$), signaling that playing generated higher electrodermal activity than watching a video.

As for interaction effects, we found an interaction between time and preference (b = 4.29 × 10-5, 95% CI [3.40 × 10-5, 5.18 × 10-5], t = 9.45), indicating that the player groups' EDA state developed differently during the course of the experiment. When compared to players who liked violent dynamics, players with a dislike had a steeper increase in electrodermal activity across time, as seen in Fig. 1. There was also an interaction between time and condition (b = -2.16 × 10-5, 95% CI [-3.05 × 10-5, -1.27 × 10-5], t = -4.77), showing that there was a steeper increase in EDA in the watching than the playing condition. However, there was a three-way interaction between time, preference and condition (b = -8.97 × 10-6, 95% CI [-1.79 × 10-5, -7.80 × 10-8], t = -1.98), illustrating that EDA effects changed differently in the video and gaming conditions across time in the two preference groups.

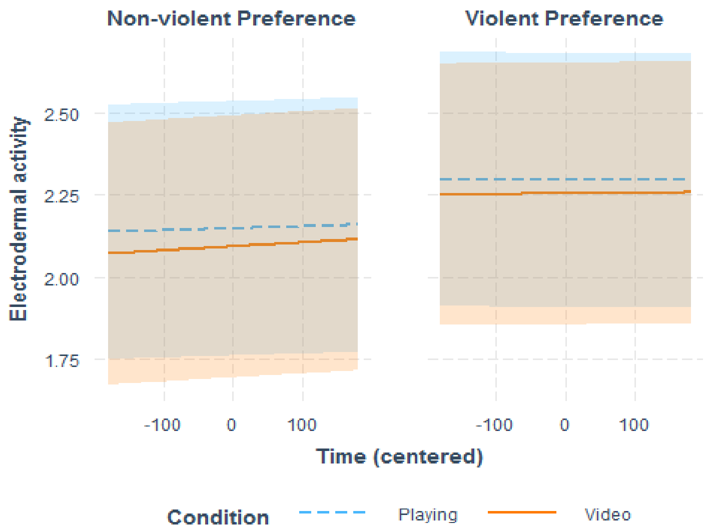


**Fig. 1.** Electrodermal activity in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

The three-way interaction was examined by fitting the model at different levels of preference (see Fig. 1). This revealed that there was a significant interaction between time and condition for those who disliked violent dynamics (b = -3.06 × 10-5, 95% CI [-4.32 × 10-5, -1.80 × 10-5], t = -4.77). When looking at Fig. 1, it can be seen that for this group the rising tendency in EDA activity was greater in the video as opposed to playing condition. For this group there was also a main effect of time (b = 9.07 × 10-5, 95% CI [7.82 × 10-5, 1.03 × 10-4], t = 14.14) which showed that, overall, there was change in their EDA activity. Furthermore, the EDA activity for this group was in general higher in the playing condition as opposed to watching (b = .03, 95% CI [3.17 × 10-3, .05], t = 2.22).

For the group preferring violent dynamics, the interaction between time and condition (playing vs. watching) was smaller but significant (b = -1.27 × 10-5, 95% CI [-2.52

× 10-5, -7.59 × 10-8], t = -1.97). For this group the main effect of time was not significant which showed that their EDA stayed stable over time (b = 4.981 × 10-6, 95% CI [-7.59 × 10-6, 1.76 × 10-5], t = .78). For the group that liked violent dynamics, there was no difference between the overall EDA while watching vs. playing (b = .02, 95% CI [-3.62 × 10-3, .05], t = 1.67). Therefore even though the interaction between time and condition was significant for both groups, the main effects of time and condition did not reach significance for those with a preference for violent dynamics, whereas they were both significant for the group that disliked such actions.

**Table 2.** Model for EDA.

| Random effects | n | Variance | SD | Correlation |
|---|---|---|---|---|
| Participant (Intercept) | 24 | .48 | .69 | |
| Participant (Condition) | | $1.86 \times 10^{-3}$ | .04 | -.24 |
| Residual | | .74 | .86 | |
| **Fixed effects** | **Estimate** | **95% CI** | ***t*** | |
| (Intercept) | 2.20 | 1.92, 2.48 | **15.54** | |
| Time | $4.79 \times 10^{-5}$ | $3.90 \times 10^{-5}$, $5.67 \times 10^{-5}$ | **10.55** | |
| Group | $-7.72 \times 10^{-2}$ | -.35, .20 | -.55 | |
| Condition | $2.42 \times 10^{-2}$ | $6.92 \times 10^{-3}$, .04 | **2.75** | |
| Time x Group | $4.29 \times 10^{-5}$ | $3.40 \times 10^{-5}$, $5.18 \times 10^{-5}$ | **9.45** | |
| Time x Condition | $-2.16 \times 10^{-5}$ | $-3.05 \times 10^{-5}$, $-1.27 \times 10^{-5}$ | **-4.77** | |
| Group x Condition | $3.40 \times 10^{-3}$ | -.01, .02 | .39 | |
| Time x Group x Condition | $-8.97 \times 10^{-6}$ | $-1.79 \times 10^{-5}$, $-7.80 \times 10^{-8}$ | **-1.98** | |

*Note*. *t*-values > 1.96 are in boldface to indicate statistical significance.

### 3.3 Heart rate (HR)

For heart rate, there was a main effect of time (b = 5.67 × 10-5, 95% CI [4.84 × 10-5, 6.50 × 10-5], t = 13.40). This means that participants' heart rate increased as the game progressed.

As for interaction effects, there was an interaction between time and preference (b = 4.74 × 10-5, 95% CI [3.91 × 10-5, 5.57 × 10-5], t = 11.19), indicating that the player groups' heart rate changed differently during the course of the experiment. When compared to players who liked violent dynamics, players with a dislike had a steeper increase in heart rate across time, as seen in Fig. 2. There was also an interaction between time and condition (b = -2.34 × 10-5, 95% CI [-3.17 × 10-5, -1.51 × 10-5], t = -5.53), showing that there was a steeper increase in heart rate in the watching rather than the playing condition. Most importantly, there was a three-way interaction between time, preference and condition (b = -2.59 × 10-5, 95% CI [-3.42 × 10-5, -1.76 × 10-5], t = -6.11). This revealed that heart rate changed differently in the video and gaming conditions across time in both groups.

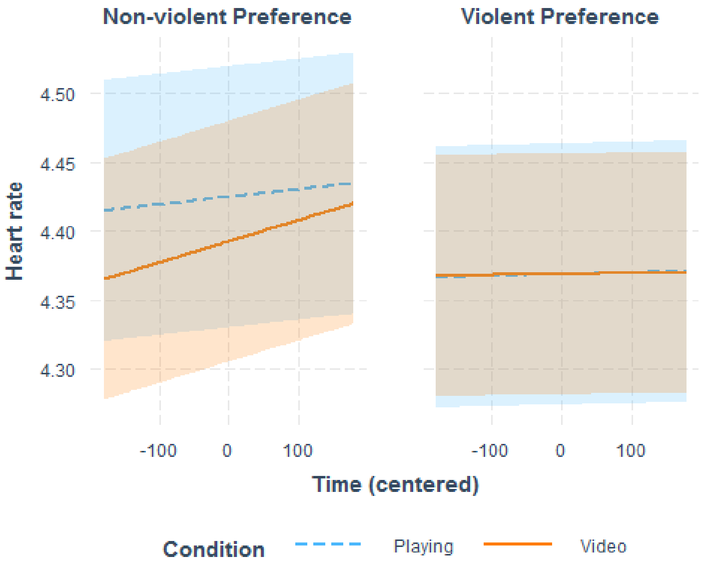


**Fig. 1.** Heart rate in in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

**Table 3.** Model for heart rate.

| Random effects | n | Variance | SD | Correlation |
|---|---|---|---|---|
| Participant (Intercept) | 24 | .03 | .16 | |
| Participant (Condition) | | $4.63 \times 10^{-4}$ | .02 | .30 |
| Residual | | $3.32 \times 10^{-3}$ | .06 | |
| | | | | |
| Fixed effects | Estimate | 95% CI | *t* | |
| (Intercept) | 4.39 | 4.32, 4.45 | **134.90** | |
| Time | $5.67 \times 10^{-5}$ | $4.84 \times 10^{-5}$, $6.50 \times 10^{-5}$ | **13.40** | |
| Group | .02 | -.04, .08 | .61 | |
| Condition | $8.01 \times 10^{-3}$ | $-6.45 \times 10^{-4}$, .02 | 1.81 | |
| Time x Group | $4.74 \times 10^{-5}$ | $3.91 \times 10^{-5}$, $5.57 \times 10^{-5}$ | **11.19** | |
| Time x Condition | $-2.34 \times 10^{-5}$ | $-3.17 \times 10^{-5}$, $-1.51 \times 10^{-5}$ | **-5.53** | |
| Group x Condition | $8.04 \times 10^{-3}$ | $-6.12 \times 10^{-4}$, .02 | 1.82 | |
| Time x Group x Condition | $-2.59 \times 10^{-5}$ | $-3.42 \times 10^{-5}$, $-1.76 \times 10^{-5}$ | **-6.11** | |

*Note*. *t*-values > 1.96 are in boldface to indicate statistical significance.

The three-way interaction was examined by fitting the model at different levels of preference (see Fig. 2). This resulted for the finding of a significant interaction between time and condition for those who disliked violent dynamics (b = -4.93 × 10-5, 95% CI [-6.10 × 10-5, -3.75 × 10-5], t = -8.22). When looking at Fig. 2, it can be seen that the rising tendency in heart rate was greater in the video than playing condition. Further for this group there was a main effect of time (b = 1.041 × 10-4, 95% CI [9.24 × 10-5, 1.16 × 10-4], t = 17.37) showing that, overall, their heart rate increased during the course of the experiment. In general their heart rate was higher in the playing than watching condition (b = .02, 95% CI [3.81 × 10-3, .03], t = 2.57).

For those with a preference for violent dynamics, there was no interaction between time and condition (b = 2.473 × 10-6, 95% CI [-9.25 × 10-6, 1.42 × 10-5], t = 0.41). Because the effect of time for this group was not significant their heart rate was stable over time (b = 9.35 × 10-6, 95% CI [-2.37 × 10-6, 2.11 × 10-5], t = 1.56). Interestingly, as Fig 1 shows the heart rates of this group were practically identical in different conditions. This was evidenced also by statistics showing no difference in the heart rate (b = -3.36 × 10-5, 95% CI [-.01, .01], t = -0.01).

## 4 Discussion

Players who liked game dynamics prevalent in first-person shooter games showed a relatively stable arousal state when playing such a game. Instead, those who disliked the content showed rising arousal. The results thus showed that self-reported likes and dislikes for game contents have a profound impact on players' physiological arousal.

One possibly conflicting factor in our results may have been task difficulty. Namely, those who dislike and therefore play less first-person shooter games may have been more aroused because the task of playing was more difficult to them than to active players of first-person shooters. However, the results were similar when participants were watching a video of a first-person shooter game: those who liked the content exhibited a stable arousal state, whereas those who disliked the content again showed rising arousal. As video watching is not a cognitively demanding task, the results are more likely to refer to preferences rather than task difficulty.

In future studies, participant selection should ideally include both more participants as well as include an equal amount of men and women. Future studies would also benefit from adding qualitative methods to correlate the quantitative data and gain a deeper understanding of player preferences. Future ventures might also explore whether players with preferences in different game genres react differently to FPS.

The results indicate that prior knowledge of players' preferences are important when evaluating player experience. Namely, the results indicate that self-reported game dynamics preferences [7, 8, 9] are not just abstract beliefs – they do have an effect on physiological responses to game dynamics that are in line or discordant with said preferences. This should be taken into account when considering target groups in game design and gamified solutions, as reactions when playing do not seem to be universal. Designers seeking to personalize games using emotional arousal and valence data, i.e. tailoring game experiences to individual players in the process of playing based on physiological responses [16] may also benefit from acknowledging that different player groups react differently. Of particular interest is the relatively stable arousal state of those players who self-report liking the content presented.

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