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Self-reported playing preferences resonate with emotion-related physiological reactions during playing and watching of first-person shooter videogames

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ABSTRACT

The present aim was to investigate emotion-related physiological responses and subjective ratings of two groups of active gamers (N = 24) in response to both playing and watching a video of a first-person shooter game. Participants of one group had high preferences for game dynamics in first-person shooter games, whereas the other group disliked such dynamics. Electrodermal activity (EDA), heart rate (HR), and electromyographic (EMG) activity of the *corrugator supercilii* (i.e., brow furrowing) and the *zygomaticus major* (i.e., smiling) muscles were measured while playing and watching a gameplay video. After the playing and watching sessions, the participants rated their experienced level of valence and arousal. The results showed that those who liked the game dynamics showed comparable and stable levels of EDA and HR during both playing and watching. Those who disliked the game dynamics showed overall higher levels of EDA and HR during playing than watching a video, and a rising EDA tendency especially during watching a video. Playing evoked overall higher *corrugator supercilii* activity than watching in both groups. The group that liked the game dynamics showed a steep EMG increase in the activity of the *corrugator supercilii,* whereas the group that disliked the game dynamics showed less EMG increase. As for ratings of valence and arousal, both groups reported more positive valence and higher arousal after playing than after watching a video, and there were no differences between the groups. In sum, the results showed that player preferences were associated with players' emotion-related physiological responses. The results also showed that playing as opposed to watching generated higher autonomic arousal, but only for players who disliked the dynamics of the game.

Videogames induce unique emotional experiences in players (Bopp et al., 2016). For example, emotion-provoking negative events such as being shot at or getting killed, typical for first-person shooter games, may be central elements for a rewarding player experience and videogame enjoyment (Bopp et al., 2016). However, there are individual differences in what kind of game actions players tend to prefer (Nacke et al., 2014; Tondello et al., 2016; Vahlo et al., 2017, 2018), which might be important in how game events induce emotional responses in different players. For example, those who enjoy killing in a game environment are likely to react differently to a violent videogame than those who prefer dancing or taking care of pets. Another dimension that has recently evoked interest in respect to emotions is the type of involvement in gaming. The increasing popularity of e-sports and gameplay videos (Burroughs & Rama, 2015) suggests that not only playing but also watching other people play videogames may provide positive emotional experiences and is considered enjoyable. In the present study, we examined how players' preferences for different types of game actions are reflected in their emotional responses when playing and watching first-person shooter games. An interesting question is whether the responses depend on active agency in the game as a player or not. In the present study, we examined how players' preferences for different types of game actions are reflected in their emotional responses when playing

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and watching first-person shooter games.

We will start by an overview of previous research on emotional responses to videogames and gameplay videos. We will then review previous literature on game preferences and their relation to emotional responses, and finally, introduce the present study.

1.1. Emotional Responses to Videogames

According to a consensual componential model of emotion, an emotional response is initiated by an appraisal of personal significance or relevance of an event, which then leads to an emotional response involving changes in subjective experience, physiology and behavior (Mauss & Robinson, 2009). Different theoretical accounts hold different positions on whether emotional responses are discrete or dimensional in nature (Mauss & Robinson, 2009). Proponents of discrete emotions suggest that each emotion has a unique physiological, experiential and behavioral profile, indicating that different emotions, such as sadness or joy, can be isolated from other emotions (Ekman, 1999). On the other hand, proponents of dimensional models contend that emotions can best be described on a limited number of dimensions, such as valence and arousal (i.e. pleasantness and activation; Bradley & Lang, 1994; Plutchik, 1980; Russell, 1980; Schlosberg, 1952). For example, in one of these dimensional models, the circumplex model (Russell, 1980), excitement is categorized as an emotion of high arousal and positive valence, whereas boredom is an emotion of low arousal and negative valence. In the present study, we approach videogame-related emotional responses from the dimensional perspective by examining the valence and arousal during videogame playing and viewing. By triangulating experiential and physiological measures of players' emotional responses, our goal is to investigate how emotion-related responses evolve during gaming.

Emotional reactions are thought of as ongoing processes, during which an initial affect response may be reappraised (Ellsworth, & Scherer, 2003) and hence can lead to another emotion. This phenomenon is particularly prevalent in videogames, in which players often fail in challenges during playing and experience negative affect, yet continue to play. Mekler and Bopp (2015) have integrated the concept of 'meta-emotions' to video games to explain why initial frustration, sadness or anger may lead to high appreciation of video game play. Meta-emotion (Oliver, 1993) refers to evaluation of initial emotions and the emotions procured after this processing. When it comes to videogames, initial frustration or other types of negative affect may be thought of as appreciated and rewarding during the evaluation phase (Bopp et al., 2018; Mekler & Bopp, 2015). In other words, players may want to feel sad, frustrated, and challenged at times, and while the initial affect may be negative, the overall feeling the players are left with is positive appreciation.

There is a growing body of research investigating physiological emotion-related responses to videogames by measuring electrodermal activity, heart rate, and facial muscle activation during playing (e.g., Christy & Kuncheva, 2018; Drachen et al., 2010; Granato et al., 2020; Kivikangas et al., 2011; Klarkowski et al. 2018; Kneer et al., 2016; Mandryk, 2008; Nacke & Lindley, 2008; Ravaja et al., 2008). Different physiological measures are thought to reflect different dimensions of the emotion-related responses. Facial expressions are often scoped as a measure of expressed emotional valence, for example whether a participant expresses a positive or negative emotion. A sensitive method for analyzing facial expressions is the measurement of electrical activity of facial muscles via electromyography (EMG). Two muscles in particular are of interest: the *corrugator supercilii* (active when furrowing the brow or frowning) and the *zygomaticus major* (active when smiling), indicating negative and positive valence, respectively (Bradley et al., 2007). Changes in electrodermal activity (EDA) and heart rate (HR) have been found to reflect the activity of the autonomic nervous system (Appelhans & Luecken, 2006; Dawson et al., 2007). Thus, a combination of EMG, EDA and HR recordings provides information about both valence and arousal dimensions of emotional responses.

Previous research shows that violent game content typical for first-person shooter games induces emotion-related physiological responses in players (e.g., Drachen et al., 2010; Lang et al., 2013; Ravaja et al., 2006; 2008;). In a study by Ravaja et al. (2008), players' emotional responses to violent game content in a first-person shooter game were examined with EMG and EDA recordings. The results showed that violent events induced high arousal as indexed by increased EDA activity. The results of EMG recordings showed that while some violent events triggered a negative emotional response, as indicated by lower activation of the *zygomaticus major*, wounding and death of the player's own character actually induced higher activation of the *zygomaticus major* and reduced activation in *corrugator supercilii,* implying that seemingly negative game events may also induce positive emotional responses (see also Ravaja et al., 2006). The results by Drachen et al. (2010) suggest that different arousal measures may reflect different aspects of the emotional experience. They examined correlations between EDA and HR recordings during playing of first-person shooter games and subjective reports of positive and negative emotions and found that low mean HR was correlated with positive emotion and high overall EDA level with negative emotion. These results lend support to the notion that a pleasurable gaming experience is associated with variable emotional responses – both positive and negative and high or low arousal – induced by game events (Bopp et al., 2018; Mekler & Bopp, 2015).

It is important to note that the physiological responses indexing arousal might change during gaming (e.g., Lang et al., 2013). Lang et al. (2013) showed that violent game events in a first-person shooter game increased arousal as indexed by players' HR and EDA activity and were rated as positive experiences. However, exploring and finding enemies induced a decrease in arousal. What Lang et al.'s (2013) results suggest is that players experience various emotional responses during a gaming session – some of them generating more arousal and some of them decreasing arousal. However, the topic of how emotional states evolve during a gaming session has not been explored much in the current literature available. Instead, most research has focused either on specific events, in a phasic or stimulus-response manner (e.g., Ravaja et al., 2008), or on overall means of self-reports or tonic signals (e.g., Drachen et al., 2010) of physiological data. However, in order to understand how a gaming experience develops and evolves, it is important to examine how the different physiological measures change across time during gaming and combine that information with subjective reports of experienced emotions.

There is some evidence suggesting that the nature of the emotion-related physiological responses depend on whether the player is actively participating in the gameplay or is simply watching a gameplay video (Ravaja et al., 2006). In line with the results on first-person shooter games described above (Ravaja et al., 2008), Ravaja et al. (2006) found that negative game events such as falling and death of the player's own character in a platformer game induced increased arousal and positive emotional response as indicated by EDA and EMG recordings. In contrast, watching a replay of the death event was related to increased activation of *corrugator supercilii,* indicating a negative emotional response (Ravaja et al., 2006). These results suggest that during active participation initially negative events may induce a positive emotion-related response, but during passive watching the same events may induce a negative response. Also results of a brain imaging study suggest that observing the death of the player's own character during active gameplay and viewing of a gameplay video involve different activity in the reward system of the brain, implying that active gaming and watching a gameplay video induce different neurocognitive processes (Kätsyri et al., 2013).

1.2. Game Preferences and Emotional Responses

There are individual differences in what kind of games players prefer and choose to play. Recently, there have been attempts to identify player profiles based on players' preferred gameplay activities or dynamics, that is, player-game interactions such as dancing, killing or taking care of pets (Nacke et al., 2014; Tondello et al., 2016; Vahlo et al., 2017, 2018). For example, Vahlo et al. (2017) first identified different game dynamics from published game descriptions and reviews. They then created a survey to examine how much people appreciate different game dynamics, such as wrecking, crushing, destroying, and blowing things up; killing and murdering; or shooting enemies and avoiding enemy fire. Based on the responses of the survey, Vahlo et al. (2017) found five game dynamics preference categories: assault, manage, journey, care, and coordinate. The category of "assault", for example, included the violent game dynamics mentioned above. Survey respondents were then clustered, on the basis of their preferences for different game dynamics categories. This yielded seven player profiles. Relevant to the first-person shooter games and the present study, one of the player profiles was labeled "The Mercenary", and it consisted of players who reported high liking of assault and disliking of care dynamics. The player profile predicts what kind of games a player chooses to play and, not surprisingly, for example The Mercenaries tend to play action and racing games (Vahlo et al., 2018).

Individual differences in what kind of game actions players tend to prefer (e.g., Nacke et al., 2014; Tondello et al., 2016; Vahlo et al., 2017, 2018) might be important in how game events induce emotional responses in players. In a recent study, Gentile et al. (2016) used brain imaging to study individual differences in emotional responses to violent content in videogames. They studied experienced videogame players who either played violent videogames or non-violent videogames and found that when playing violent videogames, those who played them frequently exhibited suppression of activity in brain areas known to be involved in emotion processing. On the other hand, those who were used to playing non-violent games and had to play violent games in the experiment showed increased blood flow in emotional response regions, indicating that gaming generated heightened emotions in these participants. These results suggest that game preferences indeed are associated with emotional responses during gameplay.

1.3. Overview of the Present Study

In the present study, we examined how self-reported preferences for game dynamics that are typical for first-person shooter games are related to emotion-related physiological responses and ratings of valence and arousal during playing and watching a gameplay video. More specifically, we were interested in how emotional responses evolve within a gaming or gameplay spectating session, and whether this progression is influenced by game dynamics preferences. Participants were selected based on their responses to a game dynamics preference questionnaire: participants who either clearly liked or disliked violent dynamics were invited to the experiment. In the experiment, facial EMG, EDA and HR were recorded while participants played and watched a gameplay video of a first-person shooter game. In addition, participants rated their subjective experience in terms of arousal and valence.

We set out to answer the following research questions:

RQ1: Do physiological reactions and emotional experiences 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?

We expected that the progression of emotional responses as measured by facial EMG, EDA and HR during gaming and watching a gameplay video of a game containing a great deal of "Assault" dynamics (as identified by Vahlo et al, 2017) would depend on individual preferences for these dynamics. Moreover, watching a video and playing the game were assumed to elicit different emotional responses despite containing similar dynamics, as we suspected agency would affect the players' affective state.

2. Method

2.1. Participants

The Ethics Committee for Human Sciences at the University of Turku issued an ethical review statement for this study, permitting it. Participants were recruited from an internet survey that focused on their preferred game dynamics, that is, player-game interaction modes. The survey is included in Appendix 2. We set out to recruit active gamers and the survey was thus distributed in different gaming communities as well as posted to gaming-related forums, social media, and web pages. 513 participants answered the survey. After cleaning the dataset from underaged respondents and answers that were obviously misleading, a dataset of 481 participants was left. Some respondents left their contact information in order to participate in further research on digital gaming.

Based on their responses to the violent gameplay preference questions in the internet survey, 30 participants were invited to take part in the laboratory experiment. Six participants had to be dropped from the final dataset because of poor quality of electrophysiological data. The final dataset thus consisted of 24 participants (20 men, 4 women, $M_{age} = 28.67$, $SD_{age} = 6.18$).

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) because of implementation difficulties. We initially 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). These electrodes were prone to dropping off and resulting in poor data, which was discarded any time it happened. As a result of this, we kept the datasets of 14 participants with passable data from these recordings, and proceeded to use two 4 mm electrodes that were attached to the participants' right foot's sole using tape for the rest of the participants. While this approach is somewhat unorthodox, we used a data analysis method that mitigates the possibly confounding factor of the electrode site (described under 3.1. Statistical analyses). The electrodes were filled with isotonic gel (Biopac GEL101). 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. During the experiment, the participants' feet were resting on a footstool and they were instructed not to move their feet. The EDA signal was relayed to the Biopac GSR100C module. The raw signal was amplified (gain = 5 μΩ/V) and bandwith filtering was set between 0.5 to 1 Hz. The sampling rate was 2000 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.

For recording facial muscle activation (electromyography, EMG), we placed two sets of 4 mm Ag/Ag-Cl electrodes above the *zygomaticus major* muscle and the *corrugator supercilii* muscle, representing smiling and brow furrowing activity, respectively. The electrode placement was done according to the guidelines by Fridlund and Cacioppo (1986). To improve electrode impedance, the skin was cleansed with mild soap, slightly abraded, and then wiped with an antiseptic solution of alcohol before attaching the electrodes. The electrodes were attached using adhesive tape and filled with isotonic gel (Biopac GEL 100). The signal from the electrodes was amplified (gain 500) using the EMG100C module, with bandwith filtering of 10-–500 Hz. The notch filter was turned off. The sampling rate was 2000 Hz.

2.3. Materials

2.3.1. Violent Gameplay Action Preferences

An updated 50-item version (Vahlo et al., 2018) of the Gameplay Activity Inventory (GAIN) scale was used to assess participants' preferences for violent gameplay actions. The inventory is presented in Appendix 2. More specifically, we used responses to the 12 items pertaining to dynamics that loaded to a factor that could be termed as "violent action", for example: *"Firing enemies and avoiding enemy fire* rapidly" and *"Close-combat by using fighting techniques and by performing combo attacks"*. Participants were to rate how much they enjoyed 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 their violent gameplay action preferences, the participants were divided into two groups: those who had a high preference for violent action (n = 12, 3 women, Mage = 28.58 years, SDage = 9.22 years) and those who had a low preference for violent action (n = 12, 1 woman, Mage = 28.75 years, SDage = 10.1 years). Those with a preference for violent action played on average 15.67 h weekly (SD = 9.2), and those with a low preference for violent action played an average of 18.75 h weekly (SD = 10.1).

2.3.2. Game Description

Call of Duty: Modern Warfare 2 (Activision, 2009) was chosen to represent a violent action game. As a first-person shooter (FPS) game it contains a great amount 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.

2.3.3. Gameplay Videos and Game Missions

We used the campaign mode of the game for both the video watching and playing conditions. The campaign mode is composed of missions (levels) in which players have to follow the leader of the troop and act according to his commands, ensuring relative similarity of exposure to events in the game. Level A was the mission "Team Player" and Level B the mission "Wolverines!". For this experiment, we created a gameplay video of both of these levels by recording an expert gamer playing through the game missions. Both videos were 6 minlong and taken from the beginning of the mission without the video intros. The videos had a resolution of 1920 × 1080 and a frame rate of 29.97.

2.3.4. Self-Reported Valence and Arousal

To scope experiential emotions, participants were given Self-Assessment Manikins (Bradley & Lang, 1994) to rate their subjective valence and arousal after each of the conditions (playing and watching). The SAM is a pictorial tool developed for reporting subjective emotional experiences by selecting an image that corresponds with the experience of the responder (Bradley & Lang, 1994). The scales used in this experiment contained five options each, ranging from a very unhappy manikin to a very happy manikin for valence and a very calm manikin to a very agitated manikin for arousal.

2.3.5. Familiarity and Difficulty of the Game

In order to control for the potential confounding effects of game familiarity and perceived difficulty, participants answered the following questions at the end of the experiment: 1. How familiar were you with the game used in this experiment (Call of Duty: Modern Warfare 2)? 2. How familiar were you with this particular gaming console (PS3)? 3. In your opinion, how difficult was the game? 4. In your opinion, how hard was it to use the gaming pad? Responses were given on a 5-point Likert scale (1 = not at all, 5 = extremely).

2.4. Design

The experiment followed a 2 × 2 design, in which preference group was a between subjects factor (violent vs. non-violent preference) and condition was a within subjects factor (video watching vs. playing).

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.

2.5. Procedure

Participants were invited to the laboratory experiment based on their preferences for violent action gaming dynamics as indicated by the internet survey responses. In order to create two matched groups, we created pairs of players with similar experience of playing but opposite preferences for violent action dynamics: those who particularly preferred them and those who disliked them.

The experiment commenced by giving the participants general information about the experiment and having them sign an informed consent form, after which electrodes were attached. After this, electrode attachments were checked by ensuring that appropriate signal responses were seen during online monitoring. There was a short break before commencing with recordings to give participants time to relax.

Because we assumed that there would be differences in the players' skill levels, and that not all players would be familiar with playing with PlayStation 3, every participant completed a practice level task before moving on to the playing or watching condition. The practice level continued until it was successfully completed. 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. After the practice level, participants moved on to complete the watching and playing conditions in an order predetermined by counter balancing. In the playing condition, the participants had a chance to play for 15 min, 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. Participants reported valence and arousal immediately after they completed playing or viewing the video.

In the end of the experimental session, participants responded to questions about familiarity and difficulty of the game. Taking into account the attaching of electrodes, video watching, and playing, the whole session took around an hour.

2.6. Data Preparation and Processing

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

We initially recorded baselines for each of the participants at the beginning of the study. However, the measurement values tended to be much higher in the baseline than in the playing and the video condition, a phenomenon that has been reported also in other studies that have used games as stimuli (e.g. Mandryk et al., 2006). Similarly to Mandryk et al. (2006), we suspected this had to do with the participants being nervous at the beginning of the experiment. Because of this, we decided not to use the baseline data as a reference and instead opted for an

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

	Condition			
	Watching		Playing	
	M	SD	M	SD
EDA				
Non-Aggressive Group	10.21	7.82	10.77	8.10
Aggressive Group	11.43	6.46	11.69	6.12
SCR				
Non-Aggressive Group	.66	1.30	1.33	2.03
Aggressive Group	1.19	1.47	1.62	2.16
HR				
Non-Aggressive Group	81.57	10.41	84.48	12.99
Aggressive Group	80.25	15.58	80.31	16.23
EMG - *Zygomaticus major*				
Non-Aggressive Group	5.31	.30	5.66	.90
Aggressive Group	6.19	2.63	6.07	1.93
EMG - *Corrugator supercilii*				
Non-Aggressive Group	2.00	.64	3.04	1.82
Aggressive Group	2.73	2.42	3.71	3.72

Note. EDA measured in μS, SCR as number of peaks, HR in beats per minute (BPM), EMG in mV. All EMG values are presented as units of 10^{-4}.

analysis method that would take into account the individual differences in participant means, namely (generalized) linear mixed-effects models (GLMM/LMM). This type of an analysis models the random variance in the per-participant means. This means that variability in the overall means for each participant is taken into account.

For the EMG signal, we used average rectifying and multiplied the signal by 10,000. In the case of one participant, the data for the EMG had to be dropped entirely because of poor quality, resulting in a total of 23 participants in the analysis of EMG results. The same participant's data for EDA and heart rate were deemed of good quality and retained in the analyses, resulting in 24 participants for the EDA and heart rate analyses.

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. We identified skin conductance responses using the software's "locate SCRs" function.

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, we computed averages across 1 s intervals for each measure (see e.g., Sato, Kochiyama & Yoshikawa, 2020), which were used in the statistical analyses.

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.

3. Results

3.1. Statistical Analyses

Analyses for physiological responses were carried out with (generalized) linear mixed-effects models (GLMM/LMM) using the lme4 package (Bates et al., 2015) in the R statistical software, version 3.3.2(R Core Team, 2016). Tonic EDA, HR, and EMG measures were analyzed with LMMs, whereas the count data from SCR recordings were analyzed with GLMM using Poisson distribution and Laplace approximation. 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 actions) were contrast coded. Playing was coded as 1 and video watching as -1. The group with no preference for violent actions was coded as 1 and the violence preference group as -1. Participants and random slopes for condition were included in the models as random effects. For SCRs the model with the random slope failed to converge, so an intercept-only model was computed. Three-way interactions of time, condition and preference were further examined by computing model estimates at different levels of preference group.

As measures for EDA, HR, and EMG *corrugator supercilii* were right-skewed, they were log-transformed before the analyses to meet the assumption of normality. We also removed observations that exceeded 2.5 SD of the overall mean. The percentage of outliers removed from the data was .95% for EDA, .66% for heart rate, 1.05% for EMG *corrugator supercilii* activity and 2.01% for EMG *zygomaticus major* activity. A threshold value of $t > 1.96$ was used for statistical significance. All models are reported in Appendix 1. Descriptive statistics for all the measures as a function of condition (playing vs. video) and preference group (preference for vs. dislike of violent actions) can be found in Table 1.

Ratings of valence and arousal were analyzed with a repeated measures ANOVA. Preference (liking vs. disliking violent actions) was a between-subjects and Condition (video vs. playing) a within-subject factor. Differences between participant groups in familiarity and experienced difficulty of the game were examined with an independent samples t-test.

3.2. Electrodermal Activity (EDA)

The descriptive statistics for EDA as a function of condition and preference group are presented in Table 1. The model for EDA is presented in Table A1 in Appendix 1. For EDA, there was a main effect of time ($b = 4.79 \times 10^{-5}$, 95% CI [3.90×10^{-5}, 5.67×10^{-5}], $t = 10.55$), which showed that participants had an overall rising tendency in electrodermal activity both while watching and playing. There was also a main effect of condition ($b = 2.42 \times 10^{-2}$, 95% CI [6.92×10^{-3}, 0.04], $t = 2.75$), showing that playing generated higher electrodermal activity than watching a video.

As for interaction effects, we found an interaction between time and preference ($b = 4.29 \times 10^{-5}$, 95% CI [3.40×10^{-5}, 5.18×10^{-5}], $t = 9.45$), indicating that the player groups' EDA state developed differently. When compared to players who liked violent content, players with a dislike had a steeper increase in electrodermal activity across time (see Fig. 1). There was also an interaction between time and condition ($b = -2.16 \times 10^{-5}$, 95% CI [-3.05×10^{-5}, -1.27×10^{-5}], $t = -4.77$), signaling that there was a steeper increase in EDA in the watching rather than the playing condition. However, there was a three-way interaction between time, preference and condition ($b = -8.97 \times 10^{-6}$, 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 the time in both preference groups.

The three-way interaction was examined by fitting the model at

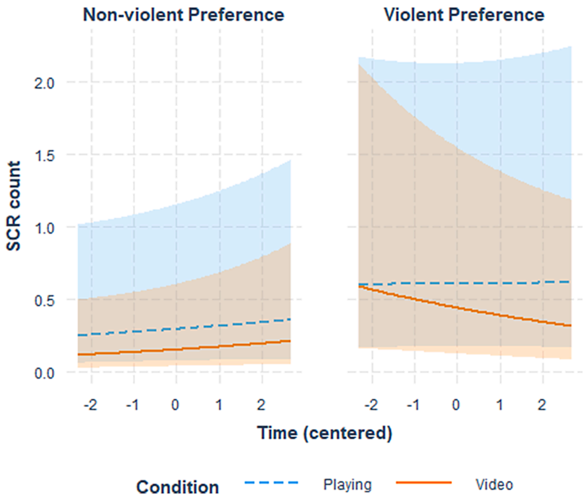

Fig. 2. N of skin conductance responses in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

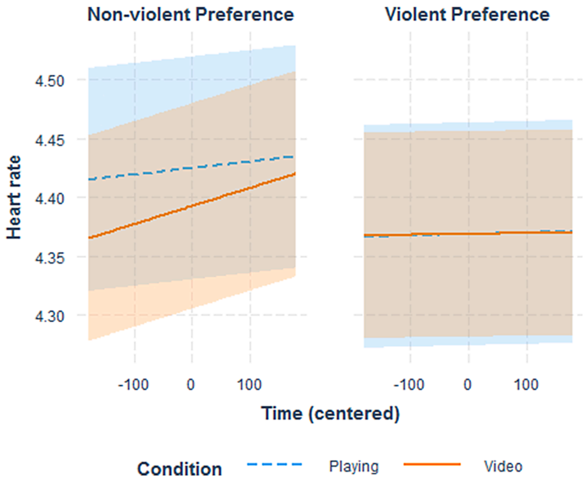

Fig. 3. Heart rate in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

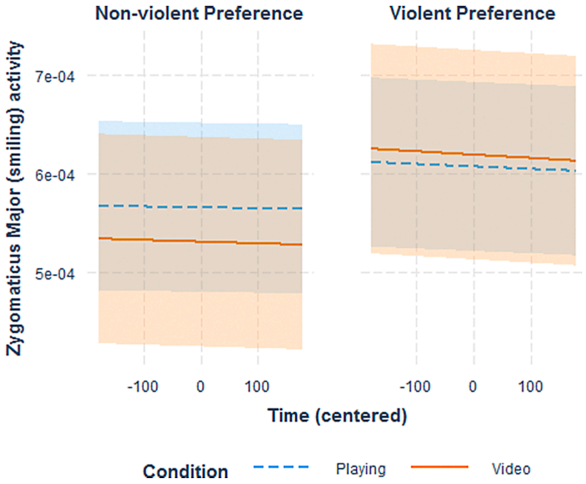

Fig. 4. Activity of the *zygomaticus major* muscle ("smiling") in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

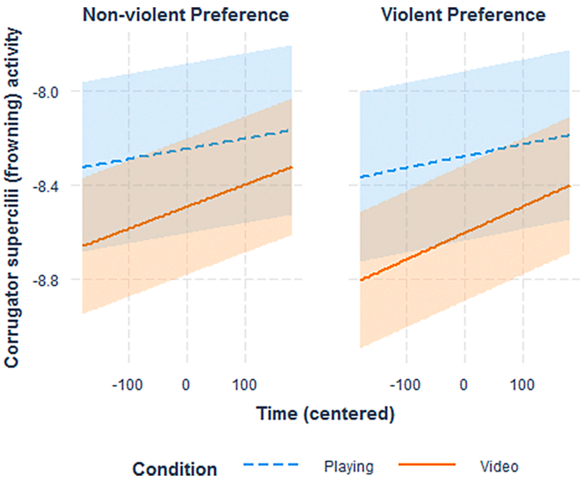

Fig. 5. Activity of the *corrugator supercilii* muscle ("brow furrowing") in playing vs. watching conditions as a function of time for the two player groups. The shaded areas represent 95 % confidence intervals.

Table 2
Means and 95% confidence intervals for self-reported valence and arousal

		Condition			
		Playing		Video	
	Preference group	M	95% CI	M	95% CI
Valence	Non-violent	3.50	[3.07, 3.93]	3.00	[2.55, 3.45]
	Violent	3.75	[3.32, 4.18]	3.33	[2.88, 3.79]
Arousal	Non-violent	3.25	[2.55, 3.95]	2.08	[1.52, 2.65]
	Violent	3.00	[2.30, 3.70]	2.33	[1.77, 2.90]

different levels of preference (see Fig. 1). For the group with a dislike for violent action dynamics, there was a main effect of time ($b = 9.07 \times 10^{-5}$, 95% CI [7.82×10^{-5}, 1.03×10^{-4}], $t = 14.14$), indicating that, overall, there was an increase in EDA levels across time. The EDA level of the preference group with a dislike was in general higher in the playing condition as opposed to watching ($b = .03$, 95% CI [3.17×10^{-3}, .05], $t = 2.22$). Moreover, there was a significant interaction between time and condition ($b = -3.06 \times 10^{-5}$, 95% CI [-4.32×10^{-5}, -1.80×10^{-5}], $t = -4.77$). Fig. 1 shows that the rising tendency in EDA activity was greater in the video than in the playing condition.

For those with a preference for violent actions, there was no evidence for an effect of time ($b = 4.981 \times 10^{-6}$, 95% CI [-7.59×10^{-6}, 1.76×10^{-5}], $t = .78$) or condition ($b = .02$, 95% CI [-3.62×10^{-3}, .05], $t = 1.67$). The interaction between time and condition (playing vs. watching) was smaller than in the group that has a dislike for violent actions but it was still significant ($b = -1.27 \times 10^{-5}$, 95% CI [-2.52×10^{-5}, -7.59×10^{-8}], $t = -1.97$). 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 action, whereas they were both significant for the group that disliked such actions.

All in all, the results indicated that those who disliked violent content showed an increase in EDA level as time progressed during both playing and watching. In contrast those who preferred violent content did not show a similar rising tendency. Furthermore, this rising tendency of those with a dislike was stronger in the watching as opposed to playing condition. These effects are highlighted in Fig. 1, in which EDA activity of the group with a preference for violent action, stays almost flat during the course of the experiment in both conditions. For participants who disliked violent action in both conditions, there was a slight increase in EDA activity with a steeper incline in the watching rather than playing condition. Even though the incline was steeper in the watching condition, the results also illustrated that for those who disliked the content,

Table 3
Means and 95% confidence intervals for self-reported perceptions of familiarity and difficulty (5-point scale: 1 (not at all) – 5 (very))

Preference group	Familiarity with the game		Familiarity with the gaming console		Difficulty of the game		Difficulty of using the gaming pad	
	M	95% CI	M	95% CI	M	95% CI	M	95% CI
Non-violent	2.33	[1.42, 3.25]	3.25	[2.35, 4.15]	2.58	[1.95, 3.22]	2.33	[1.60, 3.07]
Violent	2.17	[1.36, 2.97]	3.83	[2.86, 4.80]	2.08	[1.66, 2.51]	2.83	[1.79, 3.88]

playing generated higher EDA activity than watching. For those who liked the content, there was no difference between the conditions in EDA activity.

3.3. Skin Conductance Responses (SCRs)

The descriptive statistics for SCR as a function of condition and preference group are presented in Table 1. The model for SCR is presented in Table A2 in Appendix 1. There was a main effect of Condition ($b = .24$, 95% CI [.13, .36], $z = 4.09$), indicating that there were more SCRs during playing than during watching. Moreover, there was an interaction between time and preference ($b = .08$, 95% CI [.006, .15], $z = 2.11$), reflecting that there was a slight increase in the number of SCR responses across time for those who disliked violent actions, and a slight decrease for those with a preference for them, especially evident in the video condition (see Fig. 2).

3.4. Heart Rate (HR)

The descriptive statistics for HR as a function of condition and preference group are presented in Table 1. The model for HR is presented in Table A3 in Appendix 1. For HR, there was a main effect of time ($b = 5.67 \times 10^{-5}$, 95% CI [4.84×10^{-5}, 6.50×10^{-5}], $t = 13.40$), thus, as the watching or playing progressed, the participants' HR accelerated.

There was a significant interaction between time and preference ($b = 4.74 \times 10^{-5}$, 95% CI [3.91×10^{-5}, 5.57×10^{-5}], $t = 11.19$), thus, the player groups' HR changed differently during the course of the experiment. When compared to players who liked violent content, players with a dislike had a steeper acceleration in HR across time, as seen in Fig. 3. There was also an interaction between time and condition ($b = -2.34 \times 10^{-5}$, 95% CI [-3.17×10^{-5}, -1.51×10^{-5}], $t = -5.53$), showing that there was a steeper increase in HR in the watching rather than the playing condition. Most importantly, there was a three-way interaction between time, preference and condition ($b = -2.59 \times 10^{-5}$, 95% CI [-3.42×10^{-5}, -1.76×10^{-5}], $t = -6.11$), showing that HR changed differently in the video and gaming conditions across time in the two preference groups.

The three-way interaction was examined by fitting the model at different levels of preference (see Fig. 3). For the preference group with a dislike for violent action dynamics, there was a main effect of time ($b = 1.041 \times 10^{-4}$, 95% CI [9.24×10^{-5}, 1.16×10^{-4}], $t = 17.37$) indicating that, overall, their HR increased during the course of the experiment. The HR was in general at a higher level in the playing than watching condition ($b = .02$, 95% CI [3.81×10^{-3}, .03], $t = 2.57$). There was a significant interaction between time and condition for those who disliked violent actions ($b = -4.93 \times 10^{-5}$, 95% CI [-6.10×10^{-5}, -3.75×10^{-5}], $t = -8.22$). Fig. 3 shows that the tendency in HR acceleration was greater in the video than playing condition.

For those with a preference for violent actions, there was no evidence for a main effect of time ($b = 9.35 \times 10^{-6}$, 95% CI [-2.37×10^{-6}, 2.11×10^{-5}], $t = 1.56$), difference between watching and playing ($b = -3.36 \times 10^{-5}$, 95% CI [-.01, .01], $t = -0.01$), or an interaction between time and condition ($b = 2.473 \times 10^{-6}$, 95% CI [-9.25×10^{-6}, 1.42×10^{-5}], $t = 0.41$).

In summary, there was an interaction between time and condition as well as the main effects of time and condition individually for the group that disliked violent action content, but not for those who preferred it. The trends illustrated in Fig. 3 indicate that the HR of those with a preference for violent content was stable over time and did not vary between the playing and watching contexts. Instead, the HR of those that disliked the violent content accelerated over time, especially in the video watching condition. However, this group showed overall faster HR in the playing condition.

3.5. Zygomaticus Major Activity

The descriptive statistics for *zygomaticus major* activity as a function of condition and preference group are presented in Table 1. The model for *zygomaticus major* activity is presented in Table A4 in Appendix 1. For the activity of the *zygomaticus major* muscle, there was only a main effect of time ($b = -2.09 \times 10^{-8}$, 95% CI [-3.08×10^{-8}, -1.10×10^{-8}], $t = -4.13$), showing that as the experiment progressed, smiling activity decreased. This effect is illustrated in Fig. 4.

3.6. Corrugator Supercilii Activity

The descriptive statistics for the *corrugator supercilii* activity as a function of condition and preference group are presented in Table 1. The model for *zygomaticus major* activity is presented in Table A5 in Appendix 1. For the activity of the *corrugator supercilii* muscle, there was a main effect of time ($b = 7.48 \times 10^{-4}$, 95% CI [7.06, 7.90×10^{-4}], $t = 35.05$), showing that as the experiment progressed, brow furrowing activity increased (see Fig. 5). There was also a main effect of condition ($b = 0.14$, 95% CI [0.08, 0.20], $t = 4.62$), showing that playing generated more brow furrowing activity than watching a video.

There was an interaction between time and preference ($b = 6.13 \times 10^{-5}$, 95% CI [1.95×10^{-5}, 1.03×10^{-4}], $t = 2.87$), showing that the preference groups' brow furrowing activity increased differently during the course of the experiment. When compared to players who disliked violent content, players with a preference for it had a steeper increase in brow furrowing activity across time, as seen in Fig. 5. There was also an interaction between time and condition ($b = -2.82 \times 10^{-4}$, 95% CI [-3.24×10^{-4}, -2.40×10^{-4}], $t = -13.21$), showing that there was a steeper increase in brow furrowing activity in the watching rather than the playing condition.

In summary, brow furrowing activity increased as the experiment progressed, and this increase was higher in the watching than playing condition, even though playing induced more brow furrowing in general than watching. Moreover, even though there was no main effect of preference group, those who liked the content had a steeper increase in brow furrowing than those who disliked the content.

3.7. Ratings of Valence and Arousal

The means and 95% CI:s of the self-reports on valence and arousal are reported in Table 2.

Participants reported higher valence (more positive emotion) after playing than after viewing a video ($F1{,}22 = 6.97$, $p = .015$). There was no main effect of preference group ($F1{,}22 = 1.407$, $p = .248$), nor an interaction between preference group and condition ($F1{,}22 = 0.058$, $p = .813$).

As for arousal, playing was perceived as more arousing than viewing a video ($F1{,}22 = 19.87$, $p < .001$). There was no main effect of preference group on arousal ($F1{,}22 = 0$, $p = 1$), nor an interaction between preference group and condition ($F1{,}22 = 1{,}48$, $p = .237$).

3.8. Familiarity and Difficulty

The means and 95% confidence intervals of the self-evaluations of familiarity of the game and gaming console as well as difficulty of the game and gaming pad use are reported in Table 3. There were no statistically significant differences between the participant groups in these measures, all p's $> .05$. This indicates that the differences in emotional responses of the players are likely not caused by perceived difficulty or one group being more familiar with the particular game used in this experiment.

4. Discussion

The present study examined how individual preferences for violent gameplay dynamics are reflected in emotional responses to active playing and passive viewing of first-person shooter games. We aimed to answer the following research questions: RQ1: Do emotional reactions to a violent videogame and a gameplay video depend on game dynamics preferences? and RQ2: Are there differences between videos and gameplay in how different individuals respond to them? The results showed that both players who had a preference for violent gameplay actions and who had a dislike for violent actions experienced more positive emotion and higher arousal after playing a first-person shooter game than after viewing a gameplay video. However, the groups showed different reactivity to playing and video viewing in the physiological measures of arousal (i.e. EDA, SCR, and HR) and valence (i.e. facial EMG). The group that disliked violent game actions showed overall higher levels of physiological arousal during active gaming than during viewing, as indexed by HR and EDA. Moreover, they showed a steeper increase in both HR and EDA levels during viewing a video than during playing, reflecting the case that playing induced higher arousal overall, whereas viewing a video induced accumulating arousal. In contrast, the group that preferred violent game actions showed very little differences in HR and EDA during viewing and playing and demonstrated overall flatter patterns across time in these measures. These results indicate that even though the group that did not like violent game dynamics enjoyed playing to a similar degree as the group that had a preference for them, their physiological responses evolved in a very different manner.

There are at least two potential reasons for the observed differences. First, engaging in unpleasant actions during gaming and observing them during viewing of a video might have induced arousal reactions. Despite or perhaps because of the arousal induced by these non-preferred contents they still rated the experience as moderately pleasant. On the other hand, the group that preferred violent game actions might have been desensitized to violent game dynamics, as is suggested by fairly low levels of arousal measures in this group while both playing and viewing a video (see Gentile et al., 2016). Still, they evaluated the experience as moderately pleasant. These results are interesting, as they imply that the relationship between physiological arousal and a pleasurable gaming experience is complex (see also Ravaja et al., 2008) and that it depends on the individual preferences for certain types of game actions.

One might argue that the higher physiological arousal demonstrated by the group that disliked violent game dynamics reflected task difficulty. Those who disliked violent dynamics were probably less likely to play first-person shooter games, and they may have been more aroused because the task of playing was more difficult to them than to those who preferred violent game dynamics. Previous studies by Klarkowski et al. (2018) and Nacke and Lindley (2008) have shown that challenge and difficulty may affect physiological arousal during first-person shooter playing. However, we do not think this is a likely explanation of our findings. First, when asked about their familiarity with and experienced difficulty while playing both groups reported modest levels of familiarity and experienced very little difficulty. Second, the groups differed also when participants were merely watching a video of a first-person shooter game: those who liked the violent dynamics exhibited a stable arousal state, whereas those who disliked violent dynamics showed increasing arousal. As video watching is not a cognitively demanding task, the results are more likely to refer to preferences rather than task difficulty.

As for the effects on the facial EMG measures, playing induced overall more *corrugator supercilii* activity (i.e., brow furrowing) than viewing a video. Moreover, the group with a preference for violent game dynamics showed a steep increase in the activity of the *corrugator supercilii* (i.e., brow furrowing) during playing and viewing, whereas in the group that disliked violent actions the slope was more modest. The only effect observed in the *zygomaticus major* (i.e. smiling) activity was an overall decrease across time. In previous studies, *corrugator supercilii* activity has been taken as an indicator of negative emotional responses to unpleasant game events whereas *zygomaticus major* activity has been considered as an indication of positive response to pleasant game events (Ravaja et al., 2006, 2008). The present results do not seem to fit with this interpretation, as both groups reported more positive emotion after playing than viewing and there was no evidence for a difference between the groups. However, there is evidence that during gaming players may initially show negative emotional responses but still find the overall experience to be very positive after a reappraisal period (Bopp et al., 2018; Mekler & Bopp, 2015). The present results can thus be explained from the perspective of meta-emotions: even though getting hit in the game or seeing it happen on a gameplay video may initially trigger a negative emotional response, the overall emotional experience can still be positive.

Another potential explanation of the present results is that brow furrowing activity in the gaming context does not necessarily reflect a negative emotional response. Previous research has shown that increased brow furrowing is related also to increased effort or concentration (e.g., Cohen et al., 1992; de Morree & Marcora, 2010; Van Boxtel & Jessurun, 1993) and brow movements in general to engagement (Bosch et al., 2016). One interpretation of the present results is that as the game advances and gets more difficult, participants who preferred violent actions got more engaged with the game and started to exert more effort or focus to their concentration on the video. However, as we did not directly ask our participants how engaged or concentrated they were, this is mere speculation, and future studies should look into this in more detail.

In some previous studies (e.g., Ravaja et al., 2006; 2008), physiological responses have been examined in relation to specific game events, such as a player's character getting hit vs. shooting at or killing an enemy. In the present study we decided to analyze the overall activity in the physiological measures across a 6 min time period, as we were more interested in how the emotional experience evolves (tonic activity), not in immediate reactions to specific game events (phasic activity). Future studies could examine how individual preferences for game dynamics are reflected in the initial physiological reactions to specific types of game events, as this would provide more detailed information about how game dynamics preferences are reflected in players' gaming experience. Moreover, future studies focusing on changes in tonic activity might consider extending the 6 min time period utilized in this study to a longer time period to further explore how tonic psychophysiological measures evolve during a gaming or spectating session. In general, as our approach of studying tonic signals during playing and watching of gameplay can be considered novel, there remains room for extending the method in future studies. For example, it might be fruitful to take a snippet approach in which comparisons are made between, for example, the first five minutes of gameplay, five minutes from the middle of a play session, and five final minutes of the play session. This type of an approach could be helpful in exploring whether participants are prone to a novel stimulus effect at the beginning of a play session, or if there would be a habituation effect towards the end of the play session. Given these possibilities, it might be that the effect of player preferences may show up at different time points of a play session. Moreover, this type of base knowledge would be useful even without exploring player preferences, as the evolution of emotion-related responses during a play session are as such interesting.

One improvement that could be implemented in future studies has to do with ensuring equal length of the play session and progression of the game mission before asking for self-reports of affect. While most of our participants completed the mission in just around six minutes, a minority did not complete it within the 15 min they were given before they were stopped and asked to give their valence and arousal ratings. The play session was stopped at around 15 min to prevent the participants from becoming too tired. The experiment was quite long given that there was a lot of preparatory work with the electrodes, and some participants continued to watch the gaming video afterwards according to counterbalancing. It is therefore possible that the self-reports may have been influenced by the fact that some participants played for a longer time than others. It is also possible that some players were exposed to more content than others because they progressed further into the mission, or that successful/unsuccessful completion of the mission might have influenced the players' self-reported affect. However, based on observations of the participants playing, none of the participants got completely stuck. Moreover, the participants indicated experiencing a similar low level of difficulty across the player preference groups for the game itself as well as for using the gaming pad, indicating that neither group had problems in progressing in the game. Furthermore, the missions that were included in this study both started with the protagonist being under attack, and it usually took very little time before the protagonist got shot at in case they did not move, ensuring that all participants were exposed to a fair deal of violent content. Because of these reasons, we do not think this is a major issue. However, future studies could benefit from incorporating performance metrics alongside other measures.

One limitation of the current study is that we only focused on preferences for violent game dynamics and first-person shooter games. Our rationale here was that first-person shooter games are among the most popular, and in previous studies (Vahlo et al., 2017, 2018) the dimension of violent game dynamics have divided players clearly into those who prefer them and those who do not. In the studies by Vahlo et al. (2017, 2018), however, several different player types on the basis of people's preferences for various other kind of game actions, such as managing resources, taking care of pets, or dancing, have been identified. In order to fully understand how an emotional gaming experience develops for different players, it would be important to conduct studies on other types of preferences and games that contain elements that fit or do not fit with preferred or disliked dynamics. Moreover, if one wants to generalize these results to other violent videogames, it would be fruitful to repeat this study with another game. Another limiting factor is that we did not ask the participants about how much they spectate videogaming videos. In future studies, a measure regarding spectatorship should be included.

In summary, the present study showed that individual preferences for certain type of game dynamics (Nacke et al, 2014; Tondello et al., 2016; Vahlo et al., 2017, 2018) were associated with changes in physiological measures during playing and viewing gameplay videos. Even though there were no differences between the preference groups in ratings of experienced valence or arousal, the groups showed different patterns of changes in EDA, SCR, HR and corrugator supercilii activity across time during playing and viewing of gameplay videos. Thus, if for example game developers aim to use physiological signals as input in the game in order to present adaptive content (see Bakkes et al., 2012; Blom et al., 2014), individual preferences for game dynamics should be taken into account. The results also showed that even though active playing induced overall more pleasant and more arousing emotional experiences than viewing a video, the emotion-related physiological responses to videos depended on individual preferences for game actions, too. These findings help to understand the increasing popularity of gameplay videos (Burroughs & Rama, 2015): even though an individual might not necessarily enjoy certain game dynamics when playing a game (for example because of strong physiological reactions), watching other people play might still offer some thrill and excitement.

Credit author statement

Suvi K. Holm: Conceptualization, Methodology, Investigation, Formal analysis, Writing - Original Draft, Visualization; Johanna K. Kaakinen: Conceptualization, Supervision, Methodology, Resources, Writing – Original Draft; Santtu Forsström: Investigation, Writing - Original Draft, Veikko Surakka: Supervision, Methodology, Writing – Original Draft

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1

Table A1
Model for EDA

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

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

Table A2
Model for SCRs

Random effects	n	Variance	SD	
Participant (Intercept)	24	4.10	2.02	
Fixed effects	Estimate	95% CI	*z*	*p*
(Intercept)	-1.10	-2.05–-.15	-2.28	.02
Time	.02	-.05–.09	.48	.63
Preference Group	-.45	-1.33–.44	-.99	.32
Condition	.24	.13–.36	4.09	<.001
Time x Preference Group	.08	.01–.15	2.12	.034
Time x Condition	.02	-.05–.09	.54	.59
Preference Group x Condition	.08	-.03–.20	1.40	.16
Time x Preference Group x Condition	-.04	-.12–.03	-1.20	.23

Table A3
Model for heart rate

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

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

Table A4
Model for EMG zygomaticus major (EMGZ)

Random effects	N	Variance	SD	Correlation
Participant (Intercept)	24	2.73×10^{-8}	1.65×10^{-4}	
Participant (Condition)		1.57×10^{-9}	3.96×10^{-5}	-.47
Residual		4.66×10^{-9}	$6.83 \times \times 10^{-5}$	
Fixed effects	Estimate	95% CI	*t*	
(Intercept)	5.81×10^{-4}	5.15×10^{-4}, 6.47×10^{-4}	17.22	
Time	-2.09×10^{-8}	-3.08×10^{-8}, -1.10×10^{-8}	-4.13	
Preference Group	-3.23×10^{-5}	-9.84×10^{-5}, 3.38×10^{-5}	-.96	
Condition	5.68×10^{-6}	-1.02×10^{-5}, 2.16×10^{-5}	.70	
Time x Preference Group	8.04×10^{-9}	-1.87×10^{-9}, 1.79×10^{-8}	1.59	
Time x Condition	4.34×10^{-9}	-5.57×10^{-9}, 1.42×10^{-8}	.86	
Preference Group x Condition	1.16×10^{-5}	-4.24×10^{-6}, 2.75×10^{-5}	1.44	
Time x Preference Group x Condition	-2.73×10^{-10}	-1.02×10^{-8}, 9.64×10^{-9}	-.05	

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

Table A5
Model for EMG corrugator supercilii (EMGO)

Random effects	n	Variance	SD	Correlation
Participant (Intercept)	24	.31	.56	
Participant (Condition)		.02	.15	.43
Residual		.08	.29	
Fixed effects	Estimate	95% CI	*t*	
(Intercept)	-8.40	-8.63, -8.18	-74.12	
Time	7.48×10^{-4}	7.06, 7.90×10^{-4}	35.05	
Preference Group	-.04	-.26, .19	-.31	
Condition	.14	.08, .20	4.62	
Time x Preference Group	6.13×10^{-5}	1.95×10^{-5}, 1.03×10^{-4}	2.87	
Time x Condition	-2.82×10^{-4}	-3.24×10^{-4}, -2.40×10^{-4}	-13.21	
Preference Group x Condition	.02	-.04, .08	.64	
Time x Preference Group x Condition	-3.17×10^{-5}	-7.35×10^{-5}, 1.01×10^{-5}	-1.49	

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

Appendix 2

An updated 50-item version (Vahlo et al., 2018) of the Gameplay Activity Inventory (GAIN) scale that was used for recruiting participants. Items that loaded into the “Assault” factor (the first 12 items) are indicated in **boldface**. The boldfaced items were used in dividing participants into groups that either preferred or disliked violent game dynamics. The survey has been translated to English (originally presented in Finnish).

“In your estimation, how much do you like the following actions when playing a videogame?”

1= Very Dissatisfying, 2 = Dissatisfying, 3 = Neither, 4 = Satisfying, 5 = Very Satisfying.

1. **Piloting or maneuvering a vehicle or a character or tilting the game environment skillfully**
2. **Careful aiming at and hitting a target by shooting or throwing**
3. **Fighting by using close combat skills and techniques**
4. **Jumping from a platform to another while avoiding obstacles**
5. **Hiding or fleeing and surviving by running for your life**
6. **Exploding, wrecking, crushing and destroying**
7. **Racing in a high speed**
8. **Performing in lifelike sports such as basketball, ice hockey, or soccer**
9. **Killing, murdering or assassinating by shooting orusing knives or other weapons**
10. **Stealing, breaking in, hacking, driving recklessly and breaking the law in other similar ways**
11. **Surprising an opponent or enemy by sneaking, stalking or using traps**
12. **Shooting multiple enemies and evading enemy fire rapidly**
13. Building, expanding and developing a city, a village, or a base
14. Managing cities, villages or castles and their inhabitants and resources
15. Designing and creating your own game levels or game worlds
16. Gathering or generating materials or resources like money, energy or food by working or mining
17. Waging war and conquering territories or cities, choosing troops and commanding units
18. Considering and coming up with a strategy and choosing resources for it
19. Planning and conducting combat tactics or other tactics as a battle unfolds
20. Manufacturing, constructing and upgrading vehicles, units or weaponry
21. Managing, improving and protecting groups, clans or cities and their residents
22. Guiding, protecting, developing and herding population, people, followers or a brood
23. Flirting and dating or hugging and kissing
24. Decorating rooms or houses
25. Performing music, singing in tune or dancing
26. Choosing styles and looks, including dressing up and using make up
27. Staying in the rhythm and moving to the beat
28. Hooking up and having sex
29. Engaging in everyday social interactions such as going to school, shopping, or hanging out with friends
30. Crafting new items, weapons or objects by combining ingredients or materials
31. Selecting and equipping weapons, skills, and abilities for characters
32. Navigating in dungeons and overcoming their dangers
33. Creating your own playable character
34. Developing a character’s skills and abilities
35. Searching and collecting rare treasures, items, characters or weapons hidden in the game
36. Exploring the game world, visiting towns, cities and areas, and finding hidden places
37. Fighting by attacking, defending, using spells or by using items and skills
38. Buying, selling and trading items, weapons, gears and resources
39. Negotiating and conducting diplomacy to find a beneficial agreement
40. Acting as the main character and making meaningful choices that affect the game’s progression
41. Befriending with in-game characters, interacting with them and aiding them if they are in trouble
42. Empathizing with game characters and taking different roles
43. Investigating and interacting to unveil the secrets, mysteries and story of the game
44. Pondering and solving puzzles that require spatial perception
45. Pondering and solving word puzzles and challenges
46. Matching tiles, diamonds or other objects together to clear them away
47. Pondering and solving logical and mathematical problems and challenges
48. Memorizing and solving memory-based challenges
49. Solving problems by pondering and realizing cause-effect relationships
50. Solving problems by creative thinking and by trial and error

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