Flow and Immersion in First-Person Shooters: Measuring the player's gameplay experience

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ABSTRACT

Researching experiential phenomena is a challenging undertaking, given the sheer variety of experiences that are described by gamers and missing a formal taxonomy: flow, immersion, boredom, excitement, challenge, and fun. These informal terms require scientific explanation, which amounts to providing measurable criteria for different experiential states. This paper reports the results of an experimental psychophysiological study investigating different traits of gameplay experience using subjective and objective measures. Participants played three *Half-Life 2* game modifications while being measured with electroencephalography, electrocardiography, electromyography, galvanic skin response and eye tracking equipment. In addition, questionnaire responses were collected after each play session. A level designed for combat-oriented flow experience demonstrated measurable high-arousal positive affect emotions. The positive correlation between subjective and objective indicators of gameplay experience shows the great potential of the method presented here for providing real-time emotional profiles of gameplay that may be correlated with self-reported subjective descriptions.

Categories and Subject Descriptors

K.8.0 [**Personal Computing**]: General – *Games.*

General Terms

Measurement, Design, Theory.

Keywords

Game design, flow, immersion, gameplay experience, psychophysiology.

1. INTRODUCTION

With the growing maturity of game science as a research field, more and more studies are devoted to the empirical investigation of different experiences in gaming. The primary concern is to gain a more thorough understanding of subjective experiences referred in terms such as immersion, presence and flow. Not only do these terms currently lack well-accepted common meanings, but also for game designers, clear and *testable* definitions of constructs such as immersion and flow would be invaluable, since these are considered to be the holy grail of digital game design. Our own studies focus upon First-Person Shooter (FPS) games, which aim to provide a holistic game experience for the player by removing player representations (like avatars) and putting the player in first-person perspective. In an FPS, the player can fully identify with the game character represented only by weapons and/or hands seen as virtual prostheses that reach into the game environment [14]. This means that in an FPS a player virtually turns into the game character as they feel like they are acting directly in the virtual game world. In addition to the FPS perspective, the consequence and meaning of player action within the environment and its impact on gameplay greatly influence the feeling of immersion [21]. The study of FPS games may simplify the investigation of these factors by removing issues of identification (or not) with a character viewed from a third-person perspective.

1.1 Immersion

A qualitative study conducted by Brown and Cairns [3] analyzed players' feelings towards their favorite game and led them to propose three gradual and successive levels of player immersion: engagement, engrossment, and total immersion. The latter level is used interchangeably with the concept of presence, a state facilitated by feelings of empathy and atmosphere, which links immersion to factors of graphics, plot and sounds in addition to emergent gameplay (since visual, auditory and mental elements are mentioned in this context). While it is plausible to see immersion as a gradual phenomenon that builds up over playing time, this study shows that the lack of a clear definition for presence and immersion causes the terms to be used interchangeably for phenomena that may not be the same.

Ermi and Mäyrä [11] subdivided immersion into three distinct forms: sensory, challenge-based and imaginative immersion. "Sensory immersion" relates to the audiovisual execution of games. This dimension of immersion is easily recognizable as it can be intensified through intensifying its components, such as creating more compelling graphics or playing on a much larger screen or with a surround speaker system. "Imaginative immersion" comes close to the immersion definition used by Brown and Cairns [3], describing absorption in the narrative of a game or identification with a character, which is understood to be synonymous with feelings of empathy and atmosphere. However, atmosphere might be a mix of imaginative immersion and sensory immersion; hence, the use of this term in the study conducted by

Ermi and Mäyrä raises the need for a clearer definition of the concept of atmosphere. Imaginative immersion is held to be most prominent in role-playing games. The dimension of "challenge-based" immersion is very close to what Csikszentmihalyi describes as the flow experience [8, 9]. Challenge-based immersion describes the emergent gameplay experience of a player balancing his abilities against the challenges of the game in so far as gameplay is related to motor and mental skills. Challenges in this definition can include different mixtures of physical and mental performance requirements. In the study of Ermi and Mäyrä [11], the game *Half-Life 2* (Valve Corporation, 2004) was ranked highest in all dimensions of the SCI model, thus making it a good candidate for studies investigating immersion. The study reported here, based upon Half-Life 2, shows a fluid transition between experiential concepts of immersion and flow.

1.2 Flow

The flow model was introduced by Csikszentmihalyi [8] based upon his studies of the intrinsically motivated behavior of artists, chess players, musicians and sports players. This group was found to be rewarded by executing actions *per se*, experiencing high enjoyment and fulfillment in activity in itself (rather than goals of future achievement, etc.). Csikszentmihalyi describes flow as the "holistic sensation that people feel when they act with total involvement". Logically, one could see immersion as a precondition for flow, since immersion involves a loss of a sense of context, while flow describes a level of complete involvement. Csikszentmihalyi specified flow as consisting of several characteristics: balance of challenge and skills, clear goals, explicit feedback, indistinct sense of time, loss of self-consciousness, feeling of enjoyment and control in an *autotelic* (i.e. self-sufficient) activity.

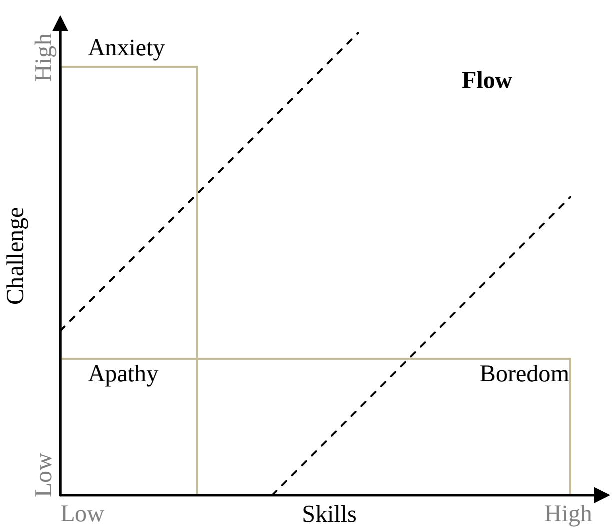

Figure 1. The two-dimensional four-channel model of flow based on Csikszentmihaly and Ellis et al. [8, 10]

The original flow model was revised by Ellis et al. [10] into a four-channel model, shown in Figure 1, which is used most commonly for describing games and gameplay experience. Defining the balance of skills and challenges is often fuzzy, which led Chen [7] to propose different "flow zones" for hardcore and novice players and an optimal intersection, within which the experience converges towards an optimal match of challenges and abilities.

However, as a study by Novak et al. [24] shows, there are many different concepts used for studying flow; they report 16 flow studies between 1977 and 1996, which all use different concepts and definitions of flow. The only commonly used questionnaire, the flow state scale [16], was designed for sports research and assessed by Kivikangas [17] as usable for game research. In more recent efforts of the EU-funded FUGA ("Fun of Gaming") project, another better suited scale was developed as part of a game experience questionnaire (GEQ) [15]. Kivikangas was also one of the first to investigate correlations between psychophysiological measures and flow experience, but his results showed flow not to have a significant relationship with psychophysiological measures of basic emotions.

1.3 Psychophysiological measurements

Emotions are a vital part of the game experience, motivating the cognitive decisions made during gameplay. *Psychophysiological research* suggests that at least some emotional states could be quantitatively characterized via measurement of physiological responses. Specific types of measurement of different responses (such as GSR, EMG, ECG and EEG, as described below) are not *per se* trustworthy signs of well-characterized feelings [4, 5]; a *de rigueur* cross-correlation of all measurements is fundamental to discover the emotional meaning of different patterns in the responses. Furthermore, the often described many-to-one relation between psychological processing and physiological response [6] allows for psychophysiological measures to be linked to a number of psychological structures (for example, attention, emotion, information processing). Using a response profile for a set of physiological variables enables scientists to go into more detail with their analysis and allows a better correlation of response profile and psychological event [6]. The central concern here is the correlation of patterns of measurement characteristics for a set of different measures with subjective characterizations of experience such as emotion and feelings (for example, the feeling of immersion in gameplay).

Facial electromyography (EMG) is a direct measure of electrical activity involved in facial muscle contractions; EMG provides information on emotional expression via facial muscle activation (even though a facial expression may not be visually observable) and can be considered as a useful external measure for hedonic valence (degree of pleasure/displeasure) [18]. Positive emotions are indexed by high activity at the *zygomaticus major* (cheek muscle) and *orbicularis oculi* (periocular muscle) regions. In contrast to this, negative emotions are associated with high activity at the *corrugator supercilii* (brow muscle) regions.

This makes facial EMG suitable for mapping emotions to the valence dimension in the two-dimensional space described in Lang's dimensional theory of emotion [18]. The *valence* dimension reflects the degree of pleasantness of an affective experience. The other dimension, the *arousal* dimension, depicts the activation level linked to an emotionally affective experience, ranging from calmness to extreme excitement. In this kind of dimensional theory of emotion, emotional categories found in everyday language (for example, happiness, joy, depression, anger) are interpreted as correlating with different ratios of valence and arousal, hence being mappable within a two-dimensional space defined by orthogonal axes representing degrees of valence and arousal, respectively. For example, depression may be represented by low valence and low arousal, while joy may be represented by high valence and high arousal.

Arousal is commonly measured using galvanic skin response (GSR), also known as skin conductance [19, 20]. The conductance of the skin is directly related to the production of sweat in the *eccrine* sweat glands, which is entirely controlled by the human sympathetic nervous system. Increased sweat gland activity is directly related to electrical skin conductance. Hence, measuring both GSR and EMG provides sufficient data to provide an interpretation of the emotional state of a player.

This paper describes a study investigating correlations between subjectively reported gameplay experience and objectively measured player responses within gameplay as measured by these psychophysiological measures, in order to provide cross-validated descriptions of the emotional experience of players during gameplay[1]. The overall goal is to establish and validate a method that can precisely assess emotional modulations during gameplay in real-time, for players of first-person shooter games and other genres.[2]. The experiment reported in this paper was conducted in February 2008 in the Game and Media Arts Laboratory at Blekinge Institute of Technology (BTH) in Sweden. Although this paper is limited to the description of EMG, GSR and questionnaire data, future analyses will take into account the other data collected.

In the following, we give an overview of our experimental methodology (Section 2), and then continue to report our results (Section 3). The findings are finally discussed and a prognosis for future work is given (Section 4).

2. METHOD

Male students from a technical University played three Half-Life 2 [1] game mods, specifically designed to test experiential gameplay constructs (and iteratively refined using game testing for half a year). Levels were designed for immersion, boredom, and flow, with each modality being played one time. Physiological responses were measured continuously during each play session for each experimental participant (as objective or external measures), while questionnaire data (assessing subjective individual responses) was collected for each participant in each modality.

2.1 Design

The Half-Life 2 mod game levels were designed around three conditions addressing the independent variable of *game experience*, to assess the three conditions of boredom, immersion and flow.

Level design (see Figure 2) was a long iterative process carried out by game level designers and researchers from Blekinge Institute of Technology, using feedback in each design cycle from all research partners of the EU FP6 NEST FUGA project in an iterative refinement process.

Figure 2. In-game screenshot for the level designed around the experiential concept of game boredom

This led to the establishment of the design criteria for the respective conditions described in the following subsections.

2.1.1 Boredom

Real boredom is defined by Fisher as “an unpleasant, transient affective state in which the individual feels a pervasive lack of interest in and difficulty concentrating on the current activity” [12]. However, boredom in a game context can be seen as the counterpart to engagement (as supposedly elicited by the immersion and flow designs, described below). Seeing boredom as a relative experience at the lower end of a scale of engagement, we propose the following design criteria for a less engaging experience:

- Linear level (walk on a line from start to end)
- Weak opponents (only of two different types)
- Repeating textures and models
- Damped sounds
- No real winning condition (after reaching the end of a level, the church, the player can continue to walk around)
- Limited choice of weapons
- High amount of health and ammo supplies throughout the level
- No surprises (no gameplay information should be concealed)

2.1.2 Immersion

According to our discussion in Section 1, we use immersion here as a description for the audiovisual or sensory experience of the game environment, which suggests the following design criteria:

[1] Both in correlating the degree of emotions experienced and comparing the session scale of subjective reports with the millisecond scale of psychophysiological recordings of emotional changes and modulations

[2] It must be noted that the experiment has a preliminary nature due to the fact that the psychophysiological characterization of gameplay experiences (such as immersion or flow) is not well developed, yet.

- Complex and exploratory environment (player has to explore the area to find the way through the level)
- Various opponents (less and weak in the beginning, strong and numerous towards the end)
- Fitting sensory effects (fires, lighting, scripted animations, sounds, etc.)
- Variety of models, textures and dynamic lights to establish a mood and scenery
- New weapons are usually found after a fight as a reward as is ammo and health
- Narrative framing (ideally this would add to immersion, in our design it is however left out due to time limitations)

2.1.3 *Flow*

The design criteria for flow are more concentrated on the sequence, pace and difficulty of challenges than on environmental settings. The design guidelines that we used for the implementation are:

- Concentrate on the mechanics of one specific weapon and design the challenges around that. (In our case, we ended up using the crossbow, which has a slow reload "cooldown" time, which makes for an interesting combat game mechanic)
- Start with easy combat. (Weak enemies are put in the start area with a moderate spawn time, resulting in persistent but less challenging combat)
- Increase combat difficulty gradually. (Combat becomes more difficult throughout the level as the number of opponents, attack pace and strength increases, while the spawn time decreases)
- Allow for "cooldown" spots. Between the areas of combat, we put short cooldown or rest spots, were players can find a sparse amount of health and ammo items

In reality, not all of these criteria are equally well implemented, but they serve as a general guideline in the design process. Each experiment participant played under each condition in the same order. It is hypothesized that the resulting learning effect existing in this repeated measures design has only minor repercussions, since the experiential dimensions of boredom, immersion and flow only marginally overlap. Physiological responses were measured as indicators of valence and arousal [18] together with questionnaires assessing self-reported game experience [15] and spatial presence [29] (thus forming the dependent variables in this experiment).

2.2 Participants

Data were recorded from 25 healthy male higher education students, aged between 19 and 38 (M = 23.48, SD = 4.76). Students were recruited within several game courses at BTH, Karlshamn Campus, Sweden. All students were participants in the local game programs or working part-time for local game companies. Therefore, we could assume an avid interest in games and a large proportion of participants being from the hardcore gamer demographic. As part of the experimental setup, demographic data were collected with special respect to the suggestions made by Appelman [2].

88% of the participants were right-handed and 56% were not wearing glasses or contact lenses. All the participants owned a personal computer (PC) and 96% rated this as their favorite gaming platform. Other preferred platforms were Xbox 360, Playstation 3 and PS2.

68% of all participants said they buy games more than once a year. All participants play games at least twice a week, while 60% play every day. 84% played between two and four hours per day. The preferred mode of play was console single player (44%) or pc multiplayer (36%), while 8% rated pc single player as their preferred play mode. 36% rated First-Person Shooters (FPS) as their favorite game type.

44% started to play digital games when they were younger than six years and 40% started between six and eight years old. This leaves only 16% that started to play between eight and twelve years. So, all the participants started playing digital games before twelve years. None of the subjects received any compensation for their participation in the experiment.

2.3 Apparatus

2.3.1 *Facial EMG*

We recorded the activity from left orbicularis oculi, corrugator supercilii, and zygomaticus muscle regions, as recommended by Fridlund and Cacioppo [13], using BioSemi flat-type active electrodes (11mm width, 17mm length, 4.5mm height) electrodes with sintered Ag-AgCl (silver/silver chloride) electrode pellets having a contact area 4mm in diameter. The electrodes were filled with low impedance highly conductive Signa electrode gel (Parker Laboratories, Inc.). The raw EMG signal was recorded with the ActiveTwo AD-box at a sample rate of 2 kHz and using ActiView acquisition software.

2.3.2 *Galvanic skin response (GSR)*

The impedance of the skin was measured using two passive Ag-AgCl (silver/silver chloride) Nihon Kohden electrodes (1 microamp, 512 Hz). The electrode pellets were filled with Signa electrode gel (Parker Laboratories, Inc.) and attached to the thenar and hypothenar eminences of a participant's left hand.

2.3.3 *Video recording*

A Sony DCR-SR72E PAL video camera (handycam) was put on a tripod and positioned approximately 50 cm behind and slightly over the right shoulder of the player for observation of player movement and in-game activity. In addition, the video recordings served as a validation tool when psychophysiological data were visually inspected for artifacts and recording errors.

2.3.4 *Game experience survey*

Different components of game experience were measured using the game experience questionnaire (GEQ) [15]. As shown in a previous assessment by Nacke and Lindley [22], the GEQ components can assess experiential constructs of immersion, tension, competence, flow, negative affect, positive affect and challenge with good reliability.

Other apparatus used but not included in this analysis were a Biosemi 32-channel EEG system and a Tobii 1750 eye tracker. This additional data will form the basis of a future paper.

2.4 Procedure

All experiments were conducted on weekdays between 10:00 a.m. and 6:00 p.m., with each experimental session lasting approximately 2 hours. The experiments were advertized especially to graduate and undergraduate students. All participants were invited to the Game and Media Arts Laboratory at Blekinge Institute of Technology, Sweden.

After a brief description of the experimental procedure, each participant filled in two forms. The first one was a compulsory "informed consent" form, with a request not to take part in the experiment when suffering from epileptic seizures or game addiction. The second form was an optional photographic release form.

Participants were then seated in a comfortable office chair, which was adjusted according to their individual height, electrodes were attached and the participants were asked to rest and focus on a black cross on a grey background on the monitor. During this resting period of 3-5 minutes, physiological baseline recordings were taken.

After each modality, participants were asked to report their subjective experiences using questionnaires. After completion of all modalities, participants were thanked for their participation and escorted out of the lab.

2.5 Data Reduction and Analysis

Recorded psychophysiological data were inspected visually using BESA (MEGIS Software GmbH, Germany) software to check correctly recorded signals. To reduce noise, EMG data were also filtered using a low cutoff filter (30 Hz, Type: forward, Slope: 6 dB/oct) and a high cutoff filter (400 Hz, Type: zero phase, Slope: 48dB/oct). If data remained indistinct, they were excluded from further analysis. EMG data were rectified and exported together with GSR data at a sampling interval of 0.49 ms to statistics software SPSS (SPSS Inc.) for further analysis. Descriptive statistics were calculated for each person over the complete game session. GSR data were corrected for errors using log transformations.

3. RESULTS

For assessing dimensions of game experience, the game experience questionnaire was used [15]. The comparison of mean scores is shown in Figure 3. Mean scores and reliability of these results has been briefly discussed by Nacke and Lindley [22].

The notable results are an increase in positive affect and immersion for the immersion level. Accordingly, this level scores lowest for negative affect items. The boredom level scores lowest on challenge, immersion and flow, but highest on competence, which is completely in line with the expectations. The flow level scores lowest on competence, but highest on flow, challenge and tension, which the following analysis will prove to be the most significant result.

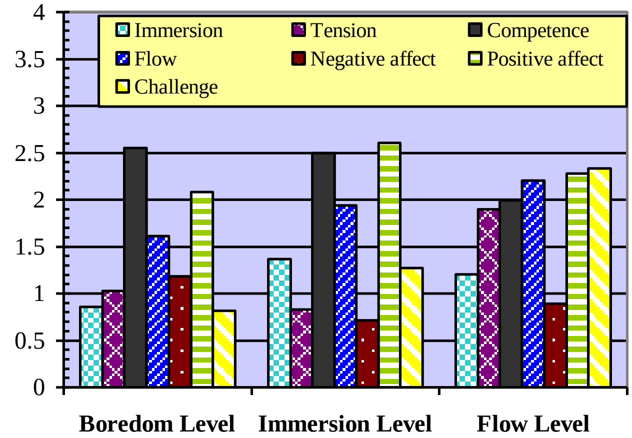

Figure 3. Mean scores for GEQ components in each level (for more detailed statistics refer to Nacke and Lindley [22])

To test statistical significance of the results, one-way repeated-measures analyses of variance (ANOVAs) were conducted in SPSS using the game mod levels as the within-subject factor for each measurement. For GEQ components immersion ($\chi^2(2)$ = 1.13, $p > .05$), flow ($\chi^2(2)$ = 1.15, $p > .05$), positive affect ($\chi^2(2)$ = 0.16, $p > .05$), negative affect ($\chi^2(2)$ = 0.66, $p > .05$), challenge ($\chi^2(2)$ = 2.96, $p > .05$) and tension ($\chi^2(2)$ = 4.68, $p > .05$), Mauchly's test indicated that the assumption of sphericity had been met. For the remaining component competence ($\chi^2(2)$ = 10.72, $p < .05$) it was violated. Therefore, degrees of freedom were corrected for the competence component using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .70$).

Statistical significance was unfortunately not achieved for the components: Immersion: $F(2, 40) = 2.00$, $p > .05$), competence: $F(1.40, 27.95) = 2.34$, $p > .05$), flow: $F(2, 40) = 2.08$, $p > .05$), positive affect: $F(2, 40) = 1.94$, $p > .05$), and negative affect: $F(2, 40) = 1.90$, $p > .05$). The items challenge: $F(2, 40) = 32.54$, $p < .05$) and tension: $F(2, 40) = 7.98$, $p < .05$) were both clearly statistically significant. This is a sign of the subjective game experiences "challenge" and "tension" (measured with the GEQ) being significantly affected by the different gameplay experience modalities.

Table 1 shows the mean scores for the MEC Spatial Presence Questionnaire [29]. It can be noted that spatial presence possible actions ratings were highly increased in the level designed for immersion. Spatial presence scores are lowest in the boredom level.

Table 1. Means (and standard deviations) of the MEC Spatial Presence Questionnaire

Modality	Spatial Presence Self-Location	Spatial Presence Possible Actions
Boredom Level	2.07 (1.10)	2.57 (1.06)
Immersion Level	2.60 (0.96)	3.30 (0.85)
Flow Level	2.68 (1.22)	2.62 (1.12)

For Spatial Presence components Self-Location ($\chi^2(2)$ = 4.73, $p > .05$) and Possible Actions ($\chi^2(2)$ = 2.73, $p > .05$) Mauchly's test indicated that the assumption of sphericity had been met. In addition, statistical significance was achieved for both components, Possible Actions: $F(2, 40) = 4.79$, $p < .05$) and Self-Location: $F(2, 40) = 3.40$, $p < .05$). These results show that the subjective feeling of spatial presence was significantly affected by the different gameplay experience modalities.

Table 2. Means (and standard deviations) of the physiological electromyography (indexing valence) and galvanic skin responses (indexing arousal)

Modality	EMG OO (µV)	EMG CS (µV)	EMG ZM (µV)	GSR (log[µS])
Boredom Level	7.61 (2.45)	7.56 (1.85)	8.70 (3.26)	0.90 (0.24)
Immersion Level	7.19 (1.77)	7.65 (1.78)	7.87 (2.07)	0.89 (0.28)
Flow Level	8.47 (2.70)	7.34 (2.09)	10.98 (4.89)	0.93 (0.25)

Table 2 displays the cumulative averages over the playing time for all participants in all levels. Histograms for EMG measures were visually inspected and data was assumed to be normally distributed. Data for galvanic skin response was logarithmically normalized. Positively valenced emotions would be indexed by increased zygomaticus major and orbicularis oculi activity [27]. The game level designed for the flow condition shows the highest values for positive valence[3] as well as for arousal[4]. In contrast to this, the immersion level scores lowest on valence as well as arousal. The boredom level scores similar, but a bit above the values for the immersion level for all physiological measurements except corrugator supercilii activity.

For the psychophysiological measurements, statistical significance was tested using one-way repeated-measures ANOVA (in the same way as for the subjective reports). Mauchly's test indicated that the assumption of sphericity had been met for responses from orbicularis oculi ($\chi^2(2) = 0.60$, $p > .05$), corrugator supercilii ($\chi^2(2) = 3.33$, $p > .05$) and zygomaticus major ($\chi^2(2) = 4.32$, $p > .05$). Sphericity was violated for normalized galvanic skin response ($\chi^2(2) = 10.14$, $p < .05$). Hence, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .66$).

Regrettably, corrugator supercilii (negative valence) electromyographic responses were statistically non-significant: $F(2, 30) = 0.98$, $p > .05$). However, statistical significance was achieved for orbicularis oculi (positive valence): $F(2, 30) = 3.77$, $p < .05$) and zygomaticus major (positive valence) $F(2, 30) = 7.51$, $p < .05$) measures as well as galvanic skin response (arousal) $F(1.32, 19.80) = 4.34$, $p < .05$). This outcome shows that objective physiological responses (for all measures taken except in the corrugators supercilii region) from an accumulated game session were significantly influenced by the different gameplay experience modalities.

Given the significance of the results, an analysis of within-subjects contrasts was conducted and showed significant differences of orbicularis oculi activity (valence) for the boredom level compared with the flow level $F(1, 15) = 7.02$, $p < .05$). Zygomaticus major activity (valence) was significantly different for both contrasts compared (boredom level vs. flow level, $F(1, 15) = 7.88$, $p < .05$), and flow level vs. immersion level, $F(1, 15) = 10.05$, $p < .05$)). In addition, galvanic skin response (arousal) showed a significant contrast for boredom level vs. flow level $F(1, 15) = 12.09$, $p < .05$)). We have to conclude that these contrasts are noteworthy because of the significance of the main effect shown in the ANOVA.

[3] Measured by orbicularis oculi and zygomaticus major activity

[4] Measured by galvanic skin responses

4. DISCUSSION AND FUTURE WORK

This paper has described and analyzed the results of an experiment to measure gameplay experience and its effect on player valence and arousal. It was the goal as well to detect any possible correlations between measurable valence and arousal features and self- reported subjective experience.

To begin with, the game experience questionnaire showed that it could accurately measure its components, but that only challenge and tension showed significant discrimination in this experiment. This can be due to the fact that in the design of the game levels, we relied on subjective experience and iterative feedback to design for each concept: boredom, immersion and flow. While flow and boredom might be intuitively understood by most gamers, immersion certainly is not. The challenge aspect of flow seems to be the one best assessed with the GEQ as it shows a high increase in the flow level (which had gradually increasing combat challenges throughout the level). This of course leads to this level culminating in a very challenging end fight and thus might have been perceived as holistically more challenging, even though combat at the start of the level had the same density as in the immersion level. Overall, the GEQ results seem to validate the intended level design for the flow level. However, there seems not to be enough evidence in the data to subjectively discriminate between experiences in the immersion and the boredom levels.

The measurements of spatial presence appear to be more significant. The level designed for immersion scores high on "self-location" and highest on "possible actions". Thus, it is very likely that what we subjectively designed for was what Ermi and Mäyrä [11] would call imaginative immersion and that this feeling is related to spatial presence, especially in the dependency of presence upon what Vorderer et al. describe as "possible actions" [29]. In contrast to this, the feeling of "self-location" might be more linked to flow in combat experiences as the flow level scores higher than the immersion level on this item. Clearly, these results present once again the need to find a more distinct terminology for the different forms of immersion.

Finally, the measurement of EMG responses was significant for the muscles indicating positive valence (orbicularis oculi and zygomaticus major). In addition, the measurement of arousal (galvanic skin response) showed statistically significant differences under the different conditions manifest in the different level designs. The flow level scores highest for these conditions, making it a foundation for high-arousal positive emotions. This is a noteworthy finding since it links gradual challenges in a competitive environment to positive emotions. One could think the contrary, that highly challenging gameplay is frustrating and leaves players with a negative feeling. But according to our results and in line with our hypothesis, the opposite is true and challenging levels are experienced as being more arousing and deliver more positive emotions than boring levels. Joy in this case does not come from victory or success, but from challenging gameplay (cf. [25-27]).

The psychophysiological findings contradict the finding of Kivikangas [17] that EMG activity over zygomaticus major and orbicularis oculi (positive valence) does not have a relationship with flow . If we assume that we can accurately assess flow with the GEQ [22], then it is found in our study to be related to positive emotion as indexed by physiological responses. This study was focused on male hardcore gamers only and thus it might be hypothesized that these results are only valid for this target group. It remains for future research to indicate whether psychophysiological measurements can accurately describe gameplay experiences for a broader demographic population.

In considering the limitations of the experiment design described here, it may be proposed that future research might explore different time resolutions[5], since emotional responses to a complete play session might be linked to smaller scale details of the modulation of emotional reactions over a sequence of specific game events [23, 27, 28].

In conclusion, the study reported here appears to show that physiological responses can be an indicator of psychological states of gameplay experience, as indicated by cross-correlation with subjective reports. Ongoing work will investigate the relationship between physiological responses and subjective experience in greater detail.

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REFERENCES

[1] *Half-Life 2 (Digital Game)*. Valve Corporation Seattle, WA, 2004.

[2] Appelman, R. Experiential Modes of Game Play. In *Proceedings of the Situated Play, Proceedings of the DiGRA 2007 Conference* (Tokyo, Japan. DiGRA, 2007), 815-822.

[3] Brown, E. and Cairns, P. A Grounded Investigation of Game Immersion. In *Proceedings of the Conference on Human Factors in Computing Systems* (Vienna, Austria). ACM Press, 2004.

[4] Cacioppo, J. T. *Handbook of Psychophysiology*. Cambridge University Press, 2007.

[5] Cacioppo, J. T., Tassinary, L. G. and Berntson, G. G. Psychophysiological Science. *Handbook of psychophysiology (*2000), 3-26.

[6] Cacioppo, J. T., Tassinary, L. G. and Berntson, G. G. Psychophysiological Science. *Handbook of psychophysiology (*2007), 3-26.

[5] Rather than looking at the net effect of subjectively reported experience over a complete play session.

[7] Chen, J. *Flow in Games*. University of Southern California, Los Angeles, USA, 2006.

[8] Csikszentmihalyi, M. *Beyond Boredom and Anxiety*. Jossey-Bass Publishers, San Francisco, 1975.

[9] Csikszentmihalyi, M. *Flow: The Psychology of Optimal Experience*. HarperPerennial, New York, 1990.

[10] Ellis, G. D., Voelkl, J. E. and Morris, C. Measurement and Analysis Issues with Explanation of Variance in Daily Experience Using the Flow Model. *Journal of Leisure Research*, 26, 4 (1994), 337-356.

[11] Ermi, L. and Mäyrä, F. Fundamental Components of the Gameplay Experience: Analysing Immersion. In *Proceedings of the DiGRA conference Changing views: worlds in play* (Vancouver, Canada). DiGRA, 2005.

[12] Fisher, C. D. Boredom at Work: A Neglected Concept. *Human Relations*, 46 (1993), 395–417.

[13] Fridlund and Cacioppo Guidelines for Human Electromyographic Research. *Psychophysiology*, 23, 5 (1986), 567-589.

[14] Grimshaw, M. *The Acoustic Ecology of the First-Person Shooter: The Player, Sound and Immersion in the First-Person Shooter Computer Game*. VDM Verlag Dr. Mueller e.K., Saarbrücken, 2008.

[15] IJsselsteijn, W. A., Poels, K. and de Kort, Y. A. W. *Measuring Player Experiences in Digital Games. Development of the Game Experience Questionnaire (GEQ)*. Manuscript in preparation.

[16] Jackson, S. A. and Marsh, H. W. Development and Validation of a Scale to Measure Optimal Experience: The Flow State Scale. *Journal of Sport and Exercise Psychology*, 18, 1 (1996), 17-35.

[17] Kivikangas, J. M. *Psychophysiology of Flow Experience: An Explorative Study*. University of Helsinki, Helsinki, Finland, 2006.

[18] Lang, P. J. The Emotion Probe. Studies of Motivation and Attention. *American Psychologist*, 50 (1995), 372-385.

[19] Lang, P. J., Greenwald, M. K., Bradley, M. M. and Hamm, A. O. Looking at Pictures: Affective, Facial, Visceral, and Behavioral Reactions. *Psychophysiology*, 30 (1993), 261-273.

[20] Lykken, D. T. and Venables, P. H. Direct Measurement of Skin Conductance: A Proposal for Standardization. *Psychophysiology*, 8, 5 (1971), 656-672.

[21] McMahan, A. *Immersion, Engagement, and Presence: A New Method for Analyzing 3-D Video Games*. Routledge, New York, 2003.

[22] Nacke, L. and Lindley, C. Boredom, Immersion, Flow - a Pilot Study Investigating Player Experience. In *Proceedings of the IADIS Gaming 2008: Design for Engaging Experience and Social Interaction* (Amsterdam, The Netherlands, July 25-27). IADIS Press, 2008, 103-107.

[23] Nacke, L., Lindley, C. and Stellmach, S. Log Who's Playing: Psychophysiological Game Analysis Made Easy through Event Logging. In *Proceedings of the International conference on Fun and Games 2008* (Eindhoven, The Netherlands, October). Springer, 2008.

[24] Novak, T. P., Hoffman, D. L. and Yung, Y. F. Measuring the Flow Construct in Online Environments: A Structural Modeling Approach. *Marketing Science*, 19, 1 (2000), 22-42.

[25] Ravaja, N., Saari, T., Laarni, J., Kallinen, K., Salminen, M., Holopainen, J. and Järvinen, A. The Psychophysiology of

Video Gaming: Phasic Emotional Responses to Game Events. In *Proceedings of the DiGRA conference Changing views: worlds in play* (Vancouver). Digital Games Research Association, 2005.

[26] Ravaja, N., Saari, T., Salminen, M., Laarni, J. and Kallinen, K. Phasic Emotional Reactions to Video Game Events: A Psychophysiological Investigation. *MEDIA PSYCHOLOGY*, 8, 4 (2006), 343-367.

[27] Ravaja, N., Turpeinen, M., Saari, T., Puttonen, S. and Keltikangas-Jarvinen, L. The Psychophysiology of James Bond: Phasic Emotional Responses to Violent Video Game Events. *Emotion*, 8, 1 (2008), 114-120.

[28] Salminen, M. and Ravaja, N. Increased Oscillatory Theta Activation Evoked by Violent Digital Game Events. *Neuroscience Letters*, 435, 1 (2008), 69-72.

[29] Vorderer, P., Wirth, W., Gouveia, F. R., Biocca, F., Saari, T., Jäncke, F., Böcking, S., Schramm, H., Gysbers, A., Hartmann, T., Klimmt, C., Laarni, J., Ravaja, N., Sacau, A., Baumgartner, T. and Jäncke, P. *Mec Spatial Presence Questionnaire (MECSPQ): Short Documentation and Instructions for Application*. IST-2001-37661, 2004.