Hades Again and Again: A Study on Frustration Tolerance, Physiology and Player Experience

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***Abstract*—Accurately quantifying player experience is challenging for many reasons: identifying a ground truth and building validated and reliable scales are both challenging tasks; on top of that, empirical results are often moderated by individual factors. In this study, we investigate the impact of individual differences in the operationalisation of player experience by cross-referencing multiple modalities (i.e. questionnaires, gameplay and heart rate) and identifying the interplay between their scales.**

***Index Terms*—player experience, game experience questionnaire, behavioural inhibition system, behavioural activation system, heart rate**

I. Introduction

Player experience (PX) modelling plays a crucial role in game development and game research by providing insights into how players perceive, interpret, and engage with games. It focuses on understanding the psychological, emotional, and cognitive aspects of gameplay, allowing game designers and researchers to create more immersive and enjoyable experiences for players.

However, accurately quantifying different facets of PX remains a challenging problem to this day for many reasons. PX is inherently subjective and influenced by various contextual factors, such as individual preferences, cultural backgrounds, and prior gaming experiences. Furthermore, it comprises multiple dimensions, including emotions, cognitive engagement, social interaction, and immersion. These dimensions interact with each other and are also influenced by personal differences.

Finally, selecting appropriate tools and methods for quantifying PX is challenging. Traditional survey-based methods may not capture the nuances of subjective experiences effectively and are summative in nature. Researchers need to develop innovative techniques, such as physiological measures (e.g., heart rate variability), behavioural observation, or eye-tracking, to complement self-report measures and provide a more holistic understanding of the player experience.

PX dimensions, such as engagement, enjoyment or frustration, all share these common challenges. For instance, some people have a high frustration tolerance and are less likely to get as annoyed or frustrated at minor setbacks, whereas those with a low frustration tolerance easily grow agitated at the same inconveniences. It is likely that these individual differences would have an impact on the operationalisation of frustration.

Within PX research, these individual and contextual differences are often overlooked as they rely on information that is often intangible and external to the games; however, aspects such as frustration tolerance have been studied extensively in other fields [9], [12].

In this paper, we present a study aimed at investigating the moderation effect of contextual and individual differences on PX. In the study, we analyse and evaluate the PX of a sample of players playing Hades [6], a competitive action game, and we investigate the interplay between a number of self-reported scales, players' performance, their heart rate and their tolerance to stress and frustration.

With this study, we aim at answering the following research questions:

- Q1 Do individual differences in frustration tolerance have a measurable impact on the player experience in action games?
- Q2 Do individual differences in players' psychophysiological responses have a measurable impact on the player experience in action games?

II. Related Work

Frustration and how it relates to gaming has been studied in many different contexts, this includes studies into how near-misses, despite causing frustration, can increase the urge for players to continue playing Candy Crush [8], adaptive design in video games where frustration plays a role [17], as well as dynamic difficulty adjustment [18].

One of the primary challenges with employing frustration or other aspects of the PX for adaptation of dynamic difficulty adjustment is the operationalisation of the chosen construct. Several studies have attempted to quantify frustration; among these, probably, the most common approach is through questionnaires, with instruments like Game Experience Questionnaire (GEQ) [7], GUESS [11] or ENJOY [4].

These questionnaires offer powerful and validated tools to estimate several aspects of PX; however, they heavily rely on players' self-awareness and they offer low granularity in terms of which aspect of the game experience and the player behaviour has elicited a specific player reaction.

To alleviate these limitations, several researchers have investigated how to operationalise PX through other means. For example, Shaker et al. [13] investigate the fusing of gameplay

data and head movement, while Burelli et al. [1] used full-body posture and movement. Other researchers have investigated the use of psychophysiological signals, such as heart-rate [5] and galvanic skin response [3], showing how they can be powerful game-independent markers of PX [10].

While some of the aforementioned studies attempt to infer individual differences from data collected within the analysed gaming experience, most of them do not take into account contextual individual differences in terms of personality and attitude. In this paper, we attempt to explore this dimension of PX, estimate the impact of these contextual differences and evaluate whether they can be measured and detected.

III. Methods

To estimate the interplay between personal attitude, reported PX and player behaviour, we conducted an empirical study of the player experience in the game Hades [6]. During the experiment, we collected self-reported feedback on the PX through a subset of the Game Experience Questionnaire, including all scales from the Core and the Post-game modules. Furthermore, we collected in-game player behaviour and the players' heart rate through the Polar H10 ECG sensor[1]. The last aspect captured is the players' tolerance to frustration, estimated using the BIS/BAS [2] questionnaire, paired with FNR [16] questionnaire.

The BIS/BAS scales are primarily used to assess dispositions to anxiety, depression and other mental disorders, but have also proven to be useful for finding relations in personality traits [15]. The questionnaire is structured into 4 subscales; BIS, BAS Drive, BAS Fun Seeking, and BAS Reward Responsiveness. BIS explains the tendency for individuals to avoid negative outcomes, this means that high BIS scores in individuals are connected to higher feelings of anxiety. BAS and its sub-scales explain individuals' tendency to respond to rewards or to engage in goals where the possibility of reward is there. FNR measure the motivational response to the lack of reward.

A. Protocol

Each recording session is individual and the player plays the first few levels of Hades for approximately 30 minutes using a joy-pad controller. All sessions were conducted according to the following procedure:

1) Set up the Polar H10 and make sure it connects with the Polar Flow app.
2) Set up Hades and the controller.
3) Test-run the recording software to make sure it works.
4) Start a new save/profile on Hades on Hell mode.
5) Invite the participant in and make sure they're comfortable.
6) Ask them to put on the heart-rate monitor. Have a picture ready to show how it's supposed to sit. Give them access to a bathroom and a towel so they can put it on in privacy.
7) Have the participant sit down and make sure they're comfortable while connecting the sensor to the app.
8) Let the player know that the first chamber will not contain enemies so they can run around and get used to the controller before continuing.
9) Let the player know that there will be a menu at the start of each new run but all they need to do is click 'Begin Escape' when it pops up.
10) Tell the player that once the 30 minutes are up, you will place a paper next to them stating "Last Run!" which means they continue to play until they complete the current, and then the Play Session will be over.
11) Start the screen-recording software at the same time as the app.
12) Sit for 1-3 minutes to capture the normal heart rate and then tell them they can begin playing.
13) After the 30 minutes are up, discreetly place the piece of paper that says "Last Run!" next to the player, and wait for them to finish the current run.
14) Let them know they can take off the heart rate monitor and make sure they're ready to take the finishing questionnaire.
15) Bring up the Game Experience Questionnaire on the computer and let them fill it out.

[1]https://www.polar.com/uk-en/sensors/h10-heart-rate-sensor

IV. Results

The study includes 20 participants with a mean age of approximately 27, mostly consisting of students from the IT University of Copenhagen and their acquaintances. For each participant, we collected answers to 29 questions corresponding to the frustration tolerance questionnaire, we recorded a video of their gameplay through screen recording, we recorded the heart rate and, at the end of the recording, we collected the answers to the 40 questions selected from the game experience questionnaire. Before the analysis, each gameplay video has been coded to identify the game events. The collected data, the video coding as well as the scripts used to analyse the data can be downloaded at https://github.com/itubrainlab/hades_player_experience/.

A. Features Extraction

The heart rate data recorded is structured as a time series of heart rates recorded at a frequency of 1 Hz. From this data, for each player, we have extracted 6 features capturing the minimum (*hr_min*), maximum (*hr_max*) and mean (*hr_mean*) value of heart rate, its standard deviation (*hr_std*), and the fraction of time each player kept their hearth rate around their minimum value (*hr_bottom*) and around the maximum value (*hr_peak*).

The gameplay events extracted contain information about the length of each run, the number of stages cleared and the number of defeats in the game. In Hades, at each defeat, the player restarts from the beginning of the game, which resets their progression. The features extracted from the gameplay data are the time length of each run (*mean_run_time*), the number of stages visited in total (*total_chambers*), the furthest

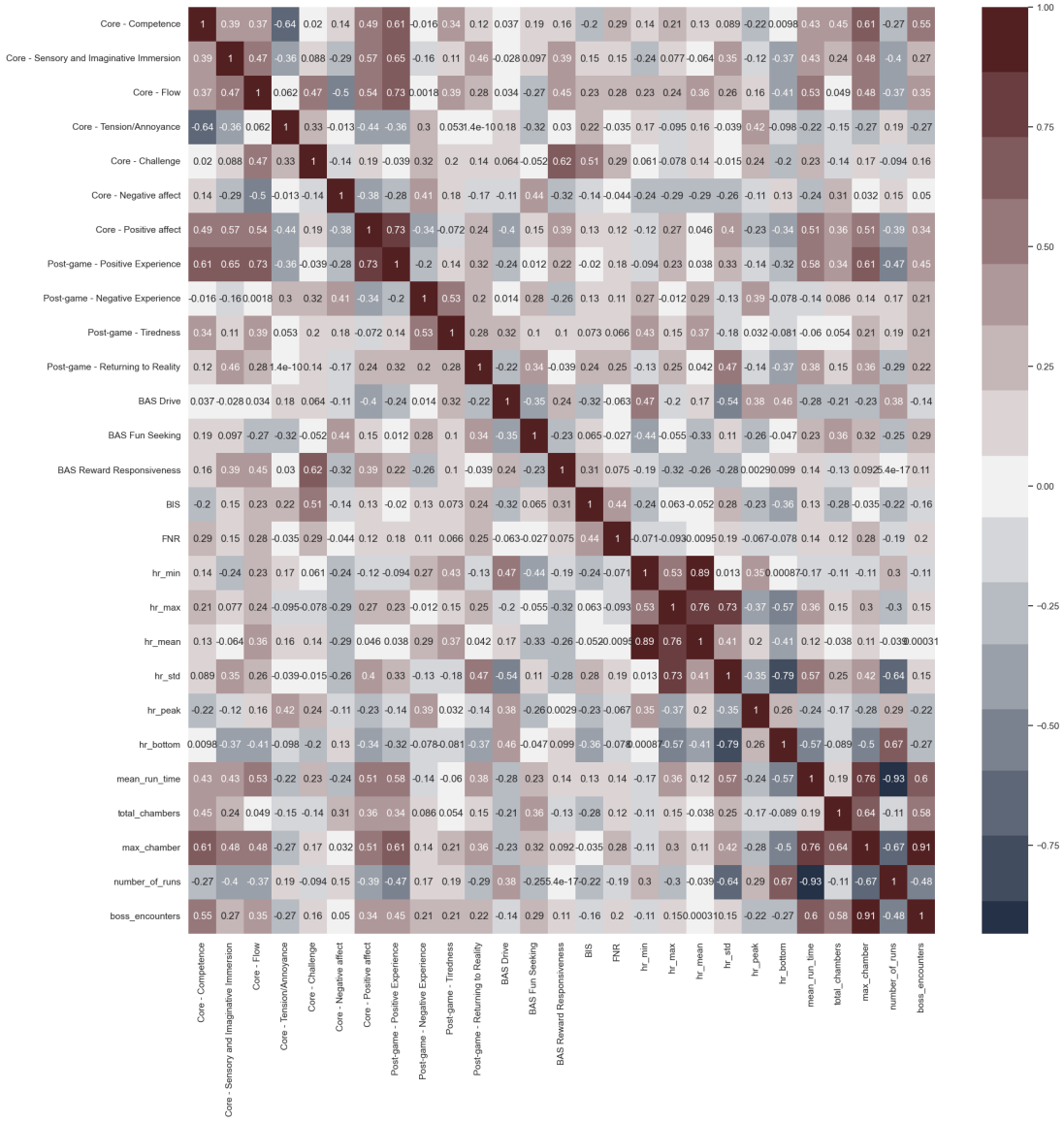

Fig. 1. Correlation matrix between the scales from the two questionnaires and the features extracted from the heart rate and game events.

stage reached in every run (*max_chamber*), the number of defeats and runs (*number_of_runs*) and the number of times a player reaches the first boss encounter (*boss_encounters*).

B. Analysis

As a first approach to answer the research questions presented in Section I, we conducted a correlation analysis to identify the presence of a linear relationship between the scales measuring the frustration tolerance, the heart rate features, the in-game behaviour and the reported PX.

Figure 1 shows the results of this analysis. The correlations show how each group of features and scales is internally correlated, with PX aspects such as *Flow* being strongly correlated with *Positive experience* ($r > 0.7$).

Across the scales, we can observe how the behavioural feature *max_chamber* shows a medium-strong correlation ($r > 0.6$) with multiple scales in GEQ (*Competence* and *Positive Experience*) which is likely due to the tight relationship between enjoyment and performance in an action game like Hades.

It is interesting to observe how performance, described by *max_chamber*, demonstrates a medium correlation with both PX scales and heart rate (*hr_std* and *hr_bottom*). This relationship emerges also by dividing the players according to their performance. When the players are split according to the median value of *max_chamber* ($median = 9$), the players with a higher performance than the threshold show a significantly higher *hr_std* (7.4 vs 4.6) and a significantly lower *hr_bottom* (16% vs 36%), both having a p-value < 0.0005.

Hearth rate variability is an established measure of the activation of the sympathetic and parasympathetic nervous systems [14], so a likely interpretation is that the capacity

to increase and decrease the heart rate is a sign of the player's ability to respond to the challenge and perform better in the game.

The scores resulting from the frustration tolerance scales do not show any strong correlation with the other scales types and features; however, there is a medium correlation between *Reward Responsiveness* and *Reported Challenge* that might indicate a role of the individual importance of reward with their perception of challenge.

Another possible impact of frustration tolerance and heart rate on player experience is their potential role as moderators on other features – i.e. whether combining individual differences with gameplay features yields a stronger correlation with PX. To evaluate this kind of effect we trained a linear regression model using either heart rate or frustration tolerance features paired with gameplay features to assess the correlation of the linear combinations with reported player experience.

This analysis reveals that *hr_bottom* linearly combined with player performance (*max_chamber*) is strongly and significantly correlated with *Competence* ($r > 0.7$, $p = 0.0004$) with a 16% improvement over the single factor correlation shown in Figure 1. This result indicates that the differences in the dynamic behaviour of the heart rate have a moderator role in the players' feeling of competence.

On the contrary, the same analysis conducted on frustration tolerance scales does not reveal any strong combined correlation.

V. Discussion and Conclusions

In this paper, we present a study investigating the role of individual differences in the quantification of player experience. The individual differences accounted for in the study include players' heart rate behaviour and their self-reported response to frustration and stress, and the player experience is quantified through the game experience questionnaire and the players' in-game behaviour.

The results and the analysis show no conclusive evidence of either an indirect or a direct impact of the reported frustration tolerance on the players' behaviour and player experience; however, the few reported medium correlations and moderator effects suggest this aspect might require some further investigation. Individual differences in heart rate behaviour, instead, show both a medium correlation with player performance and a strong correlation as a moderator effect between player performance and self-reported competence.

These results are consistent with previous studies on the relationship between the activation of the autonomous nervous system and heath rate variability [14] and hint at a potential for the dynamics of the heart rate to be a valuable feature for player segmentation and player experience interpretation. However, heart rate standard deviation has limited granularity compared to heart rate variability (HRV) [14], so to confirm the results of this study and draw a more accurate picture, we believe further studies are needed.

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