# Approaching Gameplay Reactions with Patterns in Biometric and Visual Data

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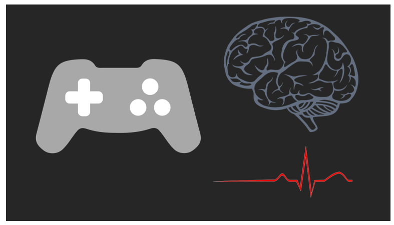

Figure 1: Human body gameplay reactions illustration

## Abstract

The question of how games, especially video games, affect players has always been a hotly debated topic in academia, industry, and in some cases, politics. Most of these debates revolve around the effects of violence portrayed in games on children and teenagers. This tendency results in other, less controversial but still important, questions about the effects of playing video games being overlooked. This project aims to empirically evaluate the emotional responses of players, as they play, by measuring and analysing some of their biometric data, and using facial recognition technology to interpret their emotional state. The ability to measure emotional reactions accurately could open doors to a new level of gaming development, adaptive gaming or even deeper emotional studies.

**Keywords:** gaming, emotions, reactions, datamining, affective computing

## 1 Introduction

The effects of video games on people who play them, specially children, have been a topic of debate since the late 80s and early 90s[1]. At that time, technology had reached a point that made realistic depictions of violence something that could bother the community. Although, the discussion about violence had created diverse points of view, we can find mainstream discussion on the effects of video games on players that continues with the same idea.[2]. There are still several different consequences of playing games that needs further research studies.

Information on how players react to certain stimuli could be incredibly valuable to game designers looking to better understand players and create more appealing games, although identifying relevant incentives and reactions can be very difficult. Human emotion can be extremely hard to accurately identify in any deterministic way, but breakthroughs have been made in this field (examples of which are used in this study), and major developers are starting to work on collecting this data [3]. The applications of the knowledge acquired from players emotions vary from informing how marketing should approach the consumer base to adapting the games themselves in real-time [4].

In this project we sought to find some kind of predictable pattern in the emotional state of a player given certain situations in a game. In order to accomplish this, we gave players a game to play while they had their heart rates monitored and faces filmed. Then the data was analyzed against footage of the game, looking for correlations of any kind. To accomplish that, we used a Naos QG mouse by Mionix [5] and the Kairos emotion recognition system [6].

Using the collected data, our goal is to find relationships between the human emotion and video games. To find these relationship we diveded gameplay footage into three sections ('calm', 'light action' and 'tense action').

We believe that video games can have distinct impacts in the human body in different situations. This work in progress act as a proof of concept of this hypothesis, showing this relationship through data analysis.

## 2 Related Work

Despite the early adoption of these studies some very promising work already exist. University of Porto, in Portugal, has a very deep and data-driven paper studying emotions risen from gaming and multimedia [7]. In this study the data used was also coming from heart rate and galvanic skin response sensors, along with electromyography data.

Another work worth citing is Disney's [8]. Disney is turning to AI and deep learning to detect reactions of people watching their movies and adapting content to it. It is even considered to be used in Disneyland's amusement parks.

## 3 Study Design

Video games as an artform attempt to create emotions in the player with a combination of story, music, visuals and gameplay. The study of the first three elements mentioned before have gone on for far longer than video games have existed and have well established theories about them. In video games such studies are sorely lacking. There is a demand for insight into the relation of game mechanics and emotions, but, although it exists [9], very little formal academic research has been made on the subject.

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One of the obstacles impeding the study of emotions in games is the fact that identifying and quantifying emotions is complex. Biometric data (heart rate, GSR, etc...) vary greatly from person to person and there isn't one specific cause for fluctuations in the results. For example, someone's heart rate can increase for a number of reasons (excitement, fear, anger, etc...). The data collected can be hard to interpret, even with full knowledge of the context.

An alternative to biometric data would be trying to read the emotions directly by automatically analyzing the behavior of the subject using a computer. In the case of a person playing a videogame, one logical approach would be to capture footage of the player and use a system that can detect their emotions from their facial expressions or body language. The trade-off of this case in relation to the biometric data is that tools to recognize emotions in this manner are much less reliable and accurate than the ones that can read simpler signals like heart rates, etc... In this project we will attempt to combine both types of technology to better understand what happens to a person while playing.

### 3.1 Data Collection

The game chosen to be used for the tests was Ziggurat, a FPS (First Person Shooter) with rogue-like elements, published and developed by Milkstone Studios and released on October 23, 2014. In it, players select a character and explore a dungeon collecting weapons, earning upgrades and battling bosses to advance to the next level. Once the player character dies all progress is lost, new upgrades and weapons to be found in the dungeon are made available and, once certain requirements are met, new characters are unlocked for selection. This game was chosen for two reasons: First, the combination of fast-paced action from the FPS genre with rogue-like's permadeath (or permanent death: the loss of progress following the death of the player character) seemed to be effective in creating tension in the player. Second, mouses are the preferred form of control for FPS games and the mouse was the main data collection tool for the player's biometrics in this project.

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Figure 2: Screenshot of the game Ziggurat

The mouse used to capture the biometric data from the players was the Naos QG, manufactured by Mionix. It has sensors that can detect the user's heart rate and the GSR (galvanic skin response), both of which are believed to be related to a person's emotional state. Mionix has a software available to display the information being collected but, for this project, custom software was developed using the mouse's existing APIs.

As an additional input to the analysis, footage of the players' faces was recorded for processing by the Kairos emotion recognition software. The software in question takes a picture or footage of a human face and uses the positions of certain facial features to determine the emotional state of the people in said photo or video. The emotional state is represented by six basic emotions: anger, disgust, fear, joy, sadness and surprise, each of them scored from 0 to 100.

After that the footage was tagged by a human to determine if the action in-game was calm, light or tense, so later the tags could be compared to the data collected by the computer.

The data collection process can be described systematically bellow.

1. The experiment focused only on analyzing 3 male subjects (they will be named Arthur, Bob and Charlie, following the convention in cryptography. Alice missed the experiment.)
2. Each subject played for a whole round (until death)
3. The subjects played in an empty and closed room
4. The game was fixed on Normal difficulty
5. The sound was kept in a reasonably loud volume
6. The gameplay and facial footage was recorded with OBS Studio software
7. Biometric and input data was collected from Mionix Naos QG Mouse
8. The gameplay footage was tagged in short clips named 'calm', 'light action' and 'tense action'

### 3.2 Data Processing

Having collected the game data a few scripts were written to process it and setup the framework for analysing it. The process is described next.

1. The biometrics data of the mouse was collected and kept in a MySQL table
2. Each biometric data had the timestamp of when the measure was taken
3. A python script cropped the face of the player from the gameplay footage
4. A python script was used to read the video tags file and insert the clip information in a MySQL table
5. With the clips info and its timestamps in the database, a python script was used to cut the video clips from the footage, both face and gameplay.
6. With the video clips ready, the facial video of each clip was submitted to kairos to gather the emotion information, also using a python script.
7. With all the video clips and data correctly indexed and synchronized in MySQL, a jupyter notebook was used to plot the data of a clip with the actual video clip to check for patterns.

The results, despite being collected only from 3 subjects, are very interesting and are discussed in the next section. All the scripts are available for review of the data on github [6], given the actual video files are present.

## 4 Discussion

The data was analyzed, as written before, using a jupyter notebook which was setup to display the footage a specific tagged clip along with the plotted data of heart rate and the emotions extracted from the facial analysis.

### 4.1 Data Value

Using the jupyter notebook it is possible to analyze any clip we want. A quick scan through the clips is enough to realize that interesting patterns are risen from the heart rate plots. However, the facial emotions reported by Kairos system do not seem to make much sense. GSR measures seemed to have bouncing issues due to the lack of constant mouse touch.

Kairos system analyzes the facial landmarks and it is trained in a general sense. It reported fear and disgust for a long period of gameplay time. It is possible that it has associated the player gazing slightly down to the laptop to fear emotions. Also, micro expressions with the mouth closed could also be the cause of the disgust emotions reported. Therefore, a general facial emotion classifier does not seem to be effective for gameplay footage, a micro expression classifier specifically trained for that purpose might have a better effect.

The heart rate measures, on the other hand, were very useful. GSR measures of conductivity are very choppy but can be visually analyzed by looking at the minimums, which indicate times when sweat measures were taken more accurately. There are also small moments where the Naos QG mouse fails to capture the heart rate consistently due to the difficult of the player to fit the hand in the mouse correctly. However, most of the measures are consistent with what happens in the game. Most patterns observed arise from the heart rate measures, which were analyzed more closely than the others. Some of them are described below.


Figure 3: Footage of the gameplay clip

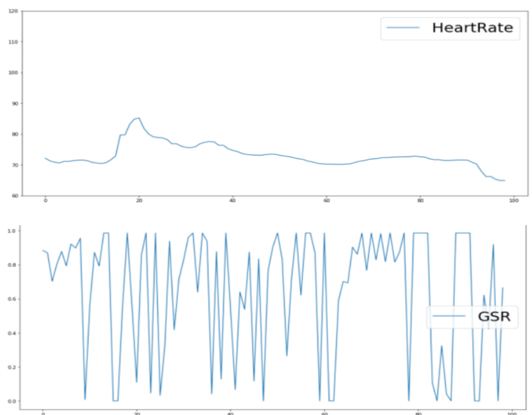


Figure 4: Heart rate and Galvanic Skin Response signals of gameplay clip

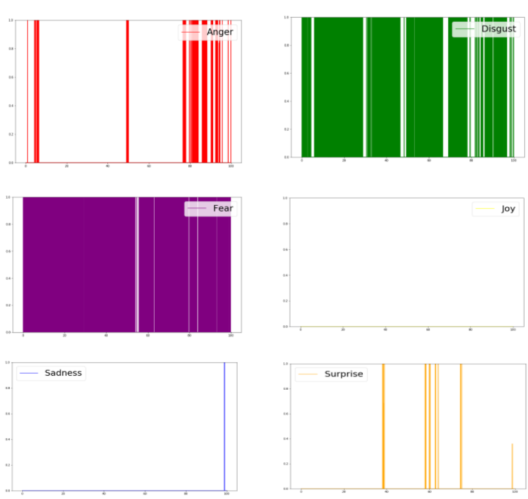


Figure 5: Facial emotions detected by Kairos system

## 4.2 Patterns of Data

Using the tagged video clips it is easy to identify these patterns emerging from specific parts of the gameplay, even though the reactions varied little according to the current player.

### 4.2.1 Tension related to tagged levels of game activity

As previously described, the game was divided into three different sections to determine if the action in-game was calm, light or tense. The patterns found were close to the what a common person would expect.

The calm section had, in average, the lowest heart rates of the three sections, that could fall further if the player was reading a menu. The light action had small variance, keeping the same heart rate in the entire section. The tense section was the most turbulent one, achieving high variance of heart rates, and the biggest average of the three sections.

### 4.2.2 Tension while struggling with enemies

It was observed that players increased their heart rate while struggling with enemies. However, this increase was not significant and it may not happen at some moments of the game. The real increase in heart rate happened when players started to receive constant damage from enemies, what may suggest that they were experiencing an emotion of danger and started to be more alert.

### 4.2.3 Spikes of tension during boss fights

Similar to other games of the same genre, Ziggurat has, from time to time, challenges with increased difficulty against stronger enemies, the bosses. The boss fights were designed to be a big challenge for the players, where they could prove themselves worthy of progressing further in the game.

These fights had the most expressive increase of heart rates among all others, which shows that big challenges in games can directly affect your body. Observing the data, we found clips where the heart rate jumped from 107 to 124 (clip number 101) in a matter of seconds, while the player was going through a boss fight.

### 4.2.4 Spikes of tension caused by eventual surprises

The game environment sometimes provided some sudden moments of surprise, when spikes came out of the ground or specific objects fire at you when you enter a room. There are a few clips where this happened together with an increase in the heart rate of the player.

As examples, in the clips number 88 and 100 this is shown very obviously. In clip 88, the heart rate jumps from 100 to 118 and on clip 100 it jumps from 110 to 120. Those variations fall exactly during the moments of stress.

### 4.2.5 Reduced heart rate during pauses

It was observed that during pauses of the game, specifically during the choices of character upgrade, the heart rate had sudden drops. That may suggest a shift into a more relaxed activity recognized by the body of the player. This reaction can be observed in clip 119 around second 13 when the heart rate dropped from 94 to 85.

#### 4.2.6 Sudden change on measures while losing focus in the game

A similar pause pattern was observed when players lost focus in the game to check if the footage and data collection were being recorded correctly or when the game was loading a new dungeon level.

### 4.3 Variations of reactions among players

After the analysis of the patterns described above, an interesting insight emerged from it. It was clear, after observing the data, that different players generate different and unique reactions to the same challenge. It still unknown the cause of these differences, however, we strongly believe that this result could be related to physiological uniqueness of each individual in a moment of tension.

All the three players had really unique reactions. Arthur, for example, had a significant raise on heart rate every time he encountered a challenge that involved timing, such as jumping away from deadly spikes at the right time. In other hand, Bob had raises on heart rate while fighting against fast enemies and Charlie stayed relatively calm for the entire session.

Another interesting fact was the base heart rate of each player. Arthur had an average of 100 bpm, Bob 90 bpm and Charlie 70 bpm.

## 5 CONCLUSION

### 5.1 Summary

Reading multiple parameters to analyze a player's emotions mid-game does seem to be the most promising way to gain a better understanding of the impact of game mechanics on people. A player's heart rate seem to be very indicative of moments of tension and stress, but the causes of these feelings vary wildly from person to person. The patterns extracted from these measures at specific parts of the game are very promising. They can and should be further analyzed in an experiment with larger amount of subjects to reach statistically valid conclusions and deeper understanding of game situations.

The visual data, on the other hand, has not shown as much promise. First, the technology doesn't seem to report the data accurately for this application, showing high scores for fear and disgust during almost the entirety of the footage. Second, the players don't seem to express much emotion with their faces in this situation and this data becomes very noisy when compared to the results obtained by the biometric analysis.

### 5.2 Future Works

This work was an initial way to prove that it is possible to extract and analyze deeper patterns between gameplay and player reactions. All observed patterns were extracted from an experiment with just 3 subjects and must be further analyzed in a more statistically valid work to be able to provide deeper insights on gaming.

There will be more experiments in this work, some improvements include:

#### 5.2.1 Collect data from more subjects

By using more subjects in the experiment, isolated patterns can be discarded or confirmed statistically. Next experiments intend to analyze data from at least 100 players.

#### 5.2.2 Controlled variations of difficulty

Even though the difficulty of the Ziggurat game was fixed on Normal, the encounters and bosses were random. This increases the variance of the experiment. Next experiments should use a simpler game where the seed can be fixed and controlled.

#### 5.2.3 Additional biometric sensors

Given that the concept is already proven, in the bigger and longer experiment there has to be additional sensors to be able to verify the value of each of them. To collect the same emotions as Kairos, a lightweight EEG Emotiv EPOC+ [10], will be used for higher reliability. Other models of facial micro-expressions can also be included. Another good device for collecting biometric data is MySignal's [11] platform and its sensors.

#### 5.2.4 Basic information of all subjects collected

With a bigger experiment, it is important to keep track of basic subject information such as age, gender, gaming experience, stress levels, medications and so on. This can be done with a simple digital form integrated with the database.

#### 5.2.5 Processing the data for patterns with Data Mining Tools

With a larger amount of data it will be possible to use better feature selection techniques, clustering or classification techniques to make patterns more explicit or even uncover new ones. Hopefully this will give deeper insights and directions to the game industry by taking advantage of these patterns.

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