Correlation between user experience in electronic entertainment and psychophysiological measurements

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***Abstract*—With the increase in popularity of electronic entertainment (EE), the demand of optimization of its individual element arose. Big studios producing products of EE (movies, video-games, music, etc.) are benefiting from any gathered feedback from their customers. Customer's reaction to individual parts of the video-game might be invaluable for future level-designers, in form of information about each single aspect/feature targeted in the optimization process. In this paper, we present a study of individual checkpoints on the way of optimizing such EE products using artificial intelligence. We also present a way of using psychophysiological measurements of subjects playing video-games or watching movies to optimize their general EE experience.**

***Keywords*—Electronic entertainment, Psychophysiological measurements, Heart rate, Video-games**

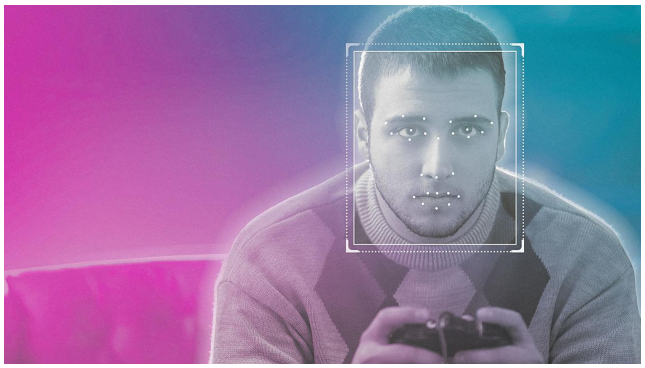

Fig. 1: What Happens When Video-Games Can Read Your Face [6]

I. Introduction

Psychophysiological measurements proved to be an objective, continuous, real-time, non-invasive precise way to assess the game experience. Although, for best results, it is needed to carefully control the experiment using the specialized equipment (both problems addressed in following sections).

Using the psychophysiological data, we should be able to find correlation between various features in tested domain and current phychophysiological state of the subject. Thus, giving the developer the information about how the subjects reacts to current segment in the domain. In the past, researchers were trying to determine the players experience through set states, such as boredom, using known emotional states instead of psychophysiological measurements [1]. For example, if the subject playing a video-game is getting bored (state determined by an exact combination of psychophysiological states) while walking in the long corridor with no enemies, the level-designer has an option to either add some enemies (if the story line allows it - [2]). Some of the another options are to change the current music played, even changing the shape of the corridor completely using a Procedurally Generated Content (PCG) algorithm [3]. This implies that video-games may definitely be considered as an emotional experience [4].

There are numerous psychophysiological measurements which may be useful for this research: Heart Rate (HR), Electro-dermal Activity - Skin Conductivity (EDA), Facial Electromyography (EMG), Electrocardiogram (ECG), etc. [5]. Although so far we have only used HR data. In the future, we are planning to gather information about subject's EDA and their individual emotional states using image recognition [6]. This opens another interesting course of research - finding a correlation between psychophysiological measurements and emotional states of the subjects. Fleming an Rickwood studied the difference between violent and non-violent video-games on children's arousal, aggressive and positive moods [7].

In our research, we plan to incorporate continuous HR data into similar demo as shown on Fig. 2. We will try to find a correlation between individual game events and responses of the subjects. Afterwards, we plan to use one the well-known artificial intelligence techniques to optimize user experience in specific domain.

II. Related Work

In the past the research of psychophysiological responses may have been focused on a different goal then optimization EE products - such as work of Ballard an Wiest in 1996, where they studied the effects of violent video-games on male's hostility and their cardiovascular responses [8]. Another interesting feature (while very easy to control during the game) is an amount of blood in the game. Barlett et. al. studied the effect of the amount of blood in a violent video-game on aggression, hostility and arousal of the players [9].

Of course, the domain with highest psychophysiological changes of subjects are horror movies and video-games. Dekker and Champion focused on said domain studying the effect of fearful experiences on the subjects [10].

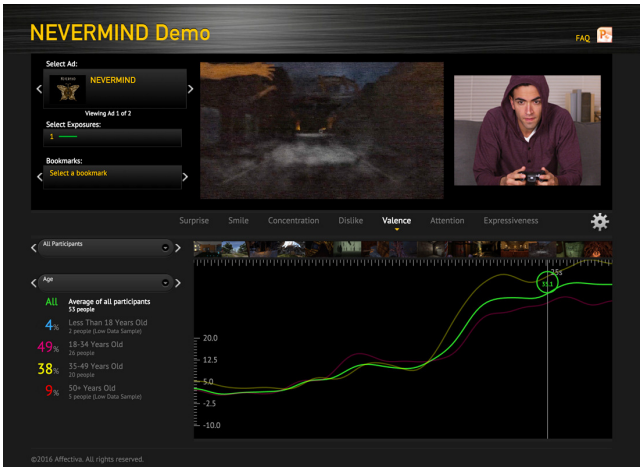

Fig. 2: Demo of Affectiva Software [13]

The experiments require fairly big number of subjects, since there are very different results throughout individuals as a players. Kallio et. al. determined up to 9 different types of gaming mentalities [11]. As stated in [12] by Tafalla, even subject's gender plays fairly important part in their psychophysiological responses during the experiment.

There is a fairly similar research done at MIT, studying player's responses to video-game in real-time, using the data gathered from subject's face (see Fig. 1) using image recognition techniques [13]. We expect this research's results to be very useful in conjunction with our data, hopefully even finding correlation between them.

III. Sensors

With the recent popularity increase of various wearable sensors, it becomes easier for developers to get valuable psychophysiological data as feedback from the customer during his EE experience. Up to recently, the most used way were simple questionnaires presented to the customers or effort to measure emotions of the subject using various image recognition techniques.

As previously stated, we have been using only HR data of the subject so far. Also only one subject has been tested during gameplay. For gathering the HR data series, we have been using the Fitbit Surge HR sensor[1]. After a brief survey of available wearable sensors, this one was chosen due to its ability to track HR during the whole day (instead of most available sensors which are tracking HR only during workout) and Fitbit's API provided for independent developers. The second sensor available for our research to gather HR data is Microsoft Band 2 which also meets said requirements[2].

For gathering EDA data (specifically Galvanic Skin Response - GSR) we are planning to use either non-commercial sensors connected to Arduino/Raspberry Pi or Shimmer3 GSR unit, which is considerably more expensive. After gathering enough GSR data, we are planning to compare it with HR data and find any possible correlation (indulging the research done in [14]).

Lastly, we will be using the facial features extracted from video stream of subject using Microsoft Kinect v2 sensor. Although Microsoft's SDK for Kinect only provides 3 basic emotional states of the subject, using image recognition we might be able to gather more specific information about subject's mood (such as [13]).

List of sensors which will be used in the research and their potential (desired) application:

1) Fitbit Surge HR for obtaining Heart Rate data.
2) Microsoft Kinect v2 for getting emotion data from face features.
3) EDA sensor for obtaining Galvanic Skin Response data real-time, to compare with HR

IV. Problem domains

Based on our extensive experience in the field, we have decided to try video-games as a starting domain of our research. Individual events in video-games are easy enough to keep track on, which is a major advantage when finding a correlation between them and subject's HR. We have chosen two games: Dota 2 (see section IV-A) and Hearthstone: Heroes of Warcraft (see section IV-B), both among the most popular games in their fields.

A. Dota 2

Dota 2 is a multi-player online battle arena (MOBA) game set in a three-dimensional (3D) graphical environment, presented from an oblique high-angle perspective. Two five-player teams compete in matches on an asymmetrical playing field. Each player commands one of 111 "Hero" characters, which feature unique abilities and styles of play. At the start of a match, all Heroes have an experience level of one: they level up, and become more powerful, by accumulating experience points through combat. Whenever a Hero gains a level, the player may unlock a new ability for them, or enhance their statistics.

Considering that Dota 2 as a multi-player game is played by two teams of 5 players, the possibility of another interesting research arises: Studying the effects of game events on each player within the team as well as whole-team impact. Having such data might open a possibility to simulate collaborative behavior of intelligent agents in a new way [15].

B. Hearthstone: Heroes of Warcraft

Hearthstone is a digital collectible card game that revolves around turn-based matches between two opponents, operated through Blizzard's Battle.net. Players can choose from a number of game modes, with each offering a slightly different experience.

Each Hearthstone match is a one-versus-one battle between two opponents. Gameplay in Hearthstone is turn-based, with players taking turns to play cards from their hand, casting spells, equipping weapons, or summoning 'minions' to do battle on their behalf. Unlike card games like Magic: The Gathering, the opposing player has no means to interactively interrupt or counter the current player's action during their turns, though may play cards on their turn that will create events that automatically respond to the other player's actions. Games may be between two players, or one human player and one computer-controlled opponent [16].

[1] https://www.fitbit.com/
[2] https://www.microsoft.com/microsoft-band/en-us

V. Experiments

As previously stated, we already did some elementary experiments in our research. We have tracked the subject playing 2 different video-games - Valve's Dota 2 and Blizzard's Hearthstone: Heroes of Warcraft (Hearthstone). The games were played in carefully controlled environment, where subject was not disturbed by any external events. These experiments already showed very different results emerging from the nature of the game itself. While Dota 2 as a Multi-player Online Battle Arena (MOBA) is more action-based game, Hearthstone is an turn-based card game.

Also, after a few sessions, we noticed the results vary slightly in each session. This might be caused by even minor changes in subject's current psychological or physiological state. Some of the factors affecting human involuntary neural system - thus the values of subject's HR are air temperature, body position, body size, medication use, even subject's satiation may take major part in the final outcome of the experiment. This again emphasize the importance of careful control over the experiments during our future research.

A. Dota 2

After 4 games of Dota 2, the subject showed an average 85.03 HR (see Fig. 4).

Resulting from the previous section, it has to be taken into consideration that recreating the same conditions for all experiments is near-to-impossible task. Especially when experiments are done with longer games, such as Dota 2, since it is difficult to play several games in a row at the same day.

After only a small amount of games played, we were already able to find some interesting patterns emerging from our experiments. It is obvious that HR of the player is rapidly decreasing while the player is dead (waiting for respawn). There are several spikes in the typical game of Dota 2, where the player is participating in so-called massfights (big encounter where most of the players are fighting enemy's team). In almost every game, there is also a significant spike in HR of player at the end of the game (see Fig. 3). This is caused due to most of the games ends with one last attempt of losing team to defend its base before conceding the victory to the enemy.

B. Hearthstone: Heroes of Warcraft

The subject played 3 sessions of Hearthstone games, one consisting of 4 games, other two of 2 games. Subject's average HR during the first two sessions was 76.97 (see Fig. 5). The third session showed average HR of 82,69 (see Fig. 6). Of course, while one Dota 2 game takes about 40 minutes to 1 hour on average, the typical Hearthstone game lasts for around 5-10 minutes. This is needed to be taken into account, since it is unlikely to preserve above-average HR for a long time during the game.

There are no obvious patterns visible from such low amount of experiments (compared to Dota 2), most likely caused by short nature of Hearthstone games. The results seem chaotic at first, but we are confident that after obtaining bigger dataset, some interesting patterns will be uncovered.

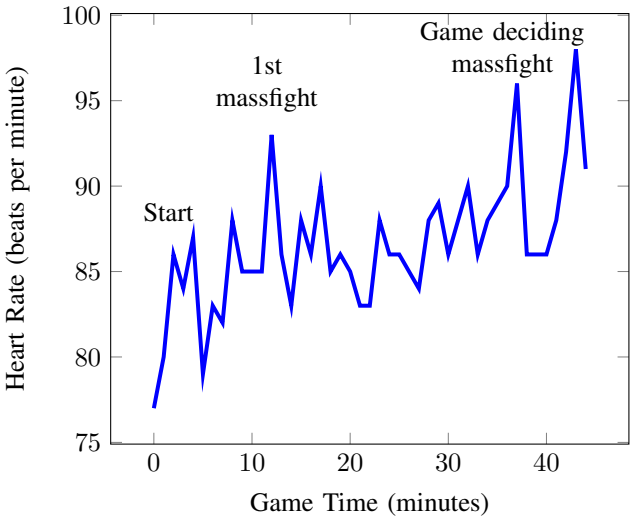

Fig. 3: Typical game of Dota 2 played by tested subject

Fig. 3 shows HR of subject during the game of Dota 2. Subject's HR increases significantly during massfights (big encounter where most of the players are fighting enemy's team), while decreases when the player is dead (waiting to respawn).

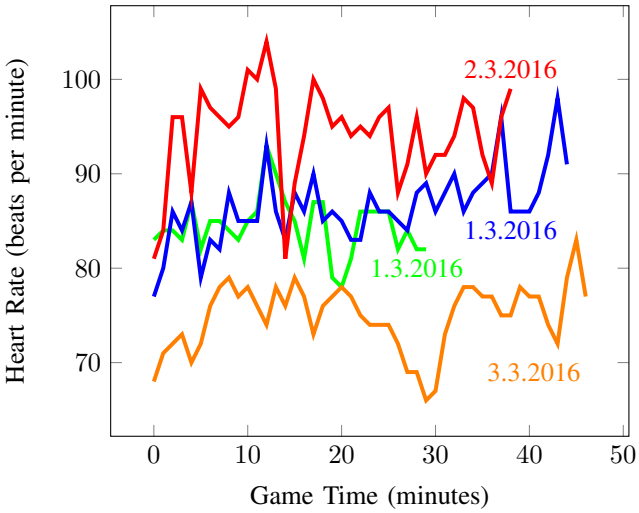

Fig. 4: 4 games of Dota 2 played by tested subject

Fig. 4 display similarities of subject's HR during 4 games of Dota 2, even though games were played in two different sessions. There are noticeable spikes of HR in several game stages, closely described in section VI.

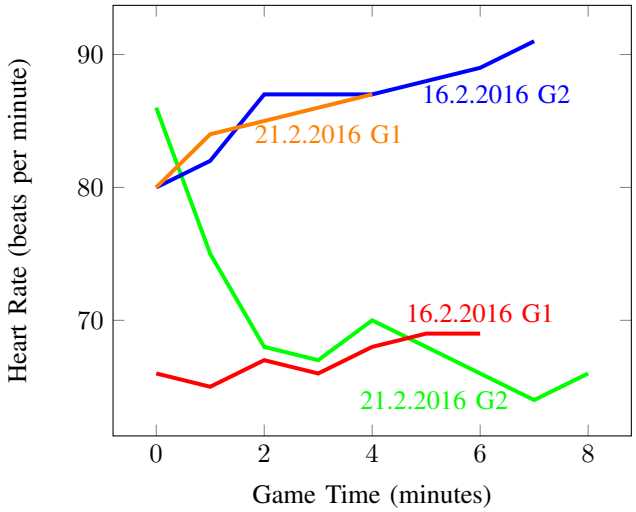

Fig. 5: Hearthstone: Heroes of Warcraft sessions 1+2

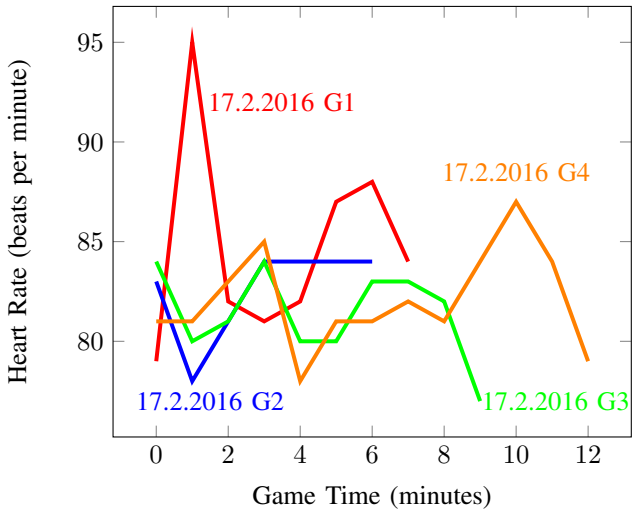

Fig. 6: Hearthstone: Heroes of Warcraft session 3

Both Fig. 5 and Fig. 6 show subject's HR during different Hearthstone games, played in different sessions. There are no obvious patterns to be seen due to low number of experiments done, this is to be changed in future research, more closely described in section VI.

VI. Conclusion and Future work

It has to be taken into consideration, that the domain has a major impact on the final data (even though we try to find a correlation). The data from both games are not easy to compare due to major difference in the game lengths.

After only a few games played by our subject, there are regular alteration in subject's HR. There are specific events which changed the HR whenever they occurred: start ot the game, first massfight, final (deciding) massfight. Also, the subject's HR decreased near to a minimum when waiting for their hero to respawn.

So far there are no particular HR-changing events found in Hearthstone. Nevertheless, this is likely to change after a higher number of experiments, even thought the game is less dynamic than Dota 2.

In future, we are also planning to run our experiments on one other genre: First Person Shooter (FPS) games, arguably the most dynamic genre of video-games. And finally, we are hoping to find differences between psychophysiological measurements of winning and losing players while understanding its effects on individual subjects.

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