A RESEARCH PROPOSAL

The effects of a biofeedback-based dynamic game difficulty balancing mechanism that works in parallel with the fight/flight response on flow-state and desire to play again in video games.

Süleyman Ceran

Mobile: +90 542 115 33 74
E-mail: **suleymansceran@gmail.com**
Institution: TOBB UNIVERSITY OF ECONOMICS & TECHNOLOGY
Deparment: Computer Engineering, Graduate

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ANKARA-TURKEY

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2- INTRODUCTION

As Homosapiens, although less frequently compared to the past, we still occasionally experience moments when our fight or flight response is triggered in our daily lives. During these moments, due to the stimulation of our sympathetic nervous system, many of our "human" skills are strengthened. For example, adrenal glands secrete adrenaline to prepare other parts of the body to respond to danger, coronary vessels expand, blood flow increases, oxygen and energy availability in cardiac myocytes increases, oxygen in skeletal muscle cells increases, circulation facilitates blood passage to skeletal muscles and the brain, oxygen delivery to metabolically active cells increases, and we hear and see better, our large muscle masses push us to run faster with the release of our metabolic energy sources, etc. (D. A. Padgett, et al. 2003) However, unlike our ancestors, life-threatening moments such as being under real attack are not the only thing that pushes us to a fight/flight response in our daily lives. Video games can simulate these moments and cause us to experience similar mental processes from where we sit. (Gentile et al., 2017) But do we gain an advantage when our sympathetic nerves are stimulated while playing games as in real life? What would be the consequences if we did?

3- HYPOTHESIS AND POSSIBLE OUTCOMES

In this research, the feasibility and outcomes of a mechanism that increases the duration and depth of players' flow-state during the gaming experience and provides them with the desire to replay will be investigated. This mechanism can be explained simply as a dynamic game difficulty balancing system that works in parallel with an evolutionary response to fight/flight. It is planned to transfer the player's real-time physiological data to the game via biofeedback. In this way, the player will be able to gain an advantage in abilities that may vary depending on the game, such as speed, field of view, balance, aim, etc. in parallel with the fight/flight response. The impact of this type of feedback on the player's enjoyment of the game and the change in the amount of "excitement" they feel during the game as a significant factor will be examined. The value proposition of the research is to demonstrate that obtaining rewards in the game through increased sympathetic nerve reactions may lead to a classical conditioning in the player. A possible consequence of this conditioning will be examined, which is the occurrence of excitement reactions in the player's physiology (activation of sympathetic nerves) in order to gain an advantage at some point in the game, despite the fact that there is no reason to be excited under normal conditions.

Biofeedback is the process of collecting information about many physiological functions of one's body using electronic means. Methods such as biofeedback and neurological feedback are often used for medical measurements. The most common parameters used for these measurements are brain waves, muscle tone, skin conductance, heart rate and blood pressure. The use of the biofeedback mechanism is currently limited in the gaming world. The studies in the literature will be covered in the second section of this proposal, titled Literature Review. When we look at the gaming industry, the examples we see are usually wellness and motivational games, or mobile applications. Two examples of labs that have worked on this are biofeedbacklabs and brainboost.de. Two important game examples are "Mindball" and "Deep". In Mindball, players use EEG data to use mental attention and relaxation skills to move a ball. Deep uses a sensor that measures the speed and depth of the players' breathing, and this allows them to move. These are not games for pure entertainment purposes, which are in our field of study, and the ways of using the biofeedback mechanism are different from the fight/flight response we mentioned. The "nevermind" game created by Erin Reynolds, which is the most important example of a recreational game on the market that uses biofeedback mechanisms, does not work in parallel with the biofeedback mechanism. In these examples, the user's state of excitement/stress is transferred to the game via biofeedback, but increased sympathetic nervous reactions have a negative effect on the player. For example, in nevermind, being scared, i.e. having a faster heartbeat, causes negative effects on the player's skills and makes it easier to dieIn addition to the above, biofeedback mechanisms have been used in the treatment of some psychiatric disorders (e.g. Regression therapy) such as post-traumatic stress disorder (Jones et al., 2020) (Kahn et al., 2013), but the games we focus on in this research are not Serious games, but games played only for entertainment purposes. Therefore, such examples are excluded.

The biofeedback mechanism that will be implemented in the research actually aims to integrate a Dynamic game difficulty balancing process into the game. Dynamic game difficulty balancing is the process of adaptively changing the difficulty of the game in order to keep the player's interest alive throughout the game. This method dynamically adjusts the difficulty of the game and offers an appropriate level of difficulty according to the player's capability. In this way, it is ensured that the players play the game in a more enjoyable way and are interested in the game for a longer time. Dynamic game difficulty balancing is performed using algorithms specifically designed for games. These can be algorithms that perform simple calculations based on in-game metrics such as the time spent on a level, the number of failures, the player's score, or they can be genetic algorithms or machine learning algorithms. With this difficulty tuning, it is aimed to increase the motivation of the players to stay in the game. Because situations such as players quitting the game or getting bored may occur more often if the difficulty of the game is constant. Additionally, the ranking system in online/competitive games, which essentially involves players of the same skill or experience level matching and playing against each other, can also be considered an example of dynamic game difficulty balancing.

The effect of the described type of dynamic game difficulty balancing on the length of the flow-state of the players and their abuse of this balance as a result of conditional learning will be investigated. Pioneering psychologist Mihaly Csikszentmihalyi defined the concept of flow, which has an important place in psychology and game design, as a feeling of full and energetic focus in an activity with a high level of enjoyment and satisfaction (Csikszentmihalyi, 1990.). And in many areas, the desire to stay in the flow state and the appropriate methods have developed. In video games, the most common definition of flow state is the balance zone between anxiety and boredom. If the difficulty is much higher than the skill, the game becomes overwhelming and creates anxiety. If the difficulty is much lower than the skill, it will cause boredom. Therefore, we can think that the length and depth of the flow state are related to the time spent in the game. One of the possible outcomes of the research is that, unlike conventional game difficulty balancing mechanisms, a biofeedback-based mechanism that works in parallel with the fight/flight response can help to stay in the flow-state longer. We will first briefly discuss what the effects of extending the flow-state (increasing its duration or depth) might be, and then comment on why the active use of this mechanism might extend the flow-state.

First, let's remember the definition of being in flow: "It's when people are so involved in an activity as if nothing else matters; The experience itself is so enjoyable that people do it even at great cost, just for the sake of having done it." (Csikszentmihalyi, 1990.). Transitioning to and staying in this state is considered one of the main motivations for gaming. (Schell, 2008.) Some game designers say that the main issue is not the flow itself, but only how long players can be kept in this flow. (J Chen, 2007). When your motivation to perform an activity increases, it is expected that the time you will devote to it will increase. The increase in the time to be devoted to the game may be an indicator of an addiction to the game (Griffiths, 2010), and there are studies in the literature showing that video game players show many signs of addiction. (Griffiths, 2005) The possibility that the active use of this dynamic game difficulty balancing mechanism, which is biofeedback-based and works in parallel with the fight/flight response, can expand the flow-state is actually the main research topic of the study. As hypothesized, if this mechanism enables the player to develop a conditioning during the game and to feel more excitement and release more adrenaline, this enlargement can be achieved.

In the research, the positive effect of adrenaline secretion, or in other words, the excitement of the activity, on re-experiencing the activity will be evaluated. The concepts of "adrenaline" and "excitement", which must be defined correctly for the health of this evaluation, will be examined in detail through the perspective of video games. Before moving on to the other section, let's touch upon the conditioning mentioned above. The development of "conditioning", that is, "observing the symptoms of excitement (sympathetic nervous reactions) in the physiology of the player who has experienced the game for a while, for accessing the reward - to gain an advantage - even if there is no situation to be excited at a moment of the game" is the question addressed by the research. Thanks to the described mechanism (which will be detailed in the METHOD section), if this conditioning is observed, the game may become more "exciting" and thus create a broader flow-state. As a result, this mechanism may become an interesting and important "factor" for game designers in the future. Especially considering the acceleration of digital content consumption and its impact on dopamine cycles, the need for various new factors in the gaming world can be anticipated.

4- LITERATURE REVIEW

This literature review will discuss current research on dynamic game difficulty balancing, biofeedback, and flow states in video games, which are key aspects of the proposed research project. It is expected that the literature to be reviewed during the research will naturally expand.

4.1 Dynamic Game Difficulty Balancing (DGD):

Dynamic game difficulty balancing is a method used to adjust a game's challenge level in real-time based on the player's performance and skill (Hunicke, 2005). This approach aims to keep the player engaged and maintain their interest by providing an optimal level of challenge throughout the game (Adams, 2010). Previous research has explored various techniques for implementing DGD, such as adaptive AI opponents (Andrade et al., 2005), procedural content generation (Togelius et al., 2011), and player performance-based adjustments (Spronck et al., 2004).

Several studies have shown the positive effects of DGD on player experience and enjoyment (Abdul Jabbar & Felicia, 2015). For example, Yannakakis and Hallam (2007) found that players preferred games with dynamically adjusted difficulty levels compared to those with static difficulty levels. Another paper of Yannakakis' presents a biofeedback-based game difficulty adaptation method that dynamically adjusts difficulty according to the player's physiological responses, enhancing the overall gaming experience (Yannakakis & Hallam, 2011). Additionally, research by Van Lankveld et al. (2011) demonstrated that DGD could be used to create tailored game experiences based on individual player preferences and personality traits. Also a study explores the use of variable difficulty adjustment algorithms in video games to maintain a balance between challenge and enjoyment, ultimately improving player engagement and satisfaction such as (Wise, 2015). DGD will continue to be a very important part of gaming and many new and inspiring studies are being published on it. For example, an awarded study presents a method to efficiently identify game levels with the right difficulty for individual players by leveraging Bayesian optimization, resulting in improved player engagement and satisfaction (Jensen et al., 2019). Also, in terms of using artificial intelligence and learning algorithms in DGD, Andersen et al. (2016) developed methods for determining the difficulty of game levels within a few trials (Andersen, 2016).

4.2 Biofeedback in Video Games:

Biofeedback is a technique that involves using real-time physiological data from players to influence the game environment or mechanics (Gilleade et al., 2005). This approach has been increasingly integrated into video games to create more immersive and personalized experiences (Nacke et al., 2011). Several studies have explored the use of biofeedback in games, such as heart rate variability (HRV) for stress management (Chanel et al., 2008), facial expression analysis for emotion recognition (El-Nasr et al., 2006), and brain-computer interfaces (BCI) for controlling game elements (Lécuyer et al., 2008). In an article which investigates the importance and potential of using biofeedback and physiological measurements to analyze and evaluate game experiences, draws attention (Kivikangas, 2018). This study highlights the benefits of using physiological measurements in game experience evaluations and provides a foundation for other research in this area. Kivikangas also investigated the psychophysiological responses to gameplay and their relationship with different game events Kivikangas et al. (2011) and the study emphasizes the importance of understanding player responses to design more engaging and immersive experiences, which can be further enhanced by incorporating biofeedback mechanisms.

Research on biofeedback in video games has shown its potential to enhance player engagement and immersion (Kivikangas et al., 2010). For instance, a study by Ravaja et al. (2006) found that players exhibited stronger emotional responses to game events when physiological data was used to alter gameplay. Additionally, Gilleade and Dix (2004) found that biofeedback could be utilized to create adaptive game systems that respond to individual player states, providing a more tailored and engaging experience. Additionally a study by Nacke et al. (2011) investigated how direct and indirect physiological control could enhance game interaction. This article provides essential information on how to use biofeedback mechanisms and how they can improve the player experience. Lastly, one of the recent studies on this topic is that the article (Guger et al. 2017) provides a comprehensive review of how brain-computer interface technology is used in game design and discusses the future potential of biofeedback games.

4.3 Flow States in Video Games:

Flow is a psychological state of optimal experience characterized by intense focus, enjoyment, and a sense of control (Csikszentmihalyi, 1990). Video games have been recognized as an ideal medium for inducing flow states due to their interactive nature and ability to provide immediate feedback (Sweetser & Wyeth, 2005). Research on flow in video games has explored various factors that contribute to flow experiences, such as game mechanics (Salen & Zimmerman, 2004), narrative structure (Jennett et al., 2008), and social interaction (Voida et al., 2010) or a study explored the significance of immersion and concentration in game experiences, asserting that biofeedback mechanisms can enhance these aspects (Vella, 215). Also, a study (Nacke, L. E., & Lindley, C. A., 2009) examines the concepts of flow and immersion in first-person shooter games, using emotional responses and biofeedback to measure player experience.

Some studies have demonstrated the positive effects of flow states on player engagement and enjoyment (Ryan et al., 2006). For example, research by Sherry et al. (2006) found that flow states were positively correlated with increased game playtime and preference for specific game genres. Furthermore, flow states have been linked to increased motivation and learning in educational games (Kiilić et al., 2009) and improved performance in competitive gaming (Weibel et al., 2008). Additionally, a study by Nacke and Lindley (2008) found that flow states could be induced by balancing the game's difficulty and ensuring that the game's mechanics align with the player's skill level.
It is necessary to know the concepts of flow state and immersion well for the propounded research. For this reason, an article that should be carefully examined in the literature is the the article by Vogle (2017) focuses on the relationship between immersion and flow in gaming experiences. This research emphasizes the significance of achieving and maintaining flow in games, which can be facilitated by incorporating biofeedback and dynamic game difficulty balancing mechanisms. For certain, there are more articles investigate the concepts of flow and immersion in video games, and one instance of them tries to explore their relationship and proposing a reconceptualization to clarify their distinct roles in game experiences (Wiemeyer & Nacke, 2018).

Lastly, Chen's (2007) master's thesis explored the concept of flow in games and provided guidelines for creating more engaging and enjoyable gaming experiences. The integration of biofeedback and dynamic game difficulty balancing mechanisms aligns with these guidelines and can contribute to achieving and sustaining flow in games.

4.4 Integrating DGD, Biofeedback, and Flow States:

The proposed research project aims to combine dynamic game difficulty balancing, biofeedback, and flow states to enhance player experience and increase replayability. There is existing research that supports the potential benefits of this approach.

For instance, Nacke and Lindley (2008) conducted a study that combined biofeedback with DGD and found that players exhibited higher levels of engagement and immersion. Furthermore, a study by Fairclough et al. (2011) integrated biofeedback with flow theory to create an adaptive game system that responded to the player's emotional state, resulting in a more engaging experience. Lastly, the significant study by Mandryk et al. (2011) on analyzing game experiences with physiological measurements suggests using physiological measurements to assess the relationship between game experience and player performance. This study lays the foundation for evaluating the effectiveness of game experiences and biofeedback systems. Adams (2009) discussed the importance of positive feedback loops in game design and their impact on player engagement and satisfaction. Integrating biofeedback and dynamic game difficulty balancing systems could create more efficient positive feedback loops, ultimately leading to an enhanced gaming experience.

By leveraging the strengths of DGD, biofeedback, and flow states, the proposed research project has the potential to create a novel and immersive gaming experience that maximizes player enjoyment and replayability.

5- METHODOLOGY

In this research paper, the experiment will be scientifically justified in the light of the predictions and past research in chapter 4 and more. After the experiment, the results will be interpreted and possible contributions to the field of game design will be suggested. The experiment and its aftermath can be phased as follows:

5.1 Participant Selection and Consent: The subjects to participate in the research will be individuals of different age ranges, not concentrated in any gender, with experience of playing video games. Among those who return to the call to participate in the research, those who meet the determined criteria will be selected, the conditions will be explained to them and their volunteering will be requested.

5.2 Game Selection and Development: A video game suitable for research will be developed by researcher Süleyman Ceran, the author of this proposal, completely original, without any potential copyright restrictions.The developed game should be suitable for the integration of the dynamic game difficulty balancing mechanism, which is biofeedback-based and works in parallel with the fight/flight response. Different types of games can host different skill exchanges. For example, in a boxing game, when the sympathetic nerves are active, the player's character can punch stronger, in a platform runner game the character can jump higher, etc. In this context, it is logical that the game to be developed should be suitable for a structure where more than one character ability can be manipulated when the sympathetic nervous reaction is detected, in terms of the player to feel this effect more. During the experiment, although it is predicted that the choice of playing offline games is reasonable in terms of development cost, the type of game that will trigger competitive feelings during the experience will be developed. The tuning of the mentioned capability changes will be provided by the control cases to be made during the development phase.

5.3 Development of Biofeedback Device Integration: In the research, a smart watch will be used as a biofeedback device that can measure the physiological data of the players. The heart rhythm data of the participants will be integrated into the game to be developed in a way that can be transferred instantly. These hours should be used in a way that does not prevent the participants from moving freely, that is, they do not reduce their normal game performance. Considering this situation, it seems reasonable to use the smart watch with a game controller instead of a keyboard. Appropriate development will be made in order to ensure the modularity of this integration and to be used after the experiment. For this reason, the software that provides the integration between the smart watch and the game will be coded as a plug-in to the unreal engine game engine where the game will be developed.

5.4 Experiment Design: Experiment design will proceed in parallel with the game development process. During this progress, the number of participants, the number of sessions and their duration, as well as the correct experience evaluation questions will be prepared on scientific grounds, and the cause-effect relationships of these foundations will be reported. In the same process, necessary ethical controls will be made and permissions will be obtained.

5.5 Experiment: The experiment will be conducted for the number of sessions and duration determined within the scope of the experiment design. Participants will be equipped with biofeedback devices and will start playing the game developed for the experiment. Physiological data obtained during the participants' game experience will be recorded, and questions about their experience will be asked at the end of the sessions.

5.6 Analysis: The data collected during the experiment will be analyzed and included in the research paper, and the results will be compared with the initial predictions and commented on.

5.7 Timeline: The anticipated start and end times of the phased parts in this section are as follows:

5.1 Participant Selection and Consent: Between weeks 9-10
5.2 Game Selection and Development: Between weeks 1-9
5.3 Development of Biofeedback Device Integration: Between weeks 1-9
5.4 Experiment Design: Between weeks 5-8
5.5 Experiment: Between weeks 10-13
5.6 Analysis: Between weeks 13-14

6- ETHIC

To ensure the ethical aspect of the research, participants' consent will be obtained by sharing the procedures during the experiment implementation phase in light of the information provided in Section 5.METHOD. Participants will be informed about the research's objectives, process, and potential risks, and they will be asked to accept participation if they wish to continue or to withdraw from participation at any time. To protect the privacy and confidentiality of the participants, anonymization methods will be used during the data collection process, and personal information will not be published in any way. The survey to be completed at the end of the sessions aims to gather information about the participants' experiences and the effects of the game, and will not contain any harmful or private life-related questions. Game selection is also an important factor, and therefore, participants will be offered games that do not contain disturbing content, and they will be informed about the possible violence elements in the games during the consent obtaining phase. With these precautions, the research aims to guarantee that it adheres to ethical standards and contributes to the scientific knowledge base while protecting the rights of the participants.

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