Using EEG and Gamified Neurofeedback Environments to Improve eSports Performance: Project Neuroprotrainer

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Abstract: Human performance has permanently been an objective for society and, specifically, for researchers. Traditional sports, board games, video games... A wide diversity of domains have recall the attention on the reasons why top players perform better than the rest. eSports can be defined as competitive multiplayer video games. Nowadays, eSports have a huge impact on society with billions of people playing or consuming related content. Being a relatively new universe, there is a wide gap when talking about applying scientific principles to performance analysis and improvement on eSports. This paper tries to establish a new research topic, introducing Virtual Reality and neuroscience as main frameworks to pursue a double objective: evaluate psycho-cognitive characteristics of eSports players aiming to profile them and, additionally, using that profile to create custom psycho-cognitive training plans. Neuroscience and EEG data from players have the ability of explaining the complex decision making procedures that involve an individual action while playing. Neurofeedback training (NFT) is a neuro-behavioral technique that will allow using real-time EEG data to drive a gamified environment aiming to adapt their brain activity to the optimum performance mode. This project aims, for the first time, to use neurofeedback within a gamified training environment in order to improve individual performance on eSports.

1 INTRODUCTION

From chess (De Groot, 2014; Simon and Chase, 1988; Chase and Simon, 1973) to air-pistol shooting (Cheng et al., 2017), going through other massive (like football (Savelsbergh et al., 2002)) or non-massive sports (like squash (Abernethy, 1990)) have been object of research aiming a double goal: (a) Identify and isolate psychological, cognitive and motor traits of best performers (experts) and (b) Try to implement these characteristics into non-expert through training programs.

For those researchers following the cognitive approach, a skilful performance in sport is traditionally linked with the combination of a skilful perception and a skilful action (Craig and Watson, 2011; Williams et al., 1999). Additionally other psychological perspectives like decision-making (Chamberlain and Coelho, 1993; Araujo et al., 2006) or risk taking (Pain and Pain, 2005; Kontos, 2004) have been studied as relevant factors related to sports for the last decades.

With the bloom of neurosciences and EEG accessibility and affordability, several labs started to introduce this neuronal component to the usual psychological, cognitive and motor dimensions. Brain plays an important role on sport performance and attending to this is needed to study its implications on the 21st century massive sport: competitive video games, the so called eSports.

In recent years, there has been a growing interest in the research potential of the application of electroencephalography (EEG) to the analysis of cortical activity in the most relevant phases of action in various sports: preparation and execution (Vernon, 2005; Perry et al., 2011; Park et al., 2015; Xiang et al., 2018).

The main goal of this project is to implement a roadmap in order to transfer this previous work on traditional sports and the potential benefits of neuroscience and neurotraining on individual performance, to eSports.

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Aiming to this, it will be needed to:

1. Identify which EEG signals have the ability of describing an expert eSports player (for different eSports).
2. Design and develop a gamified environment where neurofeedback could be implemented, supporting the training of players.
3. Develop a NFT program in order to evaluate the real outputs over the individual performance.

2 eSports RESEARCH

Social interest on eSports is continuously growing, even surpassing the popularity of some traditional sports (BusinessTelegraph, 2020), having for example, more audience than the rest of professional leagues except the National Football League.

In parallel, the research production on eSports is also acquiring some relevance, as shows the last survey paper (Reitman et al., 2020) on eSports research. Since the first work on eSports was written on 2002 (Bryce and Rutter, 2002), Google Scholar currently returns more than 30.000 articles with the key word *eSport*.

Even when the research approach to eSports could come from different domains like Sports Science, Cognitive Science, Law, Sociology, Business, Media Studies or Informatics (Reitman et al., 2020), this paper tries to introduce a new approach, using the neuroscience lens.

Following the Guttman's taxonomy of modern sports (Guttman, 1992), as it is visible on Fig.1, eSports will fall inside the Intellectual Contests class. Intellectual here could be understood as "leaded by mind" but it is impossible to separate cognition from psycho-motor relevance in eSports.

There is a reduced amount of papers focused on understanding the characteristics that distinguish and the ones which make similar eSports and traditional sports (Railsback and Caporusso, 2018).

By the same way, most eSports are collective games where teamwork and global strategy and tactics play a relevant role in the final result. This project is focused on improving the individual contribution of each player. More accurately, is focused on improving performance of each single action executed within a match.

Attending to the different types of eSports, following a taxonomy genre-leaded, it is possible to establish some main categories such as MOBA (Multiplayer Online Battle Arenas) like League of Legends or Dota 2, FPS (First-Person Shooters) like Valorant or Rainbow Six, RTS (Real Time Strategy) like Starcraft 2 or Age of Empires, CCG (Collectible Card Games) like Legends of Runeterra or Hearthstone or Sports games like NBA, NHL or FIFA.

Even considering the particular differences between each main genre, all of them have some common traits: they are collective competitive games (mainly) and they divide the gameplay in two dimensions, micro (each individual action, short-term consequences) and macro (mid/long-term strategy, teamwork). This project aims to improve micro performance using NFT.

3 NEUROFEEDBACK APPLICATIONS IN SPORTS PERFORMANCE

As Xiang et al. (2018) summarized on their meta-analysis about neurofeedback training for sport performance, expertise on a certain sport is linked to a superior cognitive-motor processing and this, with the reduction of task-irrelevant processes and the increase of task-relevant processes.

Some authors analyzed the importance of physical abilities and demostrated that motor skills are a intrinsical part of eSports (Hilvoorde and Pot, 2016).

There is a relevant corpus of works where these findings are explained (Xiang et al., 2018):

- Expert practitioners of different visuomotor based activities like golf, archery, and target shooting evidenced lower cerebral cortical activation when compared with beginners (Hung et al., 2008).
- This lower cortical activity has also been found jointly with a lesser activation in the language zones of the left hemisphere (Hatfield et al., 2004).
- In elite athletes, preparation of precise visuomotor performance is related to a low cortical activation (Del Percio et al., 2009).

The neuroProTrainer project aims to establish a translation from this findings within the sports domain to the eSports, focusing on the micro-gameplay. Micro-gameplay represents the individual performance in single actions in front of macro-gameplay, a concept that defines the more strategic, long-term performance of a team, normally.

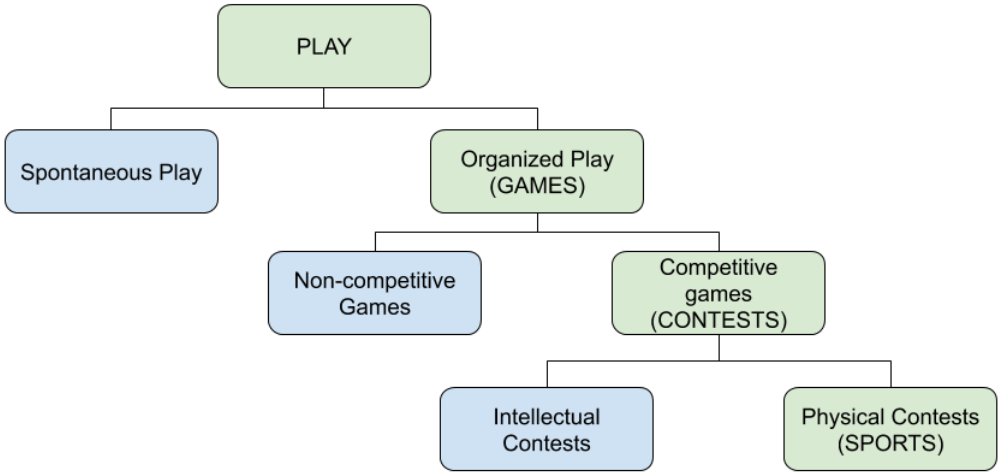

Figure 1: Guttman's modern sports taxonomy.

4 METHOD

This research is based on a basic but with a high level of ecology BCI (Brain Computer Interface) which is the Emotiv Insight (Fig. 2). It is a 5-channel dry sensors EEG device that measures activity from all cortical lobes of the brain, providing in depth information.

This BCI delivers six performance metrics that will help to establish a neural profile of players, both resting and playing. The set of metrics consists of (Emotive, 2019):

- Stress (FRU) represents a measure of comfort with a certain activity. Higher stress levels are related to negative implications, feeling overwhelmed or simply not being able to make a particular action due to adverse consequences of failing. Low level of stress could foster performance but a higher level could have terrible effects on individuals.
- Engagement (ENG) quantifies how immersed is the player on the tasks he is involved. ENG could be expressed as a combination of attention and concentration. It's the opposite of boredom. This metric presents an increased physiological arousal, beta waves presence and low alpha waves.
- Interest (VAL) is the degree of attraction or aversion to the current stimuli, environment or activity. In the psychological domain is called Valence. The interest is related with the enjoyment of the current task, normally throwing higher values of interest when the user is enjoying the task and lower values when he/she is disliking the activity. Medium Interest values usually show a neutral feeling about the task.
- Excitement (EXC) is an awareness or feeling of physiological arousal with a positive value. The detection of this performance metric is designed to detect short-term changes on excitement, usually within a few seconds.
- Focus (FOC) is a measure of fixed attention to one specific task. A high level of attention is usually accompanied by a low level of task switching which correlates positively with low level of focus and distraction.
- Relaxation (MED) quantifies the ability to achieve a calm state of mind. It also represents a metric of the ability to reduce activation levels, rest and recover from intense concentration.

Establishing a neuro-profile of players will provide relevant information about individual characteristics of those who better perform on a video game and the differences with those of lower performance. With this information, a customized training plan could be designed.

Additionally, following the works listed previously, NFT will be applied in order to get performance metrics to their optimum level. NFT could be defined as a specific paradigm based on operative conditioning, in which the individual learns how to influence the electrical activity of his brain through differ-

Figure 2: Emotiv Insight.

ent mental states (Kerick et al., 2001; Pop-Jordanova and Demerdzieva, 2010; Hammond, 2011).

NFT could be based on different frequencies, coming from different cortical areas (Fajardo and Guzmán, 2016; Xiang et al., 2018). Different cortical areas of the brain produce different rhythms:

1. Delta (1Hz-4Hz): It is a wave associated with sleep that is present in states of muscle relaxation, so it is very useful in stretching and sports warm-ups (Behncke, 2004).
2. Theta (4Hz-8Hz): This frequency has been linked to pre-competition stress. Additionally it correlates also with positive moods. (Thompson et al., 2008).
3. Alpha (8Hz-12Hz): This wave promotes focusing, diminishing emotions, toughts and distractions (Beauchamp et al., 2012).
4. SMR (Sensorimotor Rhythm, 12Hz-15Hz): This rhythm is related to body movement and concentration. A higher sensorimotor signal during the last instant before an action initiation has been demonstrated to be linked to better performance (Gruzelier et al., 2010; Cheng et al., 2017).
5. Beta (13Hz-30Hz): Is associated with the muscle contractions that happen in isotonic movements and are suppressed prior to and during movement changes (Baker, 2007). Also related to states of wakefulness and mental activity, states of alertness and active concentration (Beauchamp et al., 2012).

Relevance and contribution of each wave have to be evaluated aiming to create a subset of cortical rhythms that have influence on eSports players performance. Jointly, this subset of waves and the performance metrics given by the BCI, will compose the NeuroScorecard (NS) for each individual. Attending to their current level and the pre-fixed goal for each parameter of the NS, a customized NFT plan will be designed.

NFT will be delivered by a gamified training environment (GTE), not defined yet, with a simple design premise: Correct feedback (contributes to the pre-defined goal) will be translated into a positive action within the gamified environment and wrong feedback (that one on the contrary sense of the pre-defined goal) will represent a negative action in the gamified environment.

As an example, if the GTE is similar to a "Flappy Bird" game (Fig. 3), when an individual successfully tunes its cortical activity as expected, the main character should elude the obstacles of the level. But, if the tuning is wrong, the avatar will collide with an obstacle, loosing some health or one life.

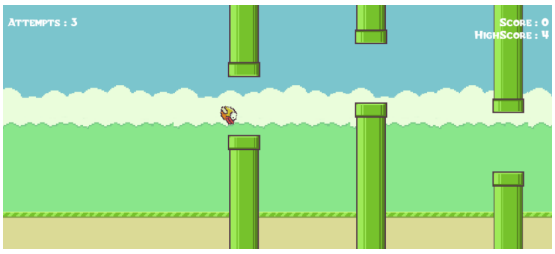

Figure 3: Flappy Bird, by .GEARS Studios, as a reference for the GTE.

This GTE should be responsive to users' activity, changing values like timing, difficulty or sounds attending to current performance. Different levels of intensity of training could be configured. Introducing machine learning elements at design level could foster a procedural GTE (PGTE) that will be dinamically set up for each user, taking into consideration his/her starting point and evolution.

Aiming to determine if NFT is effective, the training program will be delivered to three different groups with three different feedbacks:

- Right feedback.
- Wrong feedback.
- No feedback.

Following this experimental design it will be possible to isolate the influence of NFT on individual performance.

5 CONCLUSIONS AND FURTHER WORK

The purpose of this paper is to provide a solid foundation and methodology for an innovative field of study: the application of the NFT to eSports.

Starting from the extensive previous work applying EEG and NFT on sports and due to the strong similarities between certain actions on traditional sports and other actions on competitive video games, the working hypothesis of this project is that NFT could help players to improve their micro (individual performance on direct actions).

Using a mix of cortical signals: (i) Performance-metrics delivered by the BCI; (ii) Direct waves interpretation it will be possible to establish a cortical activity reference for expert players that, additionally, will serve as road-map for aspirants.

Once the pro-players cortical profile has been defined, a PGTE will be developed. It will be used to deliver a NFT program in order to develop their neural control in order to increase performance within the

game, trying to mimic pro-players cortical activity.

If both the PGTE and the NFT obtain positive results, this tools could be used by professional and amateurs eSports teams as a valuable development resource.

Next steps of this project will be related to establishing a link between complementary physiological signals and performance, using like eye tracking or electro-dermal activity (EDA).

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7 AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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