International Journal of Intelligence Science, 2023, 13, 23-32
https://www.scirp.org/journal/ijis
ISSN Online: 2163-0356
ISSN Print: 2163-0283

Intelligent BCI Headphone for a Healthier and a Deeper Immersive Gameplay

Ilman Shazhaev[1], Dmitry Mikhaylov[2], Abdulla Shafeeg[3*]

[1]Management Department, Farcana, Dubai, UAE
[2]Business Department, National University of Singapore, Queenstown, Singapore
[3]Science Department, Farcana, Dubai, UAE
Email: ilman@farcana.com, arbi@farcana.com, *abdulla.shafeeg@farcana.com, dr.d.mikhaylov@nus.edu.sg

How to cite this paper: Shazhaev, I., Mikhaylov, D. and Shafeeg, A. (2023) Intelligent BCI Headphone for a Healthier and a Deeper Immersive Gameplay. *International Journal of Intelligence Science*, **13**, 23-32.
https://doi.org/10.4236/ijis.2023.132002

Received: January 6, 2023
Accepted: April 15, 2023
Published: April 18, 2023

Abstract

The developments in the area of brain research by analysing brain activity of individuals have given rise to many useful applications, such as diagnosing mental disorders more efficiently, treatment of cognitive disorders, and developing of brain-computer interfaces for treatment, communication and entertainment purposes. However, the development of such applications is hindered by a shortage of easy-to-use and comfortable sensors, as well as a lack of high-quality brain activity data. In the first part of this paper, a review of the status of BCI applications is presented followed by a proposal of a framework for developing an intelligent BCI headphone that takes leverages of the huge amount of data coming from playing video games to let the players experience a full immersive gaming experience.

Keywords

BCI, Immersive Gaming, Artificial Intelligence, Videogames, Health

1. Introduction

People have believed for many years that electroencephalographic activity or other electrophysiological measures of brain function may provide a new non-contact channel for communicating with the outside world—a brain-computer interface (BCI). The last fifteen years have seen an enormous increase in the development of BCI applications. A brain-computer interface (BCI) is can be defined as any device that detects human brain activity and translates it into digital commands. It acts as a bridge between the human brain and a computing device, allowing users to interact with the computing device only with their thoughts, and this is especially helpful for physically challenged individuals, such as those with amyotrophic lateral sclerosis (ALS). Brain-computer interfaces (BCIs) are being developed not just to aid disabled individuals with motor replacement, motor rehabilitation, and novel communication options, but also as a form of entertainment and games for healthy users. Electroencephalography (EEG) is the most used technique for recording electrical brain activity. In the field of communication, examples include P300-based spelling systems [1] and the use of imagined movement [2] or slow cortical potentials (SCPs) [3] to drive a wheelchair.

The first BCI game was devised by Vidal *et al.* [4] and required the player to navigate a maze by focusing on regularly flashing fixation points off-screen. In the intervening period, there has been a significant rise in available computing power, coupled with a decrease in hardware costs, resulting in a surge of peer-reviewed research publications on BCIs. Since 2000, a growing number of research institutions have developed BCI games. See Plass-Oude Bos *et al.* [5] for a summary of the survey. As EEG headsets grow more inexpensive and BCI technology becomes more accessible, the use of BCIs in entertainment becomes more desirable.

A quality game immerses the player in the gaming world, making them feel the game. BCIs are fundamentally different from conventional input devices such as a mouse, keyboard, and joystick. A BCI provides the user with a non-contact input channel for controlling the game. Is this a barrier to the game's immersion and sensation of presence? Is a BCI beneficial in a popular contemporary game? Is experimenting with BCI control enjoyable? This study will aim to solve these concerns by analysing earlier research on BCI headphones and games, as well as how to quantify user experience in games using surveys and duration estimates. Finally, we present a way for incorporating BCI control into the Farcana Game, as well as our experimental design.

2. Literature Review

2.1. BCI Applications

Companies all around the globe are developing BCI (Brain-Computer Interface) devices for a variety of purposes. Although BCIs are most frequently linked with device control and medical applications, an increasing number of researchers are building BCIs for education, sports, and other industries more familiar to the general public.

Figure 1 demonstrates top companies in different categories creating life-changing BCI technology. The number of companies providing non-invasive BCI has grown in recent years, and huge corporations are purchasing non-invasive BCI start-ups.

Early BCI applications were targeted at those with limited mobility or communication impairments. Their objective was to supply consumers with more communication channels. With the rapid development of BCI technology, BCIs may become advantageous in specific situations for users who are conscious of

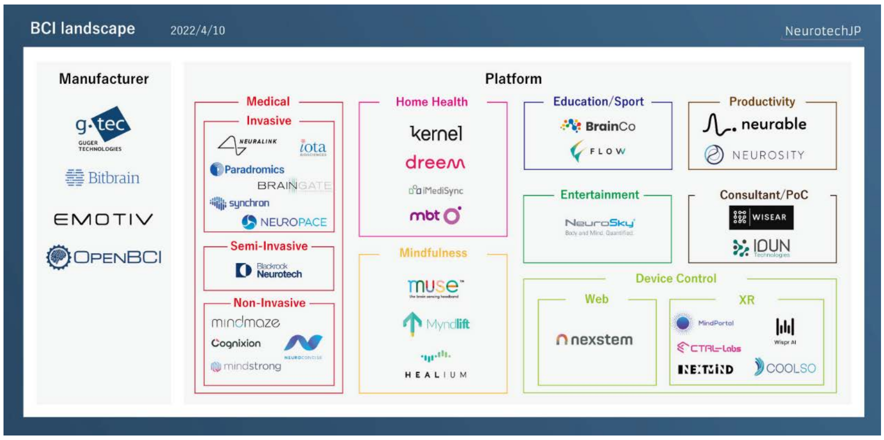

Figure 1. BCI landscape 2022.

their health. BCI can be utilized to extract and employ an individual's cognitive and emotional state. Through its ability to monitor mental states, the BCI system can aid in the early detection and prediction of various health issues, including but not limited to, brain tumors, epilepsy, narcolepsy, and encephalitis resulting from brain swelling. Additionally, as a cost-effective substitute for expensive diagnostic tools such as MRI and CT-SCAN, the BCI system can use EEG to detect tumors caused by uncontrolled cell growth [6]. [7] [8] focuses on EEG-based brain tumour detection systems, whereas in [9] the authors have worked on EEG-based breast cancer identification. Sharanreddy and Kulkarni proposed a method for identifying EEG irregularities associated with tumours and seizures in [10].

The brain-computer interface may also be implemented in smart environments, such as smart homes, workplaces, and automobiles, to enhance the safety, comfort, and physiological control of human daily life. It detects the user's mental state and adapts the environment accordingly. According to [11], they also anticipate collaboration between Internet of Things (IOT) and BCI technology.

Researchers of BCI have also been interested in marketing. The advantages of adopting EEG assessment of television advertisements for both commercials and political campaigns are discussed in [12]. The researchers investigated estimation television advertisement memorization by the viewers, which provides an alternative technique for judging advertising.

Neurofeedback is a possible method for enhancing cognitive function by responding to human brain activity. In the educational system, EEG signals can be used to determine the quality of the studied knowledge. The establishment of individualized communication with each student depends on the result response [13]. In [14], emotional intelligence based on EEG was utilized to reduce the tension related to sporting events. Using functional Magnetic Resonance Imaging (fMRI) neurofeedback, [15] discusses BCI technology for self-regulation and skill improvement using functional Magnetic Resonance Imaging (fMRI) neurofeedback.

Non-medical Brain-computer interface are commonly used in entertainment and gaming. In this form of BCI, physiological processes like brain signals, heartbeat, and facial emotions are utilized. A game which helicopters are designed to fly to any location in 2D or 3D virtual environment is discussed in [16]. In [17], Tan and Nijholt reported a brain game designed to reduce participants' stress levels. Due to the fact that players can only move the ball by relaxing, calm players are more likely to win; thus, they would learn to manage their stress while being entertained.

Biometric, knowledge-based, and object-based authentications are applied in security systems. In this industry, there are several applications, such as the detection of signal distortions via EEG and eye movement, the identification of odd behaviour, and the detection of suspicious objects [18]. In a scenario where several participants are seeing a recording of a suspicious occurrence, EEG and precise eye movement are the only methods capable of identifying potential targets [18]. As part of intelligent navigation systems, a number of researches have examined the authenticity of EEG data generated by driving behaviour. [19] [20] uses an elementary driving simulator with mental tasked state to verify a driver's identity on demand.

2.2. BCI Games

Multiple research groups have developed BCI games, typically as proofs of concept or to assess the utilization of mental processes in an online service. Brainbal, created by Hjelm *et al.* [21] [22], is a well-known BCI game that has impacted a large number of researches. The objective of the game is the player to get more relaxed than the opponent. Consequently, two players seek to be more tranquil, making it a contradictory and entertaining game. This research uses the ratio of frontal alpha to beta waves as a measure of relaxation.

Pineda *et al.* [23] designed a BCI for a first-person shooter in three dimensions. The keyboard regulated forward and reverse motion, whereas alpha levels in the motor cortex governed left and right turns. Due of the study's emphasis on participants' ability to learn to adjust their alpha/mu levels over many weeks, only four individuals participated. They observed that maintaining control over mu activity was straightforward.

Gürkok *et al.* [24] observed that while some mental tasks for BCI games are appropriate, they may not be the optimal choice as the main mode of interaction. Instead of focusing just on bit rates and accuracy, Plass-Oude Bos *et al.* took a user-cantered approach and found that the ease of doing a particular mental task is also a crucial factor [25].

A BCI game in the virtual environment is a growing field. One of the problems faced in the virtual environments is the restriction of a player's locomotion constrained by the natural environment. To overcome this hurdle Yasar implemented a BCI game in a virtual environment where the player is instantly teleported to an intended location using brain signals. To extract the features in time, frequency and time-frequency domain the brain signals were decomposed into alpha, beta and gamma bands. Results from binary classification in the frequency domain with Alpha band gave the highest performance. A study done by Halim I. Baqapuri *et al.* [26] has investigated the application of BCI gaming in virtual environment for neurofeedback training. A first-person shooter game was developed where the movement speed of the character was controlled by brain activity in a supplementary motor region of interest. The aim of the study was to evaluate the feasibility of BCI in creating an immersive Virtual Environment for neurofeedback training.

I M Vega *et al.* [27] developed a serios game called PROEZA with the aim of training players to control a hand prosthesis. Emotiv Epoc+ headband was used to capture the brain signals with Unity video game engine for developing the game. A protocol for validating a player's skill in controlling the hand prosthesis was presented and tests were carried out on 2 players. The results show the protocol to be an acceptable method for evaluating the player's ability to control the BCI system.

Gabriel Alves M.V *et al.* [28] conducted a controlled experiment for evaluating the performance and player experience of both competitive and collaborative matches in a multiplayer BCI game. Quantitative and qualitative data were gathered to evaluate the interaction of individuals with the BCI platform and other players. There was determined to be no statistically significant difference in performance between the two groups or between multiplayer and single-player modes. There was no statistically significant difference between the groups, despite the fact that the group playing competitively reported higher overall ratings for gaming experience. There were substantial connections between performance and good features of gaming experience for both forms, and multiplayer matches were much shorter than single-player matches, but this difference could not be attributable to the style of interaction alone.

Although there have been great achievements in applying BCI for entertainment such as gaming there are certain limitations to be noted such as lower transfer rate, cost and encumberment of materials and also lack of game design and graphics. For example, the number of frames per second is a major concern for BCI games [29].

2.3. User Experience

Witmer *et al.* [30] assert that sensing presence necessitates both participation and immersion. Witmer *et al.* created a presence questionnaire addressing these criteria for use in virtual environments. Now, games may be as immersive as virtual environments. A successful game captivates the player with its aesthetics, intriguing characters, and creative plot. Users can then have a sense of immersion in the game's mood or universe [31].

Distracting factors, such as audio-visual stimuli that are contradictory with the virtual world or unusual or dysfunctional interfaces, might interfere with the feeling of presence. User experience evaluation is crucial to the success of BCI games at the intersection of these games, which try to give the optimal circumstances for a sensation of high presence [32]. Van de Laar *et al.* [33] sought to evaluate a BCI game with a questionnaire based on IJsselsteijn *et al.* [34]'s game experience questionnaire (GEQ) with specific questions about the BCI's functionality. Van de Laar *et al.* [35] offered a summary of the several approaches available to researchers for analyzing BCI games and when they should be utilized.

3. The Framework for Intelligent BCI Headphone

As seen in **Figure 2**, the BCI system consists of the following elements: signal capture, pre-processing, feature extraction, classification, and application interface [36]. The structure of the BCI is a closed loop and consists of five elements. The phrases are "Control paradigm", "Measurement", "Processing", "Prediction", and "Application". Through these five steps, the BCI interprets the user's intent or mental state and uses this data to control the program. This closed loop between the user and the program is maintained until the system is shut down, with the four modules serving as their interface [37].

Control paradigm: BCI uses a "control paradigm" for which the user is responsible. The user may concentrate on a certain object or imagine a body part movement to generate brain signals that include the user's intention. In our BCI system, the user's intentional efforts are not required; instead, the system will detect the user's mental or emotional states automatically [37].

Measurement: Invasive and non-invasive methods can be used to acquire brain signals; in our intelligent BCI headphone we use EEG method for signal acquisition.

Processing: The measured brain signals are processed to optimize the signal-to-noise ratio and select target characteristics. In this stage, several techniques such as spectral and spatial filtering are used to eliminate artifacts and extract important information. The specified target characteristics are sent into classification or regression modules [37].

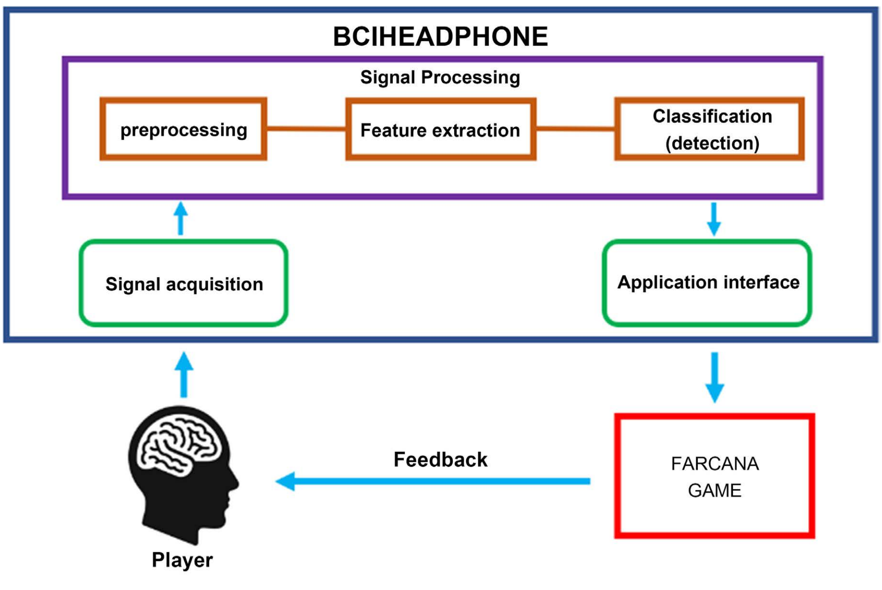

Figure 2. Proposed Framework for BCI headphone.

Prediction: This step evaluates the user's mental states and level of emotion. Classifiers such as threshold, linear discriminant analysis, support vector machine, and artificial neural network are commonly used for prediction [37]. The BCI headphone will be used by thousands of players to play the Farcana Game, hence a massive amount of data will be available to train a machine learning model for prediction. We keep this trained model in a cloud and allow BCI headphones to access the model for prediction. Meanwhile, in the cloud, the model is updated using new data as more and more data is acquired.

Application: Once the user's mental state or level of emotion is determined in the prediction step, the output is employed [37] to bring different changes to the game environment or to give feedback to the player: for example, depending on the players level of emotion the Farcana Game sounds will be changed accordingly to make the player have a very deep immersive gaming experience, or to take into account the health of the players, depending on the mental state of the player the game will advise the player to take a rest and come back, if the player doesn't stop the player will be disconnected after the current game event and will be allowed to play after a certain time. The player can learn to control alpha levels to become professional at playing the game.

The proposed framework for BCI headphones will bring the players a comfortable head gear to get immerse into the game environment and also autonomously helps the player have a deep immersive gameplay experience at the same time keeping track of the players health.

4. Conclusion

The anatomy of the human brain is incredibly intricate. Brain signals indicate the user's goals as well as the brain's controlling behaviour or the effect of information obtained from other bodily parts such as the senses or organs. BCI is a useful technology that permits communication between the human brain and computers or other electronic devices. BCI applications have inspired and attracted scientists from all around the world. In this study, we sought to determine if BCI control can add value to a current video game. This study offers a literature overview of BCI systems, with a focus on wearable BCI and BCI games. The literature regarding BCI applications, BCI games, and BCI user experience has been evaluated. Finally, we presented a framework for BCI headphones that integrates wearable BCI systems with BCI games to create a more immersive and healthy gaming experience.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Farwell, L.A. and Donchin, E. (1988) Talking off the Top of Your Head: Toward a

Mental Prosthesis Utilizing Event-Related Brain Potentials. *Electroencephalography and Clinical Neurophysiology*, **70**, 510-523. https://doi.org/10.1016/0013-4694(88)90149-6

[2] Leeb, R., Friedman, D., Mller-Putz, G., Scherer, R., Slater, M. and Pfurtscheller, G. (2007) Self-Paced (Asynchronous) BCI Control of a Wheelchair in Virtual Environments: A Case Study with a Tetraplegic. *Computational Intelligence and Neuroscience*, **2007**, Article ID: 079642. https://doi.org/10.1155/2007/79642

[3] Birbaumer, N., Elbert, T., Canavan, A. and Rockstroh, B. (1990) Slow Potentials of the Cerebral Cortex and Behavior. *Physiological Reviews*, **70**, 1-41. https://doi.org/10.1152/physrev.1990.70.1.1

[4] Vidal, J.J. (1977) Real-Time Detection of Brain Events in EEG. *Proceedings of the IEEE*, **65**, 633-641. https://doi.org/10.1109/PROC.1977.10542

[5] Plass-Oude Bos, D., Reuderink, B., van de Laar, B., Gürkök, H., Mühl, C., Poel, M., *et al*. (2010) Brain-Computer Interfacing and Games. In: Tan, D. and Nijholt, A., Eds., *Brain-Computer Interfaces*. *Human-Computer Interaction Series*, Springer, London, 149-178. https://doi.org/10.1007/978-1-84996-272-8_10

[6] Brouwer, A.-M., van Erp, J., Heylen, D., Jensen, O. and Poel, M. (2013) Effortless Passive BCIs for Healthy Users. In: Stephanidis, C. and Antona, M., Eds., *Universal Access in Human-Computer Interaction*. *Design Methods*, *Tools*, *and Interaction Techniques for eInclusion*. *UAHCI* 2013. *Lecture Notes in Computer Science*, Vol. 8009, Springer, Berlin, 615-622. https://doi.org/10.1007/978-3-642-39188-0_66

[7] Selvam, V.S. and Shenbagadevi, S. (2011) Brain Tumor Detection Using Scalp Eeg With Modified Wavelet-ICA and Multi Layer Feed Forward Neural Network. 2011 *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Boston, 30 August-3 September 2011, 6104-6109. https://doi.org/10.1109/IEMBS.2011.6091508

[8] Sharanreddy, M. and Kulkarni, P.K. (2013) Detection of Primary Brain Tumor Present in EEG Signal Using Wavelet Transform and Neural Network. *International Journal of Biological and Medical Research*, **4**, 2855-2859.

[9] Poulos, M., Felekis, T. and Evangelou, A (2012) Is It Possible to Extract a Fingerprint for Early Breast Cancer via EEG Analysis? *Medical Hypotheses*, **78**, 711-716. https://doi.org/10.1016/j.mehy.2012.02.016

[10] Sharanreddy, M. and Kulkarni, P.K. (2013) Automated EEG Signal Analysis for Identification of Epilepsy Seizures and Brain Tumour. *Journal of Medical Engineering & Technology*, **37**, 511-519. https://doi.org/10.3109/03091902.2013.837530

[11] Domingo, M.C. (2012) An Overview of the Internet of Things for People with Disabilities. *Journal of Network and Computer Applications*, **35**, 584-596. https://doi.org/10.1016/j.jnca.2011.10.015

[12] Vecchiato, G., Astolfi, L., De Vico Fallani, F., Salinari, S., Cincotti, F., Aloise, F., Mattia, D., Marciani, M.G., Bianchi, L., Soranzo, R., *et al*. (2009) The Study of Brain Activity During the Observation of Commercial Advertsing by Using High Resolution EEG Techniques. 2009 *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Minneapolis, 3-6 September 2009, 57-60. https://doi.org/10.1109/IEMBS.2009.5335045

[13] Sorudeykin, K.A. (2010) An Educative Brain-Computer Interface. ArXiv Preprint ArXiv: 1003.2660

[14] Marquez, B.Y., Alanis, A., Lopez, M.A. and Magdaleno-Palencia, J.S. (2012) Sport Education Based Technology: Stress Measurement in Competence. 2012 *International Conference on E-Learning and E-Technologies in Education* (*ICEEE*), Lodz,

24-26 September 2012, 247-252. https://doi.org/10.1109/ICeLeTE.2012.6333422

[15] Birbaumer, N., Ruiz, S. and Sitaram, R. (2013) Learned Regulation of Brain Metabolism. *Trends in Cognitive Sciences*, **17**, 295-302. https://doi.org/10.1016/j.tics.2013.04.009

[16] Royer, A.S., Doud, A.J., Rose, M.L. and He, B. (2010) EEG Control of a Virtual Helicopter in 3-Dimensional Space Using Intelligent Control Strategies. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, **18**, 581-589. https://doi.org/10.1109/TNSRE.2010.2077654

[17] Tan, D.S. and Nijholt, A. (2010) Brain-Computer Interfaces: Applying Our Minds to Human-Computer Interaction. Springer, London. https://doi.org/10.1007/978-1-84996-272-8

[18] Mathan, S. (2008) Feature: Image Search at the Speed of Thought. *Interactions*, **15**, 76-77. https://doi.org/10.1145/1374489.1374509

[19] Nakanishi, I., Baba, S. and Li, S. (2011) Evaluation of Brain Waves as Biometrics for Driver Authentication Using Simplified Driving Simulator. 2011 *International Conference on Biometrics and Kansei Engineering*, Takamatsu, 19-22 September 2011, 71-76. https://doi.org/10.1109/ICBAKE.2011.27

[20] Nakanishi, I., Baba, S., Ozaki, K. and Li, S. (2013) Using Brain Waves as Transparent Biometrics for On-Demand Driver Authentication. *International Journal of Biometrics*, **5**, 288-305. https://doi.org/10.1504/IJBM.2013.055965

[21] Hjelm, S. and Browall, C. (2000) Brainball—Using Brain Activity for Cool Competition. *NordiCHI*2000 *Proceedings*, Stockholm, 23-25 October 2000, 177-188.

[22] Hjelm, S. (2003) Research+Design: The Making of Brainball. *Interactions*, **10**, 26-34. https://doi.org/10.1145/604575.604576

[23] Pineda, J.A., Silverman, D.S., Vankov, A. and Hestenes, J. (2003) Learning to Control Brain Rhythms: Making a Brain-Computer Interface Possible. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, **11**, 181-184. https://doi.org/10.1109/TNSRE.2003.814445

[24] Gurkok, H., Nijholt, A., Poel, M. (2015). Brain-Computer Interface Games: Towards a Framework. In: Nakatsu, R., Rauterberg, M., Ciancarini, P., Eds., Handbook of Digital Games and Entertainment Technologies. Springer, Singapore, 1-18. https://doi.org/10.1007/978-981-4560-52-8_5-1

[25] Gürkök, H., Hakvoort, G. and Poel, M. (2011) Evaluating User Experience in a Selection Based Brain-Computer Interface Game A Comparative Study. In: Anacleto, J.C., Fels, S., Graham, N., Kapralos, B., Saif El-Nasr, M. and Stanley, K., Eds., *Entertainment Computing—ICEC* 2011. *ICEC* 2011. *Lecture Notes in Computer Science*, Vol. 6972, Springer, Berlin, 77-88. https://doi.org/10.1007/978-3-642-24500-8_9

[26] Baqapuri, H.I., *et al*. (2021) A Novel Brain–Computer Interface Virtual Environment for Neurofeedback during Functional MRI. *Frontiers in Neuroscience*, **14**, Article 593854. https://doi.org/10.3389/fnins.2020.593854

[27] Vega, I.M., Adarve, C.A., Villar-Vega, H.F. and Páramo, C.A. (2019) Serious Game for Real-Time Brain-Computer Interface Training. *Journal of Physics*: *Conference Series*, **1418**, Article ID: 012011. https://doi.org/10.1088/1742-6596/1418/1/012011

[28] Vasiljevic, G.A.M. and de Miranda, L.C. (2022) Comparing Users' Performance and Game Experience between a Competitive and Collaborative Brain-Computer Interface. *Behaviour & Information Technology*. https://doi.org/10.1080/0144929X.2022.2152727

[29] Cattan, G. (2021) The Use of Brain-Computer Interfaces in Games Is Not Ready for

the General Public. *Frontiers in Computer Science*, **3**, Article 628773. https://doi.org/10.3389/fcomp.2021.628773

[30] Witmer, B.G. and Singer, M.J. (1998) Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence: Teleoperators and Virtual Environments*, **7**, 225-240. https://doi.org/10.1162/105474698565686

[31] van de Laar, B., Reuderink, B., Plass-Oude Bos, D. and Heylen, D. (2010) Evaluating User Experience of Actual and Imagined Movement in BCI Gaming. *International Journal of Gaming and Computer-Mediated Simulations*, **2**, 33-47. https://doi.org/10.4018/jgcms.2010100103

[32] van de Laar, B., Gürkök, H., Plass-Oude Bos, D., Poel, M. and Nijholt, A. (2013) Experiencing BCI Control in a Popular Computer Game. *IEEE Transactions on Computational Intelligence and AI in Games*, **5**, 176-184. https://doi.org/10.1109/TCIAIG.2013.2253778

[33] IJsselsteijn, W., De Kort, Y., Poels, K., Jurgelionis, A. and Bellotti, F. (2007) Characterising and Measuring User Experiences in Digital Games. *International Conference on Advances in Computer Entertainment Technology, ACE* 2007, Salzburg, 13-15 June 2007, 1-4.

[34] van de Laar, B., Gürkök, H., Plass-Oude Bos, D. and Nijboer, F., Nijholt, A. (2011) Perspectives on User Experience Evaluation of Brain-Computer Interfaces. In: Stephanidis, C., Ed., *Universal Access in Human-Computer Interaction. Users Diversity. UAHCI* 2011. *Lecture Notes in Computer Science*, Vol. 6766, Springer, Berlin, 600-609. https://doi.org/10.1007/978-3-642-21663-3_65

[35] Başar, E., Başar-Eroglu, C., Parnefjord, R., Rahn, E. and Schürmann, M. (1992) Evoked Potentials: Ensembles of Brain Induced Rhythmicities in the Alpha, Theta and Gamma Ranges. In: Başar, E. and Bullock, T.H., Eds., *Induced Rhythms in the Brain. Brain Dynamics*, Birkhäuser, Boston, 155-181. https://doi.org/10.1007/978-1-4757-1281-0_9

[36] Tan, D., Nijholt, A. (2010). Brain-Computer Interfaces and Human-Computer Interaction. In: Tan, D., Nijholt, A. (eds) Brain-Computer Interfaces. Human-Computer Interaction Series. Springer, London, 3-19. https://doi.org/10.1007/978-1-84996-272-8_1

[37] Ahn, M., Lee, M., Choi, J. and Jun, S.C. (2014) A Review of Brain-Computer Interface Games and an Opinion Survey from Researchers, Developers and Users. *Sensors*, **14**, 14601-14633. https://doi.org/10.3390/s140814601