Questing Ruins: A Game for a Digital Inclusion

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Abstract. The inclusion of people with cerebral palsy is not an easy path, because many of them preserve their cognitive abilities, despite being unable to speak, walk, or even both. This paper presents a study on the games applied in the education of people with cerebral palsy using Brain Computer Interface (BCI). Children affected by Cerebral Palsies have a disturbance in the control of their postures and body movements as a result of a brain injury. These injuries are the result of several causes. The most frequent is linked to the lack of oxygen flow to the brain, occurring either during or immediately after birth. The objective of the current research is to study the evaluation of the game we developed, called Questing Ruins. The methodology used was that of qualitative approach and case study. At the end we present Questing Ruins, an adventure game for entertainment and environmental awareness.

Keywords: Brain computer interface · Digital inclusion · Motor impairments

1 Introduction

1.1 Game Characteristics

All games share four characteristics, which define them: target, rules, feedback system and voluntary participation [1]. The target is the reason that justifies the player participating in any of the activities; in other words, the element by which the participants of a game concentrate their attention in order to reach the set goals. The rules adjust the player's complexity level in light of the activity to be undertaken, "releasing creativity and stimulating strategic thinking […] therefore, they have the role of defining the way in which the player shall behave, or in which way the player will organize its actions in order to fulfill the challenges brought on by the game" [1]. The feedback system advises players as regards their relationship with the various aspects that regulate their interaction with the activity. This system is also responsible for encouraging motivation, also keeping participants aware of progress as regards themselves and their target [1]. According to the same author, in any game, whether digital or otherwise, one can observe that there is no need for an agreement between the conditions proposed and the player.

While there is yet little research, Granic *et al.* [2] point out the benefits of playing video games, the roles and benefits of which, in a more generalized manner, having been

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studied over decades. Evolutionary psychology has long emphasized the adaptive functions of play [3], and in developmental psychology, the positive function of game has been a recurring topic for some of the most respected scholars in the field [4–6]. Erikson [5] showed that the context surrounding games allow children to simulate and experience social and emotional alternatives that can bring-on feelings of resolution outside of the game context. Similarly, Piaget [4] theorized that the game of make-believe offers children opportunities to play-out real-life conflicts, to devise optimal resolutions for their own pleasure, and to alleviate negative feelings. Both Piaget [4] and Vygotsky [6] advocated strong theoretical links between play and a variety of elements that favor the development of social cognition.

Besides social cognition, developmentalists have emphasized that the game is an emotionally meaningful context, whereby the themes of power and domination, aggression, nutrition, anxiety, pain, loss, growth and joy can be enacted productively [7]. Granic *et al.* [2] provided a study analysis based on existing data regarding the positive effects of playing video games. They said that these games promote well-being, including the prevention and treatment of mental health issues. The same authors also said that playing video games promotes a series of social, emotional and cognitive skills, and also assists in problem solving, in addition to enabling creativity and a persistent optimistic motivational style that contributes towards success and personal fulfillment. Researchers also acknowledged that video games are changing the way in which students and teachers approach learning, and are being used by doctors in order to improve patient’s health. They suggested that video games could have a similar impact on the field of mental health, and recommended that psychologists, doctors and game designers collaborate to include video games in traditional therapies.

We now turn to the motivational, emotional and social benefits of playing video games. From an educational point of view, Johnson [8] argues that it doesn’t matter what the player is thinking while playing, but the way in which the player is thinking. This statement is strengthened by Dewey [9], when arguing that the greatest of all pedagogical fallacies is perhaps the notion that a person learns only that particular thing that he or she is studying. With regard to this, he highlights collateral learning as a path to building long lasting attitudes, these often being more important than grammar lessons or geography lessons or even the history that is being learned. Thus, when playing, users are building from the collateral learning. For some time, companies have attempted to develop low cost devices, to enable use at a personal level. In this project, games and the BCI can also be classed as a type of Assistive Technology.

1.2 Brain-Computer Interface - BCI

The first BCI was described in 1964 by Walter Grey, when he implanted electrodes directly into the motor area of the cortex of a human patient. The experiment consisted of recording the patient’s brain activity as he pressed a button. This action would make the slides of a projected slide show to move forward. Then the scientist developed a system that would make the slides advance whenever the patient’s brain activity indicated that they wanted the button to be pressed. Interestingly, besides testing the equipment and checking its effectiveness, he also discovered that there was a need to input a small delay in presenting the slide show, as the slides were advancing slightly ahead of time of the button being pressed [10].

According to Graimann *et al.* [10], until the 90s, progress on the study of BCIs was slow. For example, in the early twentieth century, there were around 10 research laboratories, on a worldwide scale, that were devoted to this study. However, there was a rapid growth over recent years regarding research on BCIs and there are currently more than 100 related research projects worldwide. However, the most important aspect is that this area of research was able to prove that it is able, not only to rehabilitate, but also extend the capabilities of human beings. On the other hand, BCIs are not yet completely conventional, they are not easy to use and as such, there is still a need to improve systems.

A BCI provides an alternate means for natural communication of the nervous system; it is an artificial system that surrounds efferent pathways of the body. It directly measures brain activity associated with the user's intention, and translates into application control signals. Typically, it has four characteristics: it must record direct brain activity; it must have feedback; it must be in real time; and should be controlled by voluntary initiative of the user [10].

The term BCI and its definition are well accepted in scientific circles. Nevertheless, it is possible to find in literature, other ways to describe this particular form of HMI [10]. According to Wolpaw *et al.* [11] "a direct brain-computer interface is a device that gives the brain a new non-muscular communication and control channel". According to Donoghue [12] "one of the main goals of a brain-computer interface (HMI [Human Machine Interface] or BMI - brain-machine interface) is to provide a command signal from the cortex. This command serves as a new functional output to control body parts with disabilities or physical devices, such as computers and robotic limbs". In line with this, Levine *et al.* [13] states "a direct brain interface accepts voluntary commands directly from the human brain without the need for physical movement and can be used to operate a computer or other technologies".

When starting this study we sought through scientific literature regarding BCI articles and/or papers. We found many in the medical field, some in education, however none that mentioned people with physical disabilities and/or cerebral palsy that used BCI. A research study between Coventry University and the Universidad Veracruzana, conducted by Rebolledo-Mendez and Dunwell [14], presented a usability evaluation of the device known as MindSet (MS), by NeuroSky. An interesting aspect was to assess whether MS readings can be combined with the data generated by the user. Already the research group at the University of Oulu, Finland, in partnership with the Human-Computer Interaction Institute, of Carnegie Mellon University, formed by Haapalainen *et al.* [15], conducted a study on the assessment of cognitive charge. The group of researchers from the LISTEN Project at Carnegie Mellon University - Mostow, Chang and Nelson [16] - showed that EEG data from the NeuroSky device could identify the frequency bands that were sensitive to difficulty and were able to discriminate between easy and difficult sentences with, better than by chance, among samples (adults and children) and modalities (oral and silent reading). They identified frequency bands susceptible to difficulties and various properties of lexical problems, which suggests that they may detect transient changes in cognitive demand or specific aspects of lexical access. Xu *et al.* [17], from University of California, used the device to develop a Wearable Assistive System Design for the Prevention of Falls, which can detect the risk of falls by monitoring the EEG signals from users and releasing an alerts prior to the actual fall occurring. Crowley *et al.* [18], from the University College Cork, Ireland, conducted two psychological tests to assess the suitability of the headset to measure and categorize a user's level of attention and meditation while playing. Wolpaw [19] states that the brain-computer interfaces (BCIs) are a fundamentally new approach to restore communication and control to people with severe motor disorders, such as Amyotrophic Lateral Sclerosis (ALS) and spinal cord injuries as well as other degenerative diseases. And he said, in 2007, that it could be an excellent assistive technology.

Schuh *et al.* [20] developed a study and prototyped simulator of a wheelchair in a three-dimensional environment controlled by non-invasive brain-computer interface. To this effect, we used a low cost EEG, NeuroSky Mindwave, as a signal acquisition device. For the development, we used Unity, a game engine. Through the prototype developed, we were able to detect blinking, and thus use this feature as a command for the simulator.

Operation. As shown in Fig. 1, one can find that:

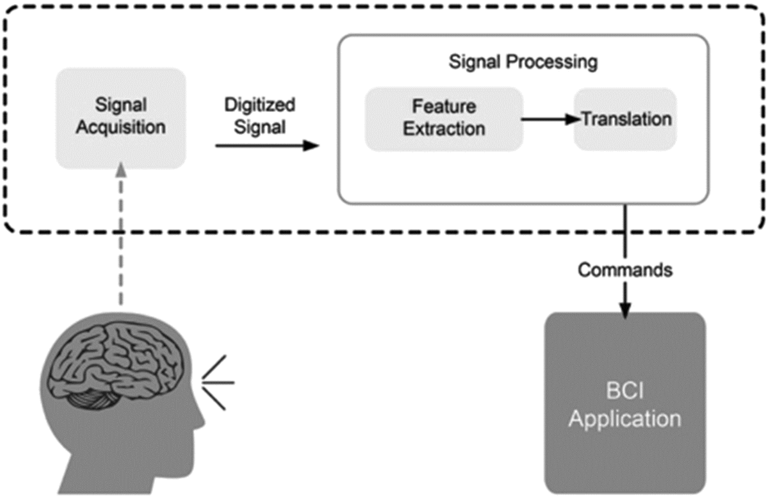

Fig. 1. BCI process diagram

- The process begins with the user's intention;
- The intention to communicate or control something triggers a complex process in certain areas of the brain;
- The activation of certain areas of the brain causes a potential difference with the adjacent areas.

NeuroSky MindWave Mobile. In the experiments we will use the NeuroSky MindWave (MW). NeuroSky is a company that was founded in 2004, in Silicon Valley, and which is focused on developing BCI devices. MW is a portable EEG machine that currently costs USD 129.90. In general terms, this machine can record brain waves, process the information and scan it. It then makes this information available to the used in applications [21].

This device is based on the NeuroSky ThinkGear technology, which consists of an electrode positioned in the Fp1 region, an electrode as point of reference in the ear clip, and an inside chip that processes all data as well as removes noise and interference. The device features a proprietary algorithm called eSense. It is through this that some features are extracted from the scanned signals, providing some alternative commands directly in the applications. One can for example, quote the attention and meditation levels [21].

Also known as neuro headset, due to its similarity in design to a headphone (earpiece), as can be seen in Fig. 2, it has a bluetooth interface with easy connectivity using serial ports, with support for Microsoft Windows platforms, OS X, Android and IOS. It does not have an internal battery and needs an AAA battery in order to operate. Other features to considered are: no need to use conducive gel on the electrode, no connection cables, extremely light, which makes it an easy to use device [21].

Fig. 2. Neurosky Mindwave

2 Methods and Materials

The research was of a qualitative approach. To develop the research we chose the case study. We justified our choice because the case study is an in-depth, multi-faceted research of a unique social phenomenon. We worked with Observational Case Studies. According to this author, the participatory work within the classroom and the new teaching methods can be object of participating observation. Stake [22] suggests that the case study is the study of the particularity and complexity of a case in understanding its activities within particular circumstances.

The purpose of the study was explained to all participants:

- Before each game there was an explanation of the purpose and mode of interaction (Attention/Meditation).
- The participants with CP performed the test individually in the presence of researcher and her interns.

The game developed is called Questing Ruins. This game has two versions: one that works with the blink of the eyes and the concentration levels (standard version) and, a version that works just with the concentration levels. Below, is shown (Fig. 3) the execution of some of the tests conducted with the sample, while playing the standard version (to the left) and with the concentration version (to the right).

Fig. 3. User tests

In the game Questing in Ruins, the player assumes the figure of an ancient, which aims to get to the other side of town to disable a mechanism, and thus to free his people from machines that brought destruction to its once thriving kingdom. To advance in the game, one makes use of concentration and the blink of the eyes, allowing the character to interact with the objects in the scene. Below, is shown an image (Fig. 4) with these objects and scenery.

For example, when hitting an obstacle, the player must concentrate or control the intensity of his/her wink, so to overtake it. Along the way, the player encounters puzzles and only after beat them the character can continue walking. These puzzles consist of a disc that automatically rotates, having locks of different formats. When the player selects (by blinking) the correct lock and key, the game continues. At the end of each level, the player also finds another puzzle, composed of pieces that must be rotated through concentration, in order to guide a water supply inlet to its output. Below, a reference image (Fig. 5).

Fig. 4. A sample screen of the game

Fig. 5. An example of the final challenge of the game

3 Conclusions

BCI (Brain-Computer Interface) technology provides a means for interaction with machines, products, systems, and as such, its study is shown as something of major importance, because on the one hand, through BCI it is already possible to adapt machinery, products and systems to people with mobility problems in order to improve their performance, turning disabilities into mere differences of execution, but with averages of performance similar to those of ordinary people. On the other hand, the study of BCI ergonomics allows for analyzing levels of mental burden, instantly and objectively. The study on brain computed interface seeks to improve the way of interaction between humans and machines. It is important to remember that the expansion and recovery of motor and cognitive functions are the main focus of research in this area. It can be stated that the EEG, although developed a long time ago, is still a key tool to support clinical diagnoses. However, researchers are conducting new approaches to this device. It is believed that soon we will see such approaches allied to games including educational.

It was observed after testing that this equipment has a very low precision when the game needs the input of the blink of an eye. People with motors impairments had difficulties to play. It is believed that the BCI equipment with more electrodes can solve this problem. In terms of ergonomics, materials need to be flexible so there is a better fixation on the user's head. In many people of the sample, it was not possible for the MindWave to stay steady throughout the entire test period, as it slid into smaller encephalic perimeters.

When the MindWave is used only with the concentration levels, it works better, but to our goal in assist in the education of people with cerebral palsy, MindWave was presented at this stage of testing just as a leisure tool.

References

1. Medina, B., Vianna, Y., Vianna, M., Tanaka, S., Gamification Inc.: como reinventar empresas a partir de jogos, 1st edn. MJV Press, Rio de Janeiro (2013)
2. Granic, I., Lobel, A., Engels, R.C.M.E.: The benefits of playing video games. Am. Psychol. **69**(1), 66–78 (2014)
3. Piaget, J.: Play, Dreams and Imitation. Norton, New York (1962)
4. Erikson, E.H.: Toys and Reasons: Stages in the Ritualisation of Experience. Norton, New York (1977)
5. Vygotsky, L.: Mind in Society: The Development of Higher Psychological Functions. Harvard University Press, Cambridge (1978)
6. Gottman, J.M., Mettetal, G.: Speculations about social and affective development: friendship and acquaintanceship through adolescence. In: Gottman, J.M., Mettetal, G. (eds.) Conversations of Friends: Speculations on Affective Development, pp. 192–237. Cambridge University Press, New York (1986)
7. Johnson, S.: Surpreendente: a Televisão e o Videogame nos Tornam Mais Inteligentes. Campus, São Paulo (2005)
8. Dewey, J.: Experience and Education. Free Press, New York (1997)
9. Graimann, B., Allison, B., Pfurtscheller, G.: Brain-computer interfaces: a gentle introduction. In: Graimann, B., Allison, B., Pfurtscheller, G. (eds.) Brain-Computer Interfaces. The Frontiers Collection, pp. 1–27. Springer, Heidelberg (2010)
10. Wolpaw, J.R., Birbaumer, N., McFarland, D.J., Pfurtscheller, G., Vaughan, T.M.: Brain–computer interfaces for communication and control. Clin. Neurophysiol. **113**(6), 767–791 (2002)
11. Donoghue, J.P.: Connecting cortex to machines: recent advances in brain interfaces. Nat. Neurosci. **5**, 1085–1088 (2002)
12. Levine, S.P., Huggins, J.E., BeMent, S.L., Kushwaha, R.K., Schuh, L.A., Passaro, E.A., Ross, D.A.: Identification of electrocorticogram patterns as the basis for a direct brain interface. Clin. Neurophysiol. **16**(5), 439–447 (1999)
13. Rebolledo-Mendez, G., Dunwell, I.: Assessing NeuroSky's usability to detect attention levels in an assessment exercise. In: Jacko, J.A. (ed.) Human-Computer Interaction New Trends, pp. 149–158. Springer, Heidelberg (2009)

14. Haapalainen, E., Kim, S., Forlizzi, J., Dey, A.: Psycho-physiological measures for assessing cognitive burden. In: Bardram, J.E., Langheinrich M. (eds.) Proceedings of the 12th ACM International Conference on Ubiquitous Computing, Ubicomp 2010, pp. 301–310 (2010)
15. Mostow, J., Chang, K.-M., Nelson, J.: Toward exploiting EEG input in a reading tutor. In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS, vol. 6738, pp. 230–237. Springer, Heidelberg (2011)
16. Xu, W., Gong, F., He, L., Sarrafzadeh, M.: Wearable Assistive System Design for Fall Prevention (2011). http://www.ee.ucla.edu/~wxu/papers/conference/xu-hcmdss2011.pdf
17. Crowley, K., Sliney, A., Pitt, I., Murphy, D.: Evaluating a brain-computer interface to categorise human emotional response. In: 2010 IEEE 10th International Conference Proceedings on Advanced Learning Technologies (ICALT), pp. 276–278. IEEE Computer Society (2010)
18. Wolpaw, J.R.: Brain–computer interfaces as new brain output pathways. J. Physiol. **579**(3), 613–619 (2007)
19. Schuh, A.R., Lima, A., Heidrich, R.O., Mossmann, J., Flores, C., Bez, M.R.: Development of a simulator controlled using non-invasive brain-computer interface for training in the use of a wheelchair. Revista Novas Tecnologias na Educação, **11**(3), 1–9 (2013). http://seer.ufrgs.br/index.php/renote/article/view/44716
20. Neurosky. Neurosky Mindwave. http://www.neurosky.com/Products/MindWave.aspx
21. Stake, R.E.: The Art of Case Study Research. Sage, London (1995)