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Utilizing Brain-Computer Interface to Enhance the learning Capacities of Individuals with Impairments: A Brief Review

Achraf Othman*

Mada Center, Qatar

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A B S T R A C T

Brain-Computer Interface (BCI) allows for direct brain-to-device communication. In recent years, BCI systems have been a major topic of research. These technologies may be applied in a variety of ways to aid persons with impairments and healthy people. Considering significant BCI breakthroughs, these systems are on the approach of commercialization. This study examined current trends in BCI research on inclusive education to help students with disabilities achieve better learning outcomes for all students in an inclusive setting.

Keywords:Brain-computer interface, inclusive education, student with disabilities

1. Introduction

Research on brain-computer interface (BCI) devices has been prevalent during the last several decades. BCI allows for a direct link between the brain and an external device, such as a computer, robot, neuro-prosthesis, exoskeleton, speech prosthesis, assistive technology, or wheelchair [1] [2]. Multiple focus groups with people with impairments shown an interest in leveraging BCI technology to develop new goods and solutions [3]. These systems may serve an assortment of objectives. In addition to therapeutic uses, they may be utilized for entertainment, training, security, therapy, education, safety, communication, and control [4][5]. The majority of BCI systems are divided into invasive and non-invasive methods. The non-invasive method is the most common and safest choice available. Despite the publishing of countless articles and the development of a number of practical applications, BCI systems continue to confront a number of challenges and limitations.

It is necessary to comprehend how the brain operates in order to measure and understand brain waves. During brain function, the electrical and magnetic phenomena of neural function may be measured. Electroencephalography [6] is the most common method of electrophysiological observation, in which biosensors monitor and record electrical signals produced by brain activity. Brain cells interact by the transmission of electrical impulses; the greater the number of impulses sent, the more electricity the brain creates. The pattern of this electrical activity may be monitored using an electroencephalogram (EEG); these EEG data are often studied using a quantitative EEG (QEEG) technique in which the frequency spectrum of EEG signals is analysed [7]. Figure 1 provides an overview of potential location across the scalp to detect and monitor brain activity electrical impulses [8].

* *Corresponding author.*
E-mail address: achraf.othman@ieee.org

Obtaining an EEG requires complicated, costly, comprehensive, and immobile equipment; nevertheless, technical advances have allowed mobile EEG biosensor-based embedded devices for new applications, such as entertainment, control devices, and education. In these applications, a BCI determines the correlation between EEG-observed brain activity and the produced function [9]. Advanced BCIs contain biosensors and sophisticated signal processing units, are less costly and more portable owing to their straightforward design, and are as accurate as clinical EEG equipment [10]. Table 1 provides an overview of several methodologies.

Active student engagement enhances the acquisition and retention of new material more efficiently than standard lecture-based training [11], according to education studies. In addition, when this active involvement is group-based as opposed to individual-based, students' problem-solving, writing, and spoken communication abilities, as well as their learning and cooperation skills, improve [12]. Problem-based learning (PBL) [13], team-based learning [14], and project-based learning (PjBL) [15] all allow for the effective development of applicable engineering skills. Engineering places a heavy emphasis on the capacity to apply knowledge in the actual world.

Table 1 - Summary of neuroimaging methods.

Neuroimaging method	Activity measured	Direct/Indirect Measurement	Temporal resolution	Spatial resolution	Risk	Portability
EEG	Electrical	Direct	~0.05 s	~10 mm	Non-invasive	Portable
MEG	Magnetic	Direct	~0.05 s	~5 mm	Non-invasive	Non-portable
ECoG	Electrical	Direct	~0.003 s	~1 mm	Invasive	Portable
Intracortical neuron recording	Electrical	Direct	~0.003 s	~0.5 mm (LFP) ~0.1 mm (MUA) ~0.05 mm (SUA)	Invasive	Portable
fMRI	Metabolic	Indirect	~1 s	~1 mm	Non-invasive	Non-portable
NIRS	Metabolic	Indirect	~1 s	~5 mm	Non-invasive	Portable

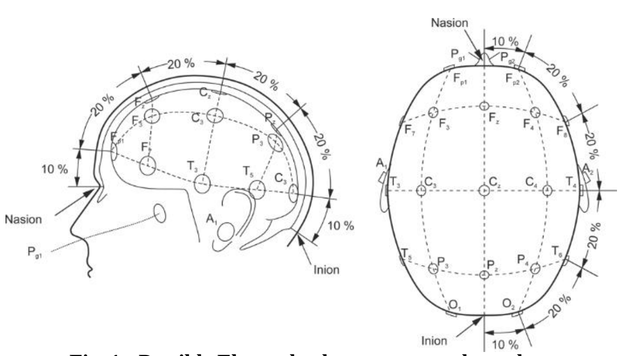

Fig. 1 - Possible Electrode placement over the scalp.

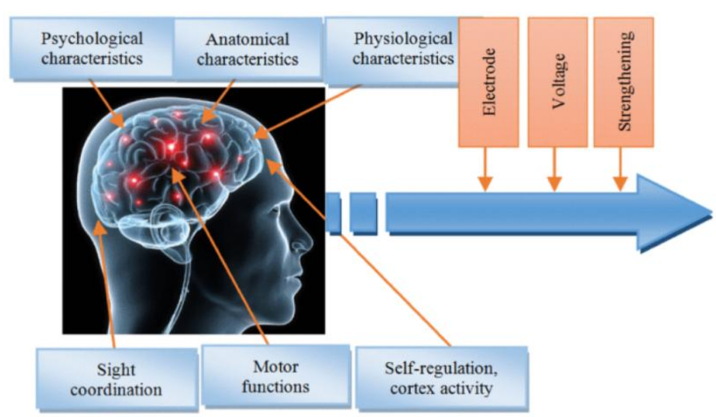

Fig. 2 - a model of bioelectric signals.

2. BCI as an Assistive Technology

Significant progress has been achieved in BCI control research [16] [17]. It may be utilized in several scenarios, including but not limited to:

- Control of external devices, such as limbs prostheses [18]
- Smart home environments [19]

- Robots and Exoskeletons [20]
- Robotic hand [21]
- Hearing prostheses [22]
- Wheelchairs [23]
- Computer programs [24]
- Virtual reality, avatars, and metaverse [25]
- Virtual environment and smart cities [26]

The most essential use of BCI is to offer paralyzed persons intuitive control over overreaching and gripping actions [27]. Additional conceivable uses include communication [28]. Restoring and replacing motor function or communication for persons with physical limitations is one of the greatest problems.

3. BCI control in Educational and Serious Games

All children depend substantially on play for their development and learning. [29] Both neurotypical and neurodiverse children benefit more from participating in activities that keep them interested, engaged, and provide chances for embedded learning. However, contemporary BCI software concentrates on utilitarian applications like spelling grids and cursor movement. While genuine, the attraction of such applications for continuous usage is limited, especially among younger BCI users. There is evidence to show that increasing participation in BCI via gamified learning may result in a wider acceptance of the technology and assist in the proliferation of BCI control schemes. [30]. A increasing trend in BCI research projects indicates that more engaged. User-friendly activities may promote a number of practical benefits in BCI usage, including both short-term task acquisition and long-term BCI precision [31]. Therefore, it is essential to encourage the creation of more engaging, accessible BCI software that incorporates crucial play components for pediatric BCI.

BCI systems provide new opportunities for both virtual and physical play (e.g., videogames and digital media) (e.g., manipulation of toy robots, cars, et cetera). BCI's non-muscular qualities may allow previously excluded groups to explore and learn via play. BCI systems provide the opportunity for both virtual and physical play (e.g., videogames and digital media) (e.g., manipulation of toy robots, cars, et cetera). BCI's non-muscular qualities may allow previously excluded groups to explore and learn via play. Previous study has indicated that children with impairments need media for continuous education and rehabilitation. For pediatric BCI end-users, advancements in BCI research that enhance the connection between BCI devices and play provide a significant untapped opportunity.

4. The outcome of learning activities using BCI

BCI can play a crucial role in bridging the knowledge gap and enhancing the educational capacities of individuals with impairments [32]. The major objectives of these courses are for students with impairments to be able to:

- Classify systems based on their properties and understand and exploit the implications of linearity, time invariance, and stability.
- Determine and use Fourier transforms and other signal analysis methods.
- Understand the application of control methods, proportional–integral–differential algorithms, and properties of a control.
- Understand and analyze the design implications and interconnections of physical and control systems.
- Develop mathematical models for real physical and control systems and produce block diagram implementations of the mathematical models and control methods.
- BCI can present an alternative technology to control and take online courses during crises [33].

5. Conclusion

Typically, BCI links the brain to external equipment [34]. BCI is appropriate for enhancing and facilitating the lives of all individuals. BCIs are applicable in several fields, including inclusive education [35][36]. Overall, the data indicate that BCI is a subject that is being researched by scientists worldwide. In addition, this research reveals that BCI technology was frequently used for medical purposes. In education, BCI may be utilized to manage the computer for students with physical limitations through remote learning [37]. The technology is still under development and has the potential to provide exceptional outcomes with future significance.

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