IJMSRI International Journal of Medical Science Research and Innovations
Volume 2 Special Issue 1 (Feb) 2025, Article 20 (pp.50-52)
ISSN-3048-9067

Original Investigation | Neurology

Bridging Minds: The Untapped Potential Of Brain-Computer Interfaces In Pediatric Neurology

Mrunal Boddu[1], Drashti Vora[1]

MD Georgian National University, SEU, Tbilisi, Georgia[1]

Key Points

Question:
Can Brain-Computer Interfaces (BCIs) be effectively adapted for pediatric neurology, particularly for children with neurodevelopmental disabilities, cerebral palsy, autism, or severe motor impairments?
What are the methodological and ethical challenges of integrating BCIs into pediatric care?

Findings:
BCIs have shown significant potential in enhancing motor function through neurofeedback and sensory awareness in children with severe motor impairments.
EEG-based neurofeedback has been effective in improving motor recovery in children with cerebral palsy.
Tailored machine learning algorithms and interface designs for children improve therapy adherence and outcomes.

Meaning:
BCIs could revolutionize pediatric neurology by improving communication, autonomy, and rehabilitation for children with neurological disorders.
Challenges such as brain development differences, behavioral factors, ethical concerns, and safety must be addressed.

Abstract

Importance:
BCIs represent a transformative potential in pediatric neurology that will permit importantly novel ways to diagnosis, treatment and rehabilitation. While there is no question that BCI technology can be translated to the young, this article posits that doing so effectively will require new methodological advances.

Objective:
This review systematically investigates literature published between 2014 and 2024 with focus on BCI platforms for children with a neurodevelopmental disability, suffering from cerebral palsy or autism spectrum disorders as well as subjects presenting severe motor impairments.

Evidence Review:
Indeed, BCIs have shown breath-taking advances in motor modulation via neurofeedback and sensory awareness for children with very limited motor capabilities. However, there are also unique limitations to BCI performance in pediatric populations; such as differences in brain structure development or behavioral aspects (eg attention and cooperation) that have relationships with the acquisition of signal processing and efficacy.

Findings:
Recently introduced BCI paradigms, where machine learning algorithms and interface design are tailored to children have the potential of providing a critical first step toward improving both therapy adherence and outcomes. EEG-based neurofeedback, for example, has been shown to enhance motor recovery in children with cerebral palsy by facilitating the formation of feedback loops that enable them to relearn and reinforce their damaged motor pathways. Especially interesting is the pioneering of new ways to train executive functions in children with ADHD and similar conditions, so that they keep their brain active instead.

Conclusion:
Although promising, much work is required before BCIs can be integrated into pediatric clinical practice. Because of the ethical concerns related to long-term neural effects, fair access and safety, it is clear that cross- discipline collaboration between neurology consultants, engineers as well as ethicists will be essential. This review highlights the critical requirement for pediatric neurodevelopment-based and clinical-specific scalable adaptable BCI systems. Such a successful and efficient introduction of BCIs into pediatric neurology could open up entirely new opportunities for improving the quality of life in children with neurological disorders regarding communication, autonomy and functional rehabilitation.

Volume 2 Issue 1 (Feb) 2025, Article 20 (pp.50-52)
ISSN-3048-9067

References (Continues...)

Zhuang M. State-of-the-art non-invasive brain–computer interface for neural rehabilitation: A review. Journal of Neurorestoratology. 2020;08(01):12-25. doi:https://doi.org/10.26599/jnr.2020.9040001

Hossein Tayebi, Azadnajafabad S, Seyed Farzad Maroufi, et al. Applications of brain-computer interfaces in neurodegenerative diseases. Neurosurgical Review. 2023;46(1). doi:https://doi.org/10.1007/s10143-023-02038-9

Jadavji Z, Zewdie E, Kelly D, Kinney-Lang E, Robu I, Kirton A. Establishing a Clinical Brain- Computer Interface Program for Children With Severe Neurological Disabilities. Cureus. Published online June 22, 2022. doi:https://doi.org/10.7759/cureus.26215

Ploesser M, Mickey Ellis Abraham, Daphne L, et al. Electrical and Magnetic Neuromodulation Technologies and Brain-Computer Interfaces: Ethical Considerations for Enhancement of Brain Function in Healthy People – A Systematic Scoping Review. Stereotactic and Functional Neurosurgery. Published online July 10, 2024:1-17. doi:https://doi.org/10.1159/000539757

Lin JW, Fan ZC, Tzou SC, Wang LJ, Ko LW. Temporal alpha dissimilarity of ADHD brain network in comparison with CPT and CATA. IEEE transactions on neural systems and rehabilitation engineering. 2024;32:1333-1343. doi:https://doi.org/10.1109/tnsre.2024.3360137

Carelli L, Solca F, Faini A, et al. Brain-Computer Interface for Clinical Purposes: Cognitive Assessment and Rehabilitation. BioMed Research International. 2017;2017:1-11. doi:https://doi.org/10.1155/2017/1695290

Letourneau S, Zewdie ET, Jadavji Z, Andersen J, Burkholder LM, Kirton A. Clinician awareness of brain computer interfaces: a Canadian national survey. Journal of NeuroEngineering and Rehabilitation. 2020;17(1). doi:https://doi.org/10.1186/s12984-019-0624-7

Zhuang M. State-of-the-art non-invasive brain–computer interface for neural rehabilitation: A review. Journal of Neurorestoratology. 2020;08(01):12-25. doi:https://doi.org/10.26599/jnr.2020.9040001

Cioffi E, Hutber A, Molloy R, et al. EEG-based sensorimotor neurofeedback for motor neurorehabilitation in children and adults: a scoping review. Clinical Neurophysiology. 2024;167:143- 166. doi:https://doi.org/10.1016/j.clinph.2024.08.009

Amalia Egle Gentile, Rinella S, Desogus E, et al. Motor imagery for paediatric neurorehabilitation: how much do we know? Perspectives from a systematic review. Frontiers in human neuroscience. 2024;18. doi:https://doi.org/10.3389/fnhum.2024.1245707

Kinney-Lang E, Auyeung B, Escudero J. Expanding the (kaleido)scope: exploring current literature trends for translating electroencephalography (EEG) based brain–computer interfaces for motor rehabilitation in children. Journal of Neural Engineering. 2016;13(6):061002. doi:https://doi.org/10.1088/1741-2560/13/6/061002

Volume 2 Issue 1 (Feb) 2025, Article 20 (pp.50-52)
ISSN-3048-9067

Article Information

Accepted for Publication: December 24-2024
Published: February 13-2025.

Corresponding Author: Mrunal Boddu, MD Georgian National University, SEU, Tbilisi, Georgia.
Acknowledgment: - MedVentures (CPD no.-#784331) for providing financial support for Publishing, Alte University.