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Cognitive requirements for effective brain-computer interface (BCI) use in children with cerebral palsy.

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Introduction: Brain-computer interfaces (BCIs) requires specific user skills for successful operation. However, the cognitive demands remain relatively unexplored, particularly in pediatric populations, where developmental differences and cognitive variability significantly influence usability and performance. This is especially true for children with cerebral palsy (CP), who often face additional cognitive and motor challenges that can further impact their interaction with BCI systems. This review aims to examine existing research on the cognitive demands of BCI technology, with a special focus on children with CP.

Methods and results: A systematic search was conducted across six databases (Scopus, Web of Science, Embase, MEDLINE, PsycINFO, and CINAHL) for original research studies involving children aged 5-18 using BCIs for control purposes. Inclusion criteria focused on studies reporting cognitive factors relevant to BCI performance. Data extraction and analysis followed the PRISMA-ScR guidelines.

Initially, 724 articles were identified, with 446 screened after removing duplicates. Of these, 420 were excluded for not focusing on BCI, children with CP, and cognition. Full-text review of 26 articles excluded 19 that did not meet inclusion criteria, leaving five studies. Participants were aged 6 to 18 years. They included children with CP with Gross Motor Function Classification System (GMFCS) levels I to V.

Activities done with BCI varied, including cognitive assessments, spelling, and controlling devices like cars, games, and robots using P300- or MI-based BCIs. Cognitive areas crucial for BCI use included **attention**, which is critical for P300 tasks, and sustained focus, which is often challenging due to fatigue, long setup times, and unengaging stimuli (1–4). **Motivation and engagement** influence BCI performance (5). **Processing speed** and **fatigue**, both mental and physical, also impacted usability, particularly in synchronous systems (real-time) (1). Neuroimaging was noted as a valuable tool to help identify neuroanatomical changes that might affect performance, informing the electrode placement and ensuring eligibility.

Conclusion: These findings emphasize the need for customized, engaging, and developmentally appropriate BCI systems. The limited number of included studies underscores the need for further research to comprehensively understand the cognitive requirements for BCI performance.

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