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Adaptive EEG-Based Brain-Computer Interfaces for Stroke Patients: A Scoping Review

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***Introduction**:* EEG-based brain-computer interfaces (BCIs) have gained attention for their potential to enhance post-stroke rehabilitation through motor imagery tasks. By dynamically tailoring the system to individual neurophysiological responses, adaptive BCIs promise more personalized rehabilitation, potentially improving patient engagement and intervention outcomes [1,2,3]. However, given the diversity in post-stroke motor impairments and neuro-rehabilitation approaches, the comparative efficacy of adaptive versus non-adaptive BCIs remains unclear [4, 5]. Hence, the current study aimed to systematically evaluate empirical evidence on adaptive EEG-based BCIs, focusing on their benefits, challenges, and effectiveness in post-stroke rehabilitation.

***Material, Methods and Results**:* A scoping review was conducted following the PRISMA-ScR protocol to investigate the benefits and effectiveness of adaptive EEG-based motor imagery BCIs for post-stroke patients. A systematic search of 3 databases (Scopus, PubMed and IEEE Xplore) with the query "(BCI OR Neurofeedback) AND stroke AND EEG AND adaptive AND motor" provided 62 original publications, 13 of which met the predefined inclusion/exclusion criteria. Data extraction from these 13 studies highlighted that adaptive BCIs can effectively address challenges such as inter-user variability and EEG non-stationarity through real-time adaptation of the feedback and model recalibration. For instance, personalized calibration could enhance classification accuracy for stroke patients by up to 13.5% when adapting to inter-session signal fluctuations [3, 5]. Additionally, real-time feedback mechanisms were shown to promote cortical reorganization. One study reported a 15% improvement in Fugl-Meyer Assessment scores for upper extremities when combining adaptive BCIs with virtual reality and functional electrical stimulation [3]. Therefore, positive trends in motor recovery and user engagement were identified [3, 6], yet direct comparisons to non-adaptive systems were considered limited. Variability in study designs and outcome measures further constrained definite conclusions about the comparison between adaptive and non-adaptive systems [4, 5, 6].

***Conclusion**:* Our scoping review shows that while adaptive BCIs offer significant promise in stroke rehabilitation by personalizing feedback and addressing EEG signal variability, limitations exist in comparative studies and standardization, highlighting the need for further research. Future studies should prioritize direct comparisons between adaptive and non-adaptive systems, alongside longitudinal designs to assess long-term impacts on motor recovery and daily functioning.

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