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Brain-Computer Interface Communication Application for Children with Diverse Learning Needs

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Introduction: The purposeful uses of communication include exclaiming, protesting, describing, and requesting, amongst others. Successfully communicating these intents is difficult, if not impossible, for children and adolescents with neurodiversity or neurodevelopmental conditions, such as cerebral palsy, genetic disorders, or Rett syndrome. This submission reports on an electroencephalography-based Brain-Computer Interface (EEG-based BCI) communication application delivered to children and adolescents with diverse learning needs using a Visual P300 event-related potential (ERP) oddball paradigm.

Materials: We used a research grade, seven-sensor dry electrode EEG system, the DSI-7 Flex (Wearable Sensing, San Diego, USA) in conjunction with a dedicated BCI communication software application built with Unity (Unity Software Inc., San Francisco, USA), and processed using an open-source, cross-platform toolbox called *BCI-Essentials* (Figure 1).

Methods: Our study used a within-participant pretest–posttest design with single baseline and control behaviors within an iterative testing approach. A four-week, 15 session intervention, applying the validated communication procedure, *The System for Augmenting Language* [1] was delivered within the contextually authentic school environment. Students learned to communicate a 'request' by visually focusing on the image that represented their desired choice. In each session, a Riemannian geometry classifier was trained on one of three or four objects available for students' selection, followed by online testing during which the software 'spoke' the estimated selection. A paired-samples t-test was conducted to determine the effect of the intervention on purposeful communication using BCI. We conducted offline analyses of the EEG data to inspect signal quality and consistency of the P300 signal.

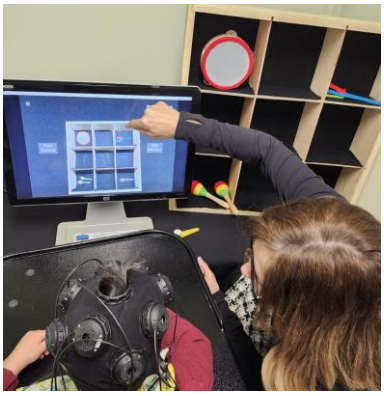

Figure 1. BCI Communication Application

Results: Trials are ongoing. Three trials of two participants each (n = 6; 4 girls, 2 boys; 6 - 13 years of age) are complete. Students' behavioral 'look to request' scores before intervention (M = 6.8; SD = 11.1) and after intervention (M = 15.8; SD = 16) indicated a significant average increase in visual focus to request an object [t(5) = -2.9, p = 0.031]. Offline analyses of the EEG revealed instances of P300 evoked potentials for each participant. However, the majority of trials contained no discernable P300, which we hypothesize were highly detrimental for training the classifier, leading to ineffective classification.

Conclusion: Our BCI communication application demonstrates early feasibility of teaching a purposeful communication behavior in a way that is accessible and engaging for students with complex learning needs. We continue to iterate and improve the BCI signal processing and classification systems to more reliably build a performant classifier based on the EEG signals from our diverse population.

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