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Online Information-Based Stimulus Optimization for P300-based Brain-Computer Interfaces

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Introduction: Brain-computer interfaces (BCIs) interpret users' intent by extracting relevant information from their brain signals. Visual P300-based BCIs [1] enable users to select a target object on a screen by interpreting their responses to a series of stimuli. The BCIs operate by identifying event-related potentials (ERPs) elicited in response to presentations of the user's target object. As ERPs are embedded within noisy brain signal data, the user's target object must typically be presented several times to be identified with confidence. Conventionally, stimulus presentation schedules are designed pseudo-randomly [1, 2]. BCI communication rates may be improved by leveraging real-time user data to adapt stimulus schedules [3, 4, 5]. We previously proposed an information-based algorithm for adaptive BCI stimulus selection that optimizes the prior probability mass of a hypothetical future stimulus [5]. Here, we present results from an online study of our proposed adaptive diffuse stimulus presentation paradigm, which uses our previous algorithm to dynamically select stimuli in real-time and mitigates adjacency distractions in a matrix BCI layout by designing stimuli with non-adjacent components.

Material, Methods and Results: We recruited 21 participants from the Duke University community for an online study comparing our adaptive diffuse paradigm and the pseudo-random checkerboard paradigm [2]. Each participant spelled 30 characters to train a user-specific classifier and spelled 30 characters using the trained classifier during online BCI operation.

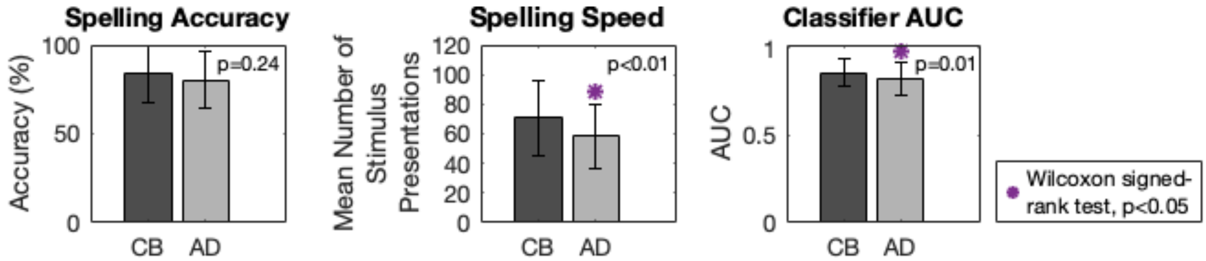

Figure 1. Mean participant performance (N=21) with the checkerboard (CB) and adaptive diffuse (AD) paradigms. AUC: Area under the receiver operating characteristic curve.

Discussion: We demonstrated statistically significant improvement in online spelling speeds with our adaptive diffuse paradigm (Fig. 1), compared to the checkerboard paradigm. However, there were slight decreases in spelling accuracy and classifier performance with the adaptive diffuse paradigm. Post-hoc analysis suggested that this arose due to refractory effects from low intervals between presentations of the target character, which can likely be mitigated by imposing a higher minimum interval between presentations of the same character.

Significance: We present a novel adaptive stimulus selection paradigm for the P300 speller that optimizes stimuli in real-time and improves spelling speeds relative to a conventional paradigm.

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