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Subject-Specific Electrode Subsets for P300 BCI: Typically Developing and Cerebral Palsy Populations

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Introduction: An electroencephalography (EEG)-based brain-computer interface (BCI) that uses the P300 response usually collects data from a default set of electrodes with fixed locations. Studies have shown that P300-based BCI performs better when used by healthy participants compared to those with impairments [1,2]. While there are studies on electrode selection and the impact on BCI accuracy [3,4], to our knowledge there is no systematic analysis on electrode selection using data of populations with impairments. Custom electrode subsets could address potential physiological difference among individuals, and thus might be particularly useful for subjects with impairments. This study investigates the effect of a customized electrode subset on P300-BCI accuracy, in particular for subjects with cerebral palsy (CP).

Methods: The selection method is adapted from McCann et al. [4]. In brief, the program uses a forward-search greedy algorithm to search for an electrode subset of size 16 among all the available 32 electrodes (Fig. 1). While there is no guarantee of a global maximum, the same study shows no statistically significant difference in performance between subset results from an exhaustive search and one from a greedy forward search. Best performance is defined as the highest accuracy in identifying a user's intended selections. Performance of the subject-specific subsets is compared to the default 16-electrode subset (Fig. 1).

An offline analysis was performed on data from a four-target selection protocol described in Huggins et al. [5]. Data was from 10 participants with CP (mean age of 19.2 ± 6.07 years), and 9 typically developing participants (mean age of 15.9 ± 4.58 years). In addition, training data of 4 CP subjects who were not able to use the BCI due to low training accuracy or unsuccessful configuration generation were also analyzed.

Results: For all 19 subjects, a significant increase ($p = 0.004$ with a paired 2 sample t-test) in P300-based BCI accuracy after 10 sequences is shown with a mean improvement of 3.24 ± 4.56%. Seven of the most-selected 15 electrodes (CP5, CP2, Pz tie at the 16th position) are not covered in the default 16 electrode subset (Fig. 1). Mean of improvements of the 10 subjects with CP is larger compared to the 9 typically developing subjects and the result trends towards significance ($p = 0.16$). Among the 4 subjects who could not use the BCI, training accuracies of 2 subjects improve greatly with custom electrode selection (12.9% and 15.0%). Of those, one subject reaches above 75% accuracy using the selected custom electrodes subset.

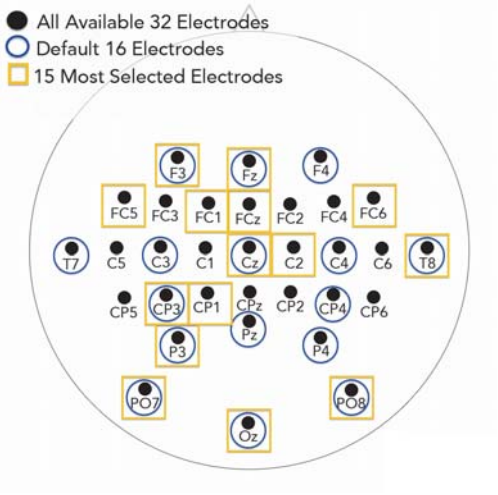

Figure 1. *Locations and Labels of All Available 32 electrodes, the Default 16-Electrode Set, and the Most Selected 15 Electrodes*

Conclusion and Significance: Subject-specific electrode selection improves P300-based BCI accuracy. The pilot data demonstrates that a custom electrode subset might allow more people to effectively use the BCI, in particular in populations with impairments.

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