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BCI-FIT: Effects of cBCI customization on performance

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Introduction: The BCI Functional Implementation Toolkit (BCI-FIT) is a customization protocol for EEG-based communication BCI (cBCI) systems that provides a set of system configuration options which might improve performance for individuals with severe disabilities [1]. We describe a single-case research design experiment investigating the effects of customization on typing performance.

Material, Methods and Results: BciPy software [2] was configured with options for: 1) event-related potential (ERP) typing interface (matrix or rapid serial visual presentation [RSVP]), 2) interface appearance (e.g. font or matrix size), 3) stimulus presentation (e.g. flash rate or number of characters flashed), 4) signal processing (e.g. trial window), and 5) cap (DSI-Flex or DSI-24, Wearable Sensing).

Using an alternating-treatments single-case research design, we compare typing performance with a customized BCI-FIT configuration to a non-customized single-character paradigm matrix speller. Up to 5 people with amyotrophic lateral sclerosis (ALS) and speech and/or physical impairments are participating in weekly data-collection home visits. First visits include informed consent, clinical screening, initial calibration of the matrix and RSVP interfaces, and discussions about customization options. For each participant, the study team determines an initial BCI-FIT configuration based on clinical screening results, system performance, and user preferences. In subsequent visits, the participant completes system calibration and a typing task (copying four 5-letter words) for both the customized and non-customized conditions. After each typing task, participants provide feedback, including any requested changes to their customized configuration. Dependent variables (DV) include percent of target characters copied (primary typing performance DV), targets copied per minute, and participant-reported workload ratings. Ongoing formative assessment includes discussion of potential changes to the customized configuration based on typing performance, participant preferences, clinical observations, ERP characteristics, and simulations. Data collection continues until 1) sufficient differentiation is observed between the two conditions for percent of targets copied or targets copied per minute (e.g., five demonstrations), 2) percent of targets copied is below 90% in five visits and the study team agrees there are no more system modifications that might improve performance; or 3) 20 visits have been completed.

Figure 1 shows data from two participants, whose customized parameters included interface type, trial window, flash rate, number of characters flashed, and matrix size. P1 consistently copied 95-100% of target characters for both conditions starting in visit 2, so for him BCI-FIT was optimized for targets copied per minute. The final BCI-FIT configuration for P1 outperformed the standard condition with three demonstrations of effect. Typing performance for P2 was variable for both conditions and never reached 90% of targets copied. Although neither condition showed superior levels of performance for P2, outcome data were instrumental in understanding and refining customization for specific participant variables.

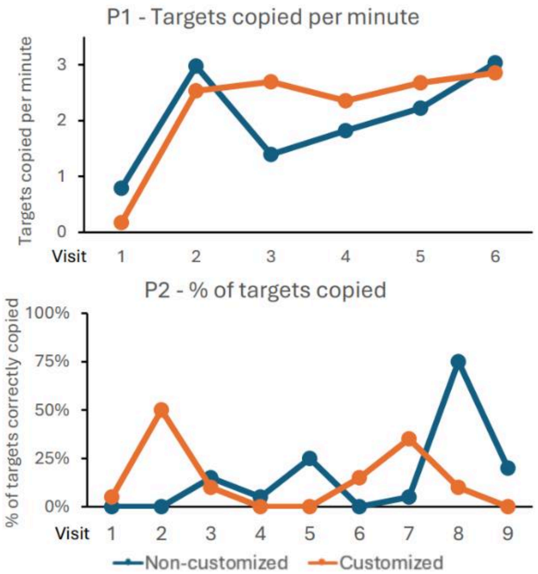

Figure 1: Data from 2 participants comparing performance with non-customized and customized versions of the cBCI across multiple visits.

Conclusion: Customization may improve cBCI typing performance or user experience for some individuals with disabilities. Additional control signals (e.g. code visual evoked potential) and other options could support successful typing for a wider range of users.

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