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Combining EEG and switch input in RSVP Keyboard

B. Peters[1]*, B. Celik[2], D. Galvin-McLaughlin[1], T. Imbiriba[2], M. Kinsella[1], D. Klee[1], M. Lawhead[1], S. Liu[2], T. Memmott[1], N. Smedemark-Margulies[2], D. Erdogmus[2], B. Oken[1], & M. Fried-Oken[1] on behalf of the Consortium for Accessible Multimodal Brain-Body Interfaces (CAMBI)

[1]Oregon Health & Science University, Portland, OR, USA; [2]Northeastern University, Boston, MA, USA

*707 SW Gaines St #1290, Portland, OR, 97239. E-mail: petersbe@ohsu.edu

Introduction: RSVP Keyboard is an EEG-based typing interface for people with severe speech and physical impairments (SSPI). It combines event-related potential and language model (LM) evidence to inform the characters presented to the user and selected for typing [1]. Here we describe Inquiry Preview (IP), a new RSVP Keyboard feature incorporating switch input as an additional control signal, and present results from pilot testing. This hybrid configuration may improve performance or user experience (UX).

Material, Methods and Results: Rapid serial visual presentation in RSVP Keyboard is divided into inquiries, typically of 10 characters. Characters in the first inquiry after a selection are those the LM identifies as the most likely targets given the previously typed string. Character probabilities are updated after each inquiry via Bayesian recursion until one character reaches a decision threshold. In IP mode, the user sees a box containing a preview of the characters in the upcoming inquiry. They can then activate a switch to either confirm that the target is included (causing the probabilities of included characters to increase and the inquiry to be presented to gather EEG evidence), or skip the inquiry if the target is not included (causing character probabilities to decrease). IP is also available without switch input.

Thirty-one participants without SSPI were recruited for pilot testing; 11 were excluded due to low calibration AUC (< 0.70; n=7) or poor EEG quality (n=4), leaving 20 included in data analysis (age 47.6 ± 19.20 years). After calibration, each participant completed copy-spelling tasks and a UX questionnaire. They copied 4 5-letter words under each of 4 conditions: standard RSVP, IP only (no switch input), IP with switch to confirm, and IP with switch to skip. Condition order was counterbalanced. Each condition included two “easy” words (in which all targets appeared in the first inquiry) and two “hard” words (in which one target did not appear until the third inquiry or later), selected at random. In the IP conditions, the preview was shown for 5 seconds or until switch activation, whichever came first. Stimuli were presented at 5 Hz, and the decision threshold was 0.80. If the threshold was not reached after 8 inquiries, the system selected the character with the highest probability based on combined LM, EEG, and switch evidence.

Typing accuracy and correct selections per minute (cspm) for each condition are summarized in the figure. Kruskal-Wallis tests revealed statistically significant differences between conditions for cspm but not for typing accuracy. Switch hits per selection averaged 3.8 for IP with switch to confirm and 0.4 for IP with switch to skip. In general, standard RSVP was the most preferred condition, followed by IP with switch to confirm. Narrative feedback revealed wide variety in opinions about the advantages and disadvantages of IP and switch input.

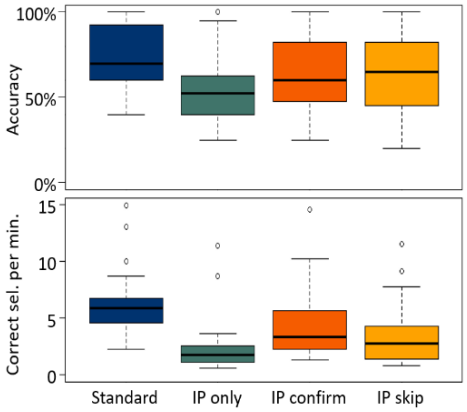

Figure: Typing accuracy and correct selections per minute by condition.

Discussion: The novel Inquiry Preview feature effectively integrated switch and EEG input in RSVP Keyboard, but did not increase typing accuracy or speed. Some participants preferred the user experience of an IP condition even if another condition was faster or more accurate. Outcomes may differ for users with SSPI.

Significance: BCIs with customizable interfaces may better adapt to user needs and preferences.

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References: [1] Oken et al. BCI with language model-EEG fusion for LIS. *Neurorehabilitation and Neural Repair*, 28(4): 387-94, 2014.