Translational Refinement of Adaptive Communication System for Locked-In Patients

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Abstract

The proliferation of brain-computer interface (BCI) technology promises locked-in patients potential ways to communicate successfully. Most BCI systems either involve selection from among a set of simultaneously presented stimuli, requiring extensive control of the interface; or use binary stimulus selection mechanisms that fail to achieve high communication rates because of slow intent detection or a fixed (context independent) ordering of stimuli. We propose a new interface using binary selection of text input via rapid serial visual presentation of natural language components. Individuals with severe speech and physical impairments (SSPI) resulting from acquired neurological disorders (amyotrophic lateral sclerosis, brainstem stroke, Parkinson's disease, multiple sclerosis, spinal cord injury) and neurodevelopmental disorders (cerebral palsy, muscular dystrophy) drive the proposed research. Four laboratories form an alliance for this translational research project: basic research (Erdogmus, engineering; Roark, computer science and natural language processing), and clinical research (Oken, neurology/neurophysiology; Fried-Oken, augmentative communication/neurogenic communication disorders).

Our aims are (1) to develop an innovative EEG-based BCI that achieves increased communication rates with fewer errors and greater satisfaction for the target SSPI populations; (2) to iteratively refine the system in the laboratory with user feedback from healthy subjects and expert LIS users of marketed AAC systems; (3) to evaluate the performance of the system within the natural clinical settings of SSPI patients. The innovative BCI is the *RSVP Keyboard* with three essential features: (1) rapid serial visual presentation (RSVP) of linguistic components ranging from letters to words to phrases; (2) a detection mechanism that employs multichannel electroencephalography (EEG) and/or other suitable response mechanisms that can reliably indicate the *binary intent* of the user and adapt based on individualized neurophysiologic data of the user; and (3) an open-

vocabulary natural language model with a capability for accurate predictions of upcoming text. Theoretical framework is based on a solid Bayesian foundation; clinical usability is based on the WHO ICF (WHO, 2001) and an Augmentative and Alternative Communication (AAC) model of participation. Rigorous experimental scrutiny in both clinical laboratory and natural settings will be obtained with able-bodied subjects and SSPI patients.

Measures of learning rate, speed of message production, error rate and user satisfaction for different iterations of the RSVP keyboard will be obtained using an hypothesis-driven crossover design for 36 healthy subjects, and alternating treatment randomization design for 40 patients with SSPI. Descriptions of the motor, cognitive, and language skills of LIS patients using the novel system in their natural environments will inform clinical guidelines and functional device adaptations to better individualize treatment for children and adults with SSPI. The collaborative nature of the proposed translational research is expected to yield new knowledge for both BCI development and clinical AAC use.