Clinic Interactions of a Brain-Computer Interface for Communication
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PROJECT SUMMARY

The promise of brain-computer interfaces (BCI) for communication is becoming a reality for individuals with severe speech and physical impairments (SSPI) who cannot rely on speech or writing to express themselves. While the majority of research efforts are devoted to technology development to address problems of stability, reliability and/or classification, clinical and behavioral challenges are becoming more apparent as individuals with SSPI and their family/care teams assess the systems during novice or long-term trials. The objective of the RSVP Keyboard™ BCI translational research team is to address the clinical challenges raised during functional BCI use with innovative engineering design, thereby enhancing the potential of this novel assistive technology. Four specific aims are proposed: (1) to develop a BCI Communication Application Suite (BCI-CAS) that offers a set of language modules to people with SSPI that can meet their language/literacy skills; (2) to develop improved statistical signal models for personalized feature extraction, artifact/interference handling, and robust, accurate intent evidence extraction from physiologic signals; (3) to develop improved language models and stimulus sequence optimization methods; and (4) to evaluate cognitive variables that affect learning and performance of the BCI-CAS. Five language modules are proposed that rely on a multimodal evidence fusion framework for model-based context-aware optimal intent inference: RSVP Keyboard™ generative spelling; RSVP texting; RSVP in-context typing; RSVP in-context icon typing; and binary yes/no responses with SSVEPs. Usability data on the current RSVP Keyboard™ and SSVEP system drive all proposed aims. Users select a language module, and the BCI system optimizes performance for each individual based on user adaptation, intent inference, and personalized language modeling. A unique simulation function drives individualization of system parameters. The robustness of the BCI customization efforts are evaluated continually by adults with SSPI and neurotypical controls in an iterative fashion. The effect of three intervention programs that address the cognitive construct of attention (process-specific attention training, mindfulness meditation training and novel stimulus presentations) will be implemented through hypothesis-driven single subject designs. Thirty participants, ages 21 years and older with SSPI will be included in home-based interventions. By measuring information transfer rate (ITR), user satisfaction, and intrinsic user factors, we will identify learning strategies that influence BCI skill acquisition and performance for adults with neurodegenerative or neurodevelopmental conditions. The translational teams include (1) signal processing (Erdogmus); (2) clinical neurophysiology (Oken); (3) natural language processing (Bedrick/Gorman); and (4) assistive technology (Fried-Oken). We continue to rely on a solid Bayesian foundation and theoretical frameworks: ICF disability classification (WHO, 2001), the AAC model of participation (Beukelman & Mirenda, 2013) and the Matching Person to Technology Model (Scherer, 2002).