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Brain Computer Interfaces as a New AAC Access Modality for Individuals with Advanced Paralysis.

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Introduction: Amyotrophic lateral sclerosis (ALS) is a progressive degeneration of upper and lower motor neurons, and the frontal cortex, with limb and/or bulbar muscular weakness [1]. Disease progressions can lead to a state of near-total paralysis including akinetic mutism, but with intact cognition and sensation, known as locked-in syndrome (LIS) [2]. Without voluntary control of the speech and motor system, individuals with ALS may lose all forms of interpersonal communication. In these cases, augmentative and alternative communication (AAC) devices can be used via a range of access methods including direct selection and eye gaze (among others) for an individual to make communication interface selections. However, there are no current clinical AAC device access methods available for individuals who do not possess overt voluntary control of limb, or eye movements [3]. The aim of this investigation is to develop a hybrid brain computer interface (BCI) method for individuals with advanced ALS to access a commercially available clinical AAC device [e.g., 4], utilizing the contingent negative variation (CNV). The CNV is a negative deflecting event-related potential that has been previously shown to precede the onset of overt and covert motor movements, beginning as early as 1.5 seconds prior to a movement cue [5].

Material/Methods: One individual with ALS (additional recruitment underway), and 4 healthy participants, used the BCI to select communication icons on an AAC device. Selection was made through performance of covert movements (e.g., imagine ‘making a fist’), performed via kinesthetic (first person) motor imagery. Icon selections were made from a Tobii-Dynavox C-15 speech generating AAC device. A preprogrammed Tobii-Dynavox page display was used, and communication icons were displayed via the row-column scan setting, with visual highlighting and spoken word feedback of each icon sequentially every 2.5 seconds. The participants were given a randomized target to select on the device for each set of trials. Online data signals were recorded via 62-channel electroencephalography (EEG) at a sampling rate of 512 Hz (g.HIAmp, g.tec). The EEG signal was bandpass filtered from 0.5 to 8 Hz to obtain the frequency range containing the CNV. An online linear discriminant analysis decoder was used to generate a binary decision (select icon versus don’t select icon) based on the presence or absence of the CNV. EEG data was decoded based on the average amplitude from -0.2 s to 0 s relative to the onset of the auditory highlighting presentation. An offline data collection of 80 covert imagery trials using the participant’s dominant hand, were preformed to train the BCI online decoder. Following training, another 80 covert trials were performed in which participants selected icons on the Tobii AAC device. Percent accuracy was calculated as the number of trials/total trials, in which the BCI correctly identified the participant’s selection. For both the training and decoding portions, a structured break was given after 20 trials to reduce fatigue; however, the participant could request a break at any time.

Results: Preliminary results for healthy participants indicate that the neural decoder was able to predict covert limb movements during AAC BCI tasks with 68.14% accuracy (healthy), and 62.62% for the individual with ALS (data collection ongoing).

Discussion: BCIs may be used as an access modality by individuals with advanced paralysis to make selections on an AAC device via row-column scanning. Performance is expected to increase in both populations with additional AAC-BCI exposure as participants learn to control the device.

Significance: Brain computer interfaces are set to revolutionize the field of communication by offering a new access method for people with advanced paralysis to communicate. BCIs access may allow an individual with advanced paralysis to continue to use their current AAC device, even if worsening paralysis has rendered their current method inefficient or ineffective.

References

[1] Chiò, A., Pagani, M., Agosta, F., Calvo, A., Cistaro, A., & Filippi, M. (2014). Neuroimaging in amyotrophic lateral sclerosis: insights into structural and functional changes. *The Lancet Neurology*, *13*(12), 1228-1240.

[2] León-Carrión, J., Eeckhout, P. V., & Domínguez-Morales, M. D. R. (2002). Review of subject: the locked-in syndrome: a syndrome looking for a therapy.*Brain Injury*, *16*(7), 555-569.

[3] Brumberg, J. S., Nieto-Castanon, A., Kennedy, P. R., & Guenther, F. H. (2010). Brain-computer interfaces for speech communication. *Speech Communication, 52,* 367-379.

[4] Thompson, D. E., Baker, J. J., Sarnacki, W., & Huggins, J. E. (2009, April). Plug-and-play brain-computer interface keyboard performance. In *Neural Engineering, 2009. NER'09. 4th International IEEE/EMBS Conference on*(pp. 433-435). IEEE.

[5] Funderud, I., Lindgren, M., Løvstad, M., Endestad, T., Voytek, B., Knight, R. T., & Solbakk, A. K. (2012). Differential go/nogo activity in both contingent negative variation and spectral power. *PloS one*, *7*(10).