BCI Usability Decreases with ALS Disease Progression

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Background: Brain Computer Interface (BCI) systems potentially provide those with disabilities an alternative method to communicate and control their environment independently. Having access to this ability can increase quality of life for users with neuromuscular diseases [1]. A BCI allows users to make letter or icon selections with electroencephalography (EEG) recorded event potentials, including the P300 potential [2]. This choice can then be translated into an action such as text-to-speech or environmental control (i.e., Alexa or Google Home). Our interest is to utilize BCI technology as a solution for promoting independence for severely disabled individuals with Amyotrophic Lateral Sclerosis (ALS). ALS individuals present with rapidly progressive neuronal loss, leading to increasing weakness and loss of speech resulting in a locked-in clinical state [3]. Persons who can no longer communicate verbally or suffer from locked-in syndrome can especially benefit from this augmentative method because no physical movement is required for access. Although BCI technology has been around for over 30 years, at-home systems are still not common for this demographic, suggesting that usability is not adequate [4,5]. The current BCI technology does not address many of the challenges that at-home ALS users face including ease of use, portability, dependence on caregivers for set up and use, extended sessions, and equipment design. There is an unmet need in understanding the usability of BCI systems by individuals with ALS and what components can be improved upon to increase the number of systems used by this demographic.

Methods: The goal of our study was to examine the effect of disease progression on the efficiency of communication using a P300 BCI speller (See Figure 1a). To address this, BCI data was analyzed from 19 individuals with ALS at various stages of disease. Data was collected using BCI2000 software [6] and a 16-channel wet electrode cap in the participant's home or in the MDA ALS Center of Hope clinic. The participants spelled five calibration words and five test words on a stimulus presentation that flashed in a checkerboard style. ALSFRS-R score, month of diagnosis, and age were recorded around the time of data collection. ALSFRS-R score reflects the functional abilities of the individual, with a lower score representing a more progressed disease [7]. Spelling accuracy was used to reflect usability of the BCI system by individuals with ALS to ensure that they could utilize the system and to understand if any characteristics (i.e., ALSFRS-R, age, etc.) impact usability.

Results: A multiple linear regression was performed to examine possible effects of age, time since diagnosis, and ALSFRS-R score on BCI spelling accuracy (See Figure 1b). Accuracy in word spelling showed

significant correlation to ALSFRS-R score (p=0.005, r=0.38) with decreased accuracy as the disease progressed using this traditional BCI system and methods.

Conclusion: This drop in accuracy may be attributed to system components and methodology that lead to an increase in fatigue for lesser functioning individuals, but alternatively may be due to the progressive changes in neural networks as the disease progresses [8,9]. For instance, having the user's head propped up and staring at a screen for an extended period can cause neck and eye strain that can decrease accuracy [10,11]. Adjustments to BCI systems, use of alternative event potentials, or alternative technologies may be necessary to optimize BCI use for individuals with ALS. As a result, we are working towards a more user friendly BCI using newer technologies that have been developed since this data was collected to address these challenges including virtual reality glasses to make head positioning more flexible and switch devices to decrease caregiver dependence. We aim to contribute to the current field by researching the usability of different BCI systems and components by ALS users and how we can improve them.

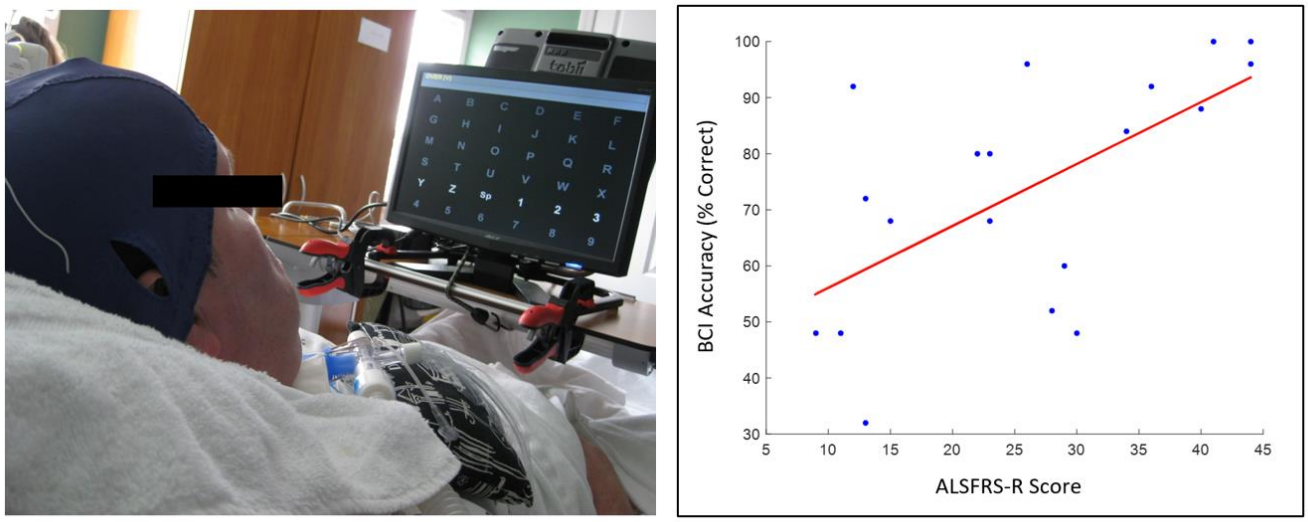

Figure 1: ***(a)*** *BCI set up used for data collection (left).* ***(b)*** *BCI accuracy versus ALSFRS-R score (right).*

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