Preliminary Design and Performance Standards for Brain-Computer Interfaces Desired by Potential Users With Neuromuscular Disease

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Abstract. Development of brain-computer interfaces requires an understanding of the end user's needs and priorities for use of the technology in everyday life. We surveyed potential BCI users with neuromuscular disease to identify preferences for BCI electrode type, BCI performance, and top prioirty applications. Our preliminary data with this group suggests BCIs are beginning to approach the end users' desired levels of performance.

Keywords: Brain-computer interface, neuromuscular disease, performance standards, assistive technology

1. Introduction

Research in Brain-Computer Interfaces (BCIs) has provided an option for empowering individuals who cannot move or have limited functional movement through an alternative means of controlling technology. Using the electrical signals emitted from their brain, individuals can express their needs and direct a variety of assistive devices without physical movement. Further advances in this field require an understanding of the constraints under which potential end user operate as well as the priorities they assign for BCI use. Systematic inclusion of potential end users can enhance the development of an effective and practical BCI [Cornwall and Jewkes, 1995; Hill, 2006].

2. Material and Methods

Our previous work in this area [Huggins et al., 2011] asked 61 people with amyotrophic lateral sclerosis (ALS) to share their perspectives and preferences on the use of BCIs. Survey research is also continuing in people with spinal cord injuries (SCI) [Moinuddin et al., 2012]. Currently, we are extending this work to persons with neuromuscular disease involving significant impairment of arm and leg function. The University of Michigan's Muscular Dystrophy Clinic as well as a search of the University of Michigan patient listings provided the initial pool of 30 participants. A 60–90 minute telephone survey addressing current use of assistive technologies, interest in BCI, and preferences for BCI performance and training was administered to each person either directly or through a caregiver.

3. Results

The preliminary data has been collected from 7 people with NMD (n = 4 women). The data thus far suggest a strong interest by NMD participants in the different options for electrodes and BCI training. While 87% reported a willingness to use dry electrodes, 71% were also willing to use non-invasive EEG gel electrodes. In addition, 57% were willing to have electrodes surgically implanted. All of the respondents agreed that they would invest in 2-5 training sessions to obtain a useful BCI. A daily setup time of 21 to 30 minutes was considered acceptable by 71%.

The survey also asked respondents to choose the minimum BCI performance they would consider acceptable. Eighty-six percent of the group stated that a BCI accuracy of at least 80% would be deemed useful. For accidental exits from a standby mode during device usage, one accidental exit every hour was acceptable to 86% of respondents. In addition, when asked about the rate of text generation, 71% responded that a minimum speed of 15-19 letters per minute would be needed for them to find the device useful.

We asked participants to select the most important BCI design feature. A large majority rated "the speed with which the BCI works" (43%) as their top choice followed by "the functions the BCI would provide" (29%). A similar series of questions were asked regarding their choice for the most important functions a BCI could provide.

Half of the group maintained that an ability to "communicate with someone in case of emergency" was paramount; another 25% felt the use of a BCI to "operate a power wheelchair" was most important.

As seen from these preliminary data, people with NMD report considerable interest in the use of BCI to enhance function. A majority were willing to have surgery to get a BCI and would participate in sufficient training sessions (57%) although this level of agreement was less than that reported by persons with SCI (67%) and ALS (72%). Gel electrodes were also less acceptable to people with NMD (71%) and SCI (53%) than to those with ALS (84%). Both the NMD and ALS (72%) groups seemed to be receptive to average BCI speeds (15-19 letters per minute); for the participants with SCI, however, a minimum of 20-24 letters per minute was favored by the majority (67%). With regard to accidental exits from a stand-by mode, a majority (84%) of respondents with ALS considered an exit every 2 – 4 hours acceptable, and 75% of persons with SCI stated an exit every 3 hours was acceptable, a comparison which seems to reflect more moderate expectations by the NMD group, where 86% found one accidental exit every hour acceptable.

4. Discussion

Overall, the responses for this group suggest current BCIs are beginning to approach the desired levels of performance. Additional features (beyond communication) should be supported and made available to give these individuals the ability to perform their desired operations.

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