Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96(3 Suppl 1):S27-32

ORIGINAL ARTICLE

Toward Independent Home Use of Brain-Computer Interfaces: A Decision Algorithm for Selection of Potential End-Users

Andrea Kübler, PhD,[a] Elisa Mira Holz, MSc,[a] Eric W. Sellers, PhD,[b] Theresa M. Vaughan, BSc[c]

From the [a]Institute of Psychology, University of Würzburg, Würzburg, Germany; [b]Brain-Computer Interface Laboratory, Department of Psychology, East Tennessee State University, Johnson City, TN; and [c]BCI Research and Development Program, Wadsworth Center, Albany, NY.

Abstract

Noninvasive brain-computer interfaces (BCIs) use scalp-recorded electrical activity from the brain to control an application. Over the past 20 years, research demonstrating that BCIs can provide communication and control to individuals with severe motor impairment has increased almost exponentially. Although considerable effort has been dedicated to offline analysis for improving signal detection and translation, far less effort has been made to conduct online studies with target populations. Thus, there remains a great need for both long-term and translational BCI studies that include individuals with disabilities in their own homes. Completing these studies is the only sure means to answer questions about BCI utility and reliability. Here we suggest an algorithm for candidate selection for electroencephalographic (EEG)-based BCI home studies. This algorithm takes into account BCI end-users and their environment and should assist in study design and substantially improve subject retention rates, thereby improving the overall efficacy of BCI home studies. It is the result of a workshop at the Fifth International BCI Meeting that allowed us to leverage the expertise of multiple research laboratories and people from multiple backgrounds in BCI research.

Archives of Physical Medicine and Rehabilitation 2015;96(3 Suppl 1):S27-32

© 2015 by the American Congress of Rehabilitation Medicine

Recent studies[1-4] have demonstrated fast and reliable control of brain-computer interfaces (BCIs) by healthy subjects and individuals with neurodegenerative disease alike, but these demonstrations have taken place either in the laboratory or in limited sessions in a home-based setting.

Noninvasive BCI technology allows people to use scalp-recorded electroencephalographic (EEG) activity as a control signal to perform a variety of tasks (eg, cursor control, word processing, e-mail, environmental control). Because BCI communication does not depend on neuromuscular activity, it can be an effective means of communication for people with severe motor impairments.

Present-day EEG-based BCIs have functional limitations, including modest rates of accuracy and low speed, as compared with other augmentative and alternative communication solutions operated by people with severe motor impairment.[5,6] However, as recently reported, BCIs can be used after eye-tracking systems fail.[7] Moreover, 1 report[8] has shown that a BCI can be less effortful to control than an eye-tracking system. Findings such as these suggest that a BCI may be the only viable option of restoring independent communication and autonomy for some individuals who are severely disabled.

Most BCI studies are conducted exclusively in the laboratory with healthy subjects, and many studies do not report online results. Such studies can provide valuable information about signal extraction, conditioning, and classification. However, the development of BCIs for communication and control depends on the individual user in a closed-loop design. BCIs that work in the laboratory need to work in real time and in real-life settings in order to give people capabilities that improve their lives. The translational research that seeks to establish the clinical value of a

Presented to the National Institutes of Health, National Science Foundation, and other organizations (for a full list, see http://bcimeeting.org/2013/sponsors.html), June 3-7, 2013, Asilomar Conference Grounds, Pacific Grove, CA.

Supported by the European ICT Programme Project FP7-288566 (Backhome). This article only reflects the authors' views, and funding agencies are not liable for any use that may be made of the information contained herein.

Disclosures: none.

0003-9993/14/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2014.03.036

BCI must answer 4 questions: (1) "Can the BCI be implemented in a form suitable for long-term home use?" (2) "Who are the individuals who need and can use the BCI." (3) Can the individual's home environment support the BCI usage, and does s/he actually use it?" and (4) Does the BCI improve the individual's life?"[9(p325)] To allow for long-term studies that are suitable to investigate reliability, BCIs must be simple to operate, need minimal expert oversight, be usable by people who are extremely disabled, and provide reliable, long-term performance in complex environments.[5,7,10,11]

Thus, the BCI community is facing translational and reliability gaps that must be bridged if BCIs are to fulfill their primary purpose and justify the generous public support their development receives. The capacity of BCI-controlled applications to satisfy these demanding criteria can be determined only through long-term studies of independent home use by their target user populations. To date, only a few studies[7,8,12,13] of independent home use exist.

Despite the fact that EEG-based systems are relatively inexpensive and offer minimal or nonsignificant risk,[9] studies that include end-users with severe disabilities in the field require substantial commitments of capital and manpower from researchers. BCI users and their caregivers also make a substantial time commitment when they agree to use the BCI over weeks and months. What is more, these early BCI home users need to accept—at least at the very beginning of a study—that researchers may need to "occupy" their home.

To promote BCI technology for independent home use, the requirements for translational and reliability studies with end-users in their home environment need to be clearly defined. Four exemplary real end-users from the authors' laboratories are presented, and their potential for being included in long-term BCI studies is assessed. We propose an algorithm for decision making about inclusion of BCI end-users in the field.

Methods

The authors conducted a workshop at the Fifth International Brain-Computer Interface Meeting entitled "Independent Home Use of BCI: Requirements for Translation and Evaluation." Workshop participants (N=22) were BCI experts from around the world including many who had experience working with individuals with severe disabilities. The participants were divided into 4 groups. Each group received the case history of a person who had either expressed an interest in using a BCI himself/herself, or had a significant other express an interest on his/her behalf. Each group was instructed to discuss whether their petitioner was a candidate for BCI home use. The questions listed in table 1 served as a guideline for the discussion. The questions were derived from the experience of the authors and on the issue raised in the article by Neumann and Kübler.[10]

Workshop structure

Duration of the workshop was 3.5 hours. One hour 15 minutes were dedicated to introductory talks by the authors as the basis for the group discussions, 1 hour was allocated for the group discussions, and 1 hour 15 minutes were allocated for discussion of the results and summary. The participants represented the multidisciplinary nature of the BCI field. They included experts from the faculties of medicine, psychology, computer science, and engineering, as well as therapists and others who provide assistive technology and outpatient and home care.

List of abbreviations:

BCI brain-computer interface

EEG electroencephalography, electroencephalogram electroencephalographic

Table 1 Workshop participants had to propose an approach of how to answer the question, "Do you consider this person a suitable candidate for BCI use?" along the following questions of detail.

No.	Question
1	Is the individual a candidate for BCI use?
2	How is the individual approached, and how is informed consent obtained?
3	How is the individual's functional and cognitive ability assessed?
4	How is the environmental suitability of BCI use assessed?
5	What type of BCI control would be chosen and why?
6	What is the realistic outcome of BCI performance?
7	What criteria would be used to determine success?

Description of end-users

The case studies were drawn from people who the authors encountered within the past years. They were chosen to represent the breadth of people in potential need of BCI.

Candidate 1

Immediately after a multifocal acute ischemic infarction predominantly within the right posterior cerebral artery, candidate 1 was described as being in a locked-in state. After 2 weeks of recovery, he could track a physician's finger, but only intermittently. Two months poststroke, he was provided with an eye tracker. However, the eye tracker does not allow him to produce meaningful messages. His current means of communication is through subtle movements of the head, eyelids, or pupils. These movements are difficult for his caregivers and family to interpret.

Candidate 2

After an accident 21 years ago, candidate 2 was left blind, severely motor-impaired, and unable to communicate verbally. For some years postinjury, he maintained the ability to control a computer. After the loss of this computer control, even though he retained the ability to control his eye muscles and remained alert and aware, candidate 2 remained functionally locked in. In large part, this was because of neglect by his doctors and mistreatment by his caregivers. After many years, one of his caregivers began to communicate with him using a binary code (ie, eyes lifted indicated "yes"; eyes down indicated "no"), using pairs of questions that verified his response (eg, question 1: "Are you hot?" question 2: "Are you cold?"). Over time, he regained some muscular control through physical rehabilitation. Today candidate 2 is able to generate a sound if he wants to communicate and to use his tongue and his right arm to communicate commands in a partner scanning approach.

Candidate 3

Candidate 3 is a 63-year-old man with diagnosed amyotrophic lateral sclerosis, symptomatic for 4 years. His current

Download English Version:

https://daneshyari.com/en/article/3448134

Download Persian Version:

https://daneshyari.com/article/3448134

Daneshyari.com