BCI Applications for People with Disabilities: Defining User Needs and User Requirements

Claudia ZICKLER.a, Valentina DI DONNA.b, Vera KAISER.c, Abdul AL-KHODAIRY.d, Sonja KLEH.a, Andrea KÜBLER.e, Massimiliano MALAVASI.f, Donatella MATTIA.f, Simona MONGARDI.f, Christa NEUPER.g, Martin ROHM.e, Rüdiger RUPP.h, Pit STAIGER-SÄLZER.h and Evert-Jan HOOGERWERF.h

a Institute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Germany
b Neuroelectrical imaging and BCI laboratory, Fondazione Santa Lucia, IRCCS, Italy
c Institute for Knowledge Discovery, Graz University of Technology, Austria
d Clinique romande de réadaptation, SuvaCare, Switzerland
e Department of Psychology I, Biological Psychology, Clinical Psychology, and Psychotherapy, University of Würzburg, Germany
f AIAS Bologna onlus/Ausilioteca, Italy
g Department II, Orthopaedic University Hospital Heidelberg, Germany
h Information center for supported communication, BUK, Bad Kreuznach, Germany

Abstract. The EU-project “Tools for Brain-Computer Interaction” (TOBI) aims at developing practical technology for brain-computer interaction. To elucidate the most urgent needs and requirements of potential users, 77 persons with disabilities from Austria, Italy, and Germany were assessed with a newly developed questionnaire. Participants had a high degree of experience in using assistive technology (AT). Despite high satisfaction ratings with current AT solutions there was still a need for better or alternative AT solutions in the areas of manipulation, communication, computer access/entertainment, and environmental control. The results also confirm the relevance of the set of applications the TOBI project is pursuing to develop. Main end-user requirements of new AT were “functionality”, “possibility of independent use”, and “easiness of use”.

Keywords. BCI, assistive technology, user needs, user requirements, user satisfaction

Introduction

Brain-computer interfaces (BCI) circumvent the human motor system and allow the user communication [1, 2, 3], environmental control, and the control of neuroprosthesis [4]. The TOBI (Tools for Brain-Computer Interaction) project aims at developing practical technology for brain-computer interaction, i.e., BCI prototypes combined with other assistive technologies (AT) which will improve the quality of life of people with disabilities. It is funded under the 7th Framework Program (2008-2012) of the European Union.
These BCI interfaces are controlled by signals of the electroencephalogram (EEG). The EEG is recorded with electrodes placed on the user’s scalp. A BCI records the brain activity of the user and translates the intentions coded in the EEG into actions – such as selecting a letter from a spelling matrix [5] – without using activity of any muscle or peripheral nerve.

An important concern of the project is the integration of people with disabilities in the development of the TOBI technology from the very beginning. The goal of the current study was to describe the needs and requirements of potential BCI-users with regards to AT. The user needs were defined as a person’s wants and necessities with respect to different aspects of independence. User requirements were considered as instrumental needs, demanding specific functions and characteristics from the product or solution. To find out about the AT needs of a person and the effectiveness of a certain device or AT solution, user satisfaction is a critical variable [6]. For this reason the following aspects were assessed:

- Current AT solutions of potential BCI end-users and their level of satisfaction in BCI relevant areas of independence (manipulation, mobility, computer access, communication, and environmental control), reasons for dissatisfaction.
- Domains in which respondents want to improve their independence.
- AT mediated access to any communication or entertainment.
- User perspective regarding requirements for any AT solution.

1. Methods and Material

Participants (N=77, 23 female) were recruited through TOBI-project members in Italy (41%), Germany (47%) and Austria (12%). Average age of the participants was 43.29 years (range: 19-71). Thirty-seven percent were diagnosed with spinal cord injury, 47% with acquired or congenital neurological/neuromuscular disease (e.g., amyotrophic lateral sclerosis, muscular dystrophy, cerebral palsy) and 16% with cerebrovascular disorder (e.g., stroke). Regarding the degree of impairment, 69% of the participants were almost or completely tetraplegic. On average diagnosis dated back 15 years with a range from 1-53 years.

Twenty-six percent of the participants were in-patients in different rehabilitation or general hospitals and 18% out-patients. Thirty-four percent were former or at present clients of AT-centers and 22% had been known through the TOBI-partners from other research studies. According to the TOBI general inclusion and exclusion criteria, people with any disability or disease leading to motor restriction took part in the study. Participants had to be at least 18 years of age. They had to be able to give informed consent, reflecting the presence of at least one functioning sensory and motor channel.

Based on a pilot questionnaire that was tested on the HANDImatica National Exhibition-Conference 2008 the TOBI Short Questionnaire was developed by a multidisciplinary team (AT experts, medical doctors, psychologists, engineers). To assess the user requirements, the consumer based criteria for the evaluation of assistive devices developed by Batavia and Hammer [7] were taken into account.

The TOBI Short Questionnaire was administered as a face-to-face interview or in a few cases by phone. Data was collected either at the work places (AT centers, research departments, hospitals) of TOBI members or at the patients’ home. To assess the needs
of the potential BCI-users, participants were firstly asked to specify their current AT solutions in the areas of manipulation, mobility, communication, computer access, and environmental adaptation/control and to rate their satisfaction with these current solutions on a four-point Likert scale from “very satisfied” (4) to “not at all satisfied” (1). Secondly, participants were asked to indicate the three most important areas in their life where they wanted to improve their independence. Thirdly, information was gathered about the independent access and the use of AT for access to different devices for communication and entertainment as well as the desire to gain access. Furthermore, participants rated their overall satisfaction with the current AT solutions on a ten-point Likert scale (1=“not at all satisfied”, 10=“absolutely satisfied”). To investigate the requirements of potential BCI-users, participants were asked to rate the importance of various aspects of AT on a four-point Likert scale form “very important” (4) to “not at all important” (1). In addition various background data (e.g., gender, age, country of residence) and medical factors (e.g., diagnosis, time since diagnosis) were recorded. SPSS 15.0 was used for data processing and analysis. Descriptive statistics, correlations, independent t-Tests and univariate ANOVA were applied to the data. For dichotomous variables significance was tested using Fisher’s exact test.

2. Results

The average overall satisfaction with the current AT solutions was high (M=7.12; SD=1.91). No relation was found between the overall satisfaction and demographical (gender, age) or medical data (diagnosis, time since diagnosis).

Between 30% (manipulation) and 95% (mobility) of the participants used AT in the different areas of independence. On average participants were rather satisfied with their current solutions in these areas with lowest satisfaction ratings for manipulation (M=3.04; SD=0.83) and highest ratings for mobility (M=3.34; SD=0.63). However, from 16% (communication) to 30% (manipulation) of the participants were dissatisfied with their current solutions in the specific areas of independence. The lowest ratings of dissatisfaction were found in the area of mobility (8%). The main reasons for dissatisfaction were problems regarding functionality/effectiveness and easiness of use.

Except for fax the majority of participants had independent access to different devices for communication and entertainment (telephone: 73%; text messaging (SMS): 62%; fax: 31%; radio: 75%; TV/DVD: 86%; Internet: 81%; e-mail: 78%; games: 62%). Between 8% and 38% of these participants used AT for access to the different devices. However, 10% to 22% (telephone: 22%; SMS: 18%; fax: 10%; radio 17%; TV/DVD: 13%; Internet: 9%; e-mail: 12%; games: 20%) would have liked to have access to e-media and even more (13% to 30%) would have liked to use AT, but did not do so for unknown reasons.

Participants were asked to choose the three most important aspects of their life in which they wanted to improve their independence. Fifty-two percent chose “mobility”, 46% “activities of daily living” (ADL), 33% “occupation/employment”. For the other aspects see Figure 1.

Participants who used communication aids wanted to improve their independence firstly, in the areas of “mobility” (44%), and secondly in “activities of daily living” (40%) in accordance with the rest of the sample. Thirty-two percent of the participants using communication aids wanted an improvement in “relationship to family/friends/caregivers”, 28% in “access to internet/mass media”, 24% in “expression of
thoughts/opinions/ideas” and 20% in “decision making about own situation”. These findings distinguished this group from the rest of the sample. Participants using communications aids indicated the need for improvement in “decision making about own situation” ($\chi^2(1)=7.678$, $p=.01$; $\Phi=-.316$) and “relationship with family/friends/caregivers” ($\chi^2(1)=6.029$, $p=.02$; $\Phi=-.280$) significantly more often than the rest of the sample (which did not use communication aids). For “expression of thoughts/opinions/ideas” ($\chi^2(1)=3.973$, $p=.07$; $\Phi=-.227$) a trend was found.

Considering the adoption of a new AT solution, participants rated “functionality” (M=3.74; SD=0.44) as the most important aspect followed by “possibility of independent use” (M=3.67; SD=0.58) and “easiness of use” (M=3.60; SD=0.59). “Aesthetic design” was rated the least important aspect (M=2.09; SD=0.96).

![Figure 1](image-url)

**Figure 1**: Areas where participants wanted to improve their independence

### 3. Discussion

The herein investigated group of AT users was very heterogeneous in age and diagnoses and showed a high degree of impairment; i.e., participants represented potential BCI-users. On average diagnosis of the disease or disability dated back 15 years. Between 30% to 95% of the participants were using AT in the different areas of independence (manipulation, mobility, communication, computer access, environment) and therefore had a high degree of experience with AT.

On average overall satisfaction with current AT solutions was high. However, 16% to 30% were “not at all satisfied” or “not particularly satisfied” in the areas “environment”, “communication”, “computer access”, and “manipulation”, which indicates a need for improvement, especially regarding AT for manipulation.

Regarding electronic media 10% to 22% of the participants did not, but would have liked to have independent access and an even higher percentage (13% to 30%) would have liked to use AT. These results underscore the need of better or alternative AT solutions regarding computer access and entertainment. They also indicate the necessity of a continuous assessment of user’s needs for (new) AT solution as time and maybe disease progresses.
“Mobility” is the aspect of life in which the majority of the participants wanted to improve their independence followed by “activities of daily living” and “occupation/employment”. This was surprising as the highest satisfaction ratings were found for aids of mobility. Probably “mobility” was understood in a much broader sense than AT solutions. However, this result points out that there is room for improvement even if satisfaction ratings are high and that being mobile in the sense of the portability of a device is a serious request of disabled people. Participants who used communication aids had needs, which where in parts different from those of the rest of the participants. They wanted to improve their independence in personal expression and social interaction. These results emphasize the need of improved AT solutions for communication.

“Aesthetic design” was rated the least important aspect of an AT. Keeping in mind that the participants were not specifically asked with regard to BCI, this aspect has to be reassessed when the first prototypes will be tested.

Overall and specific satisfaction ratings were high. As global measurements of satisfaction tend to show rather to very high satisfaction levels [6] it will be essential for the evaluation of the BCI prototypes to assess satisfaction with a multidimensional instrument and to specify the reasons for satisfaction as well as dissatisfaction.

In summary, there is the need for better or/and alternative AT solutions in the areas where BCI can contribute with applications for manipulation, communication, and environmental control/entertainment.

Considering the adoption of a new AT, participants rated “functionality” (e.g., effectiveness) as most important, followed by “possibility of independent use” and “easiness of use”. These results were underlined by the reasons participants indicated for their dissatisfaction with their current AT solutions which were functionality/effectiveness and easiness of use.

In conclusion, the main lesson for TOBI is: to develop simple (easiness of use) and effective (functional/robust) BCI applications. If communication aids are needed to provide devices which enable people to communicate their thoughts and wishes and support their interaction with significant others. Users wish AT solutions with which they are as independent from external support as possible.

References