

Evaluation of Four Different BCI Prototypes by Severely Motor-Restricted End-Users

E. M. Holz¹, C. Zickler⁴, A. Riccio², J. Höhne³, F. Cincotti²,
M. Tangermann³, S. Halder¹, D. Mattia², A. Kübler¹

¹Institute of Psychology, University of Würzburg, Germany; ²IRCCS Fondazione Santa Lucia, Rome, Italy;

³Department of Machine Learning, TU Berlin, Germany; ⁴Institute of Medical Psychology and Behavioural Neurobiology, University of Tübingen, Germany

Correspondence: Elisa Mira Holz, Institute of Psychology, University of Würzburg, , Marcusstraße 9-11, 97070 Würzburg.
E-mail: elisa.holz@uni-wuerzburg.de

Abstract. Within the TOBI project (tools for brain computer interaction, tobi-project.org) different BCI prototypes have been developed for (1) communication, (2) motor substitution, (3) entertainment and (4) motor recovery. Here, we report on evaluation results of four TOBI prototypes: Qualilife-P300-Communication, Brain Painting, Connect-Four and Hybrid-P300-Communication. BCI prototypes have been tested and evaluated by 11 end-users. Main obstacles for daily BCI use were the EEG cap/electrodes, time-consuming and complicated adjustment, low effectiveness and low speed. Highest satisfaction was expressed for the brain painting application.

Keywords: Brain Computer Interface (BCI), end-users, user-centered design, evaluation

1. Introduction

Following a user-centered approach, in TOBI different BCI prototypes have been developed and consecutively evaluated by end-users. In this paper we report on evaluation results of four BCI prototypes, two communication and two entertainment prototypes. To acknowledge the user-centered approach, we assessed satisfaction with the device.

2. Material and Methods

2.1. Subjects

11 patients (one female) tested the TOBI-BCI prototypes. Four were diagnosed with amyotrophic lateral sclerosis, two with stroke/cerebral bleeding, one with pontine infarct, two with spinal muscular atrophy, two with muscular dystrophy (Duchenne) and one with infantile cerebral palsy. Since patients were severely disabled or in the locked-in state (two), patients were considered as potential end-users of BCI.

2.2. Evaluation of BCI prototypes

The BCI-prototypes were the Qualilife-P300-communication [Zickler et al., 2011], Brain Painting [Zickler et al., under revision], Connect-Four [Holz et al., under revision] and Hybrid-P300-Qualilife [Holz et al, in preparation]. N = 9 patients tested one prototype, N = 1 patient tested two and N = 2 patients tested three prototypes, resulting in N = 4 patients per prototype. Three prototypes used the P300 as input, and Connect-Four SMR amplitude. End-users were asked how satisfied they were with different aspects of the BCI [Extended Quest 2.0, Demers et al., 2000; Zickler et al., 2011]. *Satisfaction* was rated on a scale between 1 (not satisfied at all) and 5 (very satisfied). End-users were asked whether they could imagine using the BCI in their daily life (interview).

3. Results

Table 1 displays results of *satisfaction* ratings with the Extended Quest 2.0 for the four prototypes and results of the interview. Overall, lowest *satisfaction* scores were indicated for *dimensions* (e.g. due to “EEG-cap and gel”, “cables restrict mobility, e.g. Bluetooth would be useful”, $M = 3.38$), *adjustment* (e.g. “takes too long, too complicated”, “can be erroneous”), $M = 3.33$), *effectiveness* (e.g. “too low”, “it is exhausting to reach the goal”, $M = 3.65$), *speed* (e.g. “too slow”, “for communication less sequences needed in the P300-matrix), $M = 3.5$) and *aesthetic design*. (e.g. “cap looks unaesthetic/like in hospital”, $M = 3.46$). Overall, end-users were highest satisfied with *safety* and *learnability* ($M = 4.79$ and 4.73). Best evaluated, regarding satisfaction and daily-life use, was the Brain Painting prototype. End-users could rather imagine using the entertainment BCI prototypes than those for communication. Both locked-in end-users could imagine using the BCI in their daily life (tested Connect-Four).

Table 1. Results of Extended Quest for the four BCI prototypes. Satisfaction ratings of N = 12 end-users range between 1 = not satisfied at all and 5 = very satisfied. N = 4 end-users tested each BCI prototype (Lowest average ratings displayed in bold). *one (locked-in) end-user who did not gain control over BCI, can nevertheless imagine to use the BCI if it “works better”.

	QL- Communication (N=4)	Hybrid-QL- Communication (N=4)	Brain Painting (N=4)	Connect- Four (N=4)	Average over all
1: Dimensions	3.5	3.5	3.75	2.75	3.38
2: Weight	4.08	4	4.75	4.25	4.27
3: Adjustment	3.08	3.25	3.75	3.25	3.33
4: Safety	4.67	5	5	4.5	4.79
5: Comfort	3.5	3.5	4.5	3.75	3.81
6: Ease of Use	3.58	4	4.25	3.5	3.83
7: Effectiveness	3.58	3.25	4.25	3.5	3.65
8: Prof. Services	4.5	4.5	5	4.75	4.69
Quest total score	3.81	3.88	4.41	3.78	3.97
9: Reliability	4.08	4.25	4.25	3.5	4.02
10: Speed	3.25	3.5	3.75	3.5	3.50
11: Learnability	4.42	4.75	5	4.75	4.73
12: Aesthetic Design	3.08	3	4	3.75	3.46
Quest added item score	3.71	3.88	4.25	3.875	3.93
Can you imagine to use BCI in your daily life?	Yes: 0 No:4	Yes: 1 No:3	Yes: 3 No:1	Yes:2* No:1	

4. Discussion

The results indicate, that BCIs, at the current state-of-the-art, are not competitive with other AT-solutions, but would be a solution for locked-in end-users, if it can be a better or even the only solution for them to communicate. Therefore BCI use in daily-life strongly depends on the life-situation of the person, meaning the persons’ existing solutions for communication. BCI-users prefer using the entertainment programs (for creative expression and games) in their daily life. These are probably considered as “additive” assistive applications for daily life, since for this purpose, the obstacles do probably matter less (e.g. lower speed).

Acknowledgements

This work is supported by the European ICT Programme Project FP7-224631 (TOBI). This paper only reflects the authors’ views and funding agencies are not liable for any use that may be made of the information contained herein.

References

Demers L, Weiss-Lambrou R, Ska B. Quebec user Evaluation of Satisfaction with assistive Technology. QUEST version 2.0. An outcome measure for assistive technology devices, *Webster, New York: Institute for Matching Person and Technology*, 2000.

Holz EM, Höhne J, Staiger-Sälzer P, Tangermann M, Kübler A. BCI-controlled gaming: evaluation of usability by severely motor restricted end-users. *Art Intell.Med*, under revision.

Zickler C, Riccio A, Leotta F, Hillian-Tress S, Halder S, Holz E, Staiger-Sälzer P, Hoogerwerf EJ, Desideri L, Mattia D, Kübler A. A brain-computer interface as input channel for a standard assistive technology software. *Clin EEG Neurosci*, 42:236-244, 2011.

Zickler C, Halder S, Kleih SC, Herbert C, Kübler A. Brain Painting: usability testing according to the user-centered design in end users with severe disabilities. *Art. Intell.Med*, under revision.