Bridging Gaps: Long-Term Independent BCI Home-Use by a Locked-In End-User

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Abstract. In the current study the BCI controlled application Brain Painting was installed at a locked-in ALS-patient’s home. Family and caregivers were trained to set-up the EEG-cap and amplifier and to start an easy-to-use interface for the brain painting application. BCI data, duration of painting time, and evaluation were saved automatically on a server. The Brain Painting was evaluated in terms of satisfaction, frustration and enjoyment using a visual analogue scale. In over 8 months the end-user painted in 86 BCI sessions (and ongoing). Overall, satisfaction was moderate to high (M=6.2 of 10, SD=3.65). The study demonstrates that expert-independent BCI use is possible. Nevertheless, independent BCI use is challenged by technical problems and variable BCI control.

Keywords: Brain Computer Interface (BCI), independent home-use, P300, user-centered design, evaluation, locked-in state

1. Introduction

Brain-Computer-Interfaces enable the severely motor impaired person to communicate without muscular pathways. Despite intensive research, BCIs could hardly be established at the patient’s home [Sellers et al., 2010]. Main problems are e.g., too complex and not ready to use software and time-consuming set-up, e.g. placement of EEG-cap. Another problem is the very expensive EEG equipment, e.g. EEG cap and amplifier. The BCI-application Brain Painting, which was successfully tested and evaluated in healthy subjects [Münßinger et al., 2010] and patients [Zickler et al., submitted], was implemented at the end-user’s home.

2. Material and Methods

2.1. Subject

One female, 72 years old, locked-in ALS-patient was considered as end-user for this study. The end-user is artificially ventilated and fed, using an eye-tracker (eye-gaze system) for communication. She is living with her family and has a 24-hours care. She used to be a painter.

2.2. BCI-set-up and application

The easy-to-use P300-driven Brain Painting application was installed at the end-user’s home. An initial calibration was performed in this first meeting and the family was trained how to set up and start the BCI. After 2 months the family was visited for a second time, in which a second calibration was made. The end-user was using the BCI independently at home, while the researcher team was in close contact to the family and the end-user. Evaluation reports (see below) and BCI data were automatically transmitted and stored on a remote server, enabling the experts to follow BCI usage and end-user’s experience. The BCI experts intervened only few times, e.g., when technical problems occurred or BCI parameters had to be changed. This was always realized via remote control. EEG was recorded using a 8-channel active electrode cap (g.tec, Austria) from centro-parietal regions.

2.3. Evaluation

After every Brain Painting session the end-user was asked to answer evaluation questions. The end-user rated her satisfaction with the BCI session, her experienced frustration, and the level of enjoyment on a visual analogue scale (VAS). Furthermore subjective level of BCI control was rated, choosing between zero (0-50%), low (50-70%), medium (70-90%) and high control (90-100%). Accordingly, high control means that 90 to 100% of all selections were correctly made. In the initial test phase, only VAS satisfaction was rated (first 8 sessions). After this proof-of-principle phase the extended evaluation was assessed (reported for session 9 to 86). Furthermore a command line enabled the end-user to give further feedback or report on errors.

3. Results

The end-user painted in about 86 sessions within 8 months. Mean total painting time of M=66.21 (SD=38.19). Overall, the end-user was moderately to highly satisfied (M=6.20, SD=3.65). Ratings for VAS Satisfaction across all 86 sessions can be seen in figure 1. VAS enjoyment ratings indicated that the end-user enjoyed the painting in most of the sessions, with an average of M=6.81 (SD=3.57). On the other hand,
frustration was rather low, with an average over all sessions of $M=3.74$ ($SD=3.66$). One of the main reasons for her dissatisfaction and frustration were technical problems, especially in the first BCI sessions. Further sources of dissatisfaction were bad or not good control due to possibly not sufficient electrode gel or bad cap placement, tiredness/bad concentration and loss of control due to drying electrode gel or shifting of cap after 2-3 hours of painting. Dissatisfaction also occurred when she could not produce the painting that she desired. The end-user indicated the subjective level of BCI control in 33.33% of all sessions being zero, in 26.92% low, in 25.64% medium and in 14.10% high. Setup of BCI equipment took around 20-40 min, while setup and operation of the application took around another 10-20 min, as reported by the family.

![VAS Satisfaction](image)

**Figure 1. VAS Satisfaction**: Satisfaction was rated on a visual analogue scale from 0 (not satisfied at all) to 10 (very satisfied). Note that ratings in session 2 and 7 are missing.

4. **Discussion**

The results of the study demonstrate independent home-use of BCI. However, BCI usage is challenged by technical problems and varying BCI control. It cannot be excluded that control could have been better and less varying, if calibration would have been performed regularly. The moderate to high ratings in satisfaction and enjoyment and the number of sessions conducted, notwithstanding the occurring problems with the BCI, indicate that in this case the BCI well matched the patient’s needs. For the end-user, Brain Painting has become an important part of her life (personal statement). Further steps to increase effectiveness, efficiency and satisfaction are planned, comprising inclusion of face stimuli in the Brain Painting matrix [Kaufmann et al., in press] and to integrate the optimized computer interface for autocalibration [Kaufmann et al., 2012].

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**References**


