Auditory P300 and the altered consciousness: detecting altered states of consciousness using the P300 speller

D. Lulé1,2,3,4, S. Kleih1,4, C. Chatelle1, M. Thonnard1, A. Demertzi1, M.-A. Bruno1, A. Vanhaudenhyse1, O. Gosséné1, C. Schnakers1, S. Laureys1, A. Kübler2,4, Q. Noirhomme1
1 Coma Science Group, Cyclotron Research Center, University of Liège, Liège, Belgium
2 Neurophysiology, Department of Neurology, University of Ulm, Ulm, Germany
3 Psychology I, Interventional Psychology, University of Würzburg, Würzburg, Germany
4 Medical Psychology and Behavioural Neurobiology, University of Tübingen, Tübingen, Germany

Introduction

In the recovery from coma, the acquisition of command following represents an important milestone, indicating emergence from the vegetative state (Schnakers et al., 2009). In some patients, recovery of consciousness may precede motor recovery. Brain-computer interfaces (BCI) might permit these patients to show non-motor dependent signs of awareness and in a next step might enable communication. This study aims at testing to what extent a four choice auditory P300 speller ('yes', 'no', 'stop', 'go') (Furdea et al., 2009) could help detecting signs of awareness and communication in disorders of consciousness. This study aimed at testing to what degree of motor impairment and of altered states of consciousness severely handicapped patients could be provided with a P300 based BCI.

Methods

We studied 13 patients with a minimally conscious state (MCS, 5 TBI – 8 anoxic, mean time post injury 70 ± 109 months; mean age 42 ± 21) and 2 in pseudo-coma or locked in syndrome (LIS; brainstem stroke, time post injury 26 and 46 months; aged 63 and 29) and 16 healthy controls (aged 45 ± 19). Patients were evaluated using the Coma Recovery Scale Revised (CRS-R). An auditory P300 four choice speller paradigm (Furdea et al., 2009) was used. 16-Channel EEG was recorded using a g.tec USBamp amplifier. A trial constituted of 15 presentation of four sounds the order of presentation being pseudo-randomized (sound duration: ~400ms; inter-stimulus interval: ~600ms). After a training session of 4 trials, patients and healthy subjects were required to answer 10 or 12 questions, respectively. Questions were of the following kind: “Is your name Quentin?”, “Is your mother’s name Dorothee?”. A stepwise linear discriminant analysis based on the training session was used to classify the data and to provide online feedback. Offline, all training and testing trials were pooled. Trials with artifacts were discarded and a leave-one-out approach was used to classify the data.

Results

Healthy subjects presented a mean correct response rate of 73% online and 93% offline. LIS patients showed a correct response rate of 30 and 60% (online) and 36 and 79% (offline). Three MCS patients had a correct response rate of ≥50% offline (10, 18, 0% online and 50, 53, 57% offline). Two of these three patients did not show any command following at the bedside. The 10 remaining MCS cases showed online and offline correct answers <50% (mean 33±9% online and 25±13% offline).

Discussion

Our data obtained in patients with locked-in syndrome and disorders of consciousness demonstrate the potential clinical usefulness of the technique following coma. However, it shows lower accuracy in patients as compared to healthy volunteers. This might be due to fluctuating attentional levels and exhaustibility in the MCS. Furthermore, it is due to the suboptimal EEG recording quality due to movement, ocular and respiration artifacts in these challenging patients. Further algorithmic developments should include automatic artifact detection and single trial classification. For patients with fluctuating levels of attention such as in MCS, the P300 BCI needs to be more robust and sensitive for EEG changes that indicate states of unconsciousness. In the future, BCI may be developed to serve as a tool to distinguish between different clinical states of consciousness. Despite the need for further improvement in BCI devices adapted to post-coma patients, our results already indicate that MCS patients without any clinical sign of command-following can employ a yes-no speller. A P300-based BCI might as well be a communication aid for people in the locked-in state. In the future it offers the hope of functional interactive communication and a possibility for decision making and autonomy in non-communicative patients.

References:

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