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A "yes/no" auditory-based BCI: trying to communicate with complete locked-in patients

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Introduction: Severe motor disabilities can impede communication. The most tragic situation is the locked-in syndrome (LIS), due to a brainstem lesion. This situation can also be met after some severe brain damage or in advanced Amyotrophic Lateral Sclerosis (ALS). In these patients, even brain-computer interfaces (BCI) based on visual event-related potentials could be inefficient due to oculomotor impairments. Recent studies suggest that auditory BCI could restore a communication through a « yes-no » code [1]–[3]. We developed such an EEG-based interface which makes use of voluntary modulations of attention.

Methods: This binary BCI uses repeated speech sounds (alternating "yes" on the right and "no" on the left) corresponding to either standard (short) or deviant (long) stimuli. Users are required to pay attention to the relevant stimulus only. We tested this BCI with 18 healthy subjects and 5 brainstem damaged patients (4 "classical" locked-in and 1 complete locked-in). We report online BCI performance and finer offline ERP analysis.

Results: On average in healthy subjects, BCI accuracy reached about 86% based on 50 questions. Ten subjects had an accuracy above 90%. However, all patients tested so far obtained online performance at chance level. Offline ERP analysis revealed an evoked component to the attended sounds known as the "processing negativity" [4].

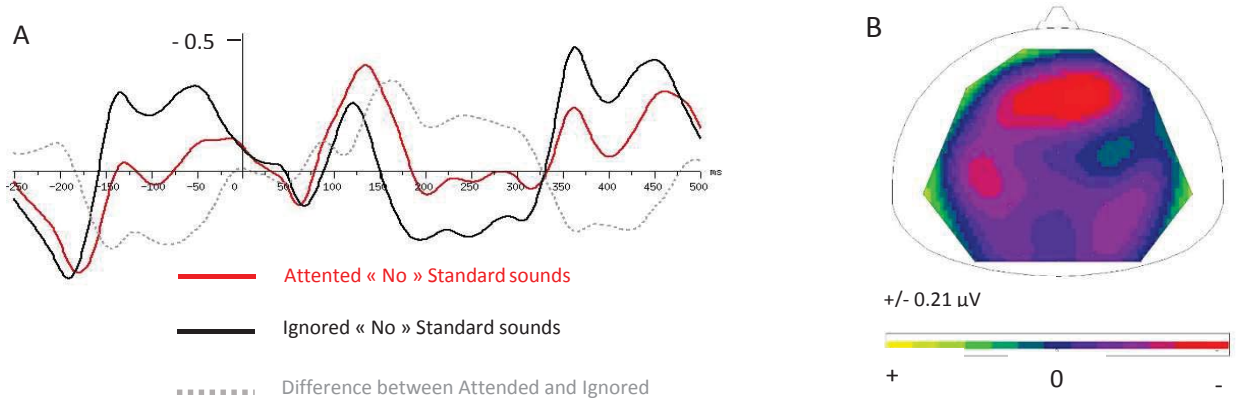

Figure 1: Effect of attention on evoked responses to standards. Grand average data from the 15 healthy subjects with BCI performance above chance level. (A) ERP at Fz location to attended and ignored standards are depicted in red and black, respectively. The difference ERP is represented by a dashed black line. (B) Scalp topography of the difference ERP for time window 150–300ms.

Discussion: To our knowledge, our study is the first to use both attentional ERP to standard and deviant speech sounds. This yields one of the shortest online time to answer (18 sec), which we could reduce down to 6s offline, with no loss of performance. In our study, only three control subjects out of 18 could not achieve online control. In the remaining subjects, accuracy proved fairly high compared to the ones reported in the literature [1]–[3], but still not 100% accurate. The patient study is ongoing. The few tested patients so far had poor BCI performance. This raises important questions on how to adapt BCI protocols from healthy subjects to patients, and eventually to each patient individually [5].

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