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Poster

Spatial Tactile Brain-Computer Interface by Applying Vibration to User's Shoulders and Waist

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Abstract **We aim at an augmentation of communication abilities of locked-in syndrome (LIS) users by creating a brain-computer interface (BCI), which can control a computer or other device by using only brainwaves. As a method, we use a stimulus-driven BCI based on vibration stimuli delivered via a gaming pad to the user's shoulders and waist. We identify P300 responses from brainwave data in response to the vibration stimuli. The user's intentions are classified according to the P300 responses recorded in the EEG. From the results of the experiments, we are able to classify successfully the brainwave P300 or the so-called "aha-"responses.**

Keywords **Brain-computer interface; locked-in syndrome (LIS); stimulus-driven BCI; P300; EEG.**

I. Introduction

Recently in neurotechnology applications, the vibrotactile-based somatosensory modality BCIs have gained in popularity [1, 2]. In this abstract we report a successfully implemented alternative tactile BCI that uses brainwave P300 responses (a so-called "aha") to a somatosensory stimulation delivered to the user's shoulders and waist, defined as a back-tactile BCI (btBCI).

We report on experiments conducted by applying vibration stimuli to the user's shoulders and waist, which allows us to stimulate places at larger distances on the body in order to verify our hypothesis of the full body-based tactile BCI paradigm validity.

In the experiments reported in this abstract, the users lay down on the vibrotactile-stimulating pad and interacted with stimulus patterns delivered in an oddball-style paradigm to their shoulders and waist, as illustrated in Figure 1.

II. Methods

In the research project reported in this abstract the online EEG experiments were carried out with seven healthy BCI-naive users (three males and four females) with a mean age of 25 years (standard deviation of 7.8 years). All the experiments were performed at the Life Science Center of TARA, University of Tsukuba, Japan (experimental permission no. 2013R7). In the btBCI online experiments, the EEG signals were captured with a bio-signal amplifier system g.USBamp by g.tec Medical Instruments, Austria. Active EEG electrodes were attached to the sixteen head locations. The EEG signals were captured and classified by in-house modified BCI2000 software. The EEG recording sampling rate was set at 512 Hz, and the high and low pass filters were set at 0.1 Hz and 60 Hz, respectively. The notch filter was set for a rejection band of 48 ~ 52 Hz. The vibrotactile spatial pattern stimuli (stimulated body locations used as cues) in the two

Figure 1. A btBCI user lying on the vibrotactile pad as in the experiments reported in this abstract. The g.USBamp by g.tec with g.LADYbird EEG electrodes is also depicted. The photograph is included with the depicted user permission.

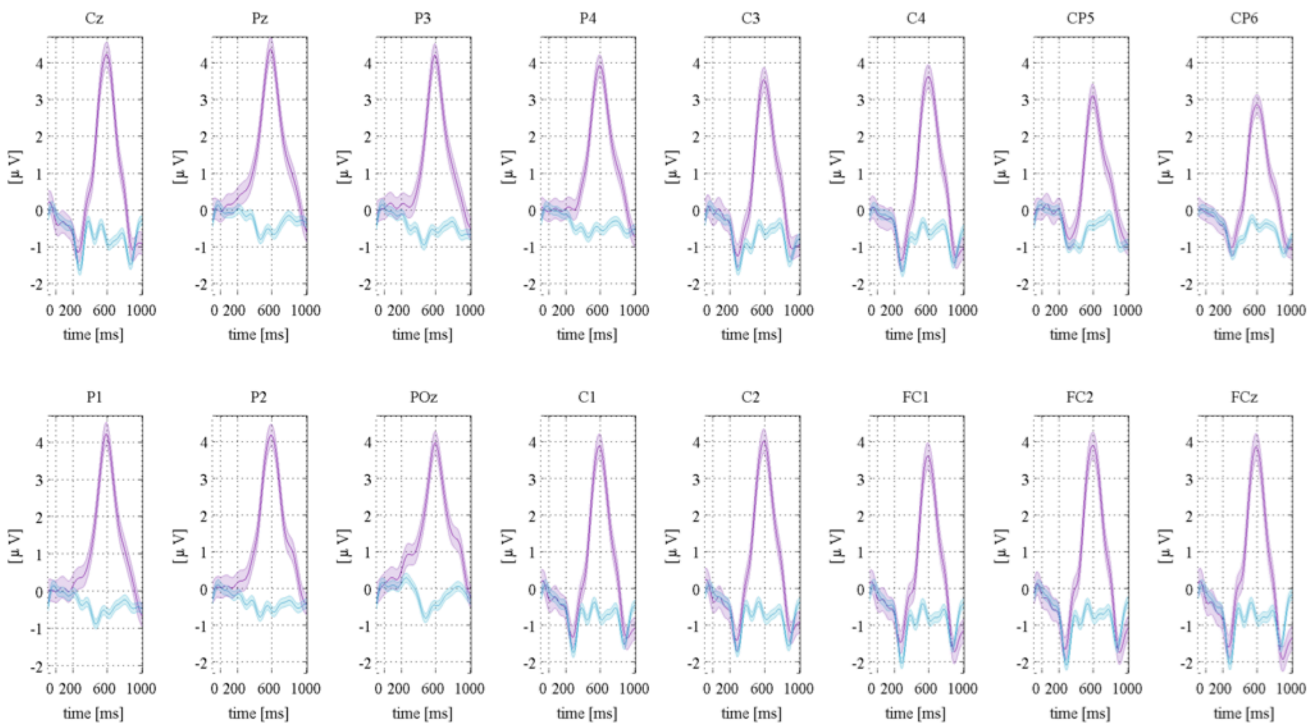

Figure 2. Grand mean averaged ERP for attended (purple lines) and ignored (blue lines) stimuli. The very clear "aha-" responses are easy to notice for each EEG electrode in the latencies of 200 ~ 800 ms.

experimental settings were generated using the same MAX 6 visual programing application.

III. Results

The EEG experiment results are summarized in Figure 2 in the form of grand mean averaged brainwave event related potentials (ERPs). The results elucidated very clear "aha-"responses in latency ranges of 200 ~ 800 ms. Mean information-transfer-rates (ITRs) ranged from 0.6 bit/min to 3.3 bit/min, for 10-trials averaging based step-wise linear discriminant analysis (SWLDA) classification, to 0.5 bit/min to 10.9 bit/min for single trial offline analysis cases.

IV. Conclusions

This abstract reports results obtained with a novel six-command-based btBCI prototype developed and evaluated in experiments with seven healthy BCI-naive users. The experiment results obtained in this study confirm the validity of the btBCI for six command-based applications and the possibility to further improve the results. The EEG experiment with the prototype confirms that tactile stimuli applied to large areas of the back can be used to interact with six-commands-based applications.

The results presented offer a step forward in the development of somatosensory modality neurotechnology applications. Due to the still not perfect interfacing rate achieved in the case of the online btBCI, the current prototype obviously requires improvements and modifications. These requirements will determine the major lines of study for future research. However, even in its current form, the proposed btBCI can be regarded as a possible alternative solution for locked-in syndrome patients, who cannot use vision or auditory based interfaces due to sensory or other disabilities.

References

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