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Neural Signature of Selective Sensation based Tactile BCI in the Context of ECoG Investigation

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***Introduction**:* Tactile BCI, independent of the visual and gaze participation, has recently received much interest. The first prototype of tactile BCI has been proposed by Mueller-Putz in 2006 and was based on steady-state somatosensory evoked potentials (SSSEP) [1]. Experiments on five subjects have shown that the classification accuracy for this BCI modality ranged from 64% to 84%, with average accuracy of 70.4%. Later, similar to the visual P300 BCI, a tactile P300 system, based on the oddball paradigm, has been proposed by Brouwer in 2010 then [2]. This system achieved a mean accuracy of approximately 72% in 11 subjects for two targets selection. Recently, we have proposed a tactile BCI based on oscillatory dynamics from the somatosensory area of the brain and we termed this approach as selective sensation BCI [3,4]. Up to now, 43 subjects have been recruited so far, with a mean accuracy of 79.2% and BCI-illiteracy rate of 16.3% (7 out of 43 below 70%). In this study, the neural signature of SSSEP-based and ERD/ERS-based (selective sensation) tactile BCI will be examined in the context of ECoG signal modality.

***Material, Methods and Results**:*

One subject (female, 18 years old) suffered from intractable epilepsy, and underwent temporary placement of a subdural electrode. This Study was approved by the Ethics Committee of Huashan Hospital. Participant signed the informed consent forms by themselves or legal guardians before participating in the experiment.

Mechanical stimulation was applied to the index finger. The stimulation device produced 27-Hz sine wave, which was modulated with a 175-Hz sine carrier wave. Linear resonant actuators (10 mm, C10-100, Microdrives Ltd.) were used. ECoG signals were recorded using a SynAmps2 system (Neuroscan). The reference electrode was located on the right mastoid, and the ground electrode on the left mastoid. The signals were recorded from DC to 500 Hz, digitally sampled at 2000 Hz.

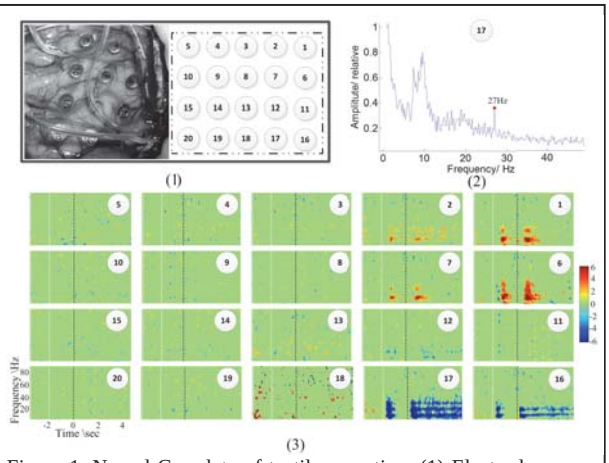

Figure 1. Neural Correlate of tactile sensation. (1) Electrode array on the cortex and number order. (2) Power spectrogram at channel No. 17 with respect to 27 Hz tactile stimulation. (3) Event related spectrum perturbation across all channels, non-significant parts were wiped out under bootstrap significance level of P = 0.01. Time zero corresponds to the start of sustained tactile stimulation.

The ECoG electrode array was placed on the left frontal lobe, see in the Fig. 1(1). Subject was required to close her eyes and rested. When the index finger was tactile stimulated, the subject was required to focus attention on the sensation. 40 trials were recorded, which lasted for 6~7min. Within each trial, after 2s a vibration burst, lasting 200 ms, was applied to alert the subject to be ready for the subsequent task. Then 2 second later, sustained stimulation was applied, which lasted for 5s. After 2~4 second random time interval, next trial started. Power spectrum in Channel 17 (localized on sensory cortex) with respect to 27Hz sustained stimulation was shown in Fig. 1(2). Event related (De)synchronization (ERD/ERS) across all channels was shown in Fig. 1(3).

Discussion: The stimulation evoked SSSEP response has a frequency specific feature, complementarily the induced ERD/ERS oscillatory dynamics, which also reflects somatosensory processing, has a non-stimulation frequency specific feature. In the context of ECoG investigation, we have found the coexistence of both frequency responses and also much stronger ERD responses, which lays the mechanism for tactile BCI construction. Interestingly, we have found that there is an ERS response on the motor cortical area (Channel 6), indicating motor cortex suppressing or in idle state during sensation tasks for better stimulation processing.

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