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Single-trial decoding of somatosensory evoked potentials: Effect of stimulation frequency

AUTHOR BLOCK: *D. GUPTA[1,2], J. A. BRANGACCIO[3], H. MOJTABAVI[4], J. R. WOLPAW[5], J. HILL[6,2];
[1]Somatosensory Res. Lab., Natl. Ctr. for Adaptive Neurotechnologies, Stratton VA Med. Center, Albany, NY, Albany, NY; [2]Electrical and Computer Engin., Univ. at Albany, State Univ. of New York, Albany, NY; [3]Research/physical therapy, NCAN/Stratton VA Med. Ctr., Newburgh, NY; [5]Natl. Ctr. for Adaptive Neurotechnologies, [4]Natl. Ctr. for Adaptive Neurotechnologies, Albany, NY; [6]Natl. Ctr. for Adaptive Neurotechnologies, Albany Stratton VA Med. Ctr., Albany, NY

Abstract:
Objective: Single-trial decoding of somatosensory evoked potentials (SEPs) is important for developing Brain Computer Interface applications for rehabilitation post brain injury. However, it is unclear how SEP decoding is affected by stimulation parameters such as the stimulation frequency. We assess this with tibial nerve electrical stimulation at frequencies of 0.2 Hz, 1 Hz and 2Hz. **Method:** Nine healthy people (50.4±18.8y, 6m/3f) participated with informed consent (IRB #1584762). Referential electroencephalography (EEG) was acquired at 300 Hz (DSI-24, Wearable Sensing; BCI2000). Bipolar electromyography was measured from the soleus muscle (3200 Hz, AMT-8; EPOCS software). Biphasic 1-ms electrical stimuli were delivered to tibial nerve with a constant current stimulator, controlled with our EPOCS software. At each stimulation frequency, the soleus M-wave and Hoffman-reflex recruitment curves were obtained, followed by SEP measurement (75 trials), at a current intensity that elicited an M-wave of 10-20% Mmax. The 3 stimulation frequency blocks were repeated after a short break, presented randomly. EEG was notch and bandpass filtered (0.2 - 40 Hz) and denoised with independent component analysis. Preprocessed data were epoched (-50 to 400 ms); noisy epochs were removed using trial statistics. The SEP was obtained by averaging baseline-corrected epochs. The Friedman Test was used for repeated measure comparisons. Single trial classification was assessed with linear discriminant analysis (LDA) and 5-fold cross-validation. Classification performance was assessed with AUC (ROC curves). Decoding generalization was assessed by applying LDA models from set-1 recordings, to predict the SEPs in set 2. **Results:** SEP N_{70} latencies remained similar across stimulation frequencies ($p>0.05$), while the N_{70} peak amplitude was significantly different ($p= 0.0084$); higher stimulation frequency elicited a smaller N_{70} peak. The N_{70} classification accuracy was 0.89, 0.79 and 0.80 for 0.2 Hz, 1 Hz and 2 Hz respectively. Generalization AUC scores were 0.81, 0.76 and 0.77 for 0.2 Hz, 1 Hz and 2 Hz, respectively. **Conclusion:** Results show an excellent classification accuracy for SEP N_{70}, elicited by tibial nerve stimulation at 0.2Hz, with a slight decrease in accuracy at higher stimulation frequencies. This may be attributed to attenuated SEP N_{70} at higher frequencies, possibly due to desensitization. Generalization scores show an expected decrease of accuracy at all frequencies, with the largest decrease at 0.2 Hz. Most importantly, all three frequencies appear to be able to support single-trial SEP decoding and may be usable for an SEP-based brain computer interface.

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