TRACKING LEARNING OF ENHARMONIC PITCH-CHANGE IN AMERICAN POPULAR MUSIC USING SINGLE-TRIAL EEG DECODING

Jason S. Sherwin, Bryan Conroy, Anmol Gupta and Paul Sajda

Department of Biomedical Engineering, Columbia University

We present results for a detectable signal in electroencephalography (EEG) measurements in response to enharmonic changes of pitch. In particular, when the pitch-change occurs at a constant location in the same song, we find that subjects exhibit discrimination that is different from when the pitch-change is not at a constant location. Upon further investigation, we found through the neural data that each subject habituates to the pitch-change at different times in the course of the experiment. The stimulus domain is composed of four pitch-change profiles and one control superimposed on the American popular song "Eye of the Tiger."

With $N = 6$ subjects, two versions of the experiment were performed. Both versions entailed 7 runs of 5 trials, where each trial consisted of a 91-second excerpt of the song. However, one version contained completely unrelated pitch-change profiles across all trials of all runs (i.e., the *random* version), whereas the other did not (i.e., the *non-random* version). In particular, the non-random version contained pitch-changes at the same location in the song, although they could be of different directions (e.g., pitch-up or pitch-down). With these two versions of the experiment, we were able to gauge whether a learning effect could be developed in the subjects for the non-random version, as opposed to the random one. We collected EEG data with a 64-channel passive-electrode BioSemi cap.

For the analysis of data from these experiments, we extended previous work from our lab on perceptual discrimination by using logistic regression analysis. In particular, we performed a leave-one out (LOO) classification of pitch-shift (pitch-up, pitch-down, and generic pitch-change) vs. control conditions, using the area under the receiver characteristic curve (ROC) as a measure of classification accuracy. For each subject, there were multiple statistically significant (99%) post-stimulus components of pitch-shift discrimination for the random version of the experiment. This result is insensitive both to the place in the song as well as the absolute pitches of the preceding and succeeding versions of the song. Furthermore, when averaging classification results across subjects, several post-stimulus components between 200-600ms were seen, indicating a common response across subjects.

Finally, the lack of clear discrimination between pitch-change and control conditions in the non-random experiment indicates a learning effect in the subjects. Upon further investigation, it was found using a subset of epochs from the non-random version that an optimum and significant *pre-stimulus* discrimination window exists before the pitch-change. This implies two things: 1) that subjects are learning the pattern as the experiment progresses and 2) that the pre-stimulus discrimination becomes attenuated after the pattern is discovered (later trials) and before it is noticed (earlier trials).