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Decoding Intended Movement from Human EEG in the Posterior Parietal Cortex

Y. Wang, S. Makeig

Swartz Center for Computational Neuroscience, Institute for Neural Computation, University of California, San Diego, San Diego, CA, United States

Introduction: The role of the posterior parietal cortex (PPC) in sensorimotor transformations has been explored by neuronal recording in monkey studies (Quiroga et al., 2006; Calton et al., 2002). Direction and effector information for an intended movement can be predicted using firing rates of neurons in specific PPC subareas: the lateral intraparietal area (LIP) for saccades and the parietal reach region (PRR) for reaches. In humans, functional magnetic resonance imaging (fMRI) studies on the PPC have identified regions corresponding to the monkey LIP and PRR areas (Sereno et al., 2001; Connolly et al., 2003). In the present study, we asked whether it is possible to decode intended movement using human EEG recorded in the PPC. To this end, we recorded multi-channel EEGs with a delayed saccade-or-reach task and proposed an approach based on single-trial EEG classification.

Methods: We recorded 128-channel EEG from four healthy subjects. The task comprised nine conditions differing by movement type (saccade, reach to touch without eye movement, and visually guided reach to touch) and movement direction (left, center, and right). Each task was indicated to the subject by an effector cue, followed by a direction cue and then an action (go) cue. EEG data between the direction and action cues were extracted for further analysis.
Independent component analysis (ICA) was applied to decompose the scalp EEG into functionally specific component processes using the EEGLAB toolbox (Delorme and Makeig, 2004). Parietal ICs were selected and then back projected onto the scalp. Normalized single-trial amplitudes of these ICs were concatenated and input into a support vector machine (SVM) classifier. Cross validation was run to estimate classification performance. For simplicity, we included four tasks: *saccade left*, *saccade right*, *reach left*, and *reach right*.

Results: Two lateralized temporal-parietal components were identified in each subject's decomposition based on their spatial distributions and prominent contributions to the average event-related potential (ERP) waveforms. Clusters of these lateralized parietal components are shown in Figure 1a. Equivalent dipole localization fitting two symmetric bilateral model dipoles to each IC scalp map indicated that these IC processes originated from the bilateral PPC (Brodmann Area 39/40) (Figure 1b).
Figure 1c shows average response envelopes of the two parietal ICs for one subject. Movement direction information included hemispheric asymmetry (contralateral negativity and ipsilateral positivity with respect to movement direction). Effector-specific information involved distinct changes in ERP amplitude and latency.
For 4-class classification, we obtained an average accuracy of 49.8% (44.8%-55.0% across all subjects; chance level, 25%). Considered separately, with more refined parameters, direction classification accuracy was 80.3%, effector classification 69.1%. Binary condition classification was performed for all 6 pairwise condition combinations for each subject; the most distinguishable pair (mean, 84.9%; range, 80.0%-90.5%) differed across subjects.

Conclusions: Here we have shown that brain activity in the PPC is modulated by movement planning. We obtained classification accuracy well above chance level for direction and effector estimation, and for their combination. Based on these findings, we find that intended movements can be predicted using EEG recordings, providing a new basis for design of a noninvasive brain-computer interface (BCI).

References:

Calton, J.L. (2002), 'Non-spatial, motor-specific activation in posterior parietal cortex', *Nature Neuroscience*, vol. 5, no. 6, pp. 580-588.

Connolly, J.D. (2003), 'FMRI evidence for a 'parietal reach region' in the human brain', *Experimental Brain Research*, vol. 153, no. 2, pp. 140-145.
Delorme, A. (2004), 'EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis', *Journal of Neuroscience Methods*, vol. 134, no. 1, pp. 9-21.
Quiroga, R.Q. (2006), 'Movement intention is better predicted than attention in the posterior parietal cortex', *The Journal of Neuroscience*, vol. 26, no. 13, pp. 3615-3620.
Sereno, M.I. (2001), 'Mapping of contralateral space in retinotopic coordinates by a parietal cortical area in humans', *Science*, vol. 294, no. 5545, pp. 1350-1354.