Human EEG indices of movement intention in posterior parietal cortex

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The role of the posterior parietal cortex (PPC) in sensorimotor transformations associated with actions has been explored by neuronal recordings in monkey and by human functional magnetic resonance imaging (fMRI). Here, we asked whether the human electroencephalogram (EEG) indexes movement intention during movement planning. To this end, we recorded 128-channel EEG from twenty healthy subjects with a delayed saccade-or-reach task. The task comprised nine conditions differing by movement type (saccade, reach without eye movement, and visually guided reach) and movement direction (left, forward, and right). Each task was indicated to the subject by an effector cue, followed by a direction cue and then a go cue.

Independent component analysis (ICA) extracted three tight IC clusters of PPC components identified by their spatial distributions and prominent contributions to the average event-related potentials (ERPs) time locked to direction cues. Equivalent dipole localization identified two IC clusters (21 ICs from 17 subjects, and 25 ICs from 18 subjects, respectively) with equivalent dipoles in inferior parietal lobes (IPL) (BA 39, Talairach: [-38 -60 29], [39 -60 30]), and a medial superior parietal lobe (SPL) IC cluster (16 ICs from 16 subjects) (BA 7, [3 -53 56]).

In lateral PPC areas, event-related spectral perturbation (ERSP) and inter-trial coherence (ITC) analyses showed mean contralateral increases and ipsilateral decreases in low frequency oscillations (< 8 Hz) 180-240 ms after the direction cue. Mean ERP potentials during 180- 240 ms at three electrodes to which the three PPC ICs projected most strongly were subjected to statistical analysis. A two-way within-subjects ANOVA showed a significant interaction between EEG source location and intended movement direction ($F_{4, 76}=30.5$, $p<10^{-11}$). Further one-way within-subjects ANOVAs on each source location showed significant differences with movement direction (left PPC, $F_{2, 38}=22.3$, $p<10^{-5}$; medial PPC, $F_{2, 38}=15.6$, $p<10^{-4}$; right PPC, $F_{2, 38}=24.6$, $p<10^{-6}$). Relative to forward movement intention, lateral PPC ERPs were contralaterally negative and ipsilaterally positive. Directional tuning curves (quantifying leftward, forward, and rightward movement intentions as -90, 0, and 90 degrees, respectively) were well fit by linear models (left PPC, r=1.000; right PPC, r=0.998). Interestingly, leftward and rightward movement intentions showed similar negativities relative to forward movement intention in the medial PPC. Taken together, these findings suggest that movement intentions are truly encoded in the human EEG, likely indexing early visuomotor transformations in the PPC.