Intracranial EEG reveals dominant role of PM in human motor network communication

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Abstract

Both non-human primate studies and observations in humans have suggested the complex functional organization of the motor cortex, especially in subregions like the primary motor cortex (M1), premotor cortex (PM) and supplementary motor area (SMA). However, given the limited spatial and temporal resolution of current available recording and imaging techniques, it has remained unclear how information transfer within human motor regions is realized. In the current study, by using cortico-cortical evoked potential (CCEP) recordings and intracranial electroencephalography (iEEG) from epilepsy patients implanted with intracranial electrodes, we aimed to (1) map the directional information flow within the motor system, (2) explore how communication between cortical regions is established, and (3) investigate how this neural communication changes from a resting to a motor state.

Specifically, during the CCEP recordings, 1-Hz electrical stimulations were delivered to each site along intracranial electrodes implanted in motor regions, while at the same time post-stimulation responses were recorded and measured at response sites. Out of the 20 subjects who underwent CCEP procedures, iEEG was recorded from 3 subjects who additionally performed a detection task. We first identified significant stimulation-response pairs within our regions of interest (ROI) including M1, PM and SMA. For all the pairs, we calculated Pearson correlations between pre-stimulation power at the stimulation site and CCEP amplitude at the response site between different ROIs. For iEEG data, we computed similar Pearson correlations between pre-stimulus power at the sites within PM and SMA which sent out information to M1 based on the CCEP results and peak latency at 60-140 Hz in the sites within M1 which received information from the

other motor regions. CCEP results showed that PM had more information being send out than coming in from M1 and SMA, whereas M1 received more information from PM and SMA than sending out. Moreover, pre-stimulation power at beta and gamma bands in PM influenced the strength of evoked responses in M1 and SMA, which was only observed in the group of subjects with electrodes implanted in the dominant hemisphere. Furthermore, we found that pre-stimulus power in PM and SMA modulated after-stimulus peak latency in M1 via beta oscillations during contralateral hand movement.

Together, our results provide valuable insights into the directional information flow within the human motor system during rest and cognitive tasks. Understanding the neural information flow and the role of beta and gamma oscillations in motor communication is critical for gaining a deeper understanding of the brain's overall functioning and could have important implications for the development of new treatments for various motor-related disorders.