

Neural Correlates of Tactile Detection: Combined MEG and Biophysically Based Computational Modeling Study

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Cortical correlates of sensory perception have typically been observed in higher order cortical areas, while there are conflicting reports as to their presence in primary sensory cortex. To investigate the cortical correlates of somatosensory perception in humans, we conducted studies of tactile detection using MEG. To this end, we developed an MEG compatible piezoelectric tactile stimulator with real time regulation of stimulus amplitude as a function of psychophysical response. We recorded 306-channel MEG signals (Elekta NeuroMag VectorView) and extracted somatosensory evoked dipoles by combining MEG with structural MR images.

A stimulus-level dependent equivalent current dipole (ECD) in the hand area of SI was observed in all subjects. Perception of the threshold level stimuli was predicted from ongoing ‘state’ properties and from post-stimulus evoked responses in SI. Perceived trials at threshold showed lower power in alpha (7-12Hz) and/or beta frequency bands (15-35Hz) in the signal immediately prior to stimulus onset (-500ms to onset; N = 6/7 Ss). In the evoked response, the magnitude and timing of peaks in the early SI ECD waveform predicted perception as early as 70ms post-stimulus (N = 7/7).

To make a direct and principled connection between the observed phenomena and the underlying neural dynamics, we developed a biophysically realistic computational neural model of a laminar SI cortex. The model incorporated the dendritic morphology and physiology of large pyramidal neurons known to be the primary generators of MEG ECDs. Results from the model led to the novel hypothesis that polarity and magnitude of peaks in the evoked SI ECD were induced by a sequence of feed-forward (from the periphery and thalamus) and feedback (from a “higher order” cortical area) input into the local SI network, characterized by the laminar location of their synaptic inputs. Further, specific manipulations of these inputs led to predictions on the neural dynamics underlying conscious perception. The observed signatures of perception in the SI ECD were reproduced in the model by simulating feedback and late thalamic inputs with earlier latencies and stronger magnitudes during perceived trials. An investigation with the model of ongoing state dynamics and their relation to evoked responses and perception is currently in progress.

Taken together, our results suggest that evidence of conscious perception exist in SI both in the ongoing state dynamics and in the evoked response, and that these effects can be investigated using biophysically realistic computational cortical modeling.

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