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Reproduction of whole-head MEG and EEG patterns during Human Sleep Spindles in a large scale neural model with realistic cortical anatomy.

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Abstract:
Sleep spindles are prominent thalamocortical bursts of 10-15Hz oscillations lasting ~1s. They have been implicated in memory and disease, and their neurobiology at a circuit, synapse and channel level have been extensively studied in animals. Spindles measured with the electroencephalogram are largely synchronous and distributed, whereas those measured with the magnetoencephalogram are largely asynchronous and focal, leading to the hypothesis that the former are generated by the matrix thalamocortical system, and the later by the core. Here we test this hypothesis with a computational neural model containing both matrix and core elements in the thalamus and cortex. The thalamus implements all relevant intrinsic currents. The cortex includes 25,600 patches realistically arranged on the folded cortical surface. The cortical activity during modeled spindles is propagated to the EEG and MEG sensors. Three models are examined, a ‘core model’ with a single focal thalamo-cortical spindle generating system, a ‘matrix model’ with a single diffuse system, and a ‘core/matrix model’ with separate but interacting focal and diffuse systems. Only the core/matrix model reproduced the empirically observed topography, strength and coherence of EEG and MEG during spindles. The core/matrix model explicitly represents the interaction of focal and diffuse thalamo-cortical systems, with readily obtained empirical predictions at multiple levels. This integration of focal with distributed information processing may be a general mechanism of thalamocortical physiology.
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