Network for parallel gamma synchronizations during upper limb movement

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Objective: Our aim was to identify the sources of parallel gamma synchronizations (GS) and analyze the direction of information flow in their network, at the beginning of simple and combined upper limb movements.

Background: GS at the onset of movements may promote the processing between functionally related cortico-subcortical neural populations.

Methods: We measured 64-channel EEG in 11 healthy volunteers; surface EMG detected the movements of the dominant hand. In Task1 subjects kept a constant medium-strength contraction of the first dorsal interosseus muscle and superimposed on this they performed a repetitive voluntary self-paced brisk squeeze of an object. They executed brisk contraction in Task2 and constant contraction in Task3. Time-frequency analysis of the EEG signal was performed with multitaper method. GS sources were identified in five frequency bands (30-49Hz, 51-75Hz, 76-100Hz, 101-125Hz and 126-150Hz) with the beamformer inverse solution dynamic imaging of coherent sources by taking the EMG as the reference signal. The direction of information flow between the sources was estimated by renormalized partial directed coherence for each frequency band. To identify significant connections, the data driven surrogate test and the time reversal technique was performed.

Results: The first three sources in consecutive order in each movement task, in every frequency band, were as follows: contralateral primary sensorimotor cortex (S1M1), dorsolateral prefrontal cortex (dPFC) and supplementary motor cortex (SMA). Gamma activity was detected in narrower low- and high-frequency bands in the contralateral thalamus (TH) and ipsilateral cerebellum (C), in all three tasks. In the combined Task1 additional low gamma activity appeared in the contralateral posterior parietal cortex (PPC). In every task, S1M1 had efferent information flow to the SMA and the dPFC; the latter had no afferent relation to the network. S1M1 and SMA had a bidirectional connection with the TH, and the C. Afferent information flow was detected from the PPC to the SMA and bidirectional flow between PPC and the TH, in the combined Task1.

Conclusions: The same network could be identified for the parallel gamma synchronizations in the tasks; it was complemented by the PPC in the combined Task1. S1M1 drove the other cortical sources and had afferent activity from the TH and the C, which activated in variable frequency bands in the tasks.