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Whole-Brain Task-Dependent Connectivity Analysis in Functional Magnetic Resonance Imaging

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In functional magnetic resonance imaging data task activations and resting state connectivity are regularly assessed over the whole brain. Changes in the interaction between brain regions in accordance to task demands on the other hand are less often analyzed in a whole-brain manner, but such an approach offers the chance to provide interesting insights into the function of the brain.
To investigate how task-dependent whole-brain connectivity analysis can foster the understanding of experimentally controlled processes in the brain and supplement activation studies, an approach for task-dependent whole-brain connectivity analysis based on psychophysiological interactions (PPI) was developed, implemented, and applied to data from an episodic memory task.
By comparison of whole-brain PPI to multi-seed conventional PPI it could be shown that, depending on the applied parcellation scheme, a large fraction of the conventional results could also be detected by whole-brain PPI. Furthermore, whole-brain PPI was able to identify additional task-modulated connectivity effects, particularly from seed regions that did not contain significantly activated or deactivated voxels.
Graph theoretical analyses of networks constructed from the whole-brain PPI results allowed for further insight into the task-related processes. Converging evidence from the analysis of local node degrees, k-core decomposition, and link community detection identified the precuneus as a central region involved in both the task as well as the control condition of the experiment. Examination of the whole-brain results with regard to the functional network structure of the brain at rest could be used to characterize task-related connectivity changes between as well as within empirical resting state networks and offers important perspectives about the local and global integrative changes associated with a task.
A combined consideration of task-related effects on activation and connectivity has the potential of leading to a more holistic understanding of experimentally evoked changes in brain networks, and might contribute to a better understanding of pathological processes in the brain.