Task-based differentiation of functional networks during a gustatory task.

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Background: A recent bootstrap-based technique (Kudela et al.) was applied to estimate dynamic functional connectivity (dFC) and its confidence intervals for a task-based fMRI study of 24 social-to-heavy beer drinkers during stimulation with beer and Gatorade® flavor and a water baseline. dFC among 278 ROIs (Shen et al.) was first estimated at a subject level. Then subject specific estimates were used to model group-averaged dFC.

Methods: Functional data (three 4:48 min scans of each flavor, TR=2.25s, 2.5×2.5×3.0 mm³ voxels) were analyzed using standard FSL preprocessing, scrubbing, and tissue and motion based regression. The resulting voxel-wise time series were averaged for each ROI. dFC and its confidence intervals were estimated utilizing an extension of the Multivariate Linear Process Bootstrap (Jentsch et al.) technique applied to the sliding-window approach. Next, we used functional regression methods with between- and within-subject factors to model time-varying correlation estimates. All estimated pairwise FC entries were used in the modularity analyses to find local network communities.

Results: The model intercepts (interpreted as mean dFC for flavor) yielded FC patterns whose modular organization comports with resting state networks (RSN) observed by Yeo et al. as supported by modularity ratios above 60% (7 RSN) and above 40% (17 RNS) between the Q-score associated with the RSN partitions and the highest Q value as obtained by Louvain algorithm over a wide gamma range. As compared to Yeo’s reference FC matrix, flavor stimulation potentiated dFC between limbic-subcortical, somatomotor-attentional, and frontoparietal-default mode network pairs. Further analysis showed beer and Gatorade differentiation in 3 modules: (1) visual, somatomotor and attentional networks, (2) limbic and frontoparietal, and (3) default mode, subcortical and cerebellar networks. The most notable flavor differences were between associations of the limbic network with ventral attention, frontoparietal, and subcortical networks. The latter results were consistent with the conventional GLM analysis in SPM showing increased co-activations of the orbitofrontal cortex and ventral striatum to beer flavor.

Conclusions: The dFC analysis of the gustatory task fMRI data yielded functional modules closely resembling the RSN reflecting a common functionally-based brain organization as noted by Cole et al. Differential effects of alcohol cues (beer) and the appetitive control (Gatorade®) were demonstrated through increased between-network interactions. The enhancement of limbic-subcortical dFC was consistent with a 7 and 17 RSN architecture, modularity analysis, and increased activation of the orbitofrontal and ventral striatal regions to beer stimuli. The methods developed here provide a novel statistical approach to analyze task-based FC data.