Detection of Spontaneous Co-activation Patterns by Selectively Grouping Resting-State fMRI Volumes

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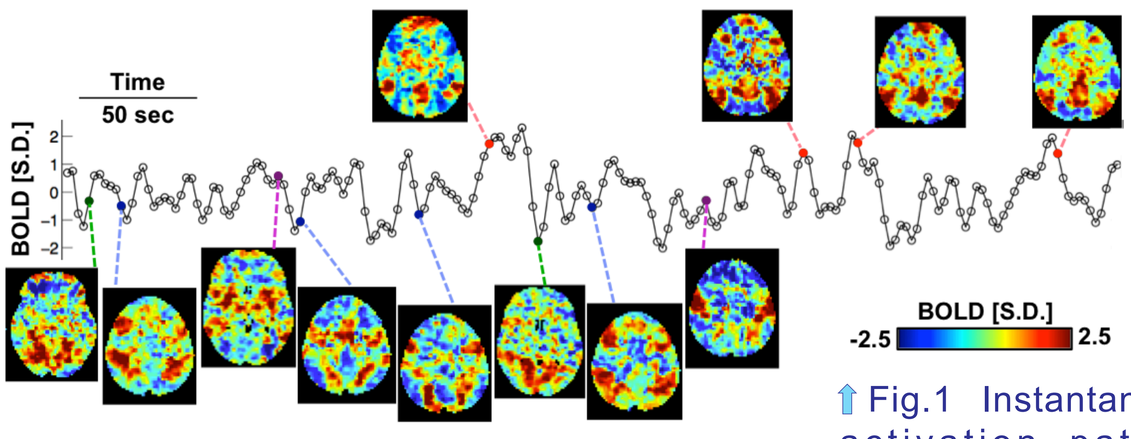
Advanced MRI

Introduction

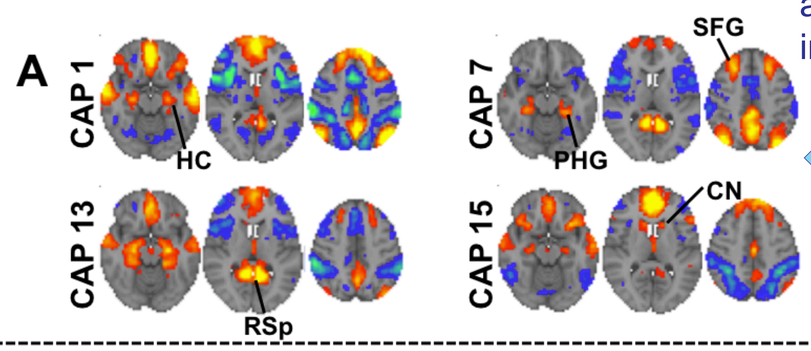
It has been shown that single fMRI time frames may closely resemble resting-state networks (RSNs) derived from the whole dataset using correlation or ICA analysis. Importantly, by grouping a subset of time frames according to spatial similarity, specific RSNs can be temporally decomposed into multiple co-activation patterns (CAPs) with distinct features (Liu and Duyn, PNAS, 2013). Here, we extend the temporal decomposition approach to include all time frames to extract 30 CAPs that may be interpreted as instantaneous network configurations and thus provide information complementary to that available with conventional analysis methods.

Methods

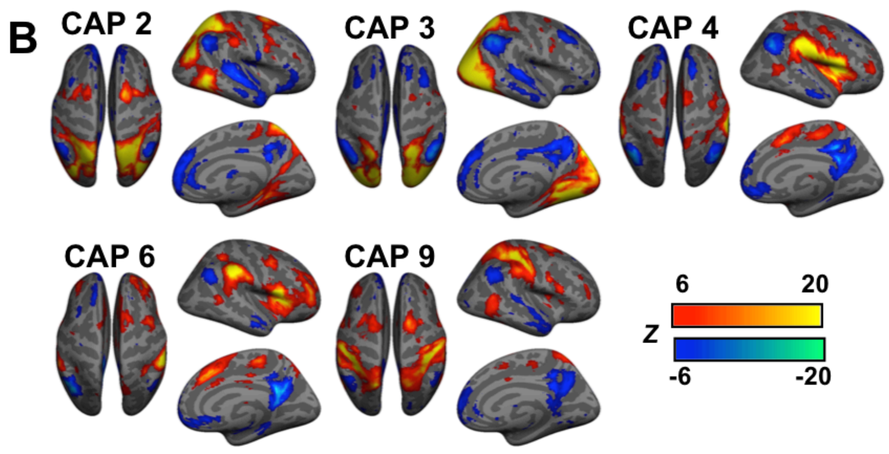
- 102 participant datasets from the "1000 functional connectomes project" (FCP) (Biswal et al. PNAS, 2010).
- Motion correction; Spatial smoothing (FWHM = 4 mm) and temporal filtering (0.005 - 0.1 Hz); Linear and quadratic temporal trends removal; Spatial co-registration to the MNI template; Nuisance regression of 6 motion parameters.
- Regressing out averaged signals from the white matter, CSF, and whole brain.
- Time series were standardized to Z scores.
- Classify and then average time frames into 30 groups based on their spatial similarity, resulting in 30 co-activation patterns (CAPs) (Liu and Duyn, PNAS, 2013).



⇑ Fig.1 Instantaneous co-activation patterns of individual volumes



⇐ Fig.2 Two groups of CAPs covering "task-negative" (A) and "task-positive" (B) regions of the brain.



Results

- Individual fMRI volumes display instantaneous co-activation patterns resembling different RSNs (Fig. 1).
- Multiple default mode network (DMN) patterns with different involvement of hippocampus (HC), parahippocampal gyrus (PHG), caudate nucleus (CN), superior frontal gyrus (SFG), and retrosplenial cortex (RSp) (Fig. 2A).
- Co-deactivation in DMN is associated with multiple patterns of co-activation in "task-positive" brain regions (Fig. 2B).
- Very specific thalamocoritical co-activations in sensory system, including anti-correlated thalamic reticular nucleus (TRN) and sensorimotor cortex (Fig. 3).
- Certain CAPs occur at different frequencies in male and female subjects (Fig. 4).

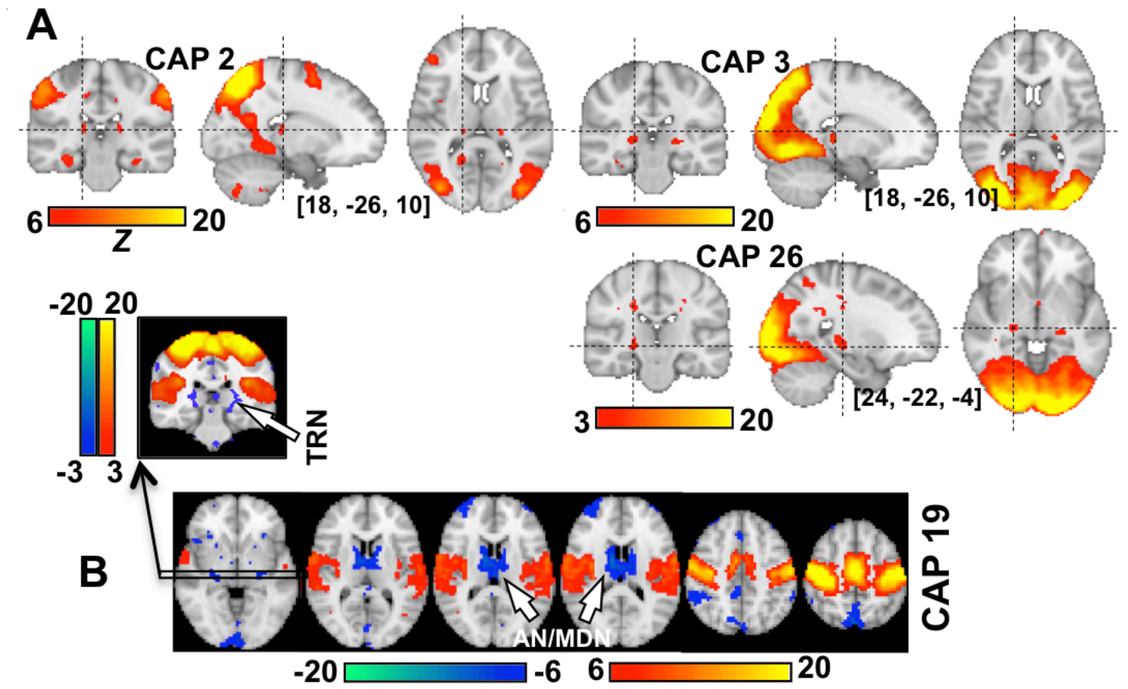


Fig.3. CAPs showing thalamocortical co-activations in visual (A) and sensorimotor (B) systems.

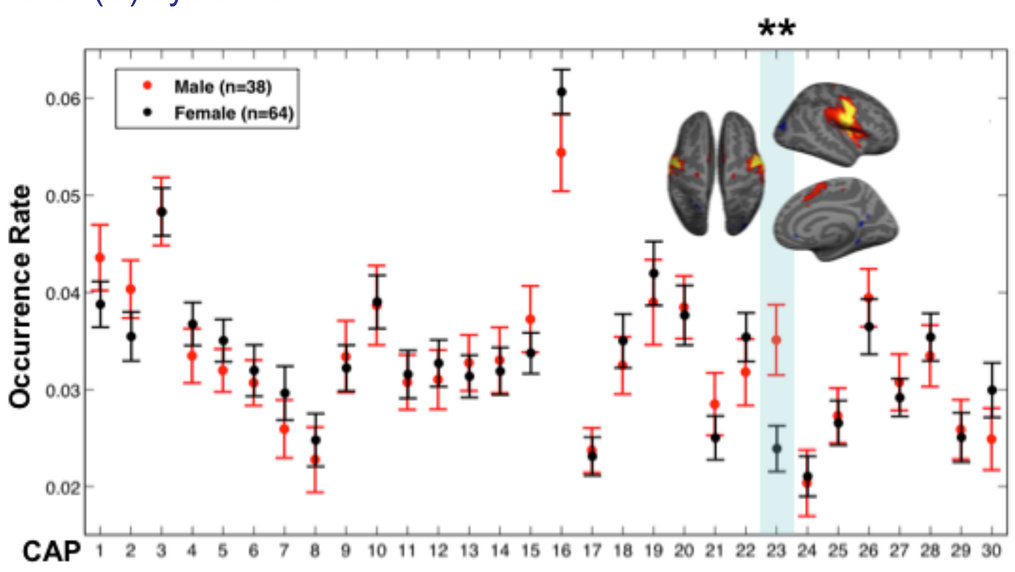


Fig. 4. Occurrence rates of CAPs in males and females.

Discussions

- CAPs may explain non-stationary functional connectivity (Chang et al. NeuroImage, 2010)
- Resting-state functional connectivity may result largely from a few sporadic co-activation events rather than continuous interactions of the brain.
- A new data-driven method for analyzing the resting-state fMRI signals, which has few assumptions and data transformations and may reveal more specific information regarding co-activation of multiple brain regions.

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