Spatial patterns of BOLD signal activation useful for identification and classification of task-state functional brain networks

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Introduction

Functional magnetic resonance imaging (fMRI) strong magnetic fields and radio waves to detect changes in hemoglobin oxygenation level in the blood, also known as the Blood Oxygen Level Dependent (BOLD) signal.

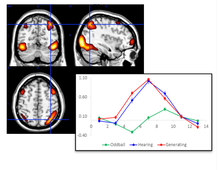
fMRI studies have shown that the human brain is organized into distinct intrinsic functional networks elicited during resting state[1]. By using a task-state paradigm instead, our lab has uncovered novel networks for which function can be inferred, and which have reliable differences in both their spatial distribution of activity and hemodynamic response shapes. The present study investigated several candidate networks in order to characterize their distinguishing features.

Materials and Methods

Data acquisition

1. Participants perform cognitive tasks in the fMRI scanner
2. Data analyzed using constrained principal component analysis (CPCA)
3. Computer generates image of BOLD signal change and HDR plot

CPCA

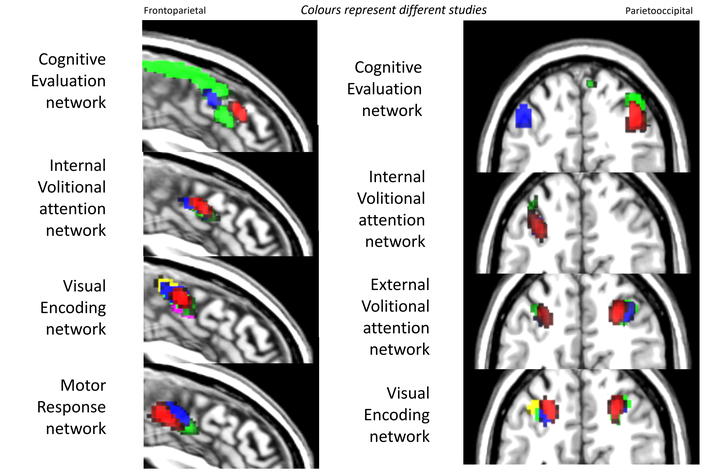


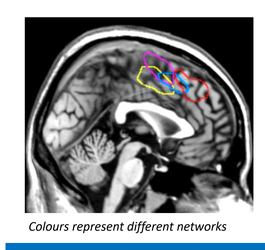
Characterization

1. Extensive side-by-side visual comparison of all networks to identify between network differences
2. Internal data compiled and classified based on HDR shapes and prior interpretations
3. Data from multiple studies is overlaid in neuroimaging software to confirm between network differences

Results

Activity in **frontoparietal** regions, and **parietooccipital** regions display spatial patterns in some networks

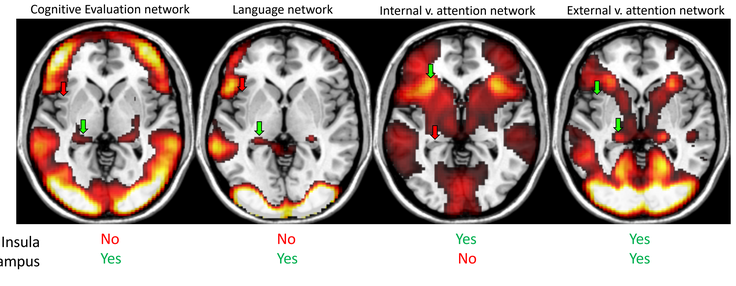


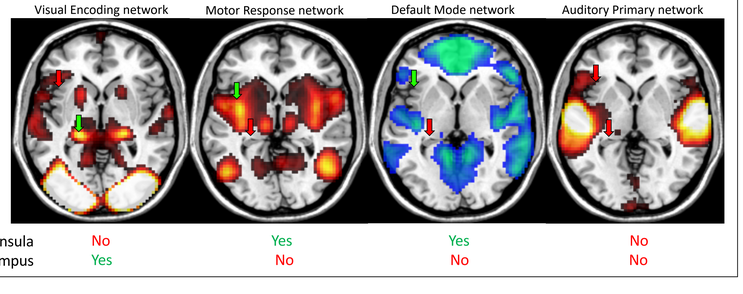


Colours represent different networks

Red: Cognitive Evaluation network
Blue: Internal Volitional attention network
Green: External volitional attention network
Violet: Visual encoding network
Yellow: Right-handed response network

Activity in the **insular cortex** and **posterior hippocampus** are present in some networks but not others





Conclusions

- **Spatial patterns:** Visual comparison of each network provide evidence that task-state networks can be reliably differentiated based on relative spatial activation in medial frontoparietal and parietooccipital regions.
- **Presence/absence of activity:** Presence or absence of activity in the posterior hippocampus/insula is useful for differentiation and also provides some insight into the function of the networks.
- **Anatomic signatures:** By combining features from all four of these regions, unique anatomical signatures can be devised in order to classify networks.
- **Limitations:** (1) spatial differences are defined visually and currently cannot undergo statistical analysis. (2) Relatively few studies were used in the comparison of networks.
- **Future work:** Other regions of potential importance include the mid frontal pole, occipital pole, and the cerebellum.

References

[1] Yeo, BT, et al. (2011) The organization of the human cerebral cortex estimated by intrinsic functional connectivity. J Neurophysiology, 106, 1125-1165.

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