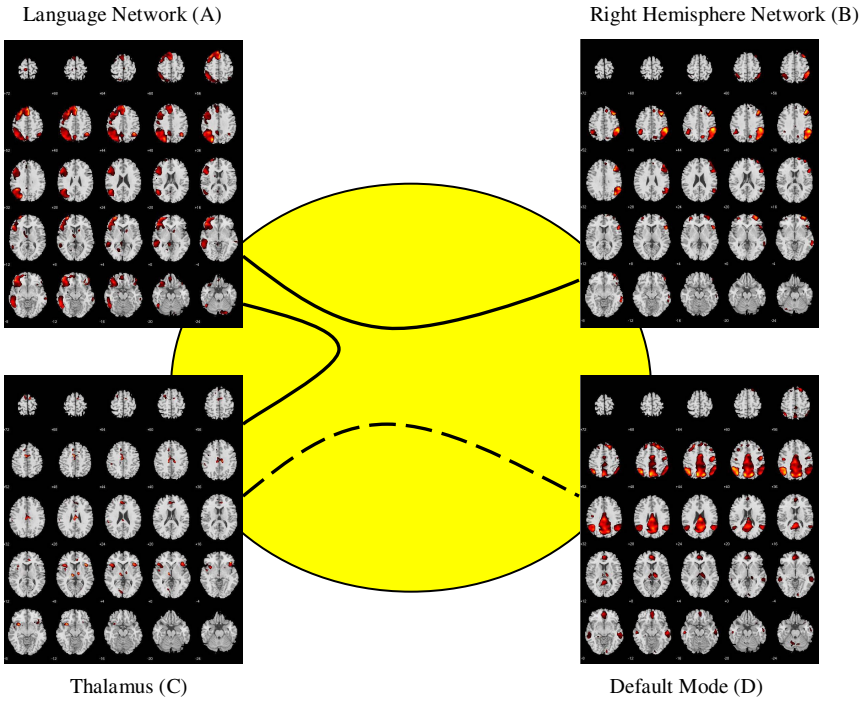
Functional network connectivity in semantic object recall task using independent component analysis

K. Jagannathan[1], M. Assaf[1,2], V. D. Calhoun[1,3], and G. D. Pearlson[1,2]

[1]Olin Neuropsychiatry Research Center, Institute of Living, Hartford, Connecticut, United States, [2]School of Medicine, Yale University, New Haven, Connecticut, United States, [3]The MIND Institute, Albuquerque, New Mexico, United States

Introduction: The recall of an object from features is a unique operation in semantic memory processing. We previously demonstrated that brain areas specifically involved in object recall include the thalamus, pre-supplementary motor area (pre-SMA), left dorsolateral prefrontal cortex, inferior parietal lobule, and middle temporal gyrus, and bilateral rostral anterior cingulate and inferior frontal gyri (Assaf et al, 2006). These regions are part of neuronal networks known to be involved in semantic processing, verbal working memory and response conflict and error detection and monitoring. Interestingly, activations in these areas were not significantly associated with task performance. We therefore hypothesized that differences in connections between the neuronal networks can explain differences between good and poor performers of the object recall task. In the current study we assess the Functional Network Connectivity (FNC) between spatially independent neural components (i.e. networks) as measured by independent component analysis (ICA) in healthy individuals and relationship to task performance (Jafri et al, 2007).

Method: Fifty-five right handed healthy native English speakers with no history of neurological or psychiatric disorder participated in the study. A Semantic object-recall task was presented to all participants while undergoing an fMRI scan. During the task, subjects determined whether word pairs describing object features combined to recall a third object. Imaging was implemented on a Siemens Allegra 3T and data was preprocessed using Statistical Parametric Mapping (SPM2). Based on the discrimination index score (i.e. (hit rate) – (false alarm rate)), subjects were grouped as good or poor performers. ICA was performed using the GIFT toolbox. Data were decomposed to 25 maximally independent patterns of spatiotemporally correlated BOLD signal changes. For the FNC analysis, we evaluated the temporal dependency among ICA time courses to four major task related components that included a language network (A), a right hemisphere language network (B), the thalamus(C) and the default mode network (D). The lag-shifted maximal correlation between the component time courses for all the subjects were computed for all pair wise combinations. Differences in correlation values for good and poor performers were considered to be statistically significant at the p = 0.05 level.



Results: There were no differences between good (n=26) and poor (n=29) performers on age, gender, race or years of education. Figure shows the 4 selected components and the FNC differences between the two groups of performers. Importantly, good performers showed higher correlations between components A and B (p = 0.002: solid line) and A and C (p = 0.03: solid line) while poor performer showed higher correlation between component C and D (p= 0.005: dotted line).

Conclusion: These results support the hypothesis that different temporal relationships between distributed brain networks underlie poorer object recall from semantic memory. This work demonstrated a new approach for understanding semantic processing in normally developed individuals and in patients in whom these processes are impaired (i.e. schizophrenia).

References:

Assaf M, Calhoun V, Kuzu C, Kraut M, Rivkin P, Hart J, Pearlson G.D. Neural correlates of the object-recall process in semantic memory. Psychiatry Res. 2006 147, 115-26.

Jafri M, Pearlson G.D, Stevens M, Calhoun V. A method for functional network connectivity among spatially independent resting–state components in schizophrenia. Neuroimage. In press 2007