Time Projection and the Executive Control Network

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Introduction

Studies examining resting-state functional MRI (rs-fMRI) connectivity over the past decade have revealed several consistent, coherent networks. A critical question now facing researchers concerns the functional significance of these networks. The executive control network (ECN) is well characterized and includes regions that are increasingly reported in studies of memory. In this study we sought to examine whether what one thinks about at rest influences what regions are recruited to the intrinsic connectivity networks (ICNs). We hypothesized that time processing would track with increased recruitment of memory areas to the ECN.

Method

24 participants (16 female, mean age 35.3) completed a 6-minute, eyes-closed rs-fMRI scan, after which they completed a survey assessing the percentage of time they spent reflecting on past events or future plans. We combined independent component analysis and seed-based analysis to generate data-driven participant networks. We regressed the self-report measure of time projection against ECN FC. The executive network peaks were the left inferior parietal lobule [Tal -40 -50 45, BA 40], right superior parietal lobule [Tal 39 -66 46, BA 7], and the right middle frontal gyrus [Tal 49 36 26, BA 46]. A white matter nuisance seed was also chosen (Tal coordinates [-27 9 24])

Parameters - scans performed on 3T GE scanner. Functional scan: TR=2000ms, TE=30ms, flip angle=77˚, FOV=22cm, matrix=64x64, 29 slices, 4.0mm slice thickness. High-resolution volume scan: TR=3000ms, TE=68ms, TI=500ms, flip angle=11˚, FOV=25cm, matrix =256x256, 124 slices, 1.2mm slice thickness

Results

In the executive control network, connectivity increased to the left cuneus (BA 18), right tuber, right anterior cingulate (BA 32), left postcentral gyrus (BA 2), left precuneus (BA 19), left superior frontal gyrus (BA 11), right precuneus (BA 7) as past and future score increased. Connectivity decreased to the right insula (BA 13) as past and future score increased.

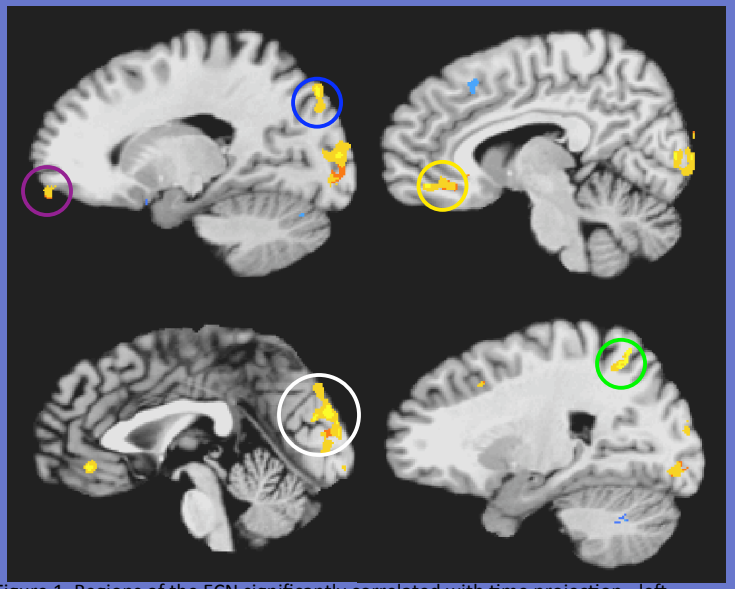

Figure 1. Regions of the ECN significantly correlated with time projection - left cuneus (white), right ACC (yellow), right and left precuneus (green and blue), and left SFG (purple).

The ECN is generally thought to be involved in goal directed behavior, target and error awareness, conflict resolution, inhibiting automatic responses, working memory, and control processes. Given this we would expect that as a person reports thinking more about past or future events that they would show increased connectivity between the seeds and areas typically activated for past and future thinking. This is indeed what we found, with increased connectivity to a variety of regions associated with mentally projecting in time.

Conclusions

All of the areas in which we found increased FC as time projection increased have been found in functional studies to have roles in processing information about the past or future. It is a reasonable assumption that connectivity would underlie function but here we have presented evidence supporting that assumption. Vincent et al., 2006, recently found a network anchored by the hippocampus that incorporated a number of regions associated with executive control, supporting the idea that the ECN might have a role in time projection.

Future directions

This study was limited in that it looked only at one measure of time-projection and relied on self-report. Future studies should assess a broader range of cognitive measures in more reliable ways. This study serves as an early look at the relationship between connectivity and cognition in an attempt to answer the bigger question about the significance of FC.

References

Seeley WW, Menon V, Schatzberg AF, Keller J, Glover GH, Kenna H, Reiss AL, Greicius MD. (2007). Dissociable intrinsic connectivity networks for salience processing and executive control. Journal of Neuroscience, 27,9:2349-2356.

Spreng RN, Grady CL (2010). Patterns of brain activity supporting autobiographical memory, prospection, and theory-of-mind and their relationship to the default mode network. *Journal of Cognitive Neuroscience*, 22,6:1112-1123.

Vincent JL, Snyder AZ, Fox MD, Shannon BJ, Andrews JR, Raichle ME, Buckner RL (2006). Coherent spontaneous activity identifies a hippocampal-parietal memory network. *Journal of Neurophysiology*, 96:3517-3531.

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