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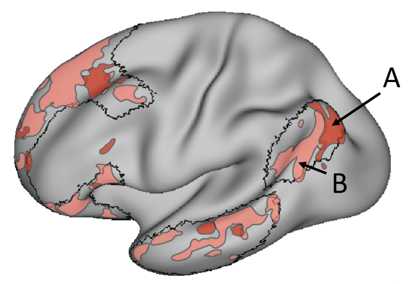
Parallel Networks Dissociate Episodic and Social Functions Across Distributed Cortical Regions Within Individuals

L.M. DiNicola[1], R.M. Braga[2], R.L. Buckner[1,3,4]

Harvard University[1], Stanford University[2], MGH[3], Harvard Medical School[4]

Introduction

- Human association cortex comprises distributed networks.[1]
- Functional connectivity (FC) analysis of repeatedly scanned individuals revealed two parallel, distributed networks within the boundaries of the group-defined default network (DN).[2]
- Network A includes regions in posterior parahippocampal cortex (PHC) and a more caudal portion of the inferior parietal lobule (IPL), both associated with episodic projection (EP; e.g., episodic memory and future prospection).[2-5]
- Network B includes a rostral region of the IPL along the temporoparietal junction (TPJ), which has been robustly linked to representational theory of mind (ToM).[2,6-8]
- **In three independent experiments, we aimed to test whether EP and ToM tasks differentially recruit the parallel networks, across distributed cortical regions.**



Braga & Buckner (2017)

Scanning Methods

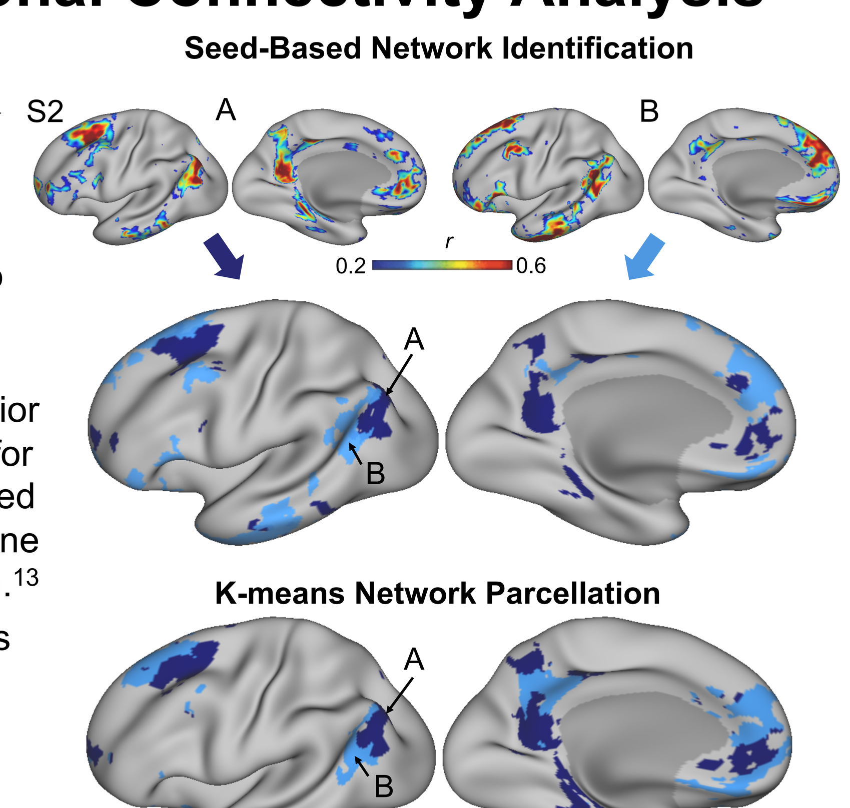
- In each of 3 experiments (*initial* – Exp. 1, *prospective replication* – Exp. 2, *and prospective triplication* – Exp. 3), 4 MRI sessions were acquired for each of 6 subjects.
- All scanning was conducted using a 3T Siemens Prisma-fit MRI scanner (64ch). T1-weighted structural images were acquired using an ME-MPRAGE sequence (TR=2200ms, 1.2mm isotropic voxels, 176 slices). BOLD scans were acquired using a multiband, gradient-echo, echo-planar pulse sequence[9] (TR=1000ms, TE=32.6, 2.4mm isotropic voxels, 65 slices, multislice 5 × acceleration).
- Up to 77 minutes of fixation task BOLD data, as well as up to 42 (ToM) or 61 (EP) minutes of BOLD data from each other task domain were acquired per subject, across experiments.
- Through a custom analysis pipeline for individualized data processing (iProc),[10] BOLD data were registered to a native space anatomical template through a single interpolation.

Within-Subject Functional Connectivity Analysis

FC Data Processing: Nuisance variables (motion parameters, whole-brain, ventricular & deep cerebral white matter mean signals and temporal derivatives) were regressed from fixation task BOLD data. Residual data were bandpass filtered (0.01 to 0.1 Hz), projected to the fsaverage6 surface mesh[11] and smoothed (2mm FWHM kernel).[12]

Seed-Based Network Identification: As in prior work,[2] a cross-correlation matrix was created for each fixation run. Matrices were averaged. Seed vertices were selected from lateral PFC to define each network,[2] using Connectome Workbench.[13]

K-means Network Identification: Time series data were z-normalized and concatenated across runs, then input to the k-means algorithm. Networks A and B were identified within the whole-brain output based on referential features.[2]

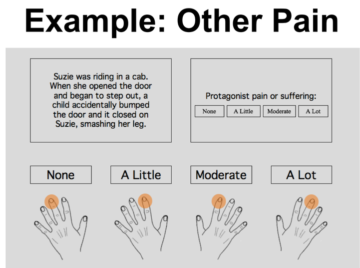


Within-Subject Task Analysis

Task Analysis: Nativespace BOLD data were resampled to the fsaverage6 surface mesh,[11] smoothed (2mm FWHM kernel), and input to run-specific GLMs (FSL FEAT). Task contrasts isolated EP or ToM.[3,4,6-8] Mean z-maps were created for each domain.

Example: Past EP

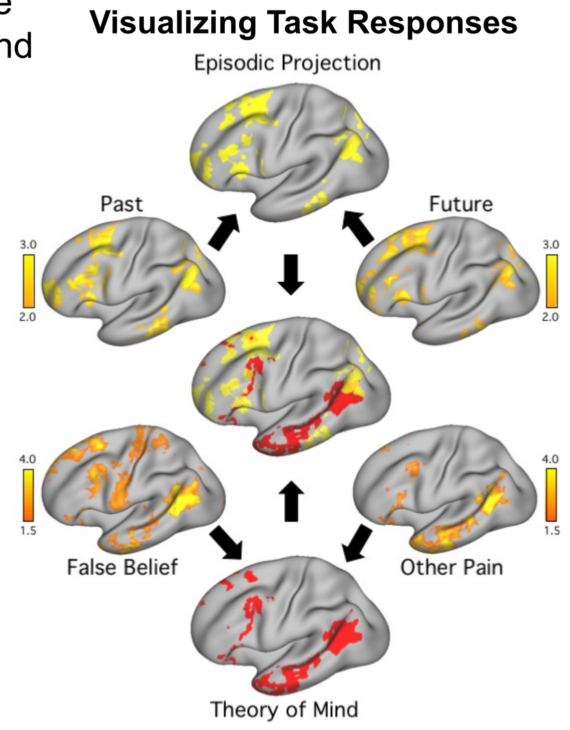
Example: Other Pain



Episodic Projection Tasks:[3] Subjects answered questions about hypothetical past or future scenarios or present beliefs/ feelings by selecting 1 of 3 possible responses per 10sec trial. Future and past EP were contrasted against the control of present self-reflection.[3]

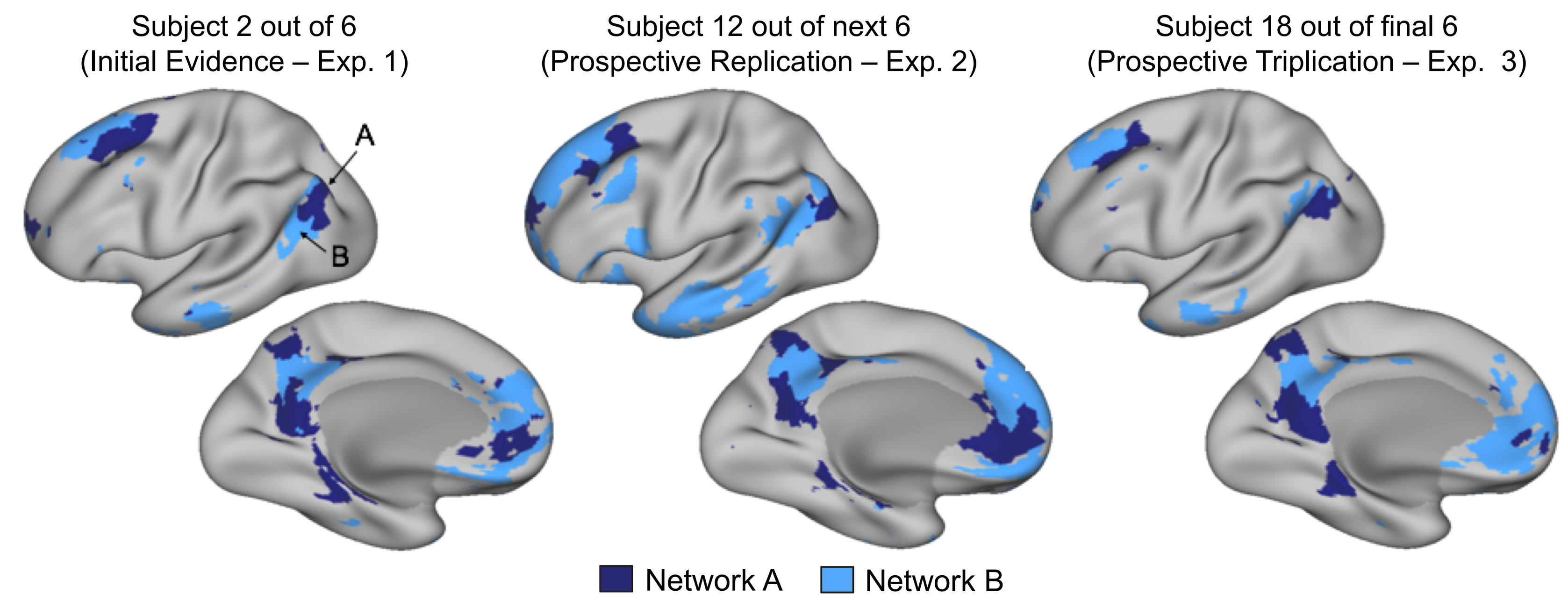
Theory of Mind Tasks:[4,6-8] False Belief task:[6,7] Subjects answered questions about stories featuring characters or objects with potentially false beliefs or information. Other Pain task:[8] Subjects rated the pain in emotionally or physically painful stories. Across tasks, trials included 10sec for reading and 5sec for responding.

Visualizing Task Responses

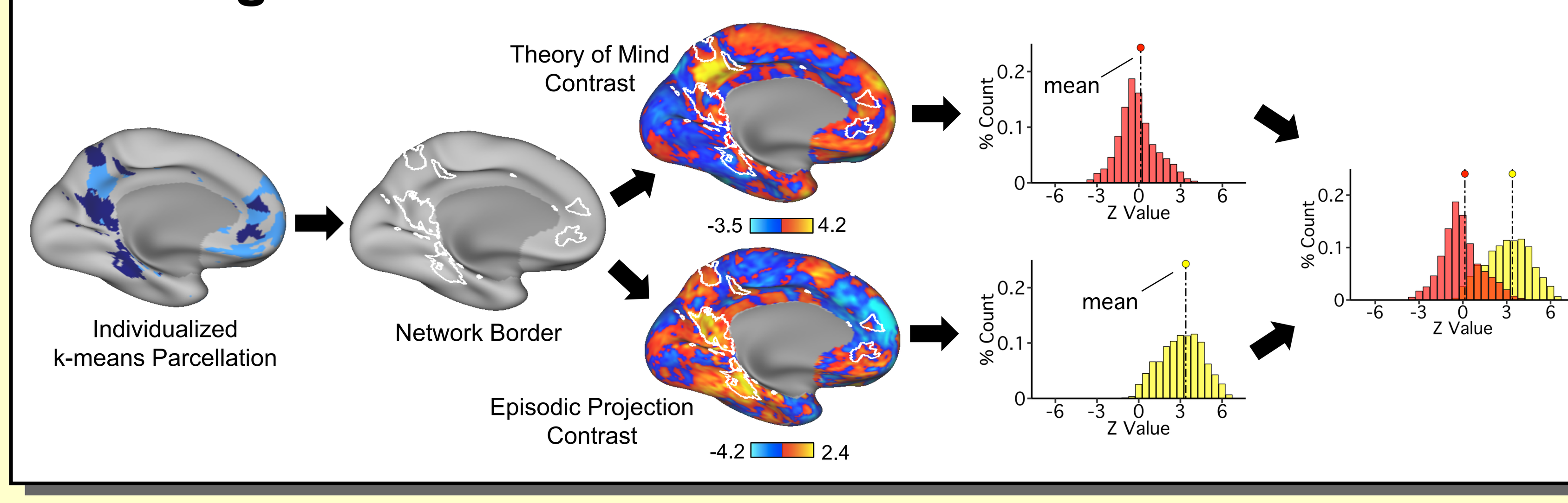


Parallel Networks Defined Within Individuals

Networks A and B were identified within all participants using both seed-based[2] and k-means parcellation strategies. Estimates were similar across methods; k-means estimates were used for analysis and are shown below for one subject from each of our three independent samples.

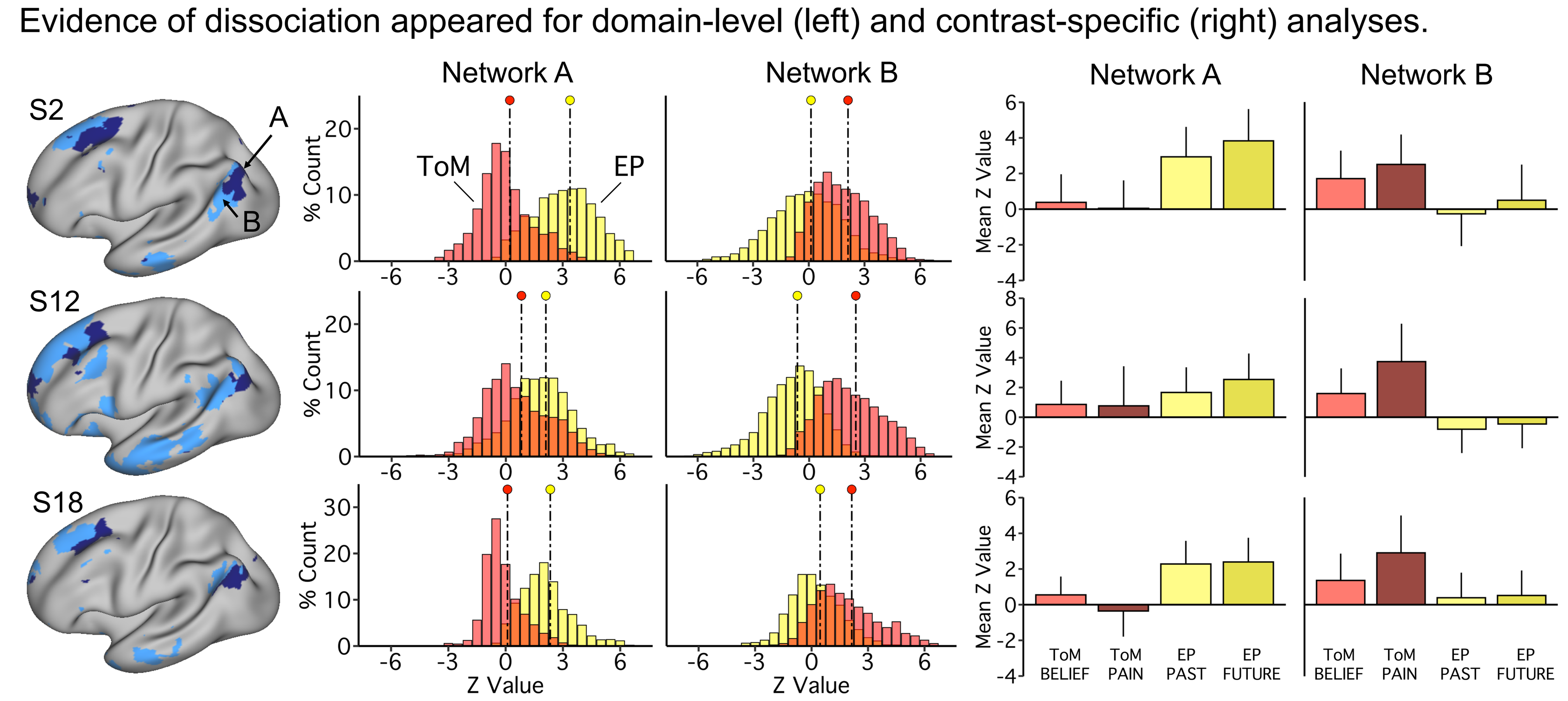


Testing for Functional Dissociation Within Individuals



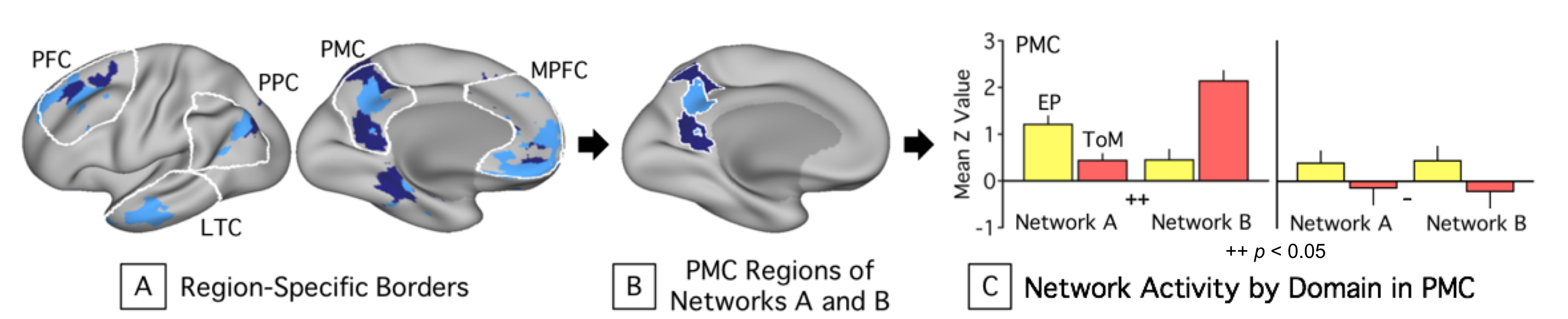
Functional Dissociation Within Individuals

A test of functional dissociation measured task contrasts' differential activity within Networks A and B. Evidence of dissociation appeared for domain-level (left) and contrast-specific (right) analyses.



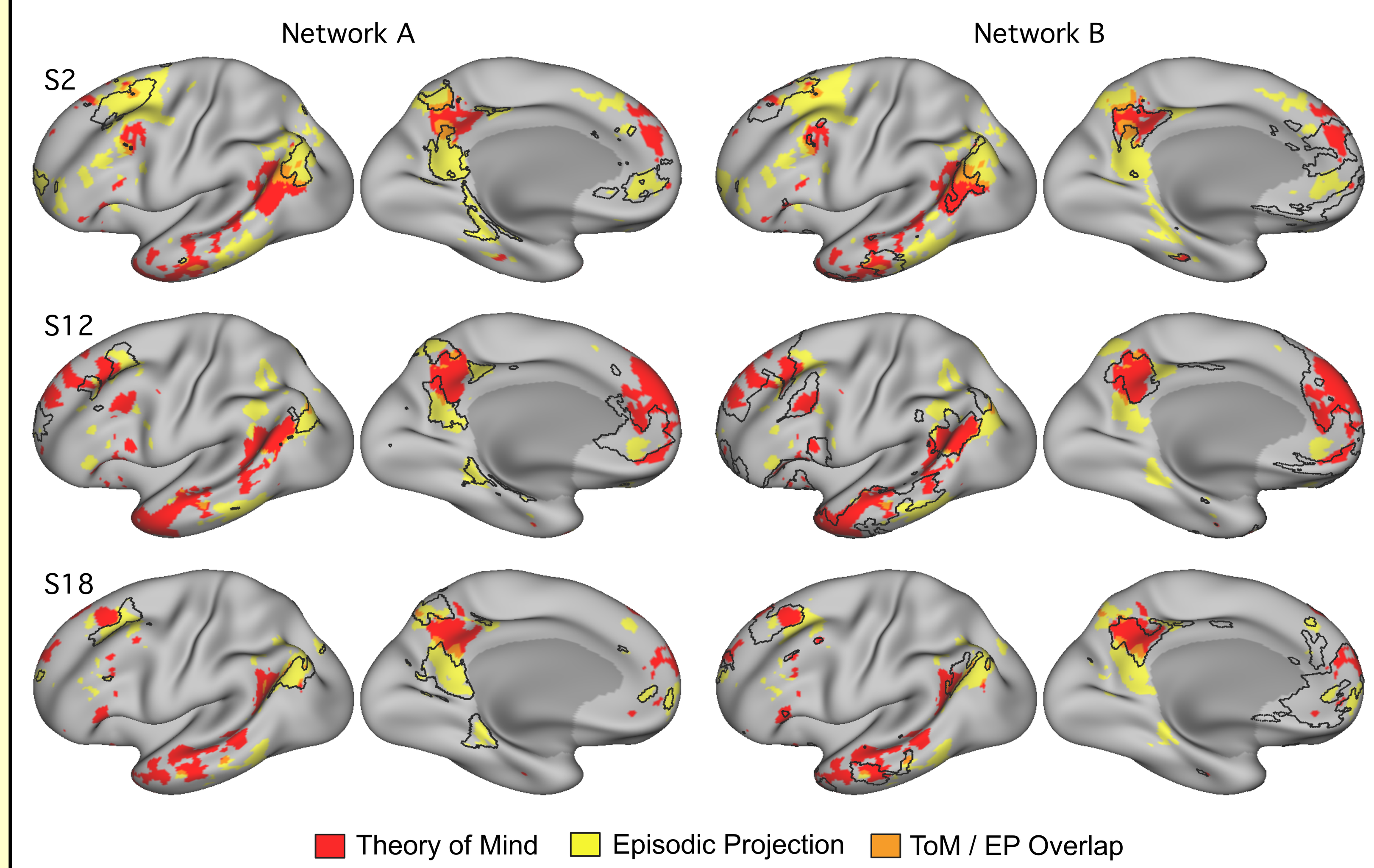
Testing for Functional Dissociation Across Regions

In Exp. 2 and 3, within-subject trial-level analyses[14] were used to test for interaction effects between networks and domains. Tests were applied, for both task and null data, to the networks in their entirety and to five cortical regions: prefrontal cortex (PFC), posterior parietal cortex (PPC), lateral temporal cortex (LTC), posteromedial cortex (PMC; ex. shown below) and medial prefrontal cortex (MPFC).



Functional Dissociation Across Cortical Regions

- For each individual, contrast maps for each domain (EP and ToM) were also visualized in relation to the network boundaries. FC network estimates showed differential task overlap, including in zones previously considered 'hubs' along the cortical midline.[3]
- Trial-level results (in Exp. 2 and 3) supported a functional dissociation across regions. For S12 and S18 (below), interaction effects were found for 4/5 regions (all but LTC).
- Overall, 60% of region-specific tests in Exp. 2 and 70% in Exp. 3 showed interaction effects. 5/6 subjects in Exp. 2 and 5/6 in Exp. 3 showed interaction effects for 3 or more regions. Analyses of null data yielded only 1 false positive result in Exp. 2 and 0 in Exp. 3.



Conclusions

- Parallel, distributed and interwoven networks, recently discovered within the bounds of the canonical DN,[2,10] can be reliably identified within individuals.
- Evidence from three independent experiments suggests a functional dissociation of Networks A and B, across distributed cortical regions, with Network A preferentially recruited for episodic projection tasks and Network B for tasks targeting theory of mind.
- These results suggest that Networks A and B may be organized to support different task demands and raise questions about how such organization might arise.[15]

For full details, go to the booth URL to see:

DiNicola, Braga and Buckner (2020)

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contact: LMD600@g.harvard.edu