Resting-State Functional Connectivity as a Predictor for Shifting Decision Criterion

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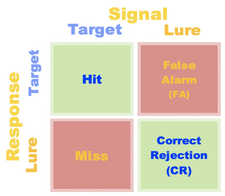
Background

- The ultimate decision to report that a stimulus has been previously seen depends not only on the level of familiarity, but also the scenario, which can dictate whether a person only relies on strong, clear memory evidence or is willing to rely on relatively weaker memory evidence.[1]
  - The ability to shift criterion thresholds has the potential to improve decision outcomes, especially where there is some uncertainty.



- Signal Detection Theory:
  - Discriminability:
    d' = Z(Hit rate) – Z(FA rate).[2]
  - Decision criterion:
    c = -0.5 x [Z(Hit rate) + Z(FA rate)]
  - Criterion shift = c(conservative) – c(liberal)

- The tendency to criterion shift appears to be a stable cognitive trait, yet the nature or origin of this stability remains to be clarified. [2]
- Prior work has identified the involvement of the inferior parietal lobe and insula in decision-making in both ambiguous and risky situations.[3]
  - Supposing that decision-making tendencies reflect consistent individual differences, we wanted to investigate whether patterns of connectivity at rest might relate to observed behavior during tasks involving decision-making under uncertainty.
  - Patterns of connectivity at rest may reflect intrinsic differences in information integration and network organization that contribute to consistent differences in decision strategies.

Main Aim: *To investigate whether resting-state functional connectivity predicts the extent an individual shifts criteria across conservative and liberal manipulations.*

- Regions of interest included the inferior parietal lobule (IPL) and anterior insula.
- Seed-based functional connectivity analysis is predicted to reveal that connectivity, during rest, correlates with the extent an individual shifts their criteria on decision-making tasks involving risk and uncertainty in the domains of memory and perception.

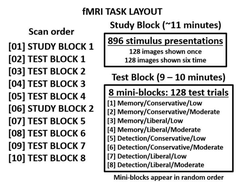
Methods

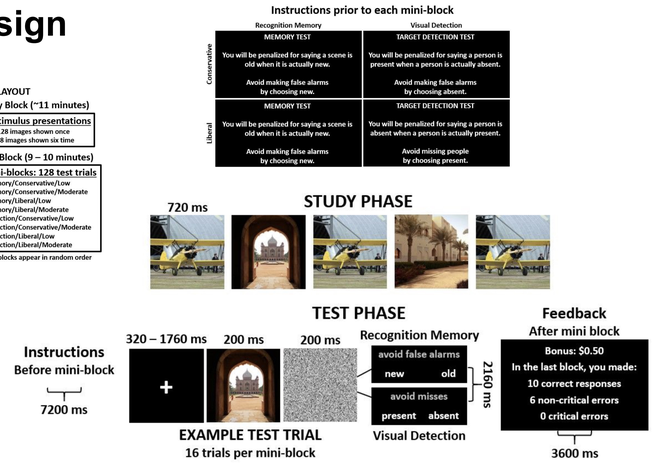
Participants

- Thirty adult participants (19 females; 11 males; ages 18 – 32, *M* = 21, *SD* = 3.0; 3 left-handed) from the University of California, Santa Barbara (UCSB) completed a resting-state fMRI and the criterion shifting behavioral task during an fMRI session. Participants were selected from 144 subjects (84 females; 60 males; ages 18-35, *M* = 21, *SD* = 2.8*)* who completed the initial prescreen behavioral computer task only. Two subjects were excluded from analysis due to unusable resting state data.
- Images were acquired by a 64-channel head and neck coil within a Siemens 3T PRISMA MRI scanner at UCSB. Participants were instructed to keep their eyes open during the resting state scan.

Methods cont.

Task Design



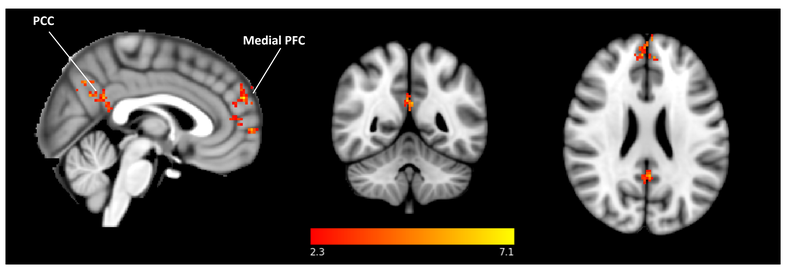


Analysis

- *Pre-processing* of resting-state data was carried out using FEAT (FMRI Expert Analysis Tool) Version 6.0.4, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl) and included motion correction using the "MCFLIRT" function, B0 unwarping corrected for magnetic inhomogeneity with participants' brain fieldmap images, removal of white matter and CSF time-series.[4]
- IPL and insula ROIs were registered to the preprocessed fMRI data. The IPL ROI was defined using the parcellation maps described by Mars et. al (2011).[7] The insula ROI was defined using the peak cortical voxel centroid found in research conducted by Aminoff and colleagues' (2015).[6] A 5 mm radii sphere was centered around the peak voxel (81 voxels per ROI) in the insula.The mean time series of voxels in these regions were extracted and used as a primary regressor in a GLM analysis of all other voxel time series, resulting in whole-brain resting state functional connectivity (RSFC) maps.
- Inter-subject differences in functional connectivity were investigated at the group level using a voxel-wise GLM analysis that modeled each participant's criterion shift measure as a covariate of interest. Gaussian random field theory was used to correct for multiple comparisons using clusters determined by Z >2.3 and a corrected cluster significance threshold of p=0.05.[4]

Results

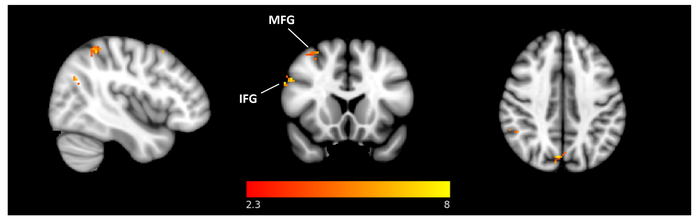
IPL ROI



- Greater criterion shift values were associated with stronger functional connectivity between the IPL and multiple brain regions, including the frontal pole, superior frontal gyrus, and posterior cingulate cortex.

Results cont.

Insula ROI



- Inter-individual criterion shift values were also associated with greater functional connectivity between the insula and multiple brain regions, including the angular gyrus, the superior parietal lobule, the inferior frontal gyrus, and the middle frontal gyrus.

Discussion

- Shifting behavior across a memory-based and perception-based task were associated with intrinsic connectivity of the IPL and insula.
- The insula is known to process interoceptive information. Perhaps intrinsic differences in the communication of interoceptive information with the insula contributes to the processing of internal signals during highly uncertain decisions.
- The IPL is a multimodal association area that also integrates information from various sources and has been linked to evidence accumulation in probabilistic contexts. Specifically, the IPL has been found to play a key role in guiding attention and increasing spatial processing, which can be particularly helpful to navigate uncertain memory and perception based decisions of scene stimuli.
- This analysis reveals that resting state functional connectivity can aid in identifying brain regions associated with individual differences in strategic decision-making under ambiguous circumstances, even when these regions are not directly activated by the task.

Future directions

- Future analyses can attempt to decode patterns of activation at rest that predict criterion shifting. We examined connectivity in association with 2 ROIs, but a fuller characterization of the patterns of activation predictive of criterion shifting behavior may help link this specific decision behavior with wider cognitive and computational processes. Recently we have found metacognition to correlate with criterion shifting, and metacognition has itself been tied to frontoparietal networks involved in uncertainty monitoring.

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