Scene Perception and Resting-State Connectivity Within a Posteromedial Network: The Importance of the Posterior Cingulate Cortex.

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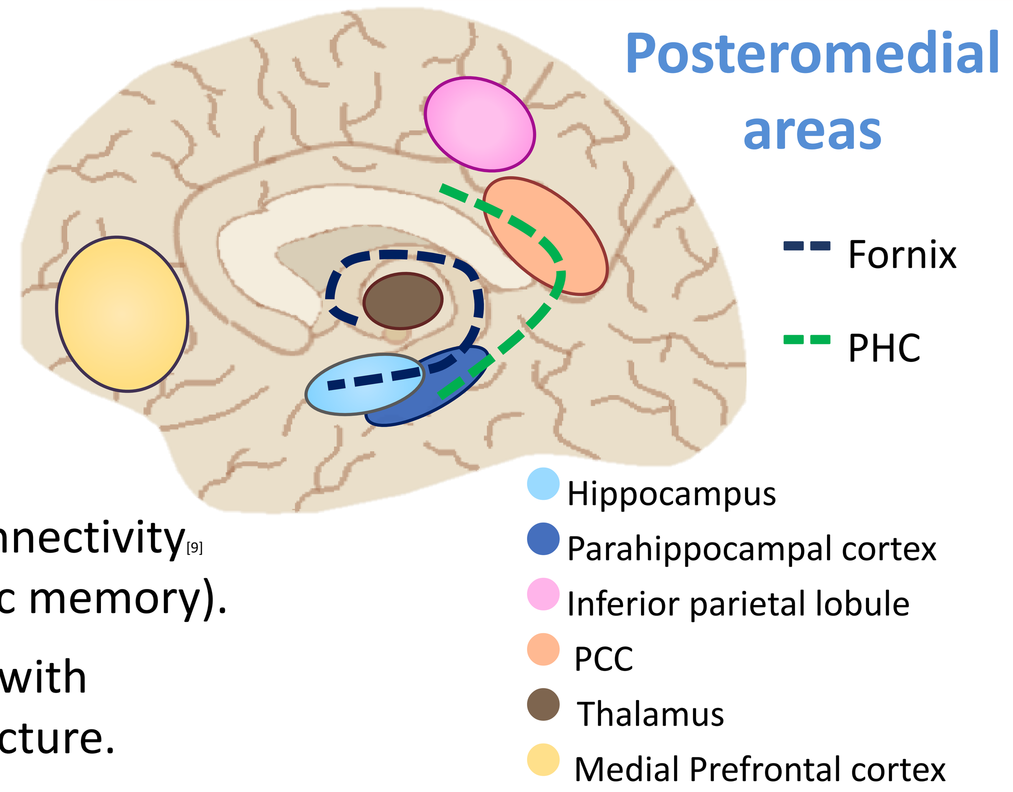
BACKGROUND

- **Posteromedial** areas, including the hippocampus and the posterior cingulate cortex (PCC), demonstrate resting-state (RS) connectivity in networks supporting spatiotemporal behaviours (e.g. navigation[1], recollection, future imagining[2]). They are connected via the fornix and parahippocampal cingulum (PHC)[3].
- **Anteroinferior** areas demonstrate RS connectivity in networks supporting aggregate processing (e.g. of objects[4] and faces[5]). They are connected via the inferior longitudinal fasciculus (ILF)[6].
- Studies using the **Oddity Task** have demonstrated that posteromedial areas are important for scene perception[7,8].
- Hippocampal activity and fornix microstructure have both been found to correlate with scene oddity performance[8]. PCC RS connectivity[9] and posteromedial theta oscillations[10] have been associated with other spatiotemporal behaviours (e.g. navigation and episodic memory).
- We tested if RS connectivity of the hippocampus and PCC to other posteromedial network areas, in the theta band, correlated with scene oddity performance and fornix microstructure. This was contrasted with face oddity performance and ILF/PHC microstructure.



HYPOTHESES

Correlations between: theta RS connectivity between PCC/hippocampus and posteromedial areas; scene oddity performance; and fornix structure.

METHODS

Oddity Task

- 40 healthy participants: oddity task during MEG scan → RS MEG scan → surprise memory test → structural MRI scan.
- Triplet images of scenes and faces, one differing in the spatial relationships of the features. A control task comprised triplet images of circles, one differing in size. Participants asked to pick the odd-one-out. Performance = % correct.
- After the RS MEG scan, scene and face stimuli displayed again, in a surprise memory task.

RS MEG

- 5-minute RS scan (MEG CTF 275-channel system).
- Analyses carried out in FieldTrip[11]. Amplitude envelope correlations across the whole brain calculated using an ROI-based approach[12] (with AAL 90 region atlas).
- Theta, alpha and beta frequency bands isolated by applying bandpass filters of 4-8 Hz, 8-12 Hz and 12-30 Hz, respectively. Source localization with LCMV beamforming.
- To remove influence of incidental encoding, partial correlations between RS-connectivity scores and scene and face oddity accuracy scores, controlling for scene and face d' scores (from the memory test), carried out.
- Alpha value Bonferroni-corrected to 0.006 to account for the number of oddity conditions and frequency bands (0.05/9, for 3 frequency bands and 3 oddity task conditions).

Posteromedial ROIs:

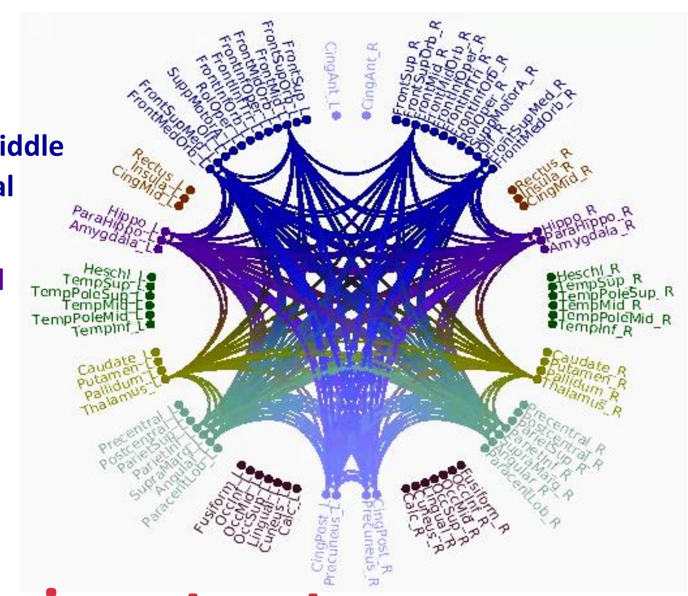
Frontal medial orbital, bilateral middle frontal, & bilateral superior medial frontal regions.

Hippocampus & parahippocampal regions.

Bilateral thalamus.

Inferior parietal, angular & supramarginal gyrus.

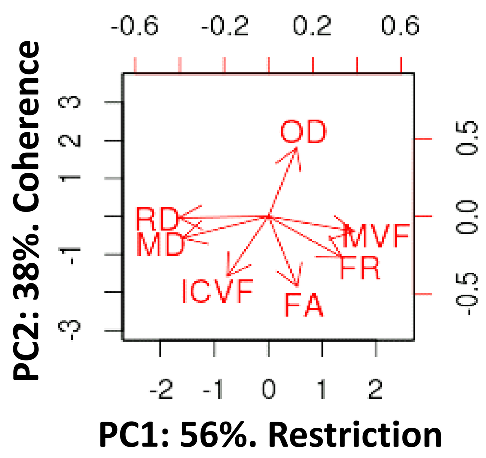
Bilateral PCC & precuneus.



Tract microstructure

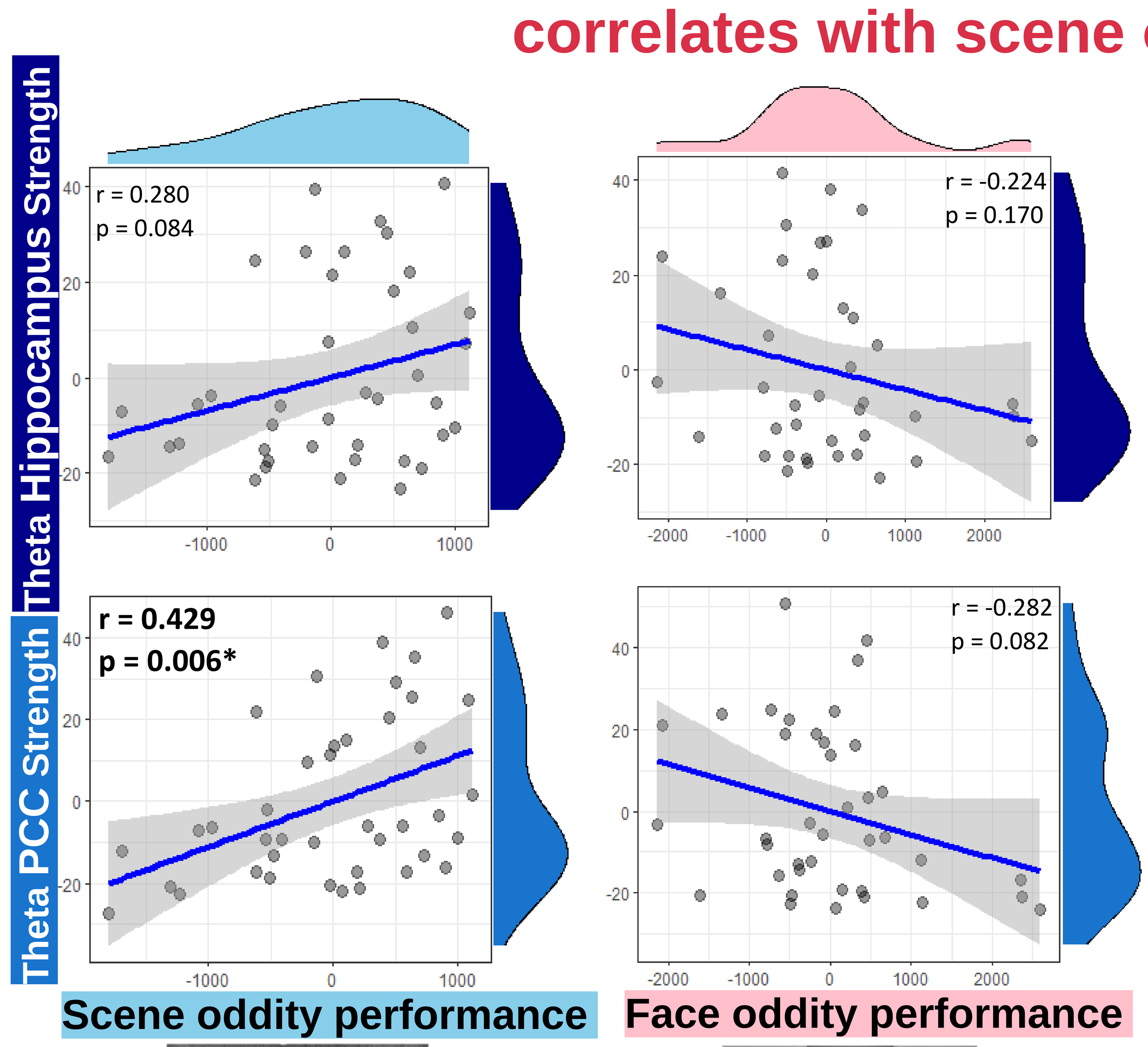
- Whole brain deterministic constrained spherical deconvolution tractography[13]. Tract streamlines isolated using Boolean gates[14].
- Microstructure properties derived from DTI[15], CHARMED[16], NODDI[17] and qMT[18].
- Microstructure measures reduced using principal components analysis, resulting in two main components reflecting 'restriction' and 'coherence' fibre properties.

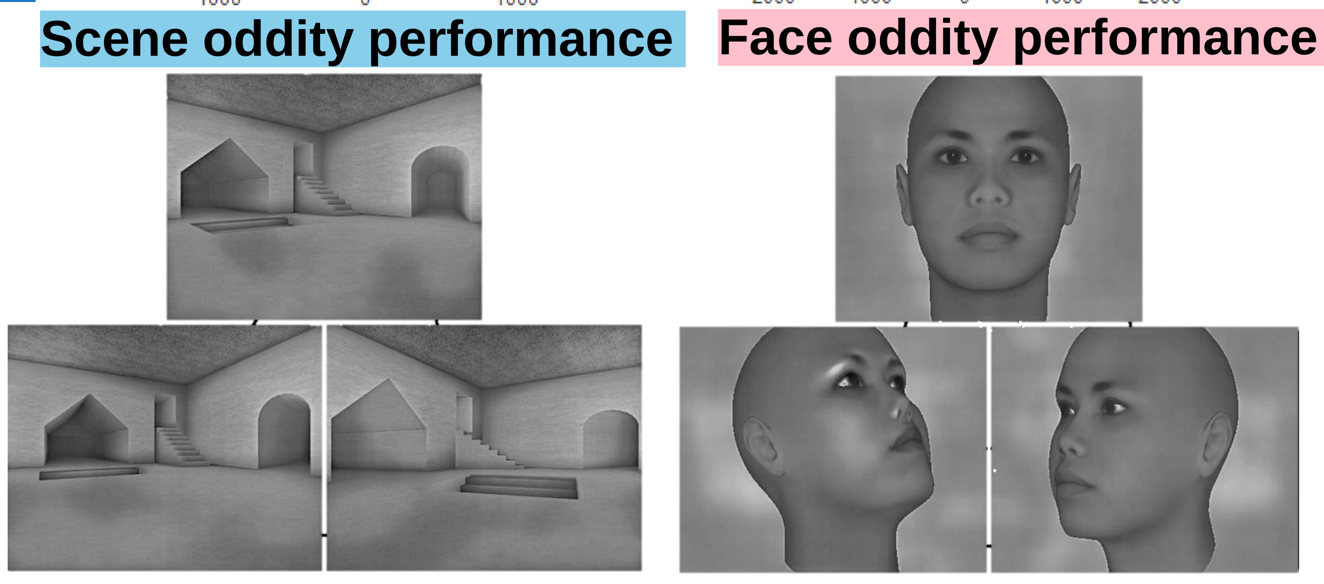
FA: Fractional Anisotropy.
FR: Restricted Fraction.
ICVF: Intracellular Volume Fraction.
MD: Mean Diffusivity.
MPF: Molecular Proton Fraction.
OD: Orientation Dispersion.
RD: Radial Diffusivity.



RESULTS

Theta PCC – posteromedial network connectivity strength correlates with scene oddity performance.



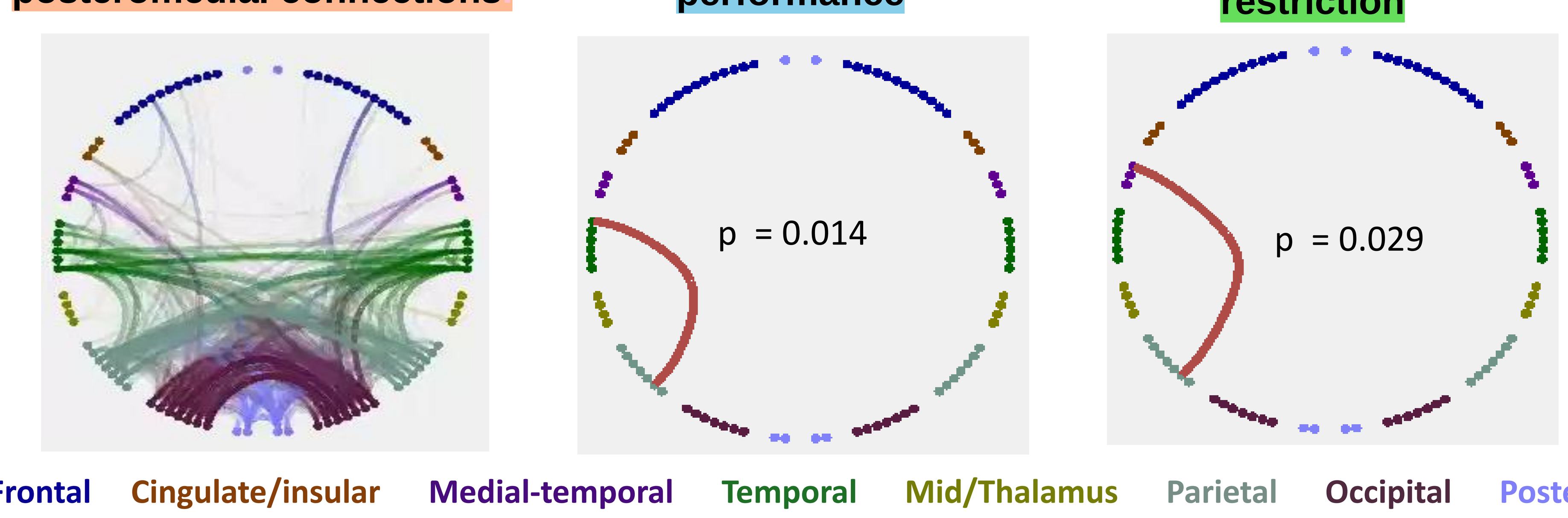


- ***PCC and hippocampus 'connectivity strengths':*** *The averages of the coefficients of the PCC-posteromedial ROIs and hippocampus-posteromedial ROIs correlations, respectively.*
- ***Theta PCC connectivity strength correlated with scene, and not face, oddity performance*** *(controlling for scene and face memory performance, respectively).*
- ***Hippocampus connectivity strength did not correlate with scene or face oddity performance.***
- ***Connectivity strengths in the alpha and beta band did not correlate with scene oddity performance.***
- ***We previously found fornix 'restriction' related to scene oddity performance, whereas PHC and ILF properties did not*. However, fornix 'restriction' did not correlate with theta PCC connectivity strength (p = 0.732),*** *so no structure-function-behaviour relationship was found.*

NB: Scenes made with [19] adapted from [20]. Faces made with [21].
Behaviour data has been transformed to normal.
Statistics and graph production carried out using [22,23]
*Unpublished results.

Exploratory analysis: searching for structure-function-behaviour relationships.

Which of the top strongest 40% of theta connections in the posteromedial network correlate with scene oddity performance and fornix restriction? The angular gyrus may be a common factor.



- ***Scene accuracy correlated with connectivity between the left angular gyrus and the left Heschl's gyrus.***
- ***Fornix restriction correlated with connectivity between the left angular gyrus and left hippocampus.***

P-values are FDR corrected.

CONCLUSIONS

Increased RS theta amplitude coupling between PCC and posteromedial areas may relate to improved scene perception.

- Theta PCC connectivity strength correlated with scene oddity performance, and not face oddity performance.
- Despite previous findings that in-task hippocampal activity correlated with scene oddity performance, theta hippocampus connectivity strength did not correlate with scene or face oddity performance.
- Since memory performance was controlled for, we can infer that PCC RS connectivity relates to perceptual performance rather than incidental encoding of the scene stimuli.
- Previously, we found fornix 'restriction' to relate to scene oddity performance, but here it did not correlate with theta PCC connectivity strength, suggesting that they relate to scene perception performance independently of each other.

Exploratory analysis suggests that research on the angular gyrus may reveal structure-function-behaviour relationships.

- It may be that theta RS connectivity of the angular gyrus is the mediator between fornix restriction and scene oddity performance as both these variables correlated with angular gyrus connection strengths.

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