Thalamocortical Structural Connectivity and Microstructural Covariance

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Introduction

- The thalamus is a diencephalic, bilateral, and highly heterogeneous structure that is extensively connected to cortical and subcortical regions
- In the past, the human thalamus has been parcellated based on thalamocortical structural connectivity using DWI[1]
- While the 'structural model'[2] proposes that regions with similar microstructure are more likely to be connected in the cortex, its implication for thalamocortical associations remains unclear

Here, we study the link between

- ➢ thalamocortical structural connectivity
- ➢ intrathalamic microstructure,
- ➢ and thalamocortical structural covariance

Methods

Data: diffusion-weighted imaging (DWI) and quantitative T1 (qT1) data from MICA-MICs dataset[3] (N=50, age 29.54±5.62y)

Structural Connectivity

Probabilistic tractography

- From thalamic seed voxels (L: 1068, R: 1029; res. 2mm) to 100 ipsilateral cortical parcels[4]
- Averaged across subjects to create a group-level structural connectivity matrix

Dimensionality Reduction:

- To extract the first two main axes of thalamocortical structural connectivity, we performed diffusion map embedding[5]
- Axes were projected onto cortex by correlating gradient loadings with structural connectivity profiles of each parcel

Microstructure

Intrathalamic Contextualization:

- Thalamic axes were correlated with a thalamic core-matrix map[6] and intrathalamic qT1 values as a proxy for myelin, while correcting for spatial autocorrelation (SA) using variograms[7]

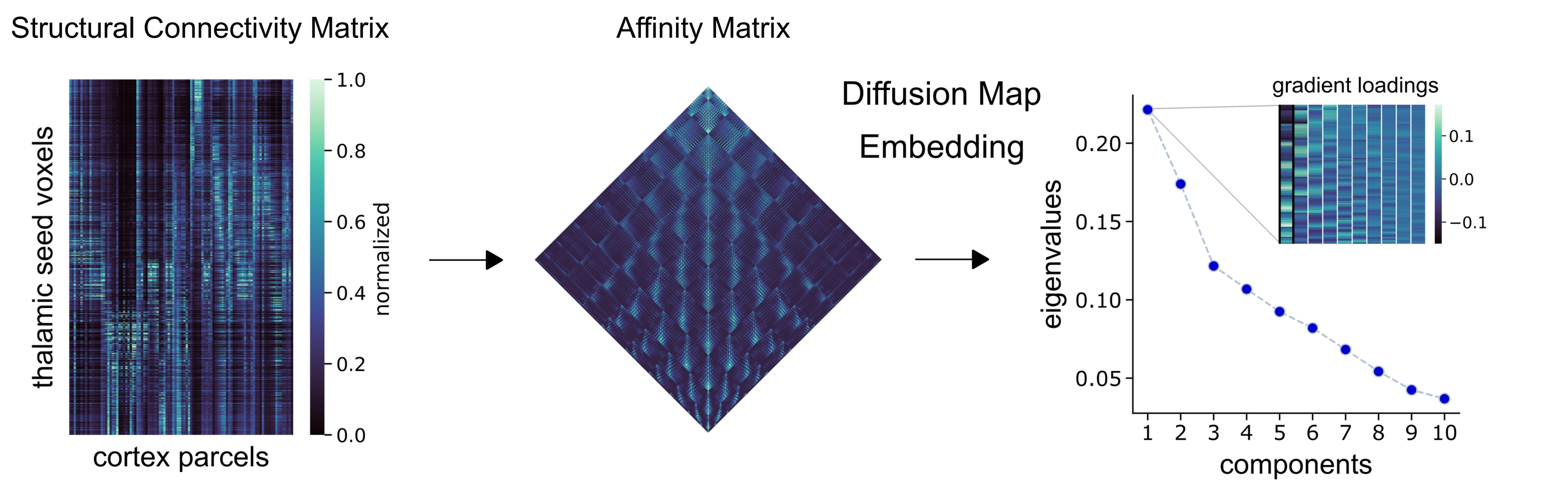
Structural covariance:

- Depth-specific structural covariance matrices were generated by correlating thalamic (voxelwise) and cortical (parcelwise; per parcel 12 compartments perpendicular to cortical surface) qT1 measures across subjects
- The correlation between gradient loadings and structural covariance was analyzed using the cross-depth average and according to variations observed between compartments

Results

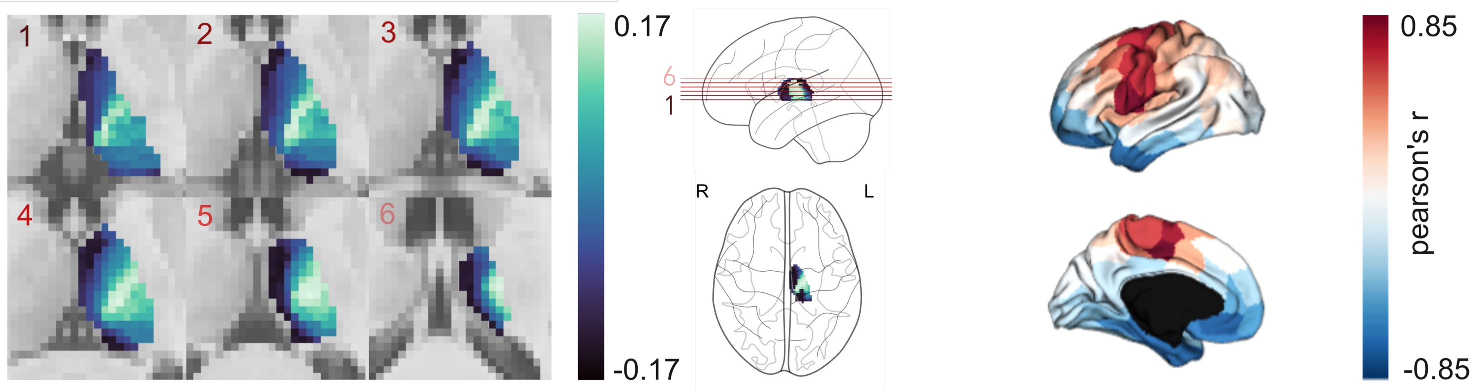
Thalamocortical Structural Connectivity Gradients

Structural Connectivity Matrix and Gradient Computation

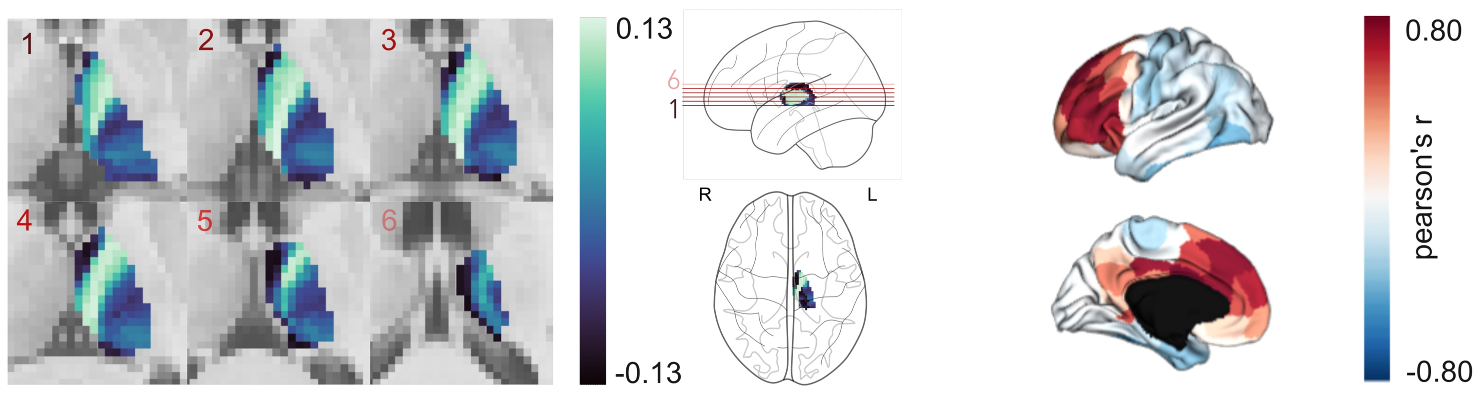


G1: medial to lateral-central axis; projected on cortex: paralimbic to somatosensory axis
G2: medial-anterior and medial-posterior to intersection from anterior-laterally to central-medially; projected on cortex: posterior to anterior axis

Principal Thalamic Axis (G1)

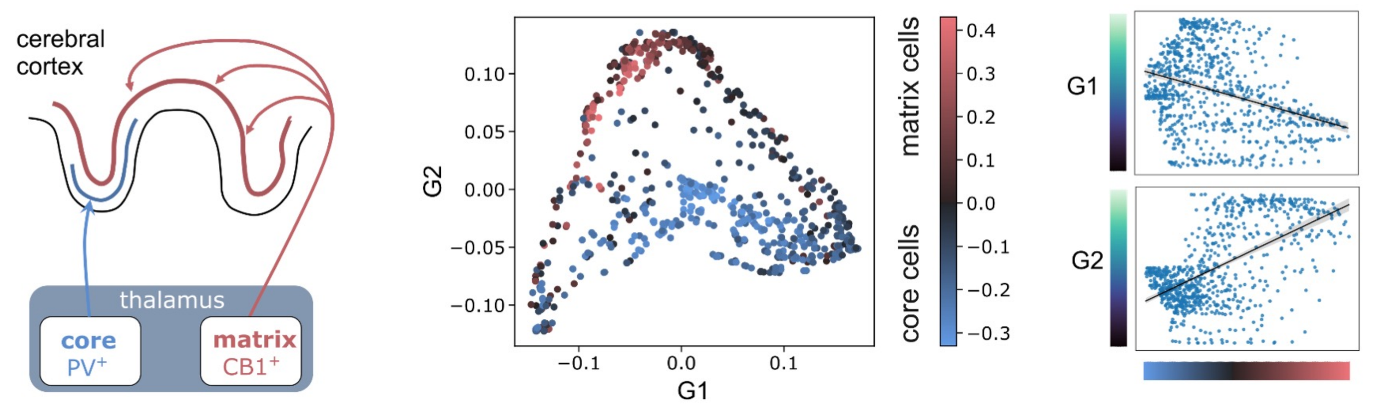


Secondary Thalamic Axis (G2)



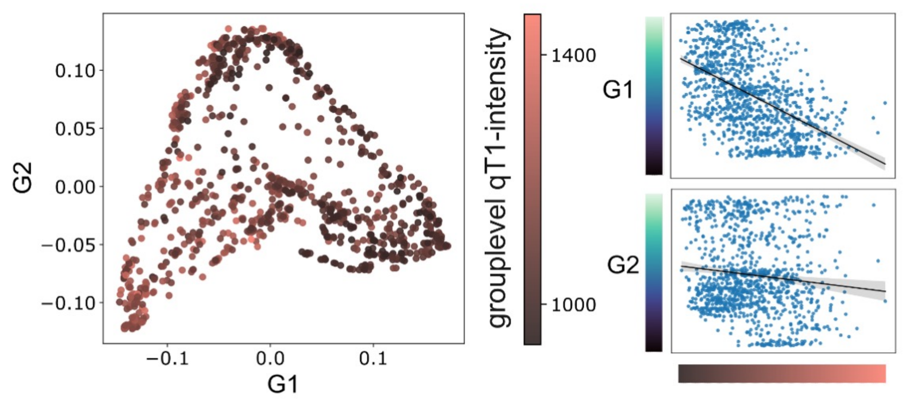
Link to Intrathalamic Microstructural Features

Core-Matrix Cell Distribution



Correlation between G2 and core-matrix cell distribution in the left thalamus (Pearson's r=0.57, p_{SA}=0.03)

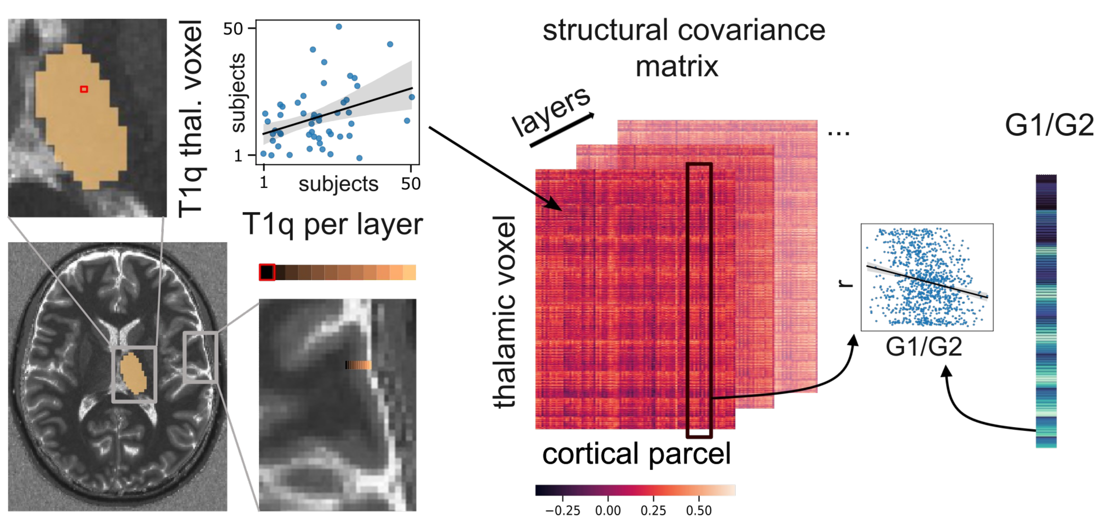
Thalamic Grouplevel qT1-Intensity



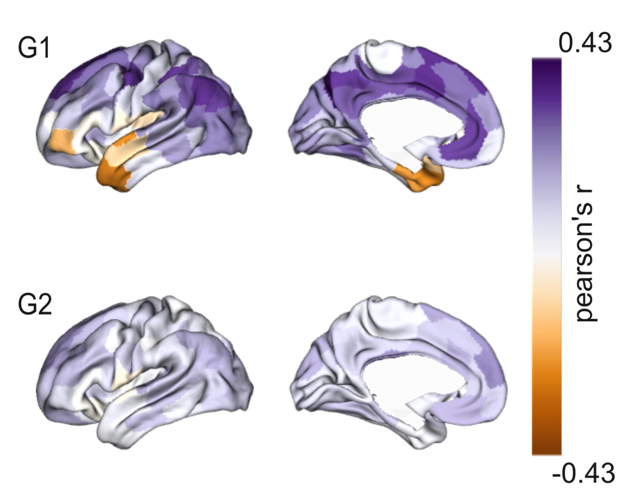
Correlation between G1 and intrathalamic qT1-intensity (L: r=-0.49, p_{SA}=0.026; R: r=-0.54, p_{SA}=0.008)

Link to Thalamocortical Structural Covariance

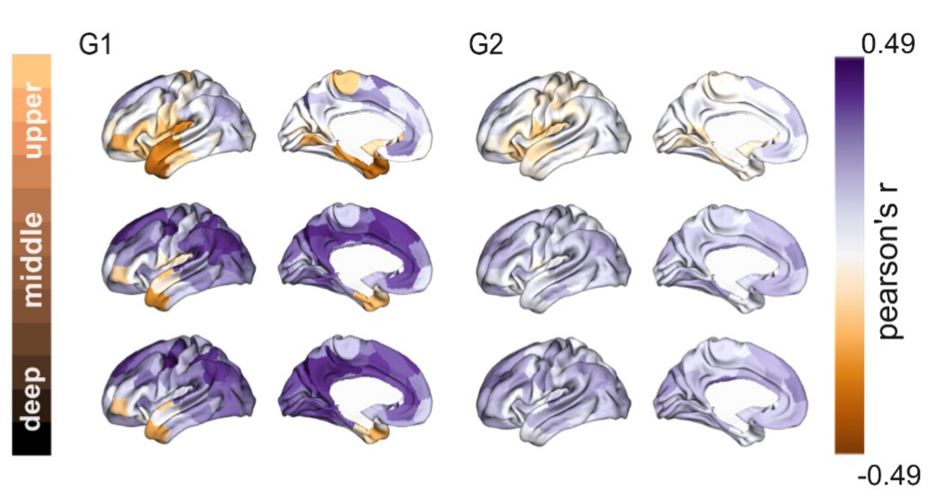
Structural Covariance Computation



Cross-Depth Average



Depth-Specifity



The association between G1 and thalamocortical structural covariance varied across cortical depths

Conclusion

- Consistent with previous research[8], we characterized variations of thalamocortical connectivity patterns across the thalamus and showed its links to intrathalamic microstructural and cellular variations
- Further, extending on research in mice[9], we demonstrated that thalamocortical microstructural covariance adheres to structural connectivity profiles in a depth-varying manner

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