Supervoxel parcellation of visual cortex connectivity

Christopher Baldassano[1], Diane M. Beck[2], Li Fei-Fei[1]

[1]Department of Computer Science, Stanford University [2]Psychology Department and Beckman Institute, University of Illinois Urbana-Champaign

Summary

- How is the cortex functionally and structurally organized?
- New tool: High-resolution connectivity matrices
  - Functional measure: Resting-state connectivity
  - Anatomical measure: Diffusion tractography
- How similar are functional and anatomical connectivity?
  - **Result:** Similar at voxel-scale, but depends on cortical location
- What is the spatial structure of these connectivity matrices?
  - Explore using spatially-informed clustering
  - **Result:** Reveals retinotopic and functional organization

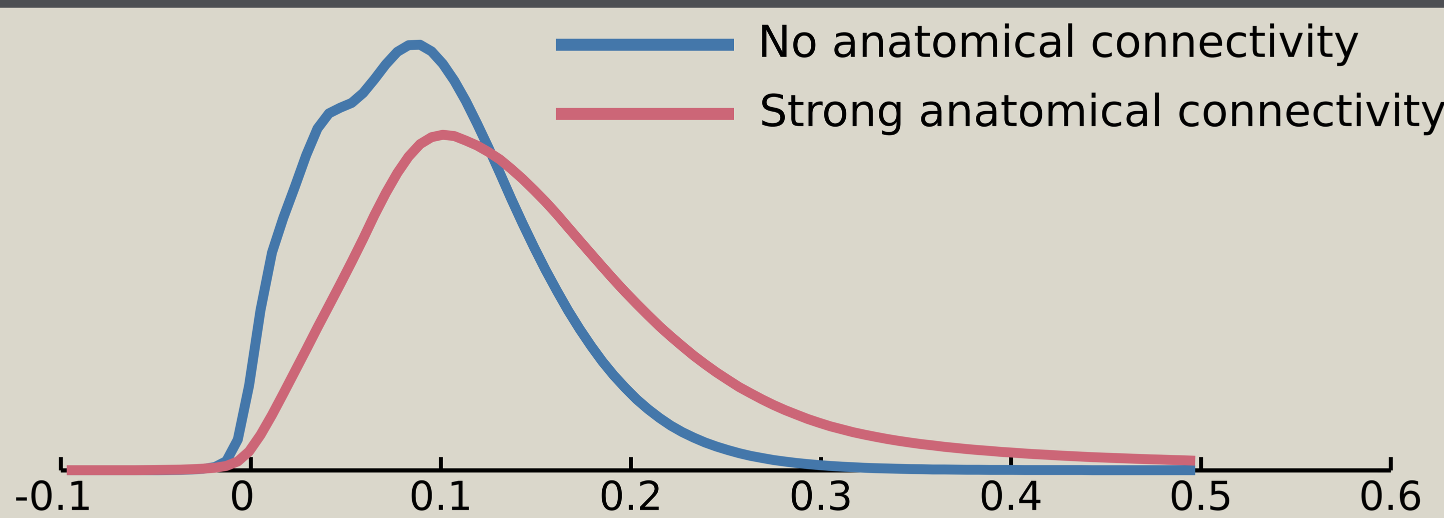
Previous Work

- Whole-brain comparisons of functional and anatomical connectivity are coarse, atlas-dependent[1;2;3;4]
- Greedy clustering algorithms give only approximate solutions[5;6;7]

Data: Human Connectome Project

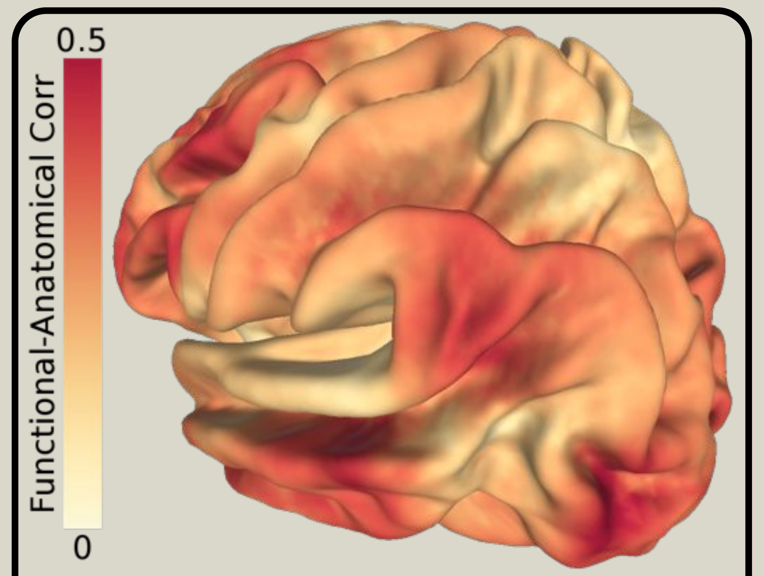
- Resting-state fMRI - 40 subjects (2mm isotropic)
  - Connectivity = correlation between timecourses
- Diffusion Tractography - 10 subjects (1.25mm isotropic)
  - Sampled 33 billion tracts using FSL
  - Connectivity = log number of fibers between voxels

Voxel-level Multimodal Comparison

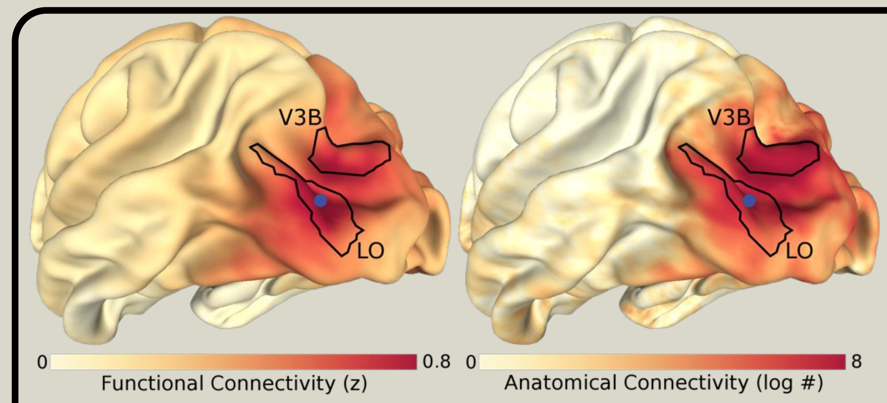


Anatomical connectivity is consistently predictive of functional connectivity for individual voxel pairs (r=0.25)

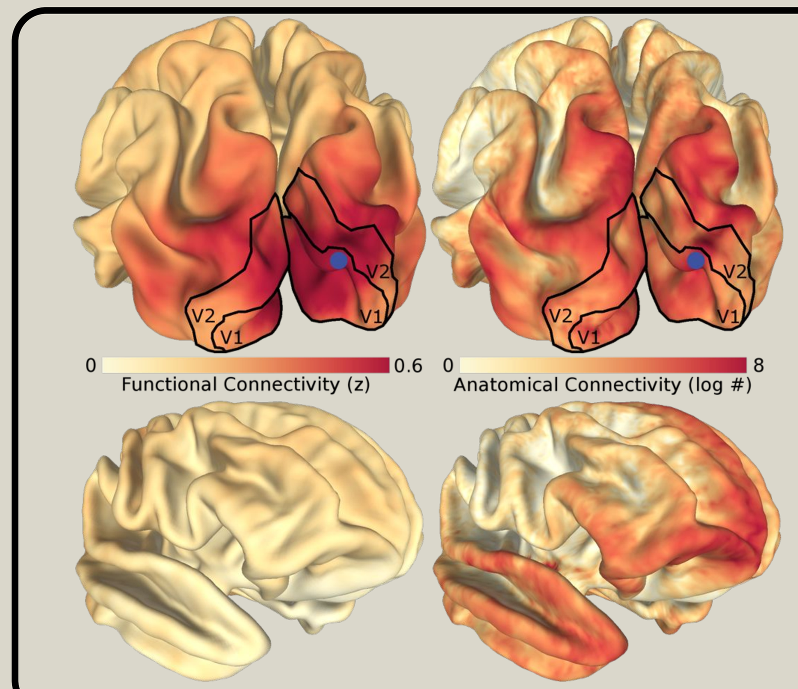
Multimodal Comparisons Across Cortex



Regions of both high and low consistency between functional and anatomical connectivity



Functional and anatomical connectivity maps are very similar in LO (r=0.57), possibly corresponding to the Vertical Occipital Fasciculus

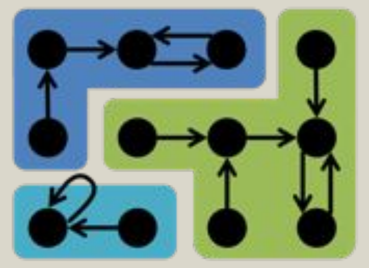


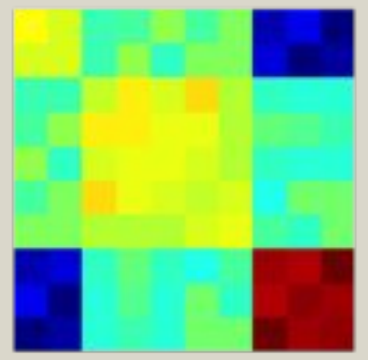
Foveal V1 has similar functional and anatomical connectivity maps in occipital cortex, but tractography reveals additional connections to anterior regions (r=0.42)

Generative Clustering Model

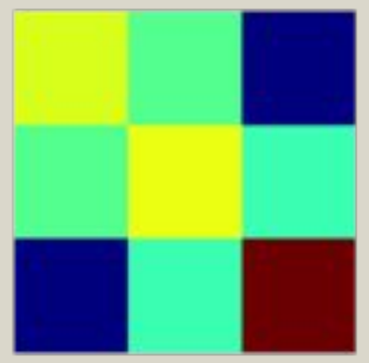
- Produces spatially-contiguous "supervoxels"
- Refines clustering with multiple passes
- Uses data statistics to help set number of clusters

① Each voxel selects a neighbor to cluster with



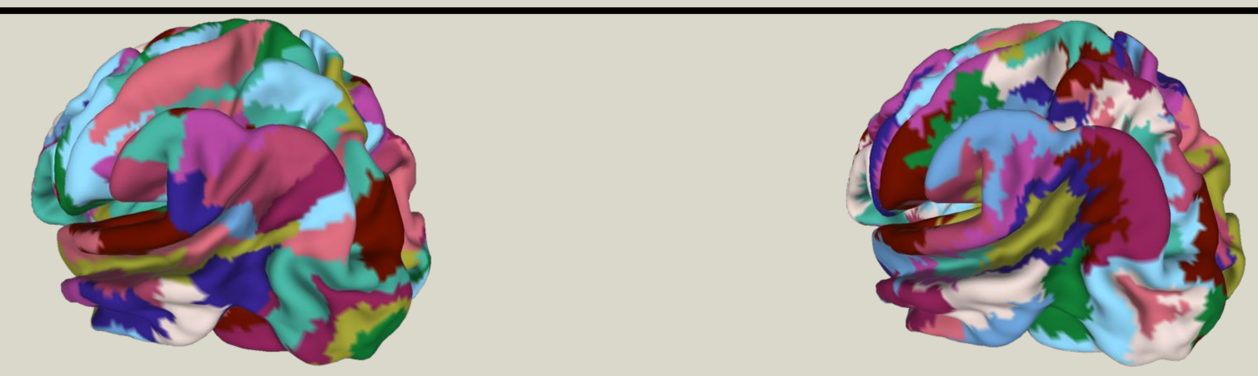


② Latent connectivity between supervoxels

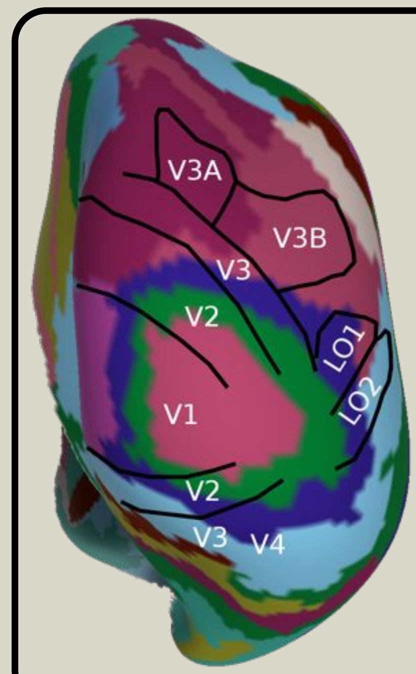


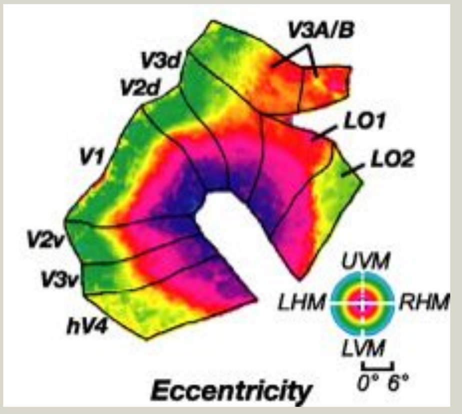
③ Observed connectivity is noisy estimate of supervoxel connectivity

Supervoxel Clustering



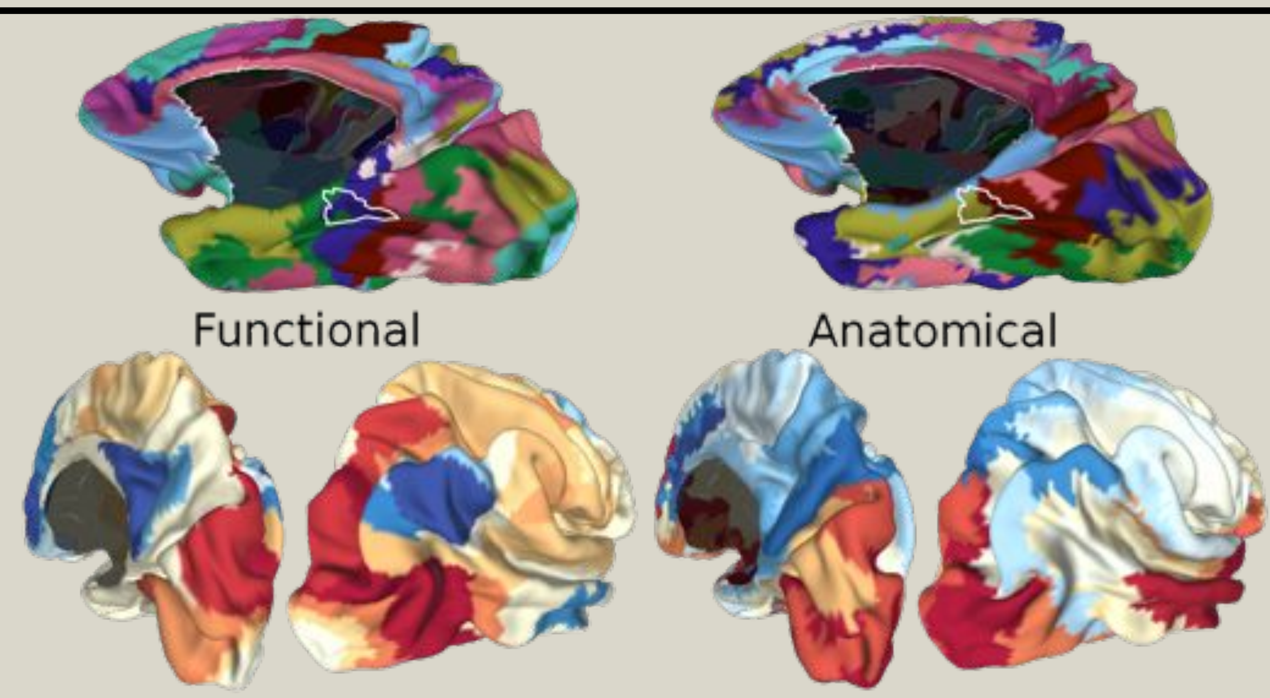
Functional (176 clust) Anatomical (190 clust)





Larsson & Heeger 2006[8]

Functional clusters divide early visual areas into eccentricity rings, and separate dorsal regions V3A/B from lateral regions LO1/2 and ventral V3/V4



The Parahippocampal Place Area (white outline) overlaps multiple functional and anatomical clusters, connected to different regions (posterior=red, anterior=blue)

Funding and References

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