Organization of temporal dynamics among hippocampal subfields as measured by single voxel autocorrelation in humans

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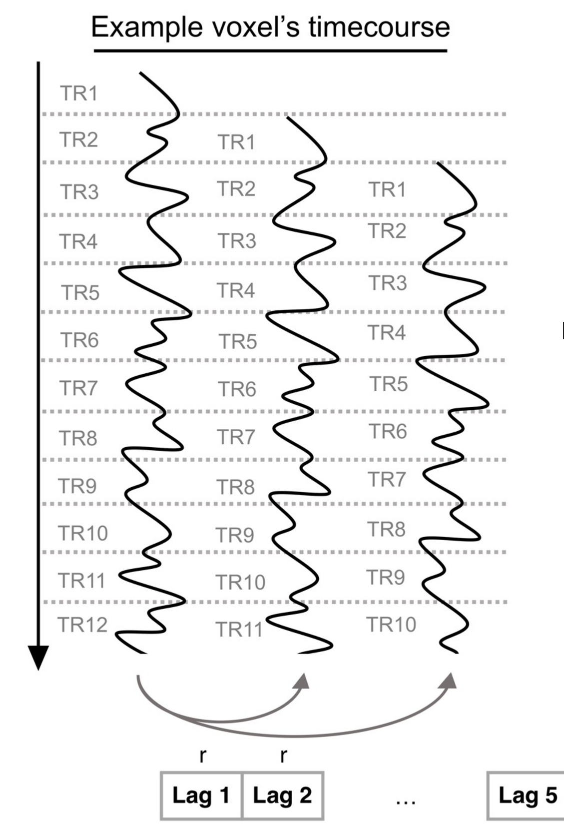
Introduction

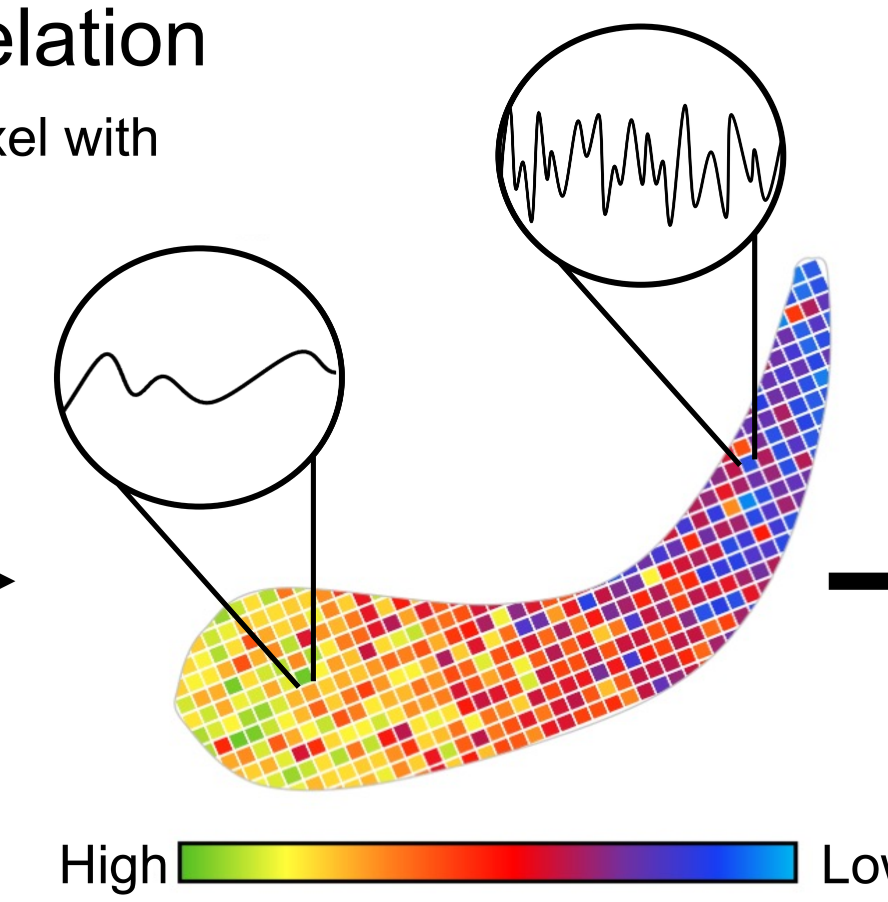
- The hippocampus can be segmented into subfields based on neuroanatomy
- Each subfield has been associated with distinct functional roles in hypothesized models of hippocampal contributions to cognition and memory[1,2,3]
  - Subiculum and CA1 are involved in integrating information and **pattern completion**
  - CA2/3 and CA4/DG are involved in creating distinct representations of information and **pattern separation**
- Recently, we developed a method that measures the signal dynamics of individual voxels[4]
- Can we relate functional roles of subfields to the signal dynamics of individual voxels (slow changing vs fast changing) throughout the hippocampus?

Single voxel autocorrelation method

Single Voxel Autocorrelation

- Correlated the timecourse of each voxel with lagged versions of itself





- Revealed gradient of autocorrelation throughout the anterior-medial to posterior-lateral hippocampus

Autocorrelation Clusters

- Data-driven driven clustering of individual voxels results in three hippocampal clusters

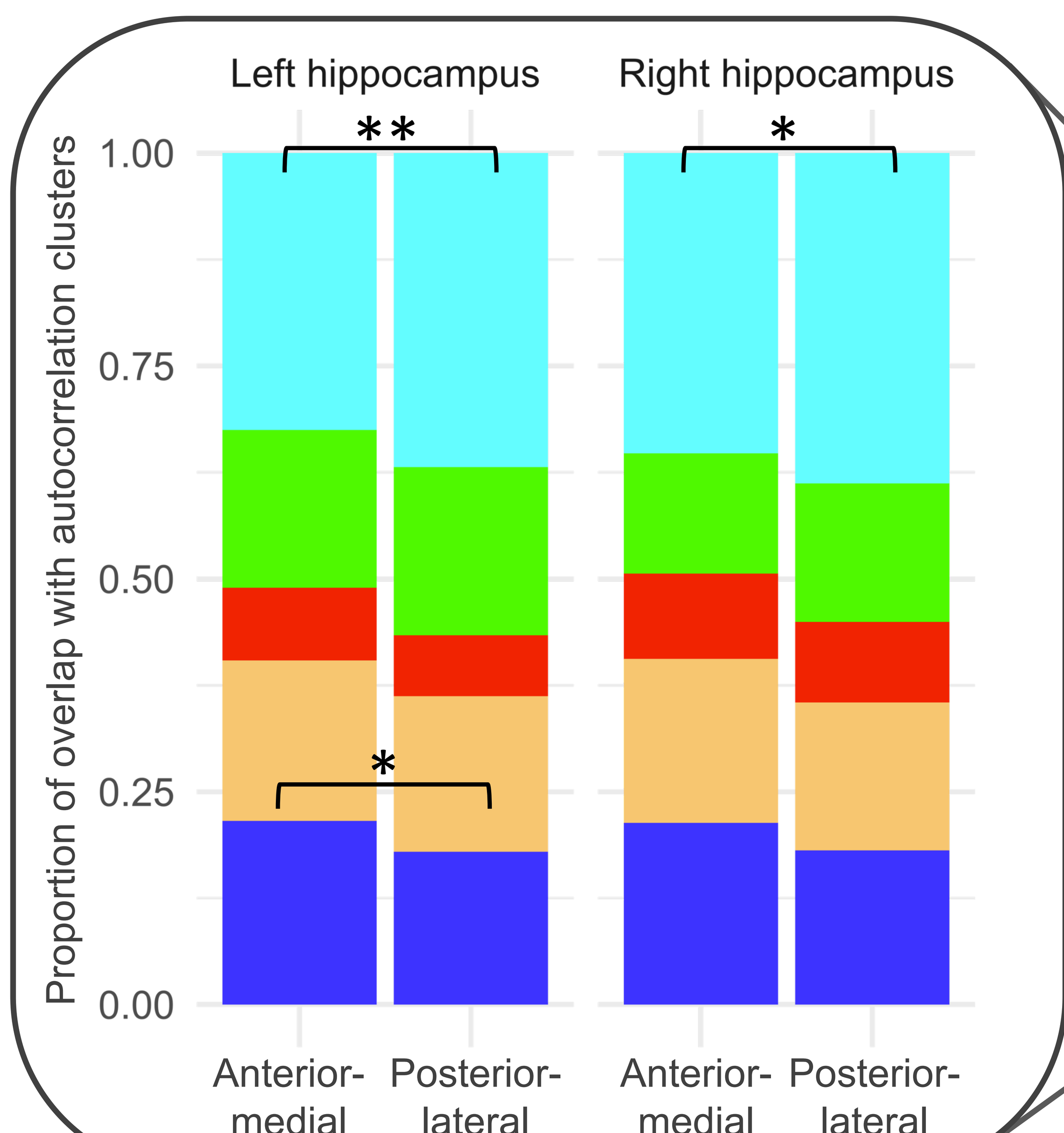
High — Anterior-medial Cluster
Intermediate Cluster
Low — Posterior-lateral Cluster

Overlap between subfields and autocorrelation clusters

- Left **subiculum** has more overlap with anterior-medial cluster than posterior-lateral autocorrelation cluster
- Bilateral **CA1** has more overlap with the posterior-lateral cluster than the anterior-medial autocorrelation cluster

subiculum
CA1
CA2/3
CA4/DG
SRLM

*p < 0.05, **p < 0.01

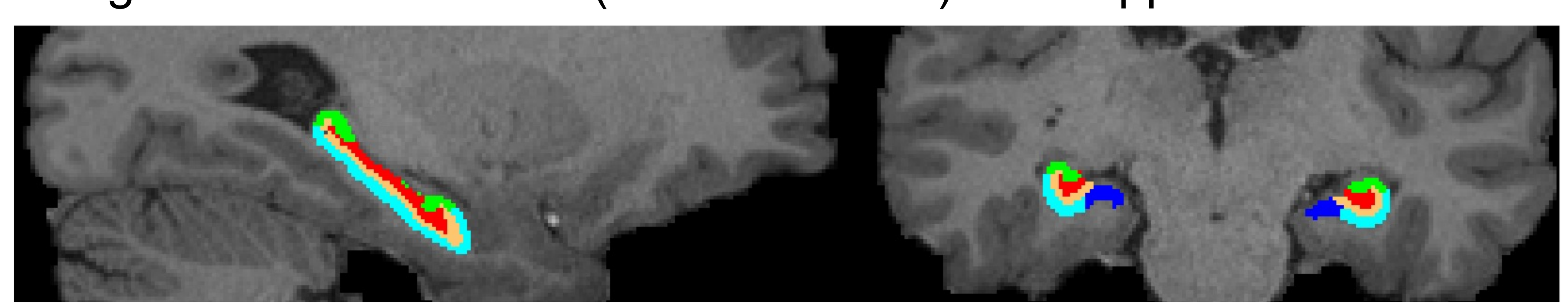


Human Connectome Project Dataset + HippUnfold Automated Hippocampal Segmentation

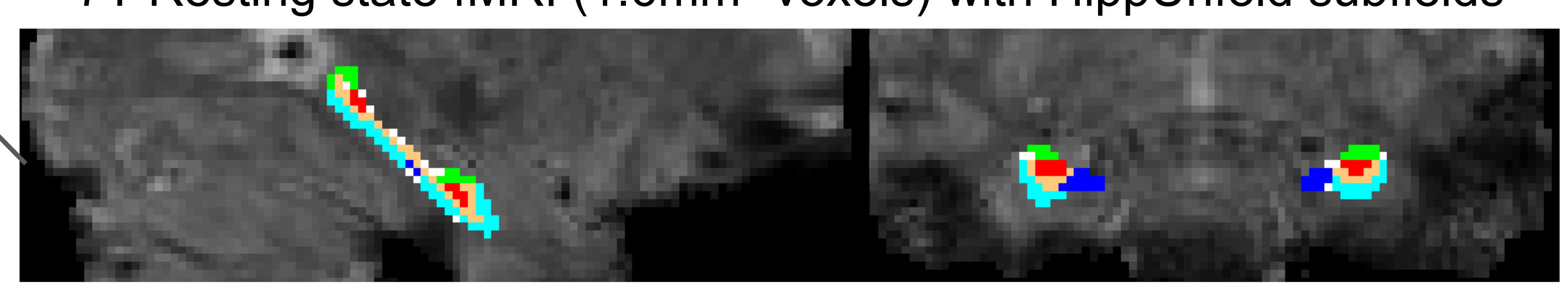
- 25 participants from HCP Database
- 7T Resting state fMRI scan
- 16 min scan, 1000ms TR
- Applied HippUnfold automated segmentation[5] in each participant's T1w native space
- Registered subfield masks to functional space

Example Participant

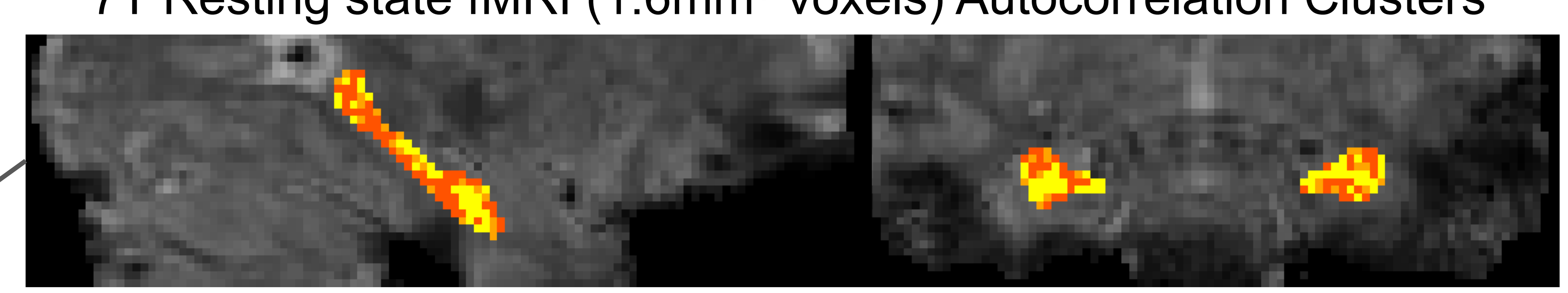
High-res T1w structural (0.7mm^3 voxels) with HippUnfold subfields



7T Resting state fMRI (1.6mm^3 voxels) with HippUnfold subfields

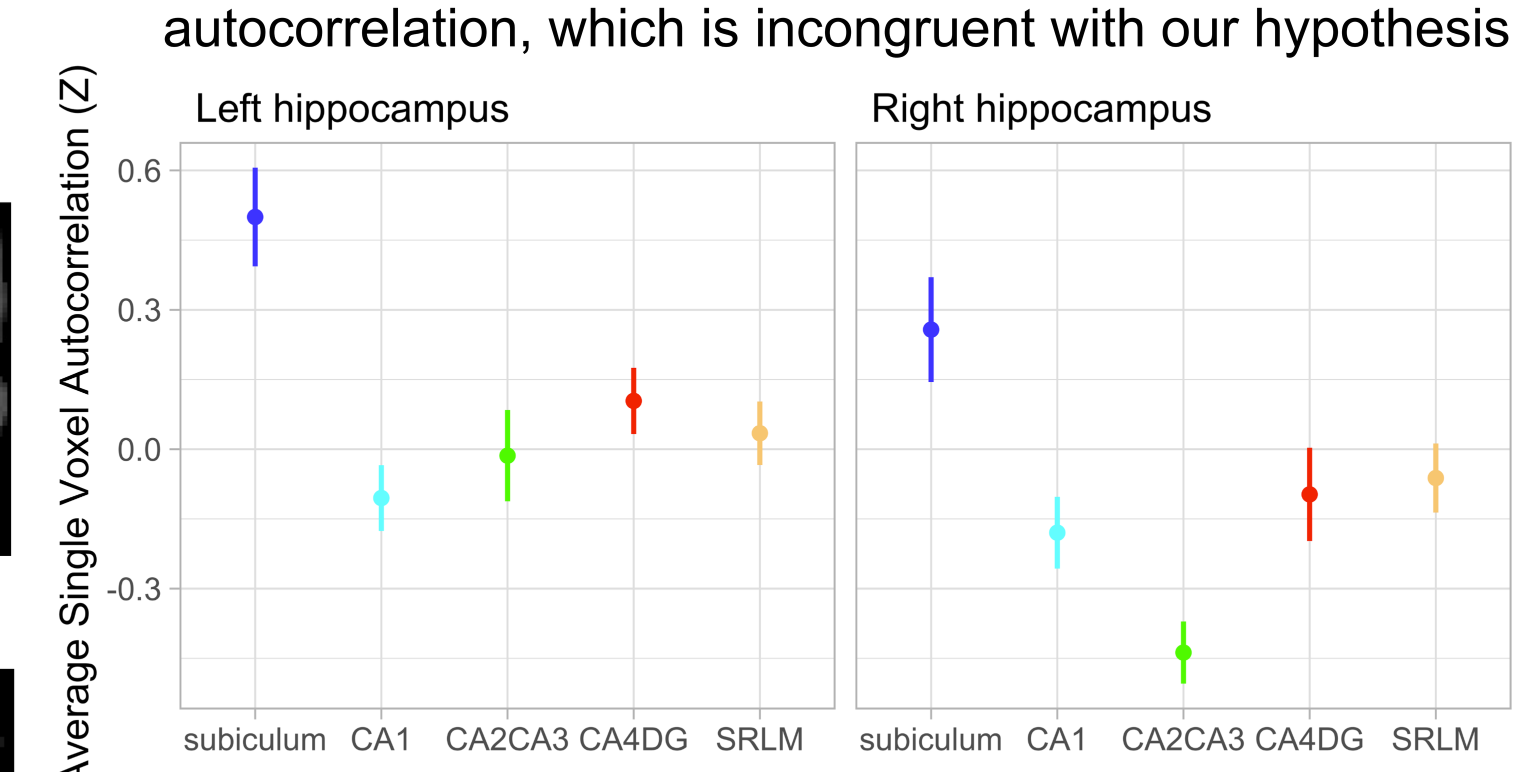


7T Resting state fMRI (1.6mm^3 voxels) Autocorrelation Clusters



Average single voxel autocorrelation per subfield

- Bilateral **subiculum** had high autocorrelation
- Right **CA2/3** had low autocorrelation
- **CA1** had low autocorrelation and **CA4/DG** had high autocorrelation, which is incongruent with our hypothesis



Take home points

- Relating the signal dynamics of individual voxels to the functional roles of subfields is not a straightforward story
- Subiculum is represented more in the anterior-medial hippocampus and is associated with high autocorrelation, which might be important for integration
- CA1 might have different signal dynamics throughout the long axis, therefore its contributions to integration vs. pattern separation might differ from posterior CA1 to anterior CA1, consistent with evidence of different structure and functional connectivity between anterior and posterior CA1[2,6,7]

References

1-Schapiro, et al., *PTRS:BioSci*, 2017; **2**-Libby et al., *JNeuro,* 2012; **3**-Lacy & Stark, *Hippocampus,* 2012; **4**-Bouffard, Golestani et al., *Cortex*, 2022; **5**-DeKraker et al., *eLife*, 2022; **6**-Suthana et al., *JCogNeuro*, 2015; **7**-Fanselow & Dong, *Neuron*, 2010