



The Hutchinson Lab
of Cognitive Neuroscience

Characterizing External and Internal Attention: Functional Connectivity Reveals Multiple Interacting Processing Streams

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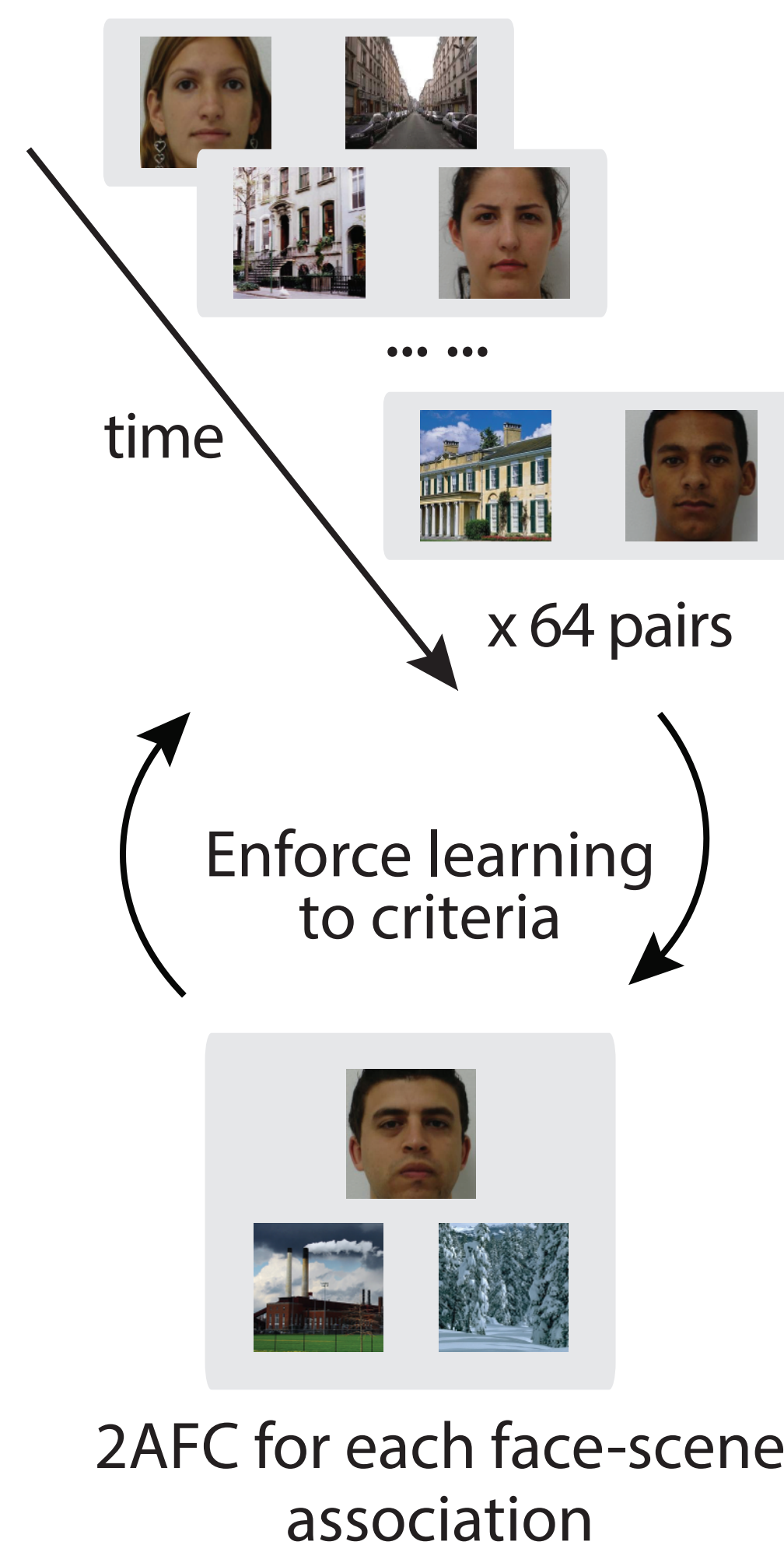
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Introduction

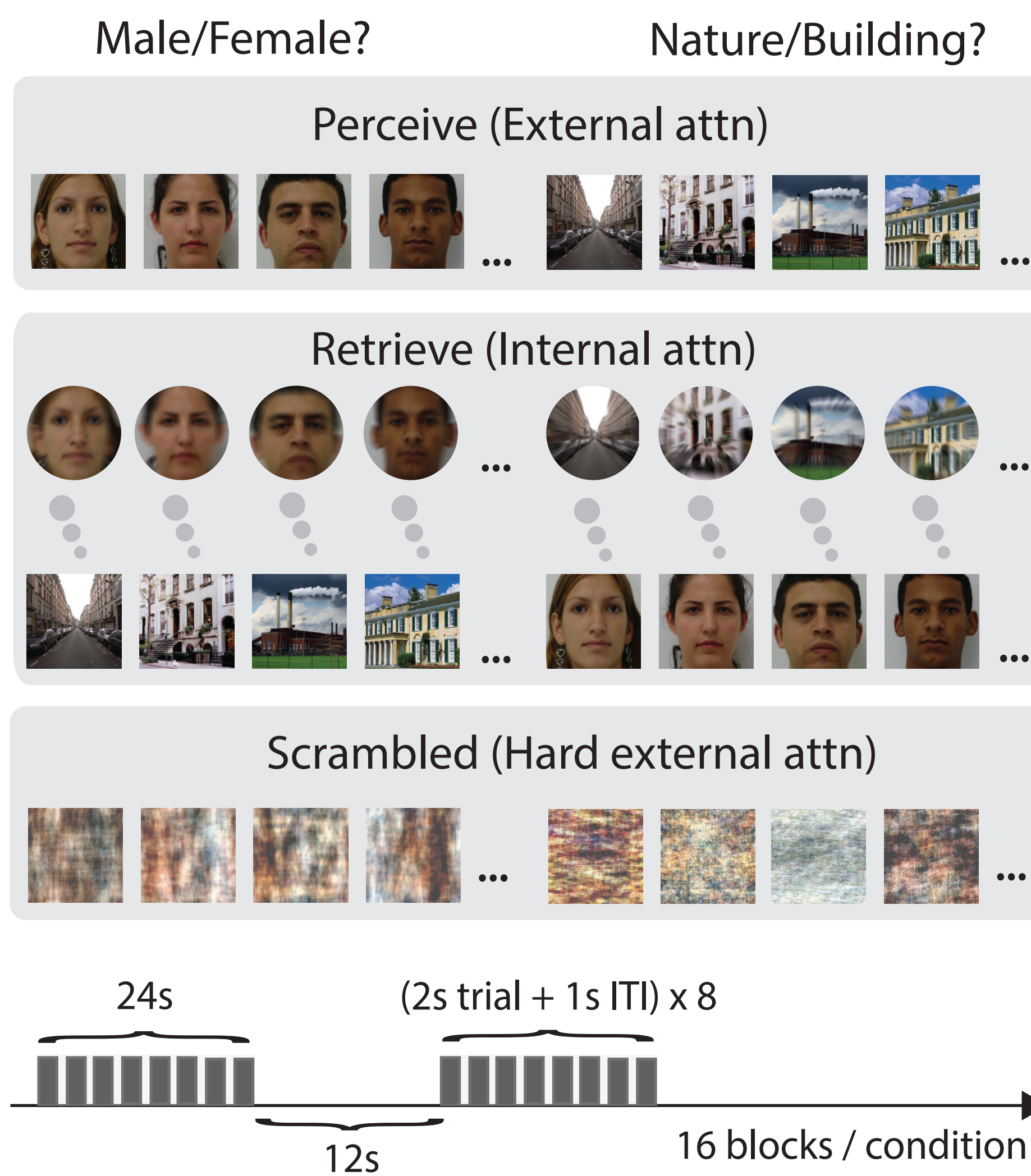
- Attention can be organized based on the source of the information being attended to¹:
 - **External Attention:** Selection of perceptual features available in the environment (e.g., during perceptual judgments).
 - **Internal Attention:** Selection of self-generated features available from internal representations (e.g., during episodic remembering).
- Background functional connectivity (FC) captures neural dynamics of selective attention between different types of perceptual features².
- How do neural dynamics of attention differ between external and internal attentional states?

Task paradigm (N = 24)

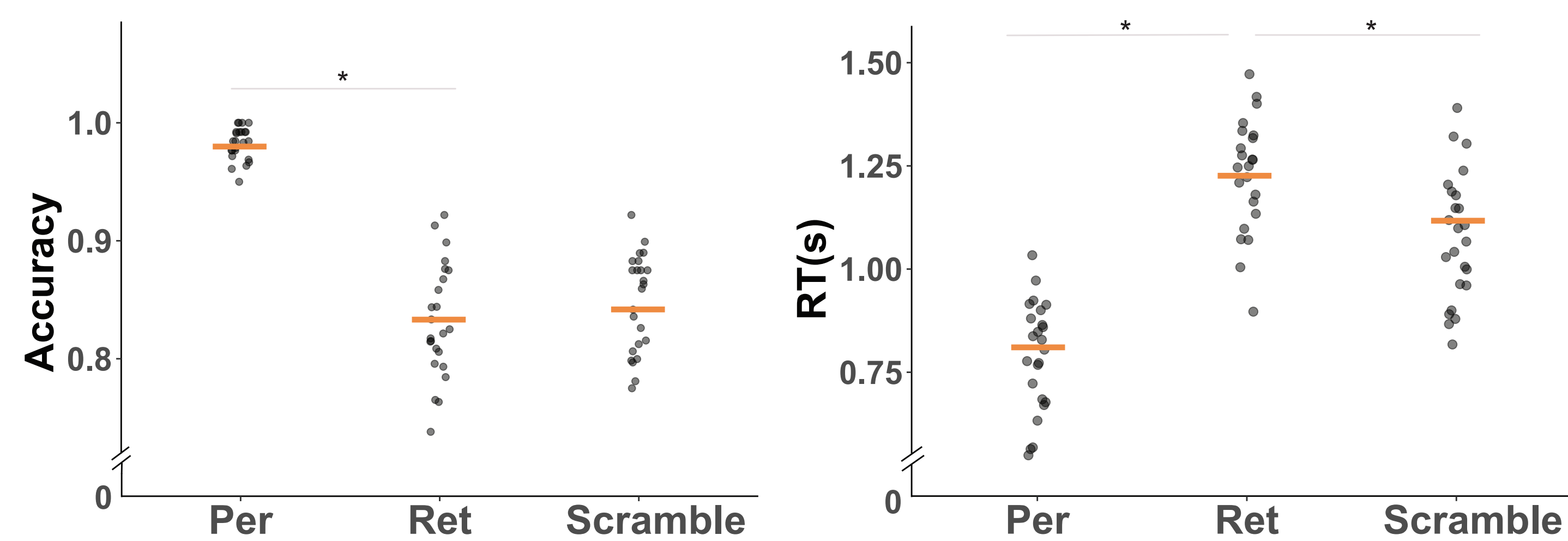
Behavioral Training:



fMRI Task:

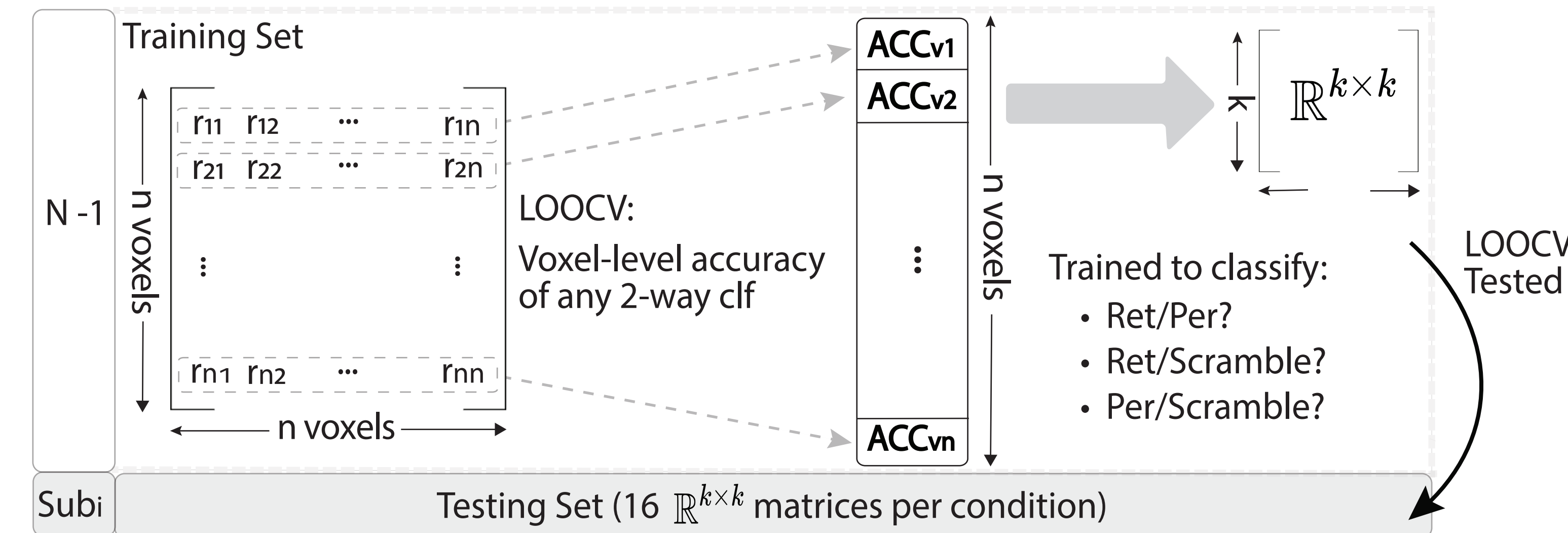


Behavioral Performance:



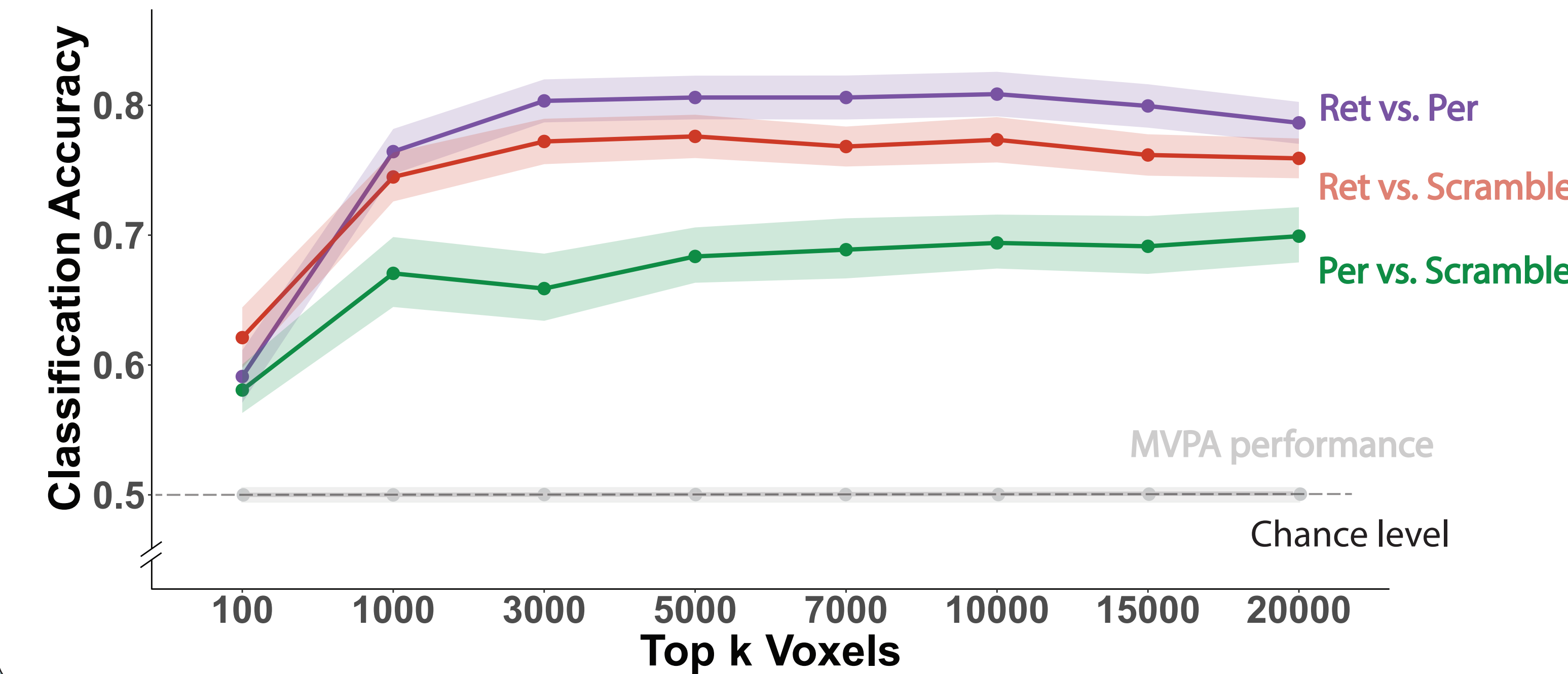
Do background FC patterns differ?

Full Correlation Matrix: whole brain functional connectivity pattern³



FCMA: Functional connectivity patterns of external attention (i.e., Perceive and Scramble) differ from those of internal attention (i.e., Retrieve)⁴.

- Not caused purely by difference in task difficulties.
- Not induced by difference in pattern of activation (background FC).

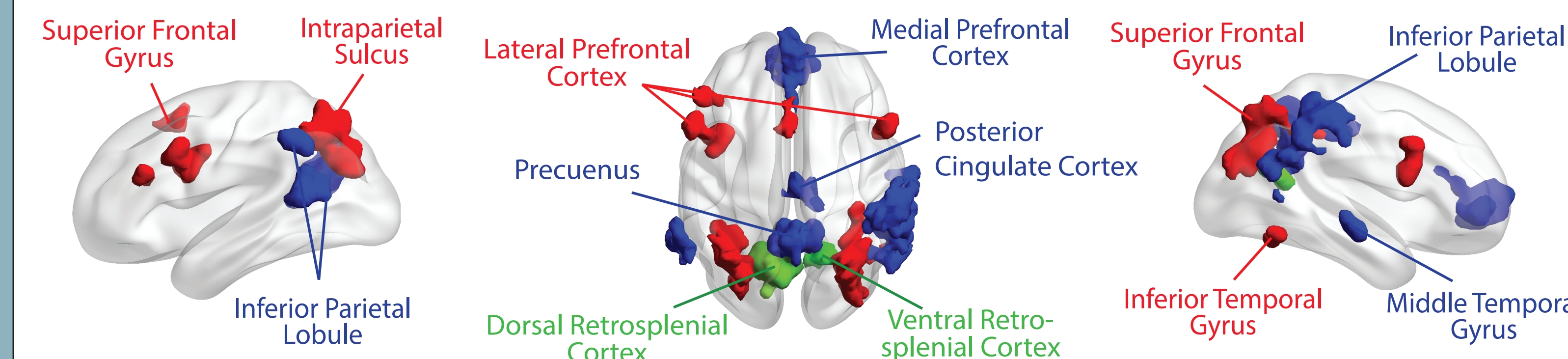


Where is the difference?

Combine FCMA feature selection with permutation test⁴:

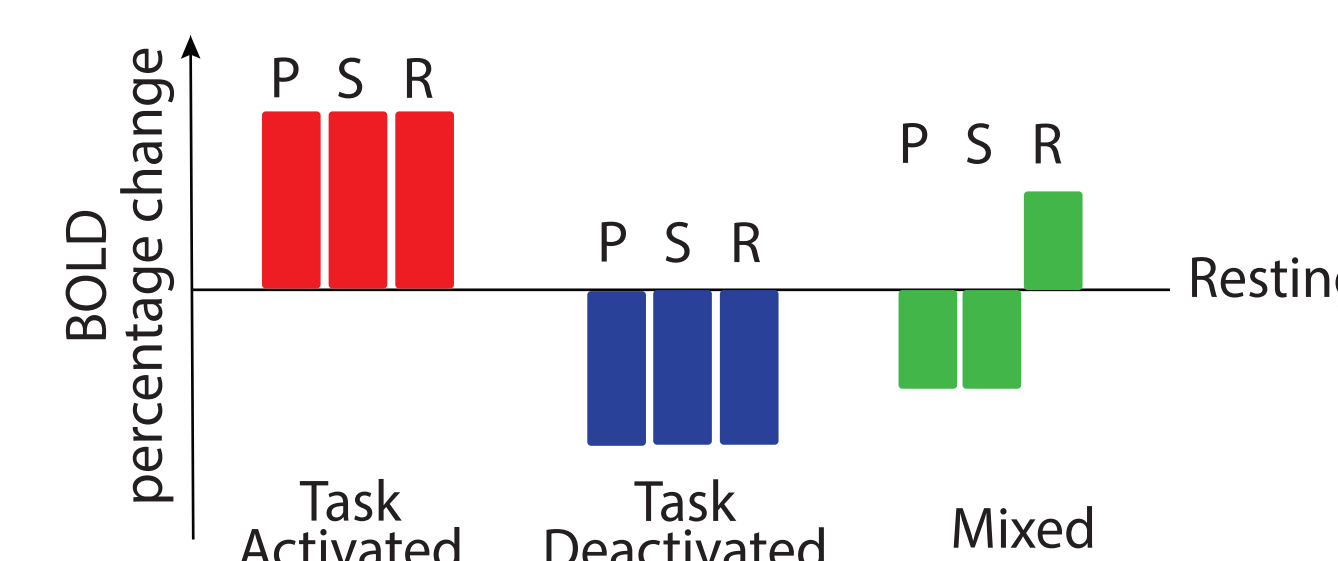
- Identify and cluster voxels whose background functional connectivity patterns can differentiate Retrieve vs. Perceive and Retrieve vs. Scramble.

16 Clusters identified based on background FC:



3 Functional communities:

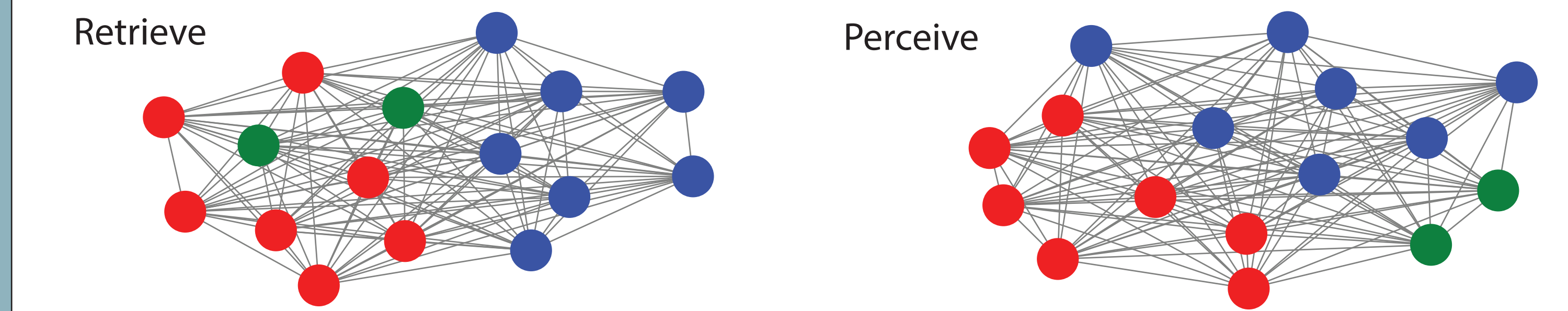
- Univariate evoked response:
 - Task-Activated community
 - Task-Deactivated community
 - Task-Mixed community (Retrosplenial cortex)



What is the difference?

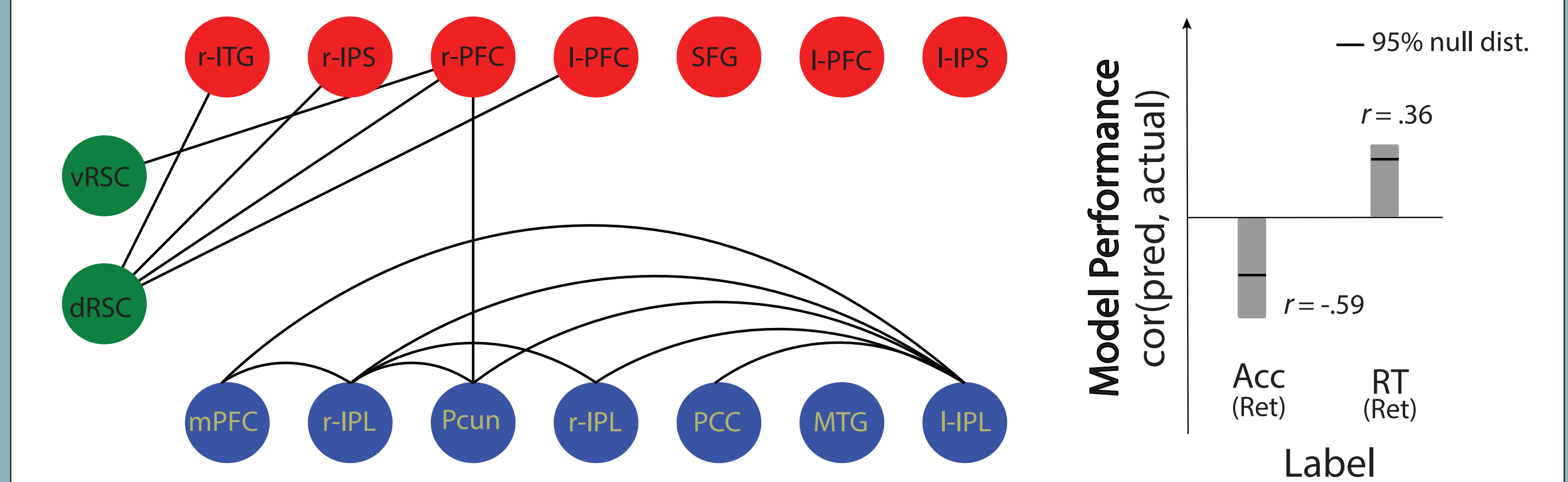
Difference in functional community organization:

- Force-directed graph drawing shows **RSC nodes** changed relative positions with respect to the other two communities in Perceive compared to Retrieve task.



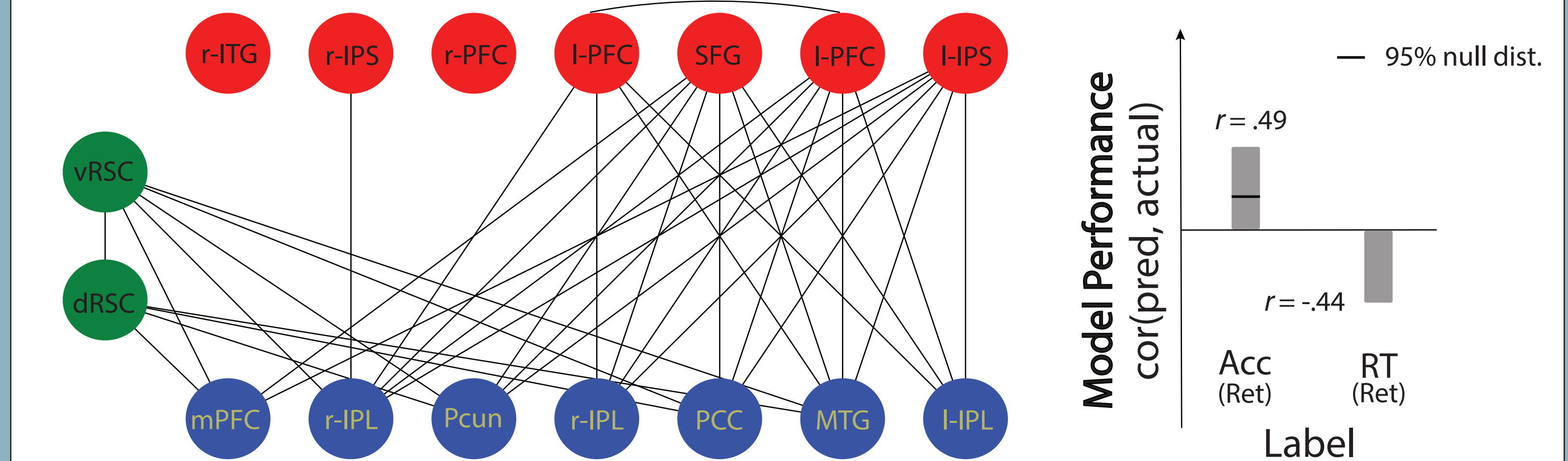
Edge level differences: Retrieve > Perceive (p < .05)

- Stronger connections **between RSC** and **task-activated** nodes & **within the task-deactivated** nodes.
- Strength of these connections during Retrieval predicts retrieve RT, but not retrieve accuracy.



Edge level differences: Perceive > Retrieve (p < .05)

- Stronger connections **between RSC** and **task-deactivated** regions & **between the task-deactivated** and **task-activated** regions.
- The strength of these connections during Retrieval predicts retrieve accuracy, but not retrieve RT.



Discussion

- External and internal attentional states could be classified across subjects using background functional connectivity patterns.
- Data-driven approach revealed 3 distinct functional communities, whose functional connectivity patterns characterize external and internal attention.
- Retrosplenial cortex showed flexible coupling with task-activated and de-activated regions, consistent with past work suggesting its role in integrating external and internal information^{4,5}.

References

1. Chun et al. (2011) *Annu. Rev. Psychol.*
2. Al-Aidroos et al. (2012) *PNAS*
3. Turk-Browne (2013) *Science*
4. Wang et al. (2015) *J. Neurosci. Method*
5. Yeshurun et al. (2020) *Nat. Rev. Neurosci.*
5. Ranganath & Ritchey (2012) *Nat. Rev. Neurosci.*