Neural Representations of Rhythm in Association Regions are predicted by Combined Sensory and Beat Representations

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Background

- Rhythms elicit auditory, motor, parietal, and frontal activity.[1]
- SMA and basal ganglia activity represent beat strength more than other rhythmic features (e.g., tempo, number of onsets).[2]
- Auditory cortex represents sensory input, activating in different patterns for different rhythms, regardless of beat.[2]
- The inferior parietal lobe (IPL) and inferior frontal gyrus (IFG) are influenced both by beat strength and by individual rhythms when beat strength is controlled, perhaps reflecting inputs from both bottom-up sensory and top-down beat-processes.

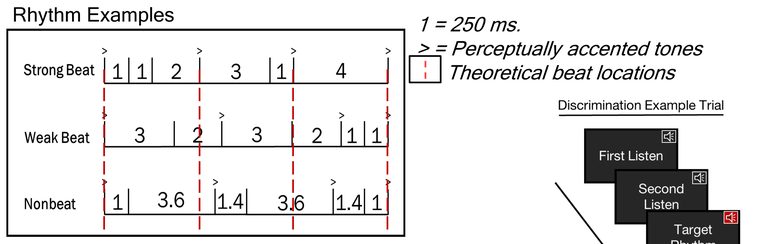
Hypothesis

- If the IPL and IFG integrate both sensory and beat information, then their activity patterns will be best predicted by *both* SMA and auditory cortex patterns.

Method

Stimuli

- 12 filled-tone rhythms: 4 strong-beat; 4 weak-beat; 4 nonbeat.

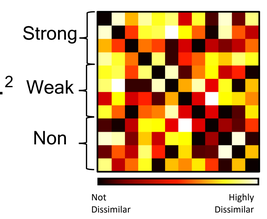


Procedure

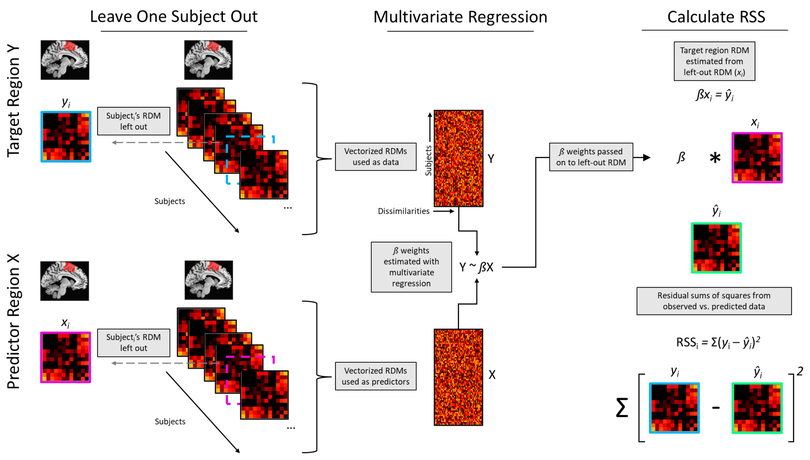
- N = 39, 7T MRI
- Discrimination Task

Neural Representation Matrices

- 12x12 rhythm dissimilarity matrices
- From SMA, HG, IFG, Occipital cortex (control).[2]
- Between-condition dissimilarities > 0
- Cross-referenced with AAL-Parcellation.[3]

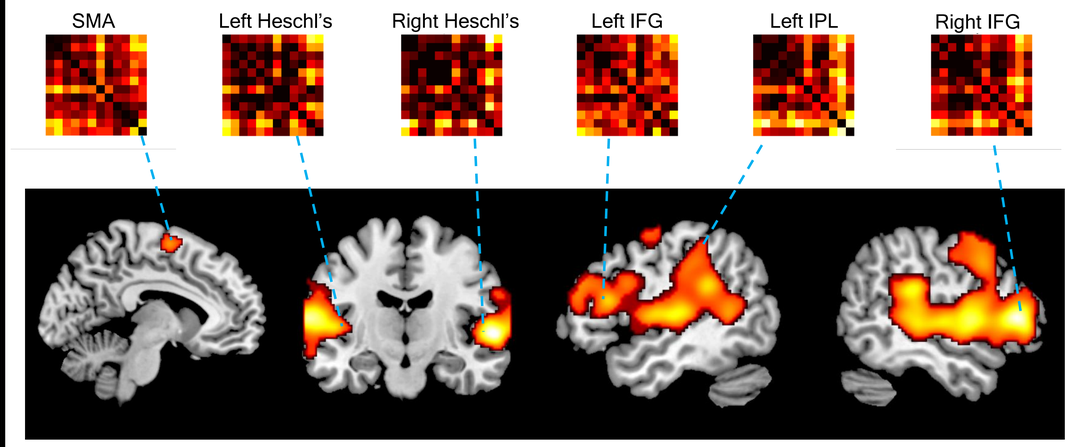


Representational Connectivity

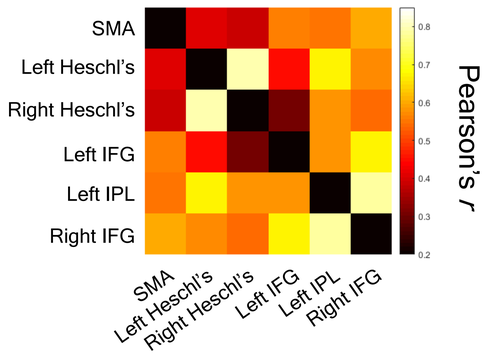


Are neural representations related?

SMA, Auditory cortex, inferior parietal lobe, and inferior frontal gyri encode rhythms via multivoxel patterns.



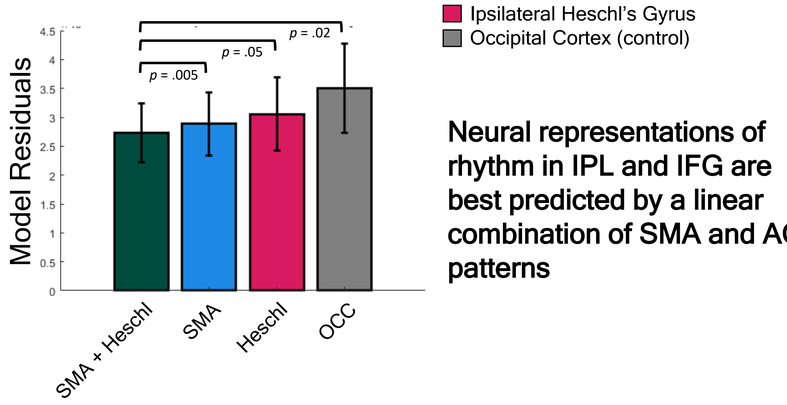
Neural representations in sensory, motor, and association cortices are correlated.



SMA and HG correlate with IPL and IFG, but less so with each other, suggesting independent information contribution to association regions

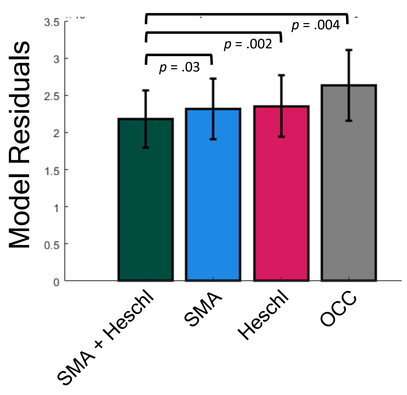
Representational Connectivity Analysis

Left Inferior Parietal Lobe

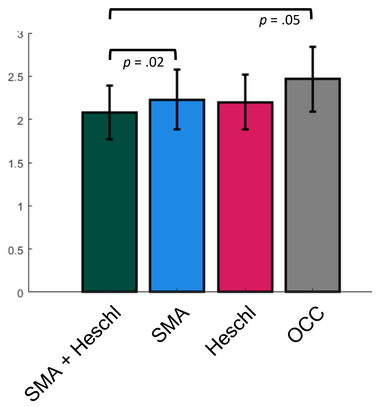


Neural representations of rhythm in IPL and IFG are best predicted by a linear combination of SMA and AC patterns

Left Inferior Frontal Gyrus



Right Inferior Frontal Gyrus



Discussion

Findings

- Representational dissimilarities in the IFG and IPL are best predicted by combined representational dissimilarities from auditory cortex and the SMA.
- This suggests association regions in the dorsal and ventral auditory stream may integrate external auditory information with internal top-down predictions, as predicted by the ASAP hypothesis[4].

Neural representations of rhythm in the IFG and IPL are best predicted by combined SMA and auditory cortex representations.

References

[1]Grahn, J. A., & Brett, M. (2007). Rhythm and beat perception in motor areas of the brain. *Journal of Cognitive Neuroscience, 19*(5), 893-906.
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[3]Rolls, E. T., Huang, C. C., Lin, C. P., Feng, J., & Joliot, M. (2020). Automated anatomical labelling atlas 3. *NeuroImage*, 206.
[4]Patel, A. D., & Iversen, J. R. (2014). The evolutionay neuroscience of musical beat perception: the Action Simulation for Auditory Prediction (ASAP) hypothesis. *Frontiers in Systems Neuroscience,* 8.

Acknowledgements

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