

# Neural Representations of Rhythm and Beat Perception

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## Background

### Introduction

- Humans spontaneously synchronize to the beat in acoustic rhythms.<sup>1</sup>
- Strong-beat rhythms elicit activity in motor brain regions, such as the basal ganglia, supplementary motor area, and premotor cortex.<sup>1</sup>
- Univariate analyses relate *average* activity across a region to beat strength.
- However, multivariate analyses relate *fine-grained spatial patterns of activity* in a region to beat strength.
- Regions may encode or 'tune' to individual rhythms that have a beat by exhibiting a unique spatial pattern of activity across voxels for each rhythm.

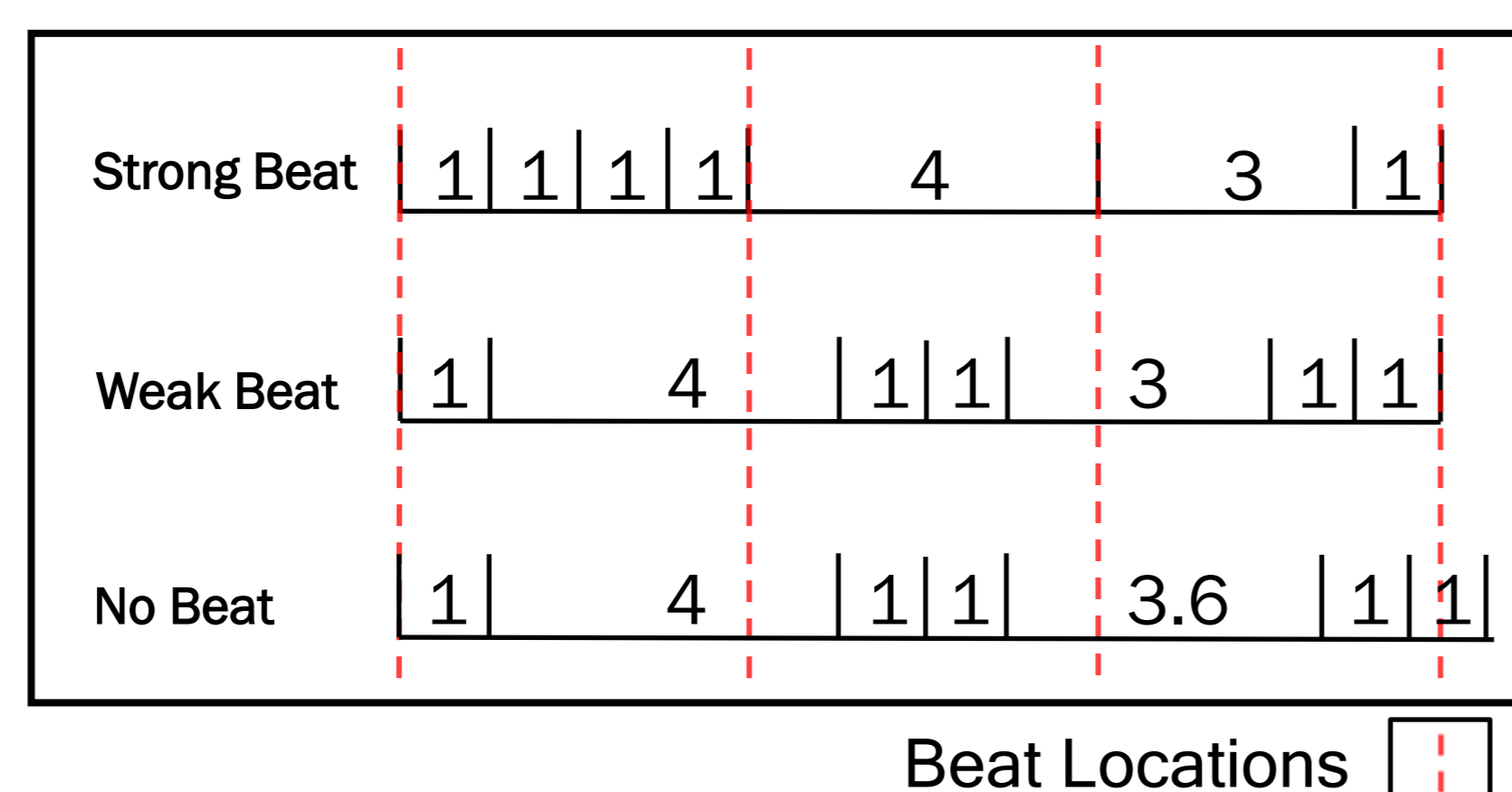
### Hypothesis

- Motor areas may be tuned to strong-beat rhythms. If so, spatial activity patterns will be highly dissimilar between strong-beat rhythms.
- Motor areas may not be tuned to weak- or no-beat rhythms. Therefore, spatial activity patterns will not be dissimilar within these conditions.

## Method

### Stimuli

- 12 filled-tone rhythms
- 4 Strong-beat
- 4 Weak-beat
- 4 No-beat

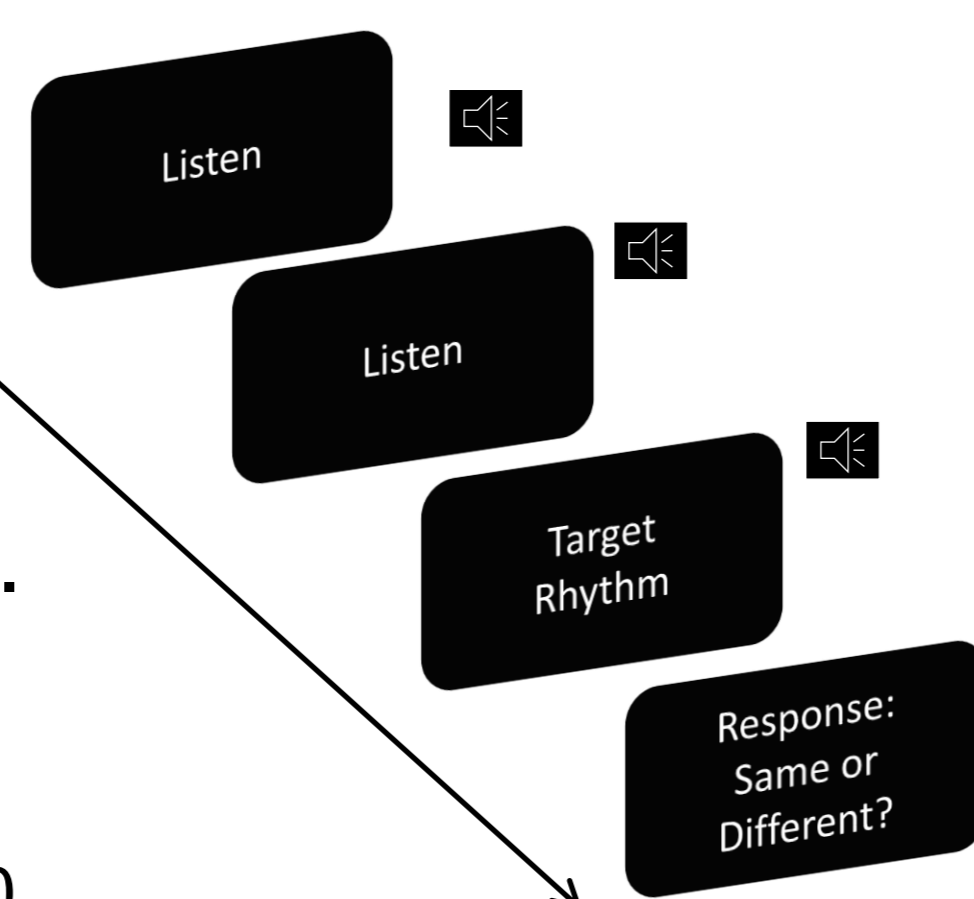


### Procedure

- Rhythm Discrimination Task.
- 8 Blocks of 24 trials each.
- 7T MRI Scanning.
- Analyze activity during 'Listen' stages

### Analysis

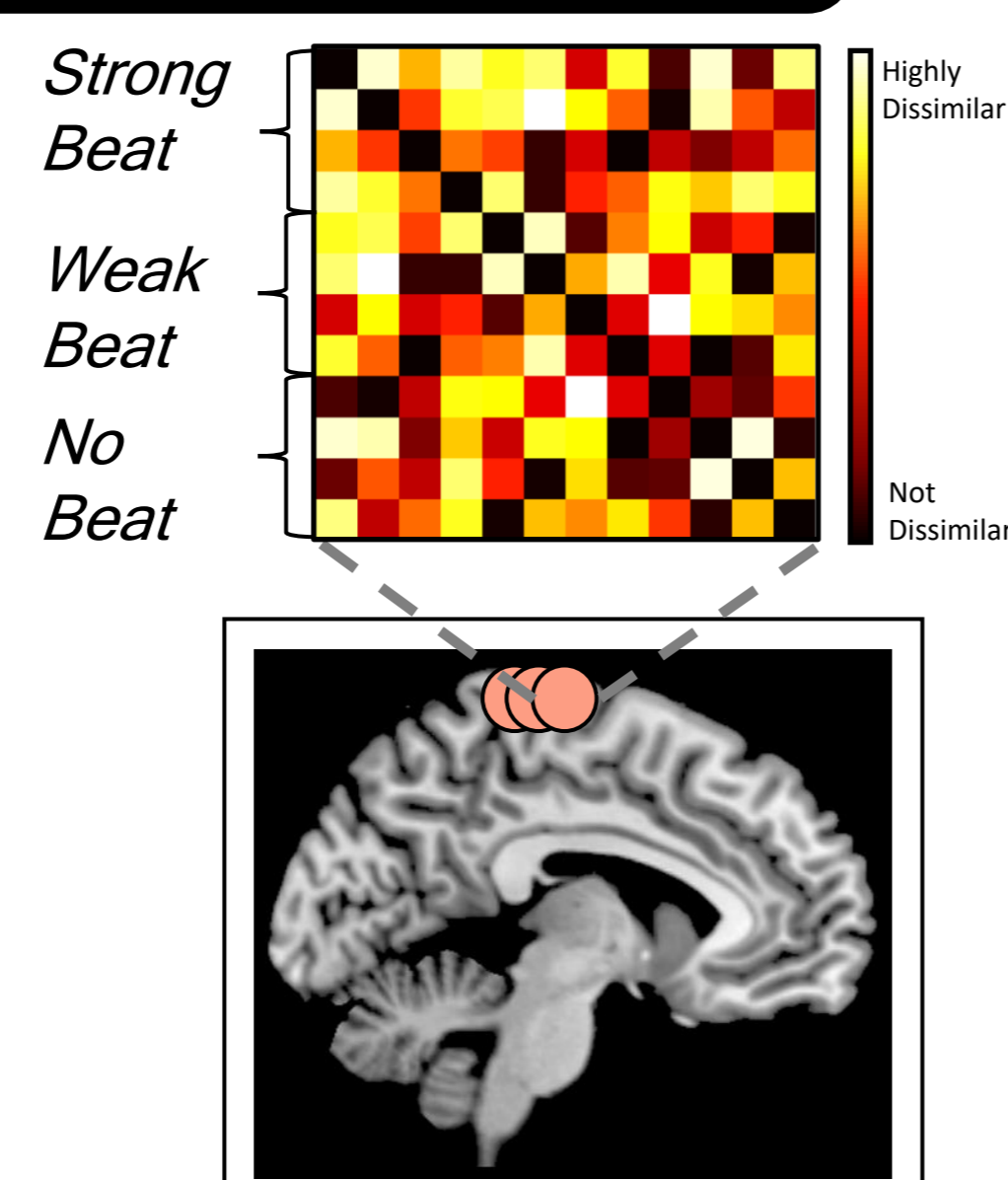
- Representational Similarity Analysis (RSA).
- Crossnobis distance estimator<sup>2</sup>.
  - Larger distances = more dissimilar patterns.
  - Cross-validation allows testing against meaningful 0.



## Whole-Brain Searchlight & RDMs

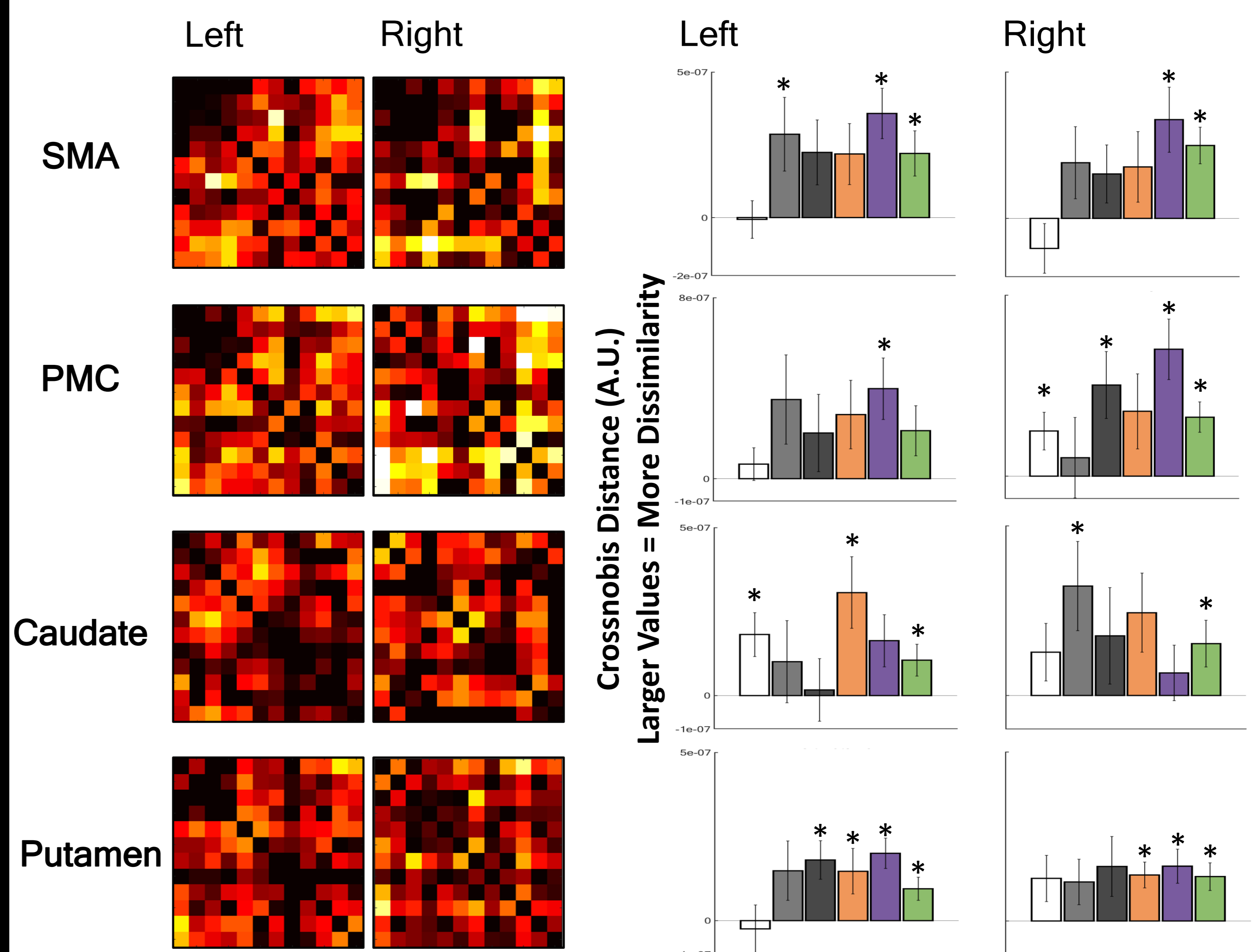
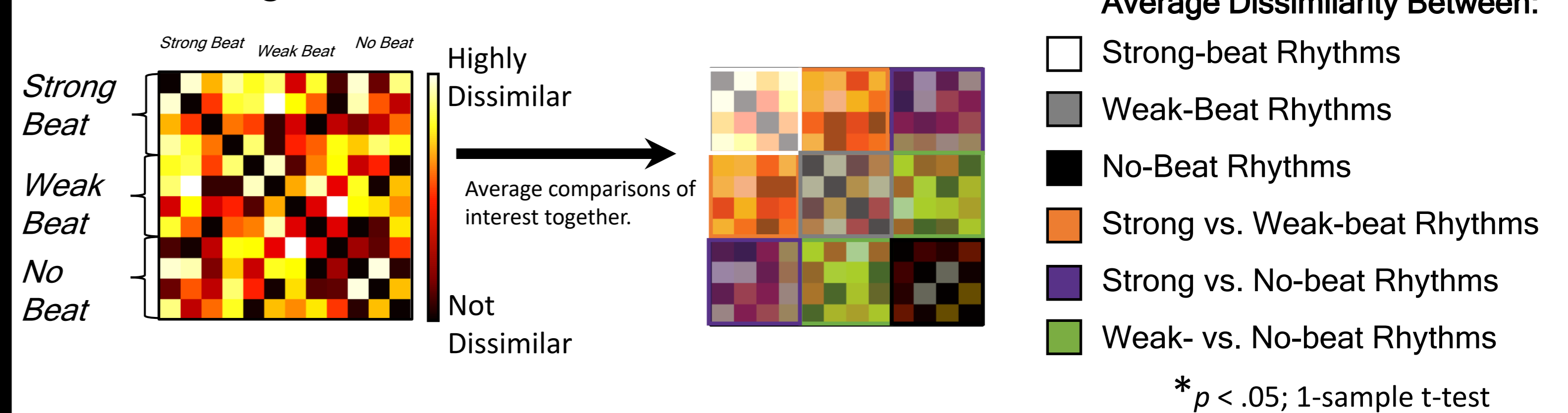
### Whole-Brain Searchlight

- Compare activity patterns in spherical ROIs across entire brain.
- Representational dissimilarity matrices (RDMs) extracted from significant searchlights.
- Areas encoding rhythmic information exhibit positive dissimilarity (across all stimulus pairs).



## Evaluating Searchlight RDMs in Motor Areas

### RDM Legend



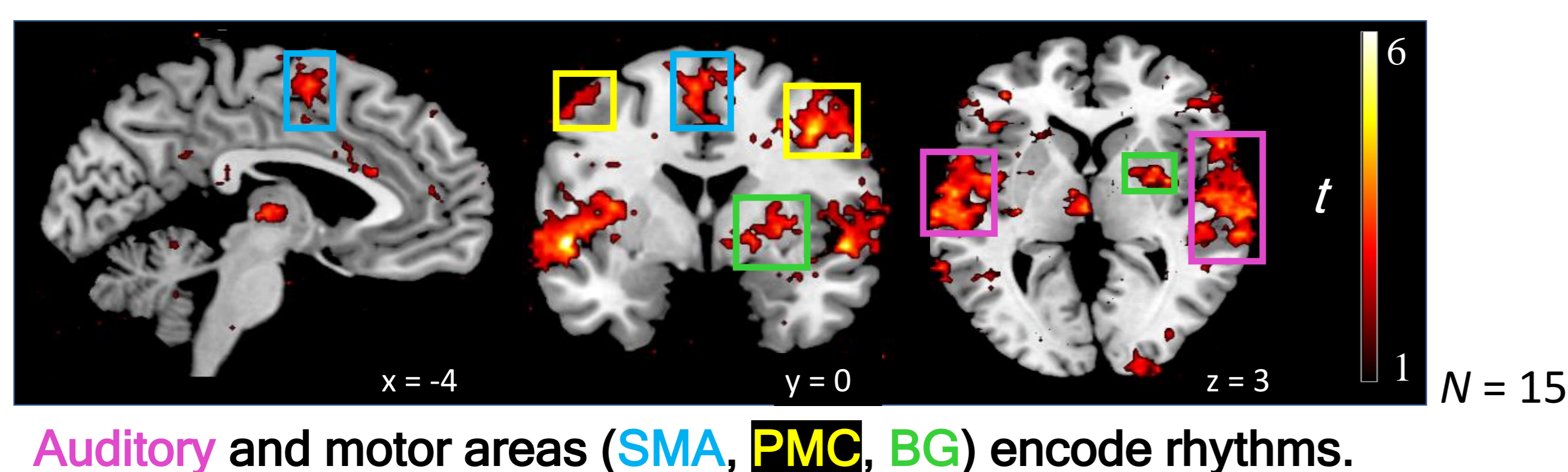
SMA may respond similarly for strong-beat rhythms, differently for others.  
 PMC and basal ganglia may encode all rhythms, regardless of beat.

## Discussion

### Conclusions

- Auditory and Motor areas exhibit consistent, discriminable response patterns for rhythms.
- Motor regions, especially SMA, exhibit unique response patterns for rhythms, except when there is an underlying beat.
- Motor regions may encode the underlying beat when available, but may instead encode the individual acoustic intervals of a rhythm when there is no beat.

## Searchlights with Significant Dissimilarity (All Pairs)



## Acknowledgements

### References

- <sup>1</sup>Grahn, J. A., & Brett, M. (2007). Rhythm and beat perception in motor areas of the brain. *Journal of Cognitive Neuroscience*, 19(5), 893-906.  
<sup>2</sup>Diedrichsen J, Zareamoghaddam H, Provost S. (2016). The distribution of cross-validated Mahalanobis distances. *ArXiv*.

### Thanks to:

