Representational Similarity Analysis

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Material preparation

- To open the .ipynb code file, Jupyter notebook/lab is needed.
  - Install conda -> Install Jupyter lab
- To open the .m code file, MATLAB/ is needed.
  - Install conda -> Install MATLAB
- Download or upload codes and files properly.

How do we know whether two systems are responding in similar ways?

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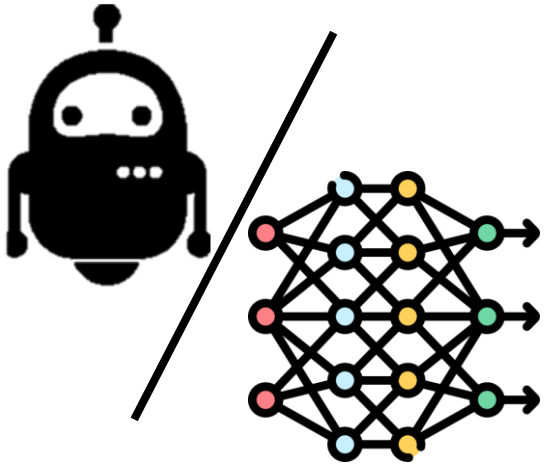
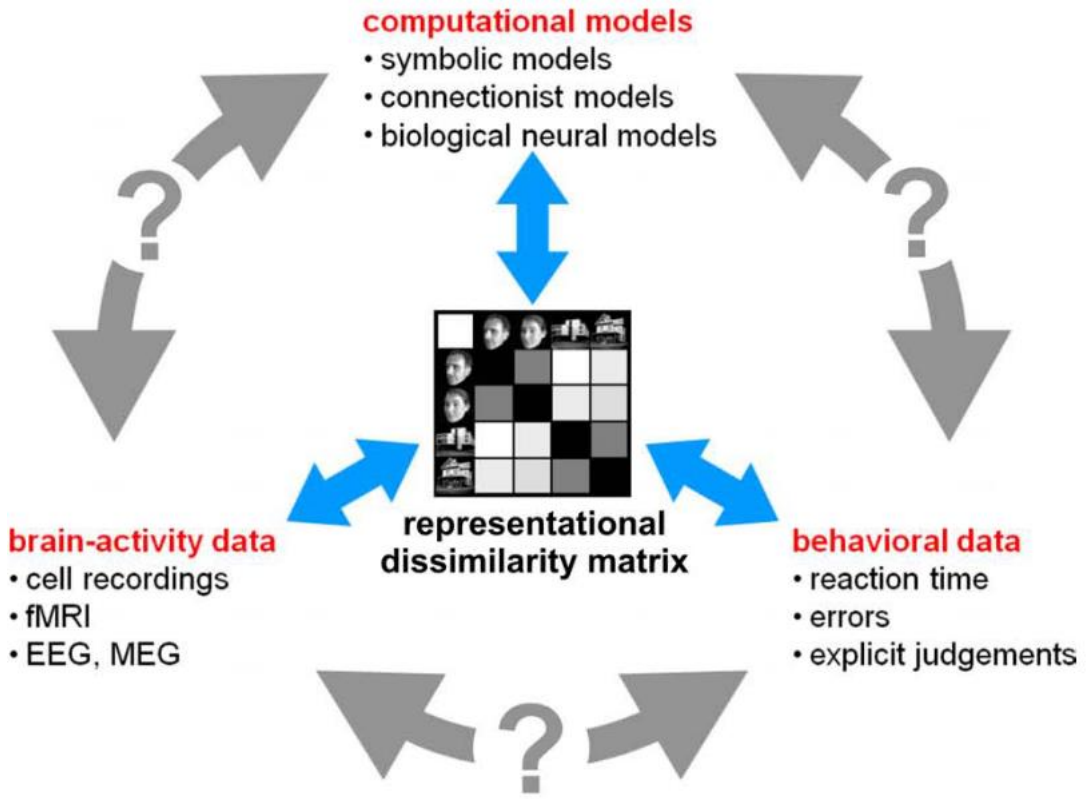


- Brain
  (Signals from behavior, fMRI, EEG, electrophysiological recording…)

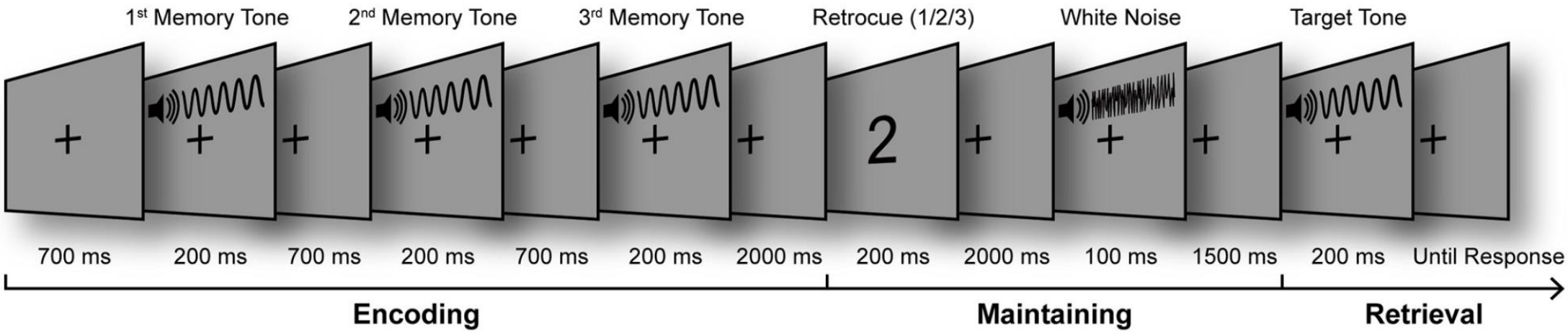
- Artificial neural network
- AI agents
- Cognitive models
- ….

How do we know whether two systems are responding in similar ways?



Kriegeskorte et al., *Front. syst. neurosci.*, (2008)

Dataset / Task

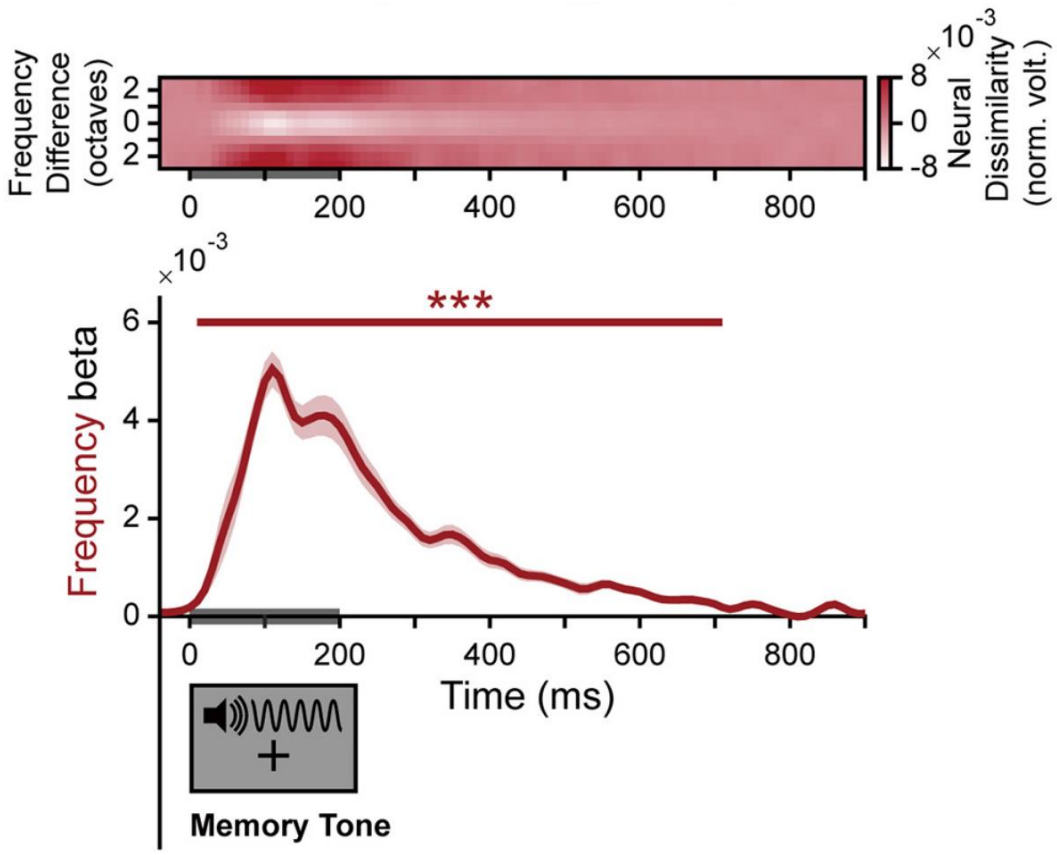


Tone pitch: 381, 538, 762, 1077, 1524, and 2155 Hz

EEG Recording

Task: Comparing the pitch of memory tone and the target tone.

Neural representation of pitch frequency during WM encoding

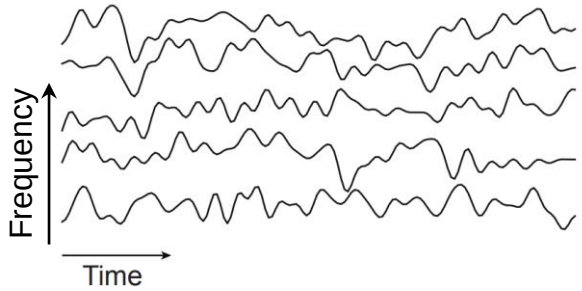


What we will be doing:

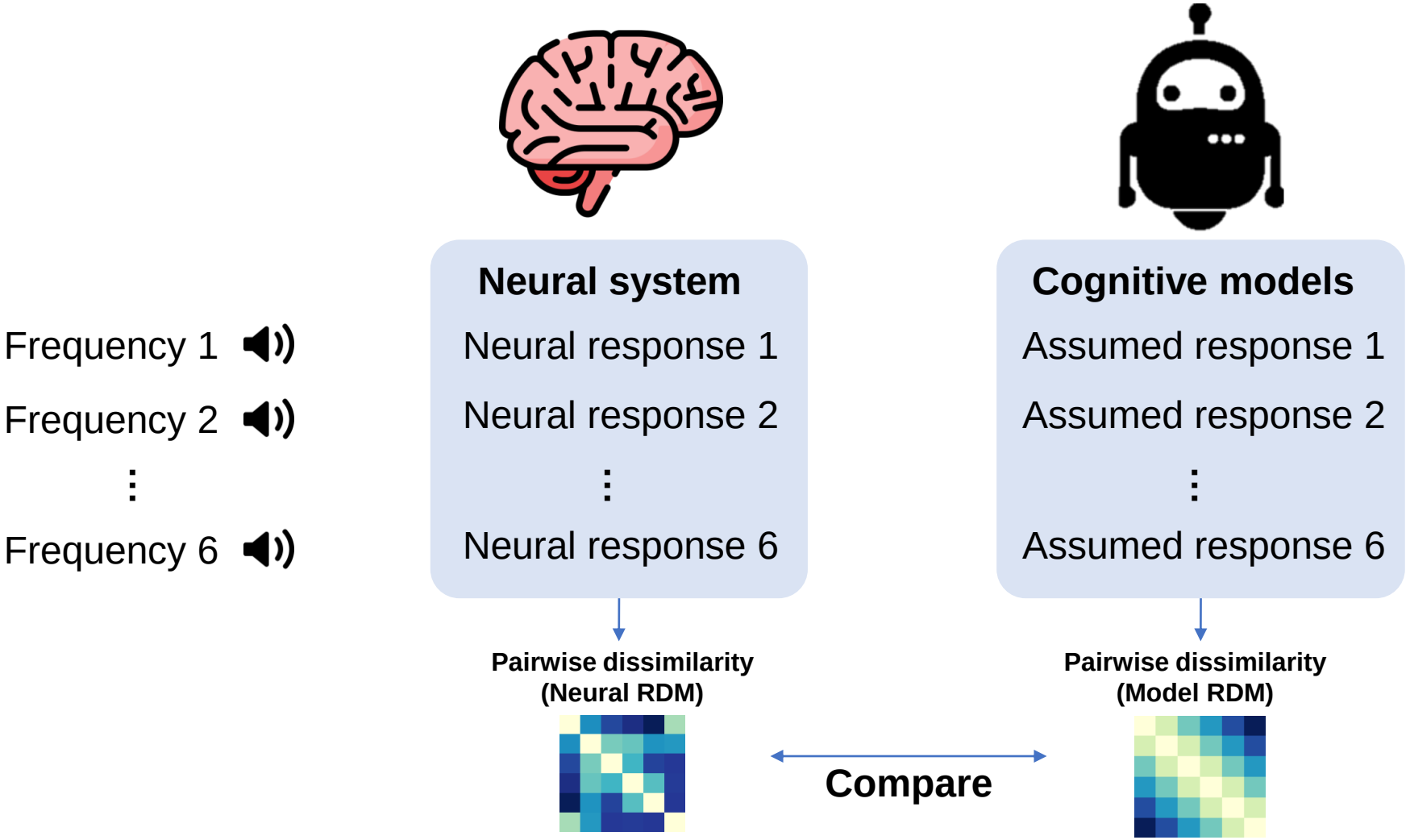
How does the brain respond to different pitches?

Representational Similarity Analysis

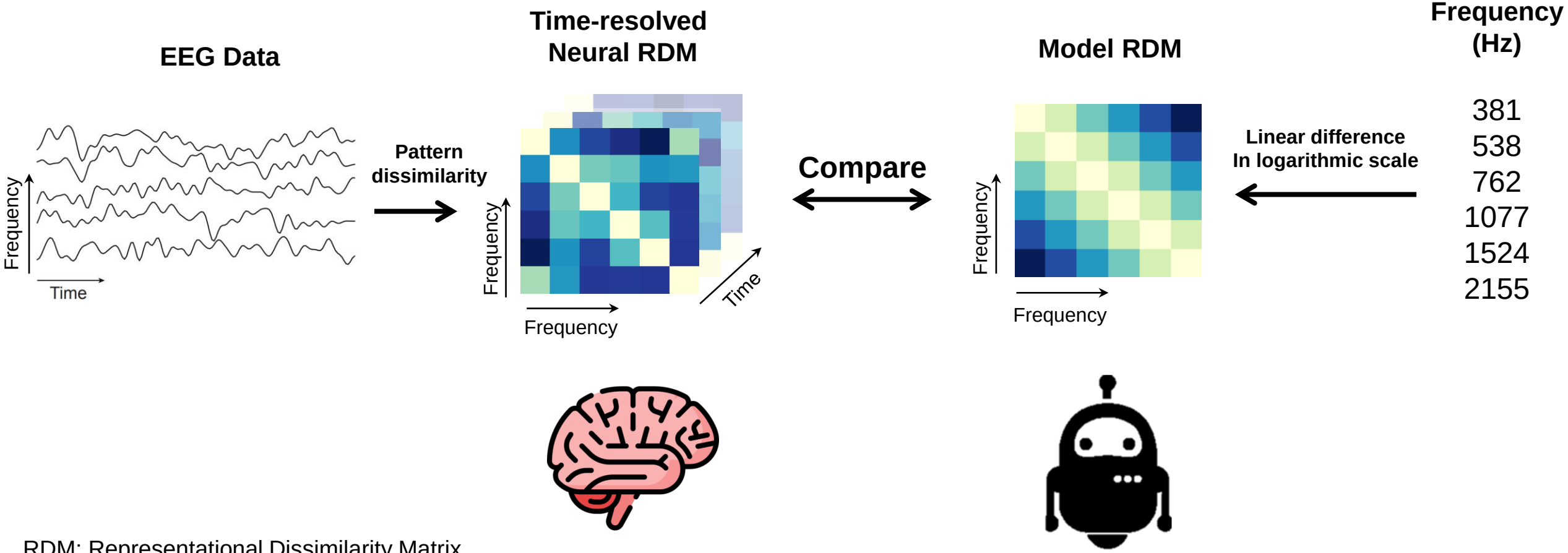
	Neural system	**Cognitive models**
Frequency 1	Neural response 1	Assumed response 1
Frequency 2	Neural response 2	Assumed response 2
⋮	⋮	⋮
Frequency 6	Neural response 6	Assumed response 6



Representational Similarity Analysis

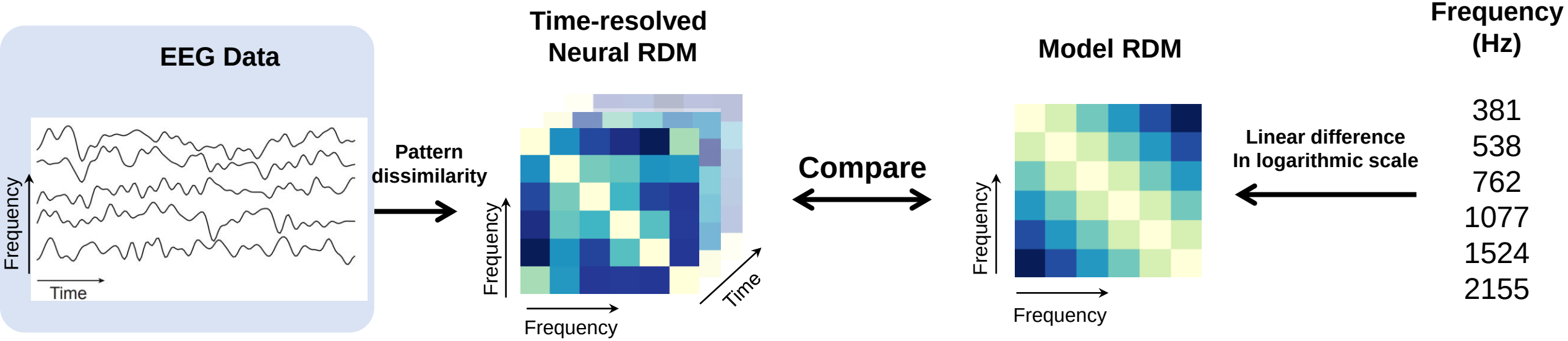


Representation dissimilarity analysis



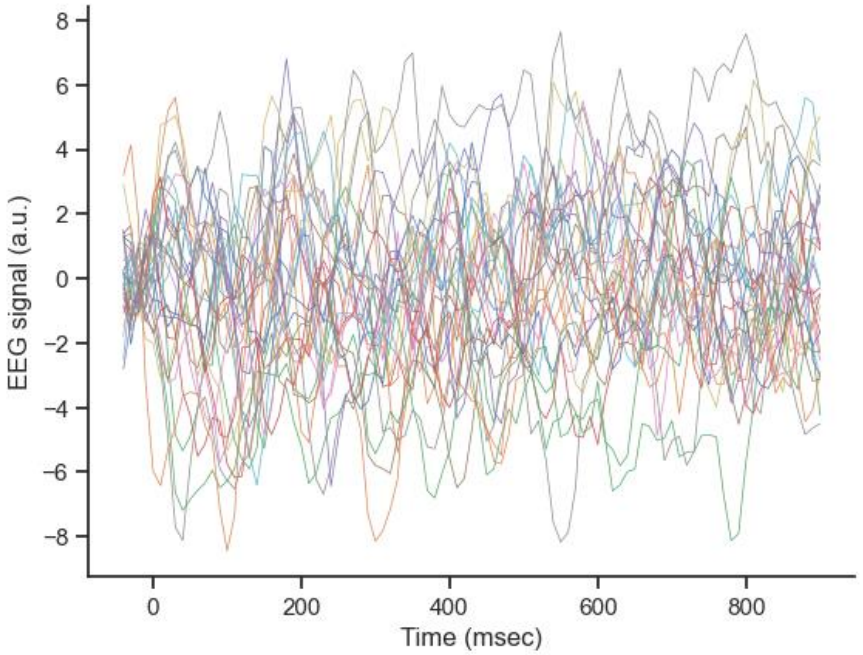
RDM: Representational Dissimilarity Matrix

Average across trials by frequency



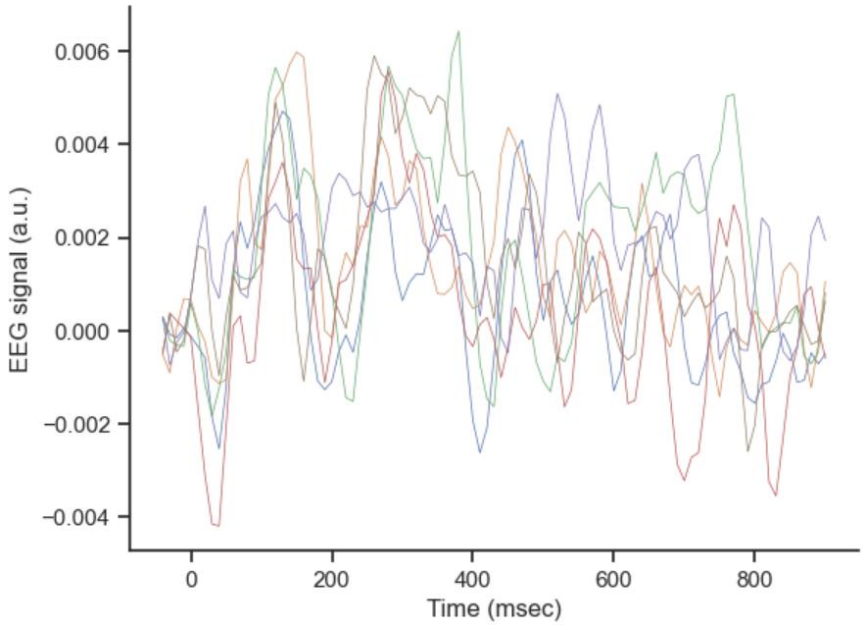
ERP for each frequency

Trial-level EEG signals are noisy

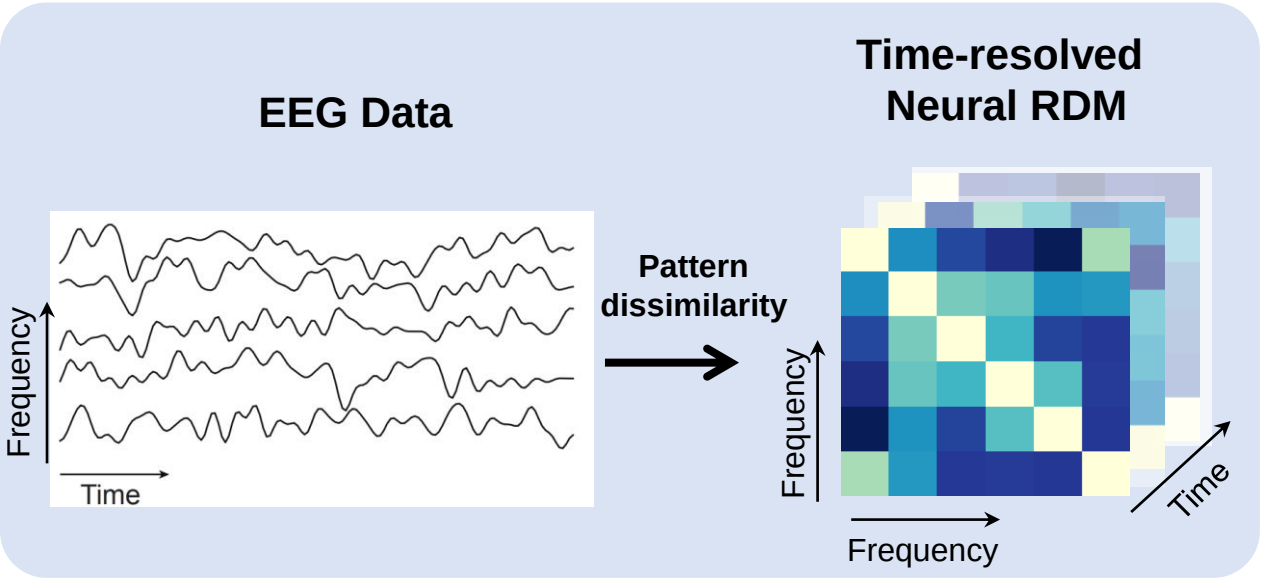


Averaging by frequency

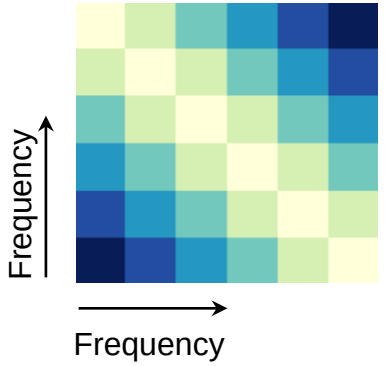
Averaged ERPs for each pitch are more robust



Neural RDM



Compare



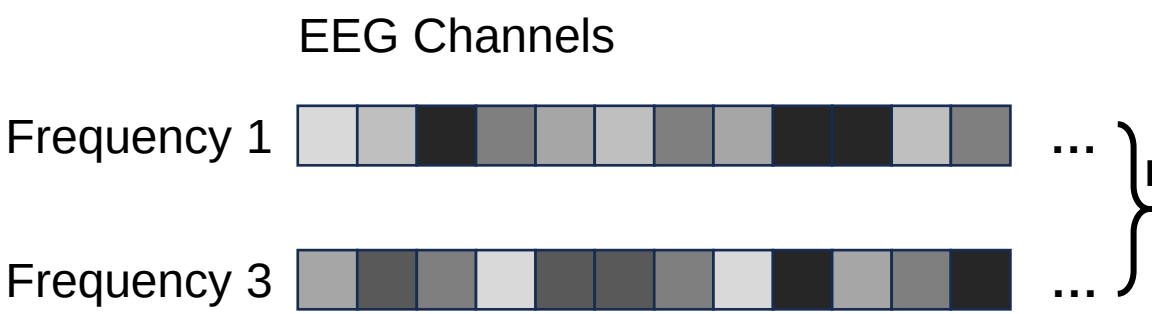
Linear difference In logarithmic scale

Frequency (Hz)

381
538
762
1077
1524
2155

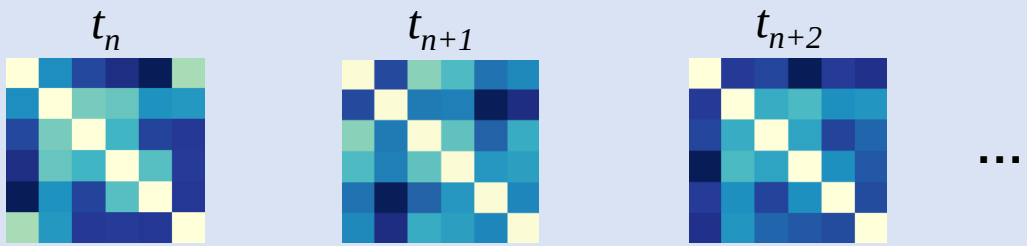
Neural RDM

For each time point,

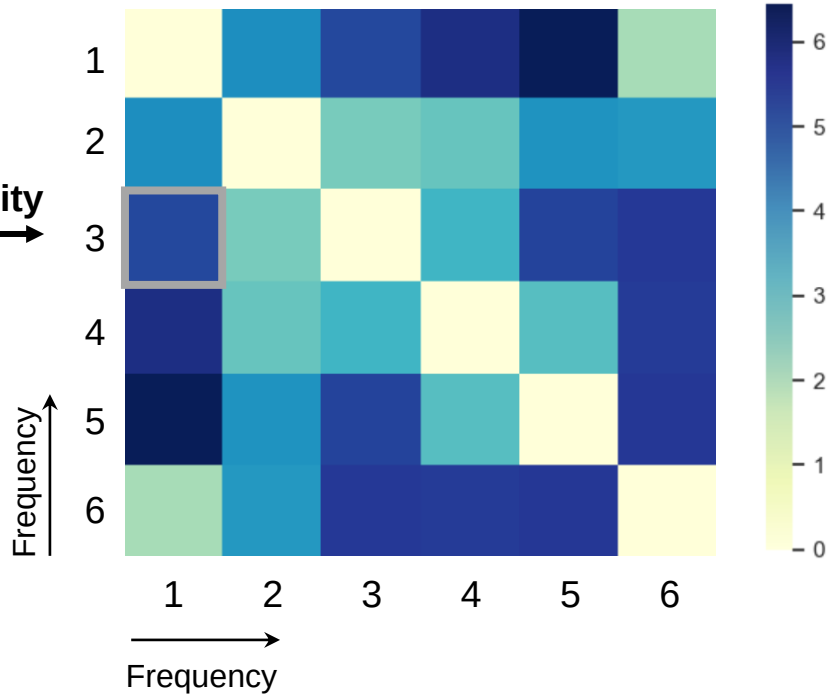


How dissimilar are the two spatial patterns?

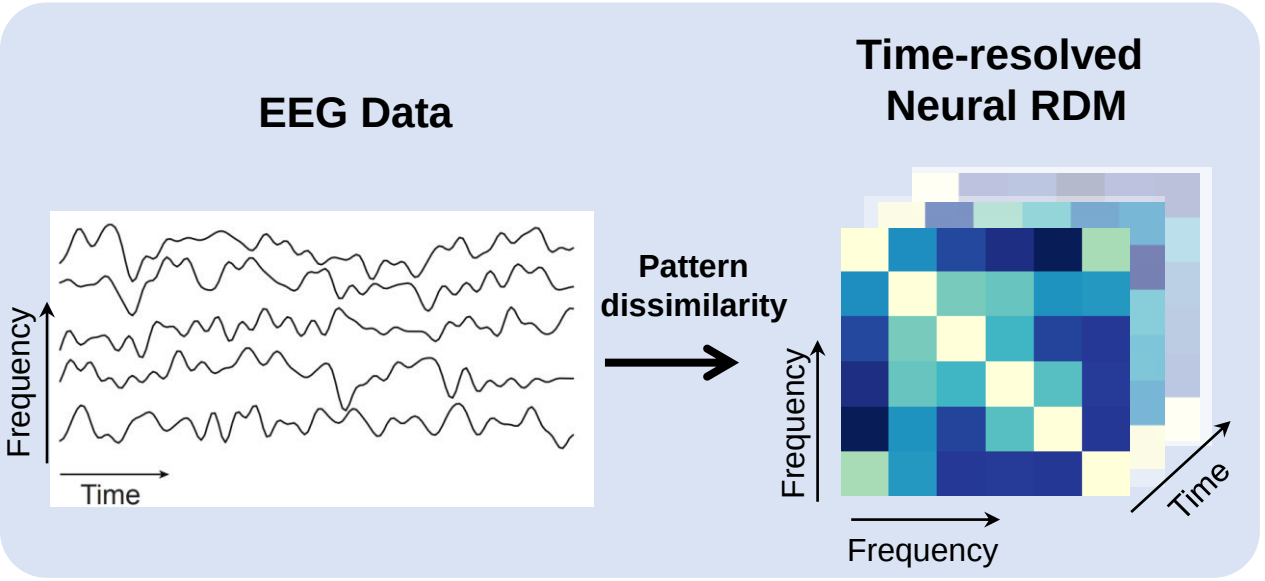
Loop over time points, we have…



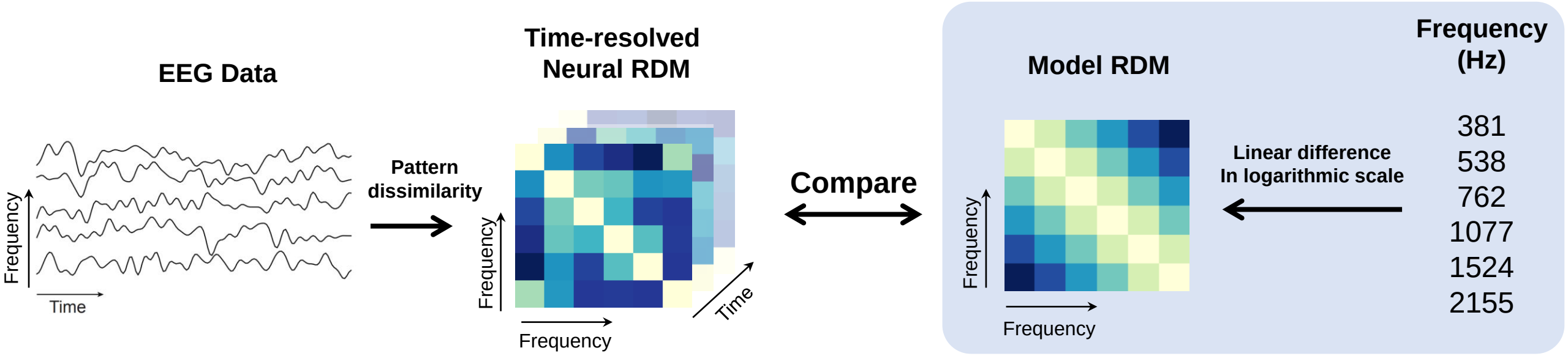
Neural RDM represents how neural system respond differently to different pitches



Neural RDM over Time

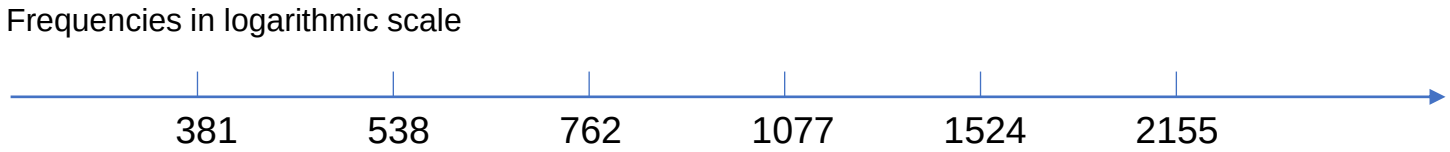


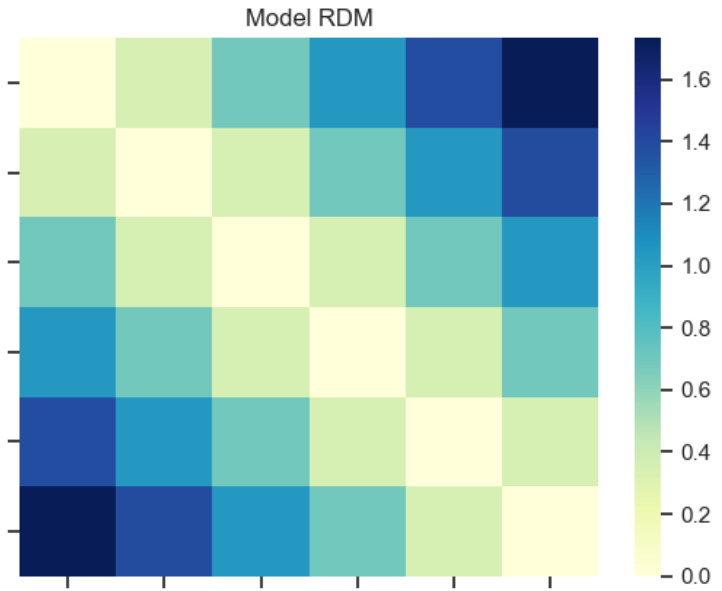
Whether neural RDM



Construct a Model RDM

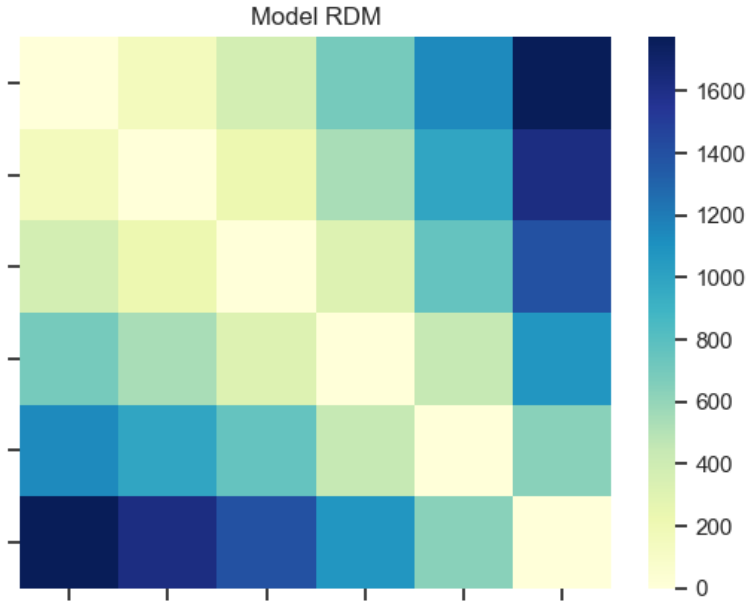
As we know, our brain responds to logarithmic of pitch frequency,



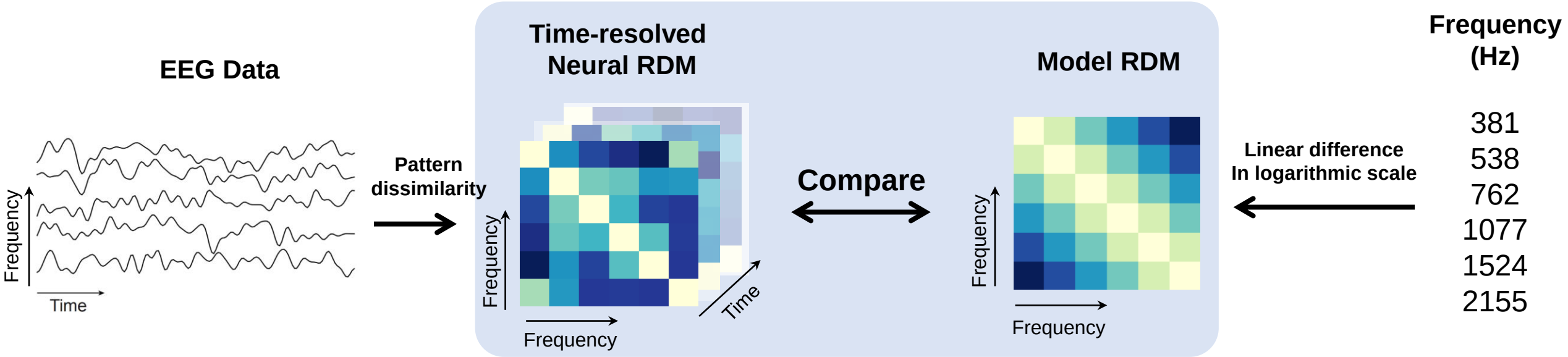


Construct an Alternative Model RDM (Optional)

Can we test if the brain responds to the original scale of pitch frequencies?



Let’s see whether the brain works as we expect

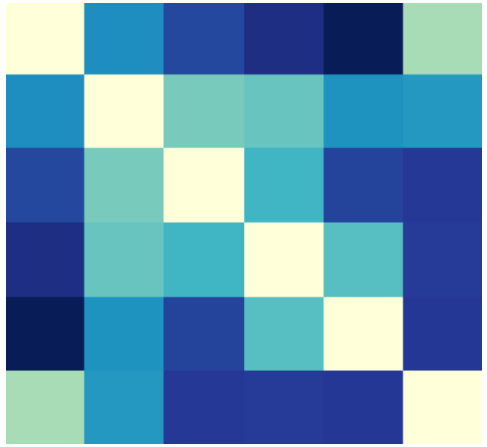


Compare Neural RDM and Model RDM

For each time point, we know the pattern of the brain's responses.

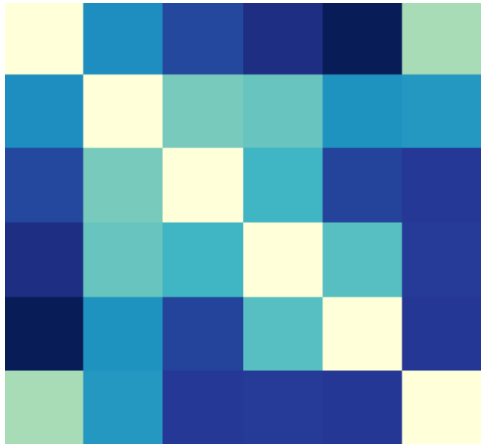
If the brain runs as we assume, the pattern should like look this…

Neural RDM

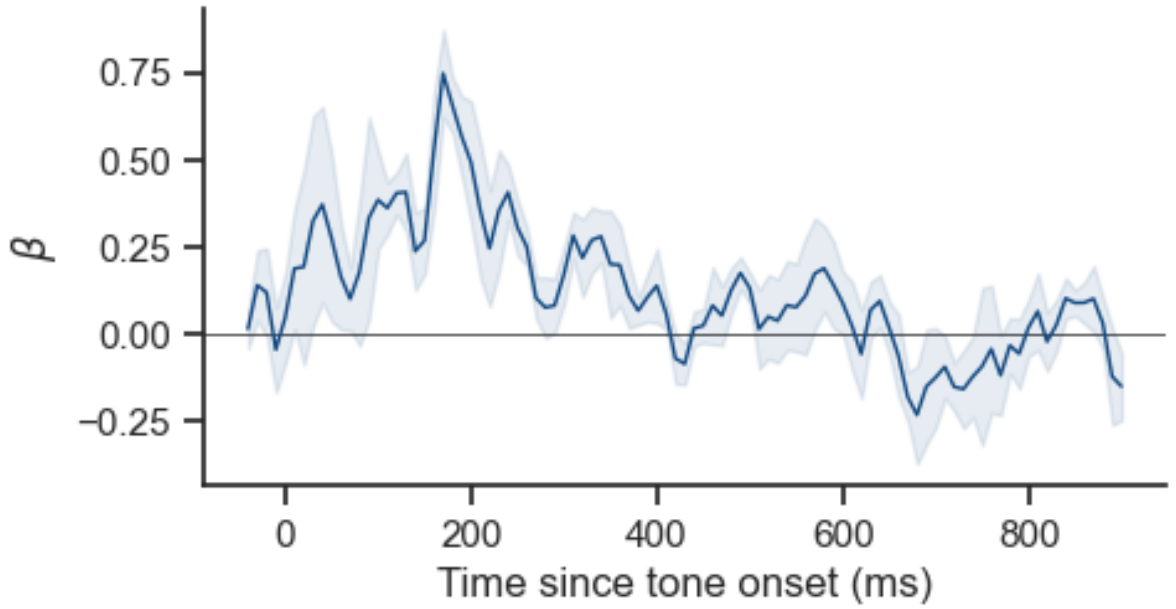


Correlation

Model RDM



Compare RDMs over time points



One Take-home Message

By measuring the similarity between the response patterns of two systems, RSA is useful tool to unify different modality: behavior, neural data, AI system, cognitive models...

Information of the RSA files

Data fold

- edata_tone
  - holds the EEG data for each subject. Each subject's data is stored in a separate cell, and within each cell, the data is a 3D matrix with dimensions corresponding to trials, channels, and time points.
- bdata_tone
  - holds the behavioral data for each subject. Each subject's data is stored in a separate cell, and within each cell, the data is a 1D vector where each element represents the frequency presented in the corresponding trial. The values from 1 to 6 represent six frequencies equally spaced on a logarithmic scale.

Code fold

- Data_Analysis
  - Codes for the RSA analysis
- cluster_test and cluster_test_helper
  - functions for cluster-based permutation test
- line_errorbar
  - functions for generating grand average plots