MRC Cognition and Brain Sciences Unit

UNIVERSITY OF CAMBRIDGE

Decoding and Representational Similarity Analysis with EEG/MEG

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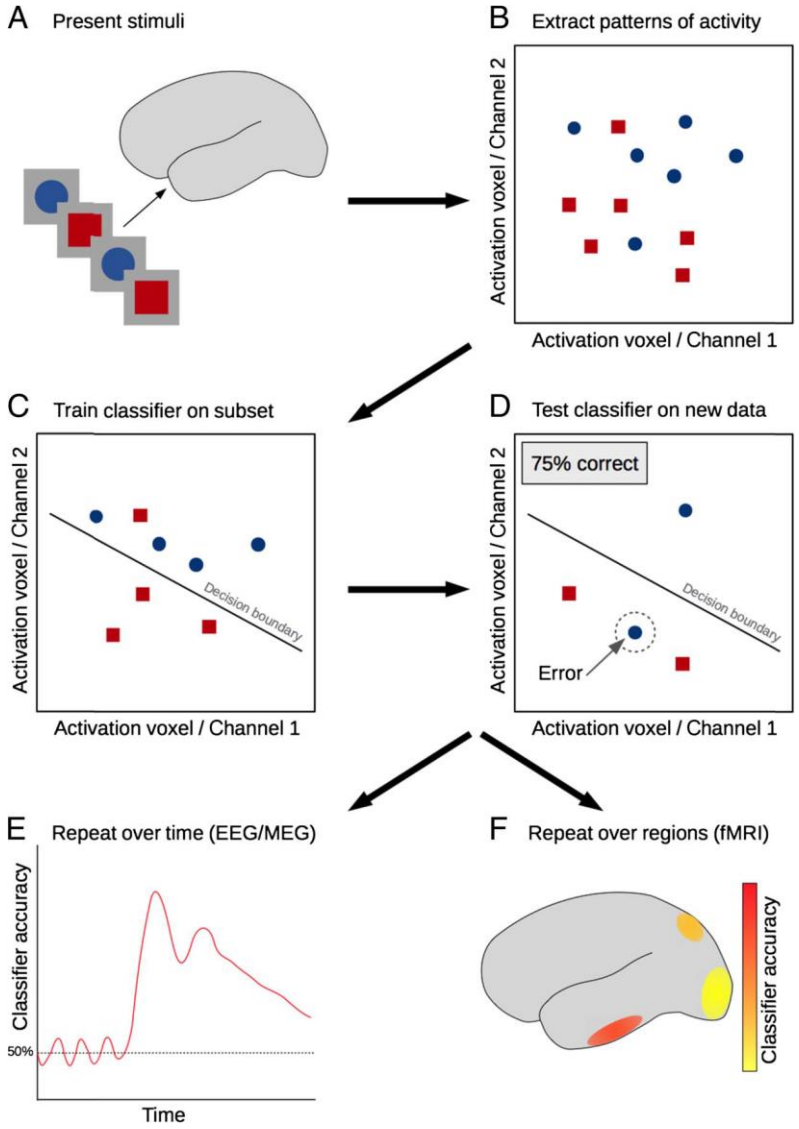
Decoding from EEG/MEG

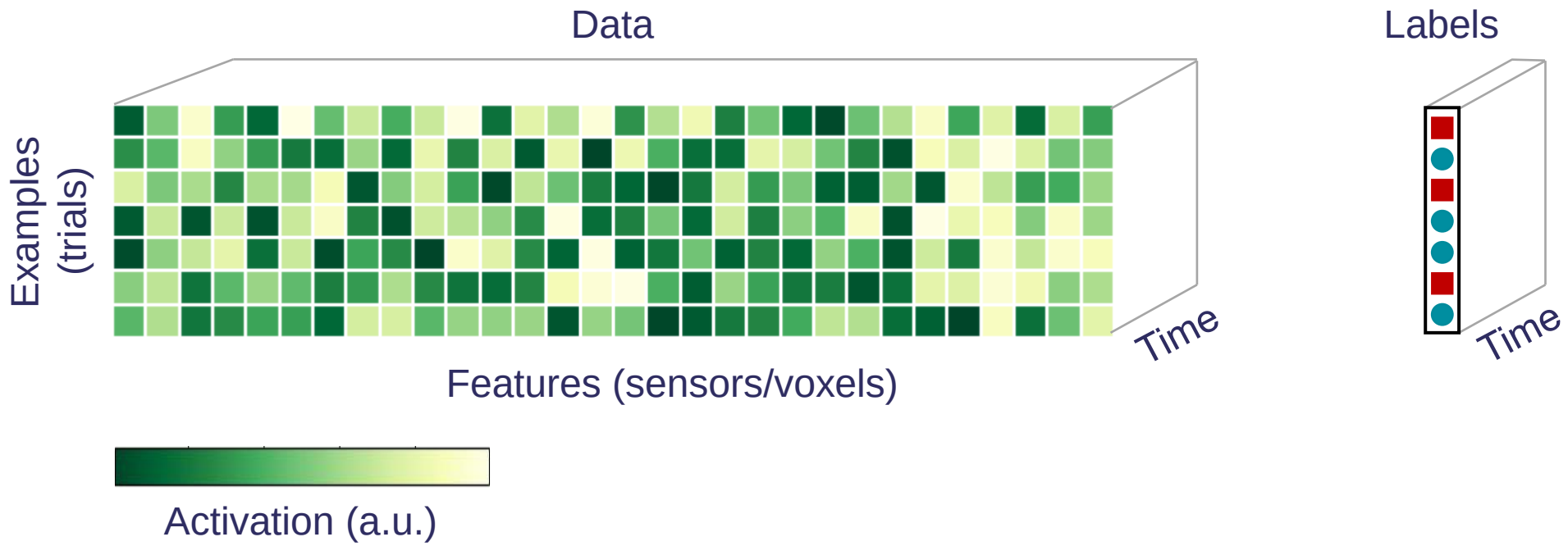
Decoding recap



	fMRI	EEG/MEG
Spatial resolution	Few millimetres	Few centimetres
Temporal resolution	1-2 seconds	0.5 – 1 milliseconds

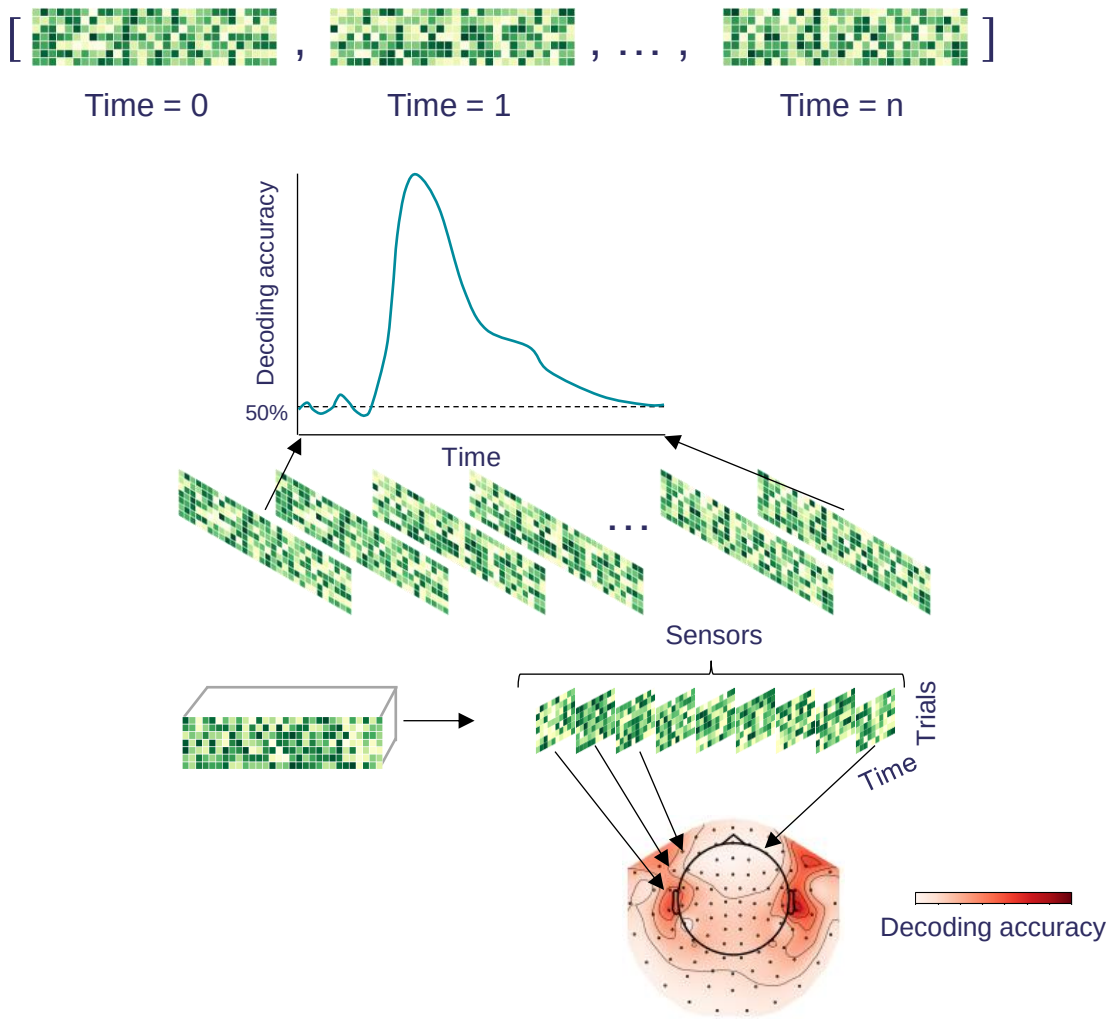
Tutorial: Grootswagers et al., JoCN 2017, https://pubmed.ncbi.nlm.nih.gov/27779910/

Data structure and notation

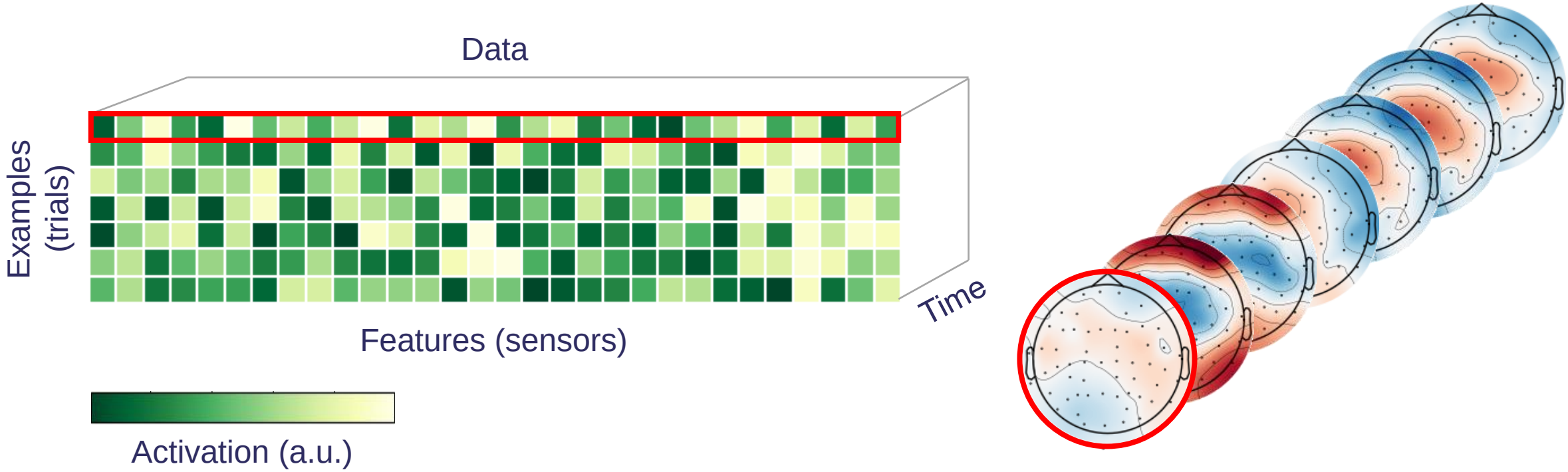


How to leverage the additional time dimension?

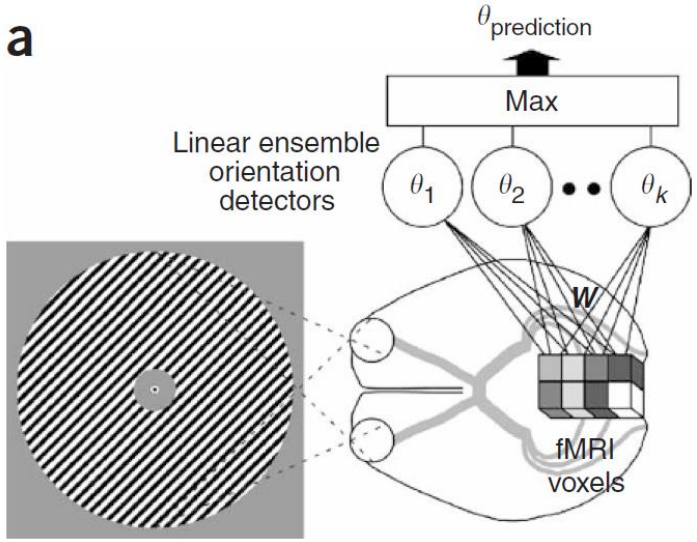
1. Concatenate across time
   - Number of features increase by number of time points
   - Most sensitive
   - No timing information left
2. Time resolved decoding
   - Decode separately at each time point
   - Time course of spatial information
3. Use time dimension as features
   - Decode separately at each sensor
   - Spatial map of temporal information

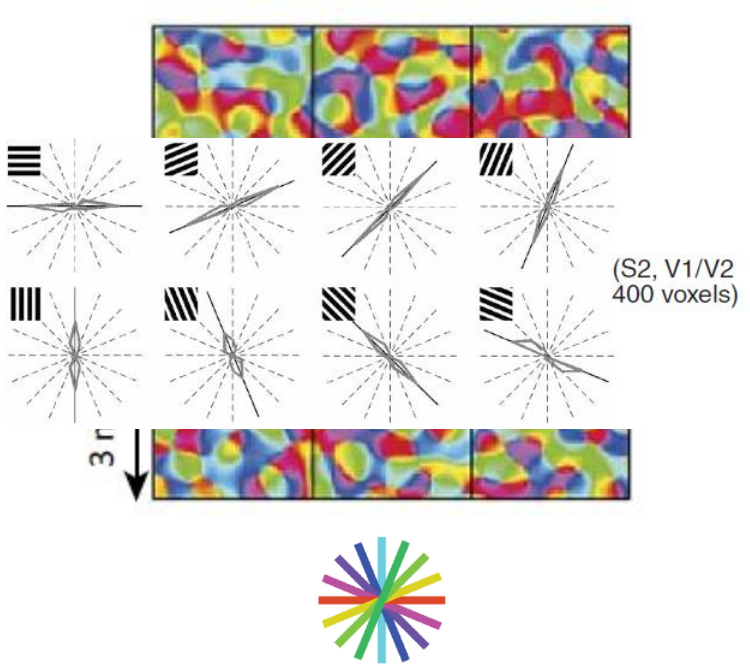


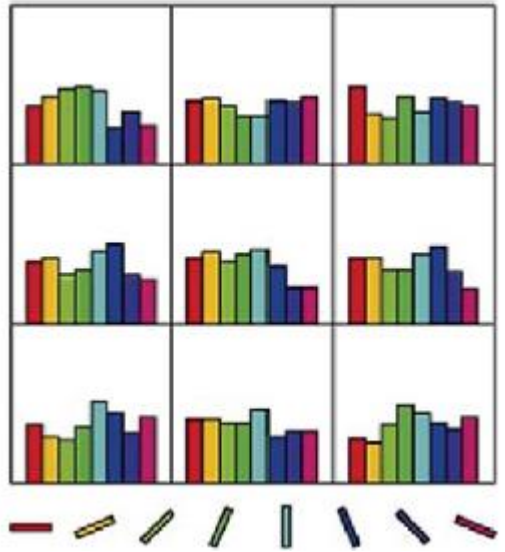
Time resolved decoding - intuition



Decoding from mass signals - fMRI



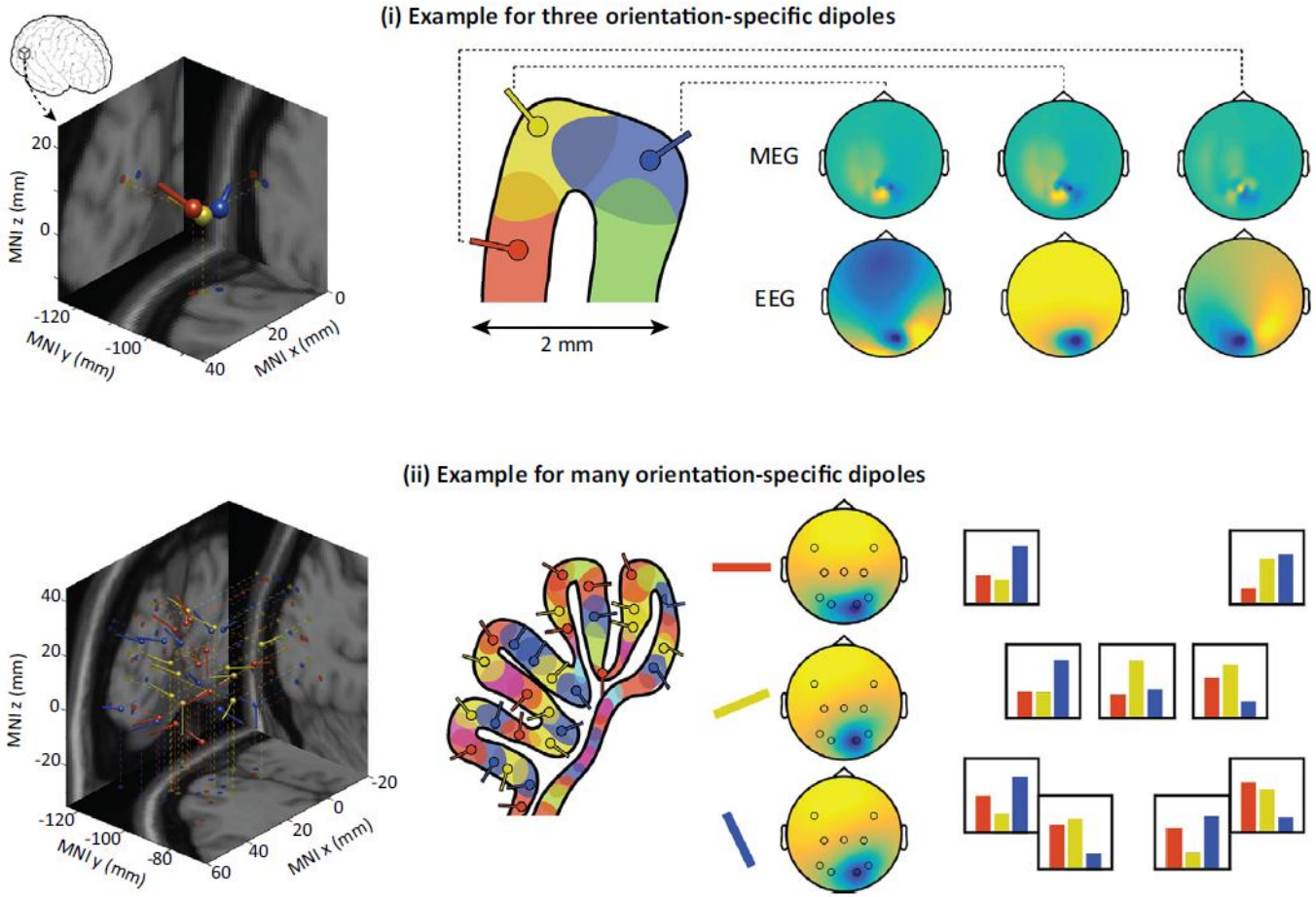




Kamitani & Tong, Nat. Neuroscience 2005
https://pubmed.ncbi.nlm.nih.gov/15852014/

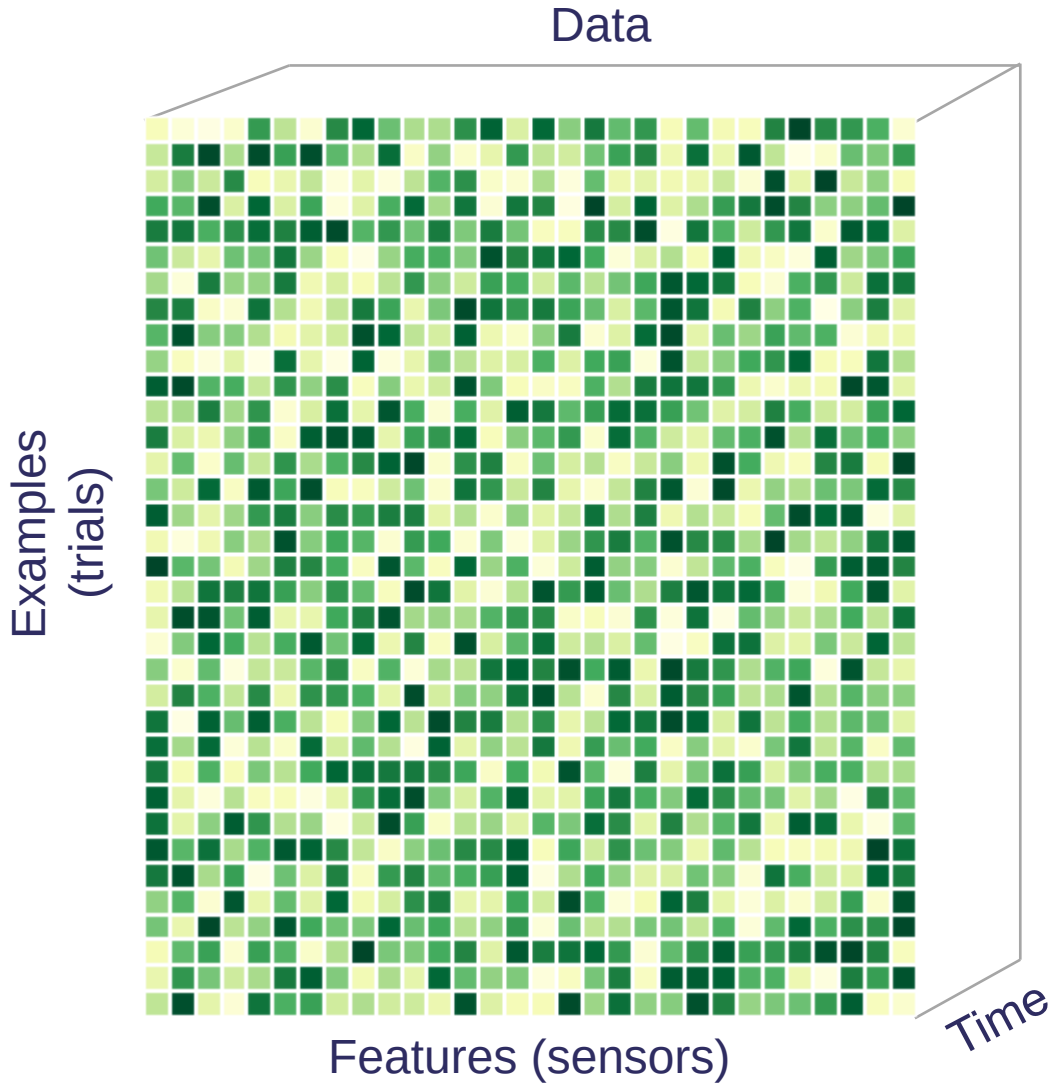
Stokes et al., TICS 2015
https://pubmed.ncbi.nlm.nih.gov/26440122/

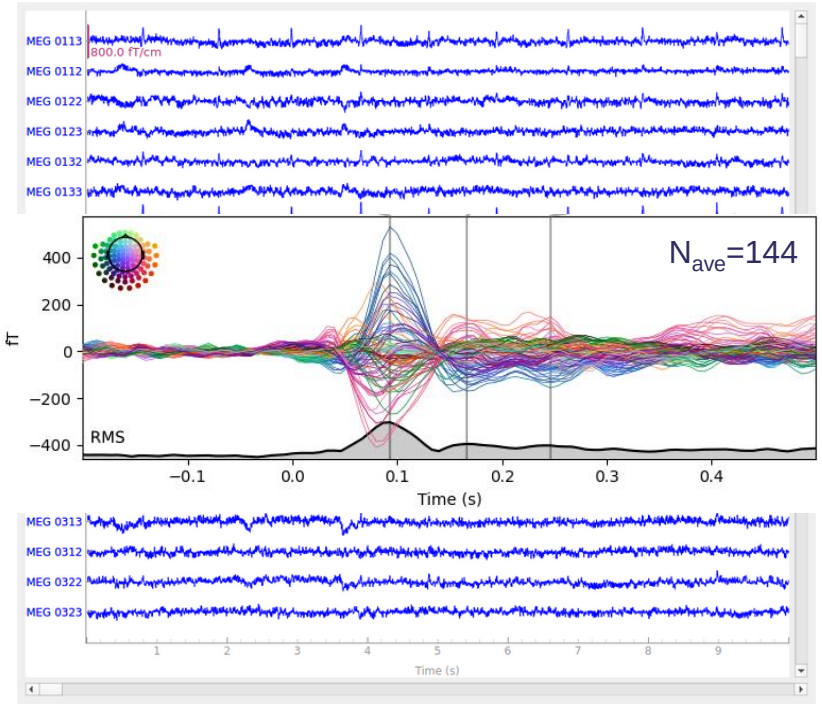
Decoding from mass signals – EEG/MEG



Cichy et al., Neuroimage 2015
Stokes et al., TICS 2015

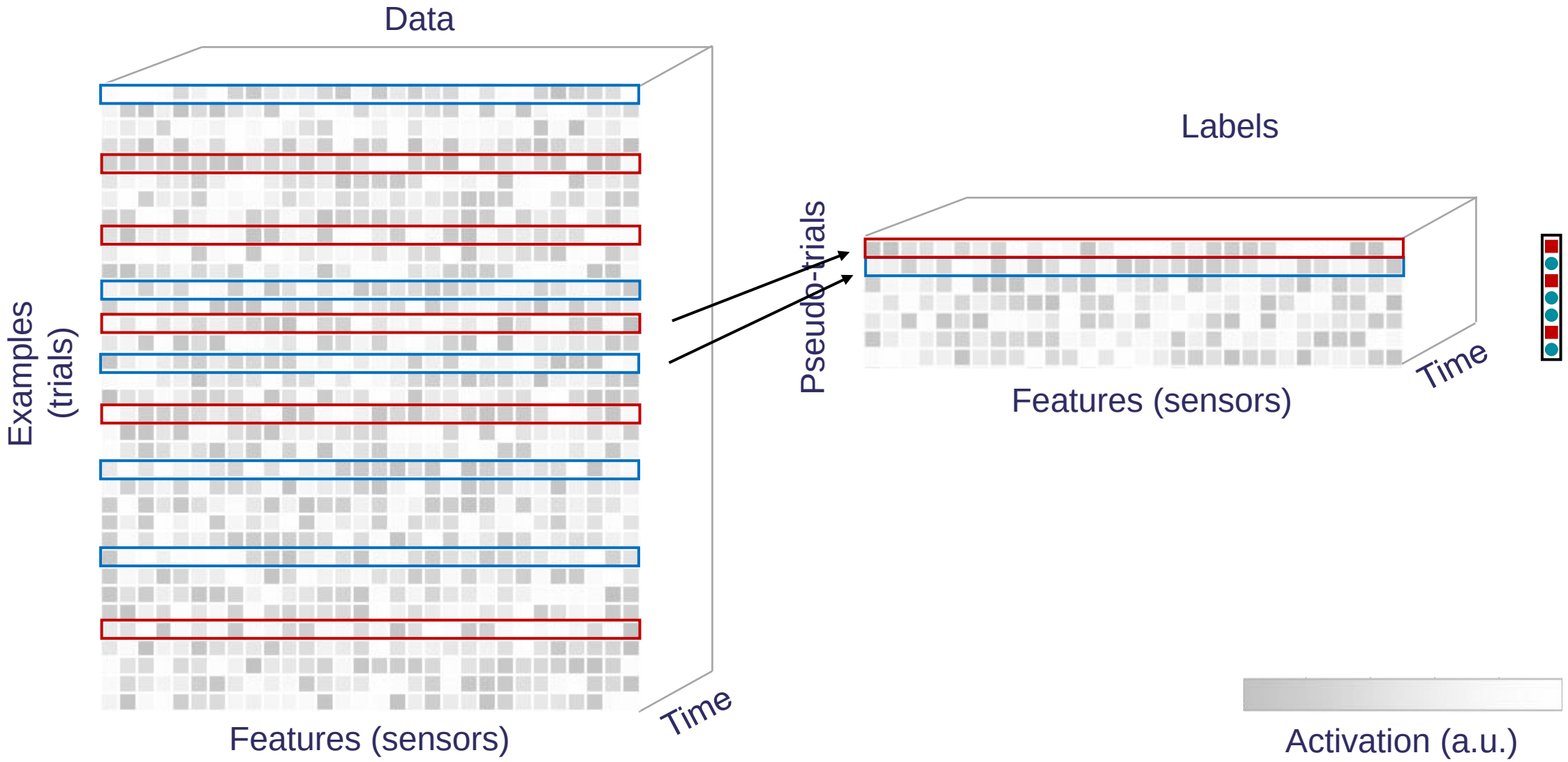
Time resolved decoding practicalities: Single trials vs pseudo-trials



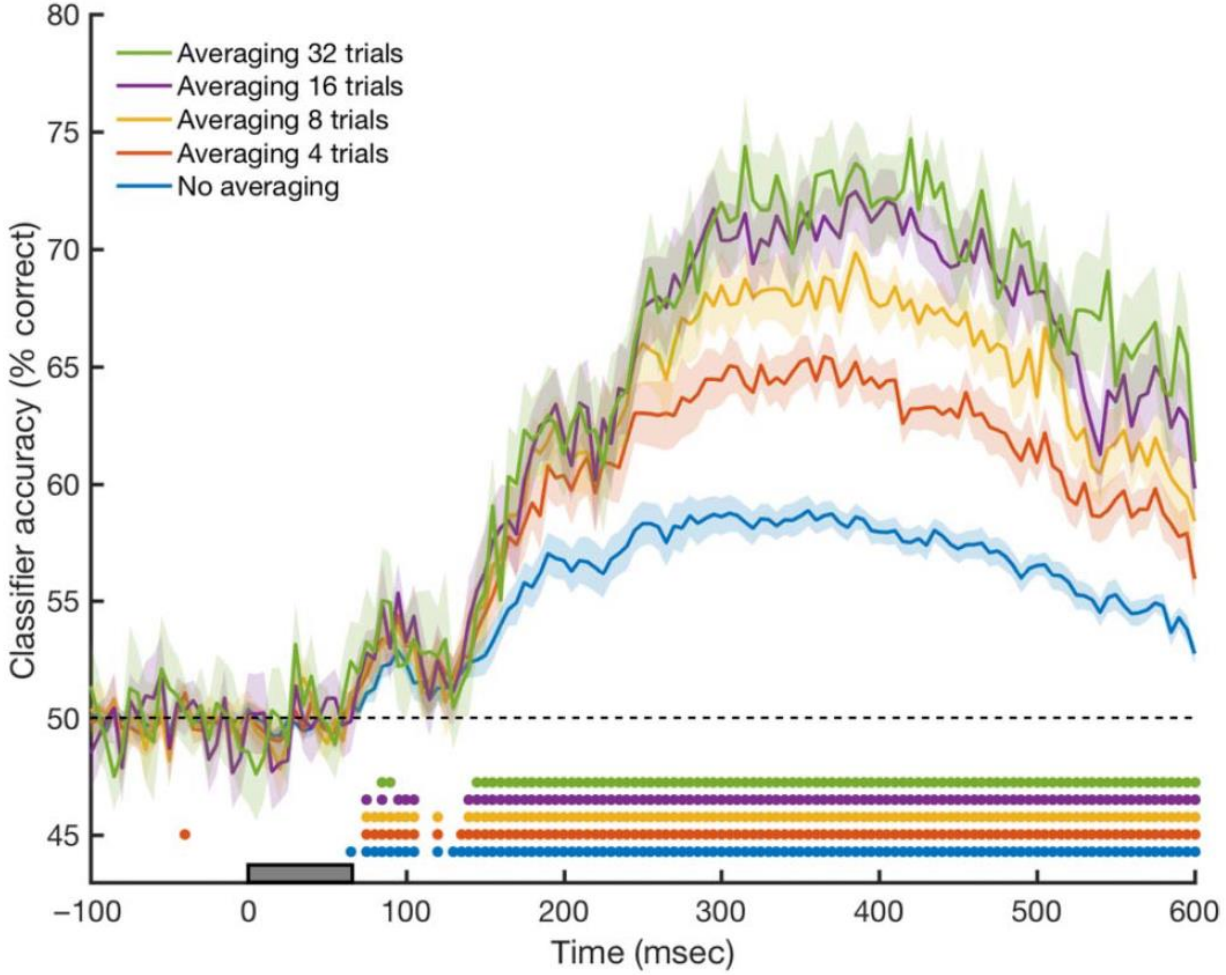


Activation (a.u.)

Time resolved decoding practicalities: Single trials vs pseudo-trials

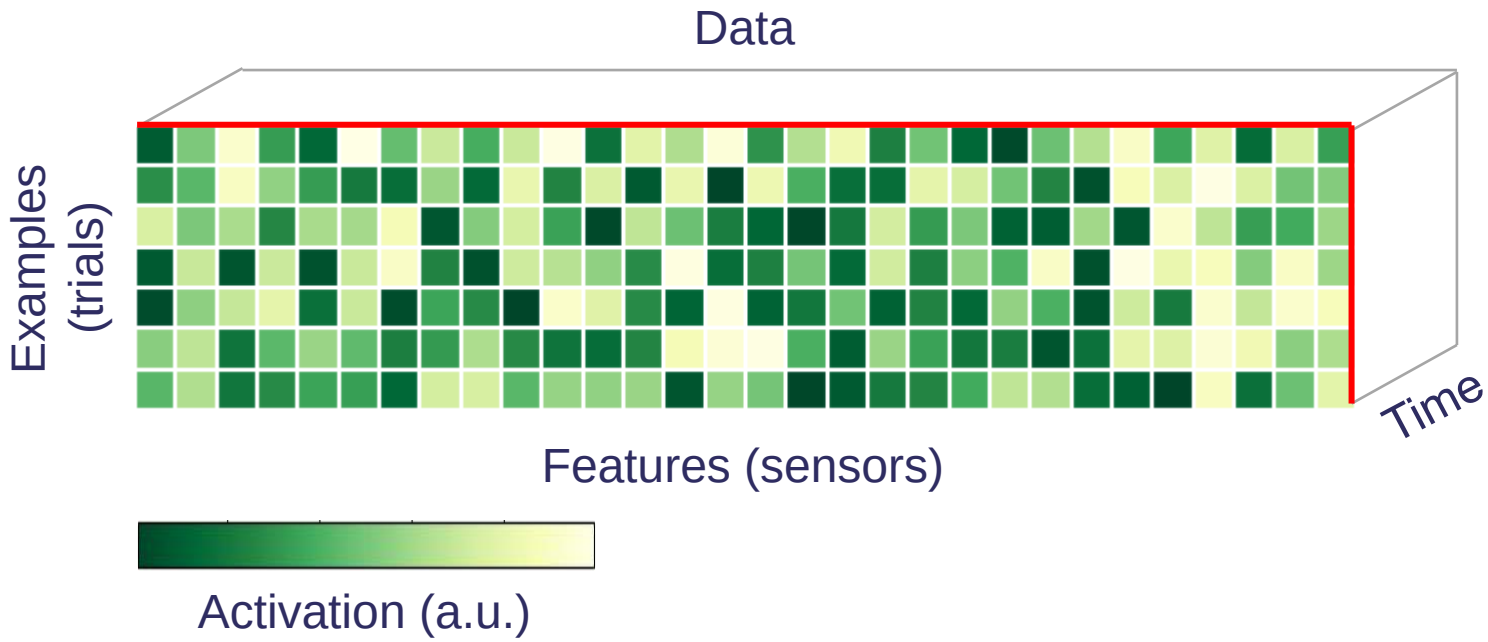


Time resolved decoding practicalities: Single trials vs pseudo-trials

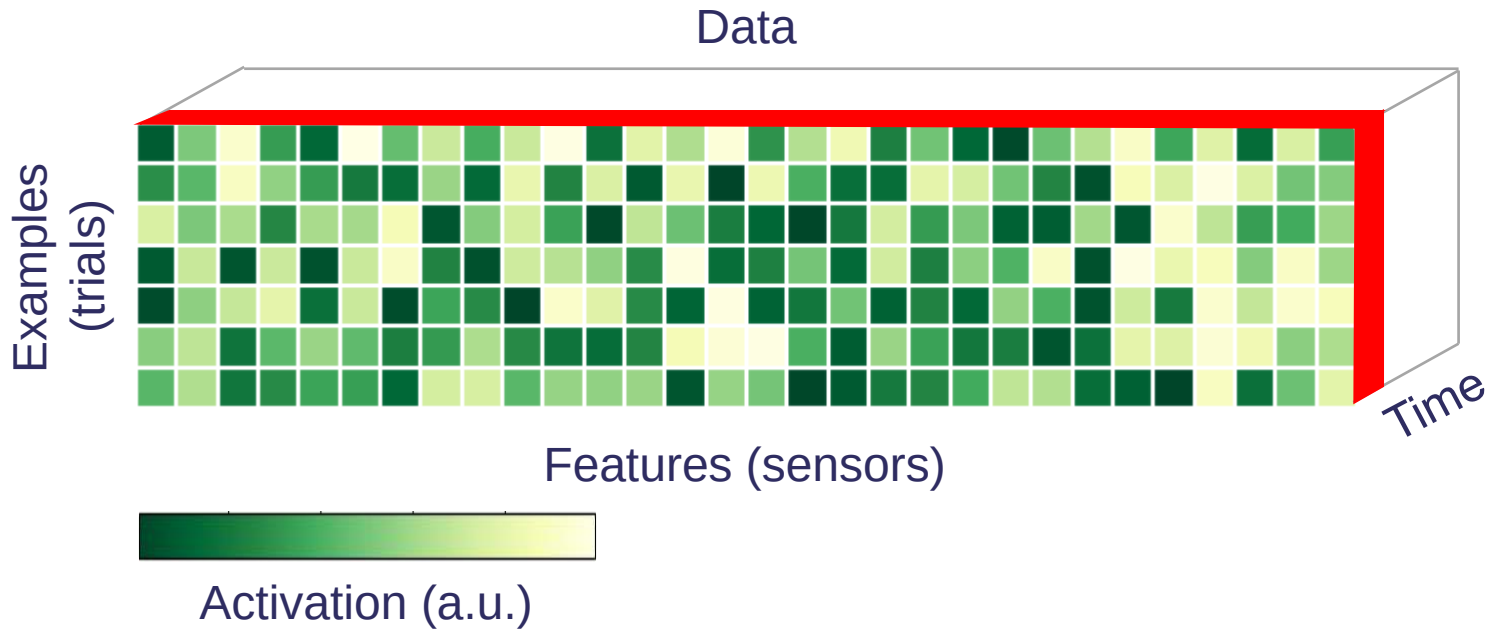


Grootswagers et al., JoCN 2017

Time resolved decoding practicalities: Single time points or moving window



Time resolved decoding practicalities: Single time points or moving window

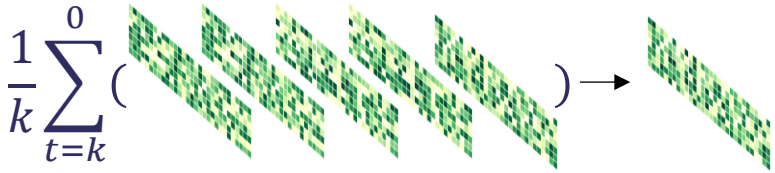


Within the moving window of size k

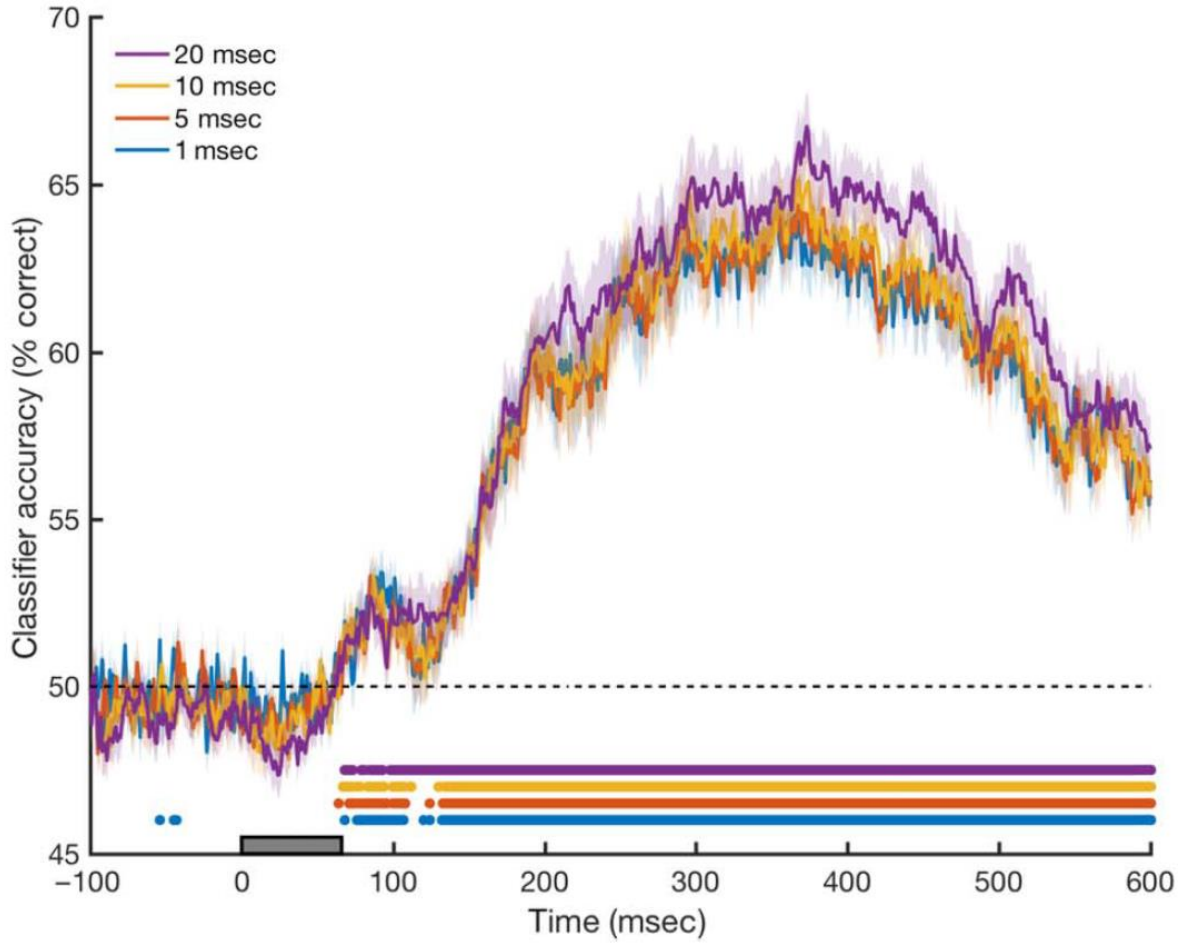
Concatenate

or

Average

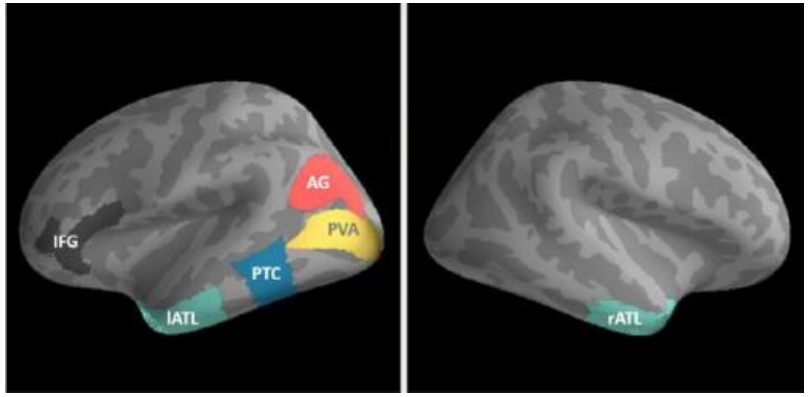


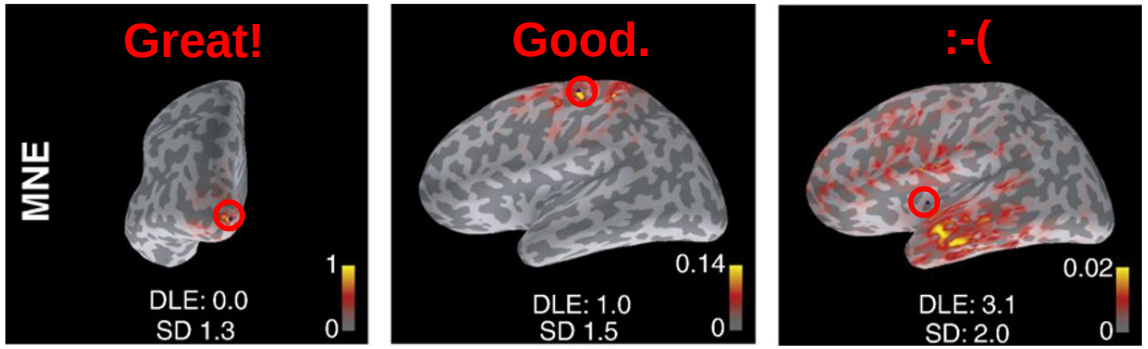
Time resolved decoding practicalities: Single time points or moving window

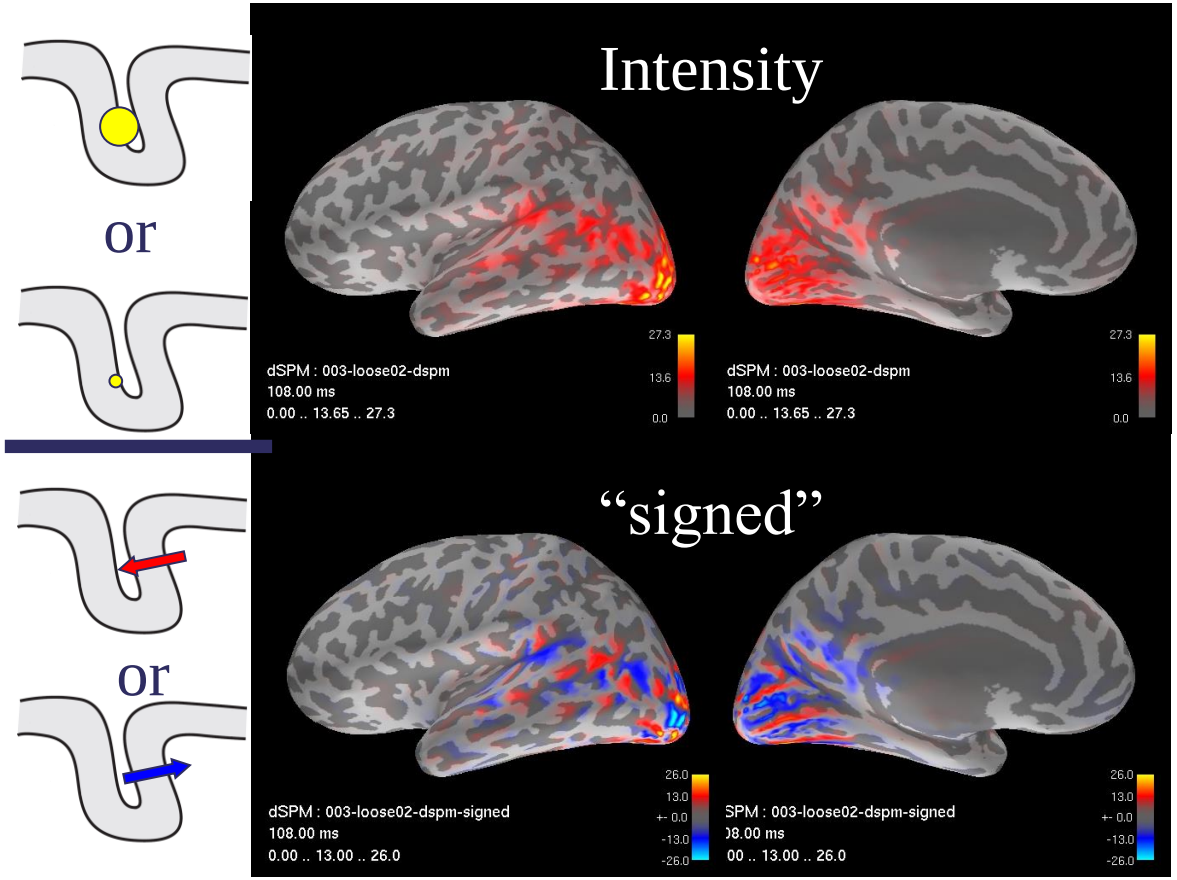


Grootswagers et al., JoCN 2017

Time resolved decoding practicalities: Sensor space or source space

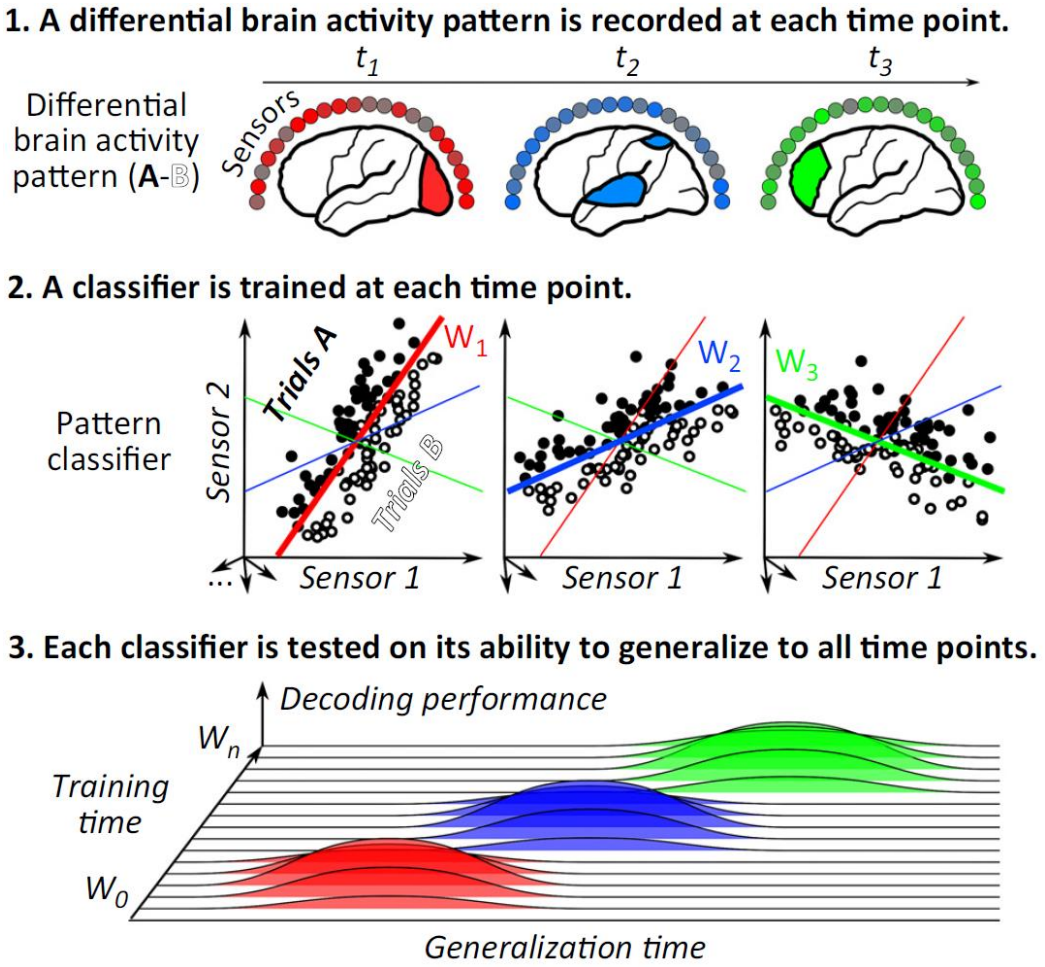


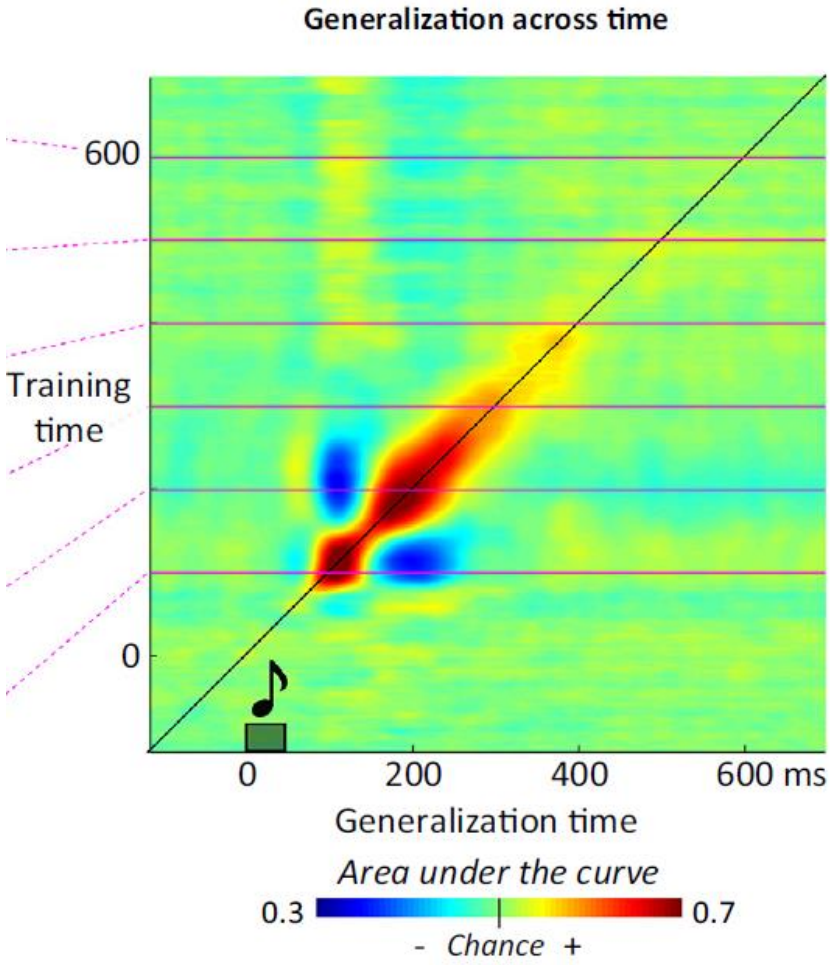




Slide from Olaf Hauk

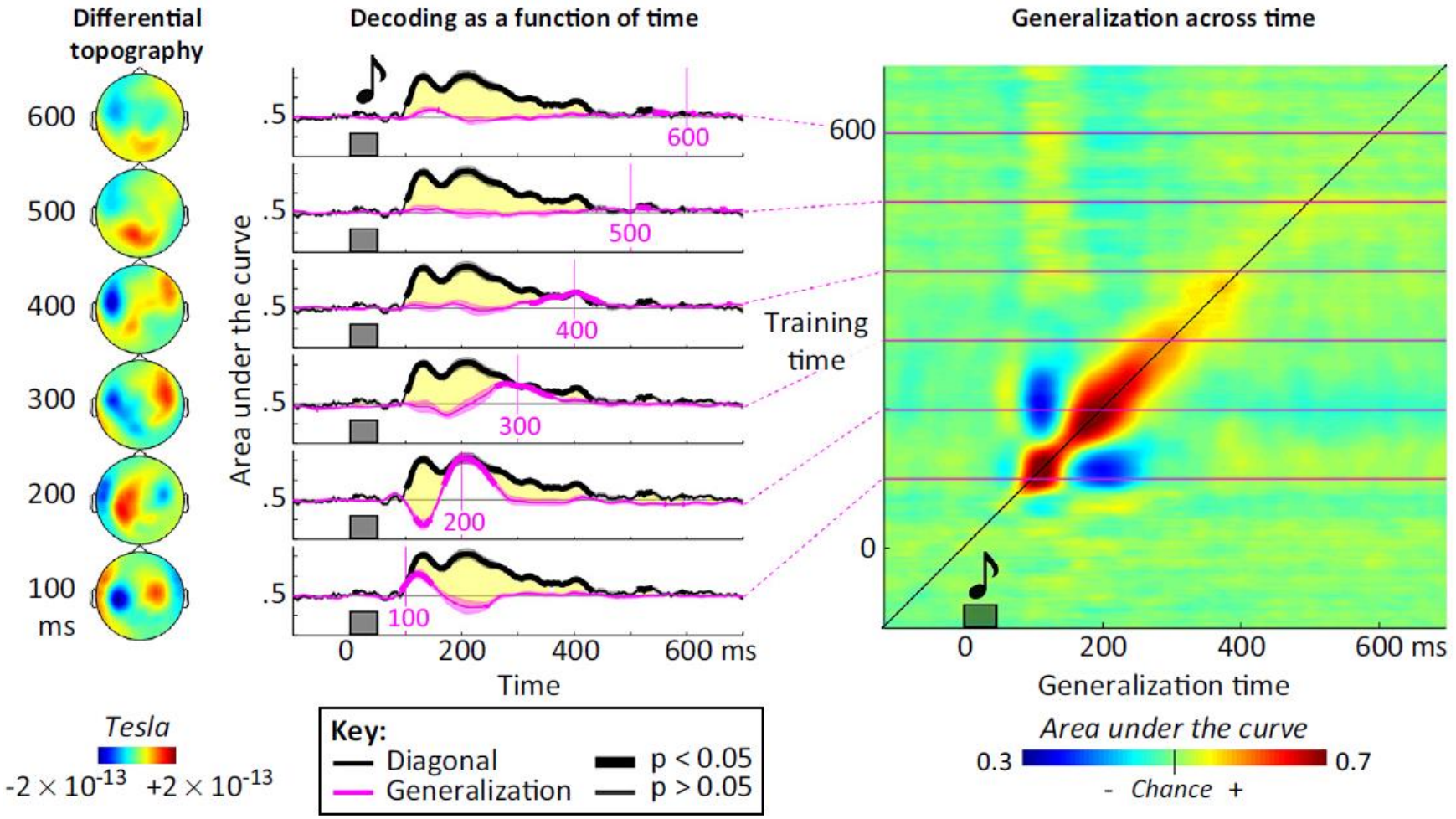
Temporal generalisation





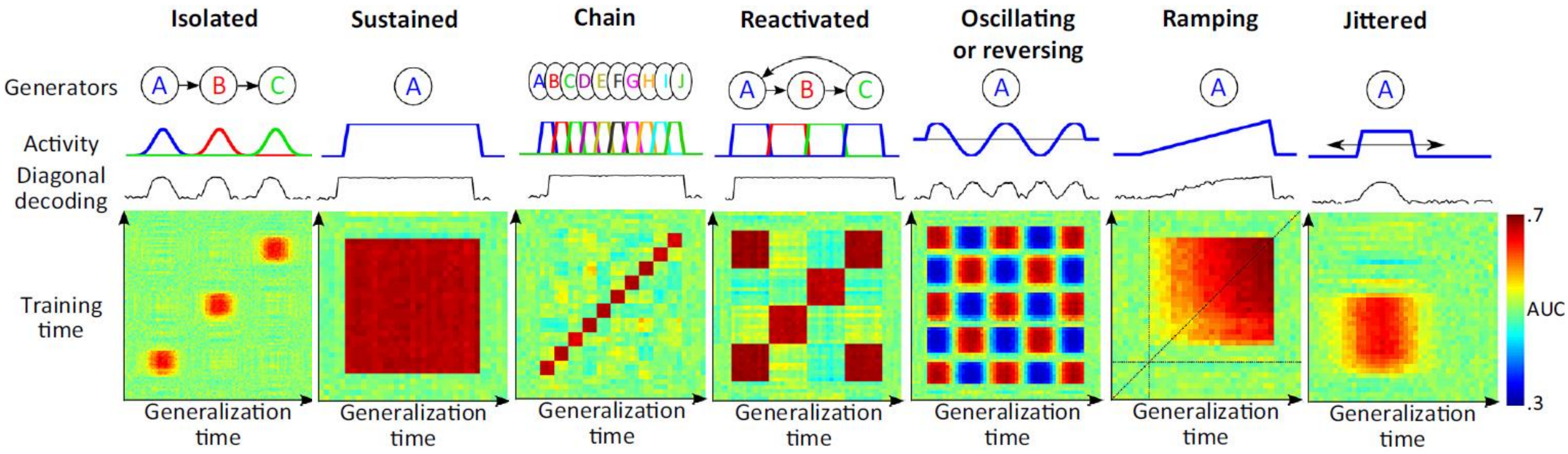
King & Dehaene, TICS 2014
https://pubmed.ncbi.nlm.nih.gov/27779910/

Temporal generalisation



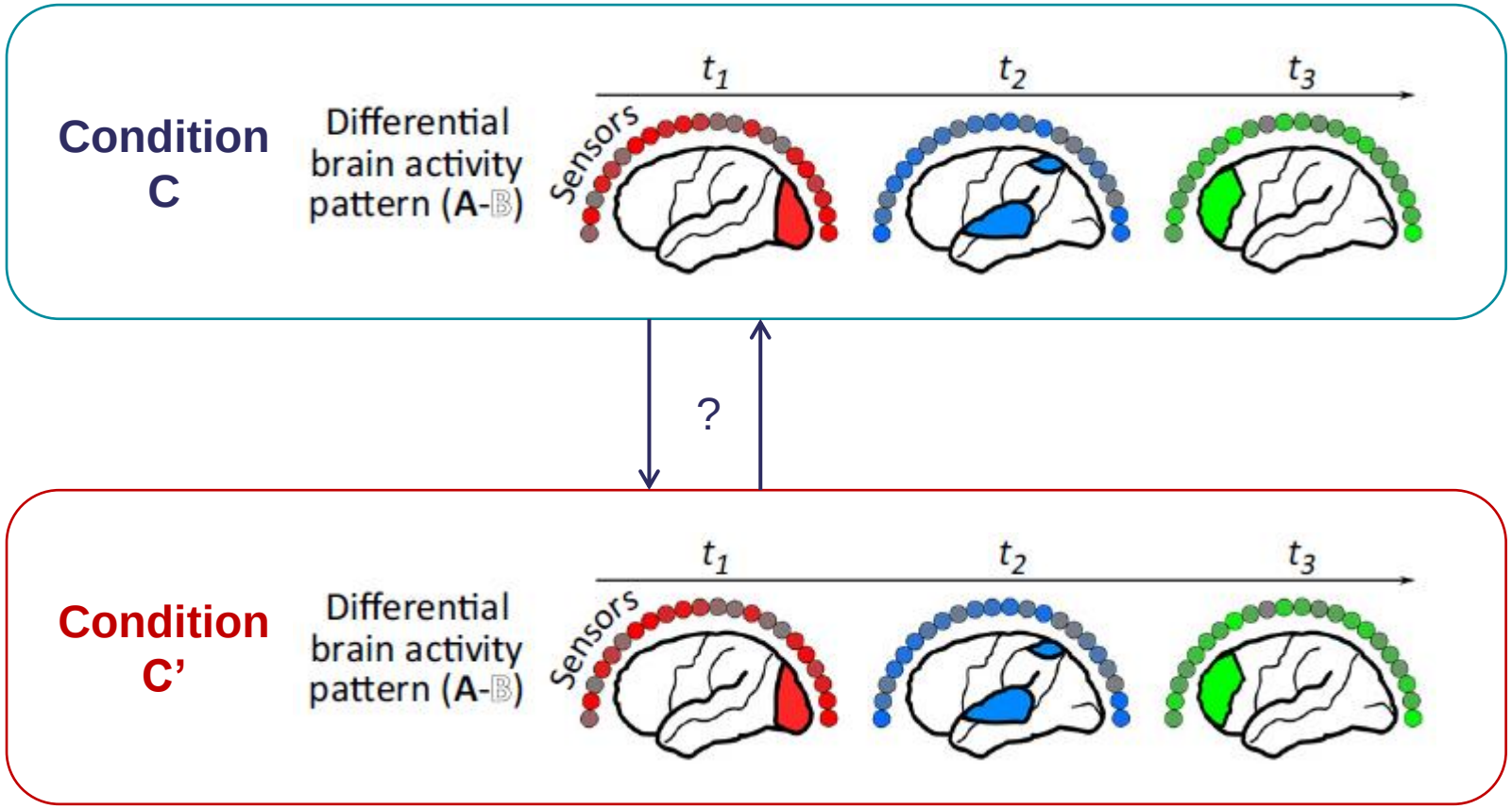
King & Dehaene, TICS 2014
https://pubmed.ncbi.nlm.nih.gov/27779910/

Temporal generalisation



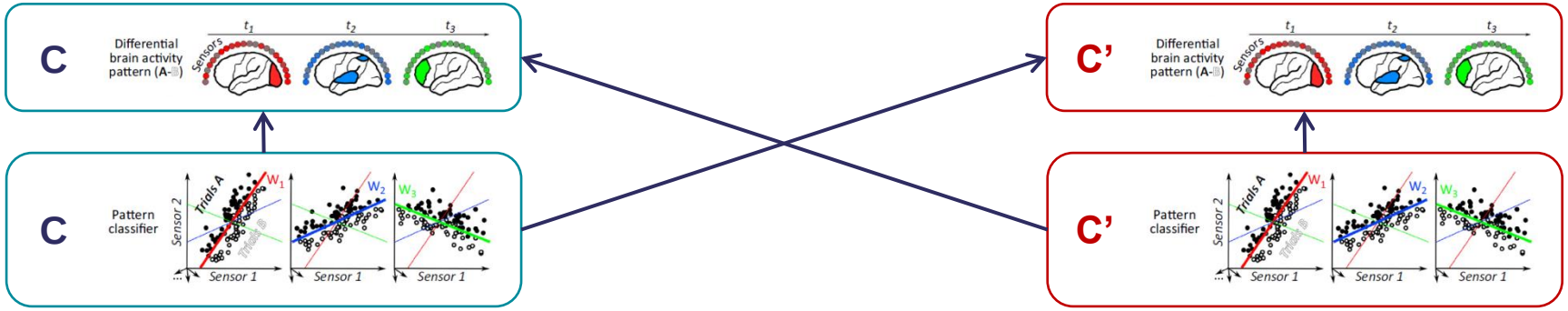
King & Dehaene, TICS 2014
https://pubmed.ncbi.nlm.nih.gov/27779910/

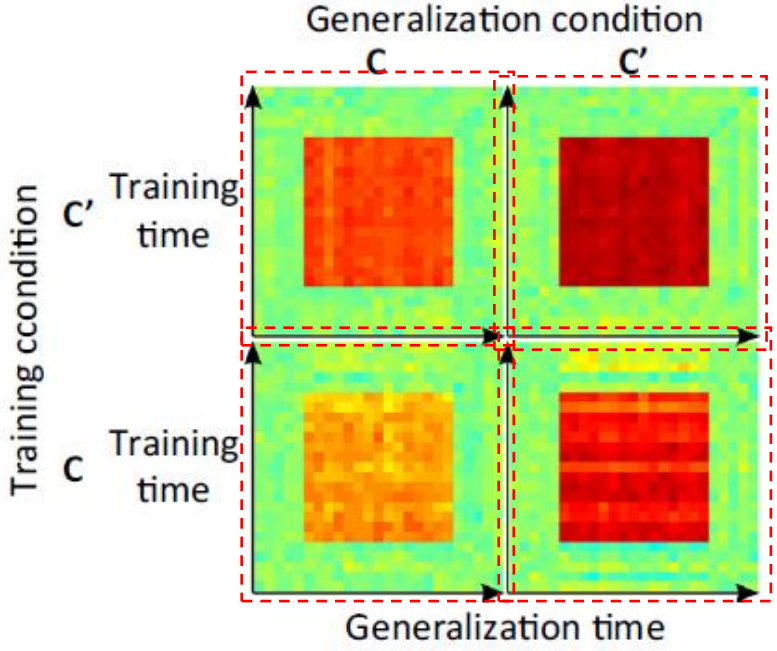
Temporal and across-condition generalisation



King & Dehaene, TICS 2014
https://pubmed.ncbi.nlm.nih.gov/27779910/

Temporal and across-condition generalisation





King & Dehaene, TICS 2014
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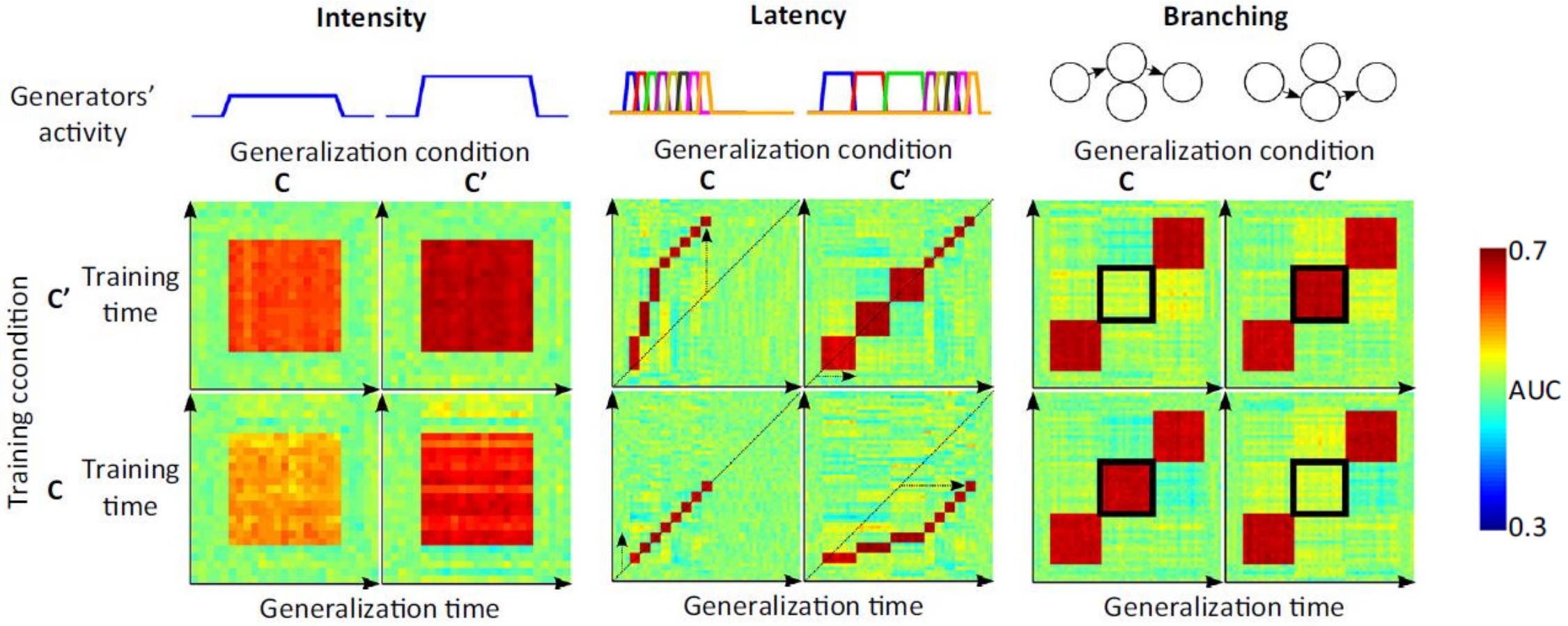
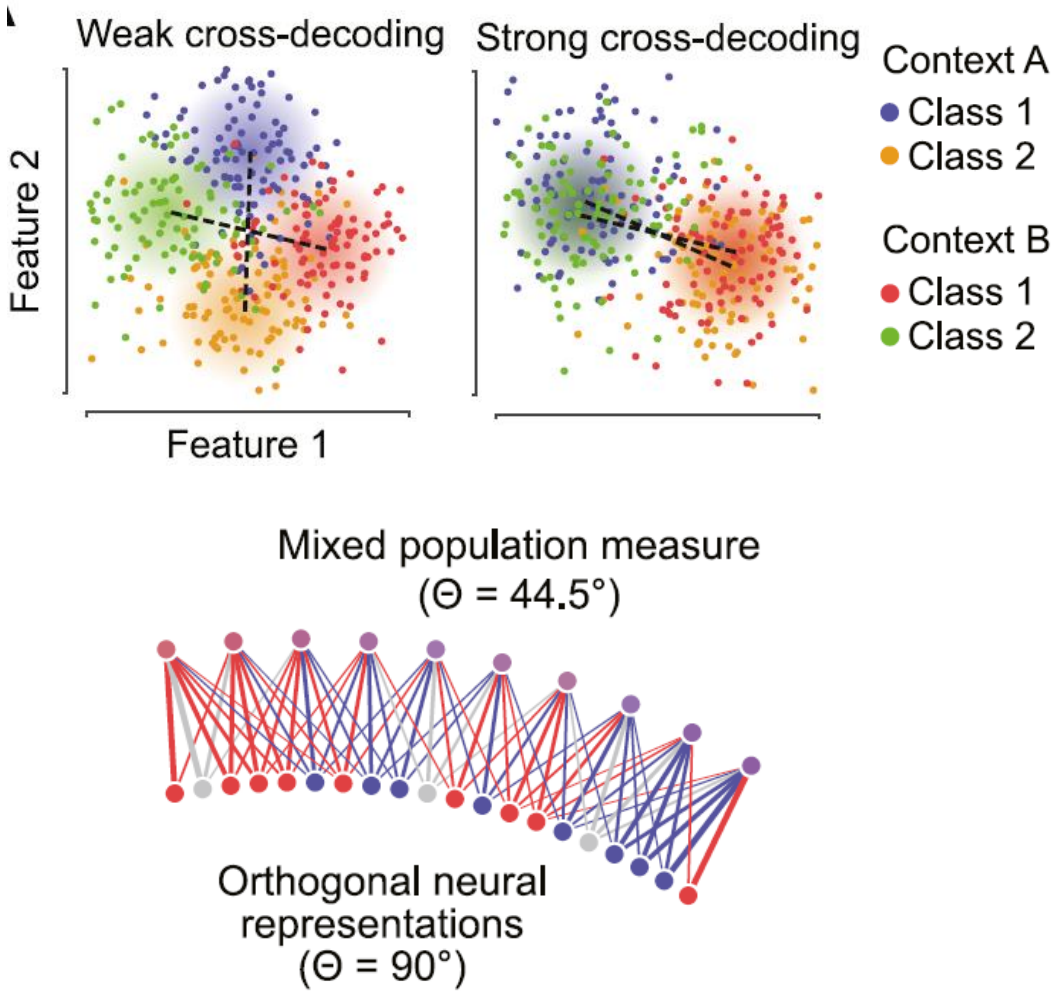
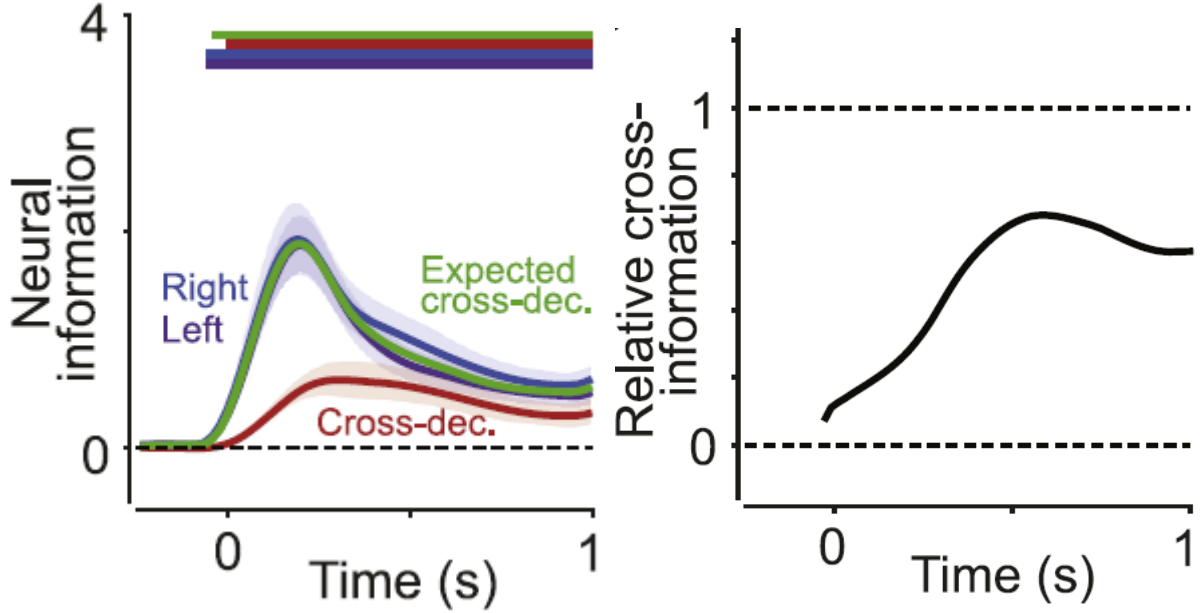
Temporal and across-condition generalisation



King & Dehaene, TICS 2014
https://pubmed.ncbi.nlm.nih.gov/27779910/

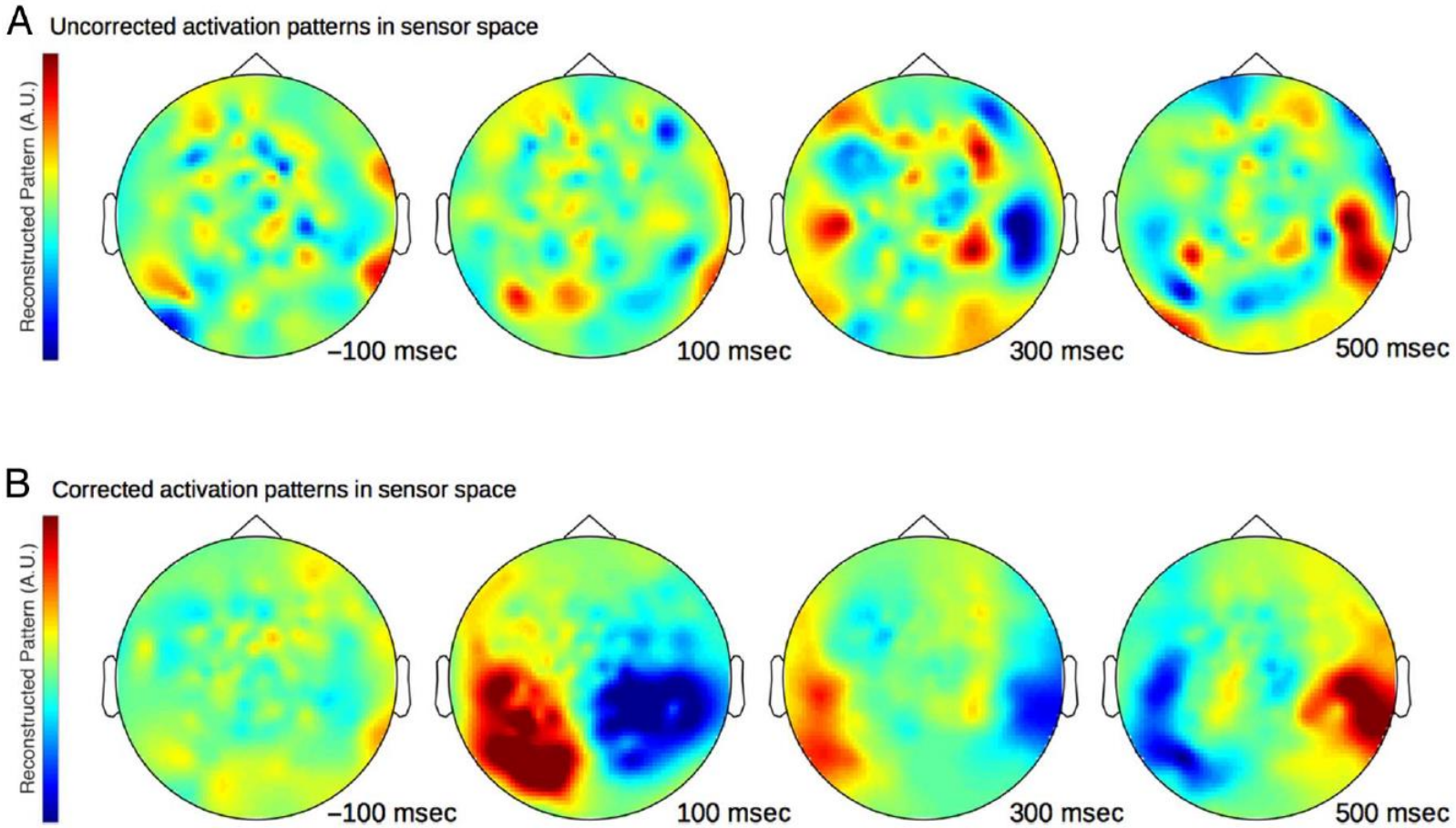
Interpreting the generalisation of neural representations





Sandhaeger & Siegel, NeuroImage 2023

Interpreting decoding weights



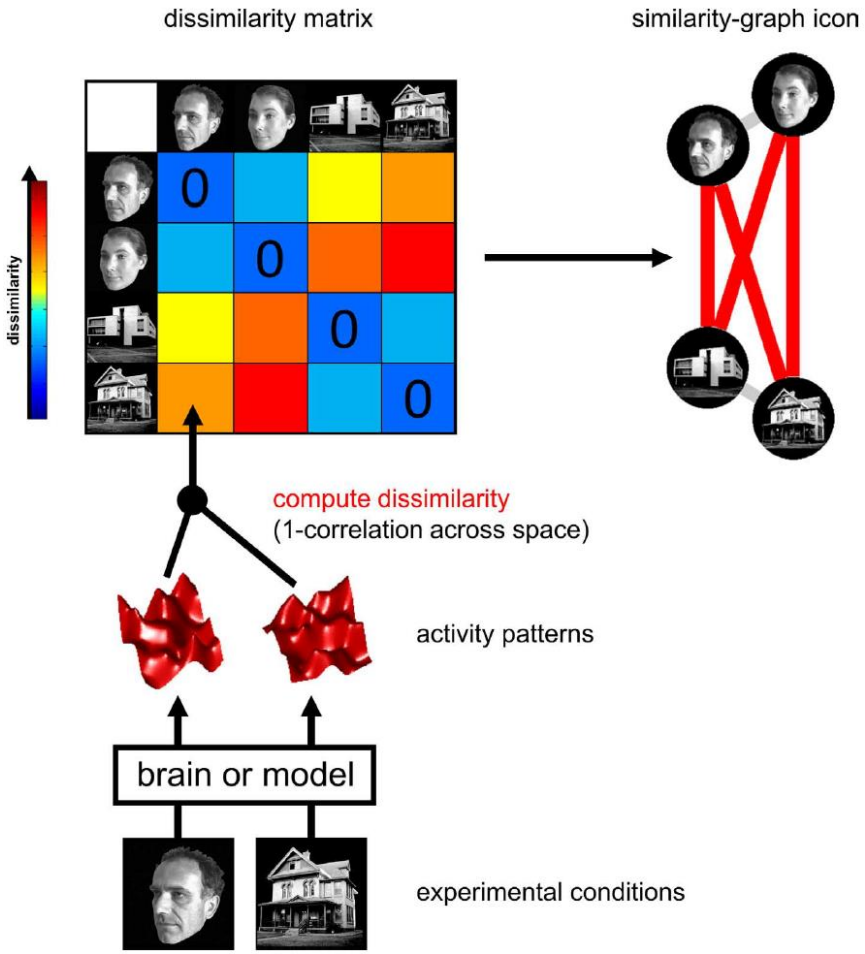
Haufe et al., Neuroimage 2014
https://www.sciencedirect.com/science/article/pii/S1053811913010914

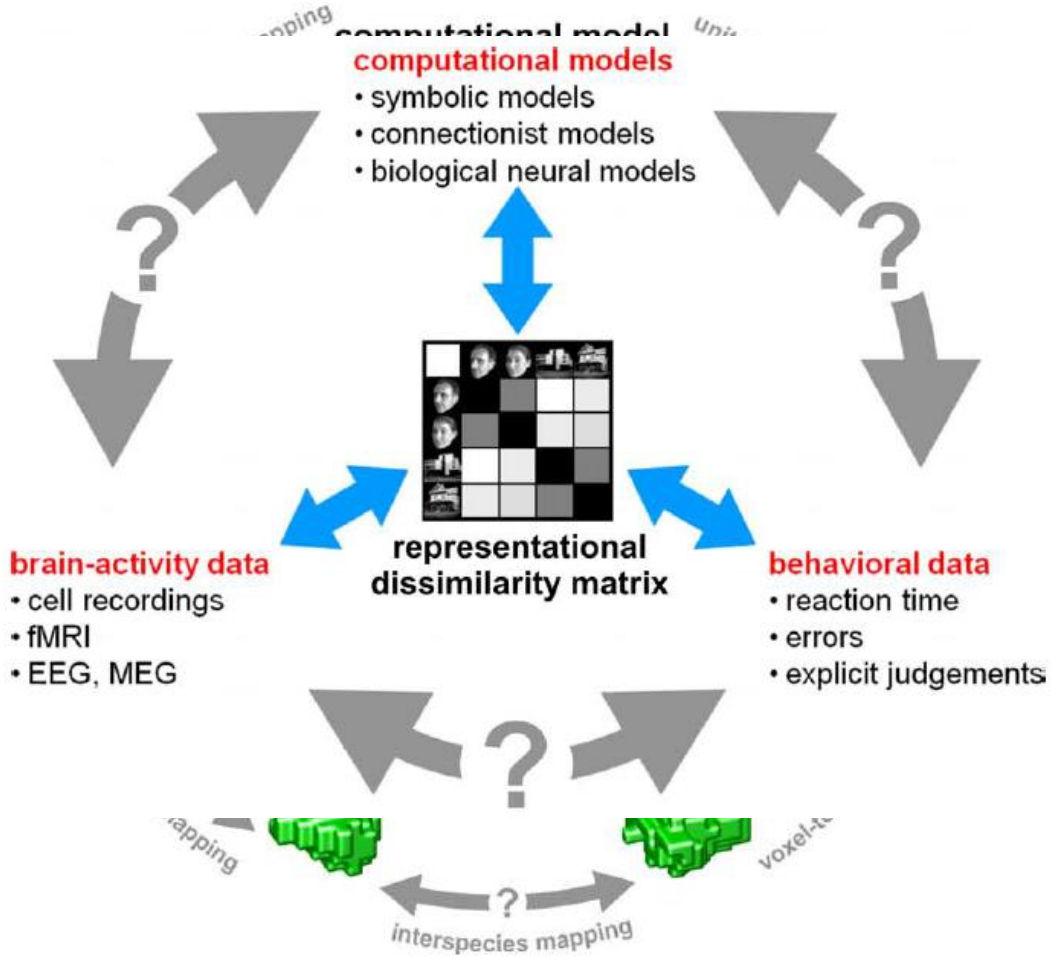
Images from: Grootswagers et al., JoCN 2017

Walk-through of demo notebook

Representational similarity analysis on EEG/MEG

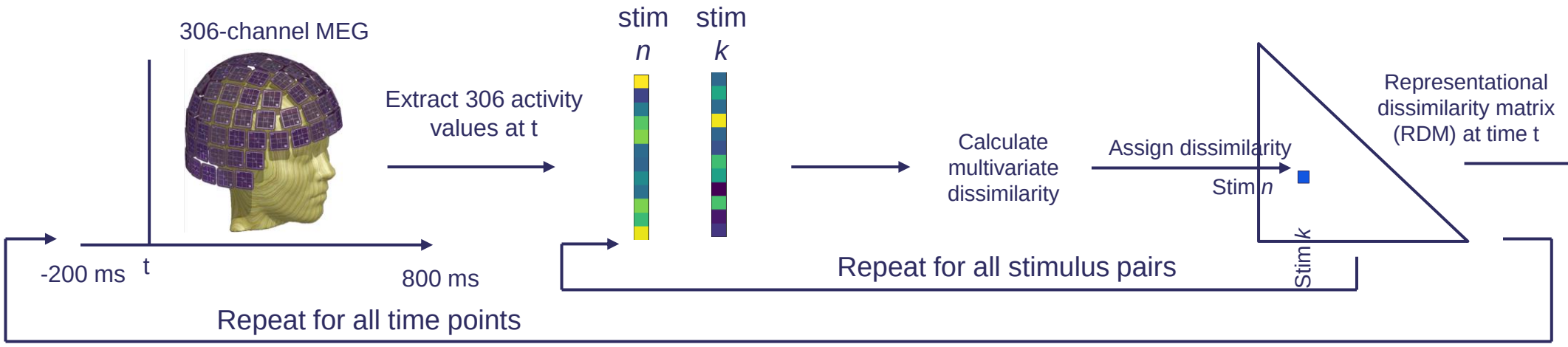
RSA recap

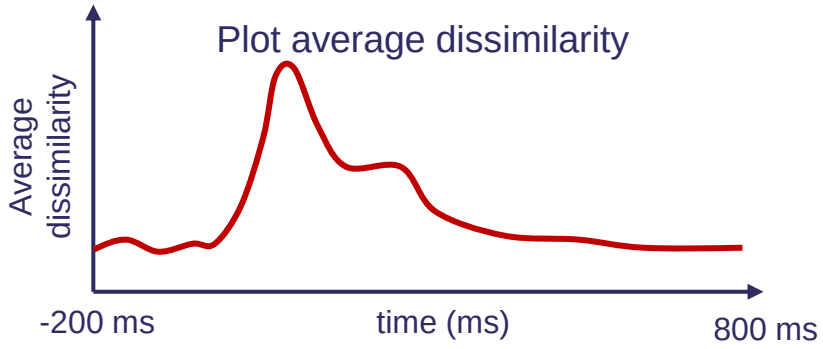


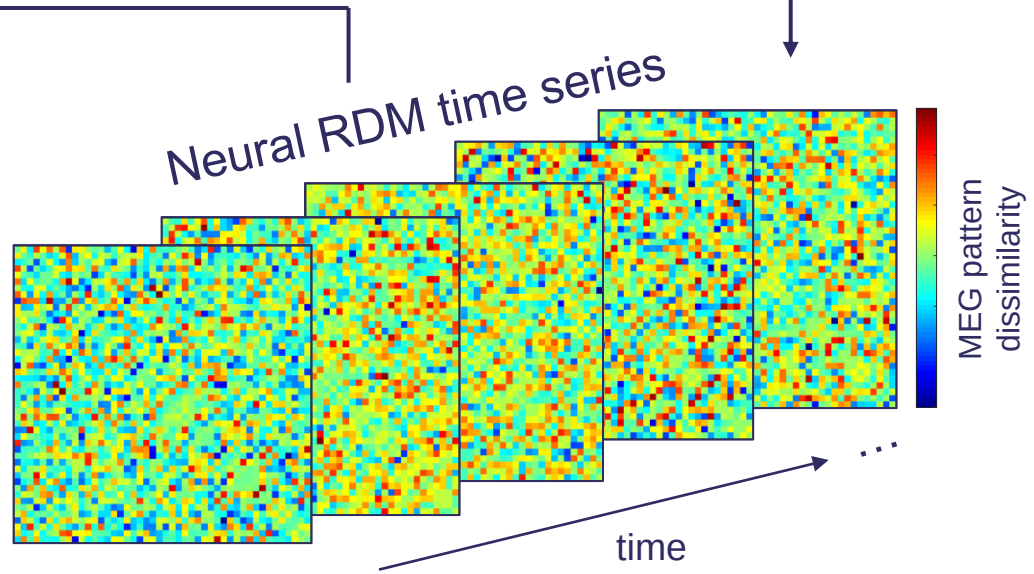


Kriegeskorte et al., Front Syst Nsc 2008, https://www.frontiersin.org/articles/10.3389/neuro.06.004.2008/full

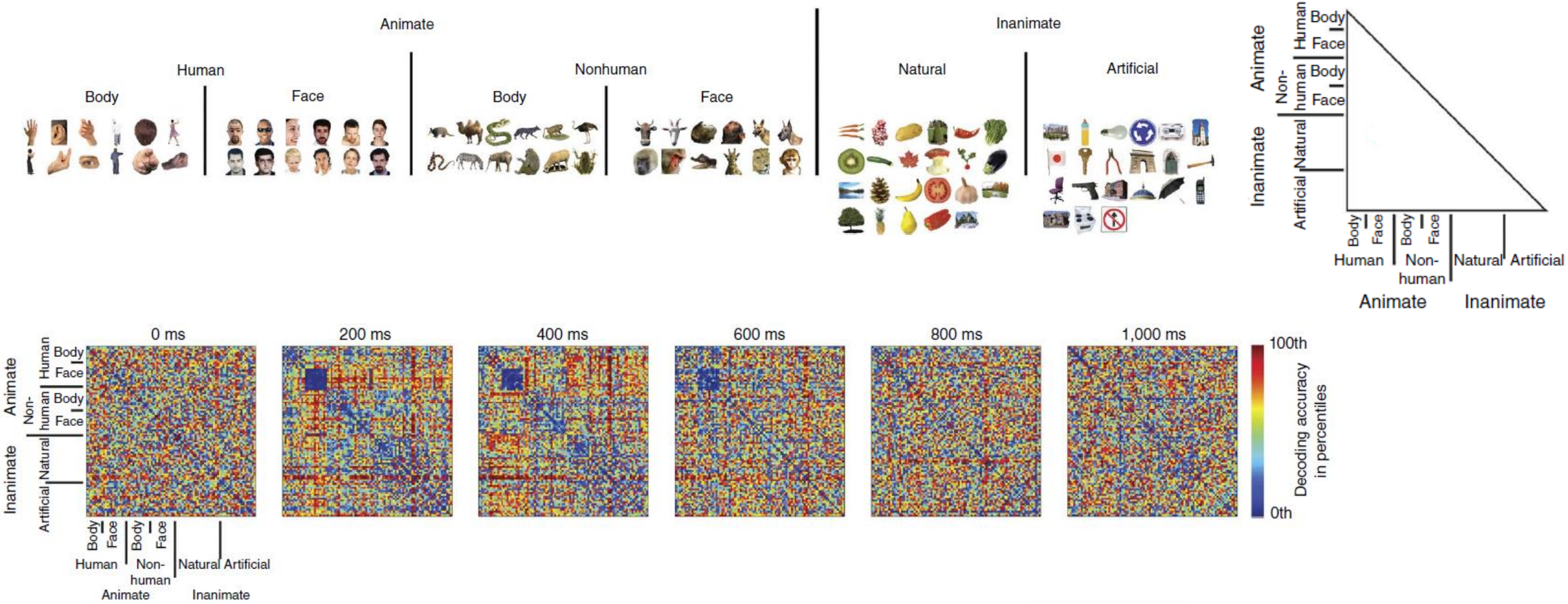
Time resolved RSA





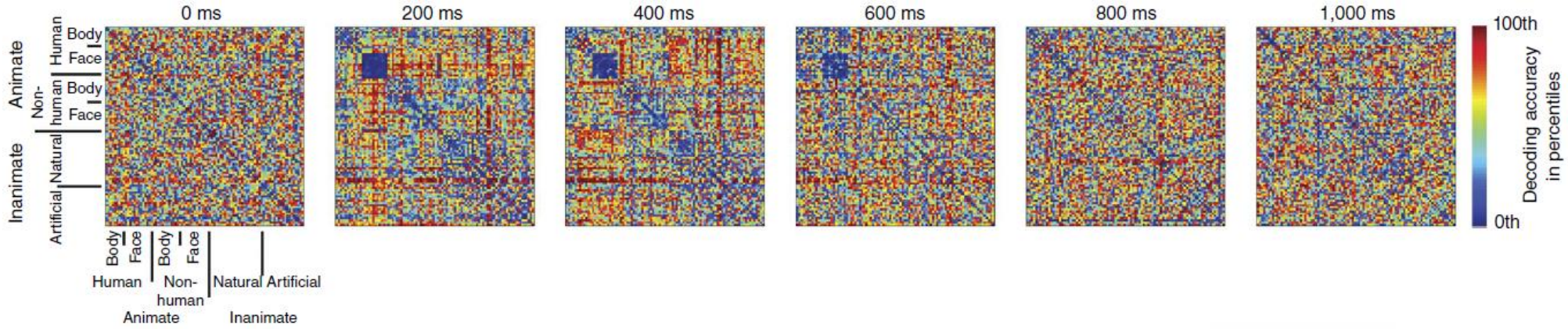


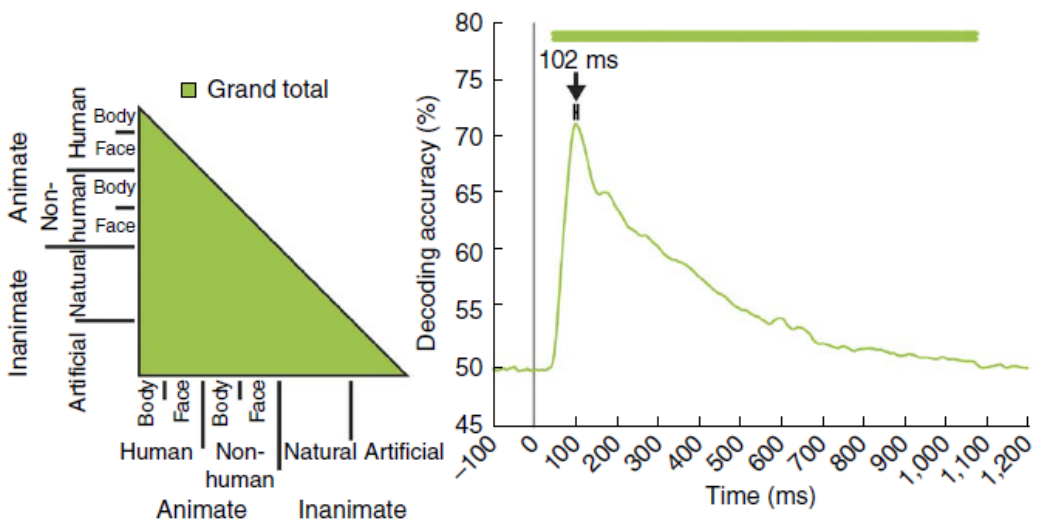
Time resolved RSA - example study Cichy et al. (2014)

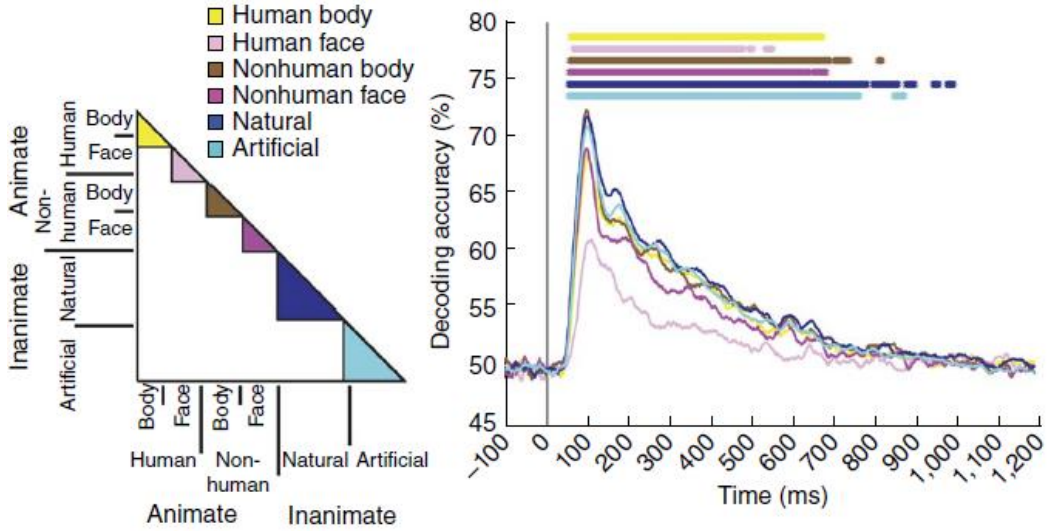


Cichy et al., Nat. Neuroscience 2014

Time resolved RSA - dissimilarity time courses

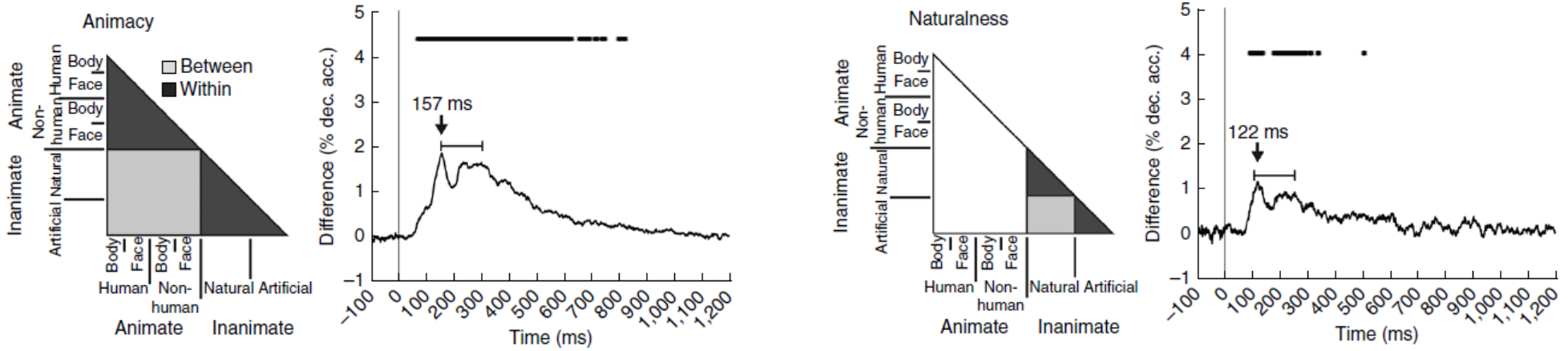






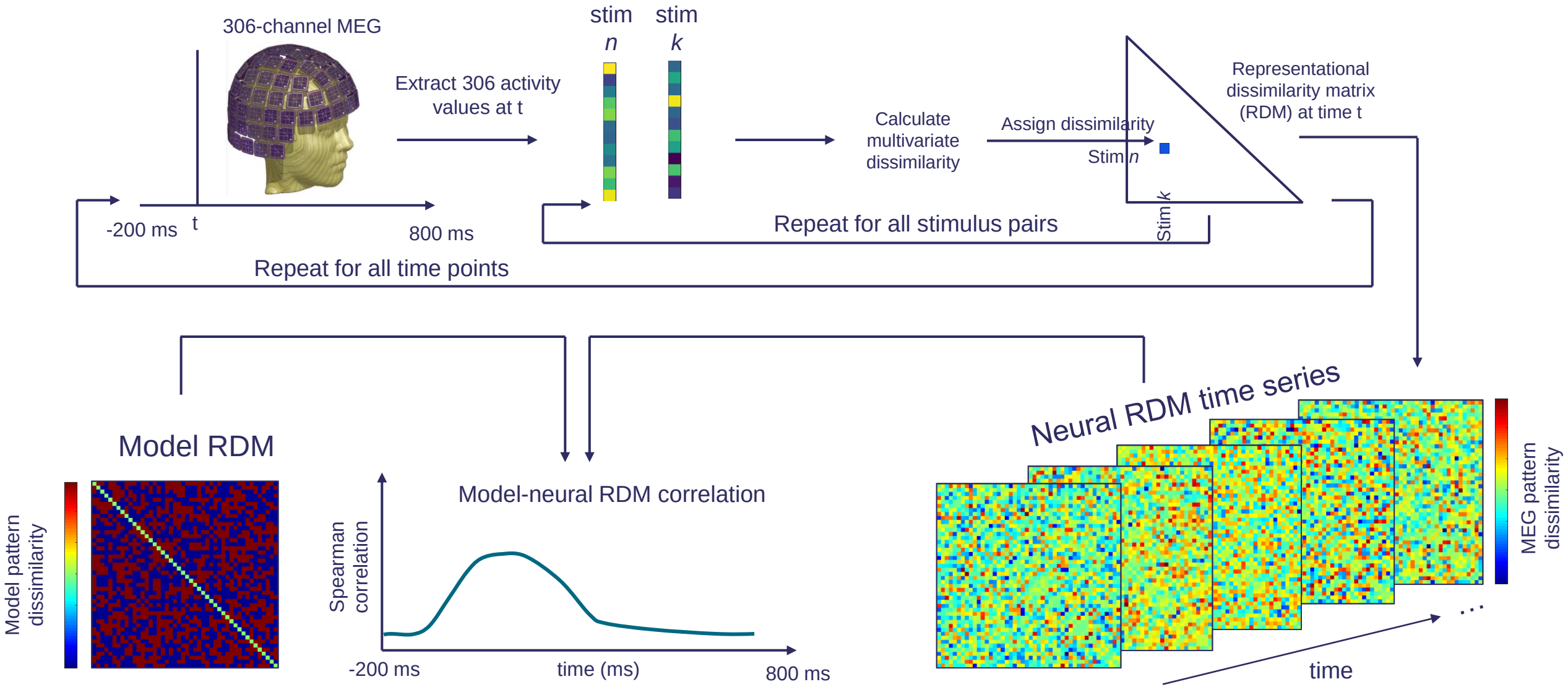
Cichy et al., Nat. Neuroscience 2014

Time resolved RSA – decoding categories

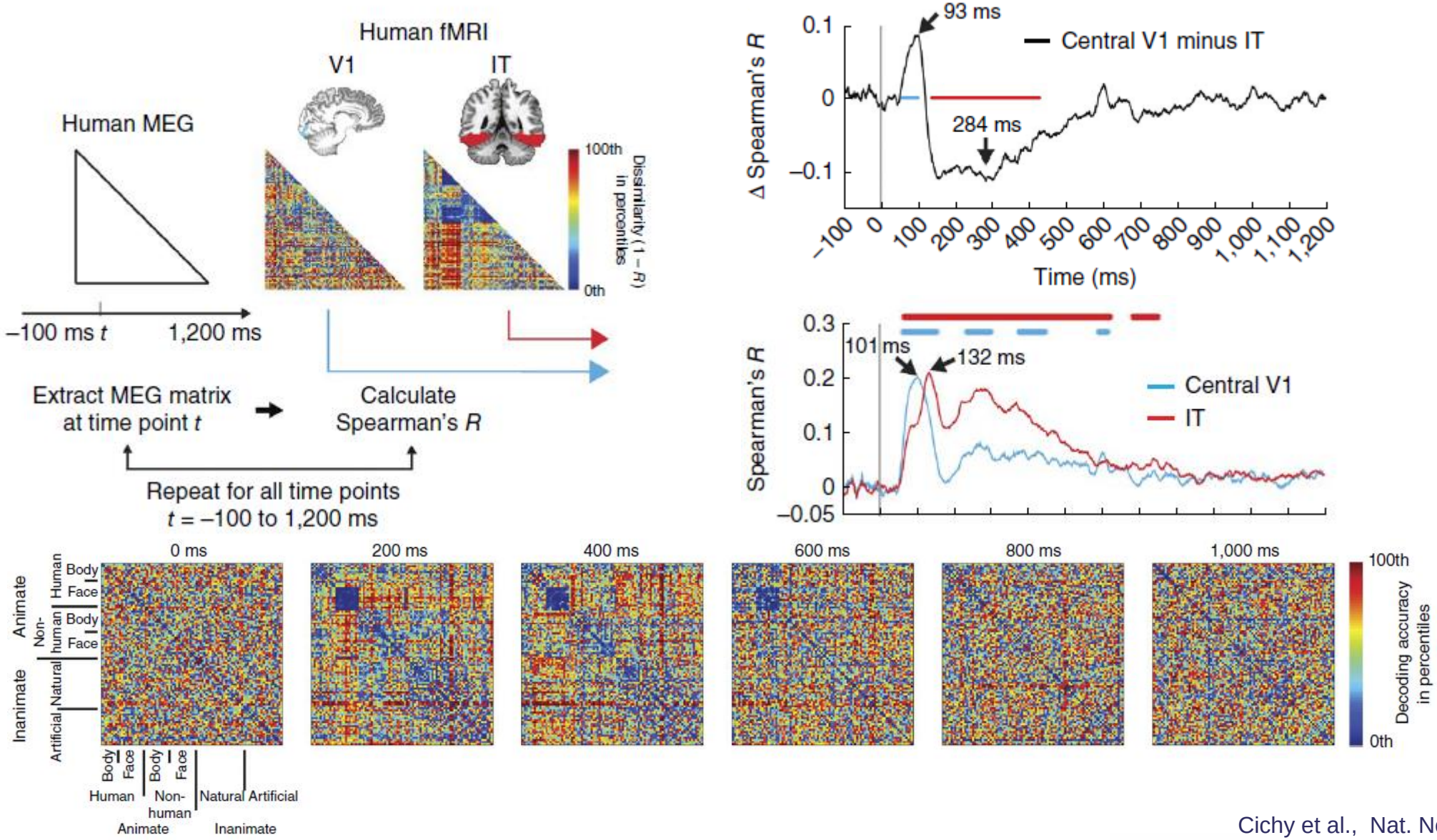


Cichy et al., Nat. Neuroscience 2014

Time resolved RSA – compare with model

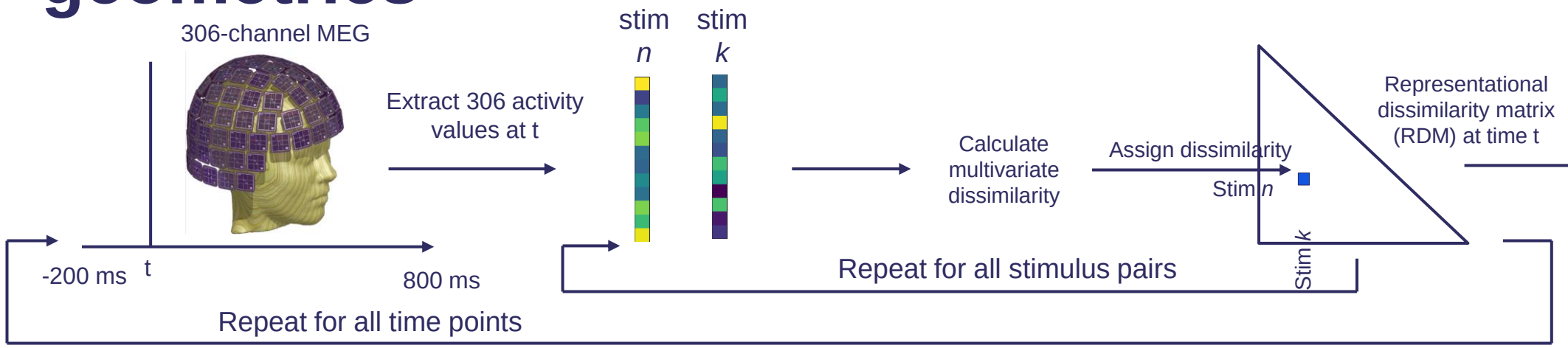


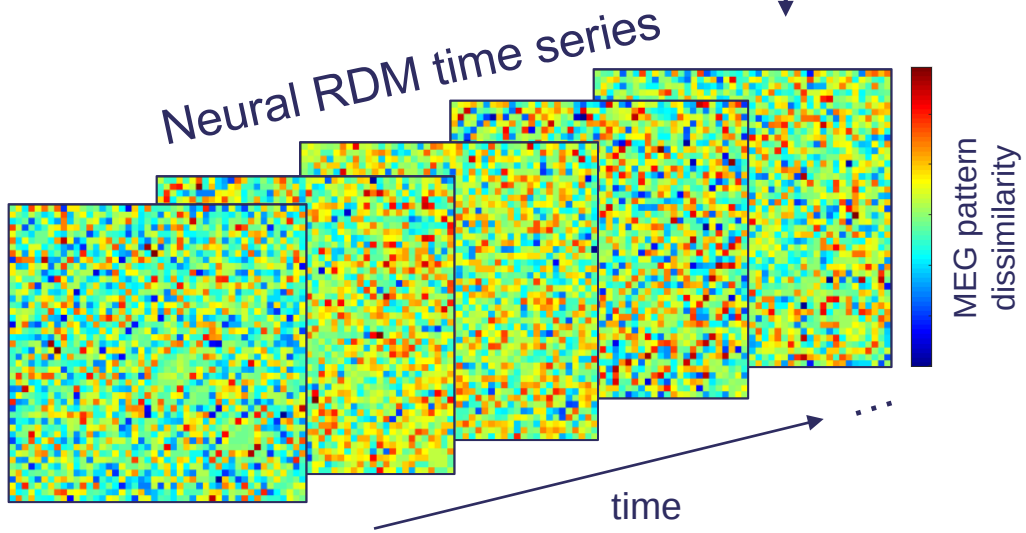
Time resolved RSA – compare with model



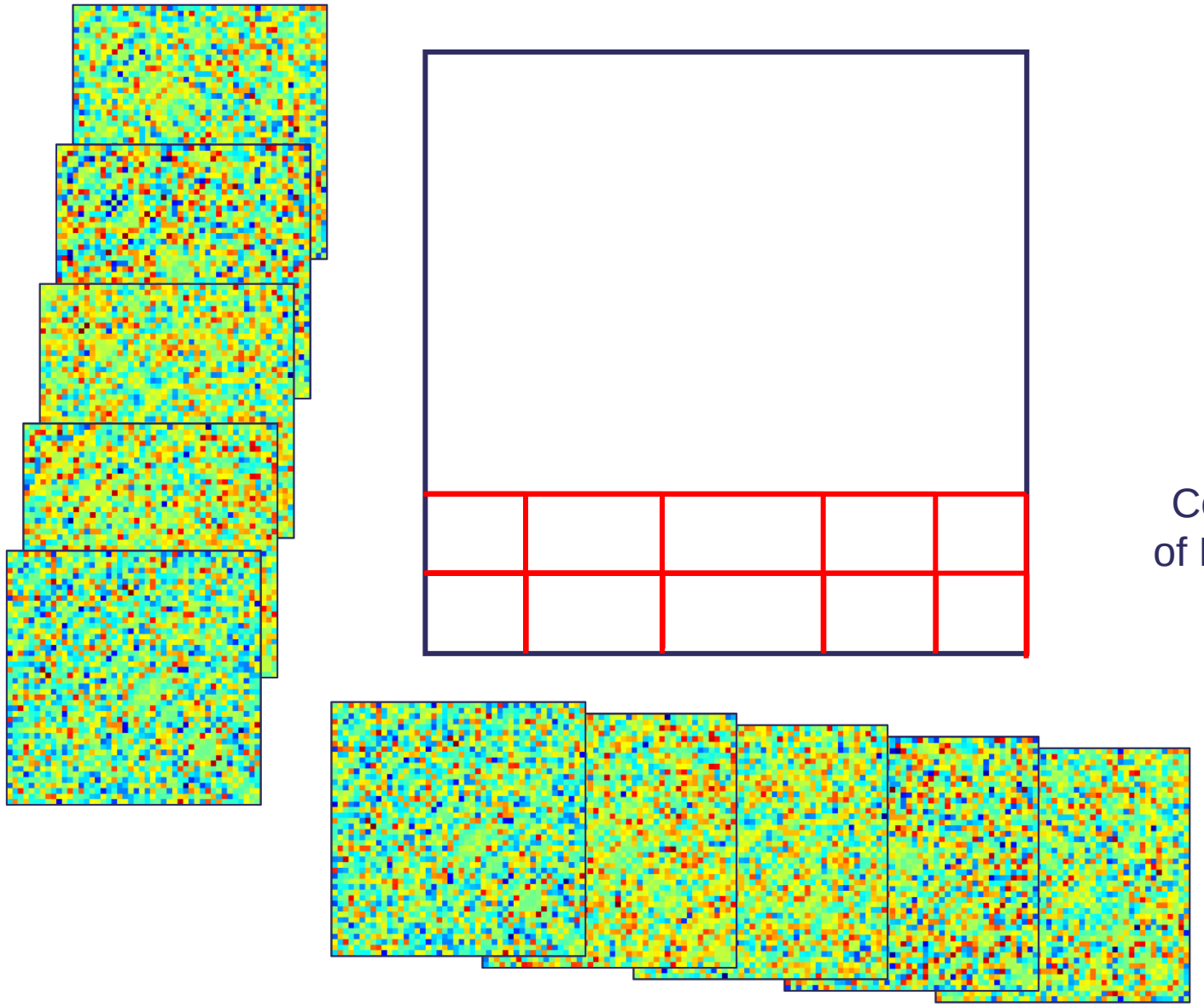
Cichy et al., Nat. Neuroscience 2014

Temporal generalisation of representational geometries



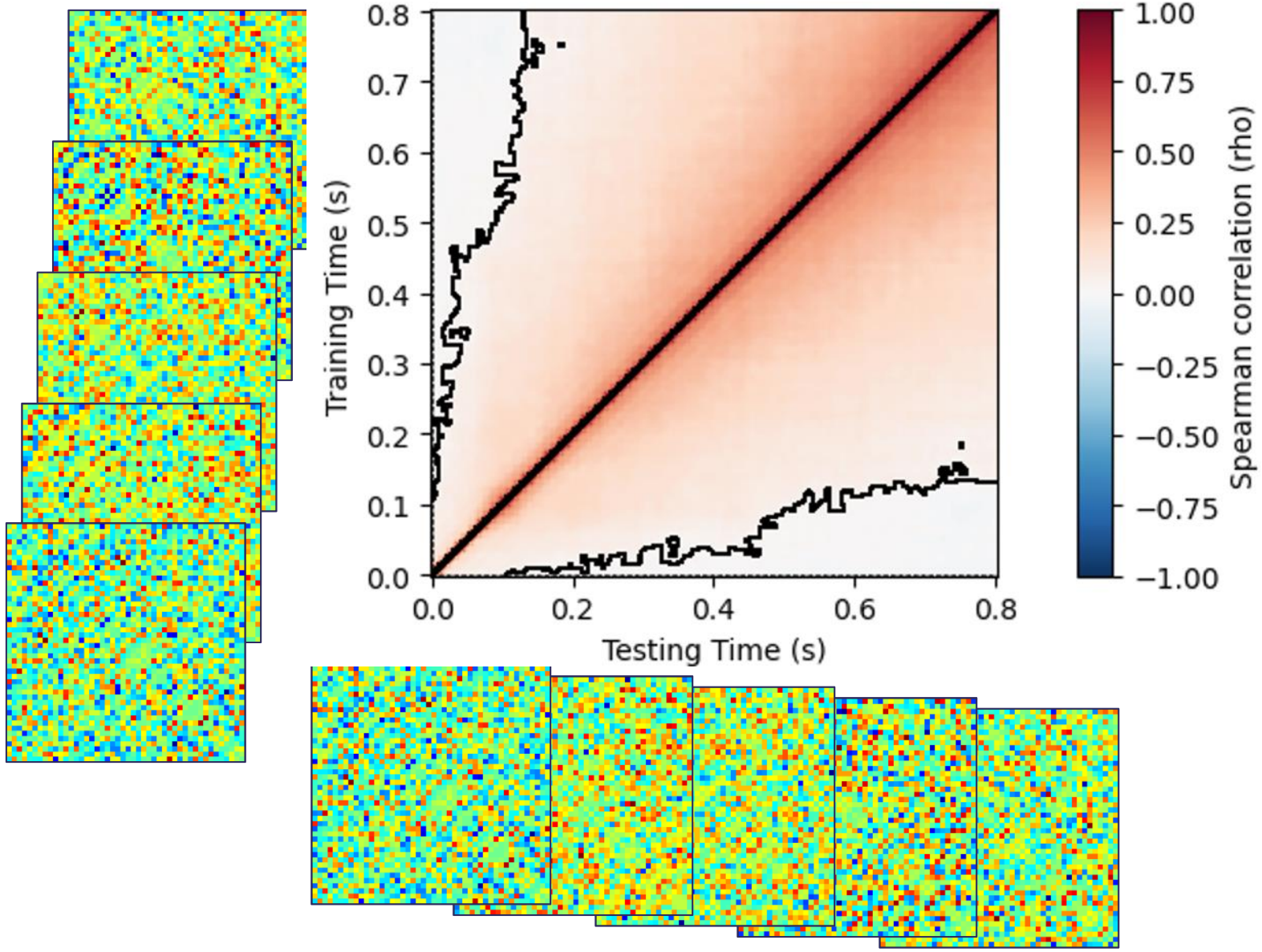


Temporal generalisation of representational geometries

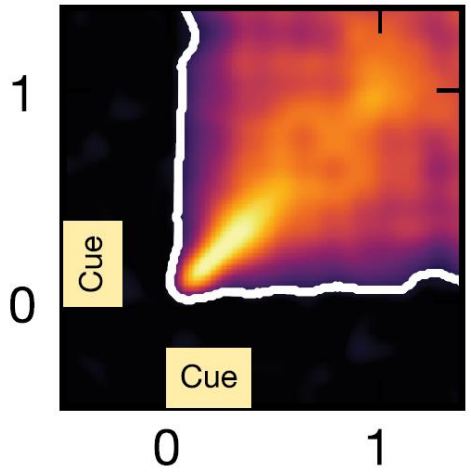


Compute pairwise correlation of RDMs between all time point pairs

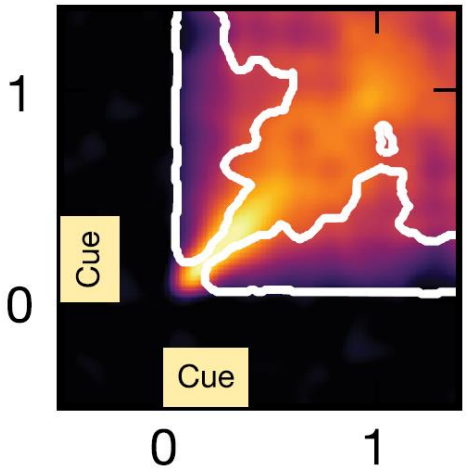
Temporal generalisation of representational geometries



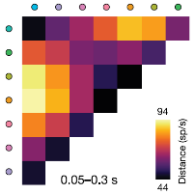
Temporal generalisation of representational geometries

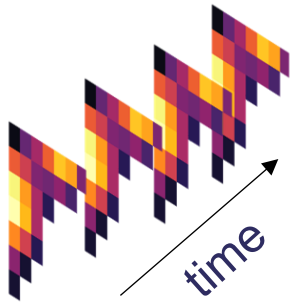


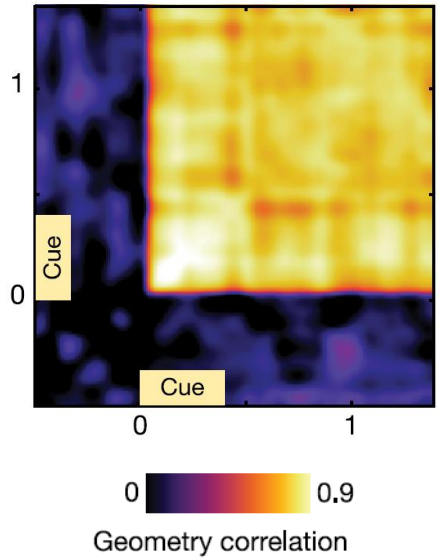
Significant generalisation



Significant dynamics



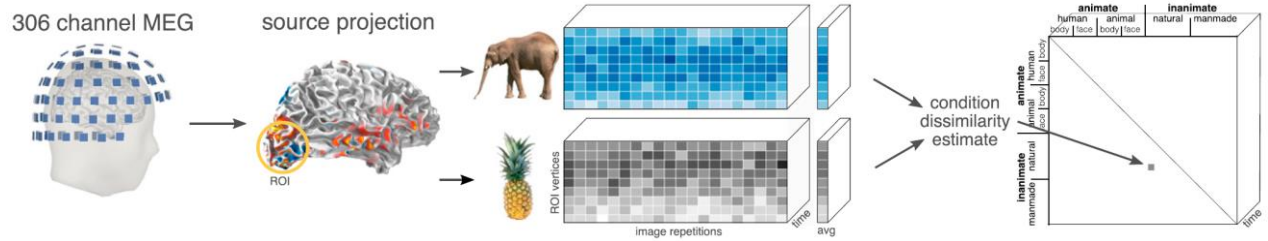


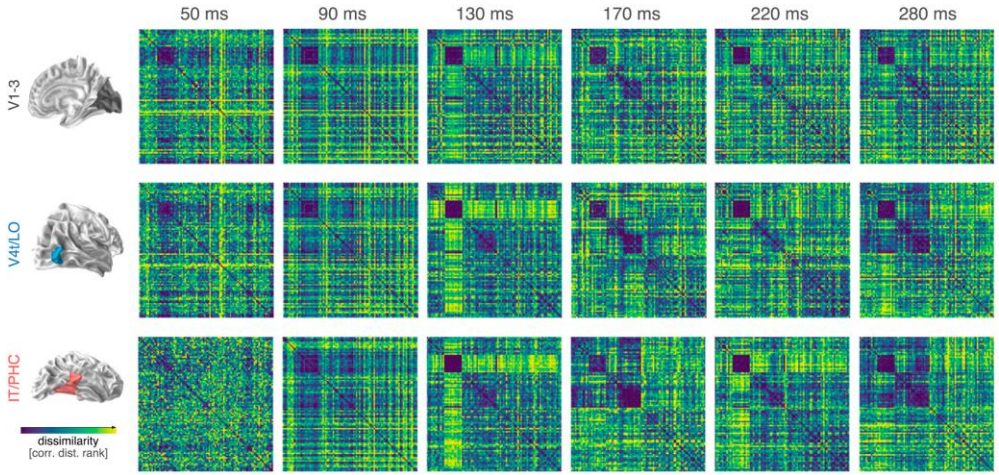


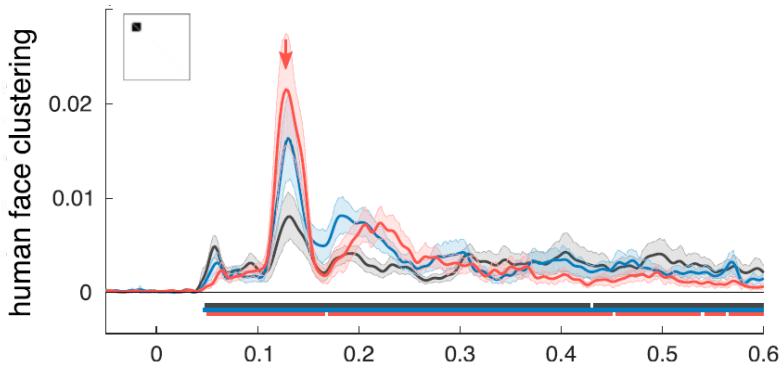
Stable representational geometry despite dynamic neural representations

Spaak et al., J Neuroscience 2017

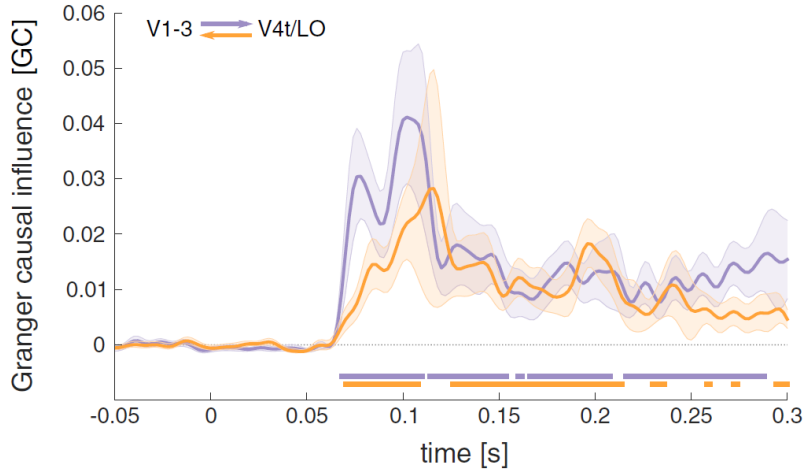
Decoding Information Over Time And Space

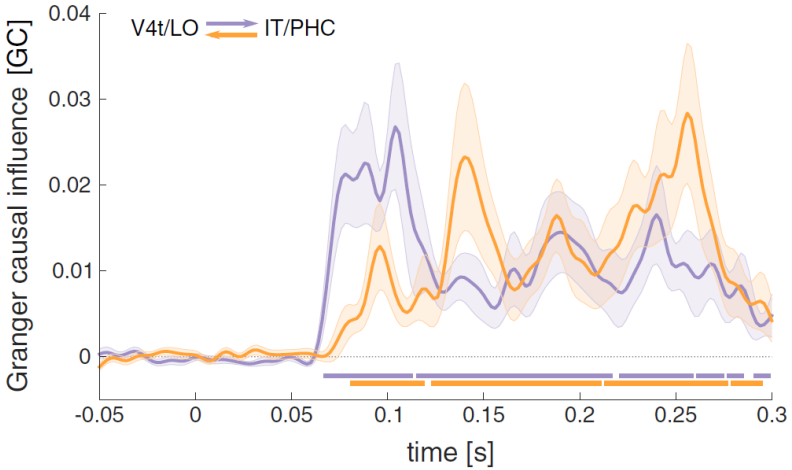






RSA Granger Analysis of Information Flow





Kietzmann et al., PNAS 2019, https://www.pnas.org/doi/10.1073/pnas.1905544116
Also: Goddard et al. 2018: https://pubmed.ncbi.nlm.nih.gov/26806290/,

Walk-through of demo notebook

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Thank you