Representational Similarity Analysis

Using MNE-RSA

Marijn van Vliet

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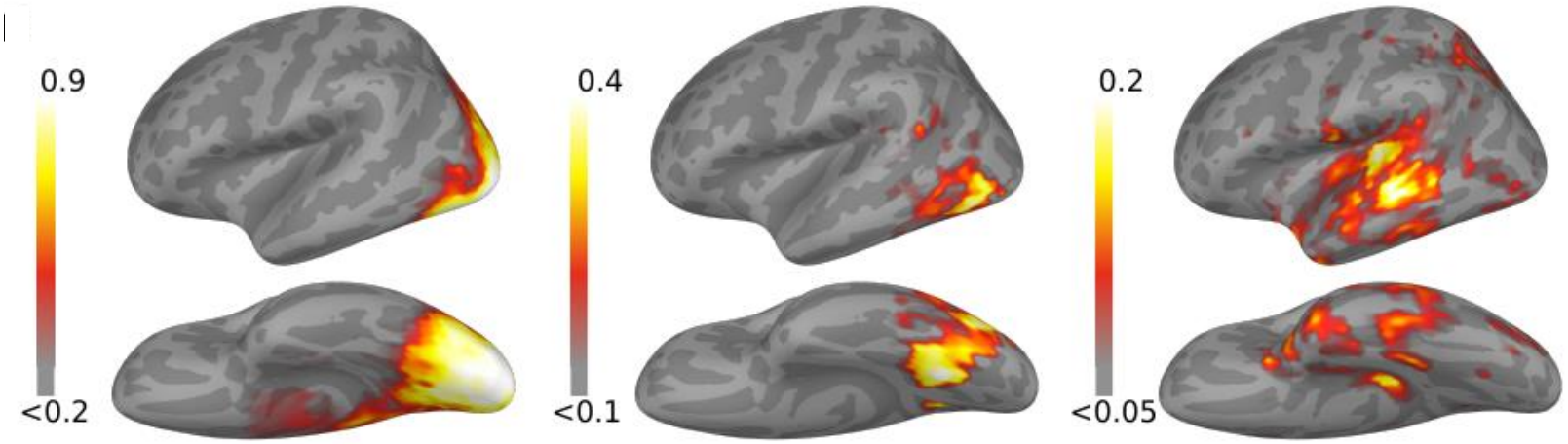
Berlin Brainwaves
Advanced MNE-Python, day 1

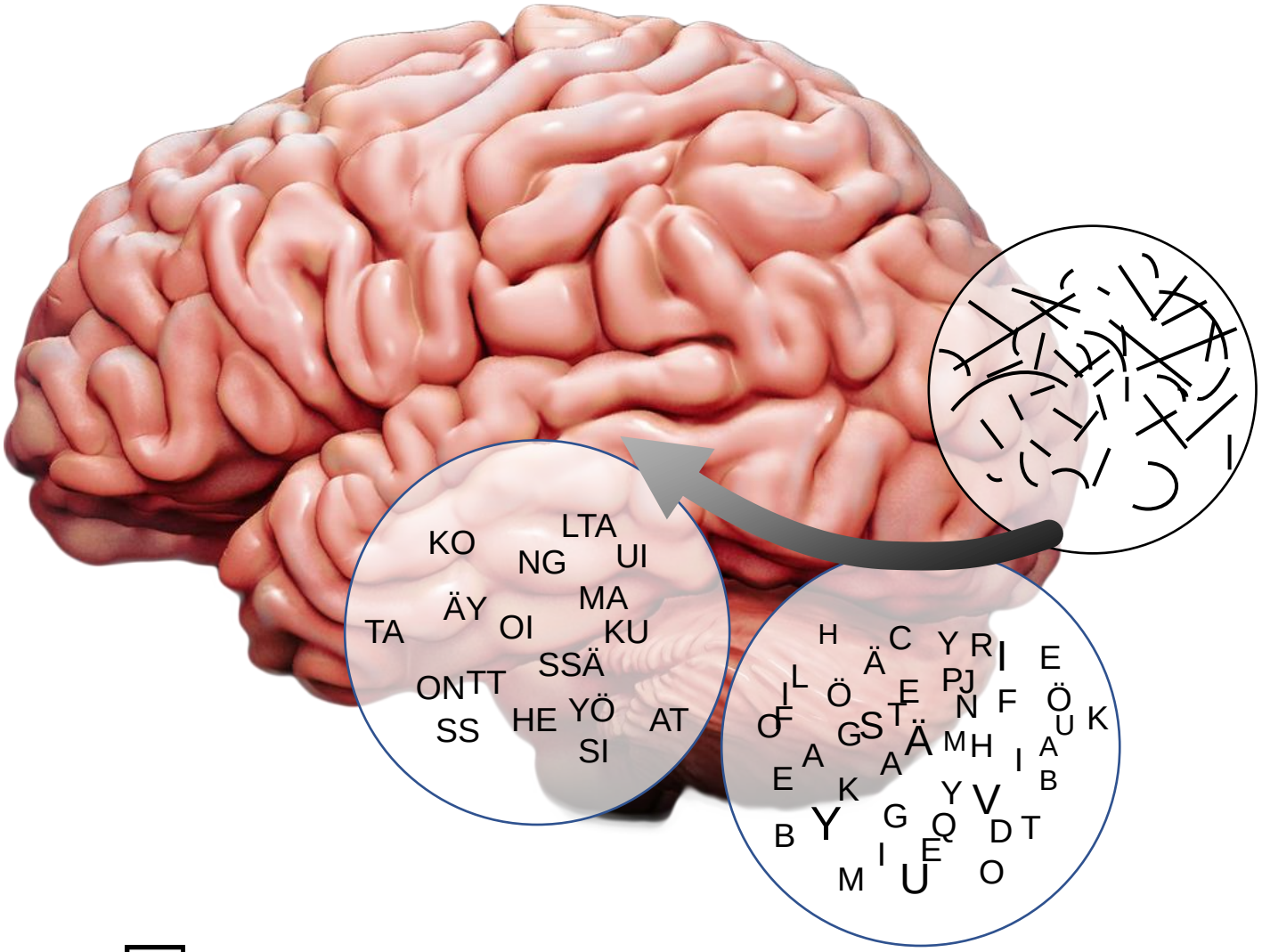
Program for this afternoon

1. **Lecture on RSA (30 mins)**
2. Hands-on RSA exercise (45 mins)
3. RSA wrap-up, Q&A (15 mins)
4. Break (20 mins)
5. Lecture on statistics (30 mins)
6. Hands-on statistics exercise (45 mins)
7. Statistics wrap-up, Q&A (15 mins)

Instead of activations…



…think in terms of representations



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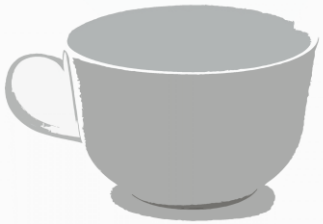
Hauk, Jackson, and Rahimi (2023)

“representation” is a very vague concept

shape



photograph

pixel values

0	0	1	0	0	0	0	0
0	1	0	0	0	0	0	2
0	0	0	0	1	2	1	2
0	0	1	0	2	2	3	3
0	0	0	2	2	3	3	4

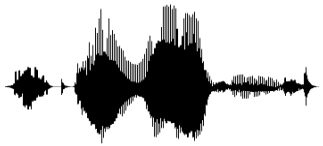
word identity

/CUP/

semantic features

✓ is round
✓ holds liquid
✗ is alive
✗ is expensive

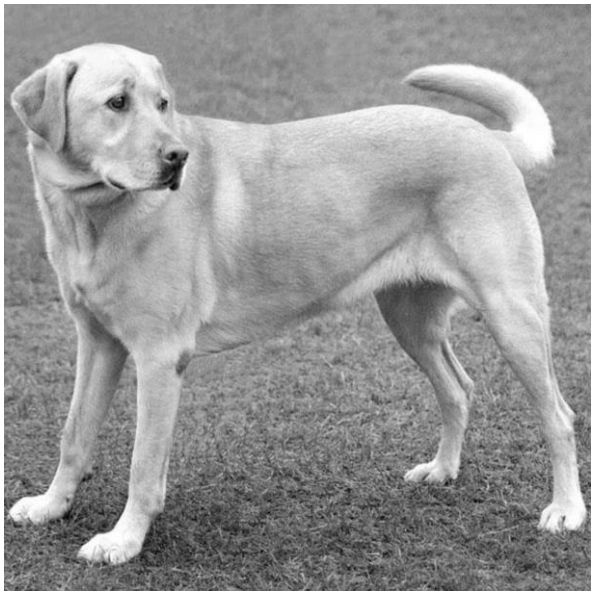
speech waveform



so how to formalize it?

Representations are defined through distances

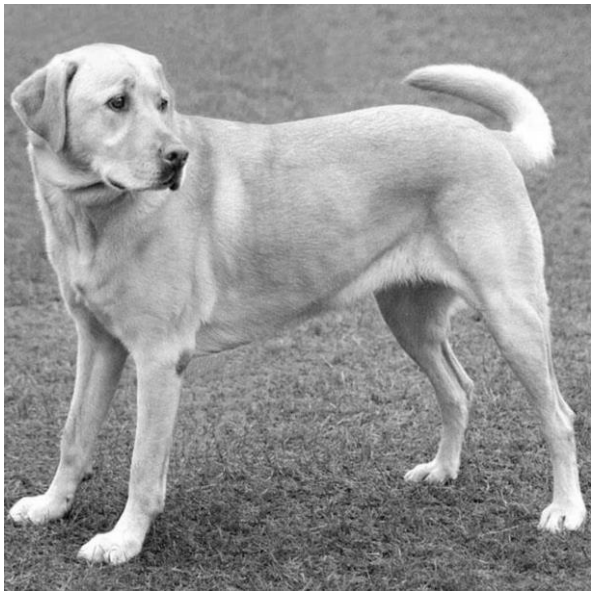
"pixel" representation



$\neq$

Representations are defined through distances

semantic representation

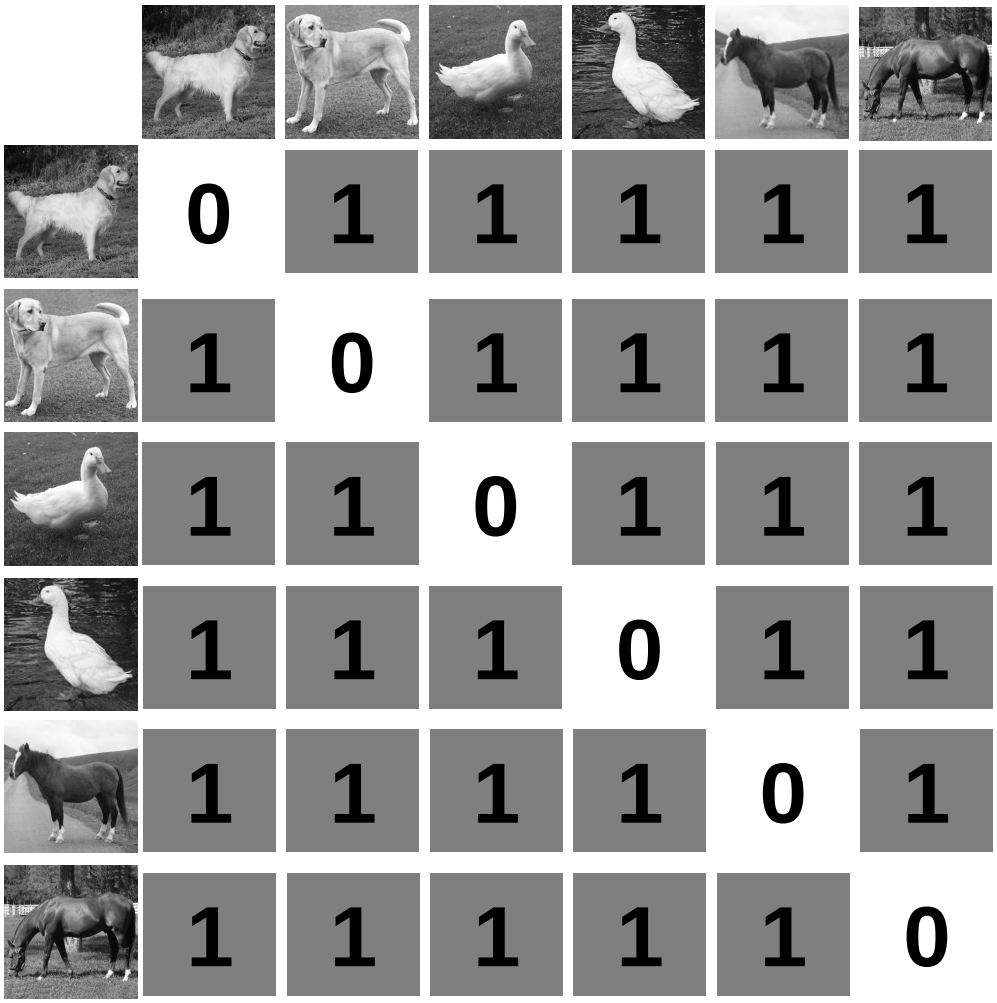


=

“dog”

“dog”

Representations are defined through distances



Representations are defined through distances

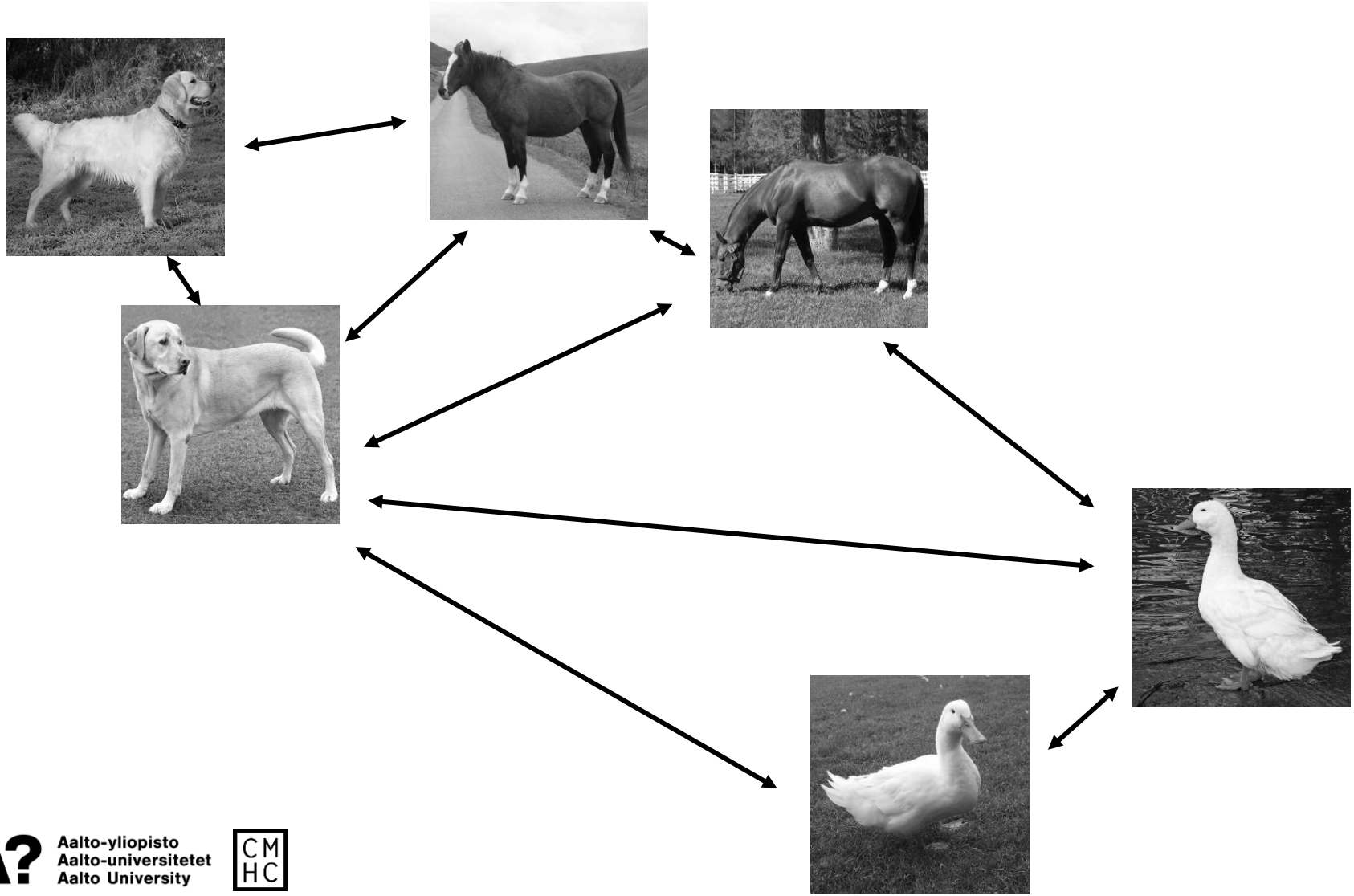
						
	0	0	1	1	1	1
	0	0	1	1	1	1
	1	1	0	0	1	1
	1	1	0	0	1	1
	1	1	1	1	0	0
	1	1	1	1	0	0

Representations are defined through distances

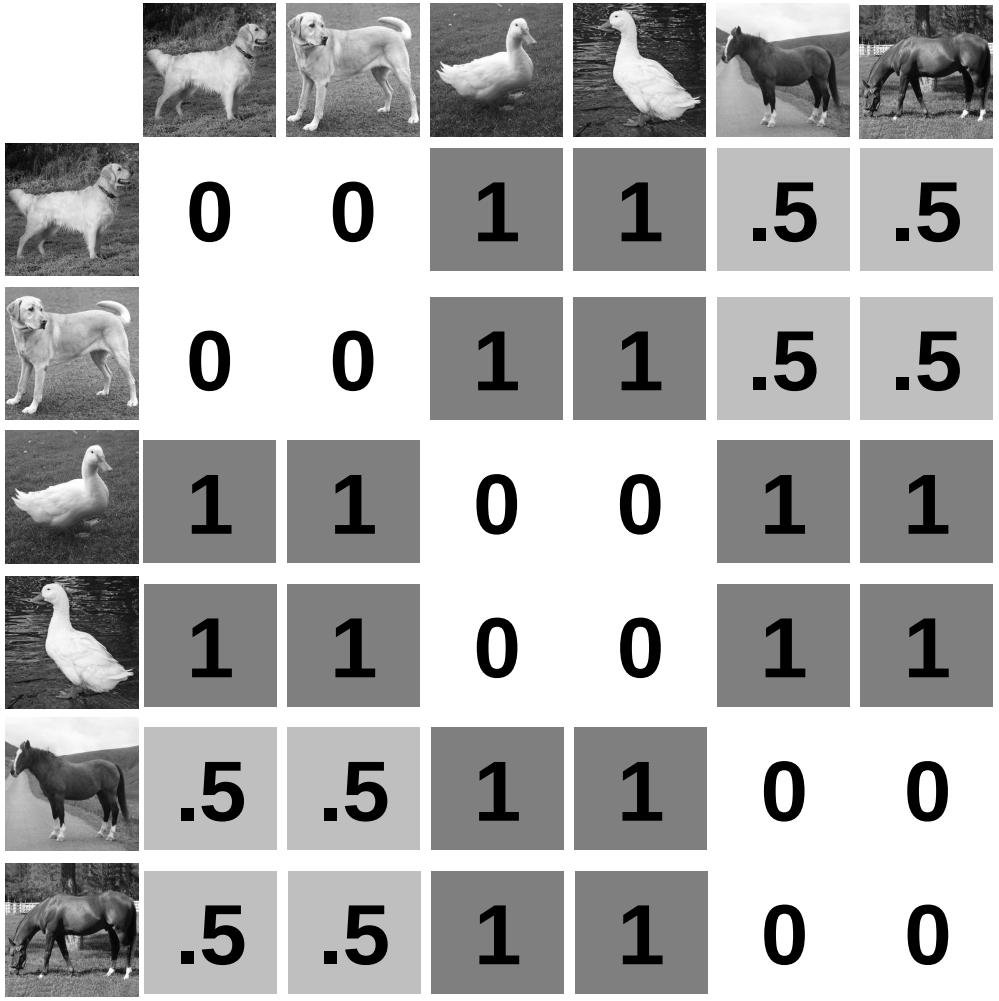
						
	0	0	1	1	.5	.5
	0	0	1	1	.5	.5
	1	1	0	0	1	1
	1	1	0	0	1	1
	.5	.5	1	1	0	0
	.5	.5	1	1	0	0

Alternative way to visualize RDMs

Multi-**D**imensional **S**caling

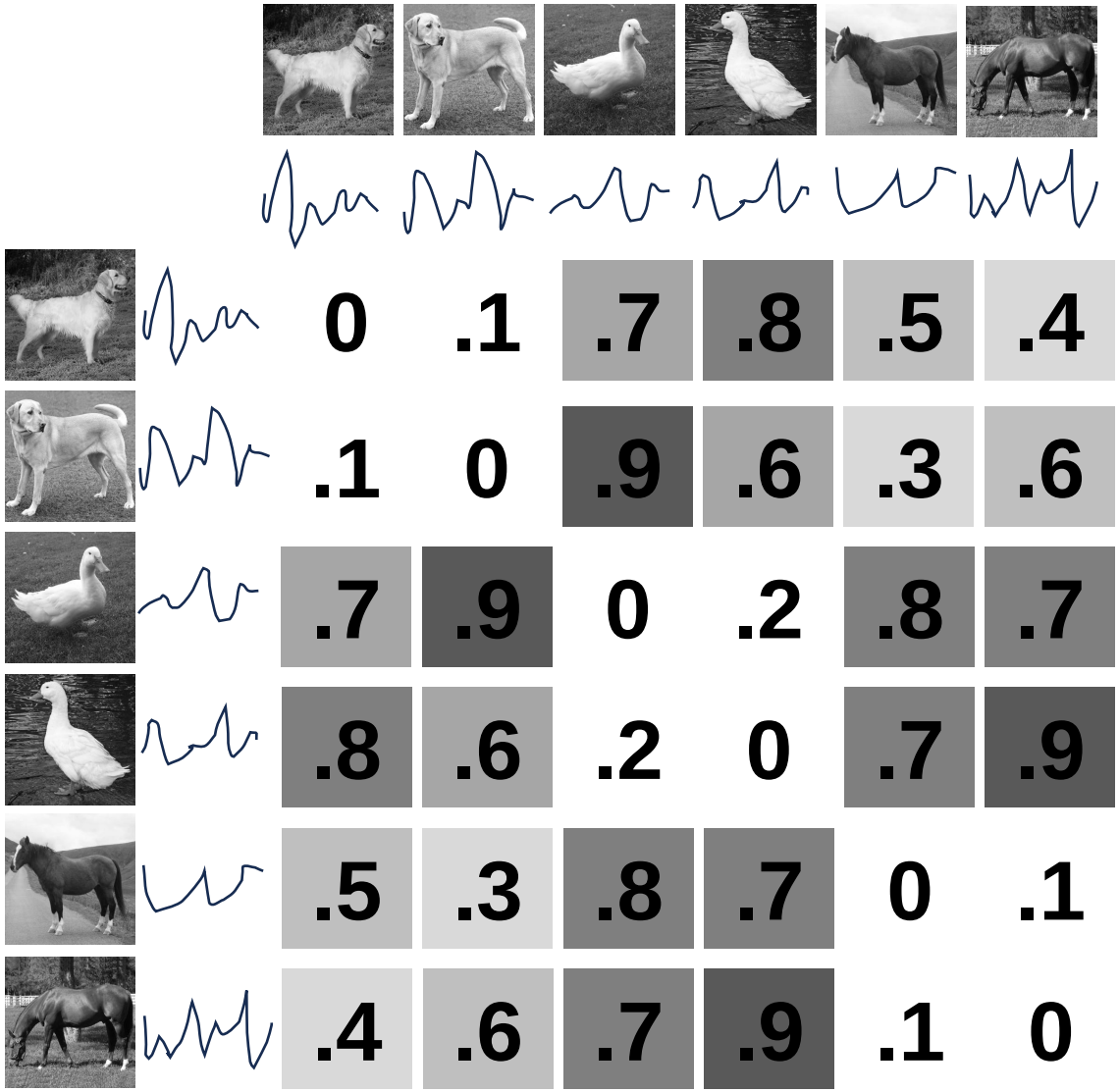


Representations are defined through distances

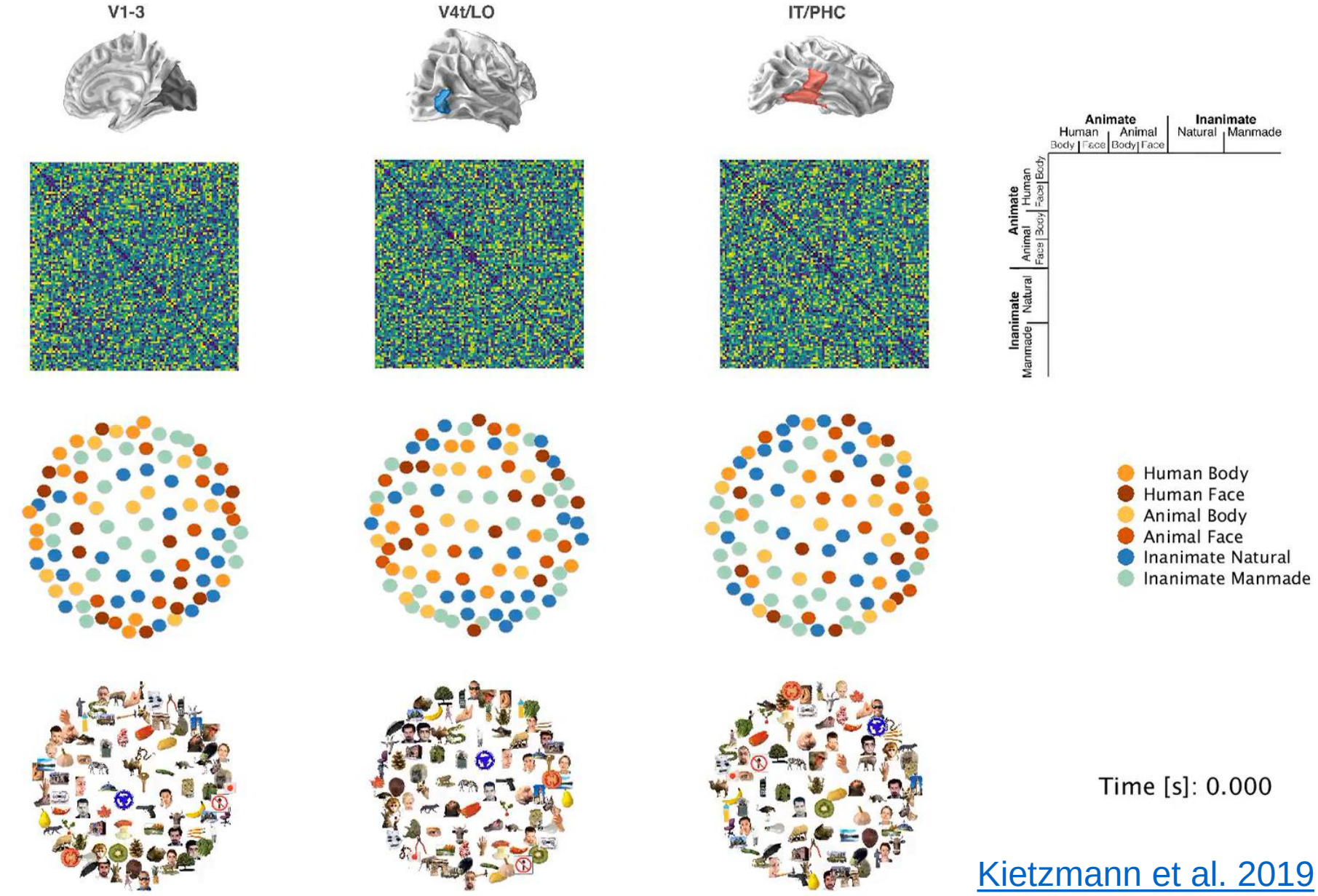


Representational
Dissimilarity
Matrix

RDM based on MEG data



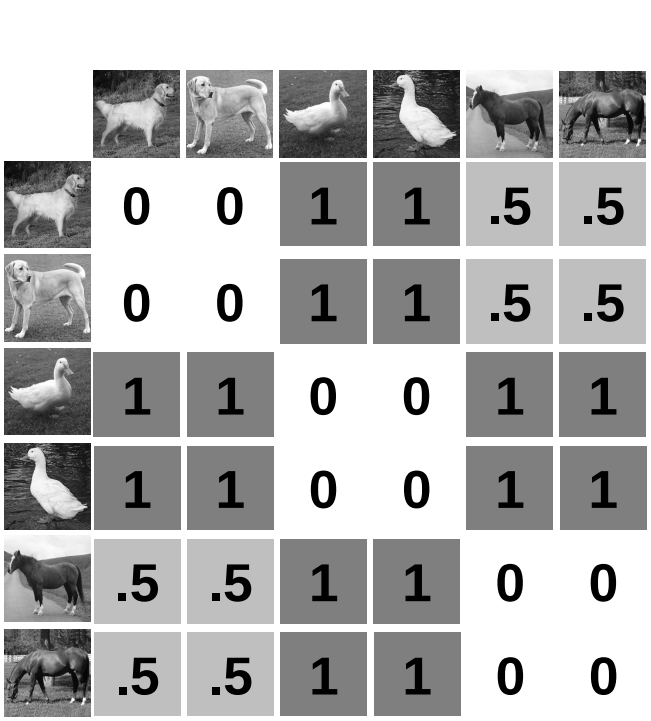
MDS on RDMs obtained from MEG

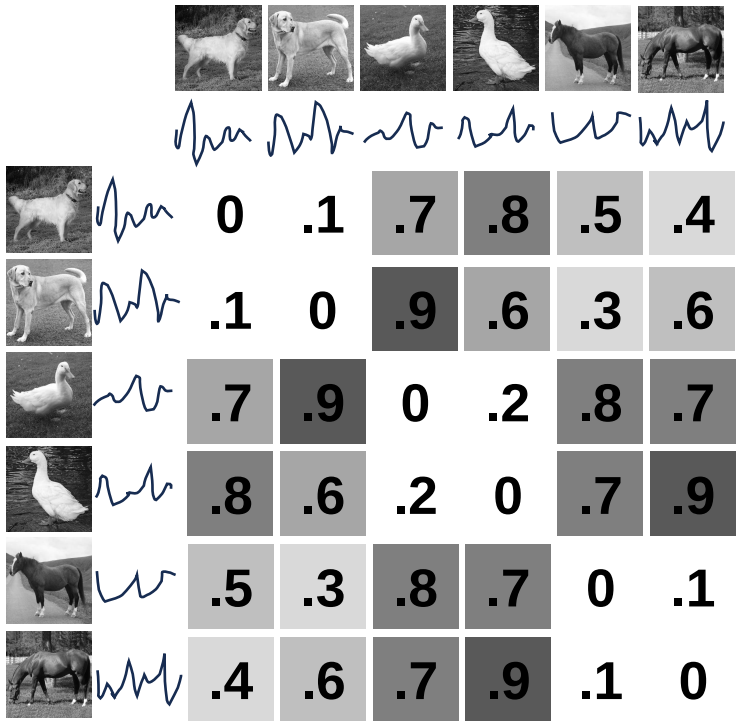


Kietzmann et al. 2019

RSA is distance between RDMs

= metric for similarity of two representations





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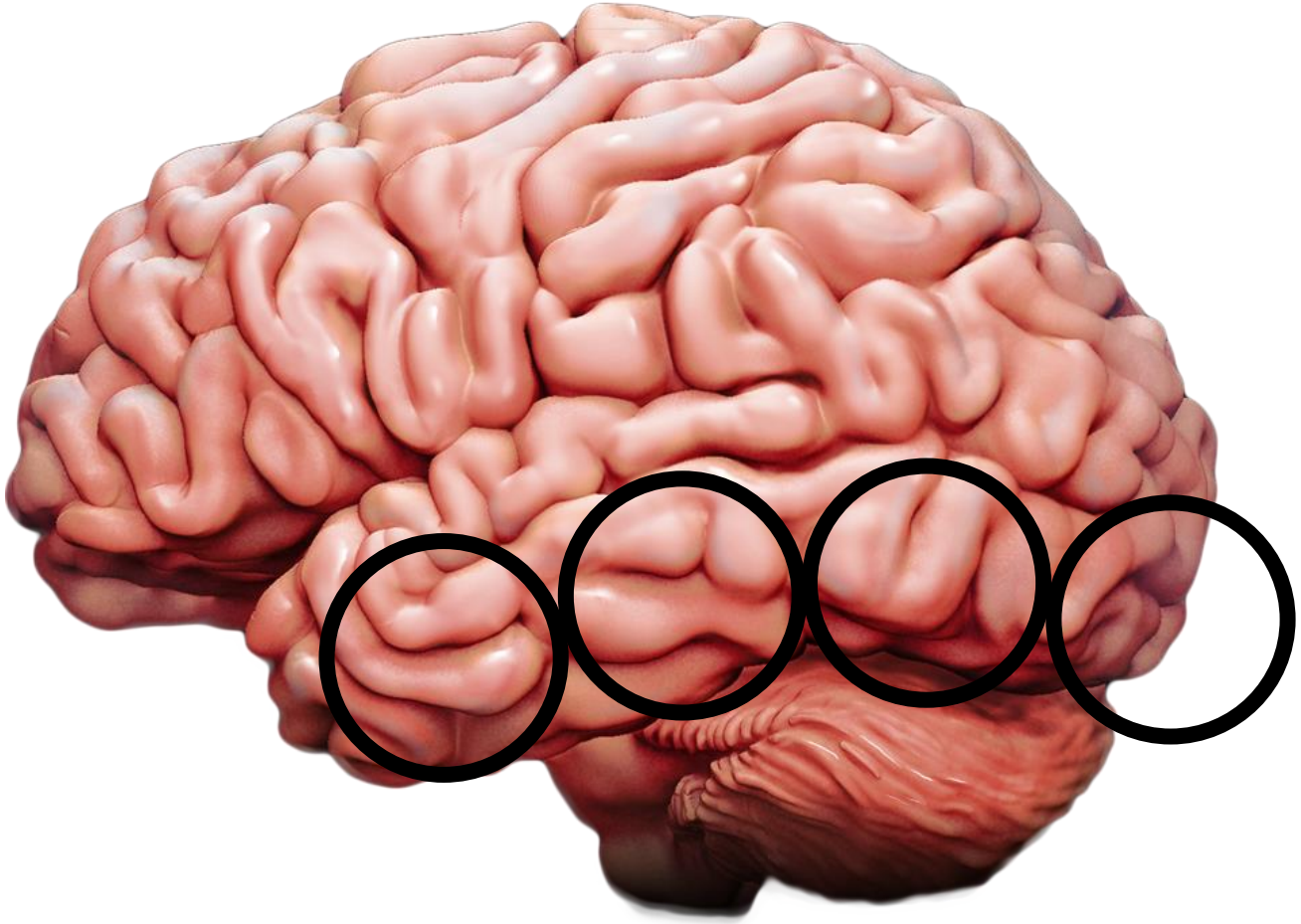
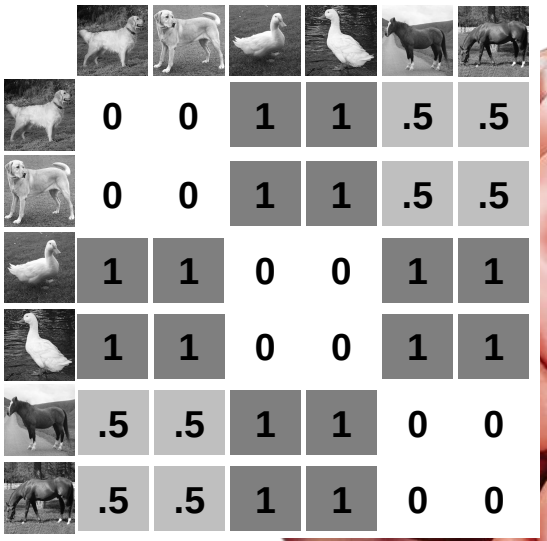
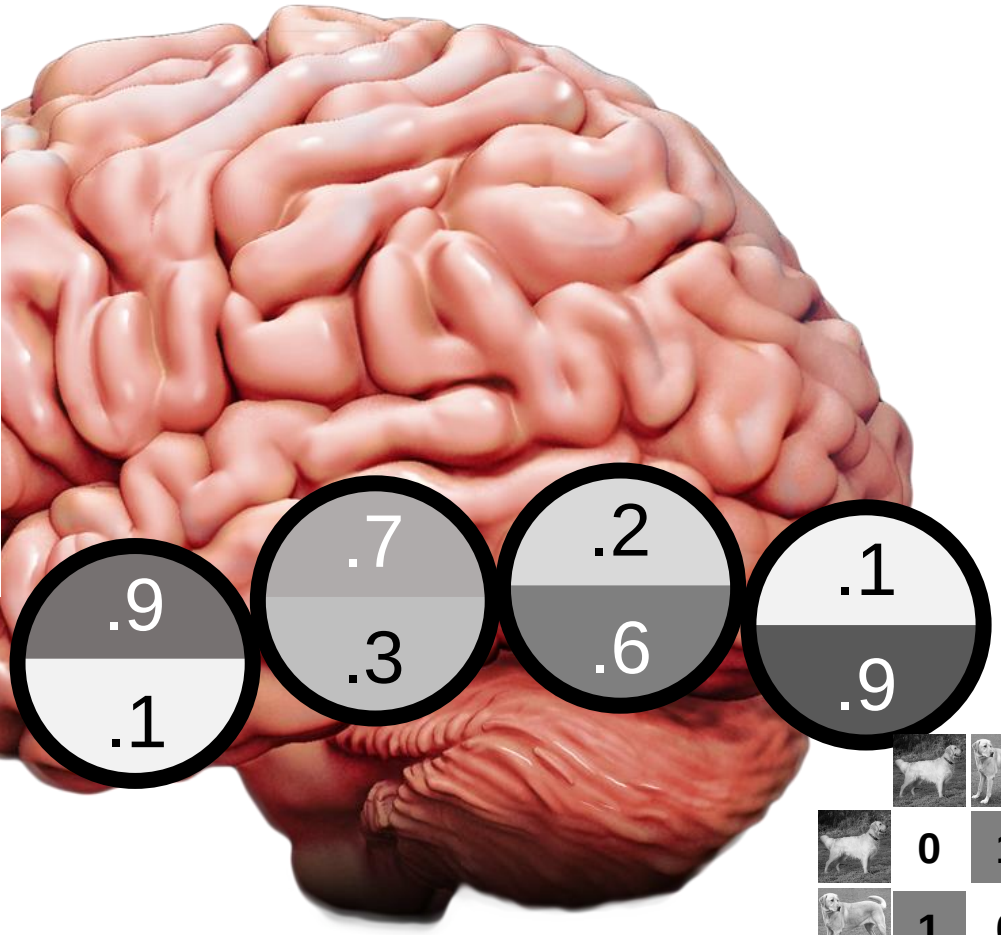
[Kriegeskorte, Mur, and Bandettini, 2008]

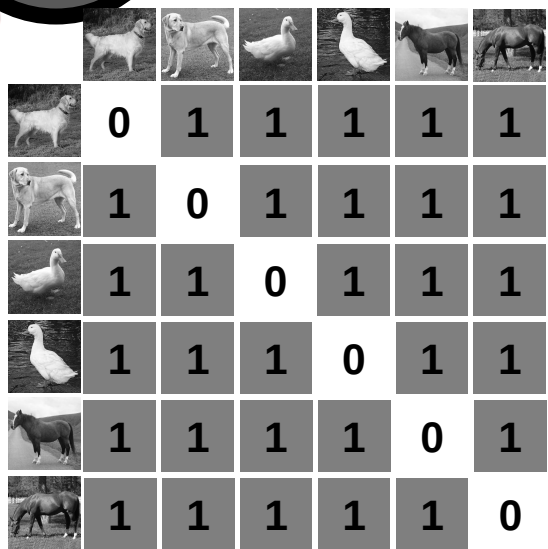
RSA across the cortex



RSA across the cortex







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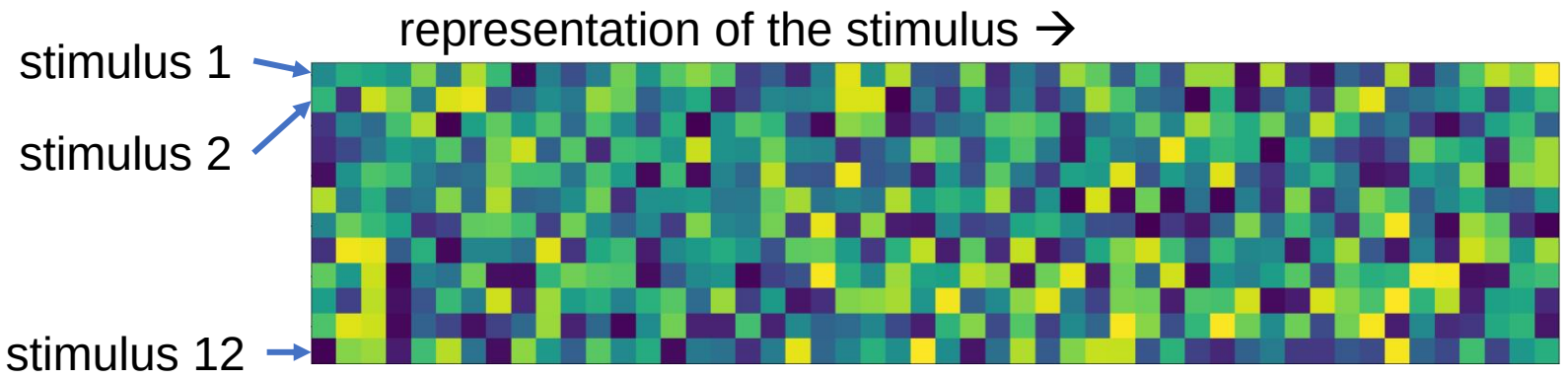
Most important ingredient:

The model RDM

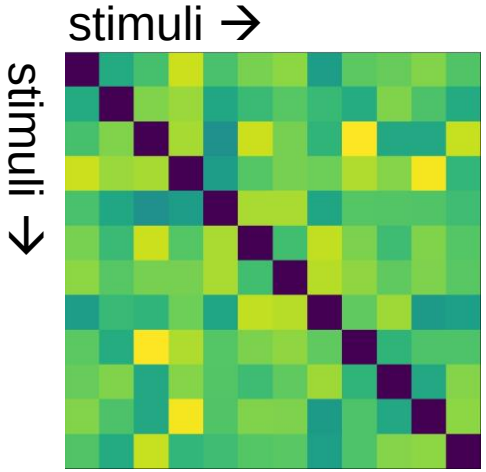
your hypothesis of representations in the brain

How to compute an RDM?

1. Start with a matrix, where each row represents a stimulus in some way:



2. Compute all-to-all distances between the rows of the matrix.
Use a metric like correlation, Euclidean distance, whatever you want.



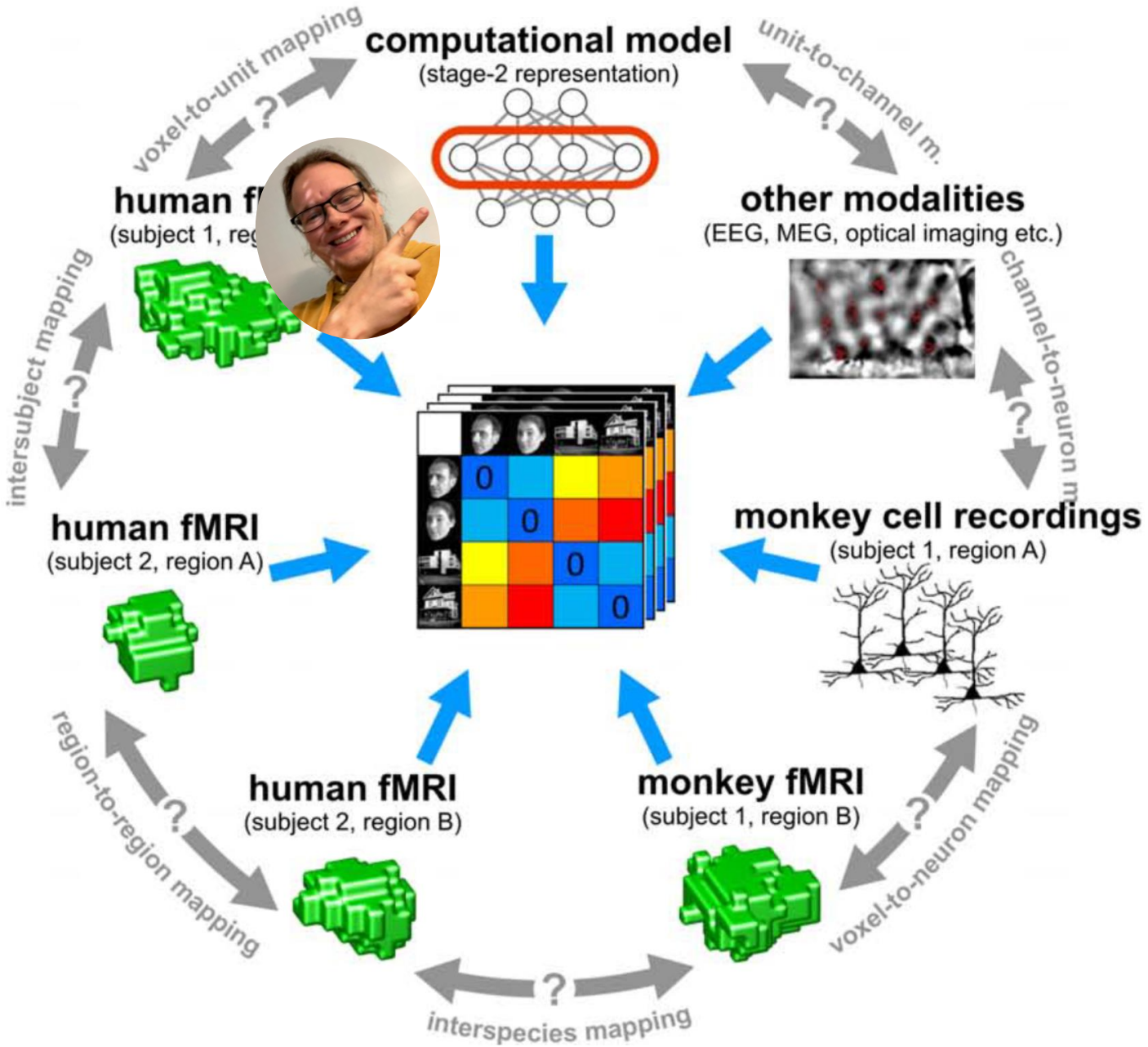
Properties of RDMs

- Records **dis**similarity (1 – similarity) to be analogous to distance.

  0 = identical representations

  1 = completely different representations

- Is a signature of the **population code**
  - Which stimulus “directions” are emphasized/de-emphasized?
  - Bit similar to “tuning” of cells
- The dimensions of RDMs are (stimuli × stimuli)
  - can be **directly compared** regardless of creation method



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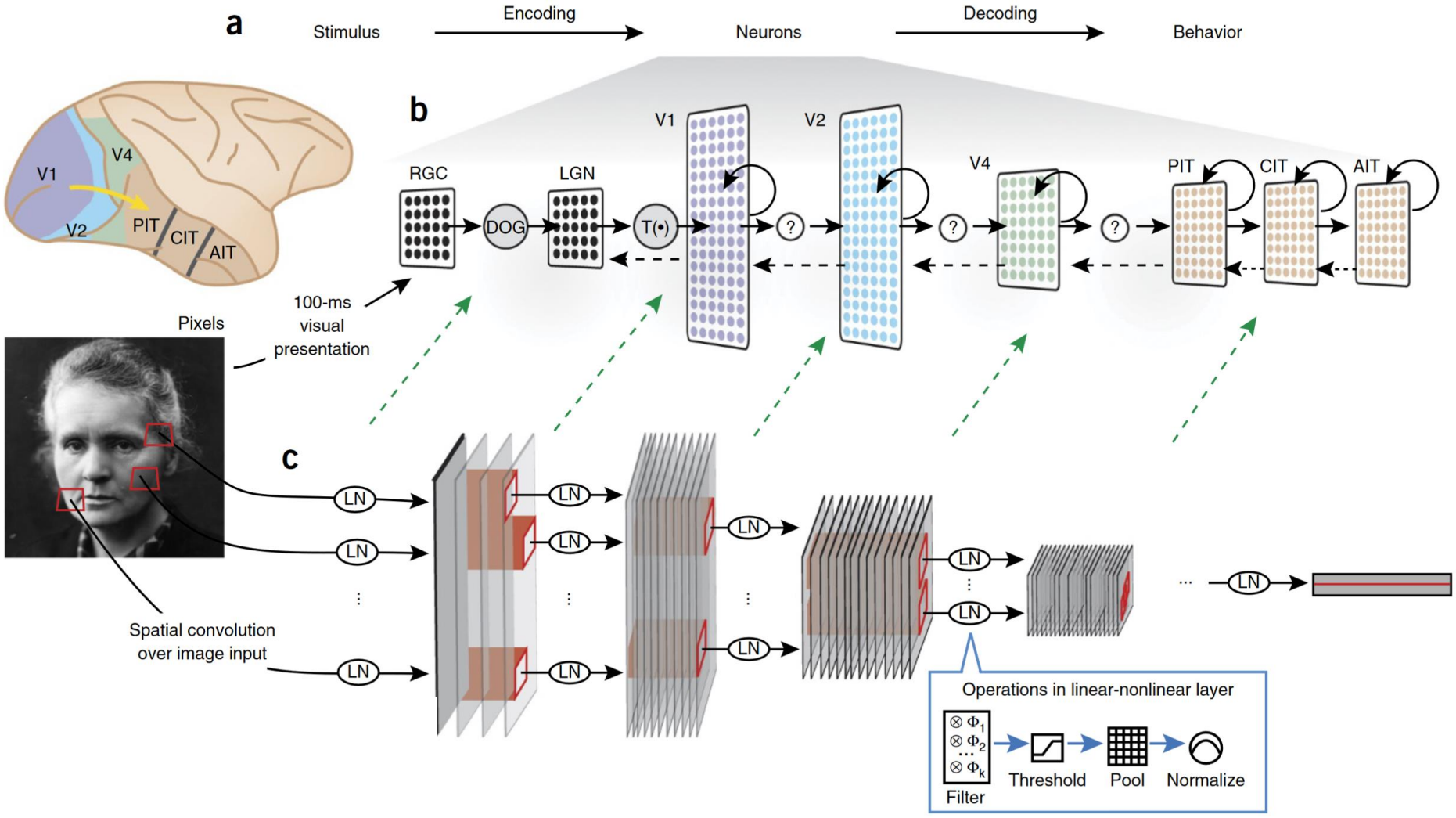
Kriegeskorte, Mur, and Bandettini (2008)

Comparing models to brain activity



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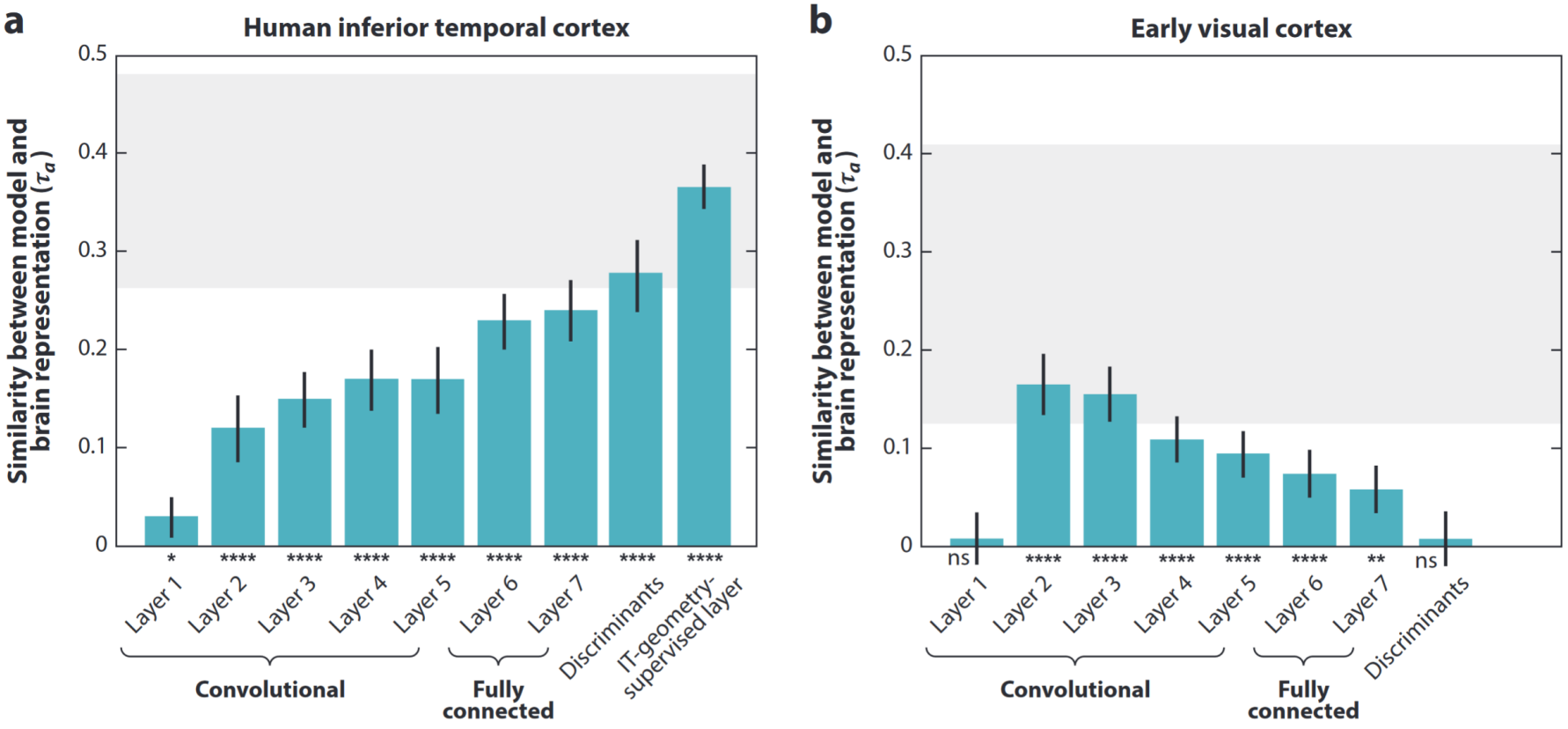
Yamins and Dicarlo, 2016

RSA between model and fMRI



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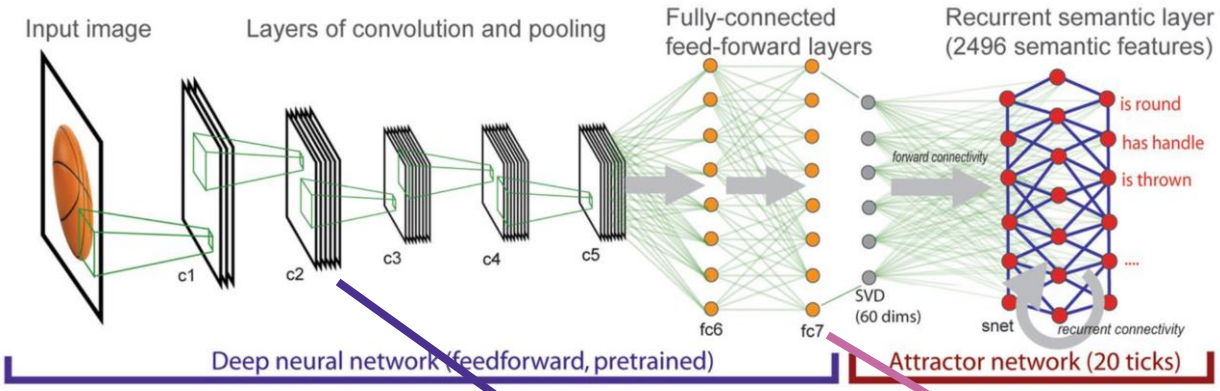
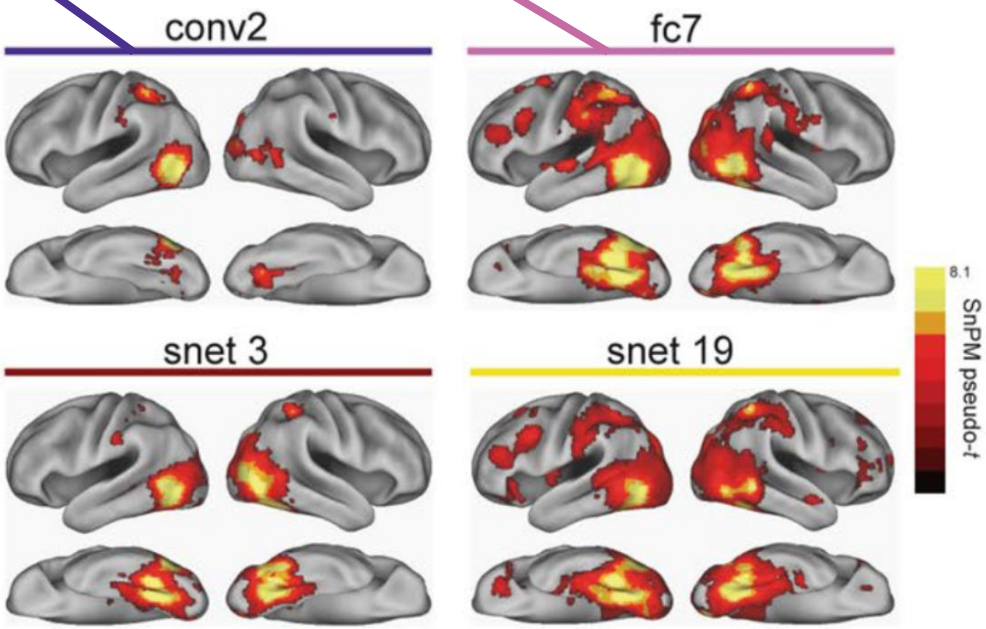
Kriegeskorte, 2015

RSA between model and fMRI





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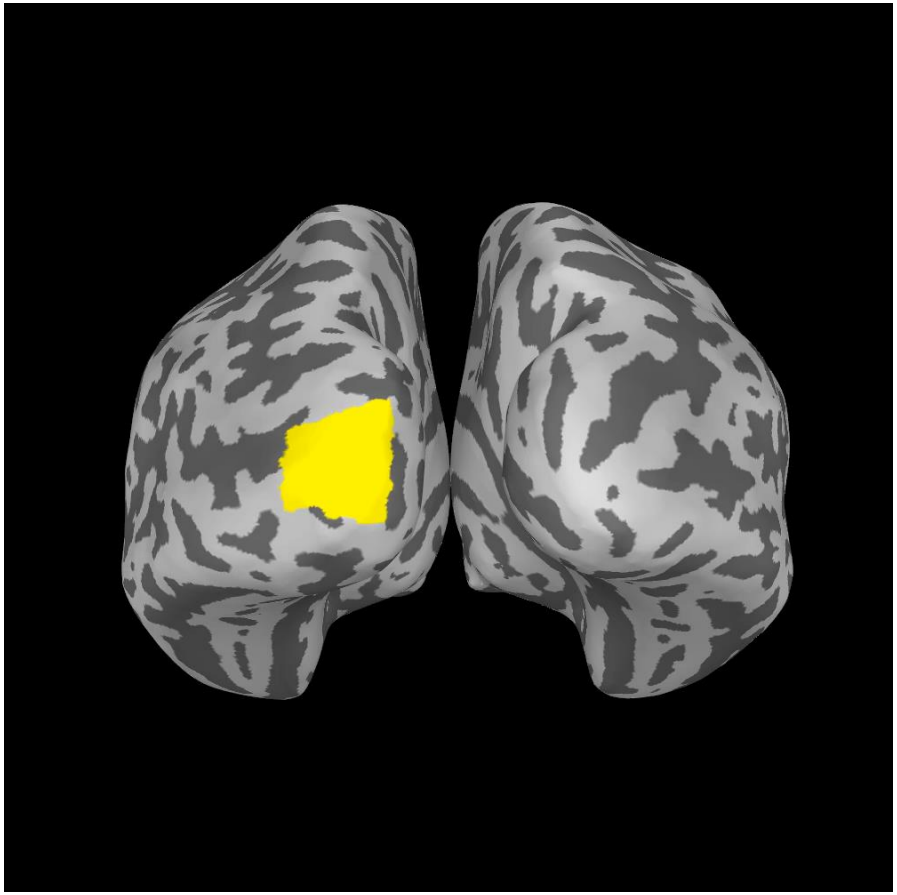
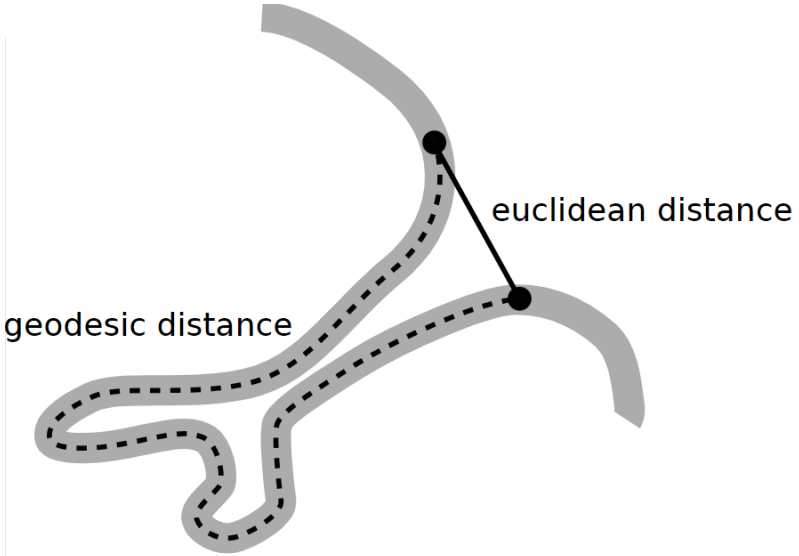
Devereux, Clarke, and Tyler, 2018

Searchlight

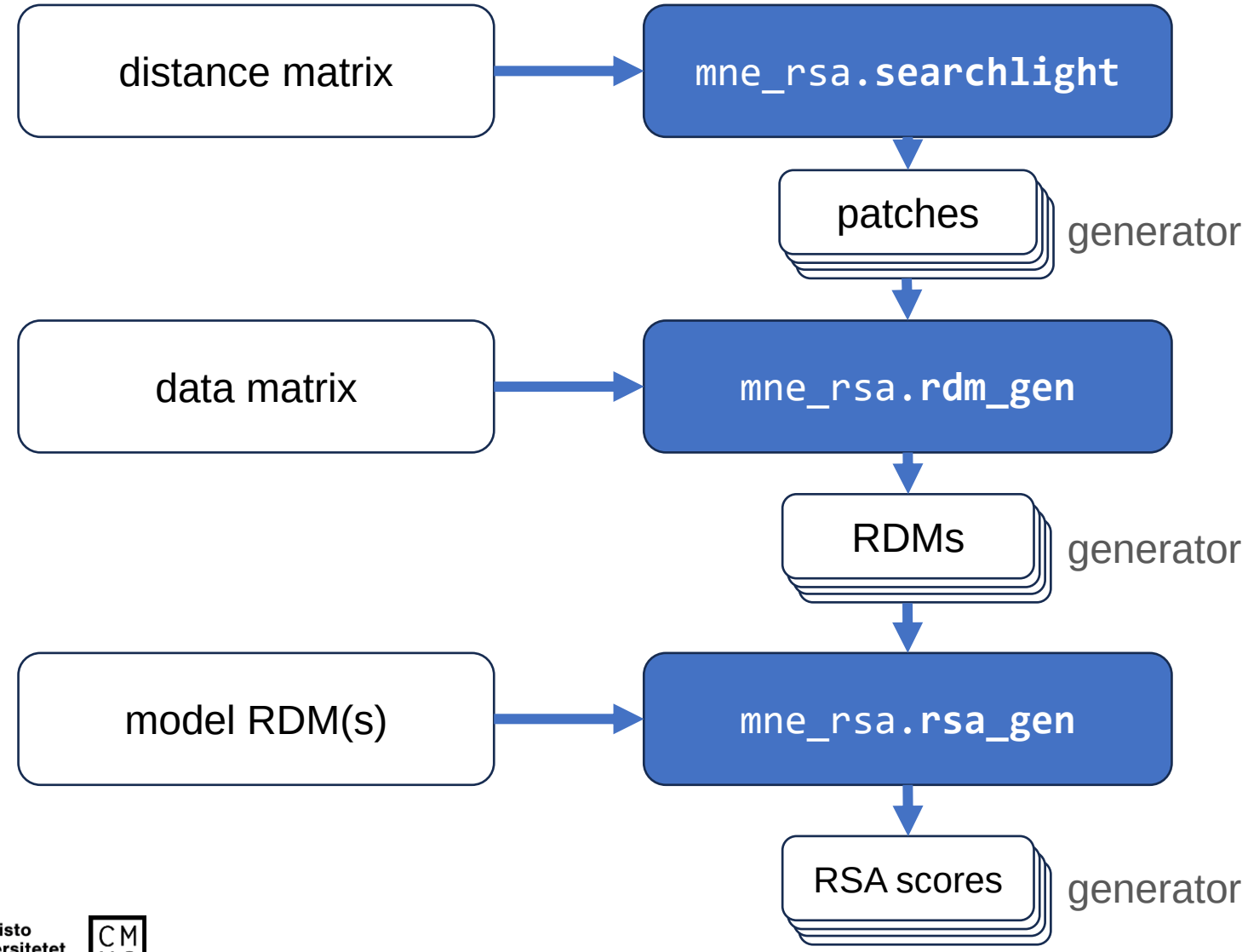




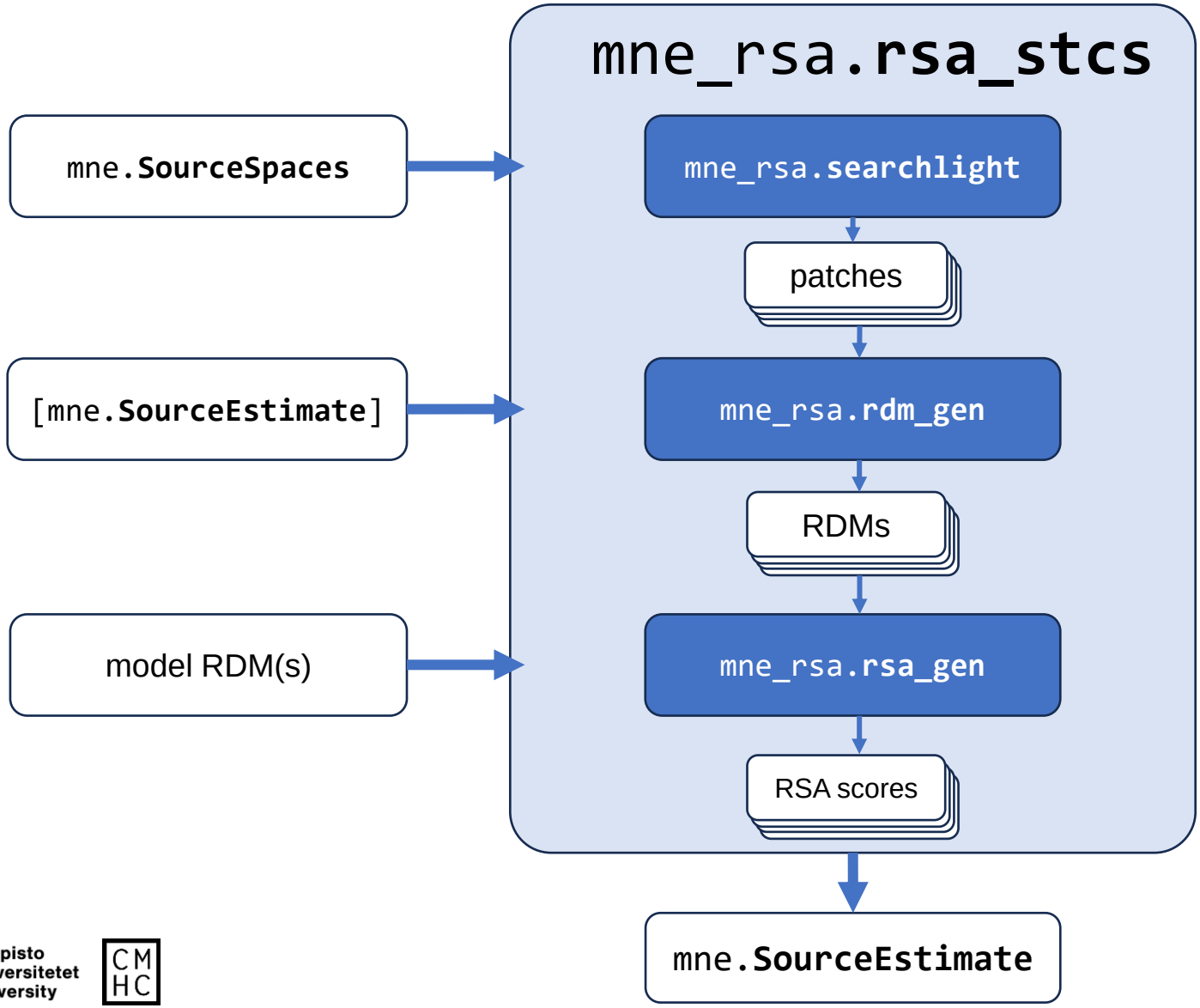
Reason MNE-RSA exists

- Because we needed to do RSA for a project
- Official RSA toolbox used to be MATLAB only
  - New version just dropped in Python
  - Low-level API operating on NumPy arrays
- **Convenient API**
  - for computing searchlight patches
  - for operating on MNE-Python datatypes
  - Easy parallelization (`n_jobs > 1`)
  - Easy access to “advanced” things:
    - whitening, cross-validation, partial correlations, etc.

MNE-RSA pipeline



MNE-RSA using MNE-Python objects



Time to get to work!

In the repository:

`rsa/index.ipynb`

make sure mne-rsa version **0.9** is installed!