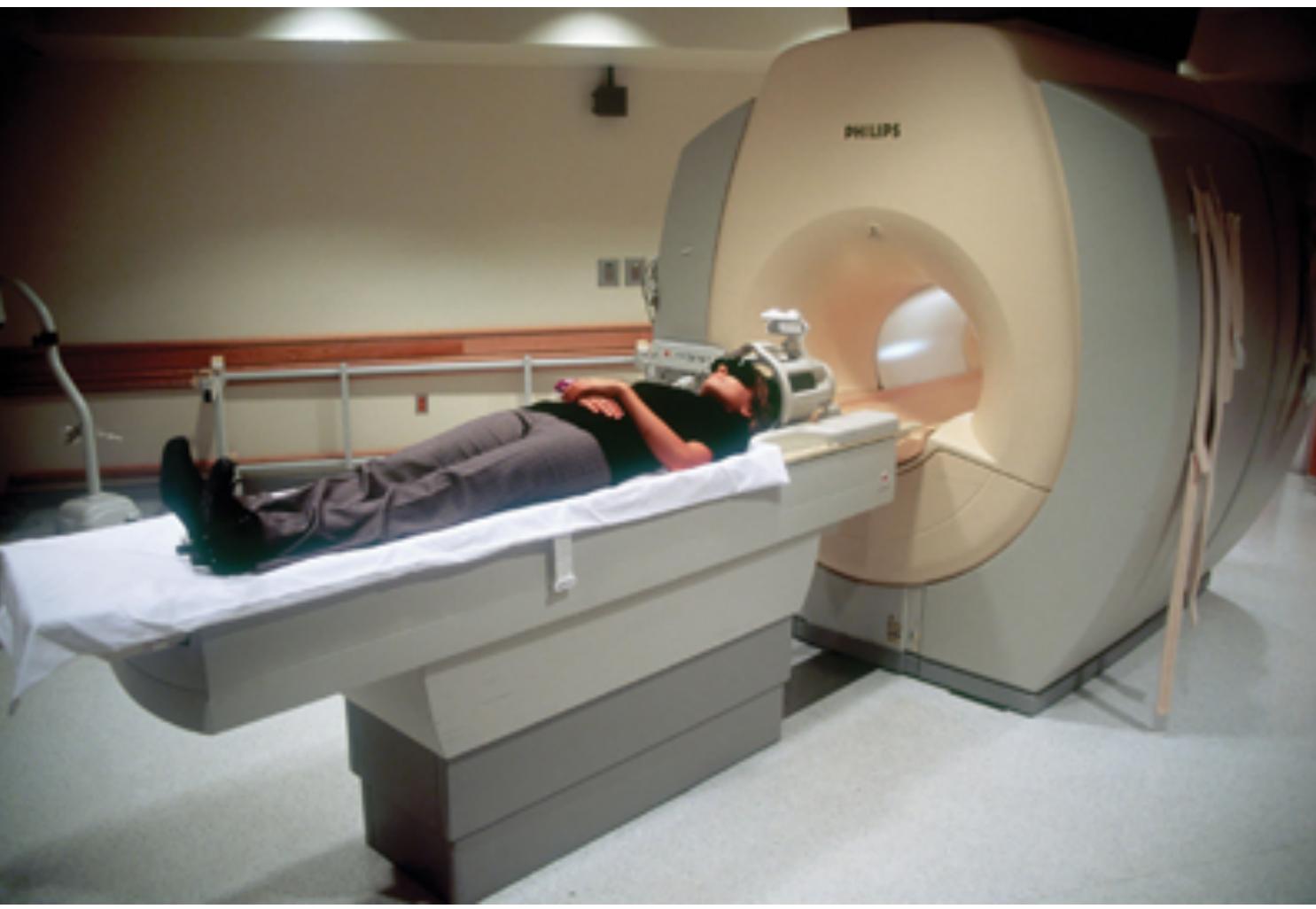


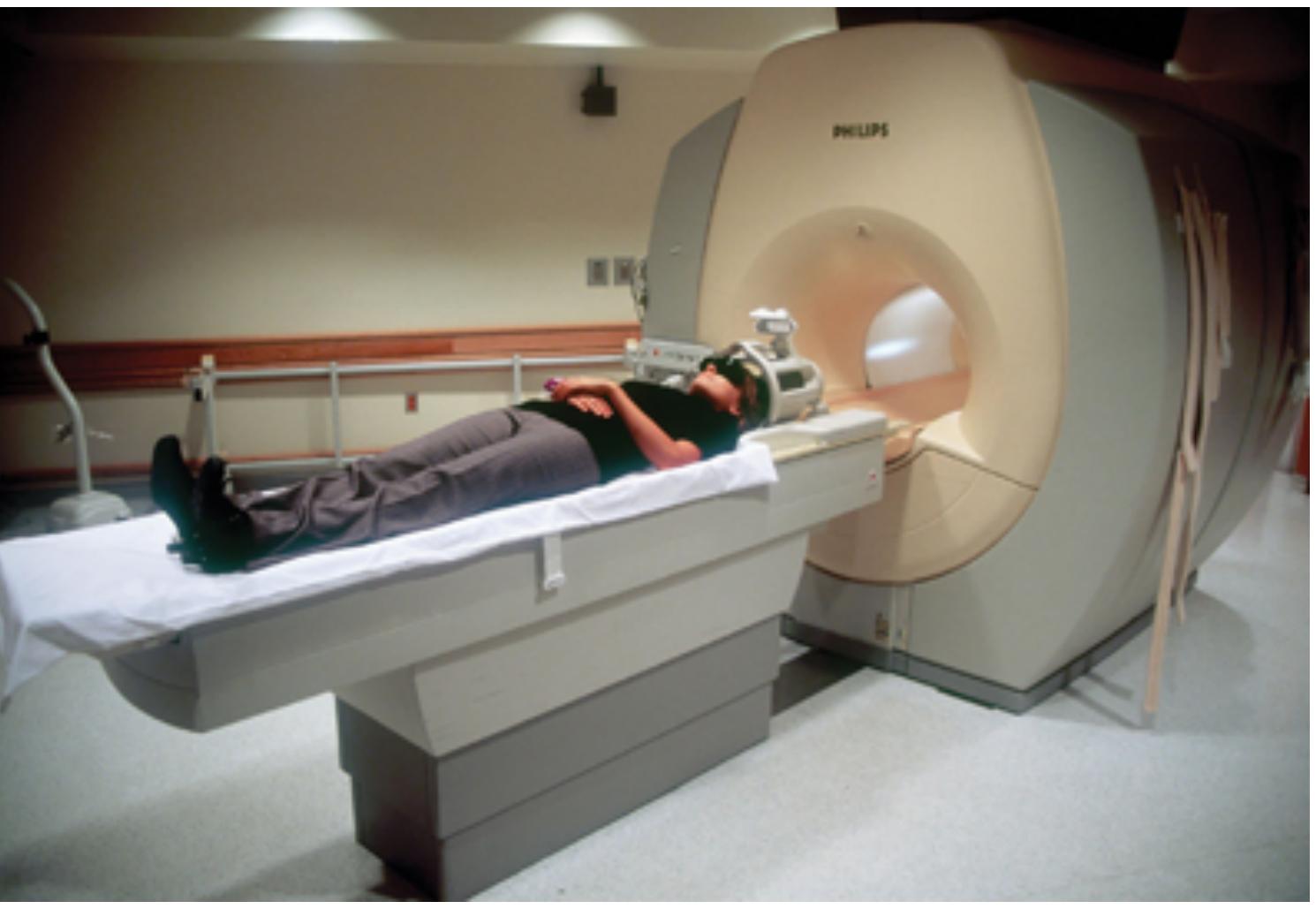
Patterns in time and space

Connectivity and Pattern analysis

Tomas Knapen Brain Imaging VU 2021



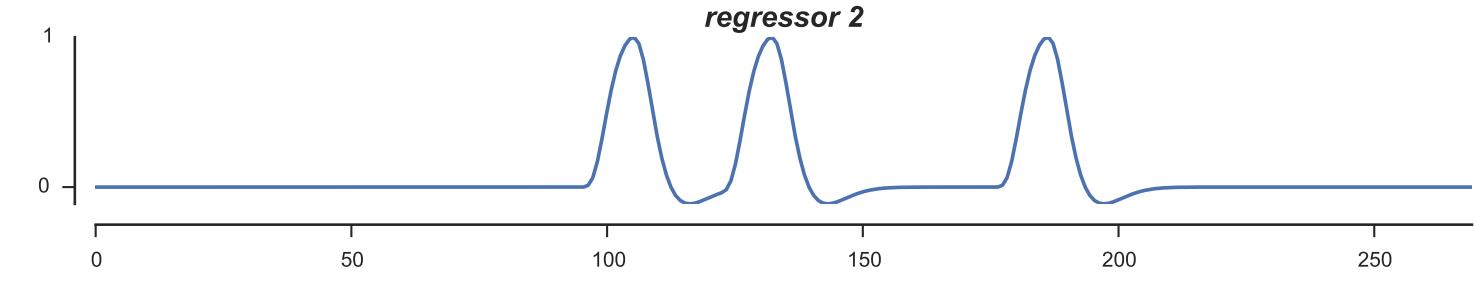
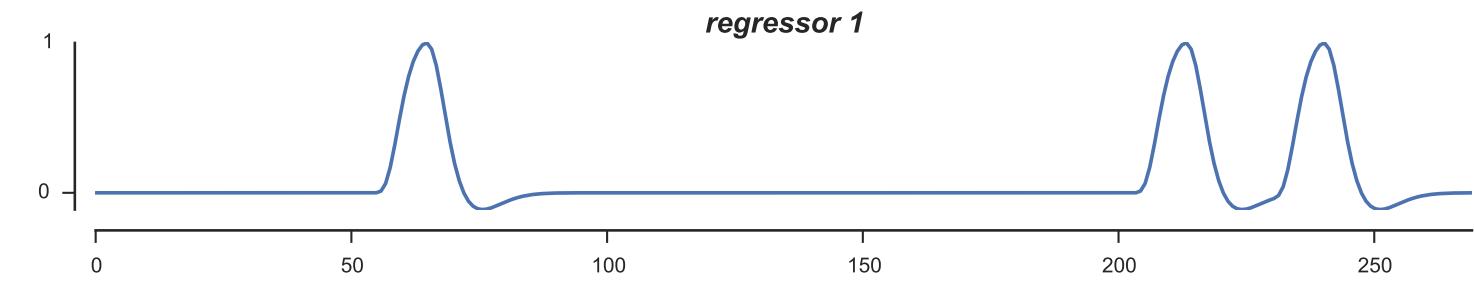
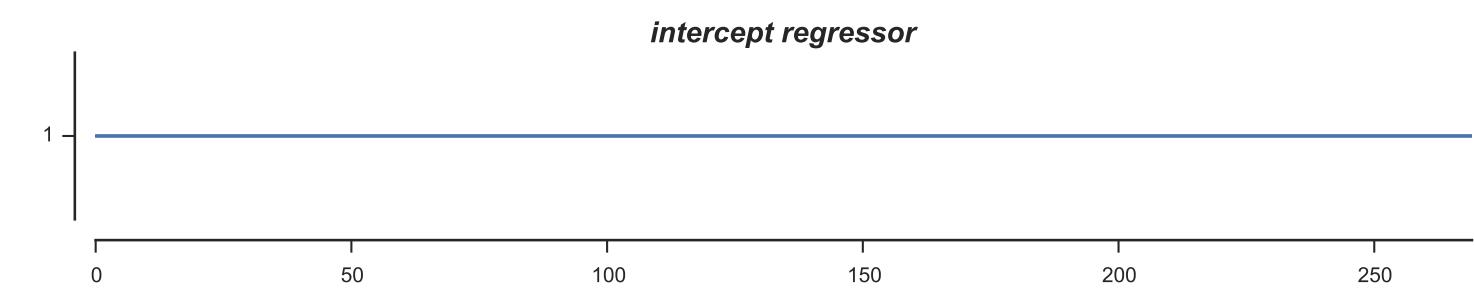




pre
processing



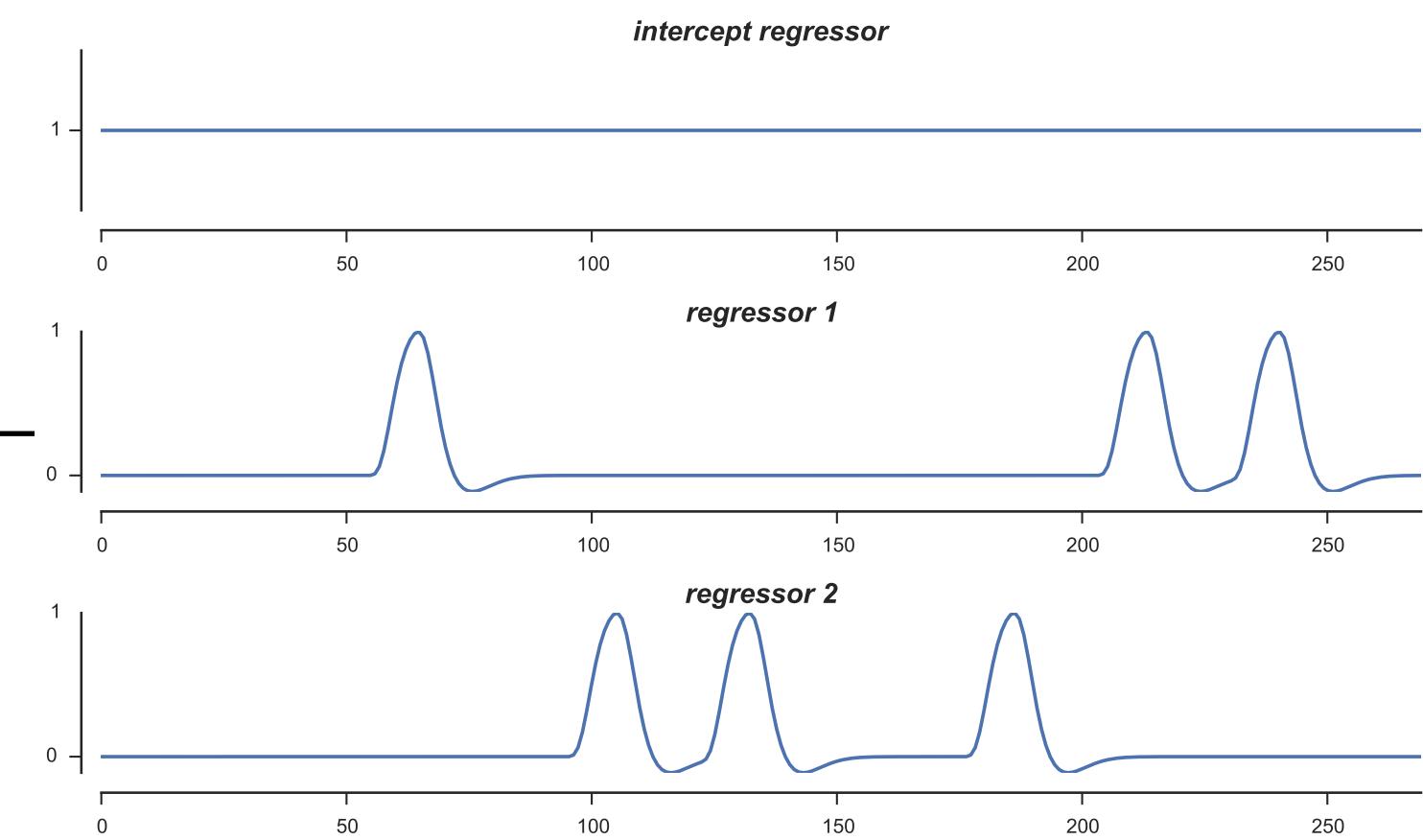
pre
processing





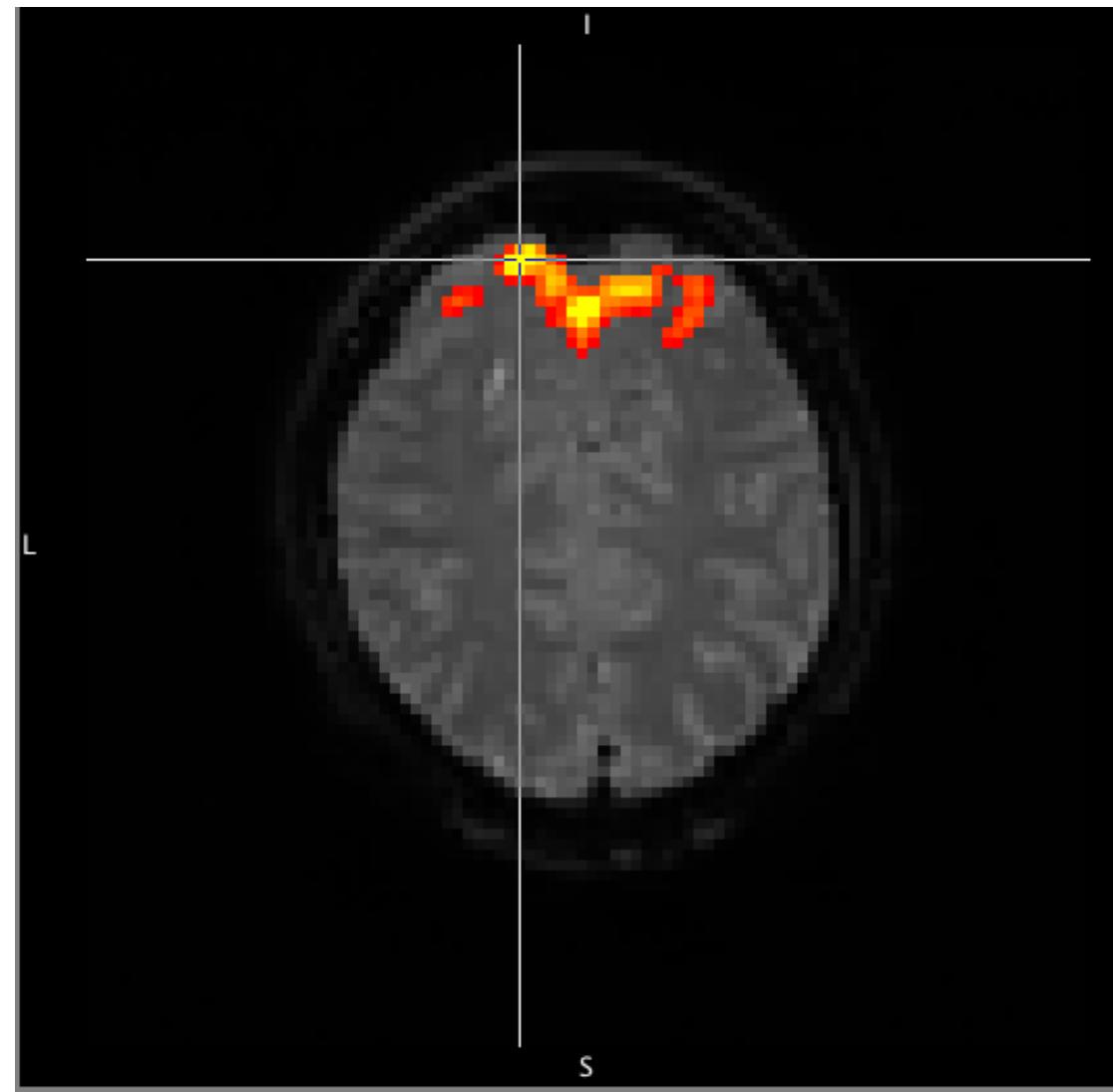
pre
processing

post-
processing

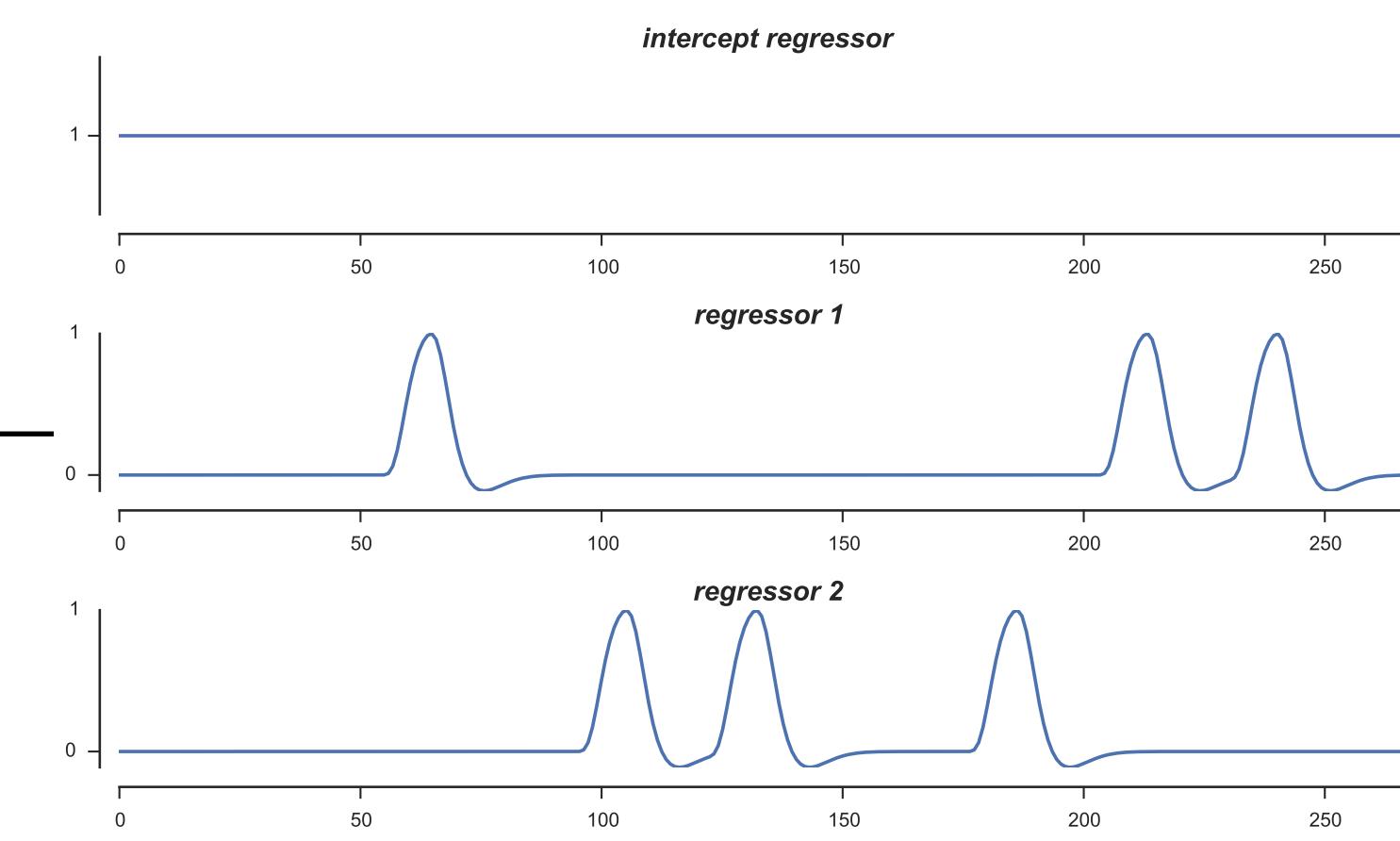




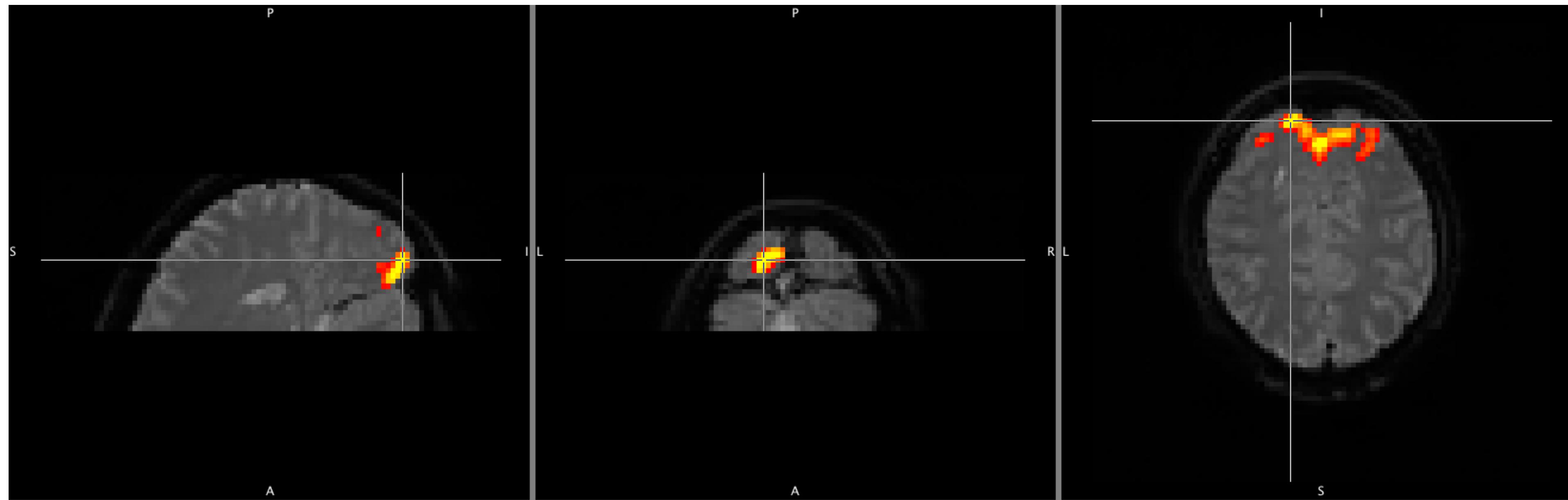
pre
processing



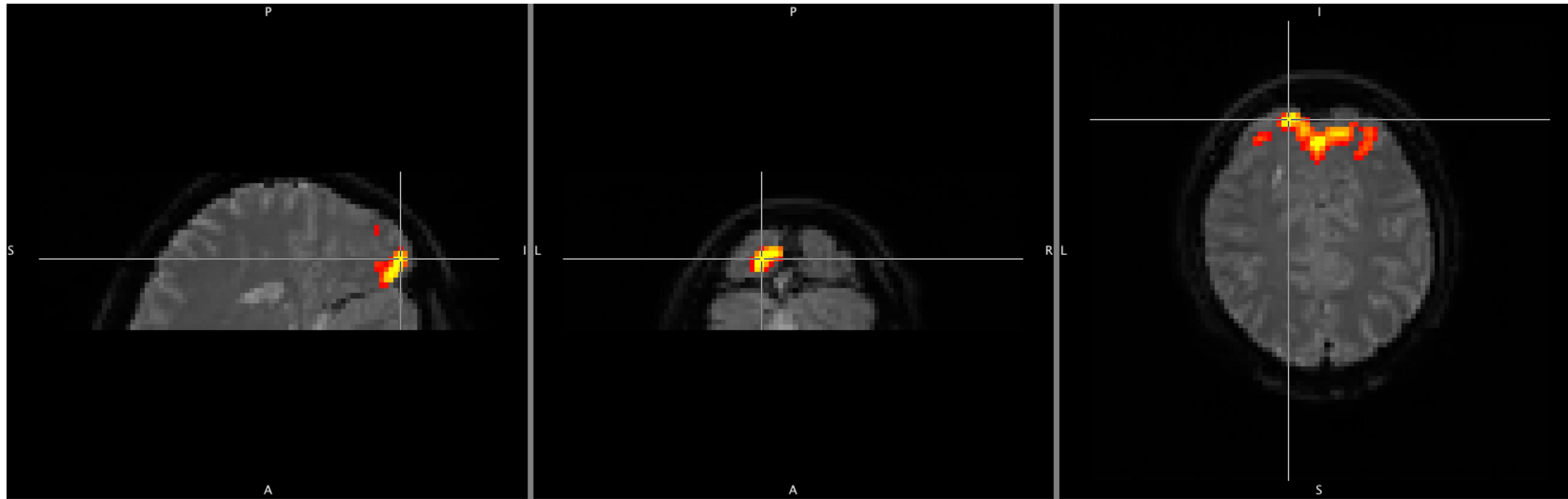
post-
processing



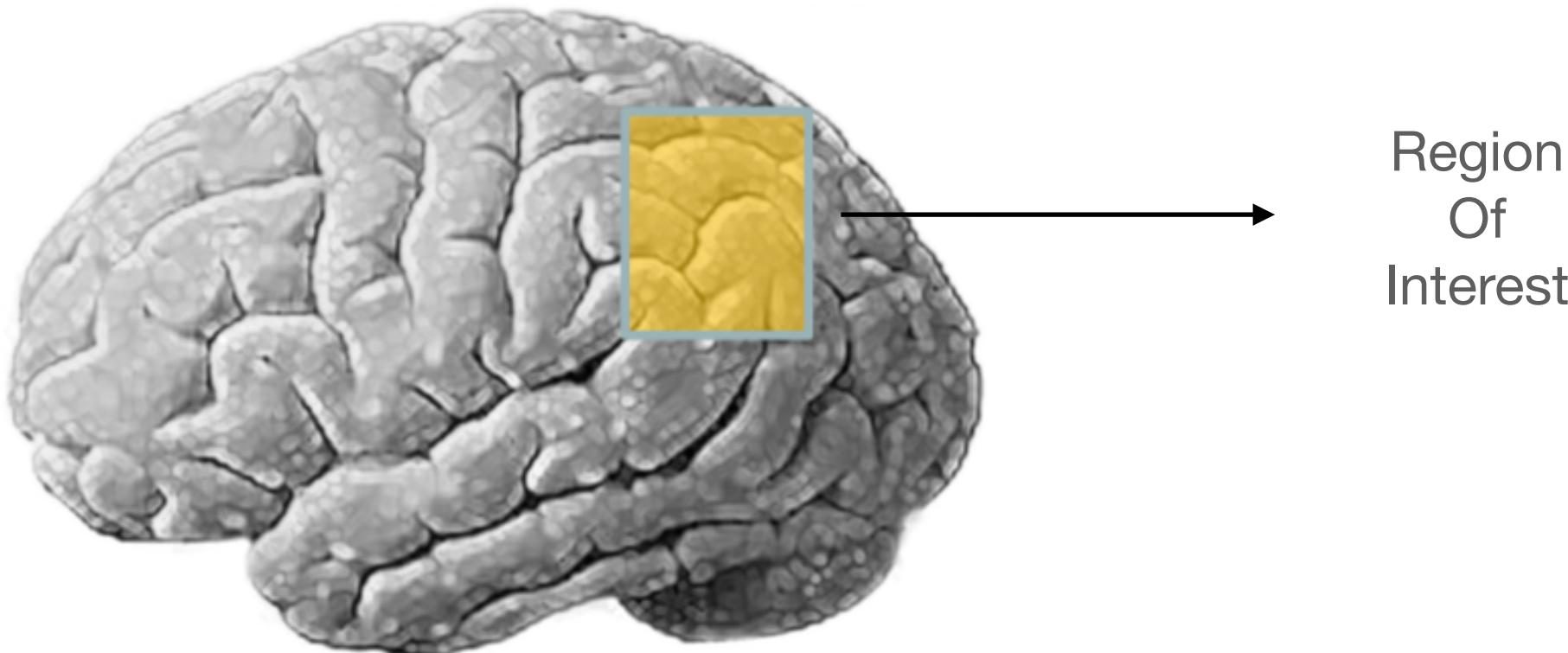
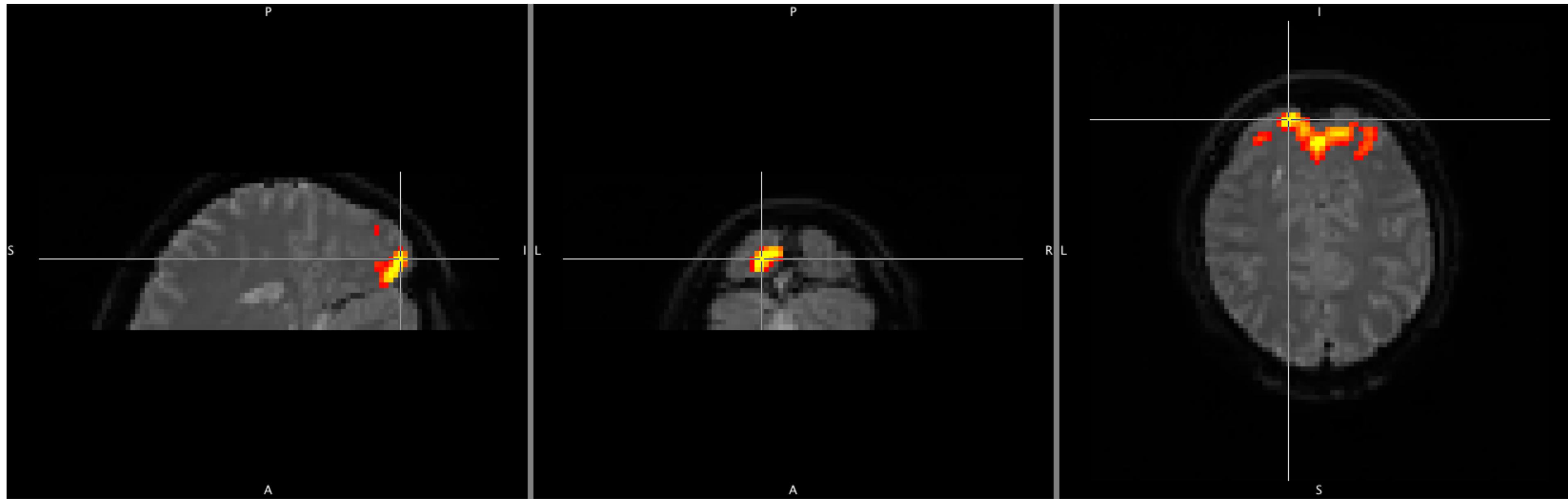
Univariate analysis a.k.a. ‘blobology’



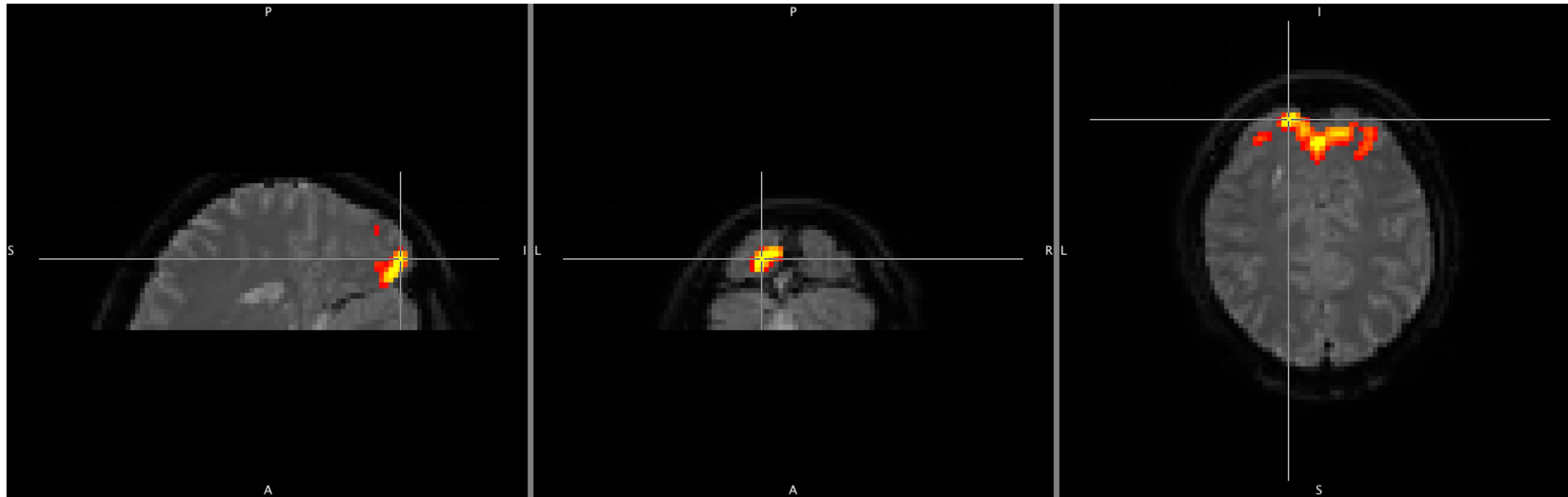
Univariate analysis a.k.a. ‘blobology’



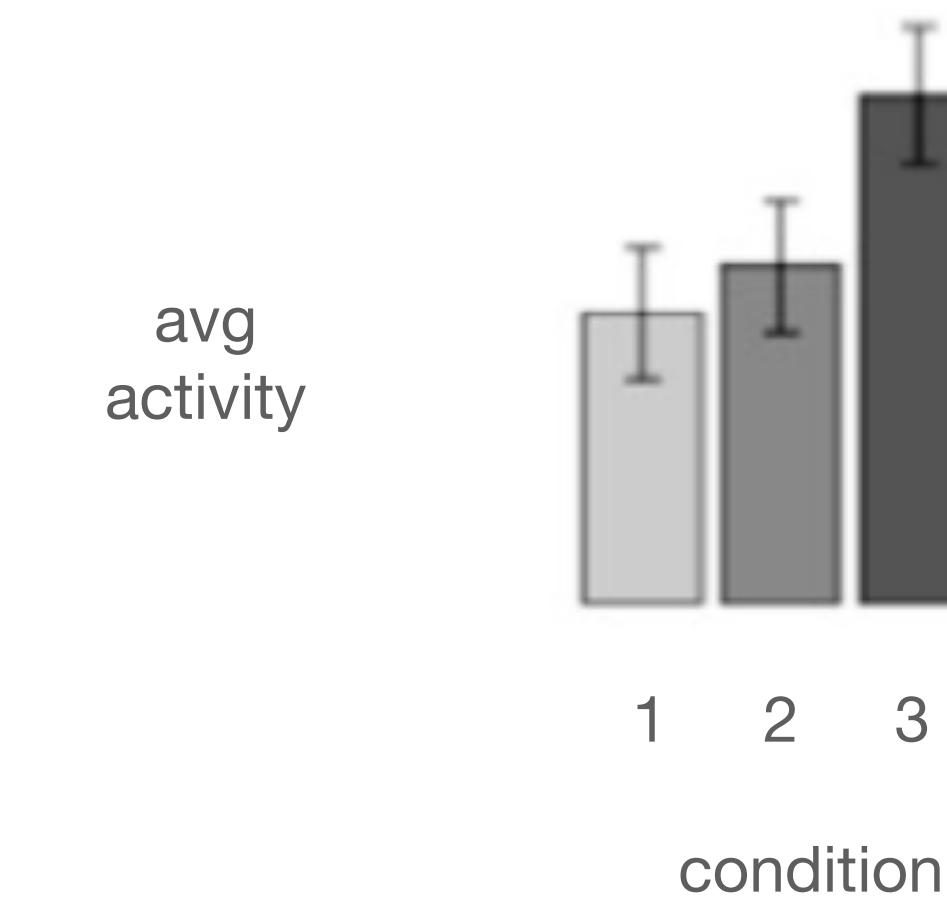
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Univariate analysis a.k.a. ‘blobology’

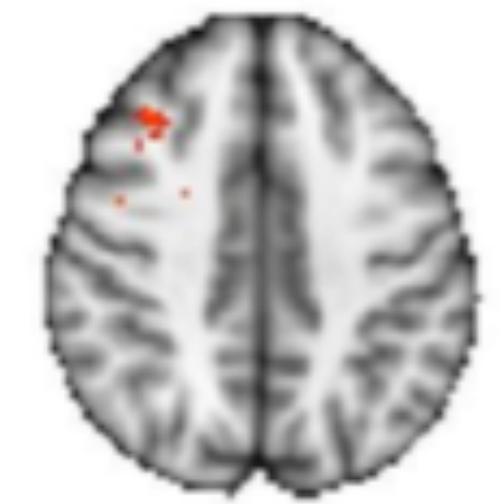


Region
Of
Interest



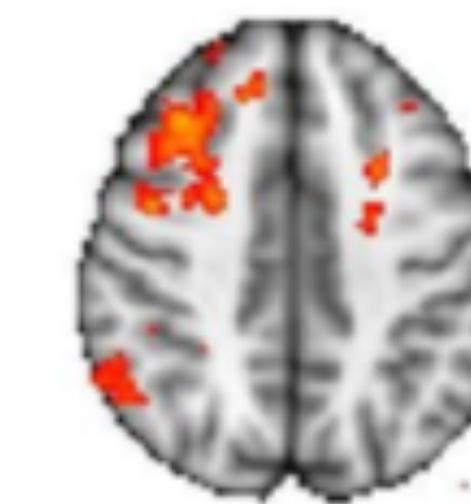
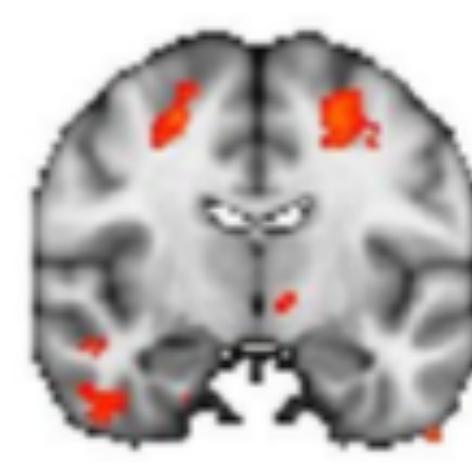
Thresholding problem

$t > 3$



"Concept X is **locally** represented in the left dorsolateral prefrontal cortex"

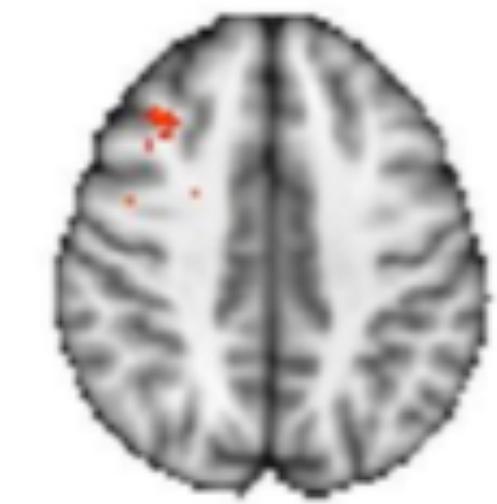
$t > 2.3$



"Concept X is **globally** represented in a **network** of the dorsolateral PFC, precentral gyrus, TPJ, and ATL"

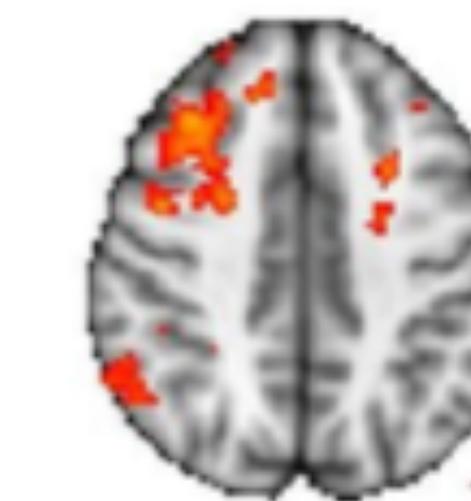
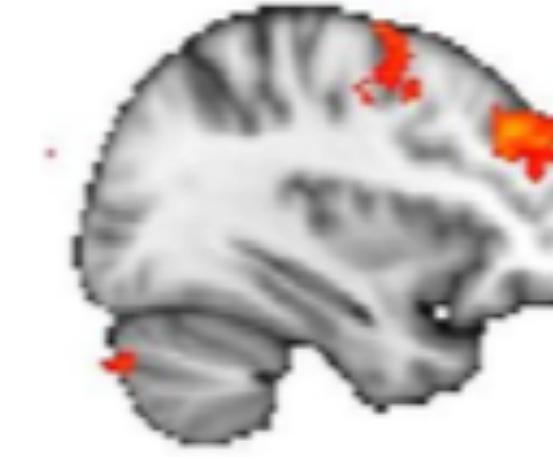
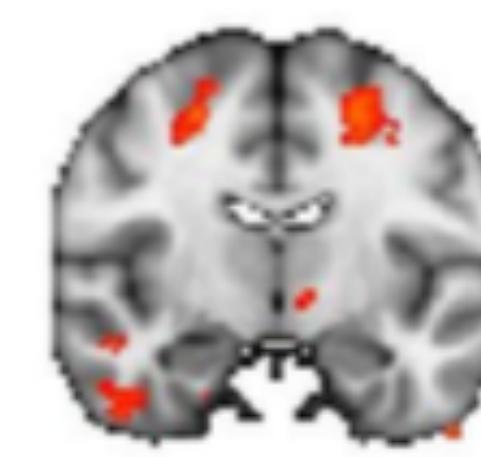
Thresholding problem

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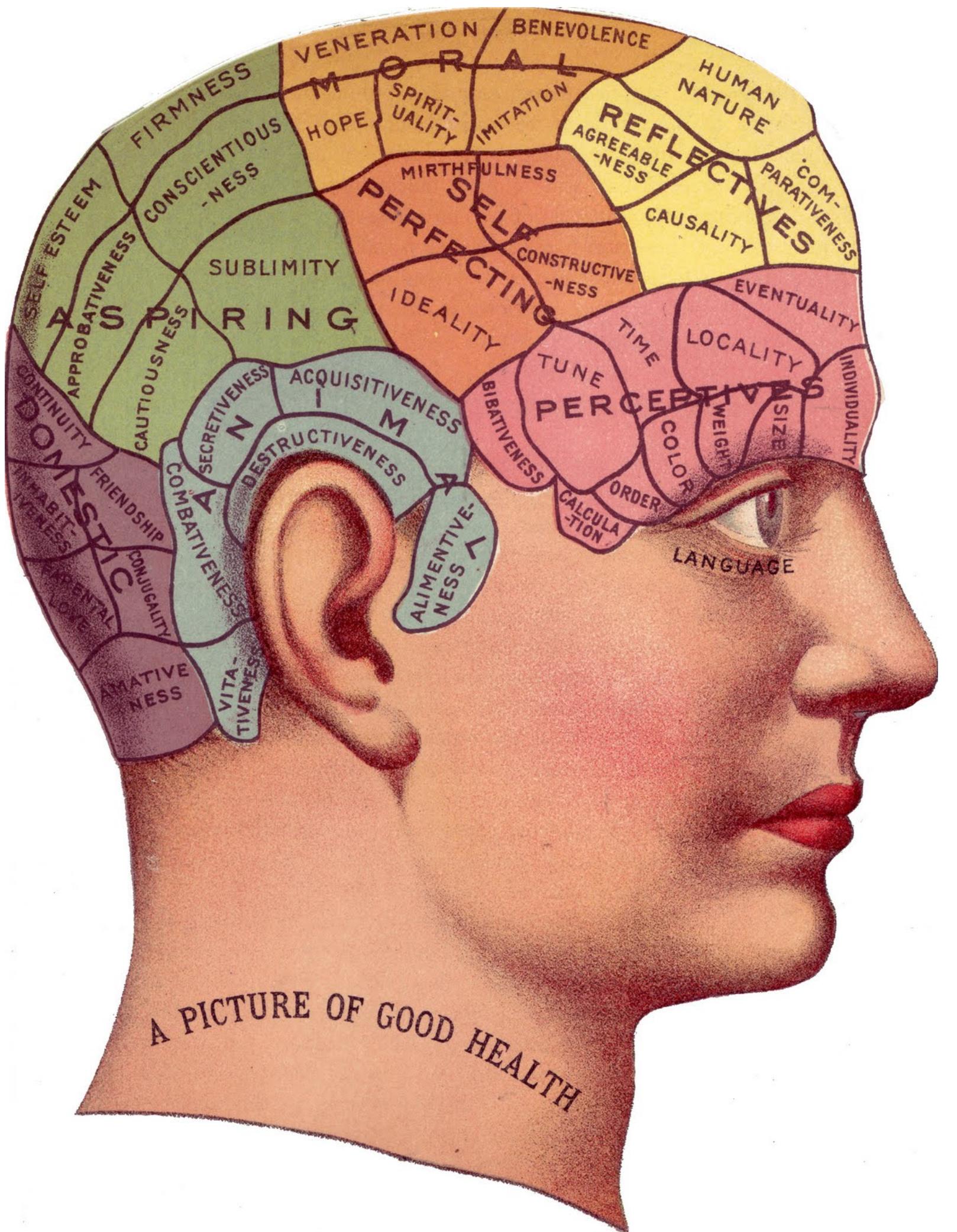
$t > 2.3$



"Concept X is **globally** represented in a **network** of the dorsolateral PFC, precentral gyrus, TPJ, and ATL"

function processed locally,
or in a network?

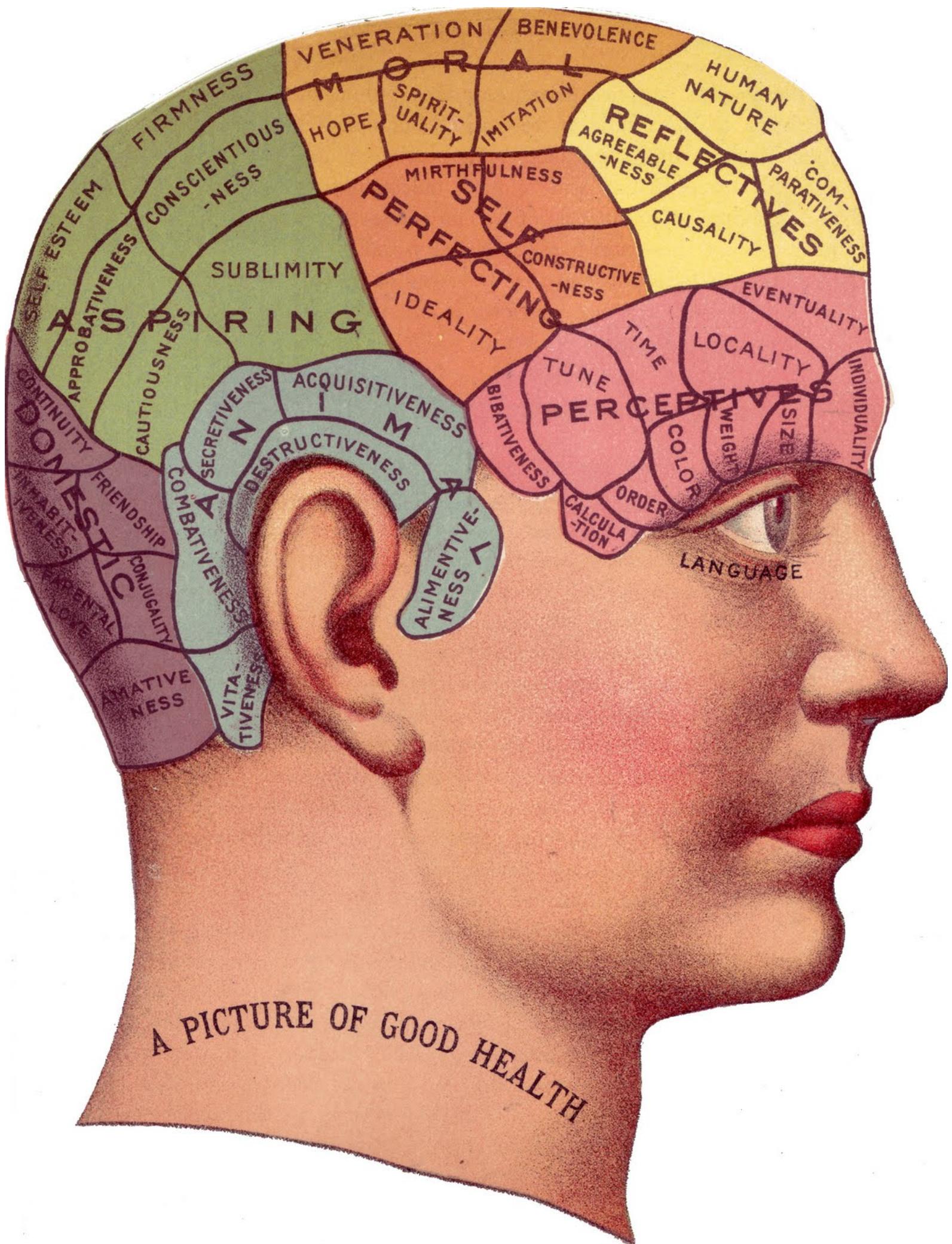
Neo-phrenology



phrenology
localising functions
in the brain

phren = mind
logos = knowledge

Neo-phrenology

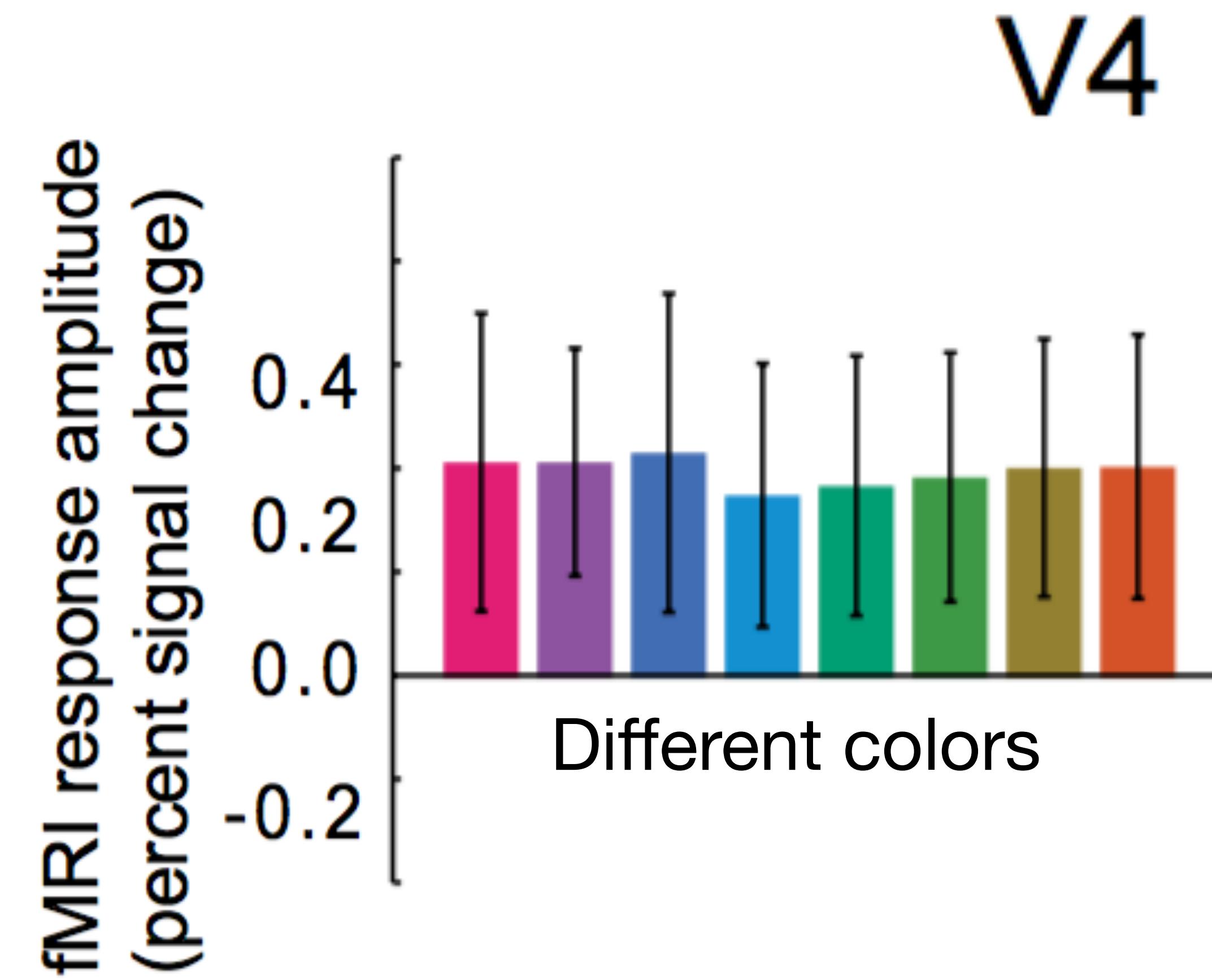


phrenology
localising functions
in the brain

phren = mind
logos = knowledge

big overlap in
functions especially
in higher-order cortex

Per-ROI amplitude averages cannot distinguish between stimulus types within ROI



Reverse Inference Problem

- inverse inference problem

cause ←

Reverse Inference Problem

- inverse inference problem



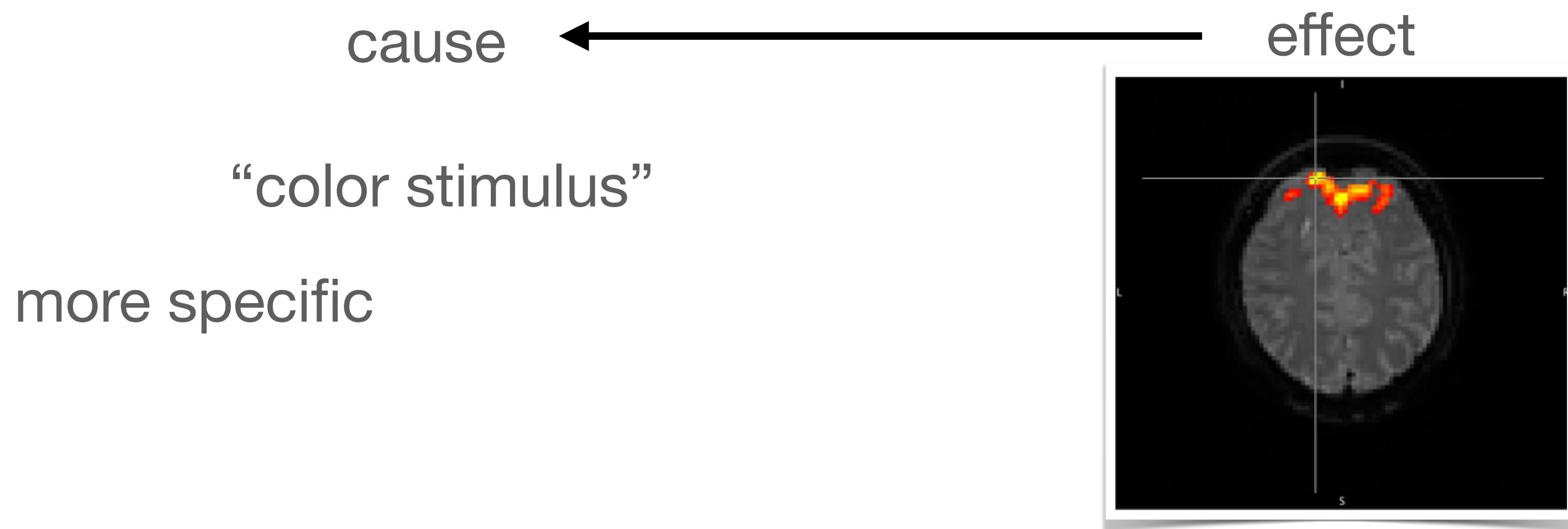
Reverse Inference Problem

- inverse inference problem



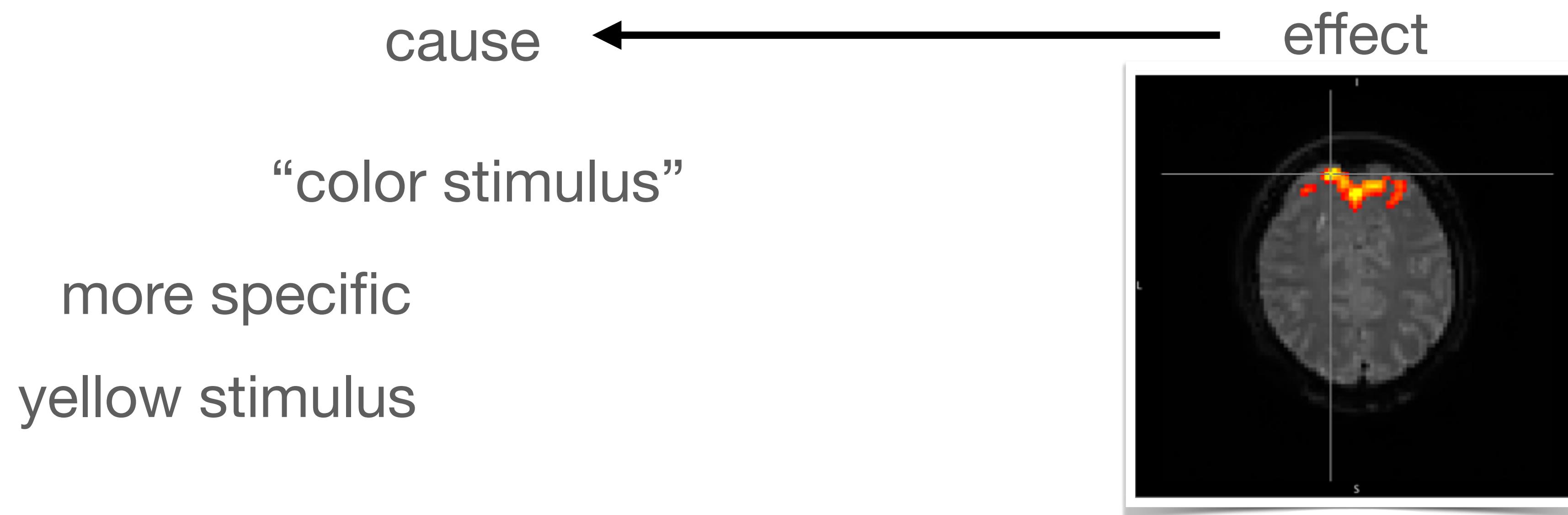
Reverse Inference Problem

- inverse inference problem



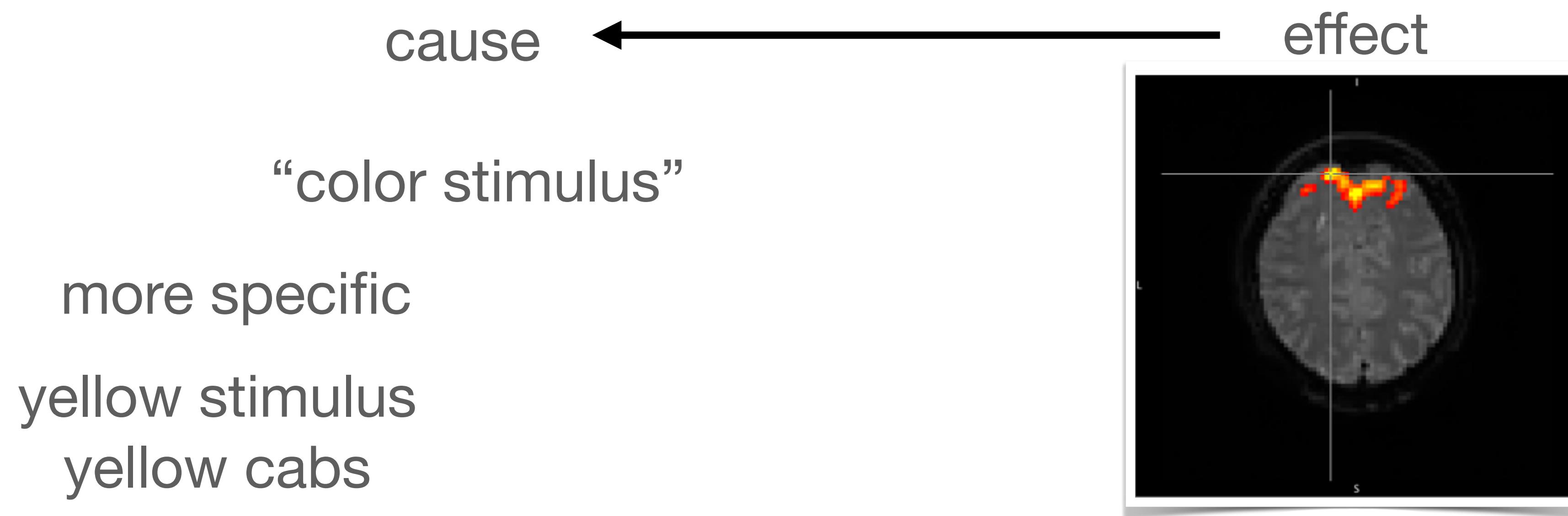
Reverse Inference Problem

- inverse inference problem



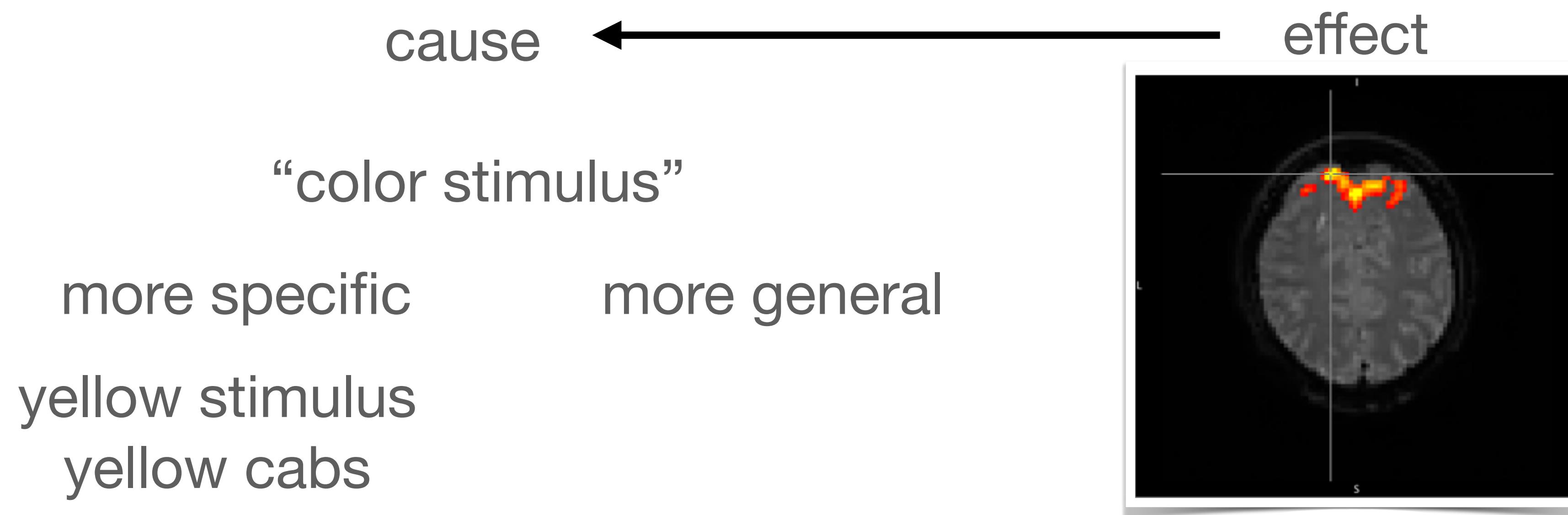
Reverse Inference Problem

- inverse inference problem



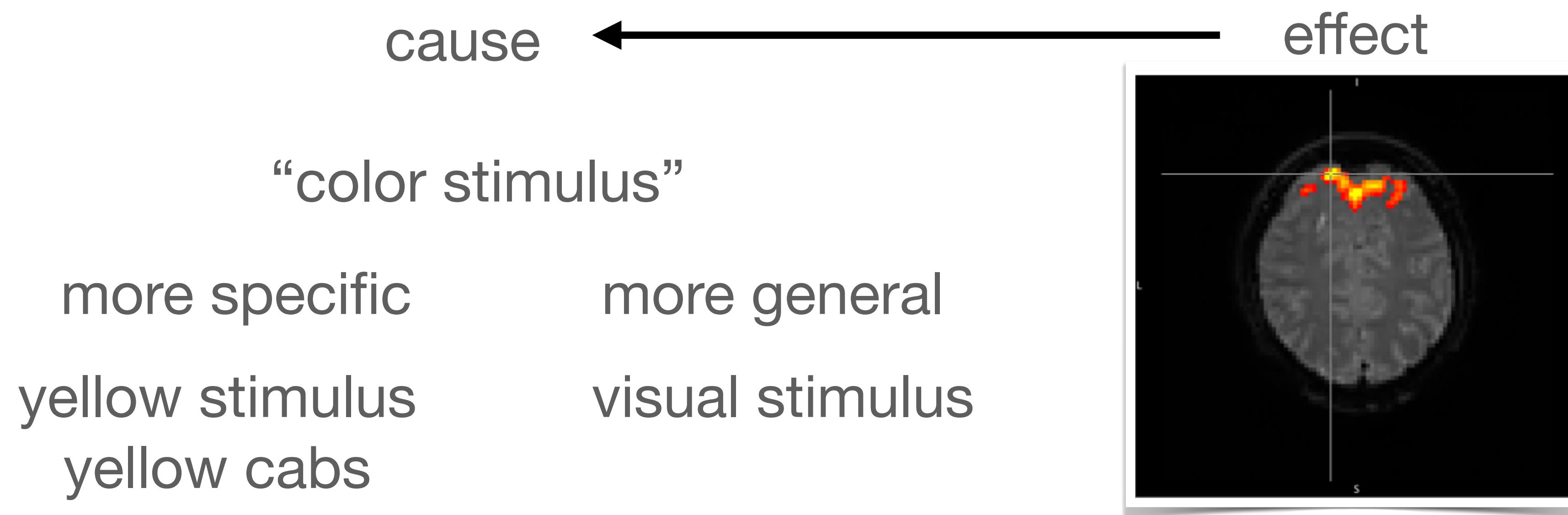
Reverse Inference Problem

- inverse inference problem



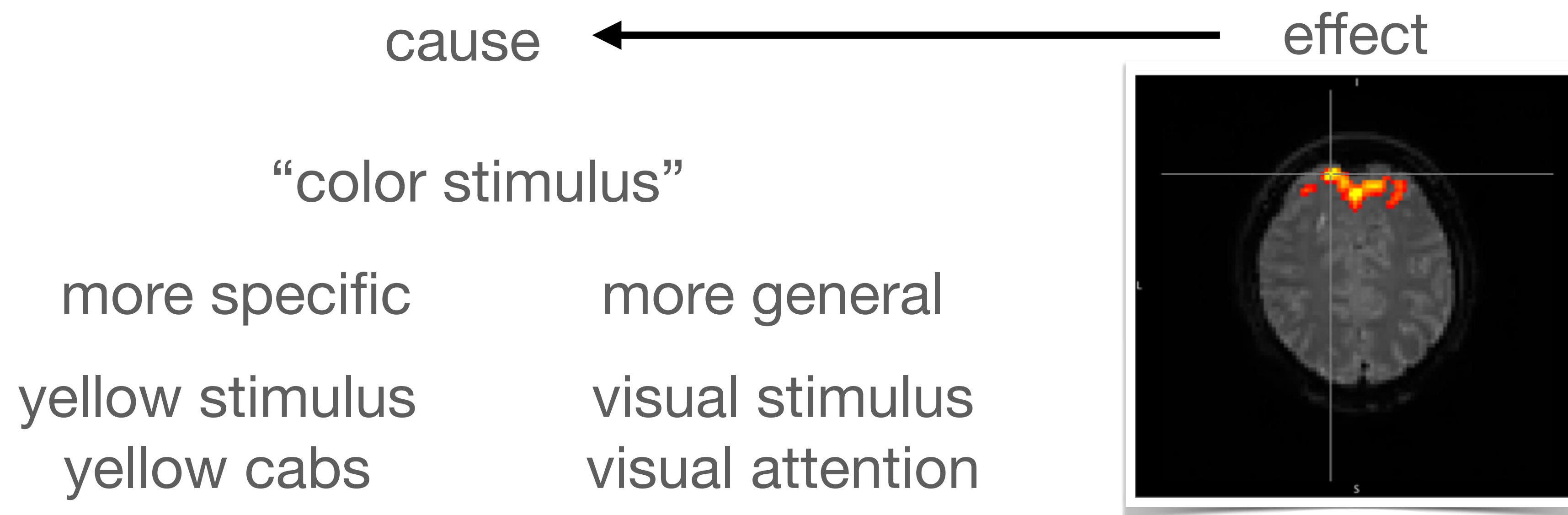
Reverse Inference Problem

- inverse inference problem



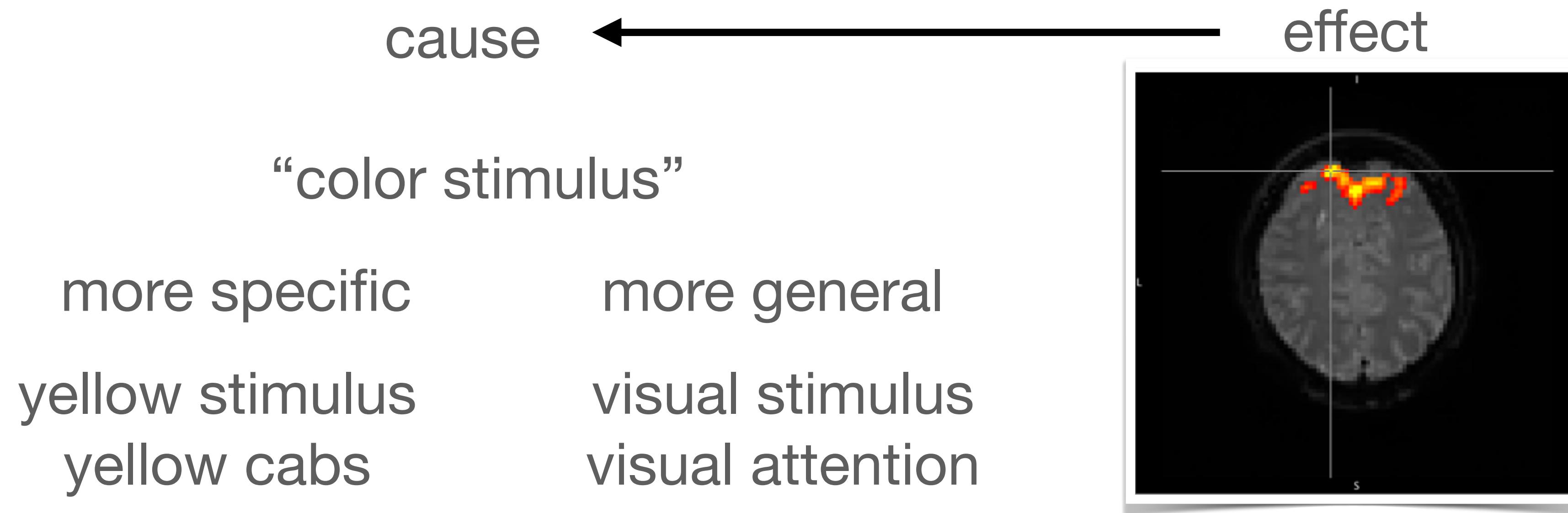
Reverse Inference Problem

- inverse inference problem



Reverse Inference Problem

- inverse inference problem



what is it about
your stimulus that
drives the effect?

Limitations of Univariate Analyses

- cannot distinguish stimulus types within ROI
- reverse inference: what is it about your stimulus that drives activity?

Pattern Classification

Forward Models

Limitations of Univariate Analyses

- cannot distinguish stimulus types within ROI
- reverse inference: what is it about your stimulus that drives activity?

Pattern Classification

Other Lectures on
Receptive Field Models

Limitations of Univariate Analyses

- cannot distinguish stimulus types within ROI
- reverse inference: what is it about your stimulus that drives activity?

This Lecture

Pattern Classification

Other Lectures on
Receptive Field Models

Forward Models

MVPA

Multivariate pattern analysis

Going Multivariate

Going Multivariate

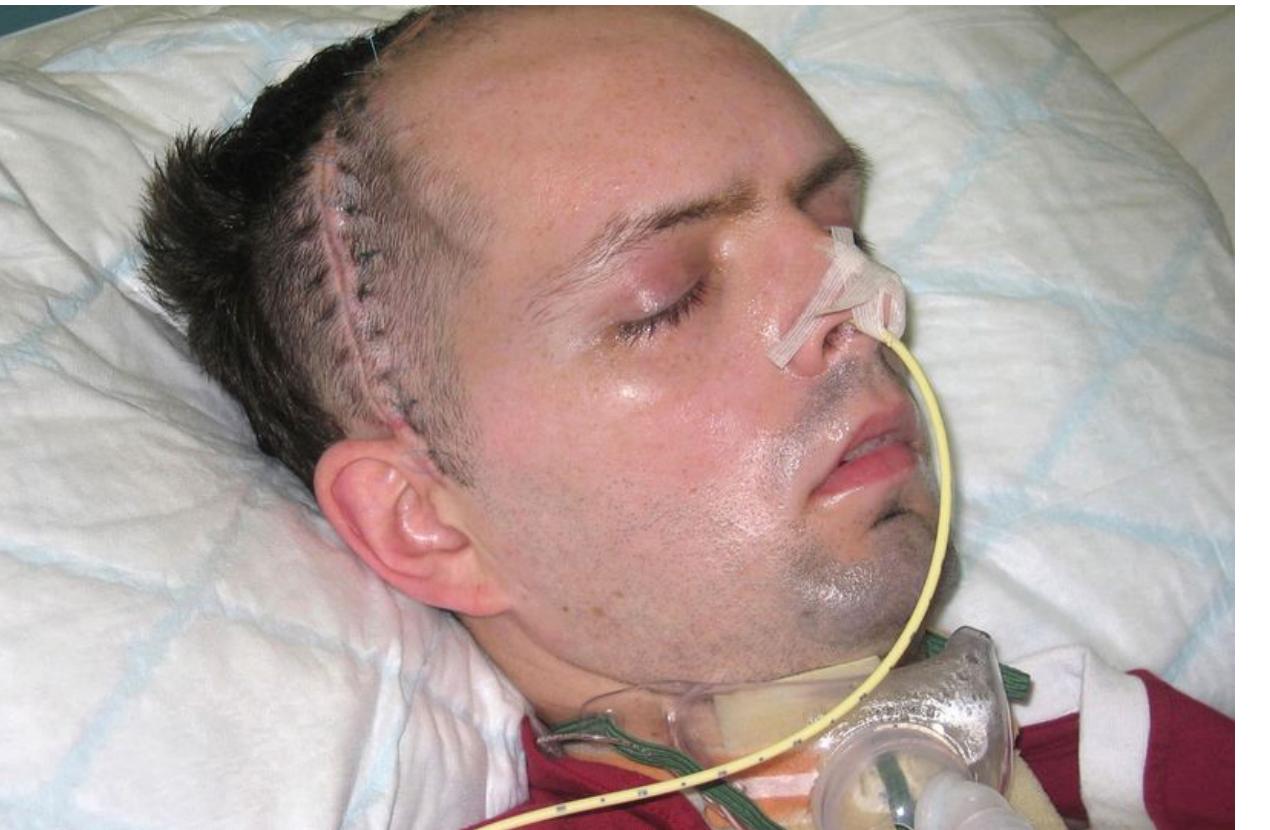
Detecting Awareness in the Vegetative State

Adrian M. Owen,^{1*} Martin R. Coleman,² Melanie Boly,³ Matthew H. Davis,¹
Steven Laureys,³ John D. Pickard²

Going Multivariate

Detecting Awareness in the Vegetative State

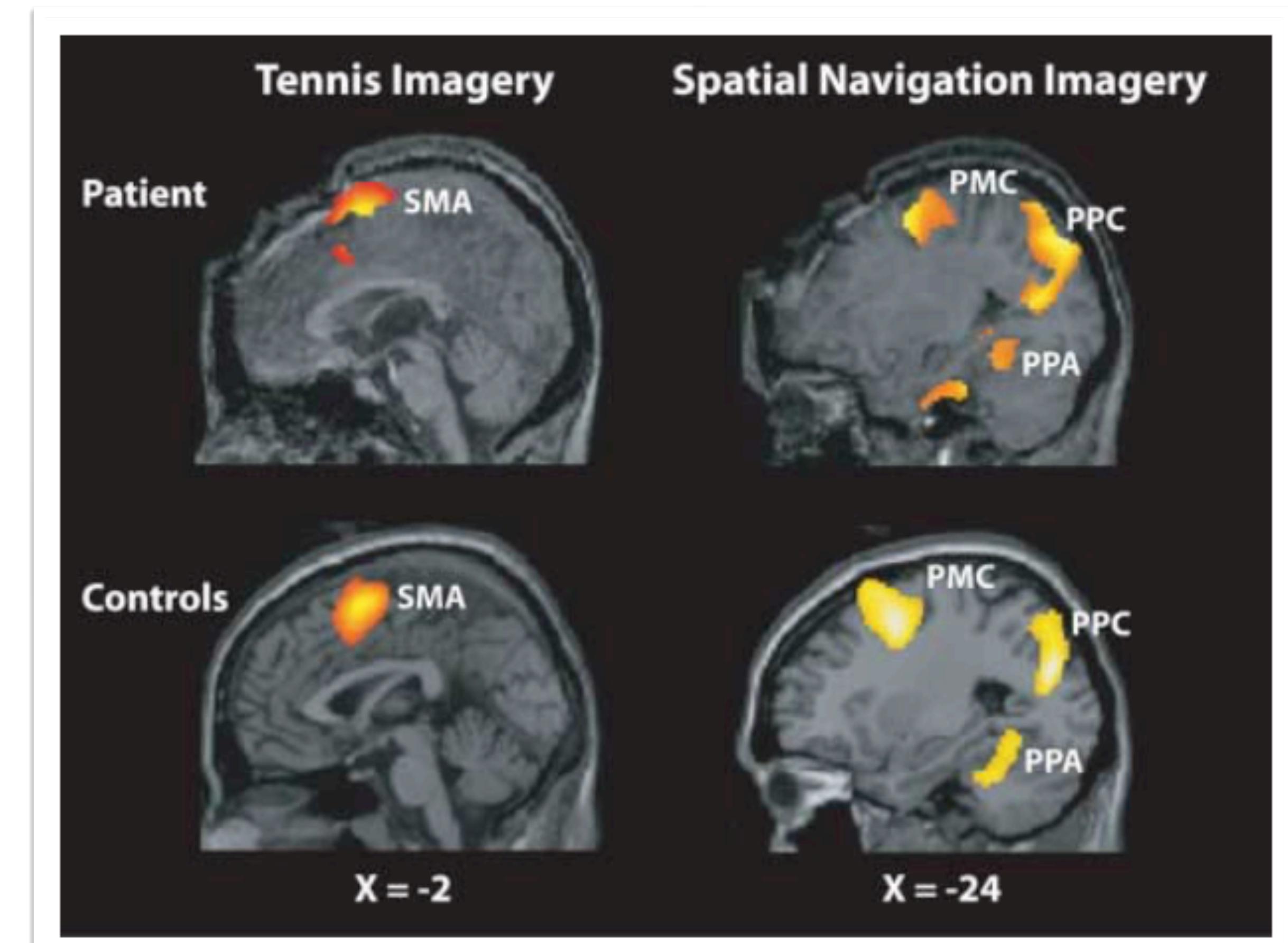
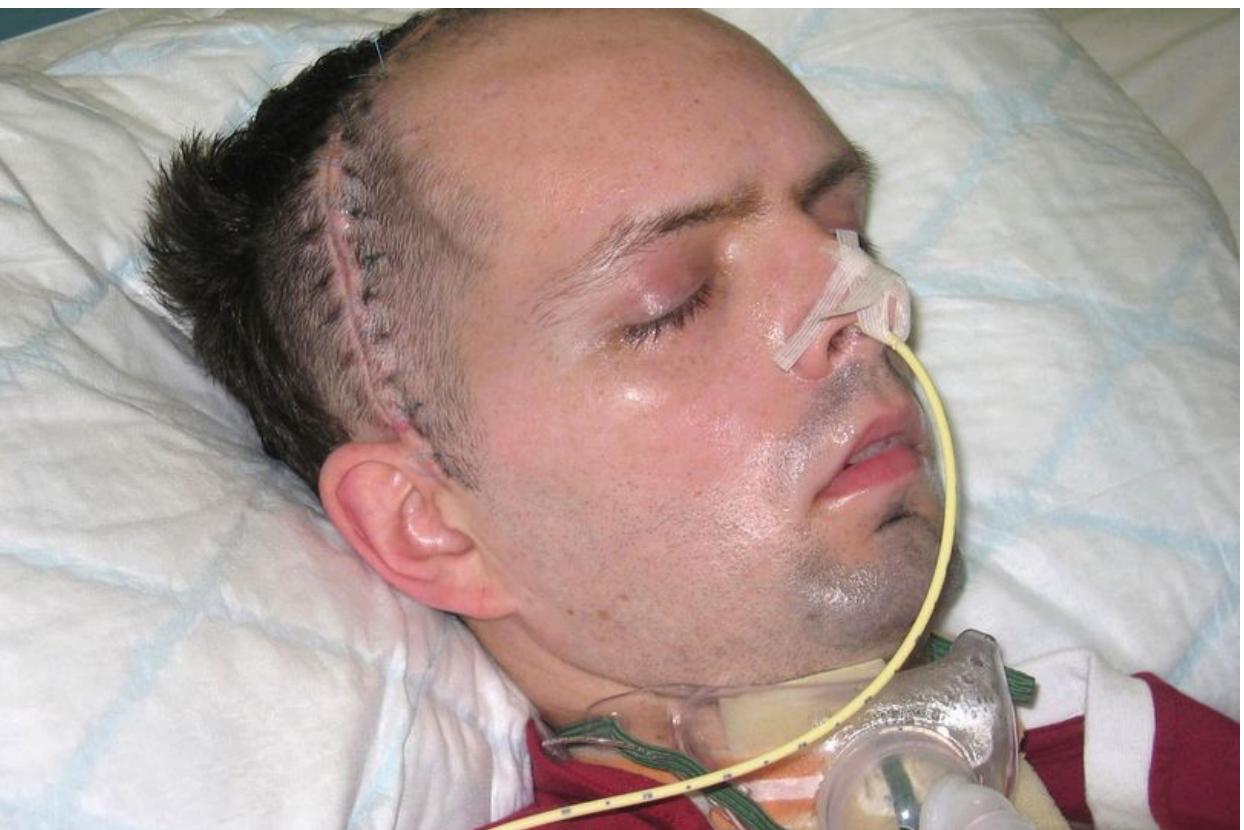
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Going Multivariate

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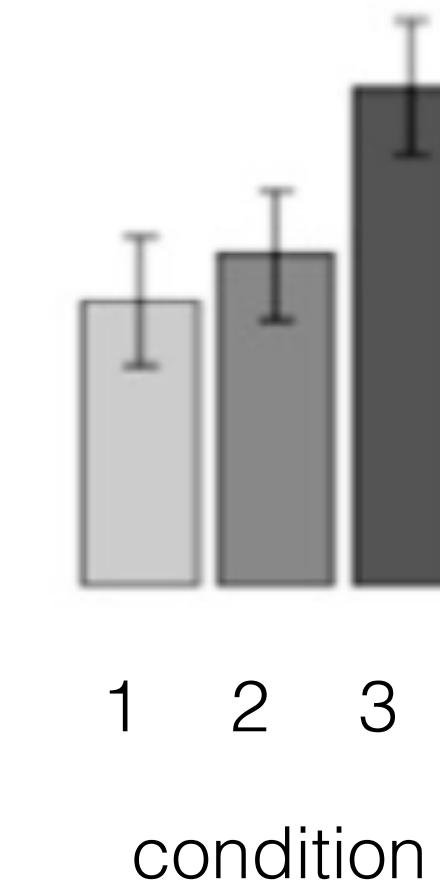
Distinguishing between stimulus types

Distinguishing between stimulus types



Univariate
Region
Of
Interest

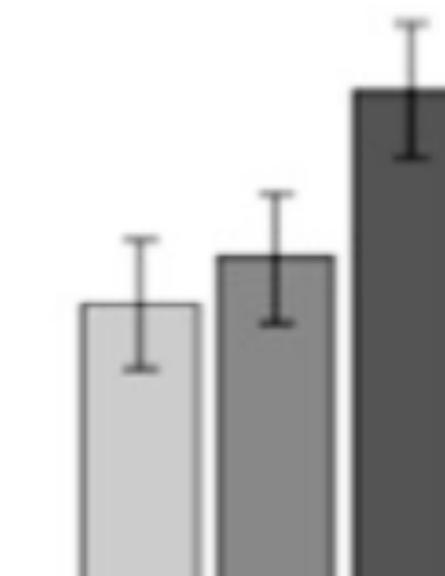
average
of activity



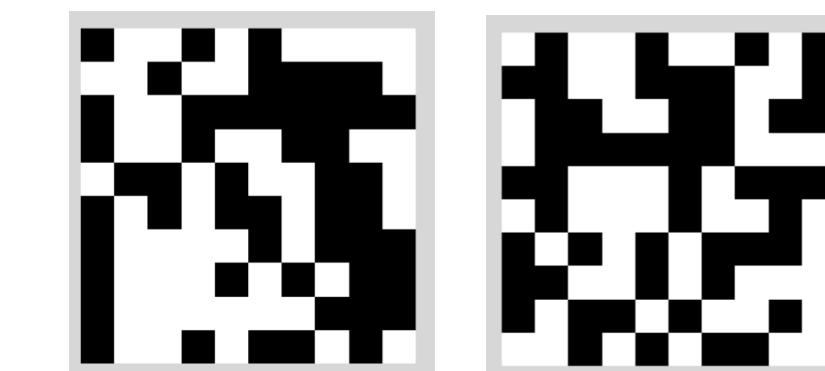
Distinguishing between stimulus types



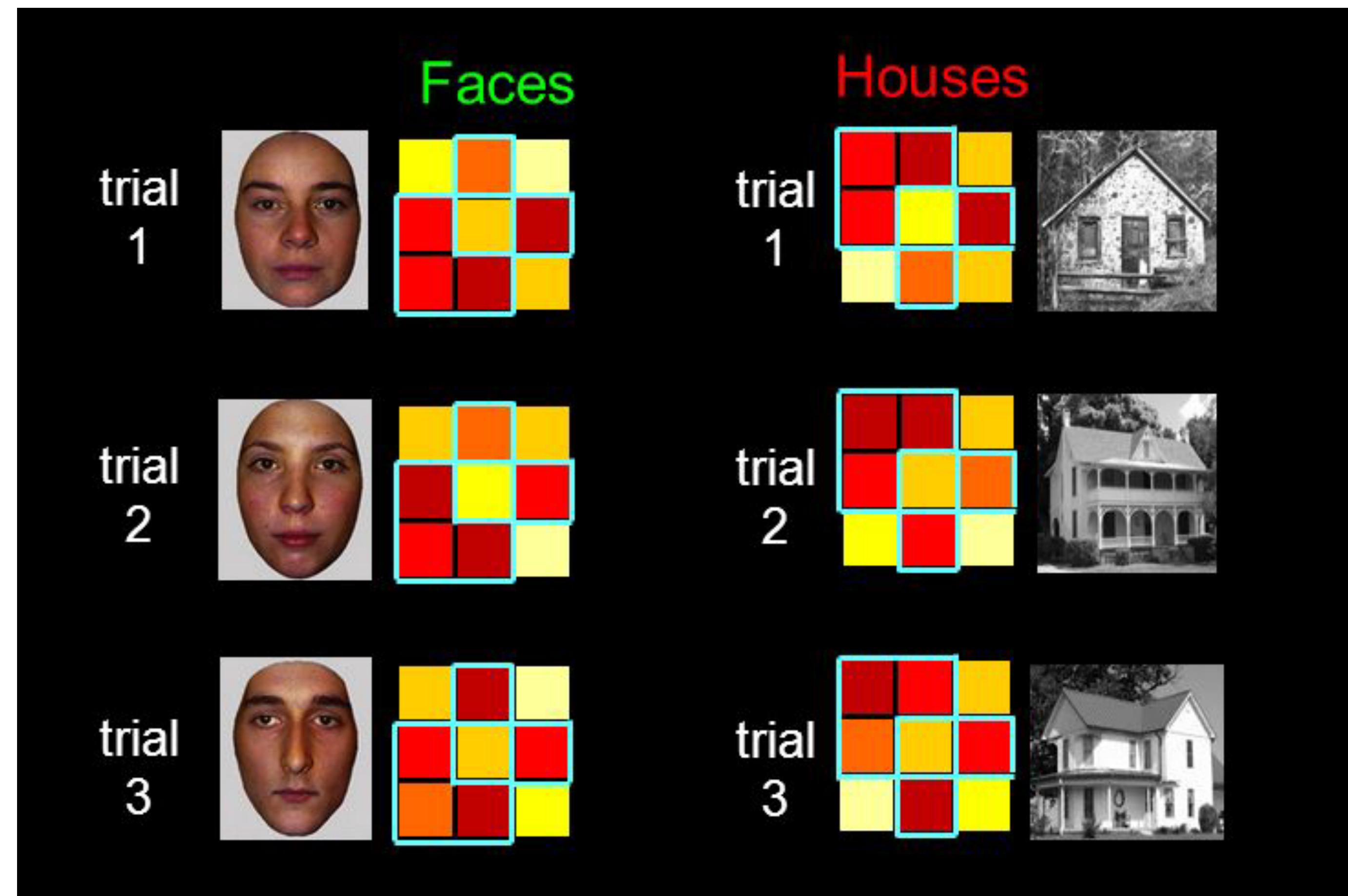
Univariate
Region
Of
Interest → *average*
of activity



Multivariate (MVPA)
Region
Of
Interest → *pattern*
of activity
(β s)



Can we distinguish between stimulus types within ROI



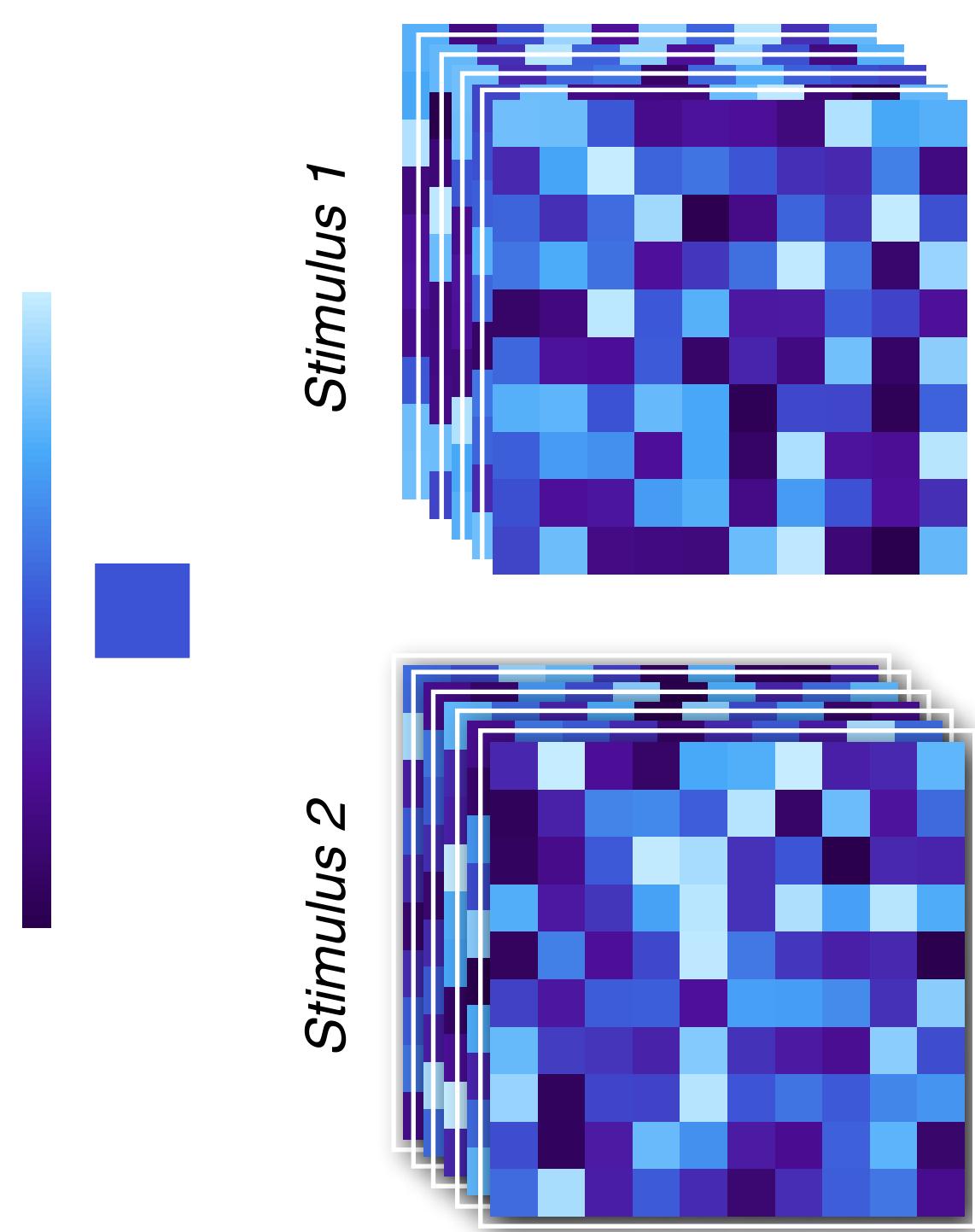
Pattern classification

Pattern classification

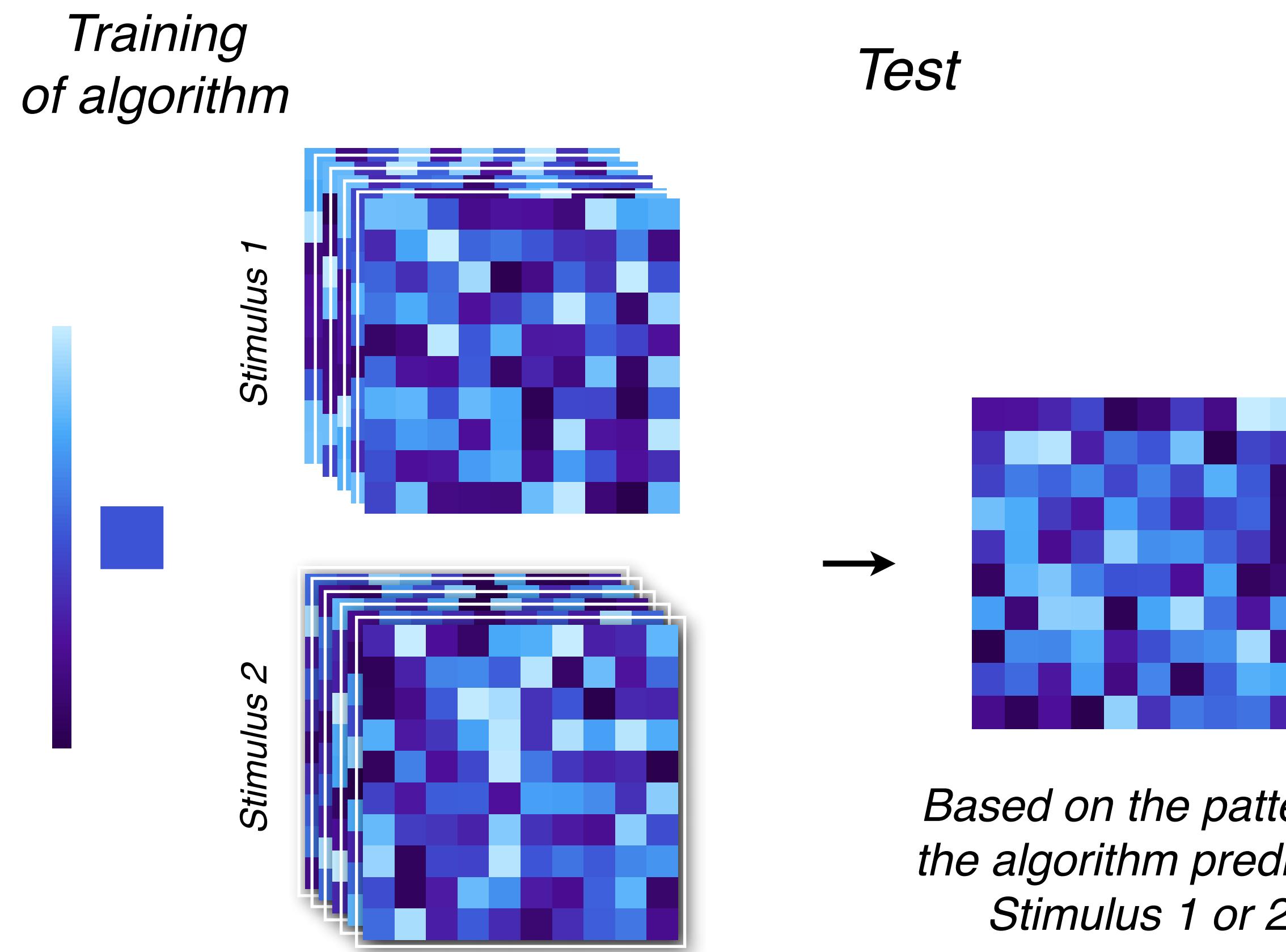
*Not mean signal intensity, but within-area **pattern** of activity, is used to classify what the brain state is.*

Pattern classification

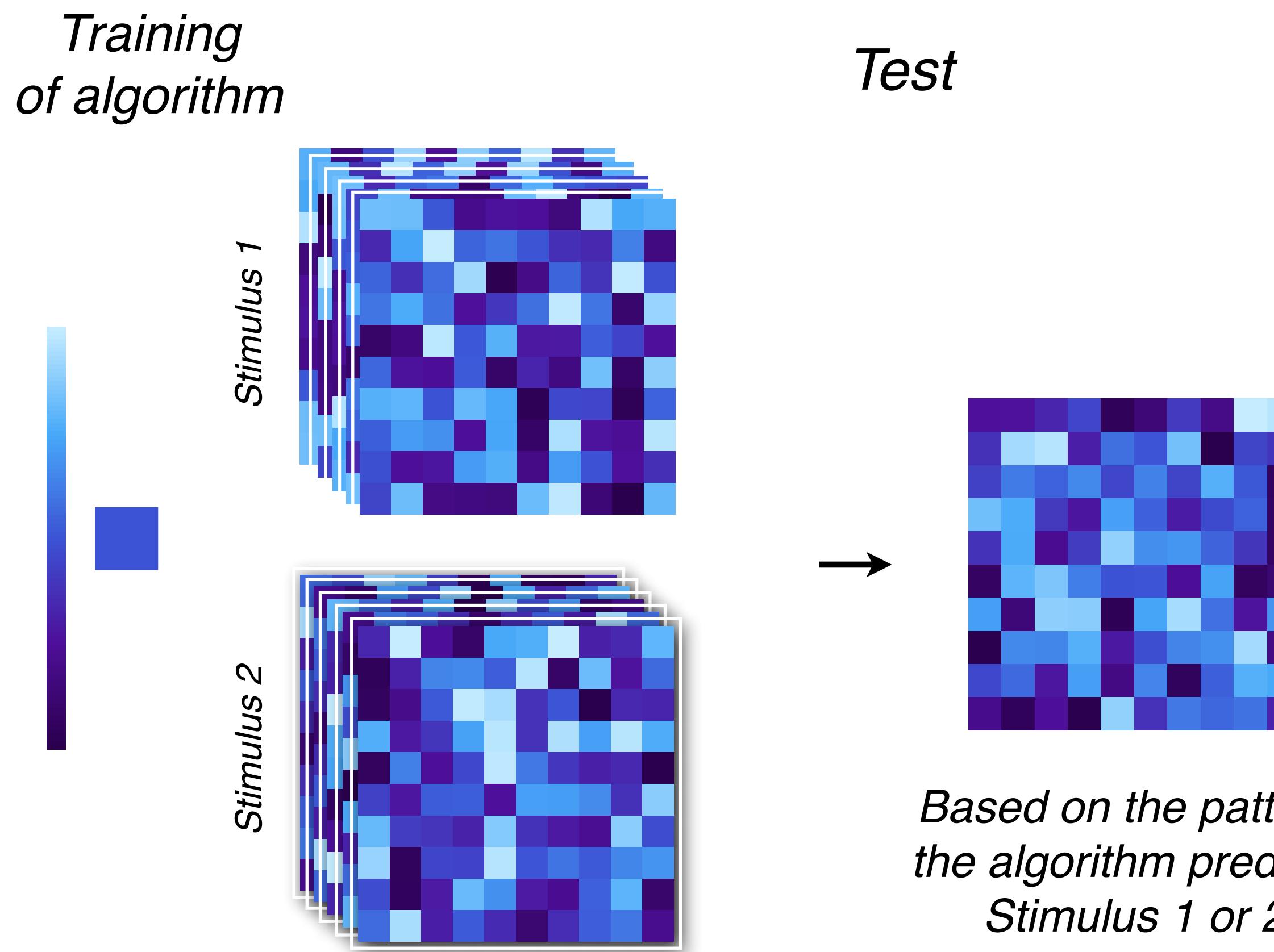
*Training
of algorithm*



Pattern classification



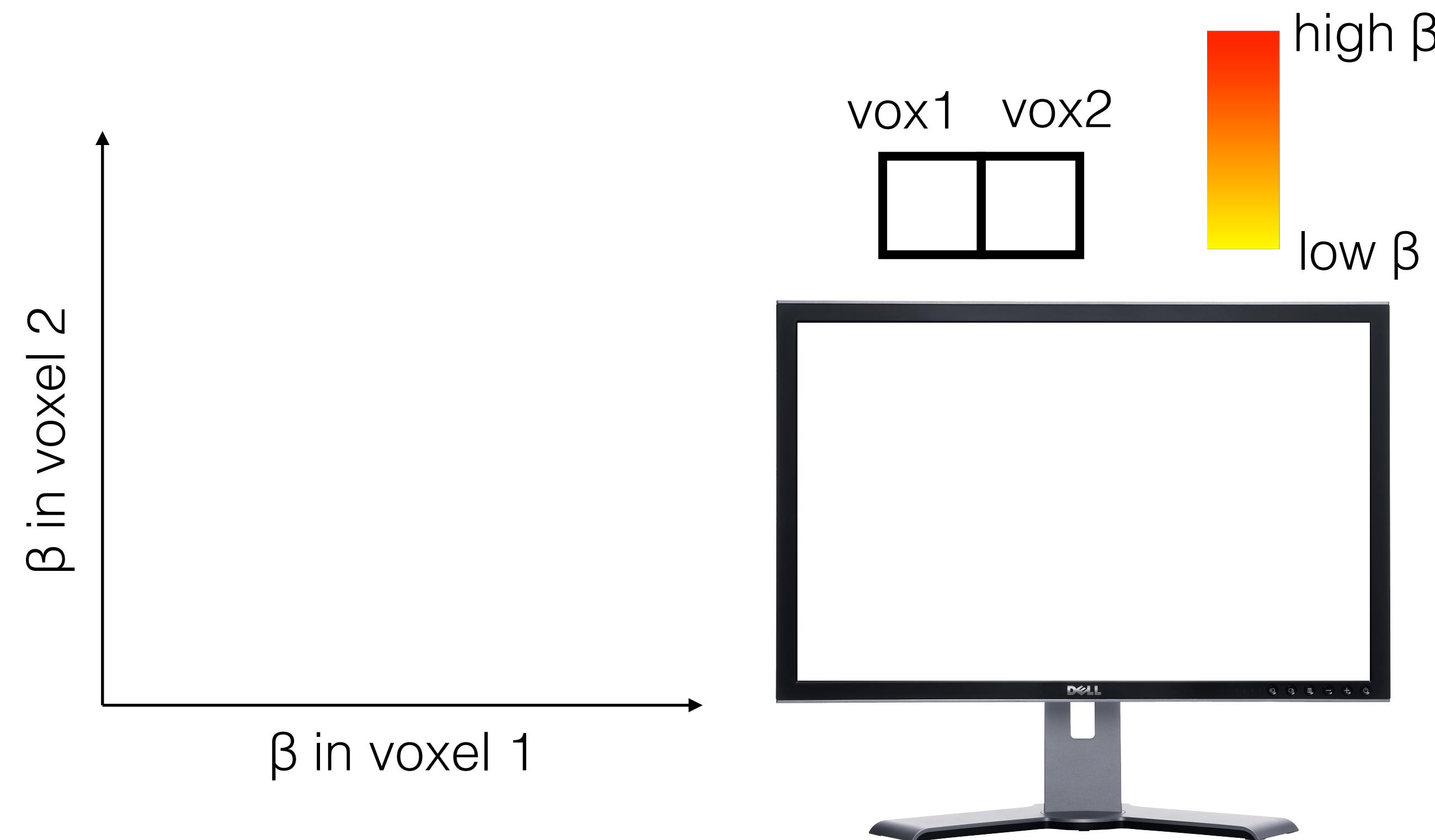
Pattern classification



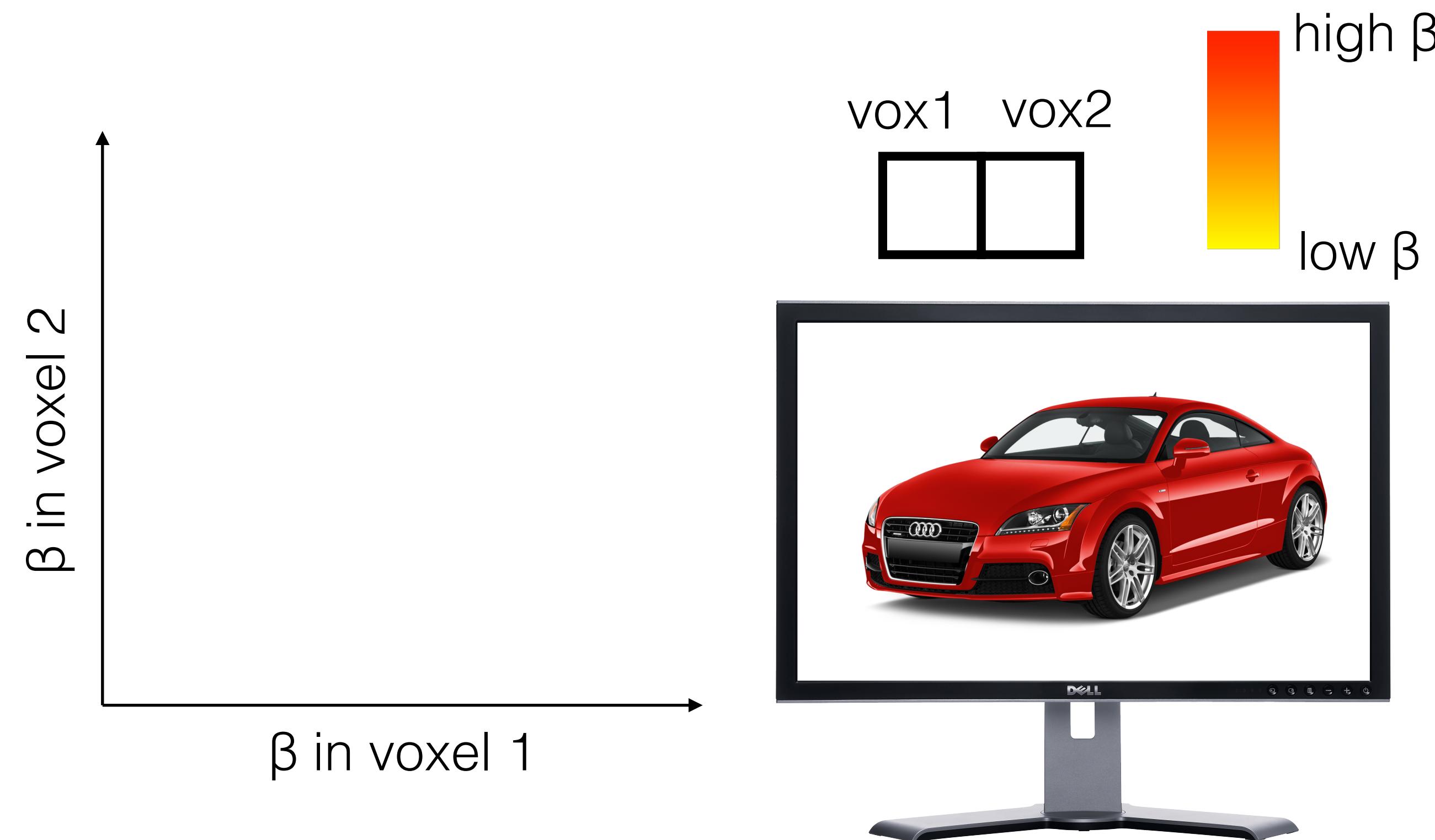
*Performance of algorithm
expressed as accuracy*

-
*gauge on “information
content” in a specific
region of interest*

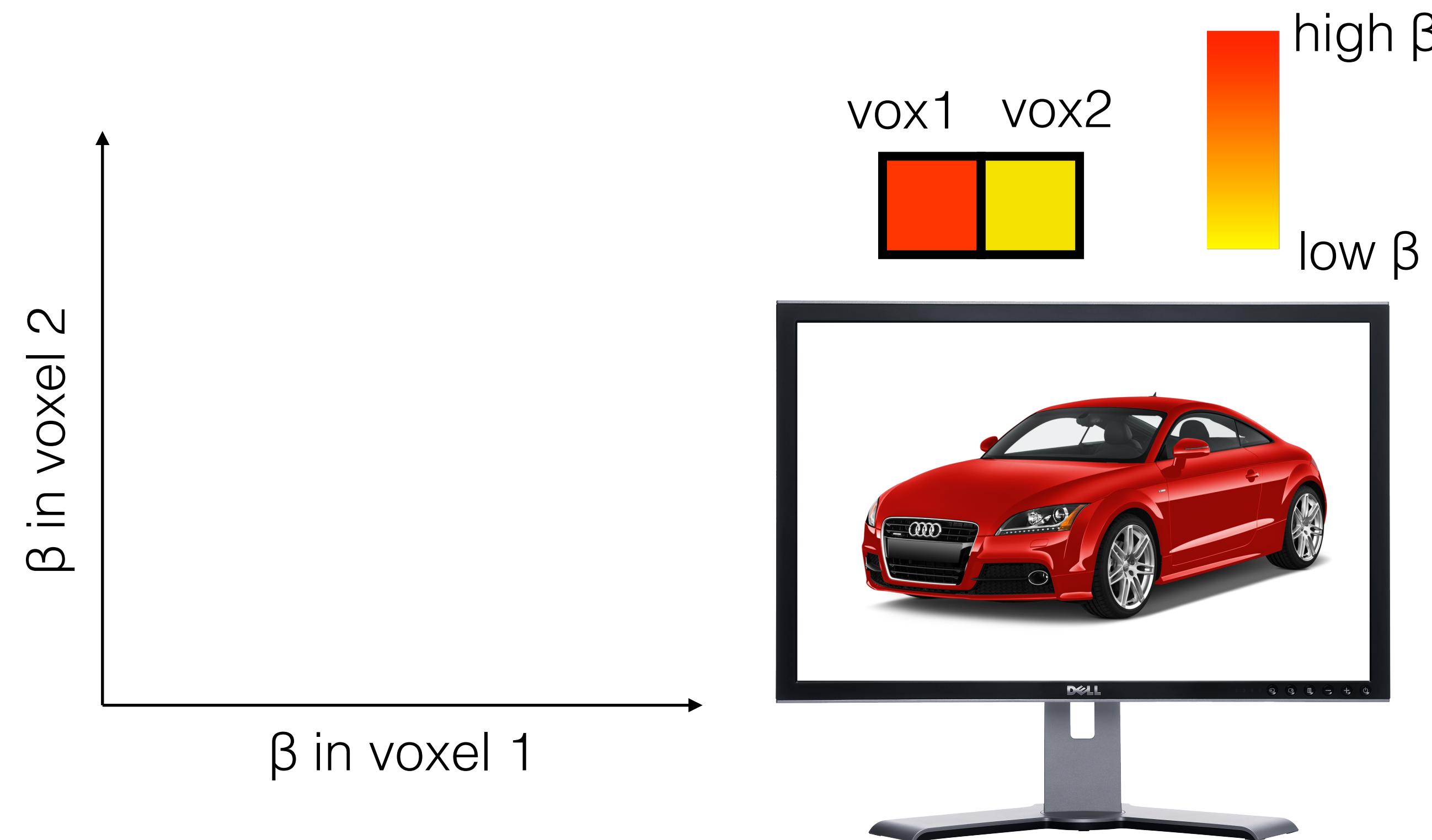
Predicting stimulus type: training a classifier



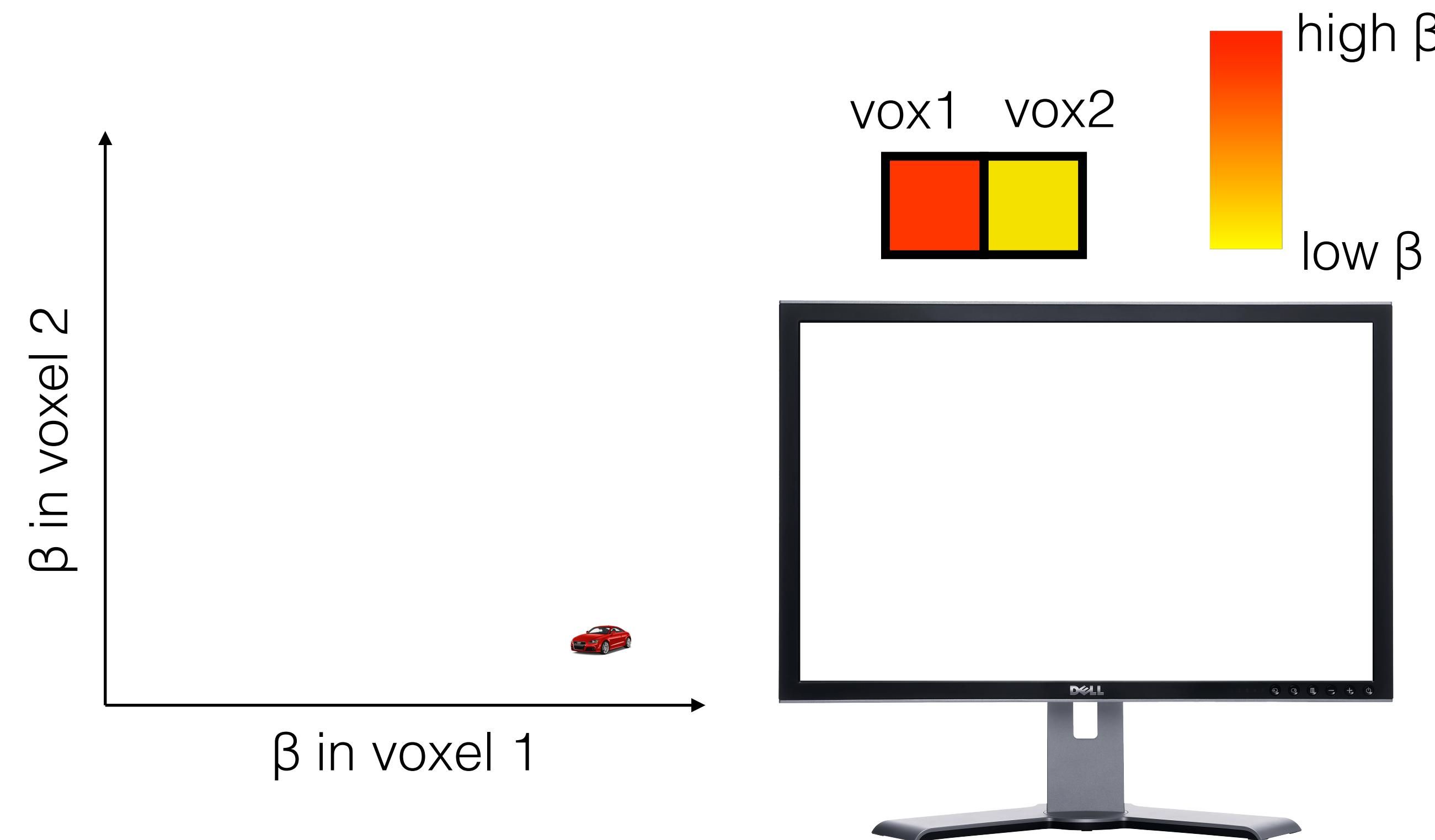
Predicting stimulus type: training a classifier



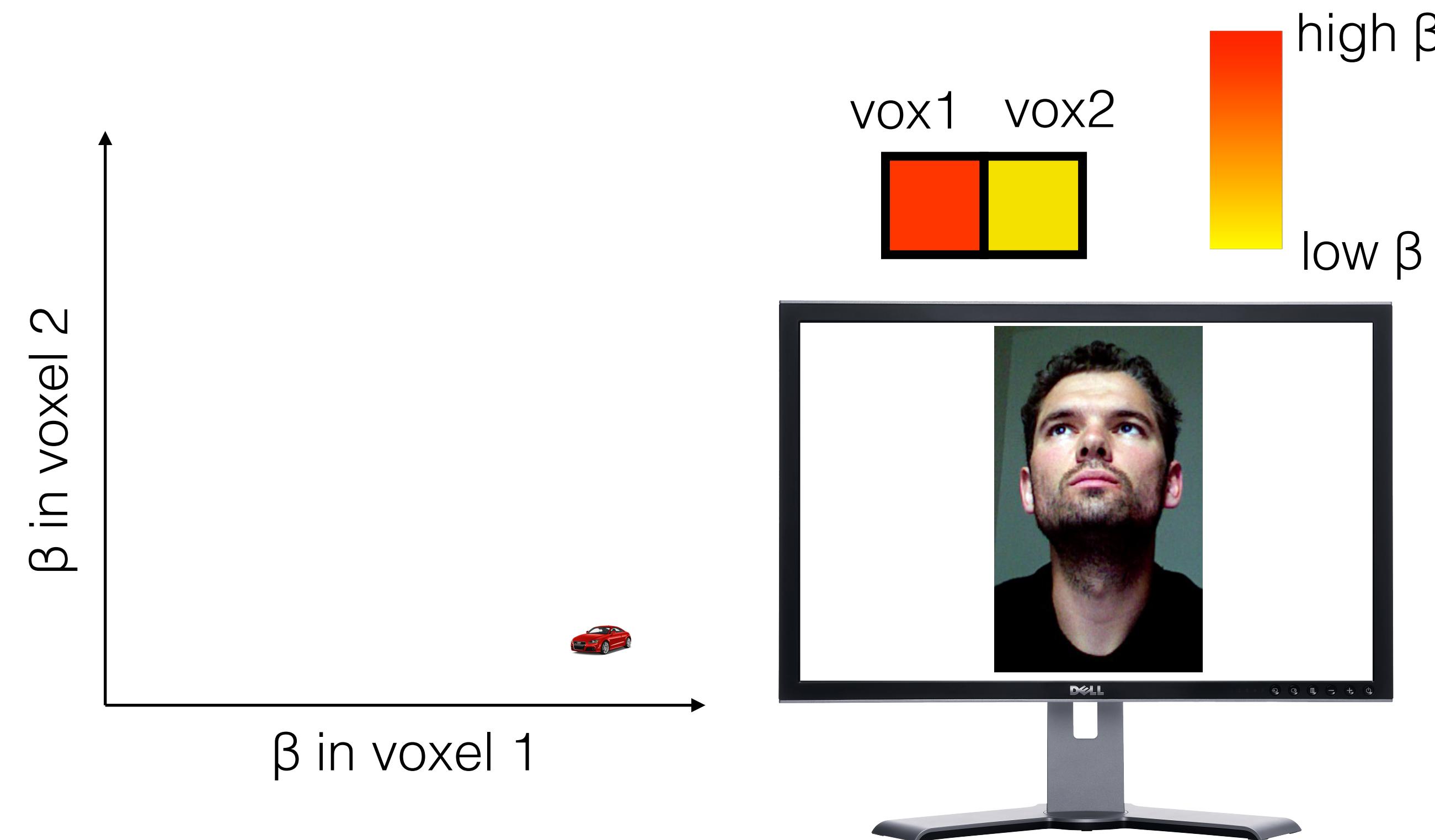
Predicting stimulus type: training a classifier



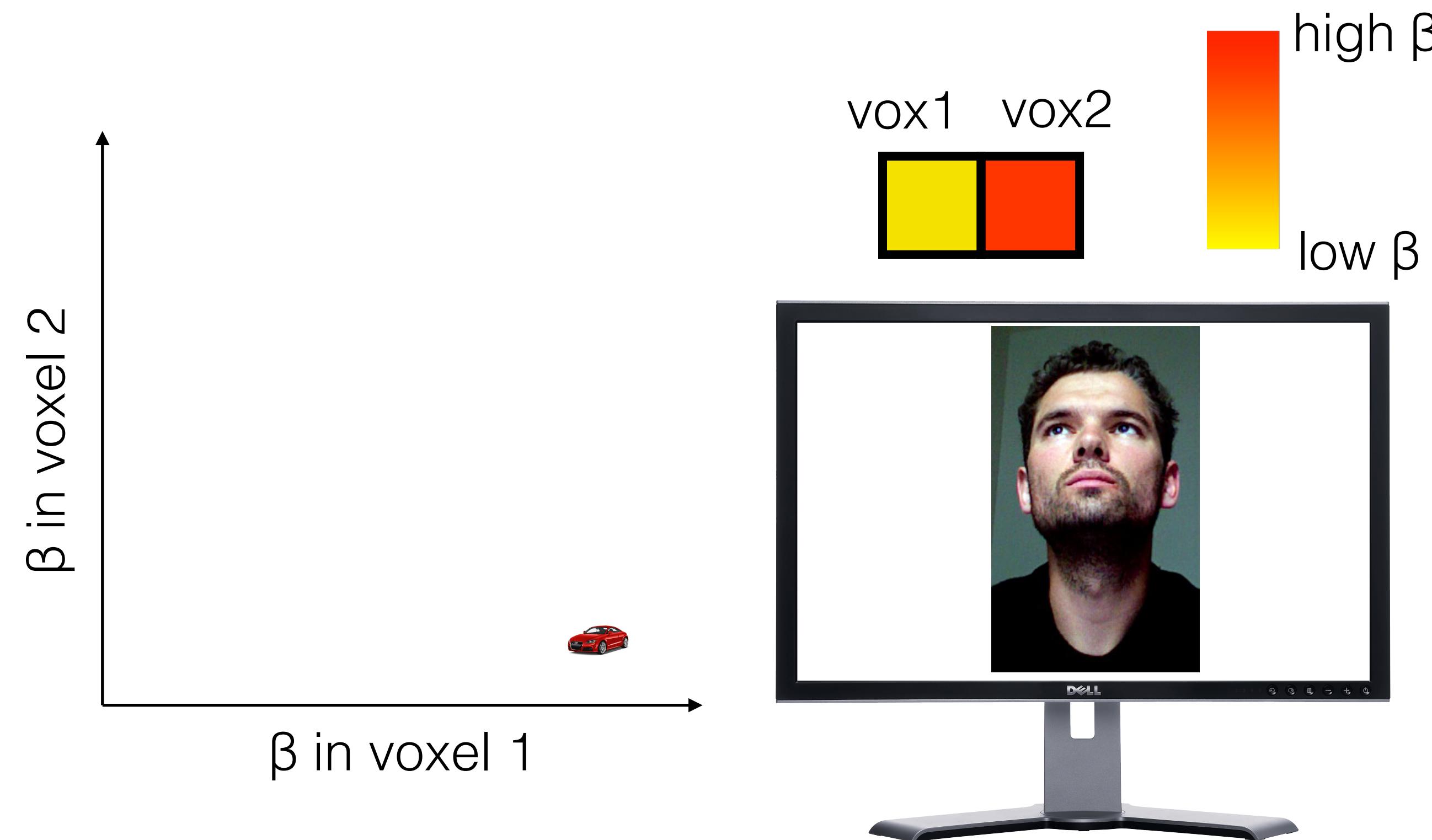
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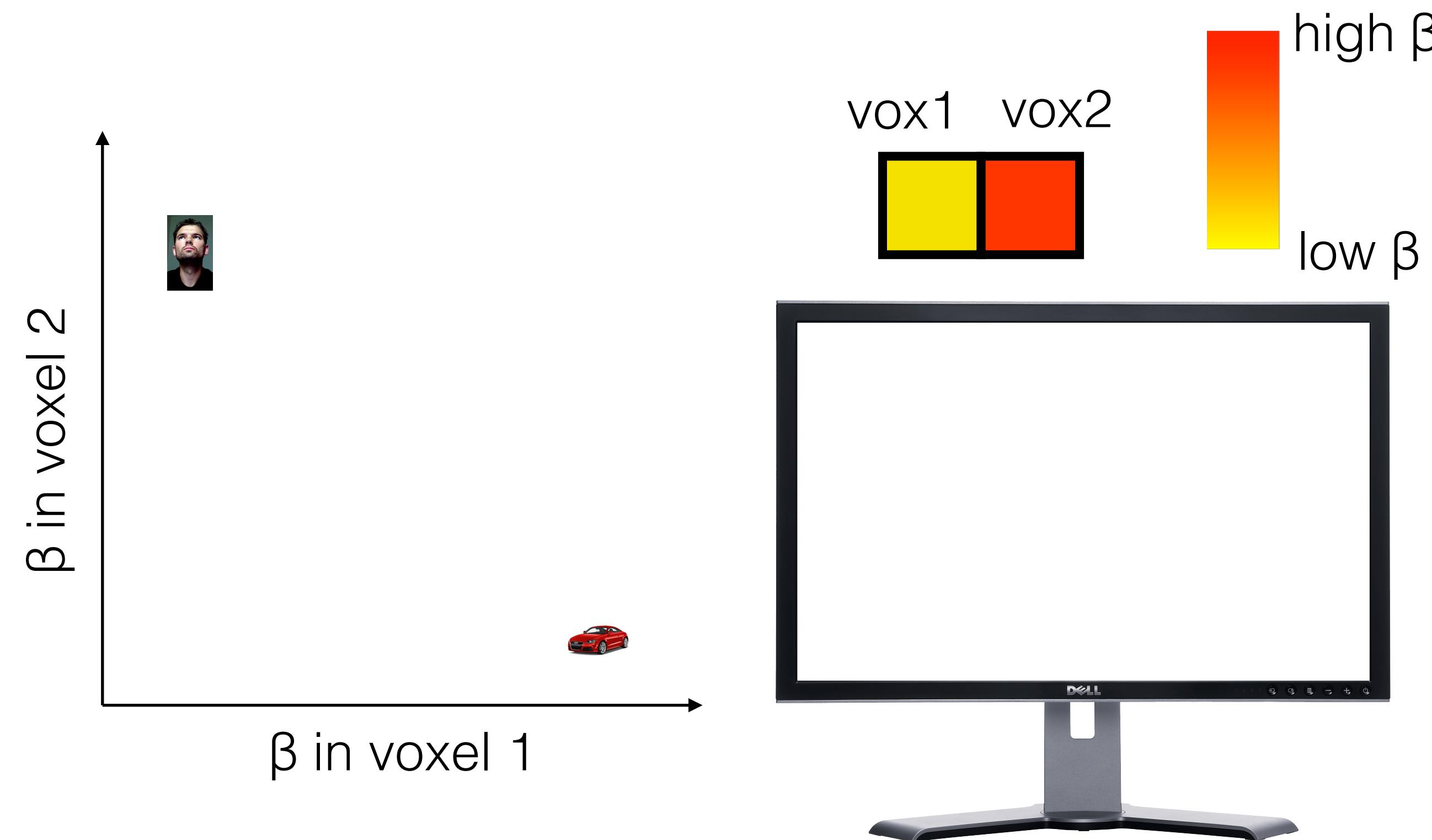
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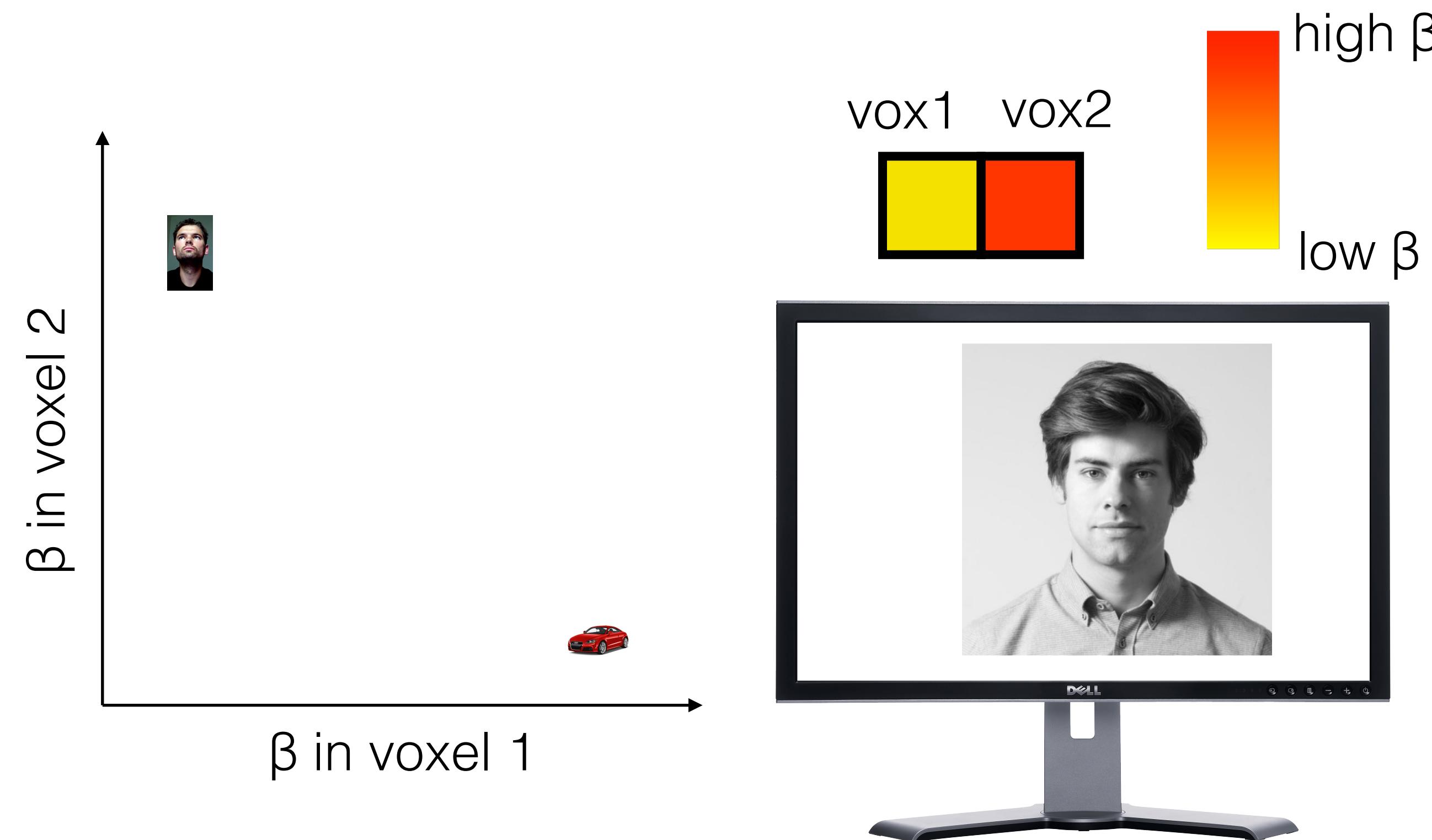
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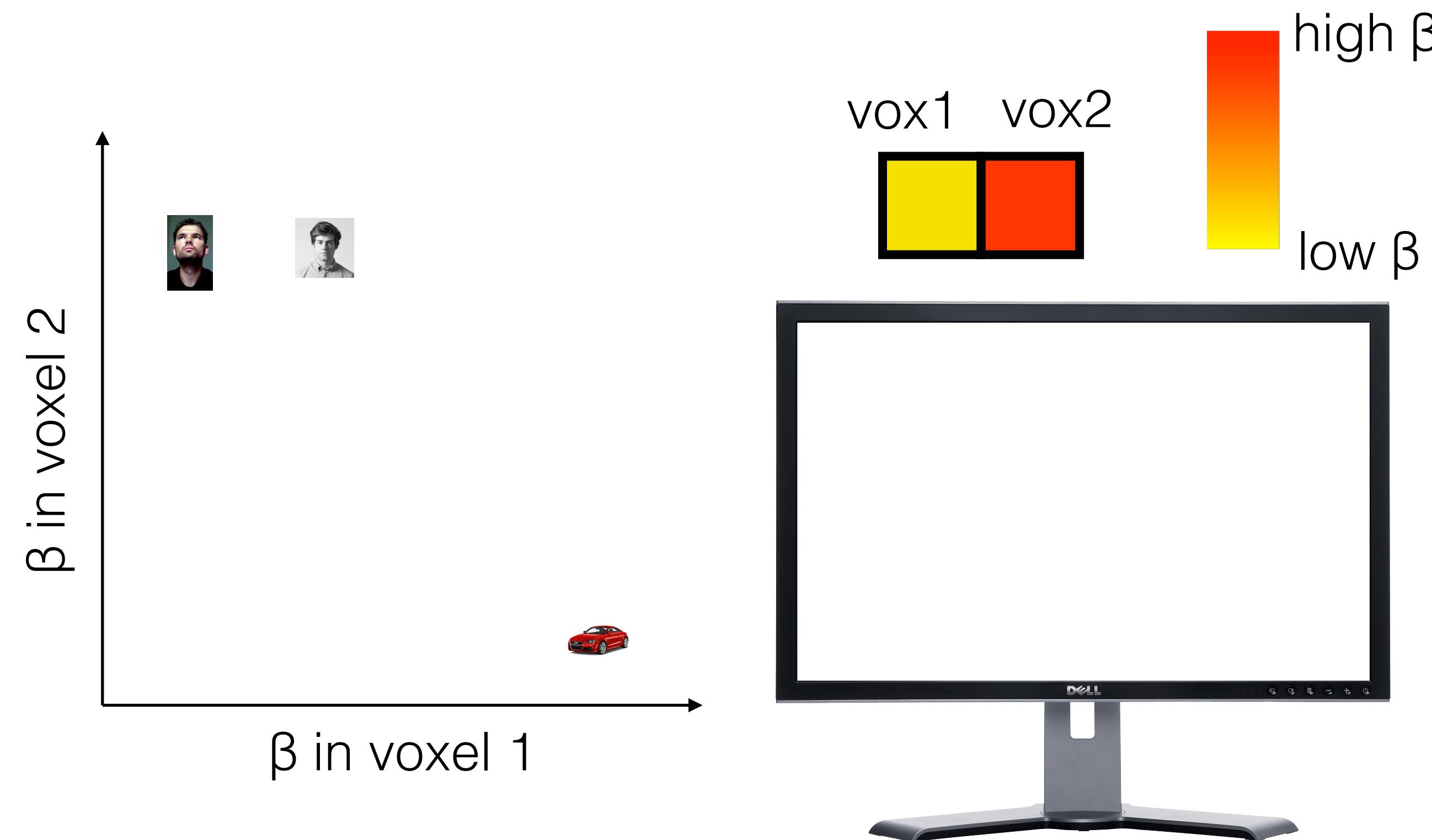
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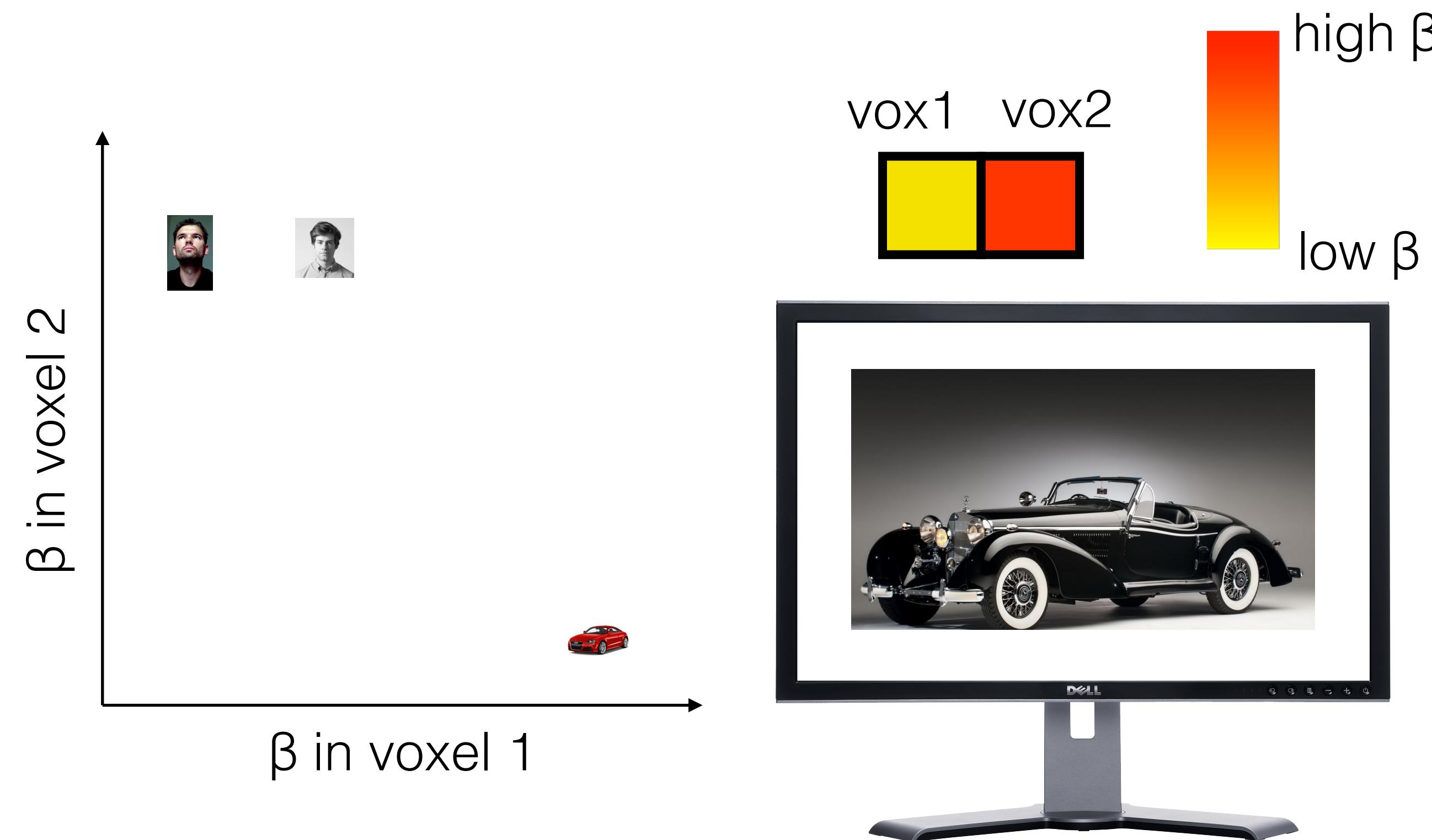
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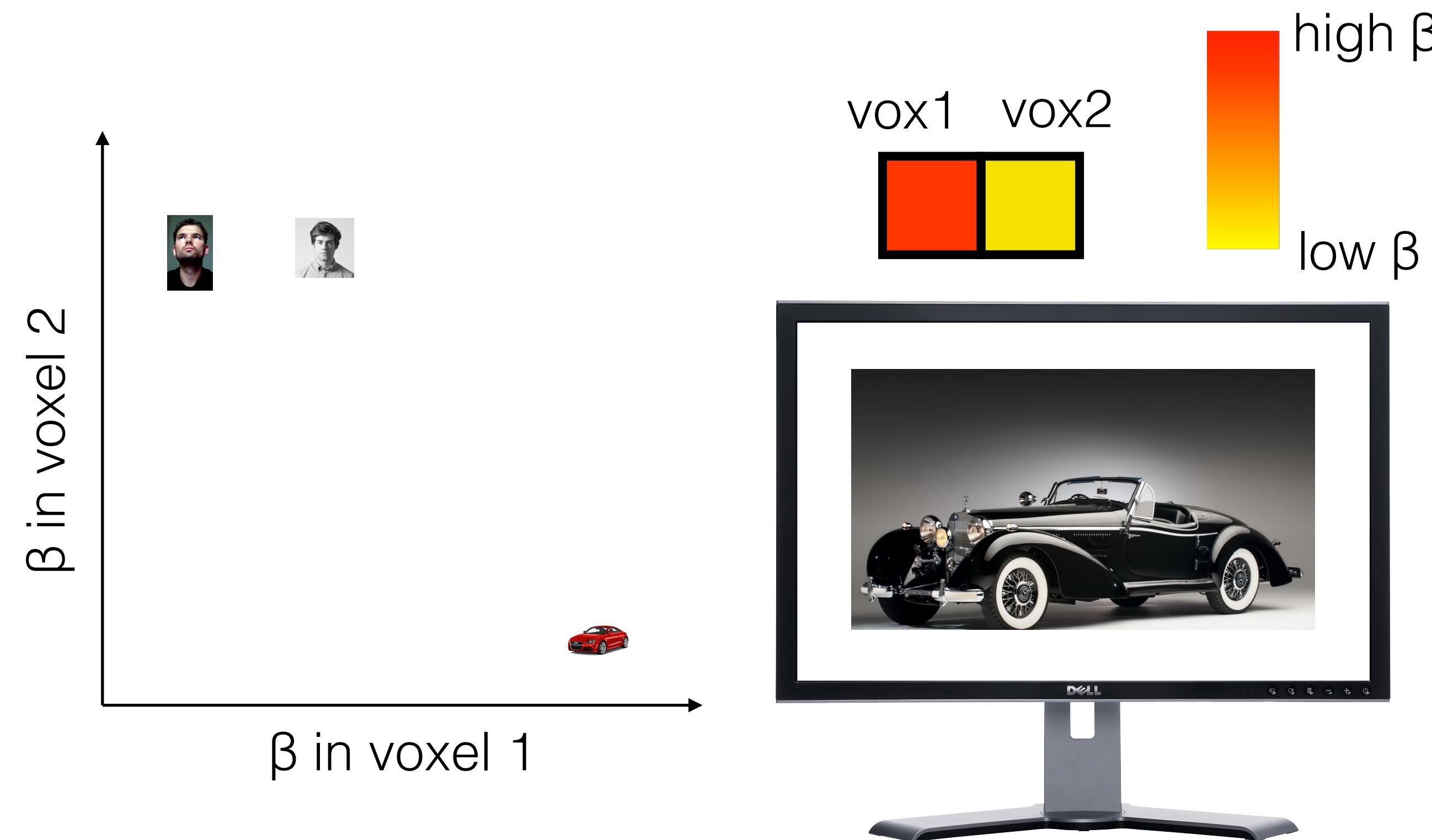
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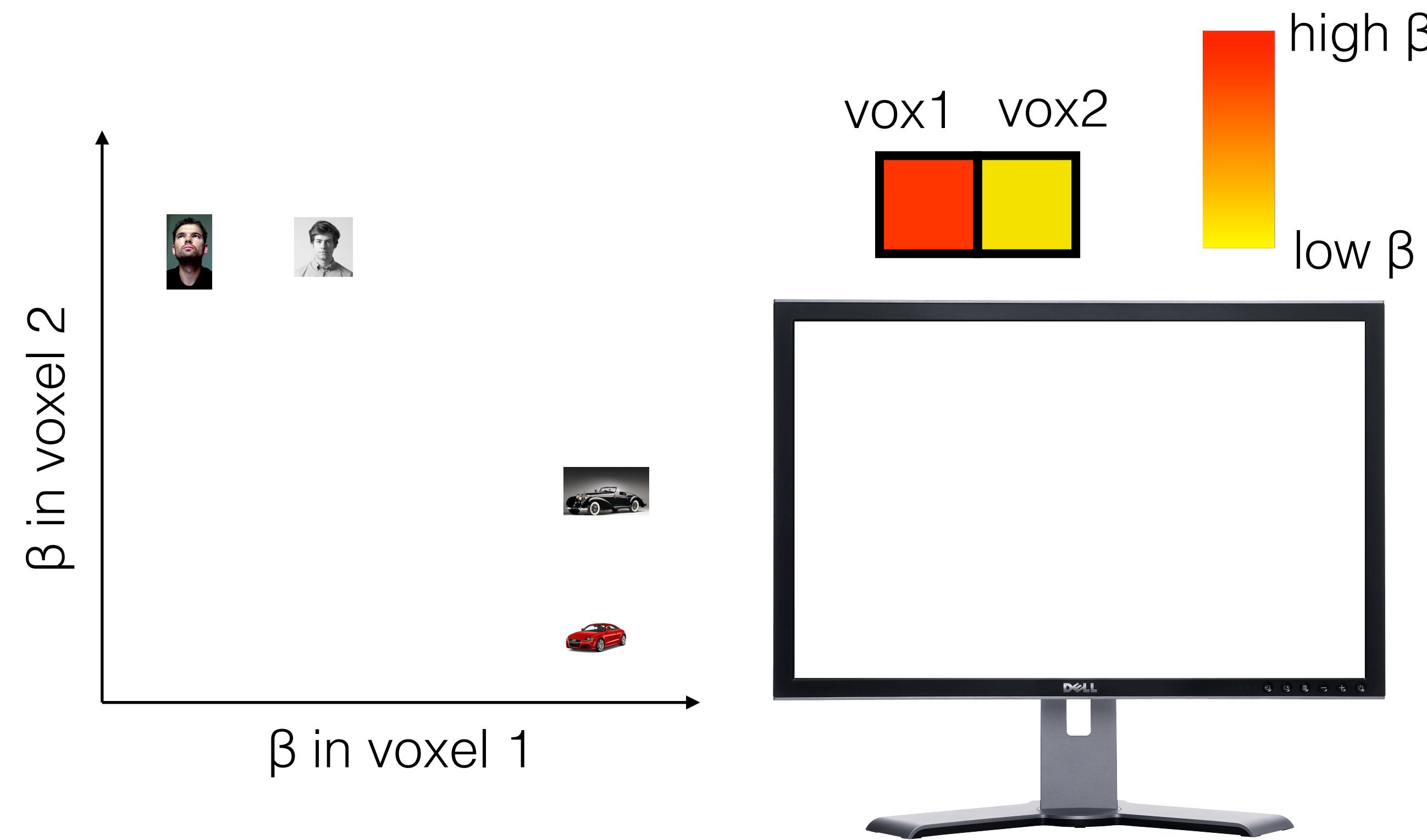
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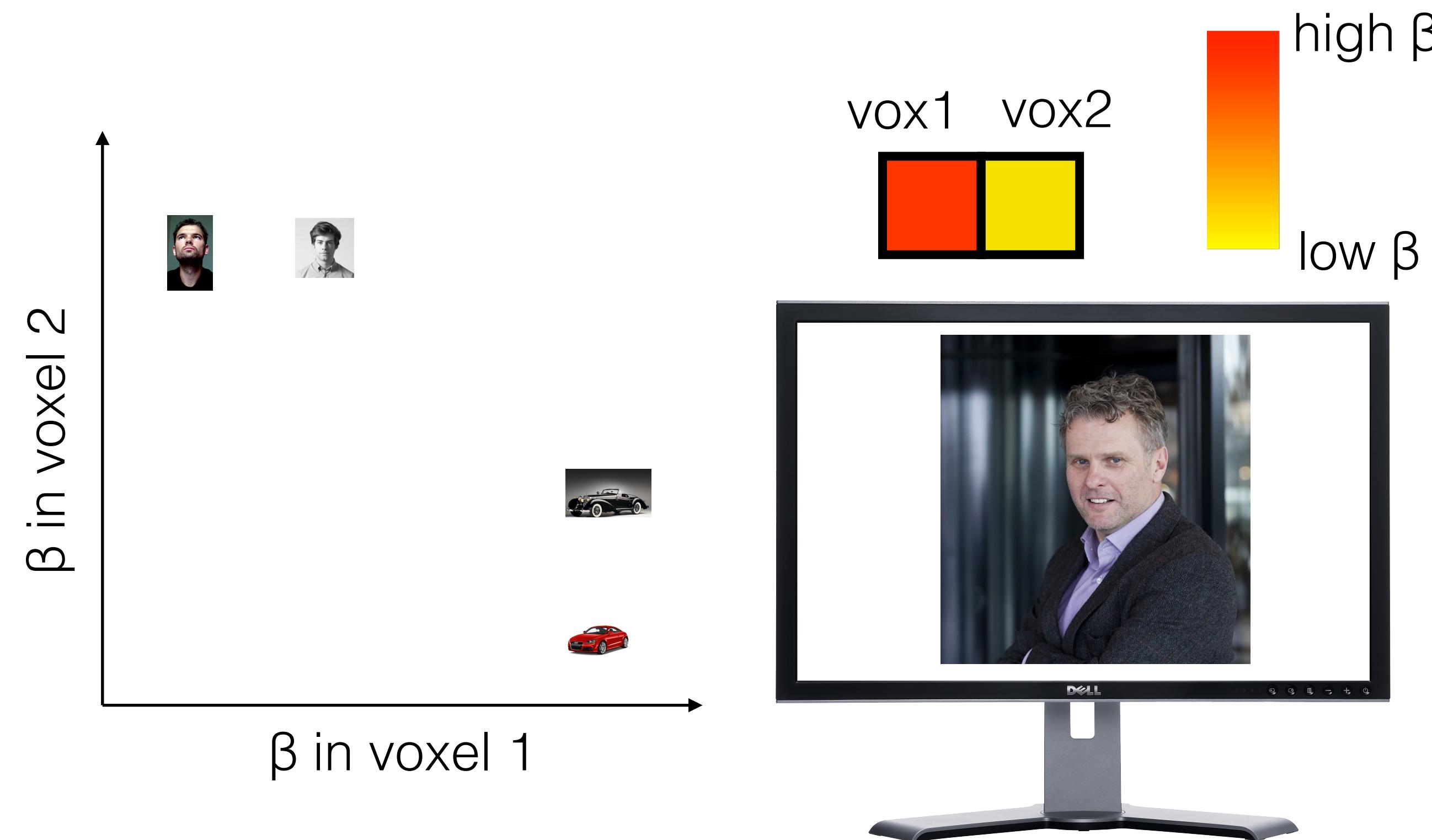
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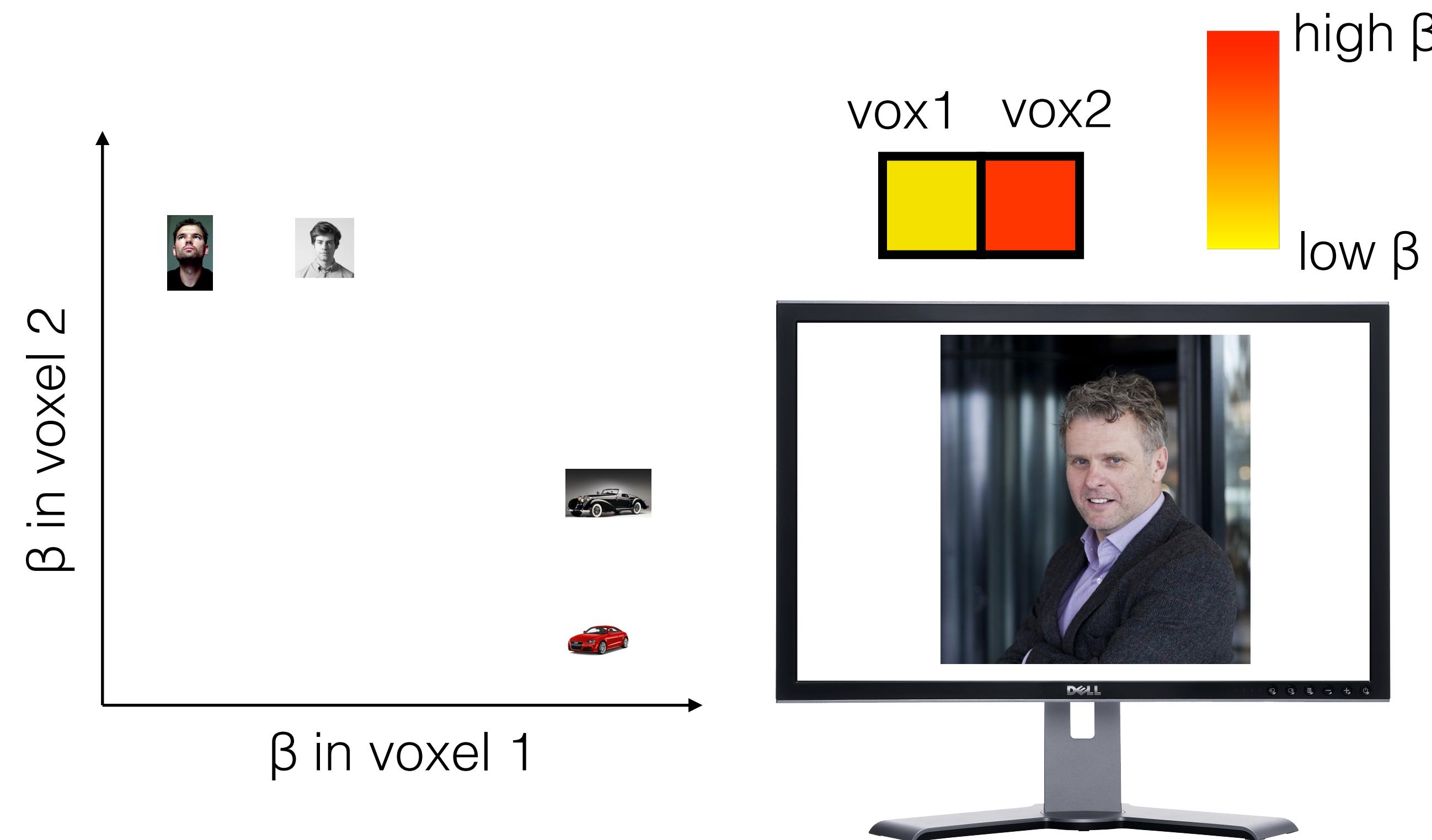
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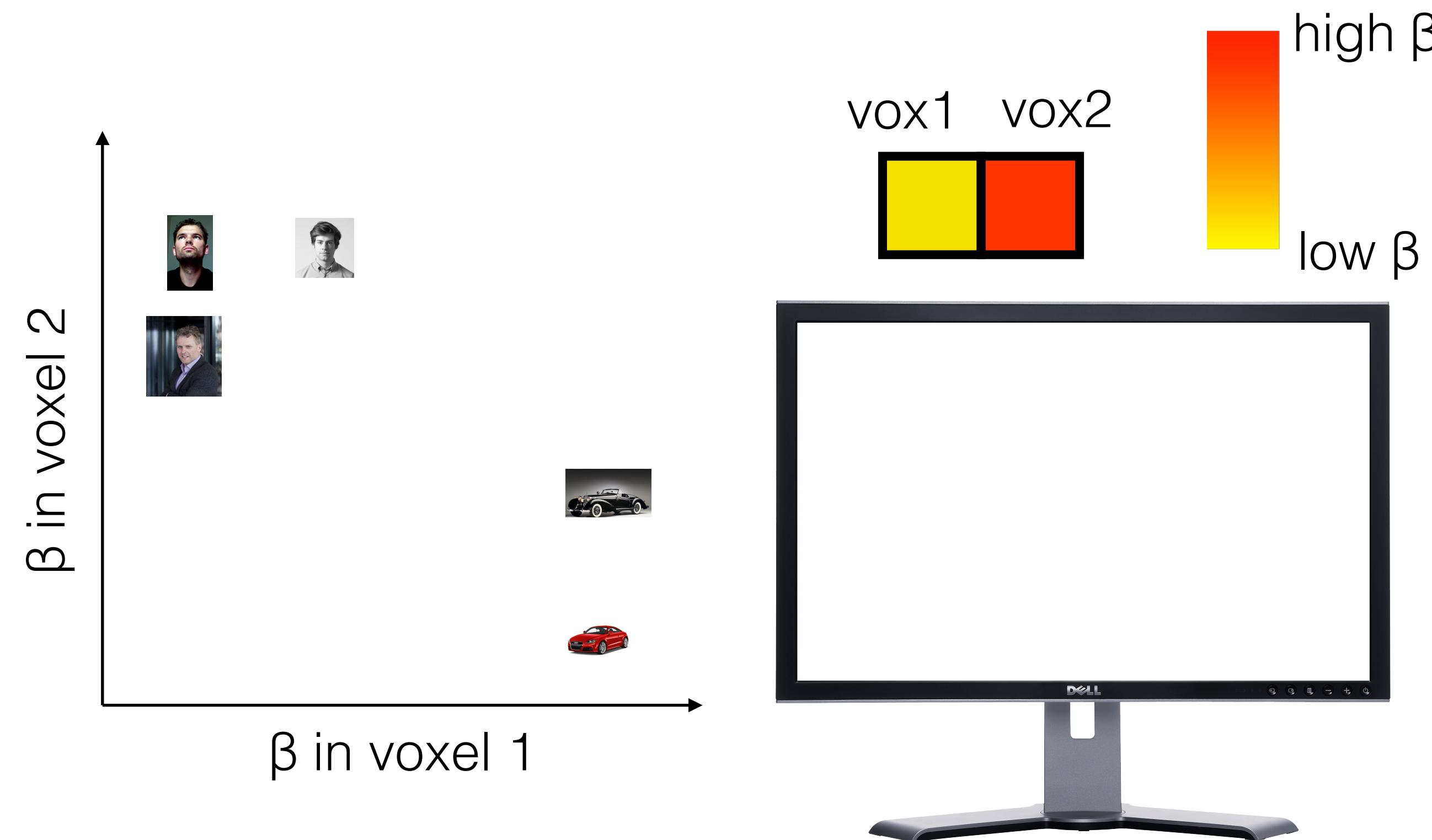
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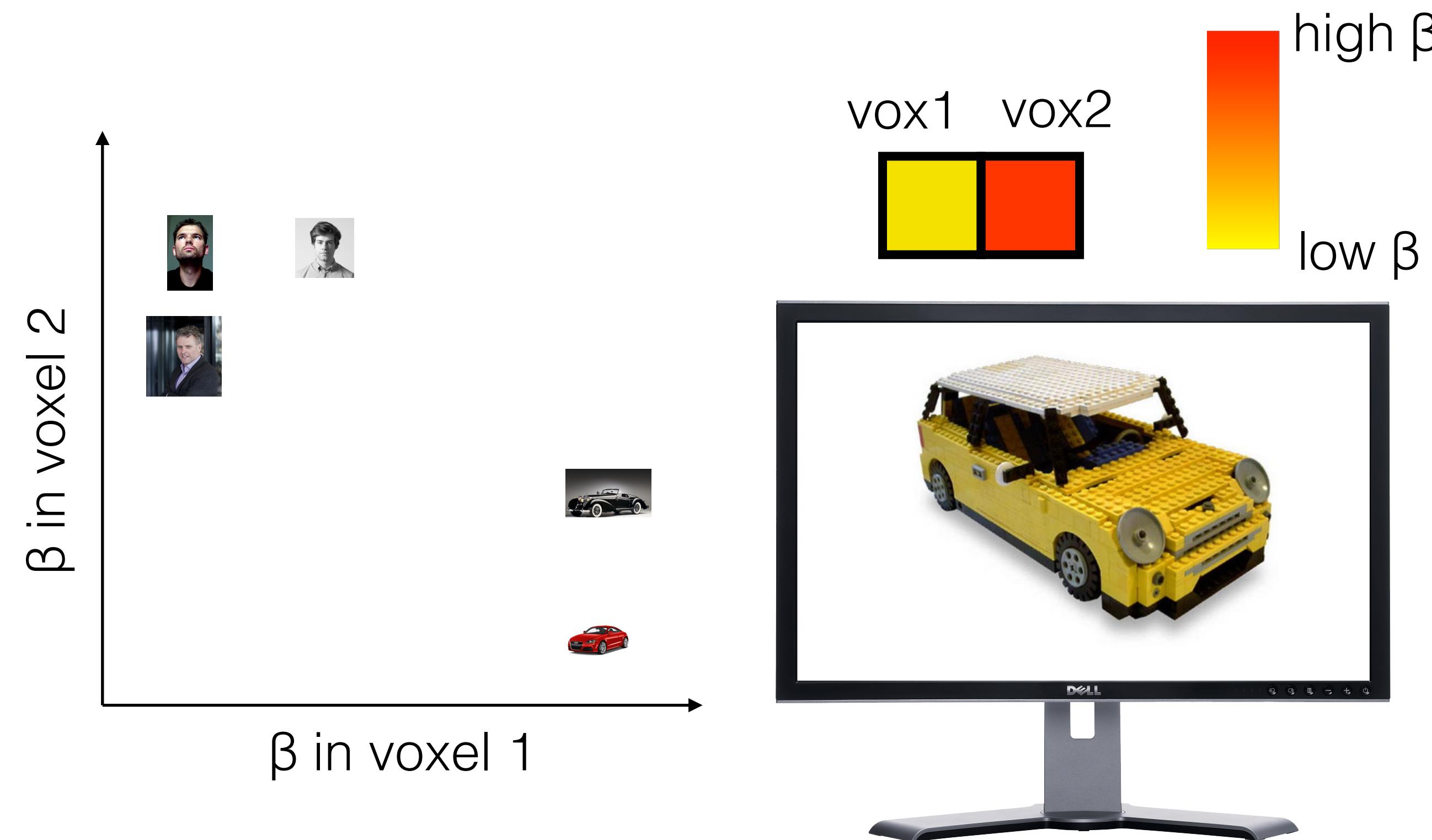
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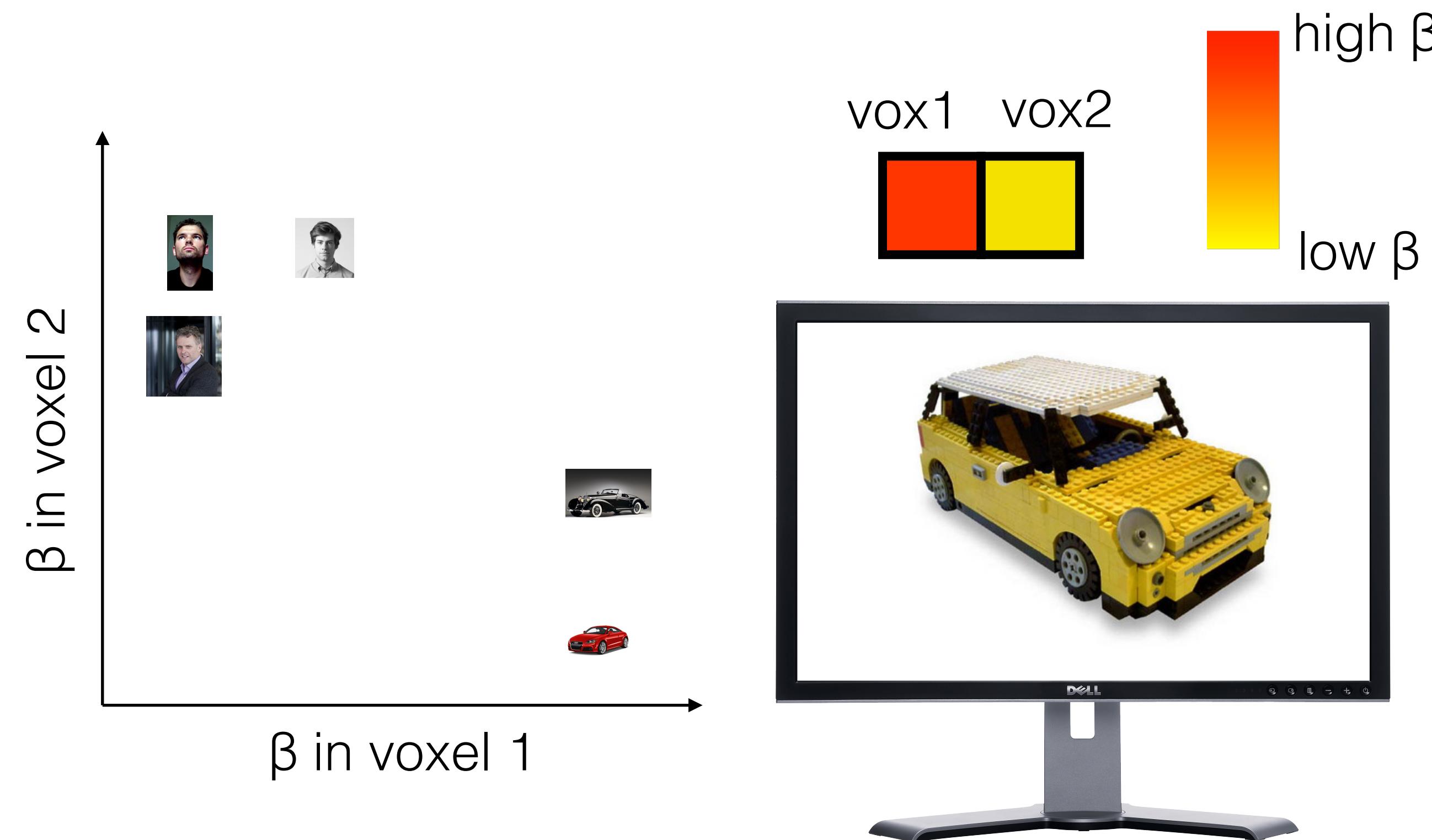
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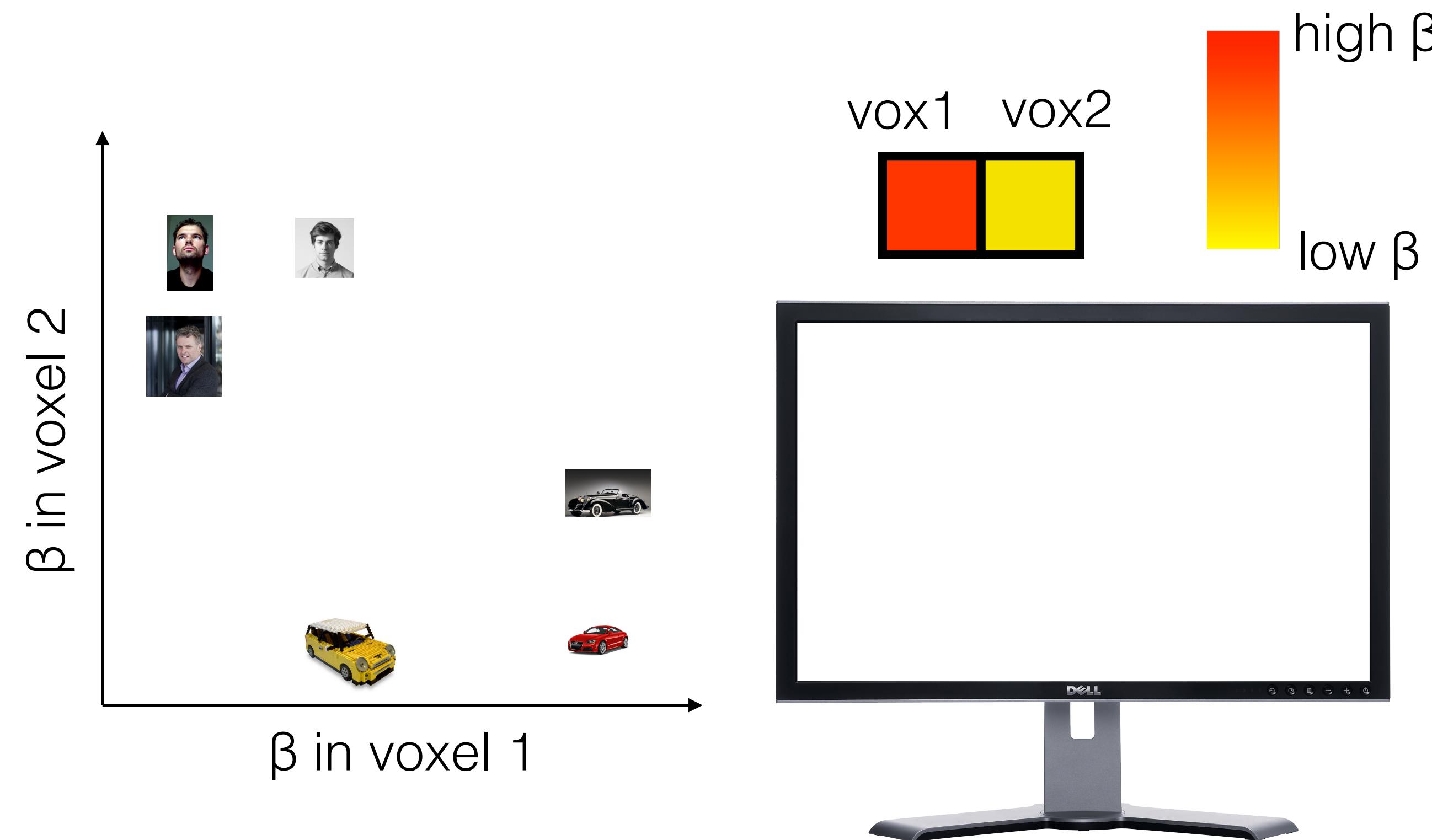
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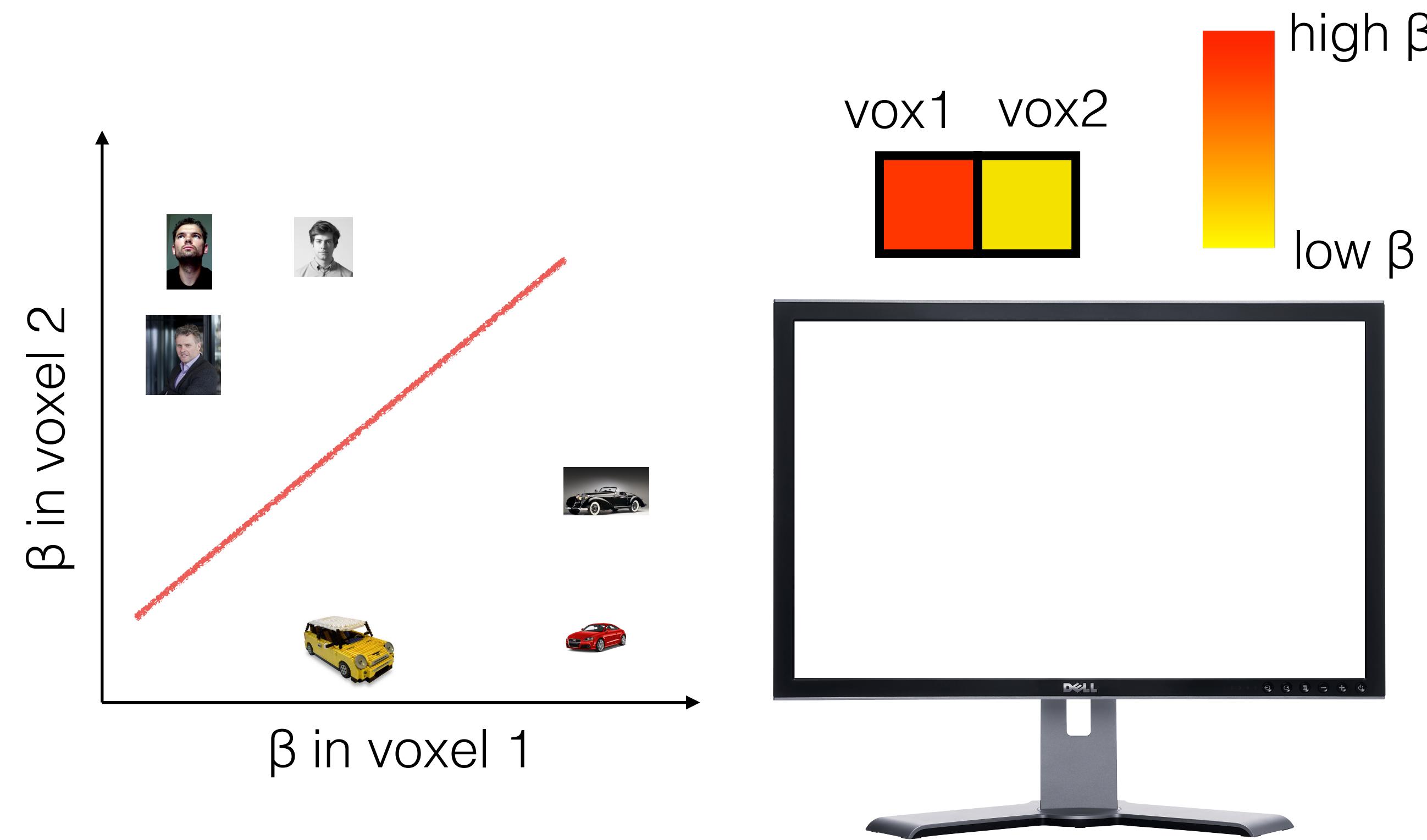
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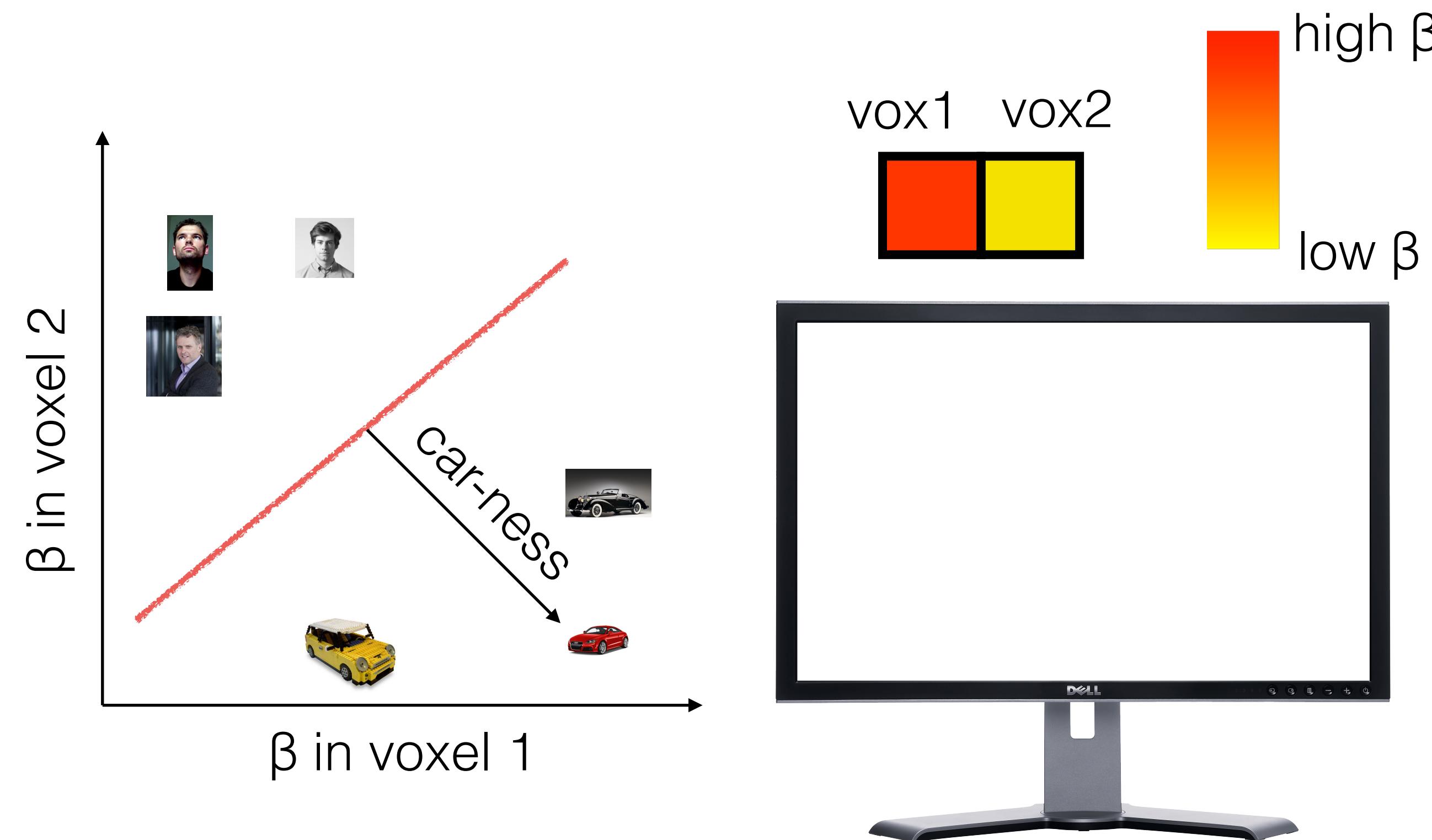
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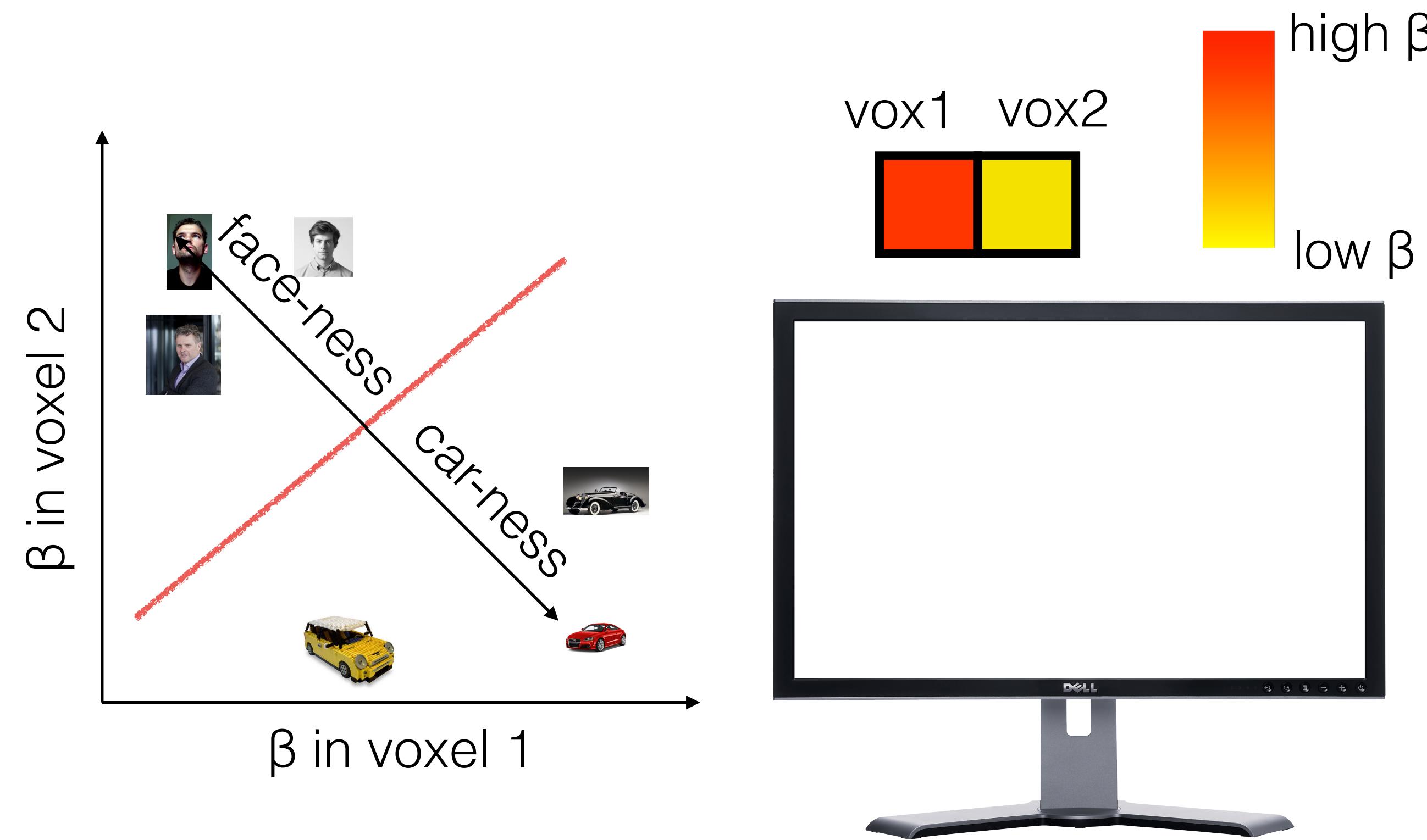
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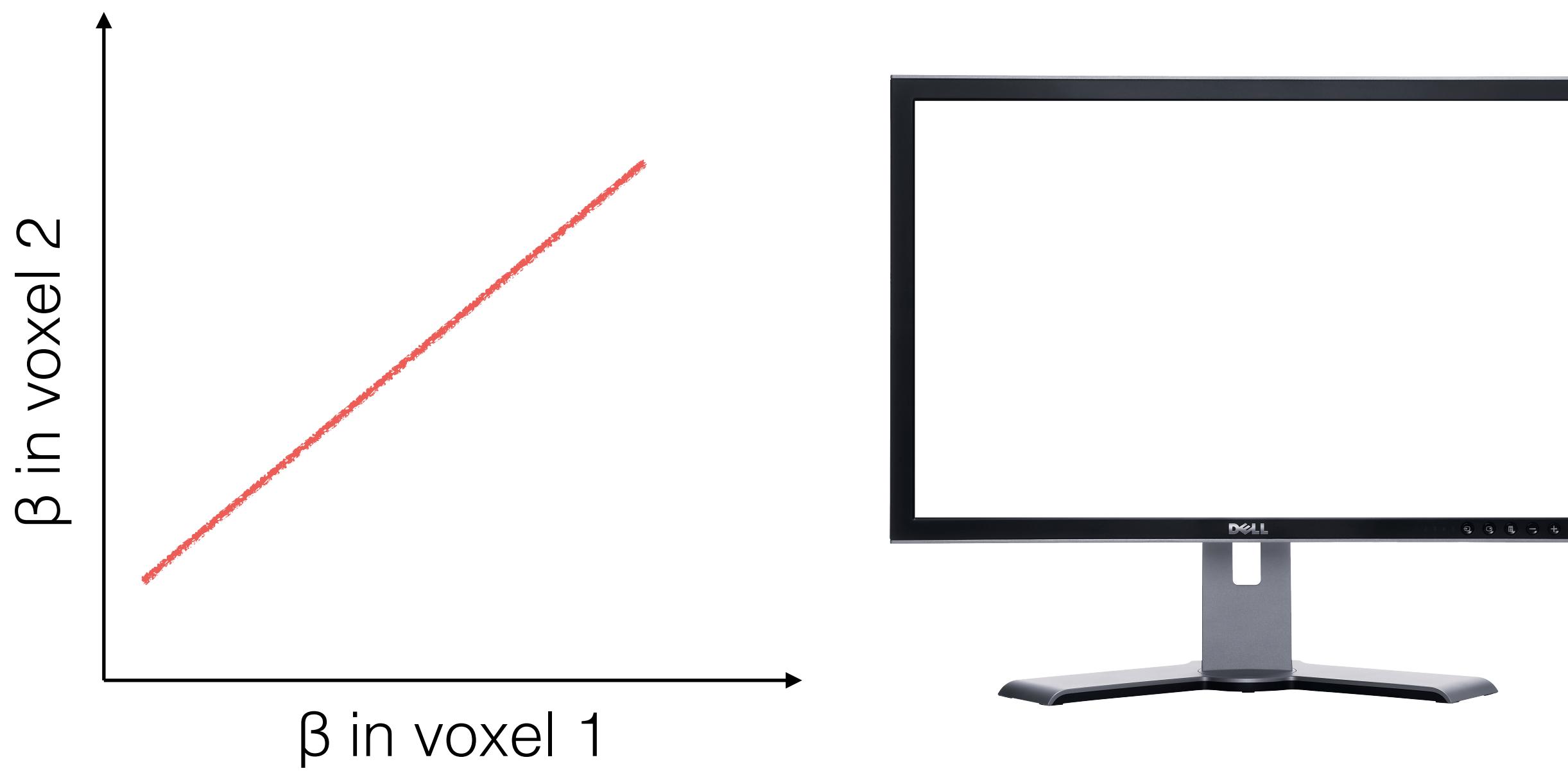
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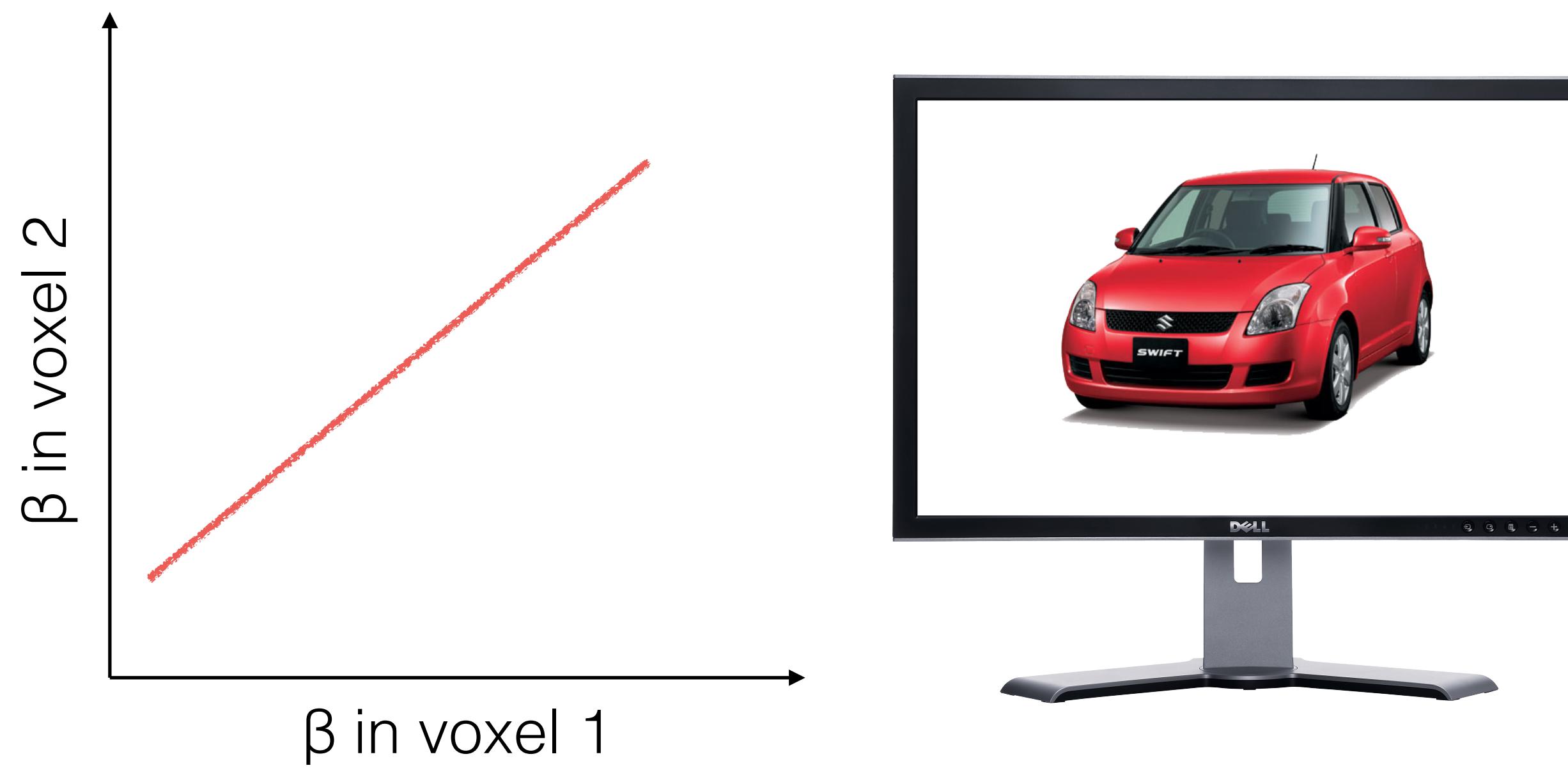
Predicting stimulus type: training a classifier



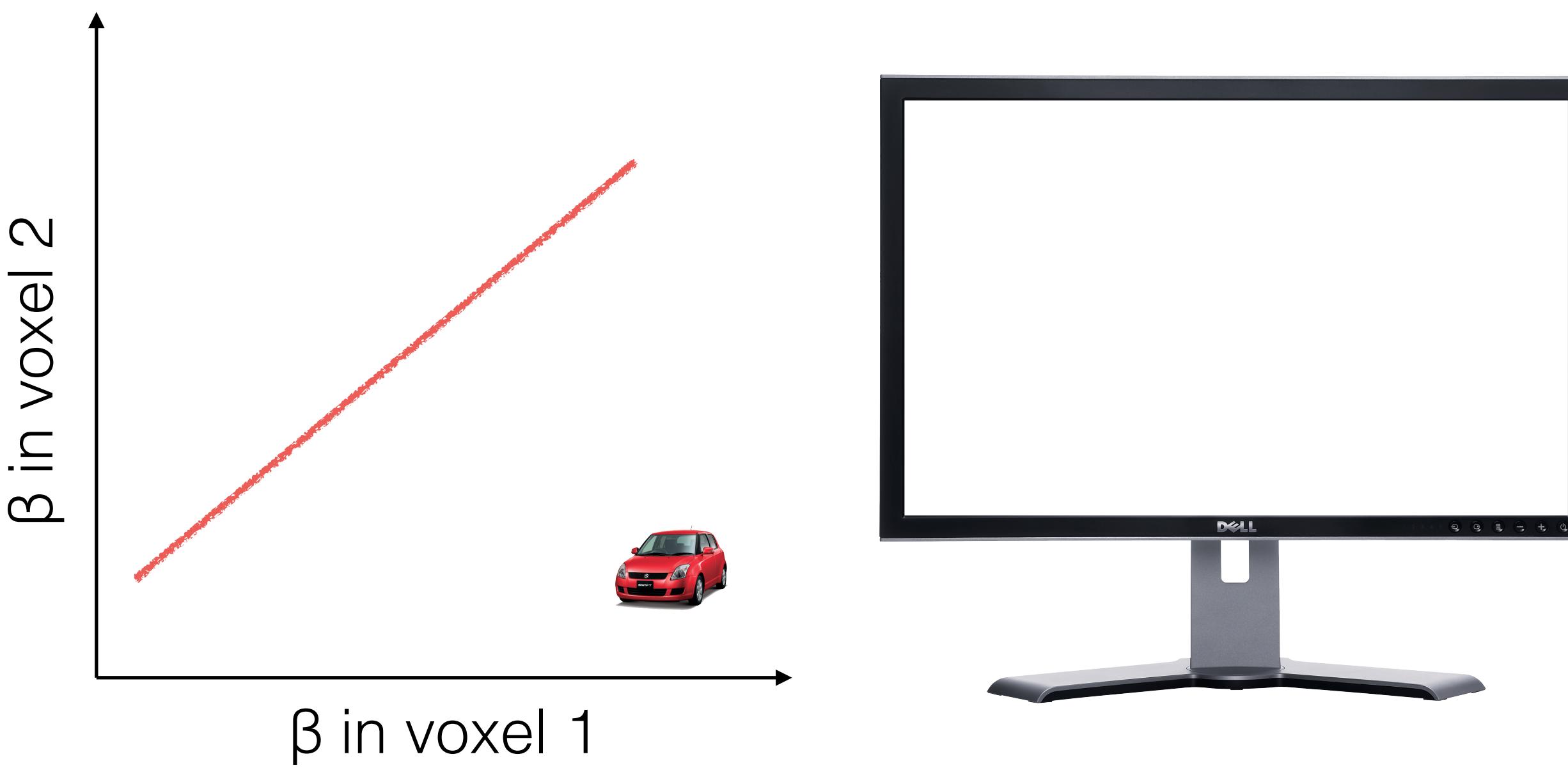
Predicting stimulus type: testing the classifier



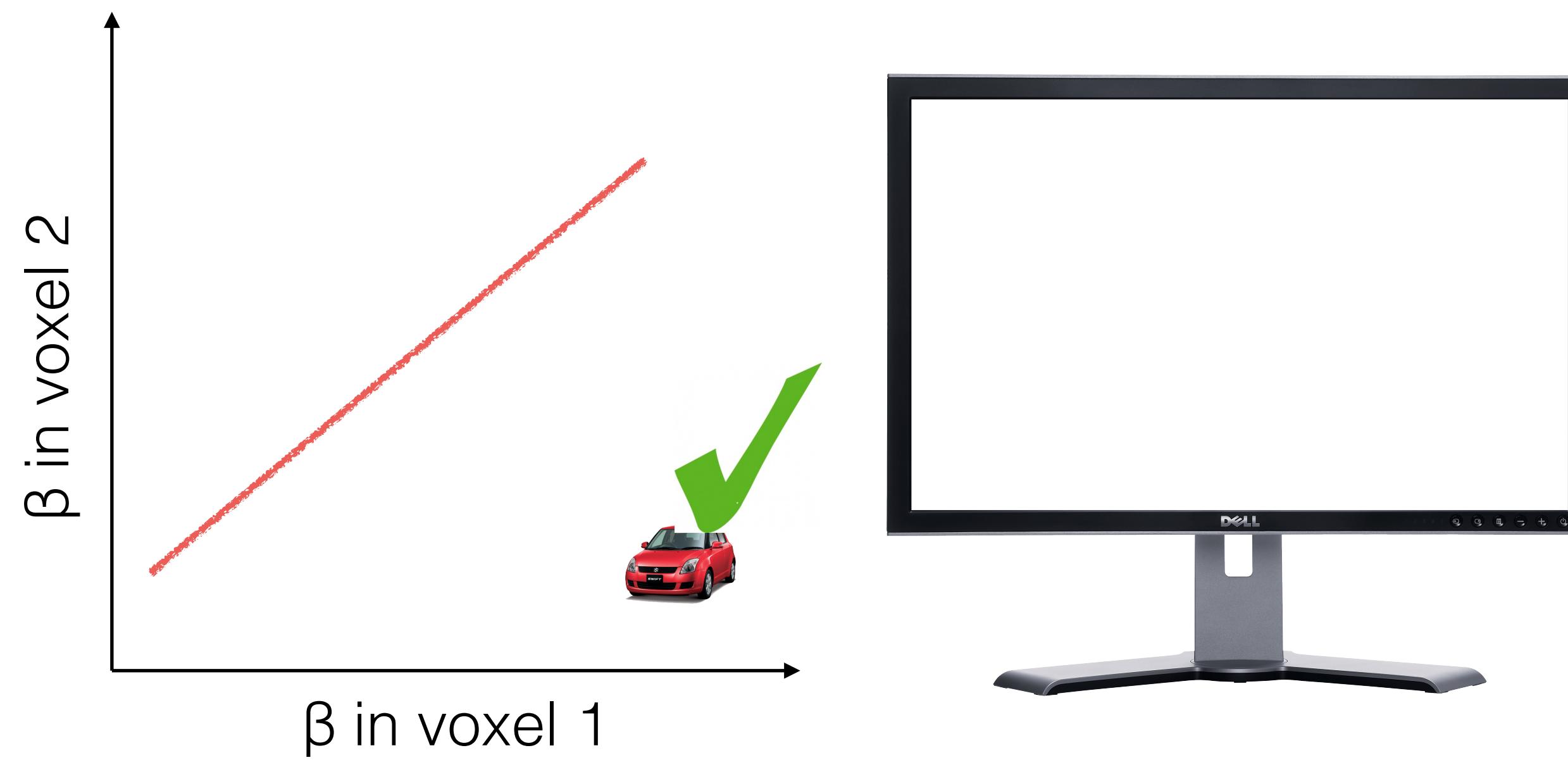
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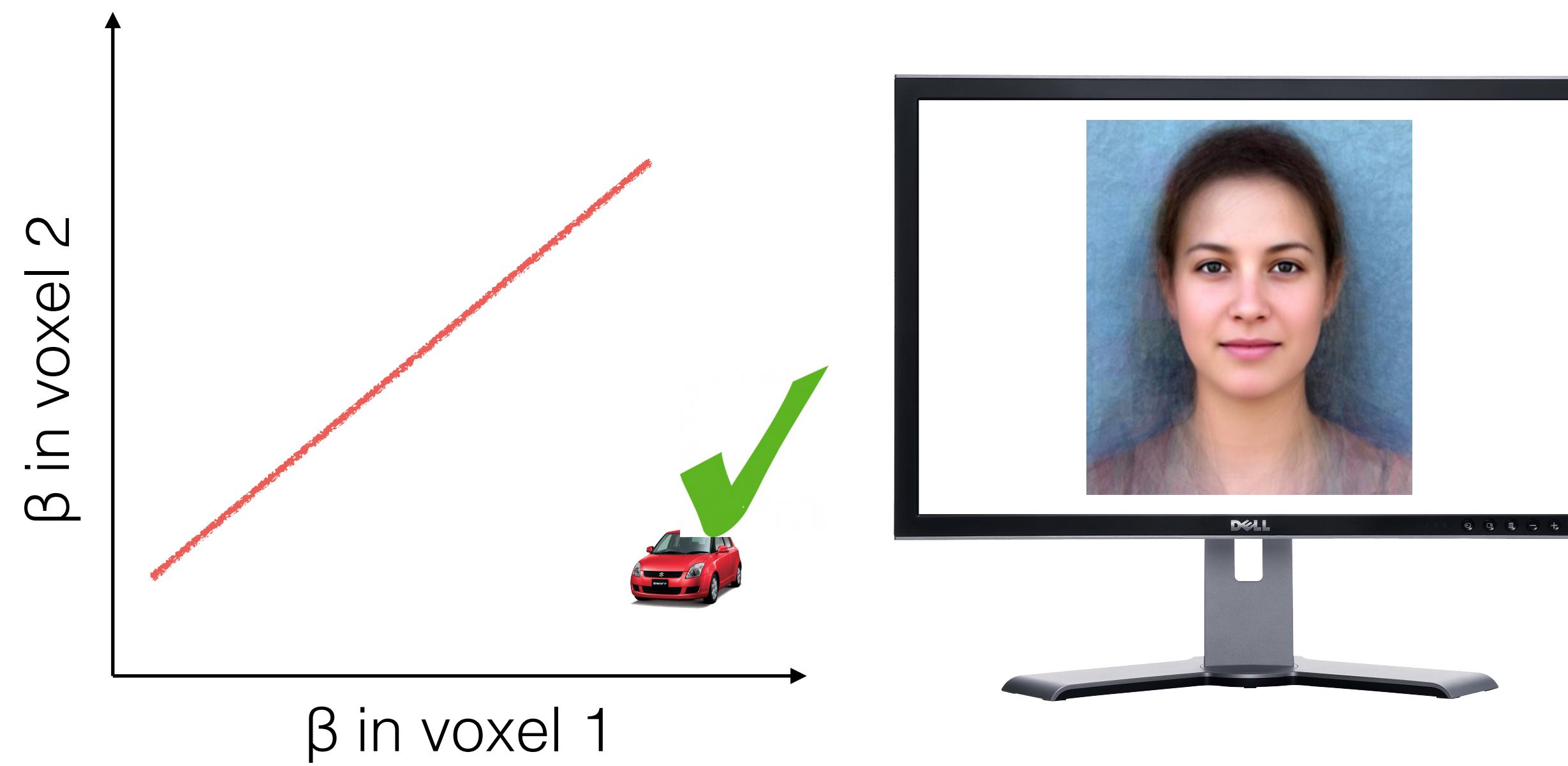
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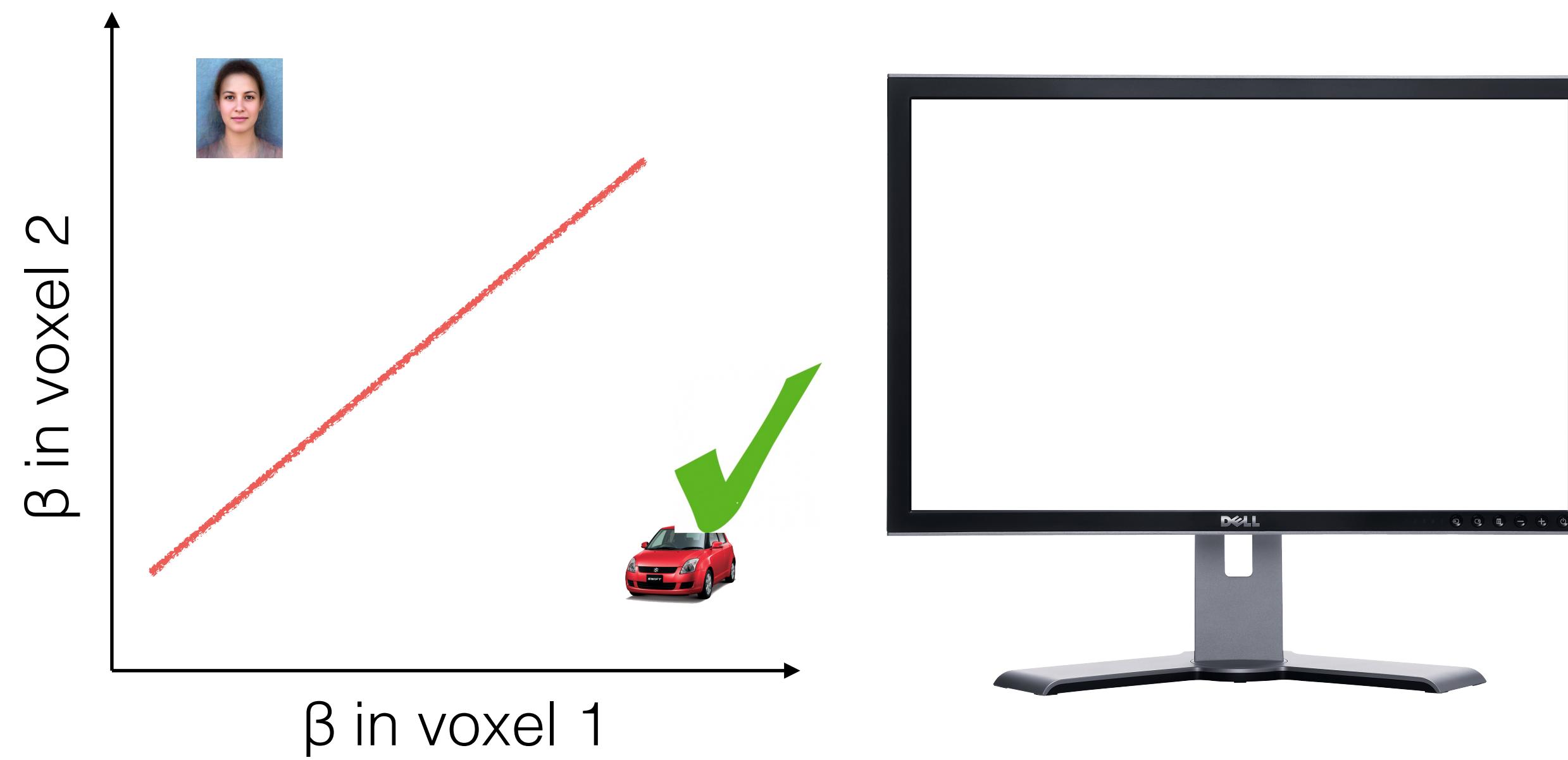
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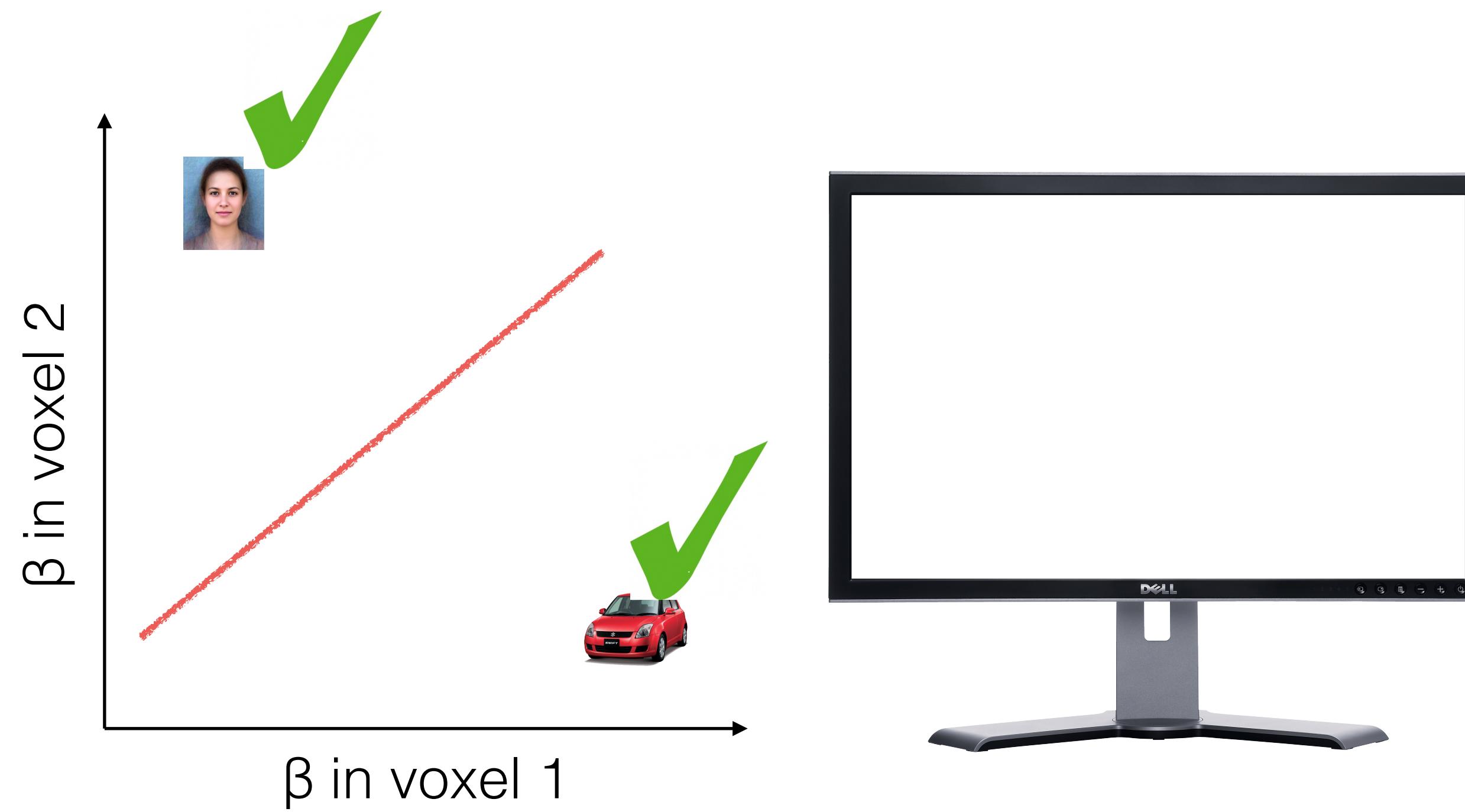
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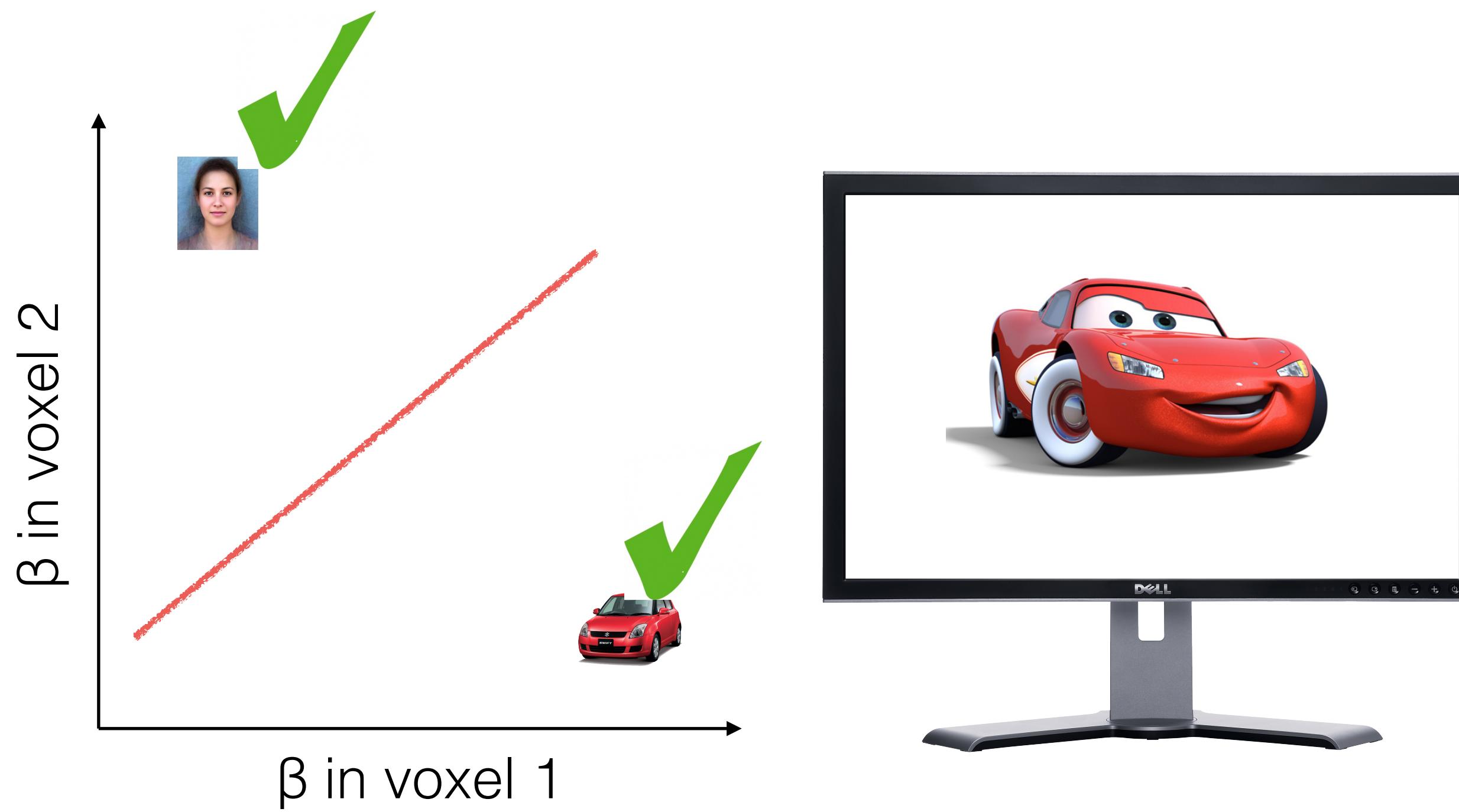
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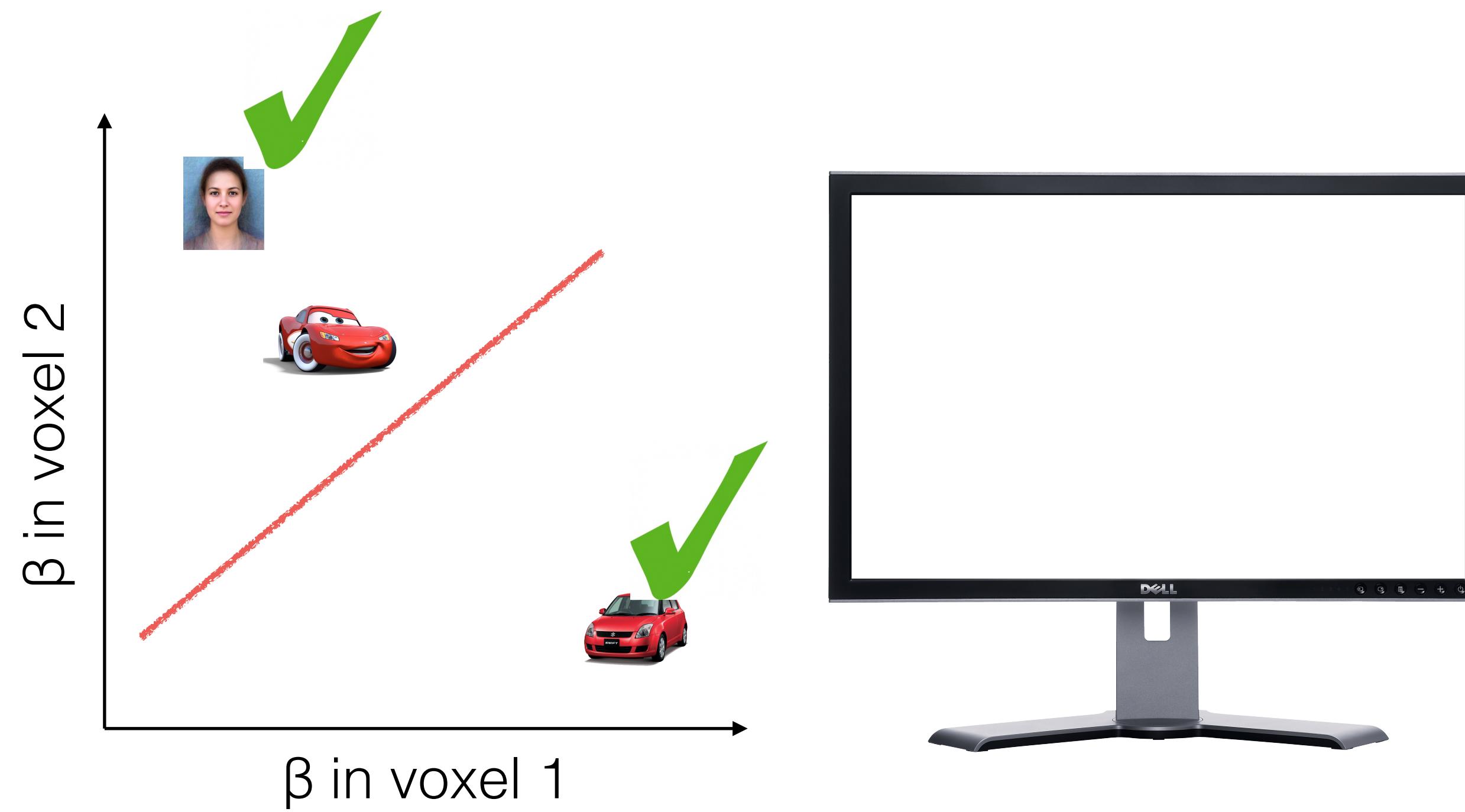
Predicting stimulus type: testing the classifier



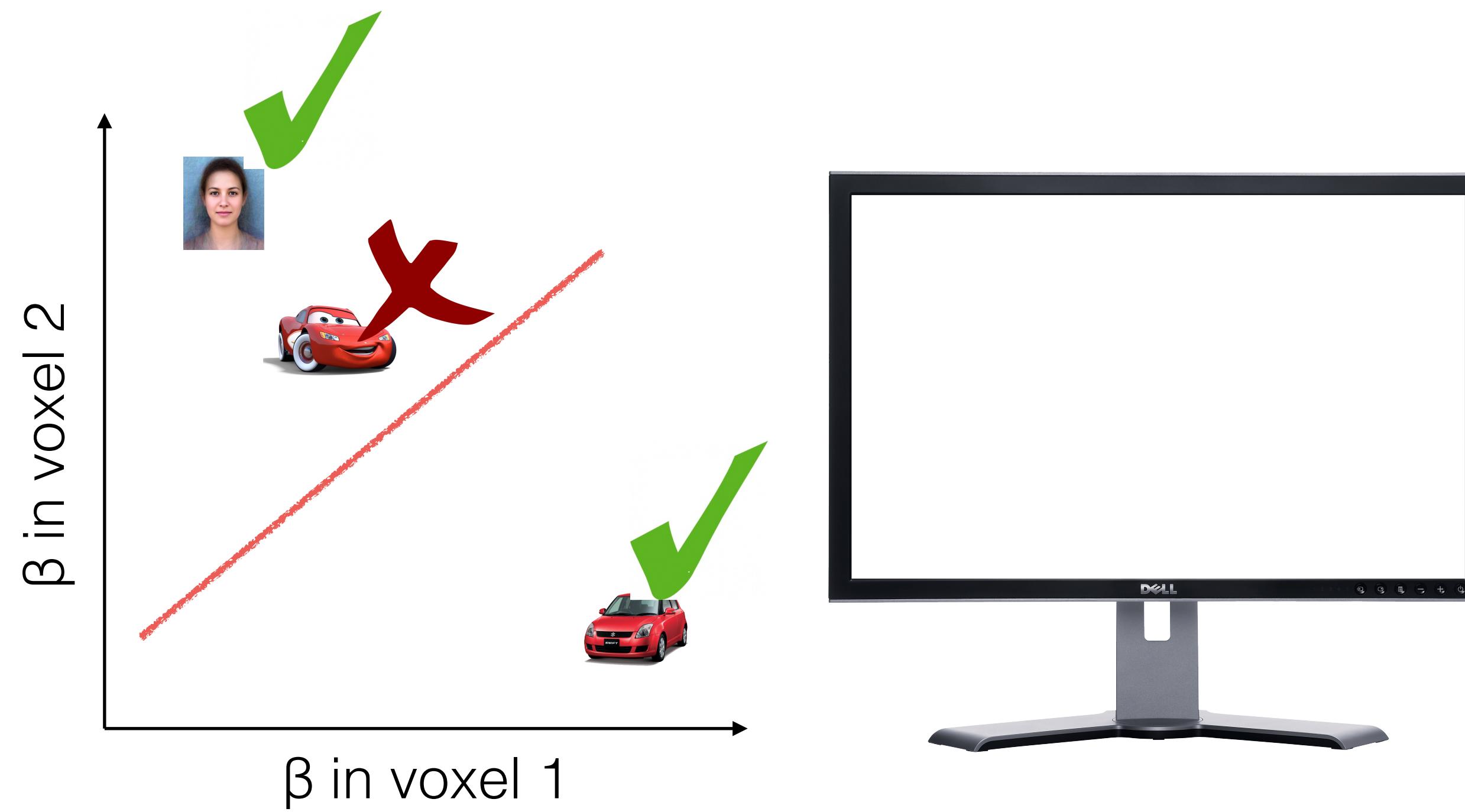
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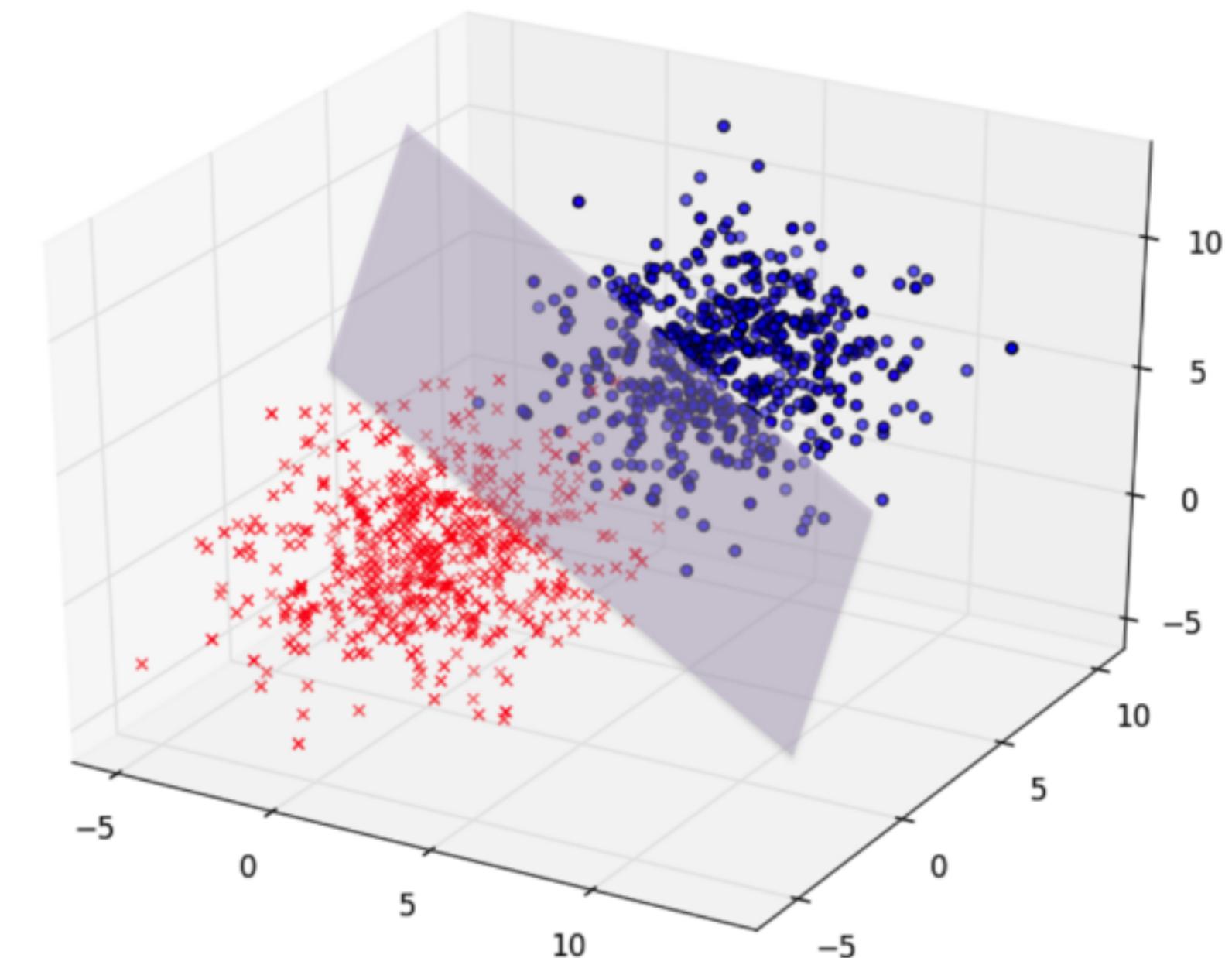
Predicting stimulus type: testing the classifier



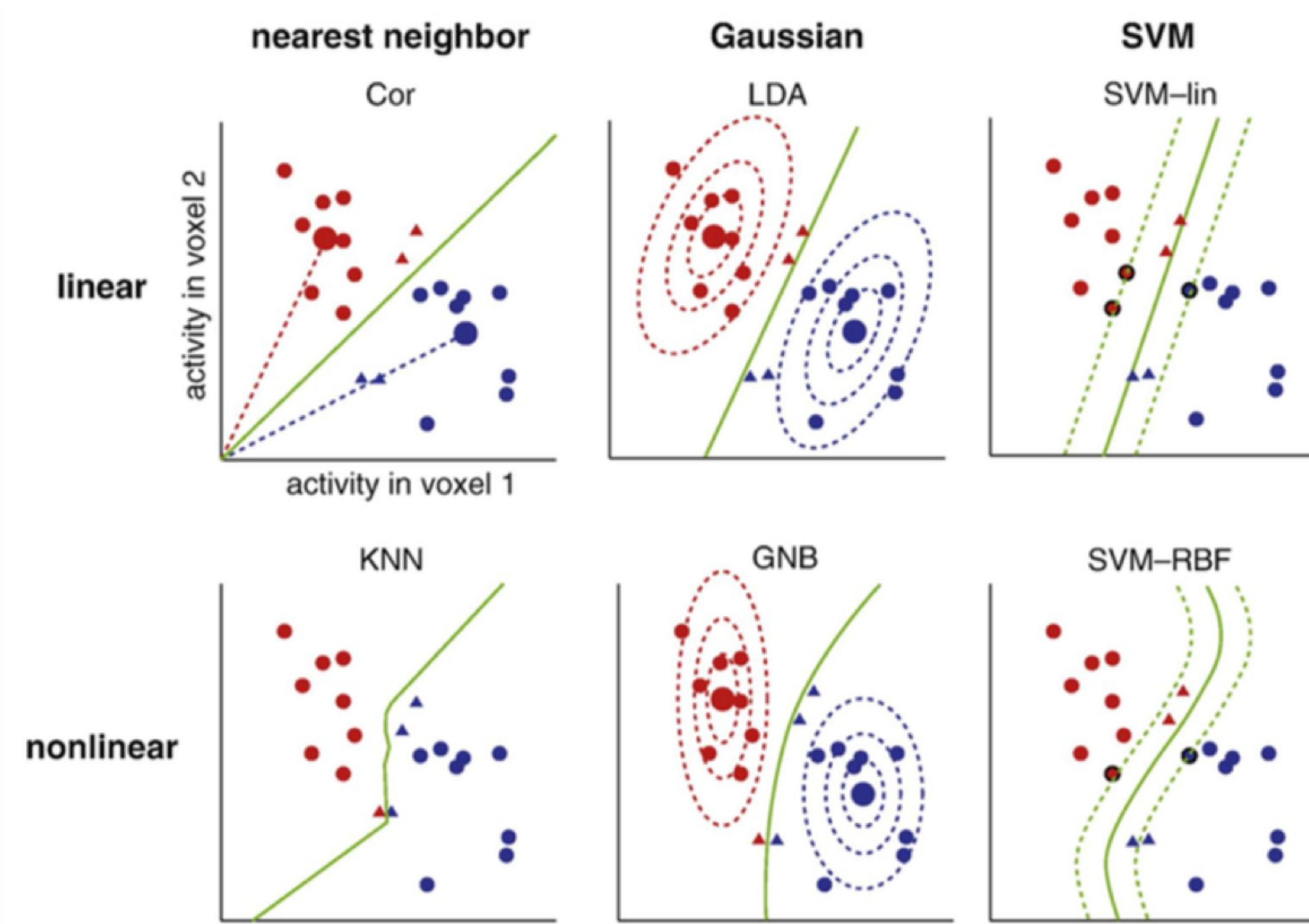
Extending to more voxels

- Finding the n-dimensional plane that separates patterns across n voxels

3 voxels

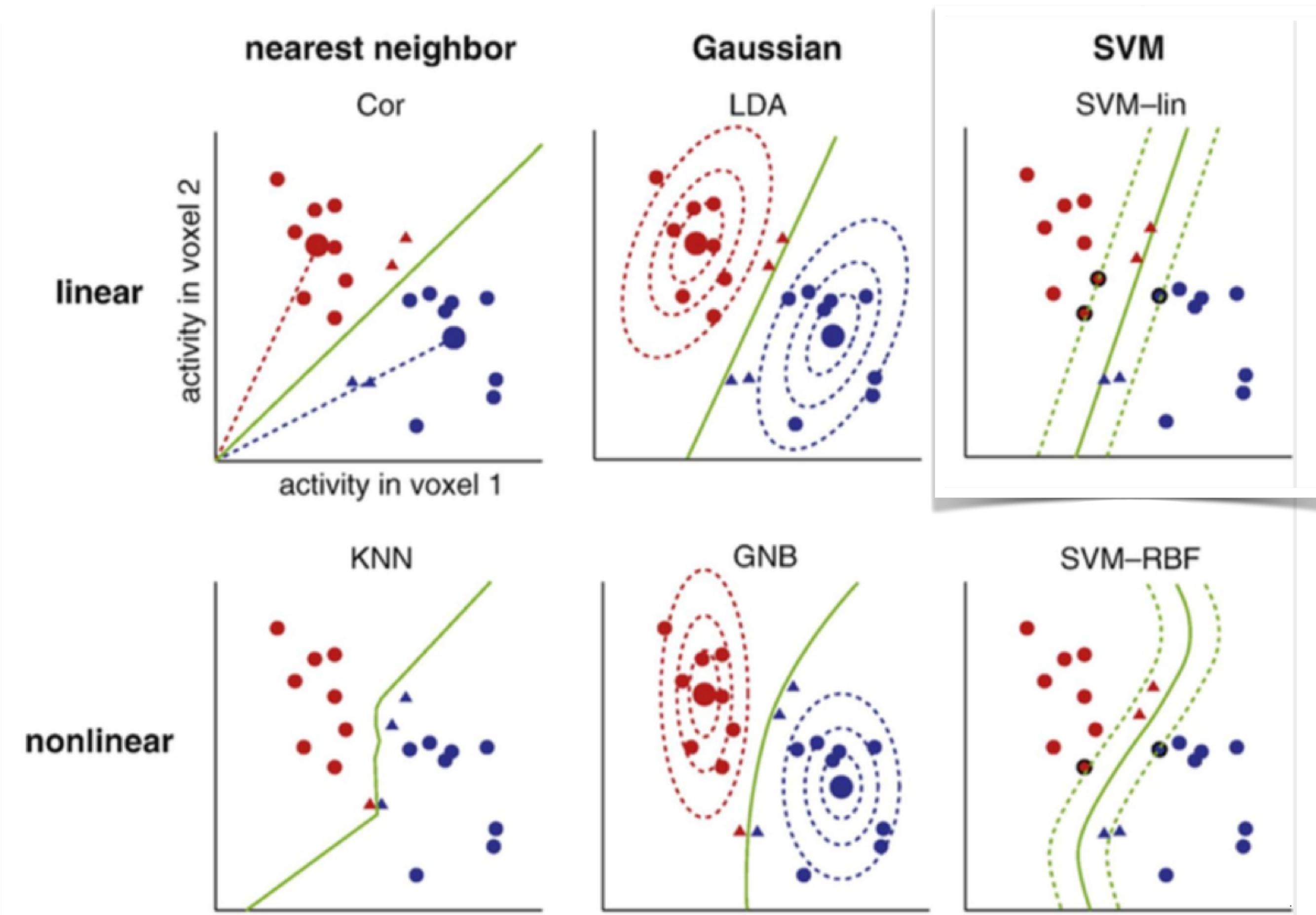


Machine Learning Algorithms: how to draw the line/plane?



Hint: Stanford Machine Learning Course on Coursera

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Why separate training and test data?

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*Training the algorithm finds predictive relations in the data.
Are these relations: 1. accurate, 2. sensitive, 3. consistent*

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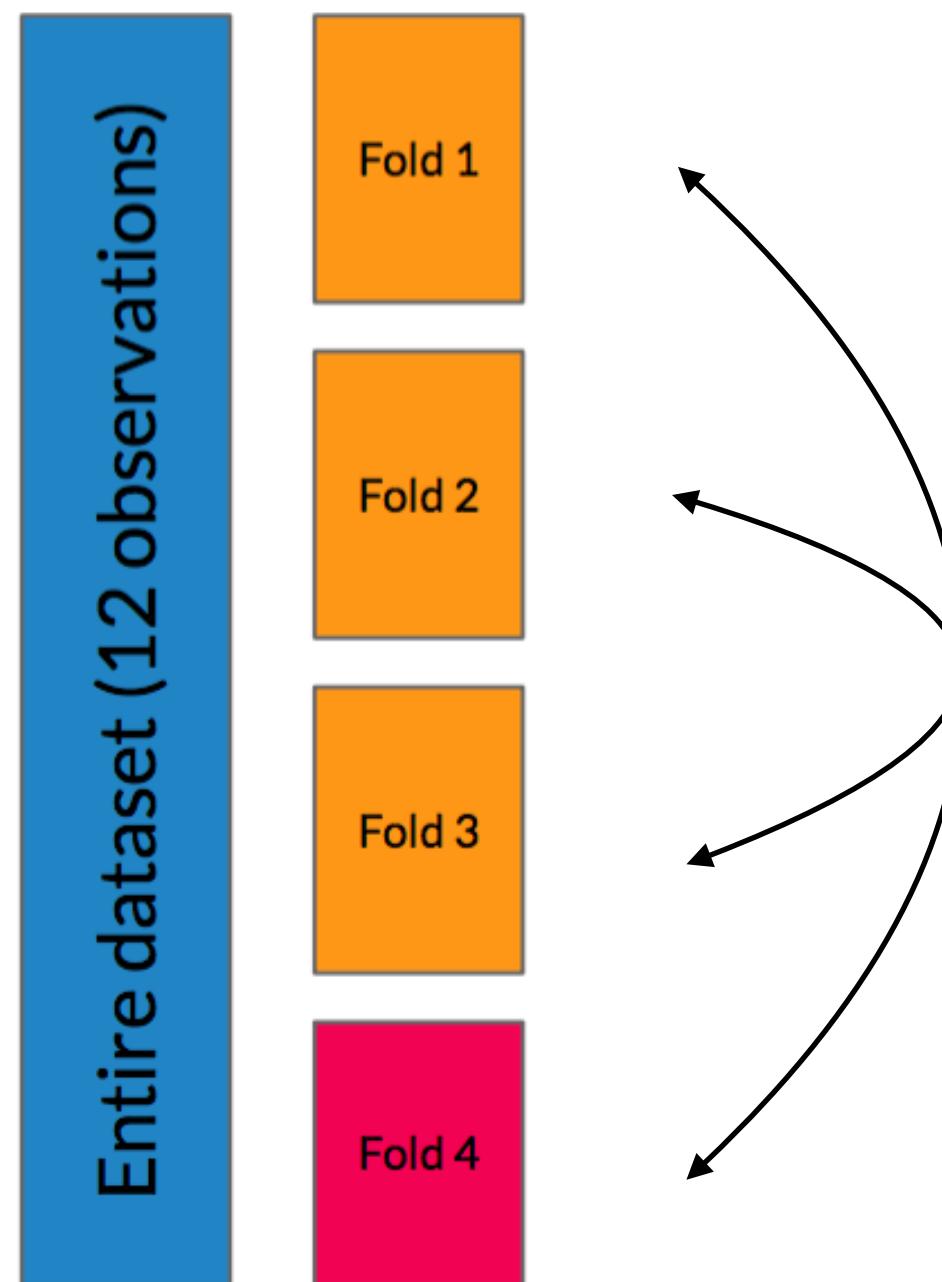
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*What happens when you test using data that the algorithm has
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Circularity!

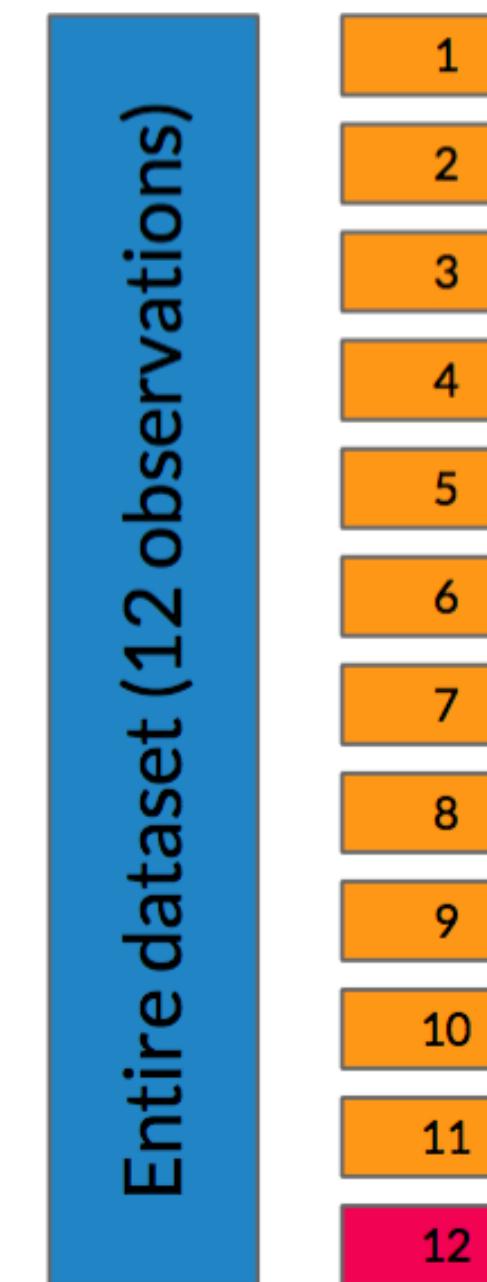
Predicting stimulus type: how to divide your data?

KFold



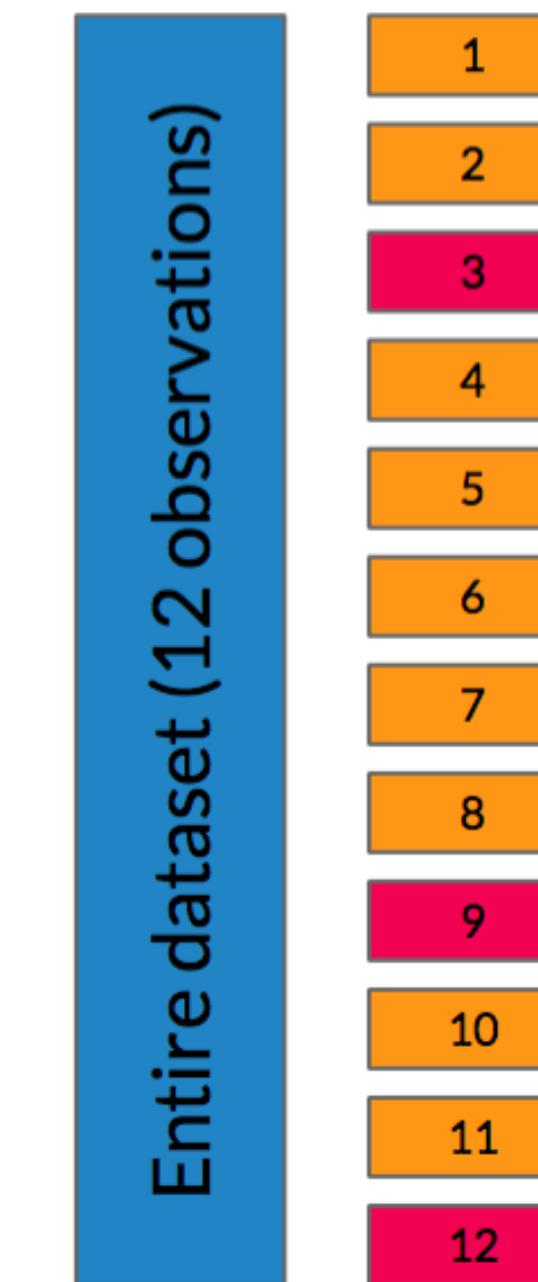
*Every '**Fold**' is
the test set once*

N-1 (leave-one-out)



*Every **run** is
the test set once*

Random subsampling

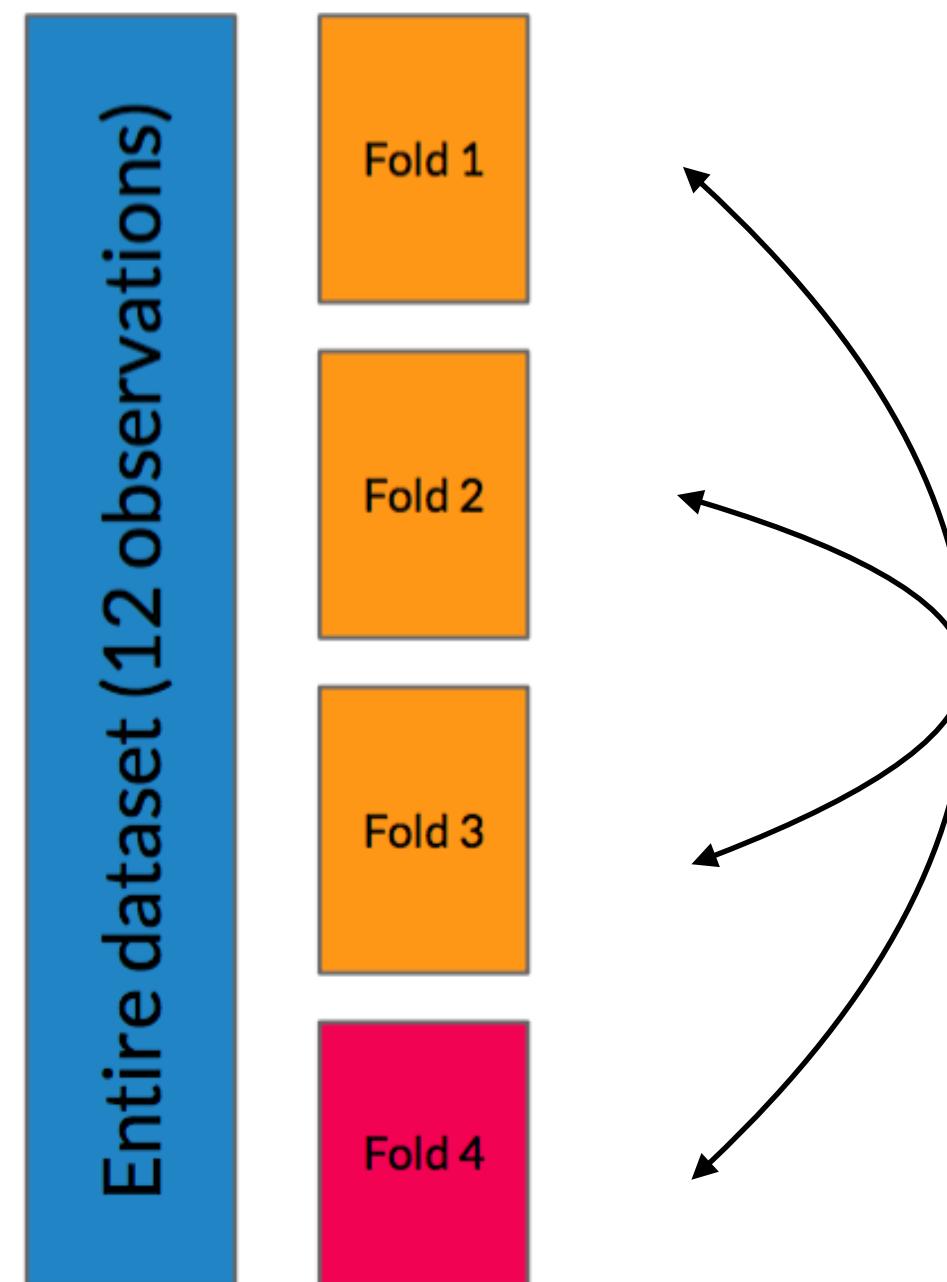


*Many different test sets:
as many as you like*

Predicting stimulus type: how to divide your data?

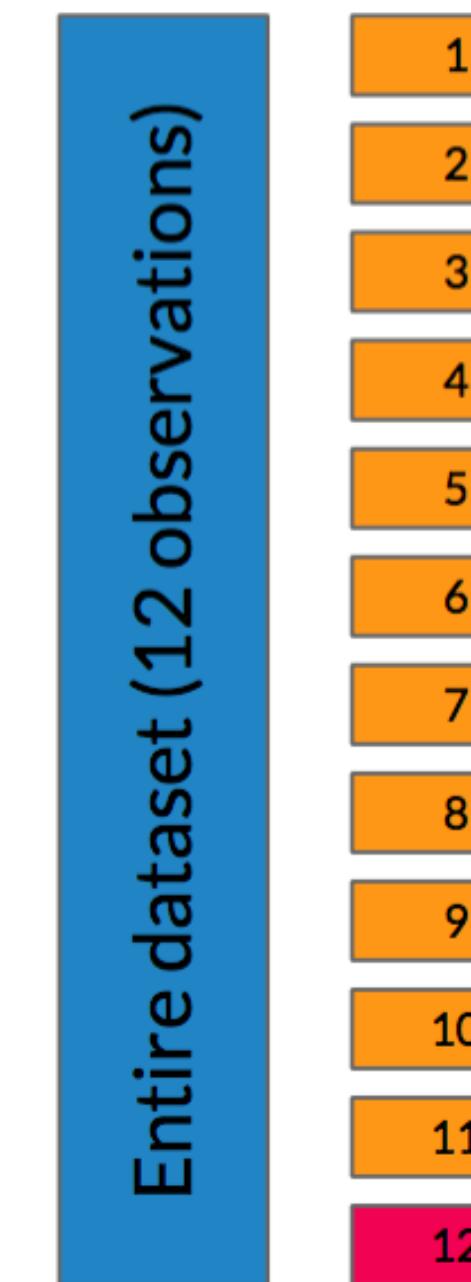
This is called ***cross-validation***

KFold



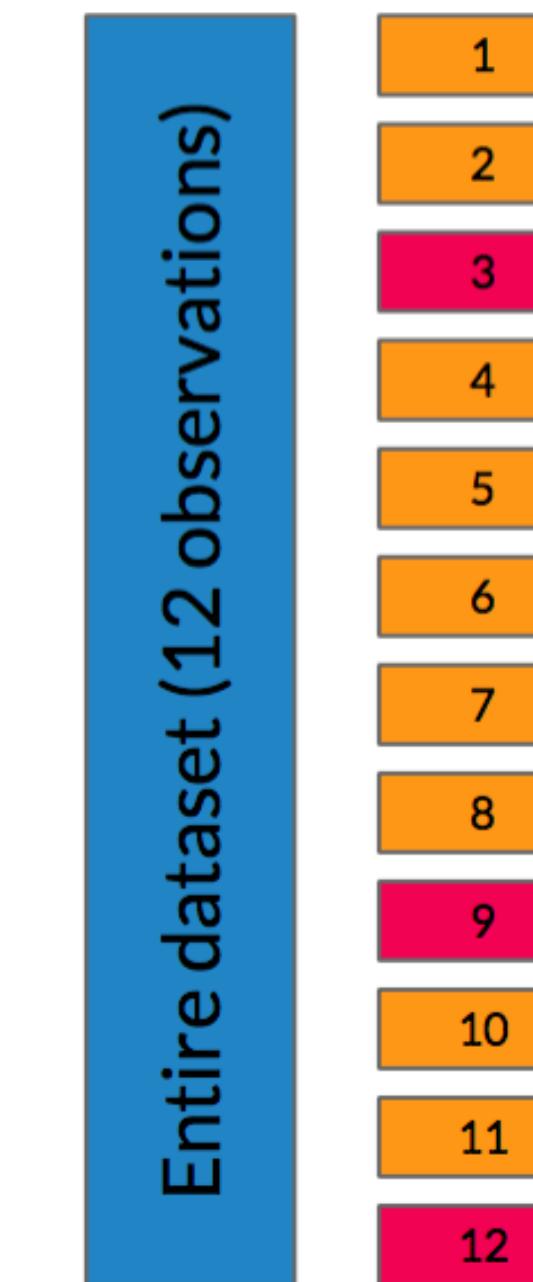
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Searchlight Analysis

Flexible ROIs

Find ‘information’ not in a region of interest,
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multivariate searchlight

(4-mm radius for 2-mm isotropic voxels)

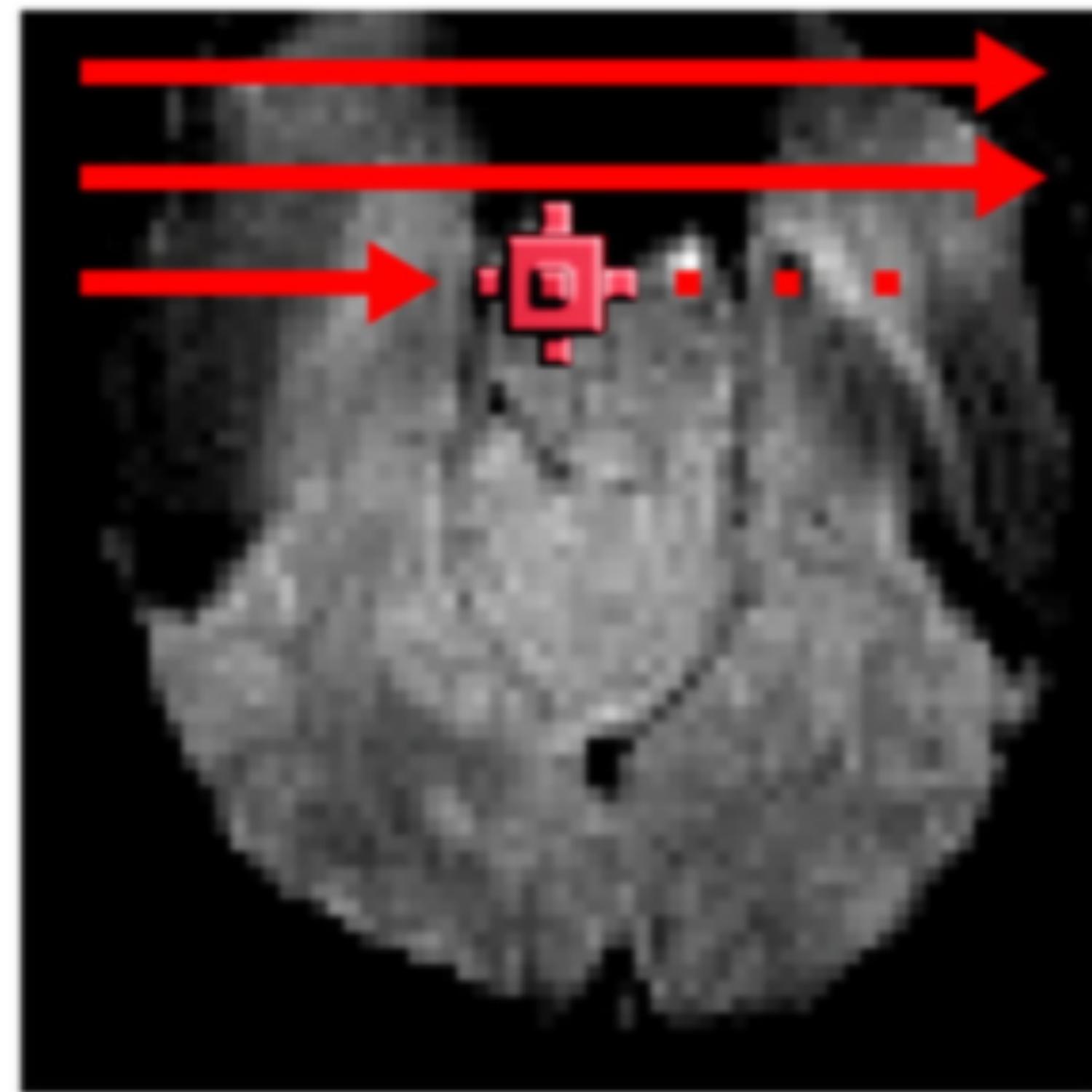
Searchlight Analysis

Flexible ROIs

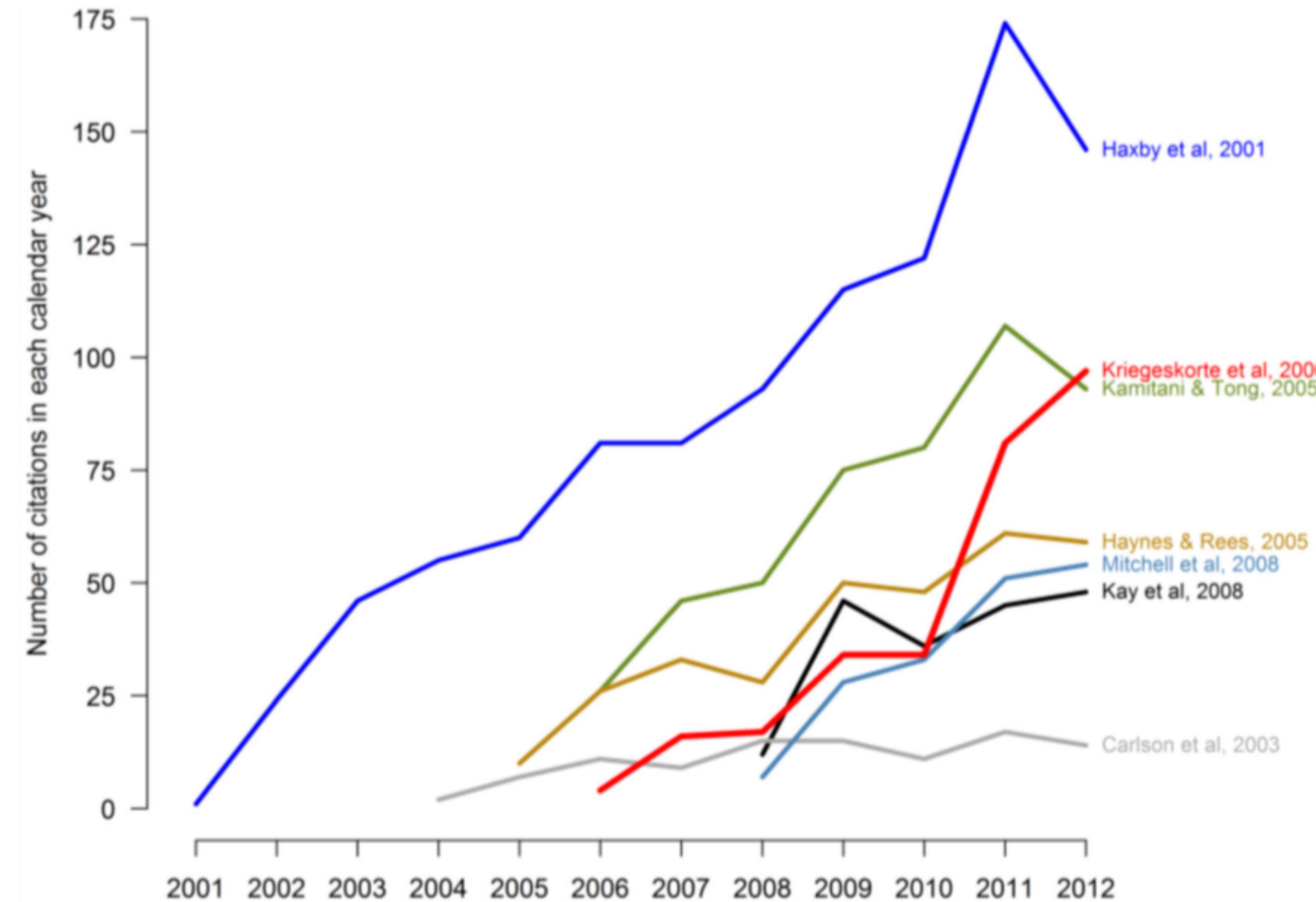
Find ‘information’ not in a region of interest,
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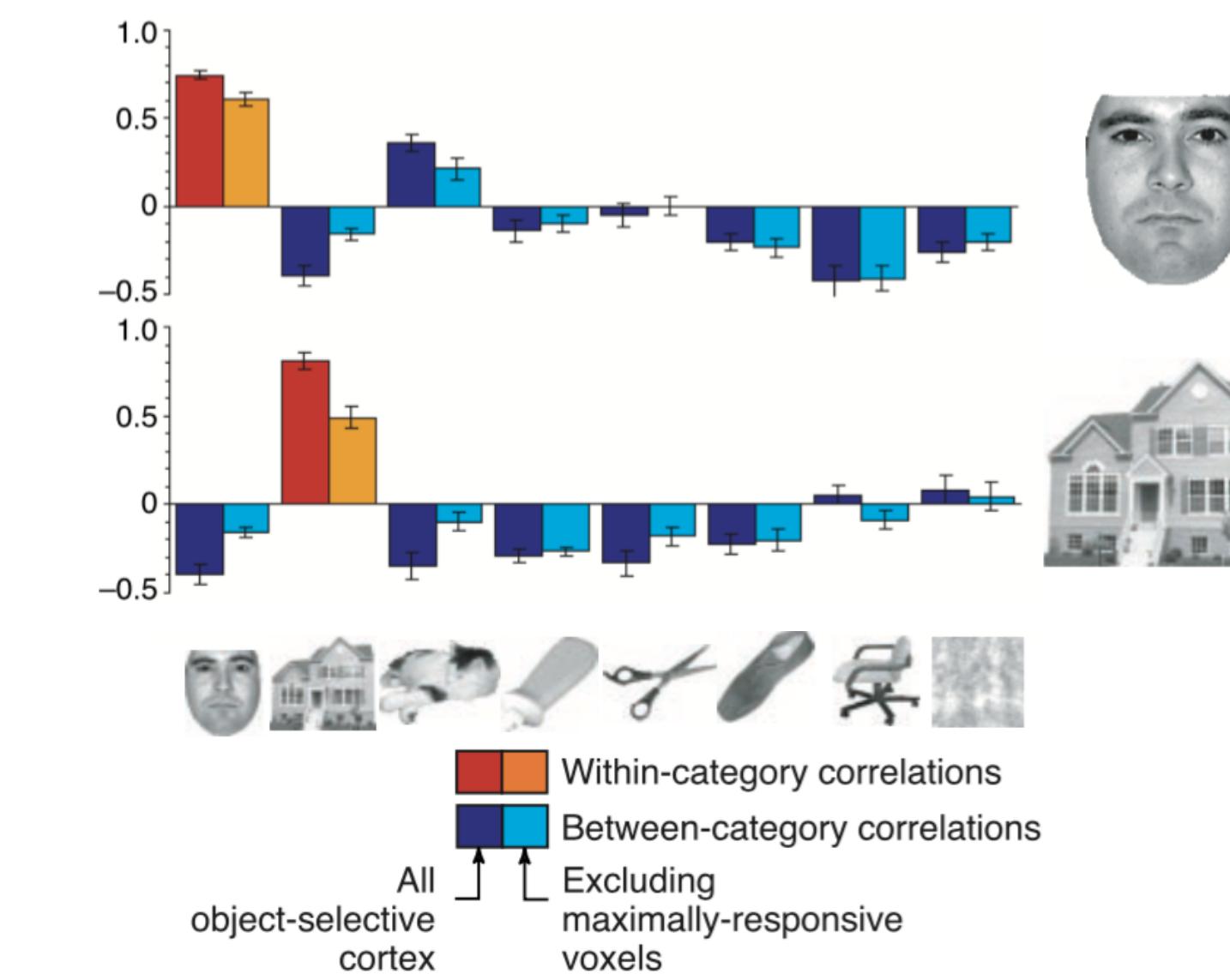
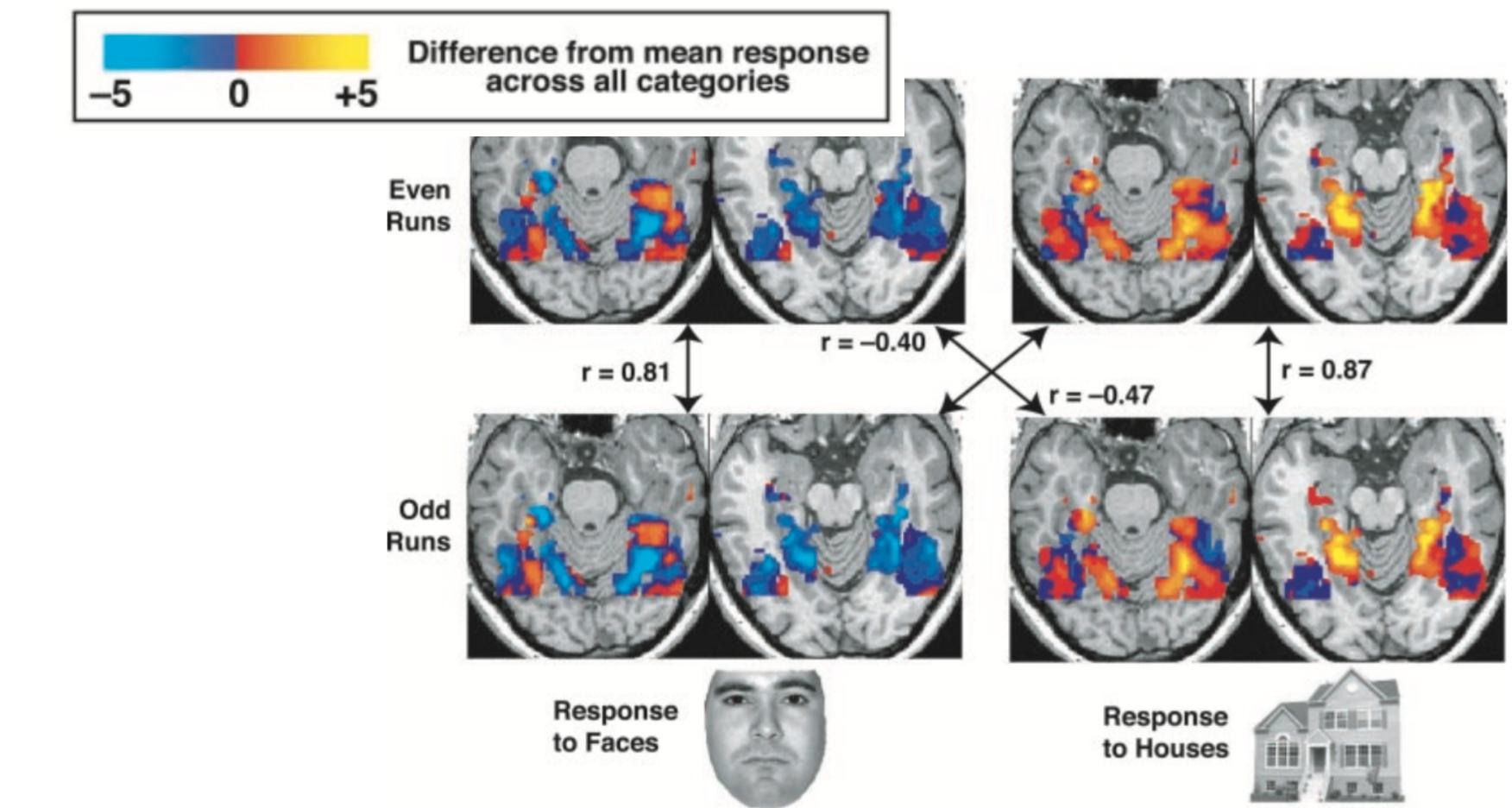
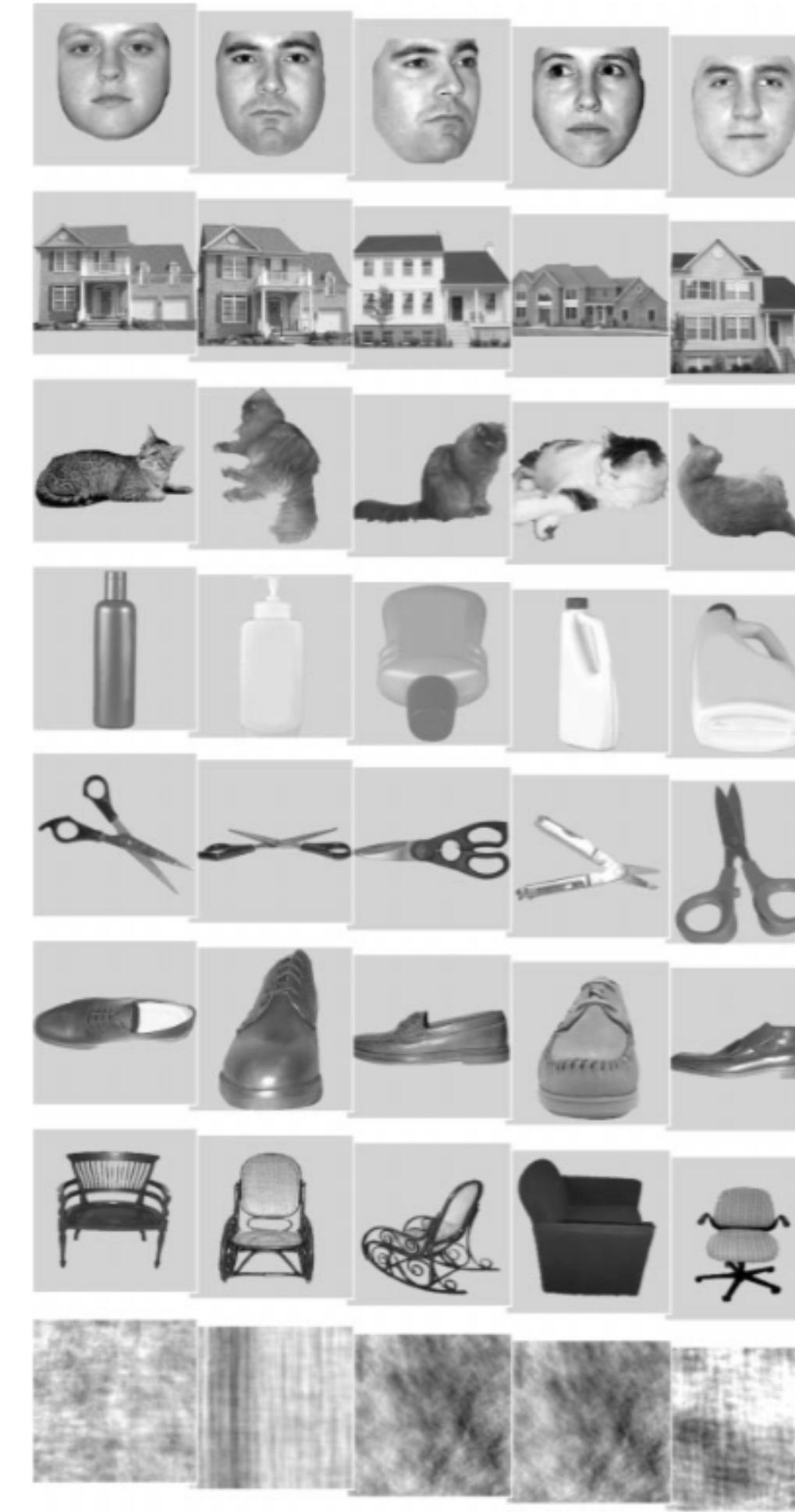
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Applications of MVPA



Decoding stimulus category

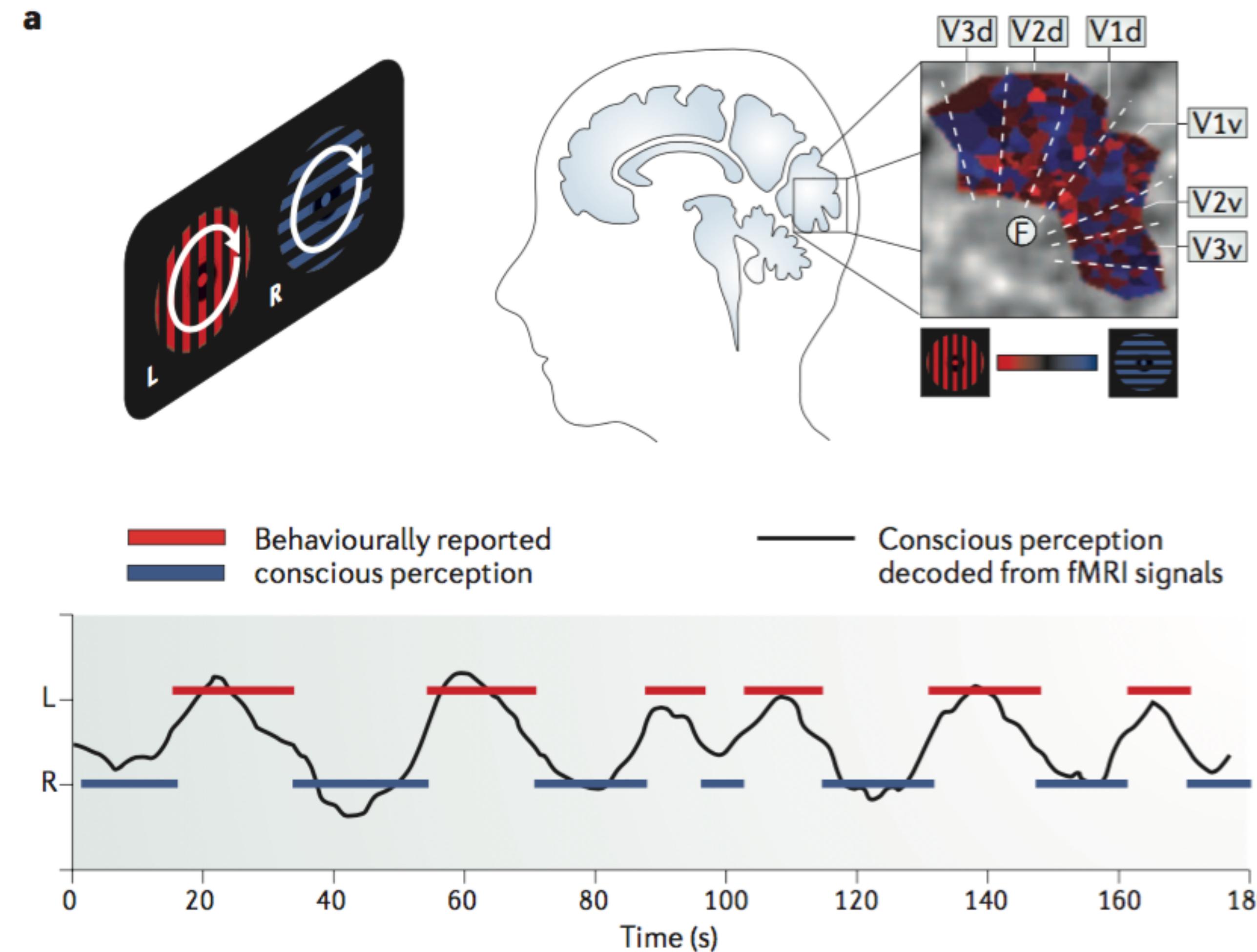


Decoding conscious perceptual state

Decoding conscious perceptual state



Decoding conscious perceptual state

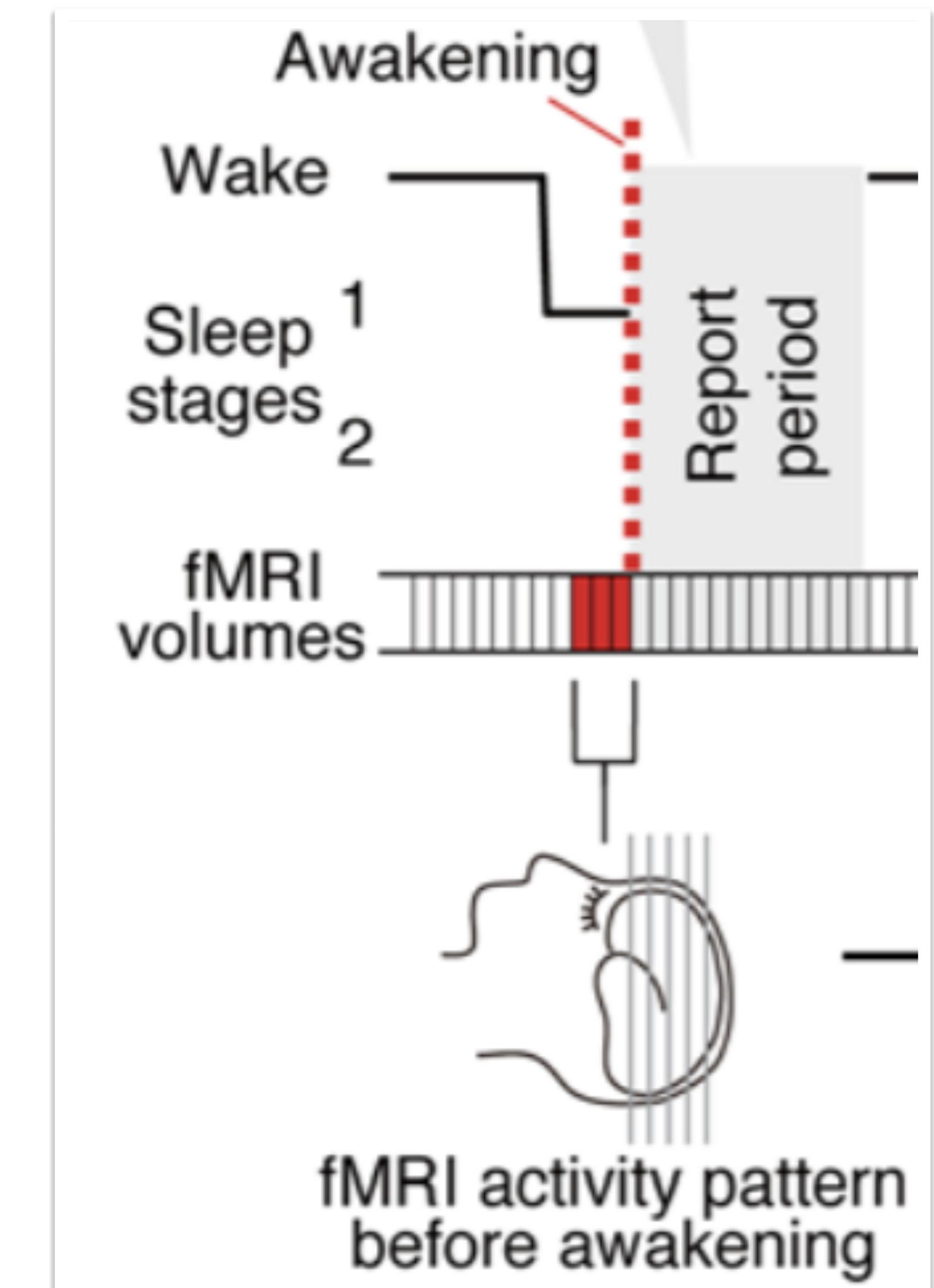


Decoding unconscious perceptual state: Dreams

We can decode the content of people's dreams from their brains

Decoding unconscious perceptual state: Dreams

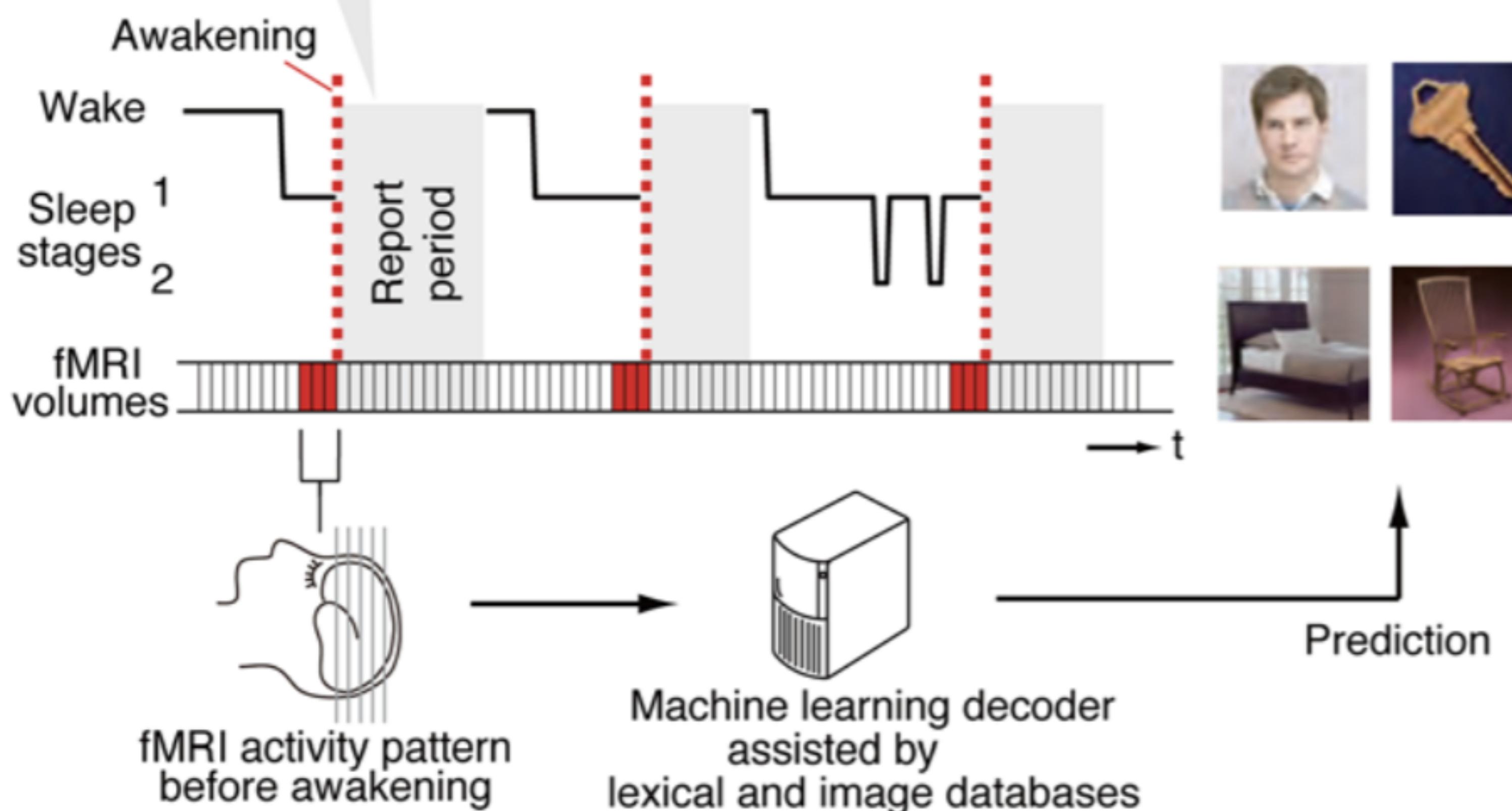
We can decode the content of people's dreams from their brains



Decoding unconscious perceptual state: Dreams

We can decode the content of people's dreams from their brains

*Yes, well, I saw a **person**. Yes. What it was... It was something like a scene that I hid a **key** in a place between a **chair** and a **bed** and **someone** took it.*



Time to awakening=37 sec



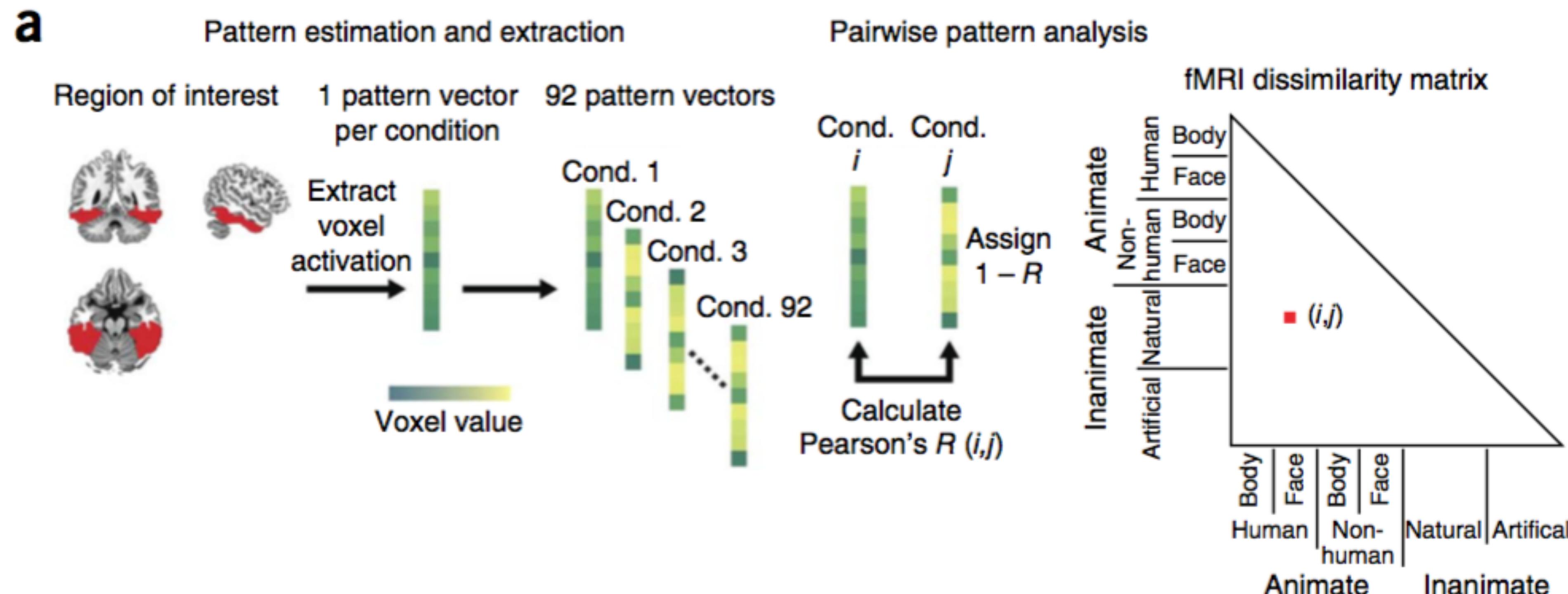
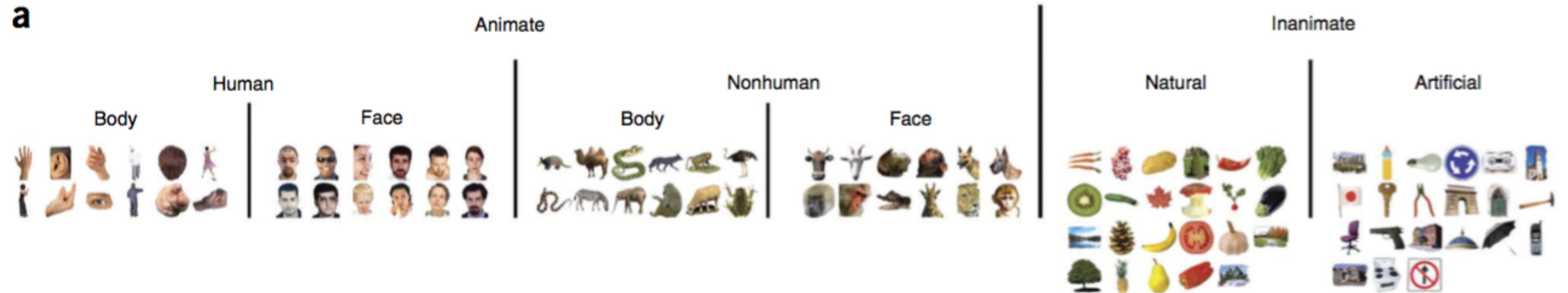
book **building** car character
commodity computer-screen covering
dwelling food electronic-equipment
 furniture male
female
mercantile-establishment point
region representation street

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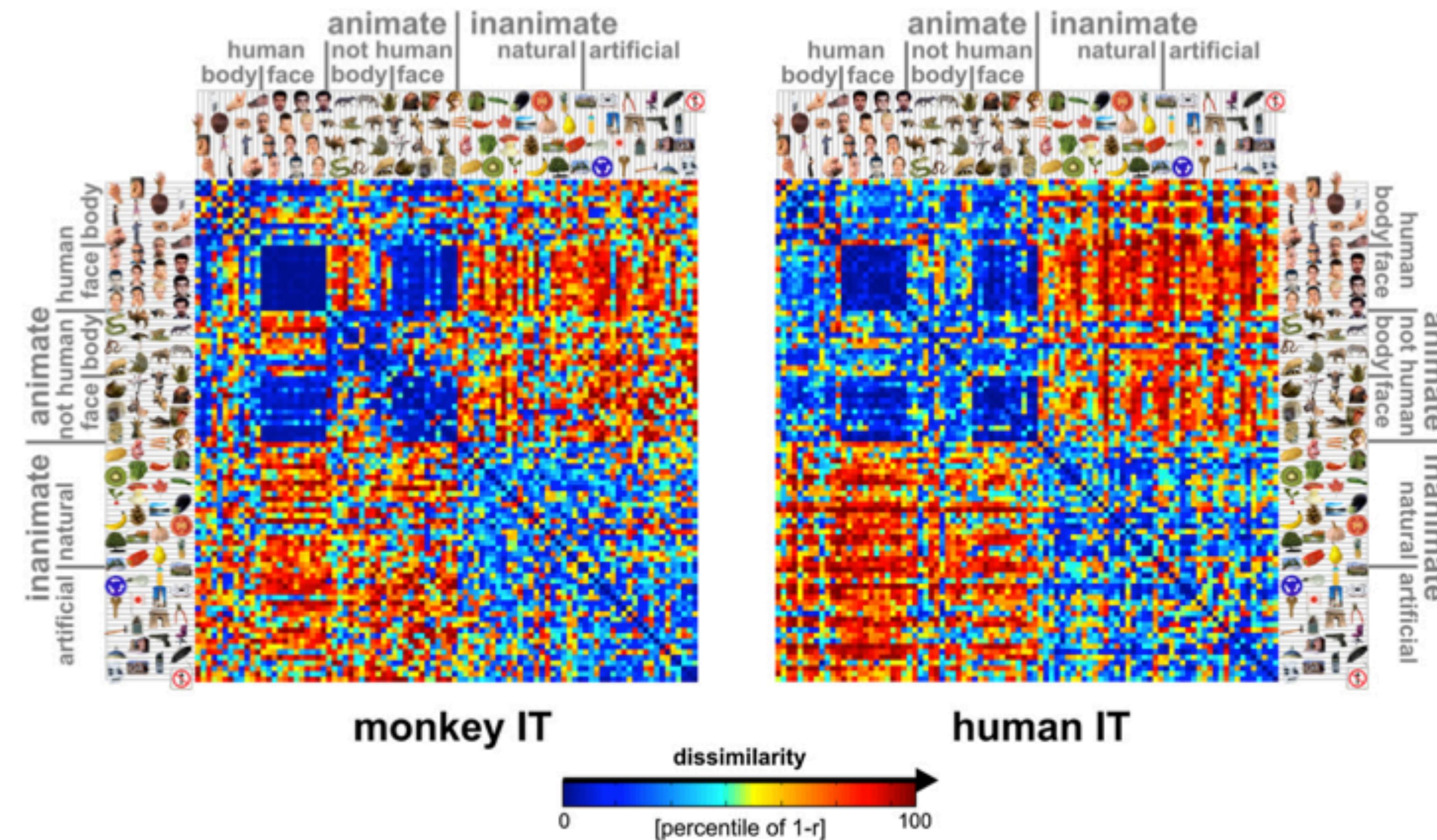


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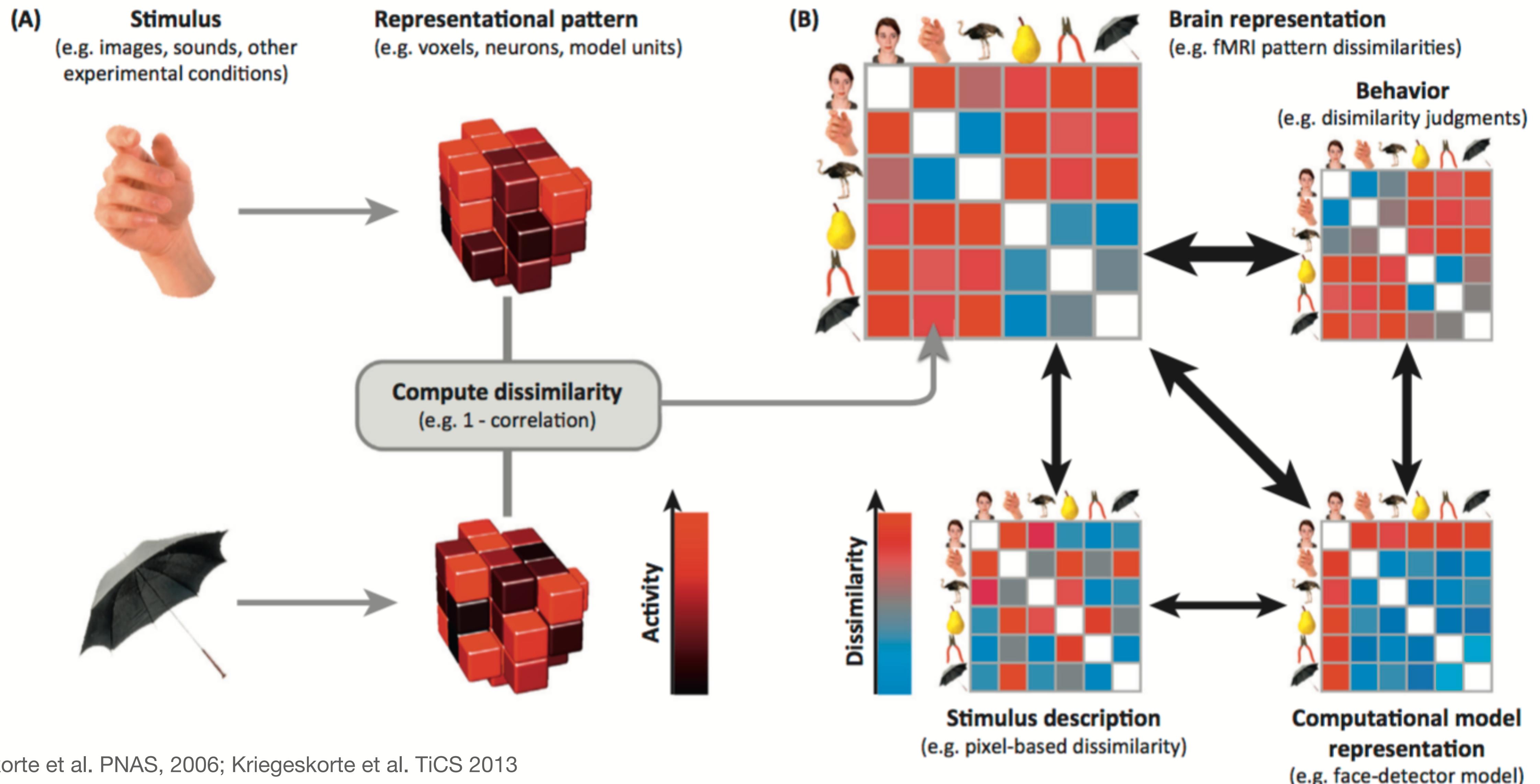
Representational Similarity Analysis



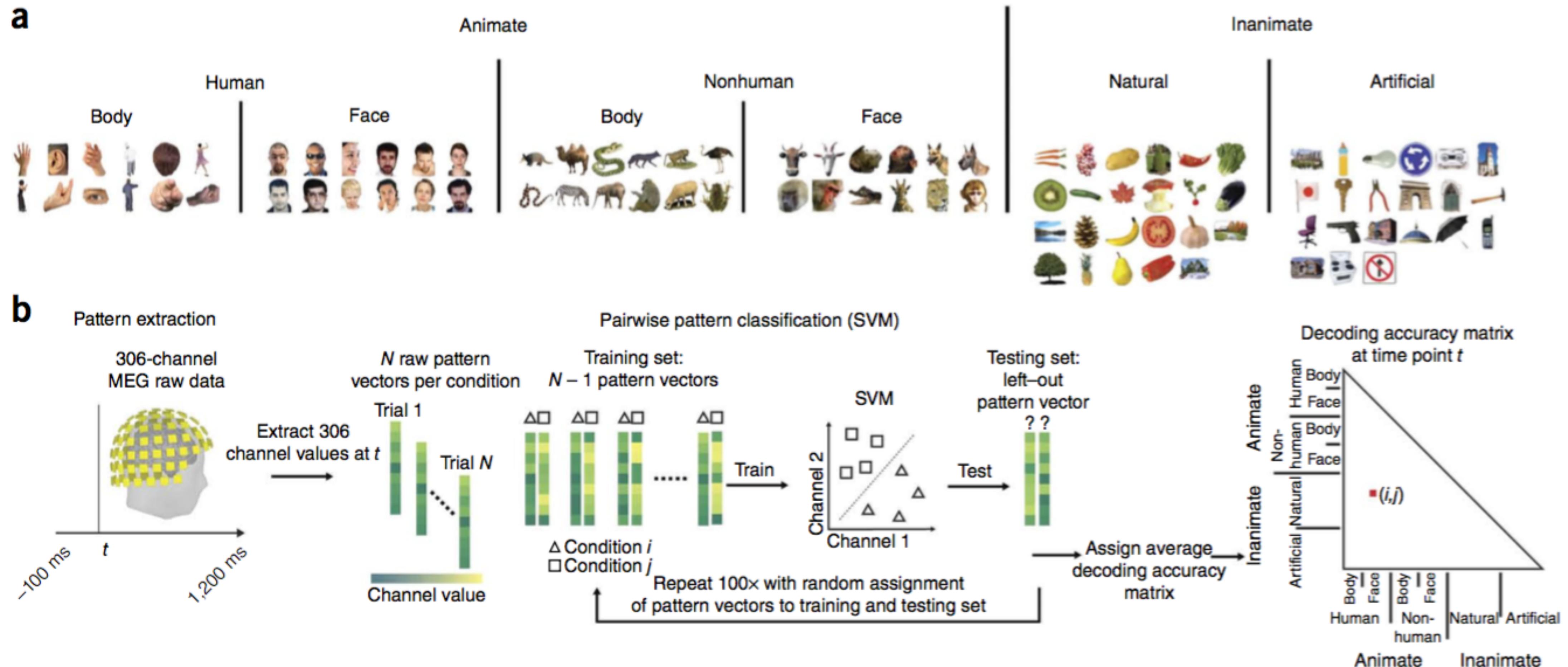
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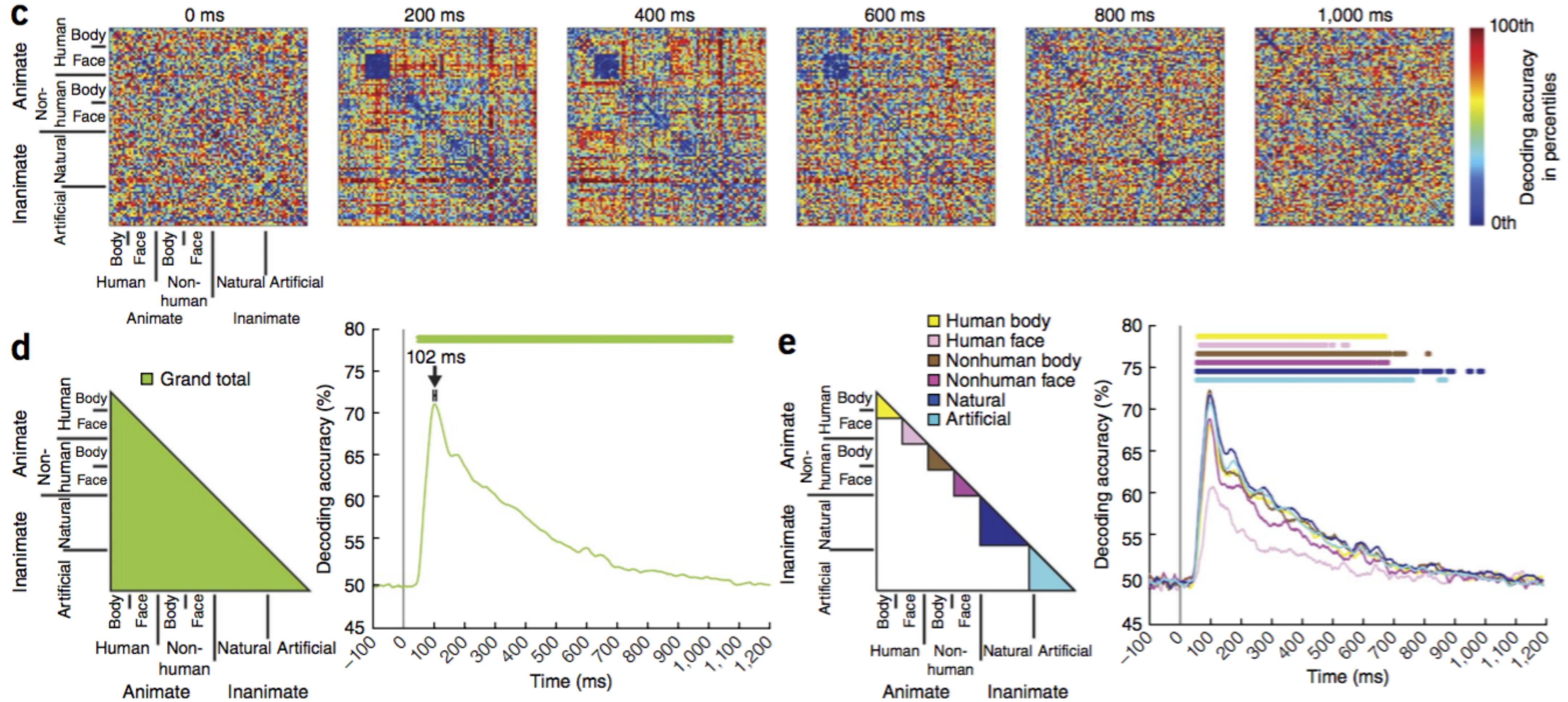
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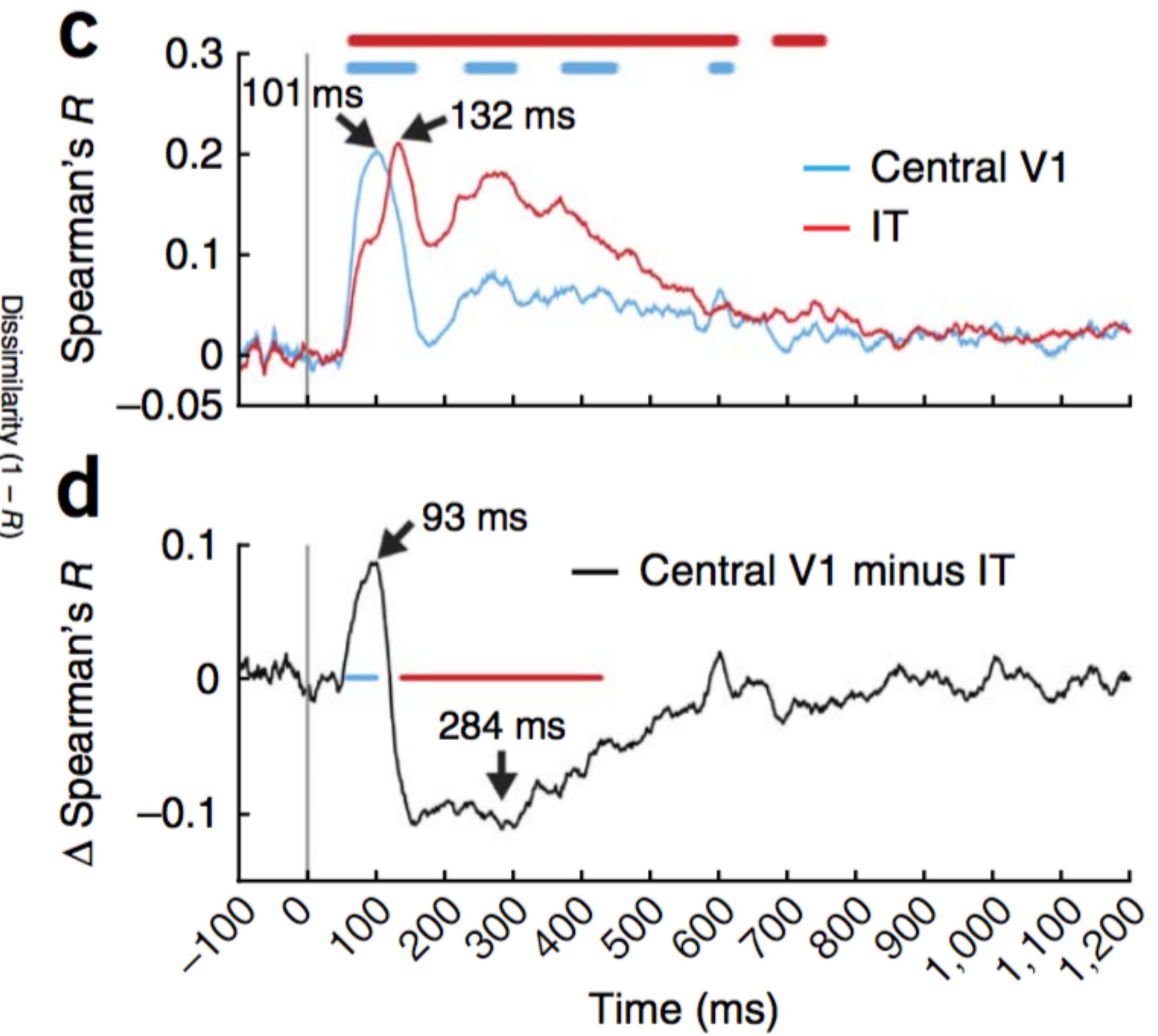
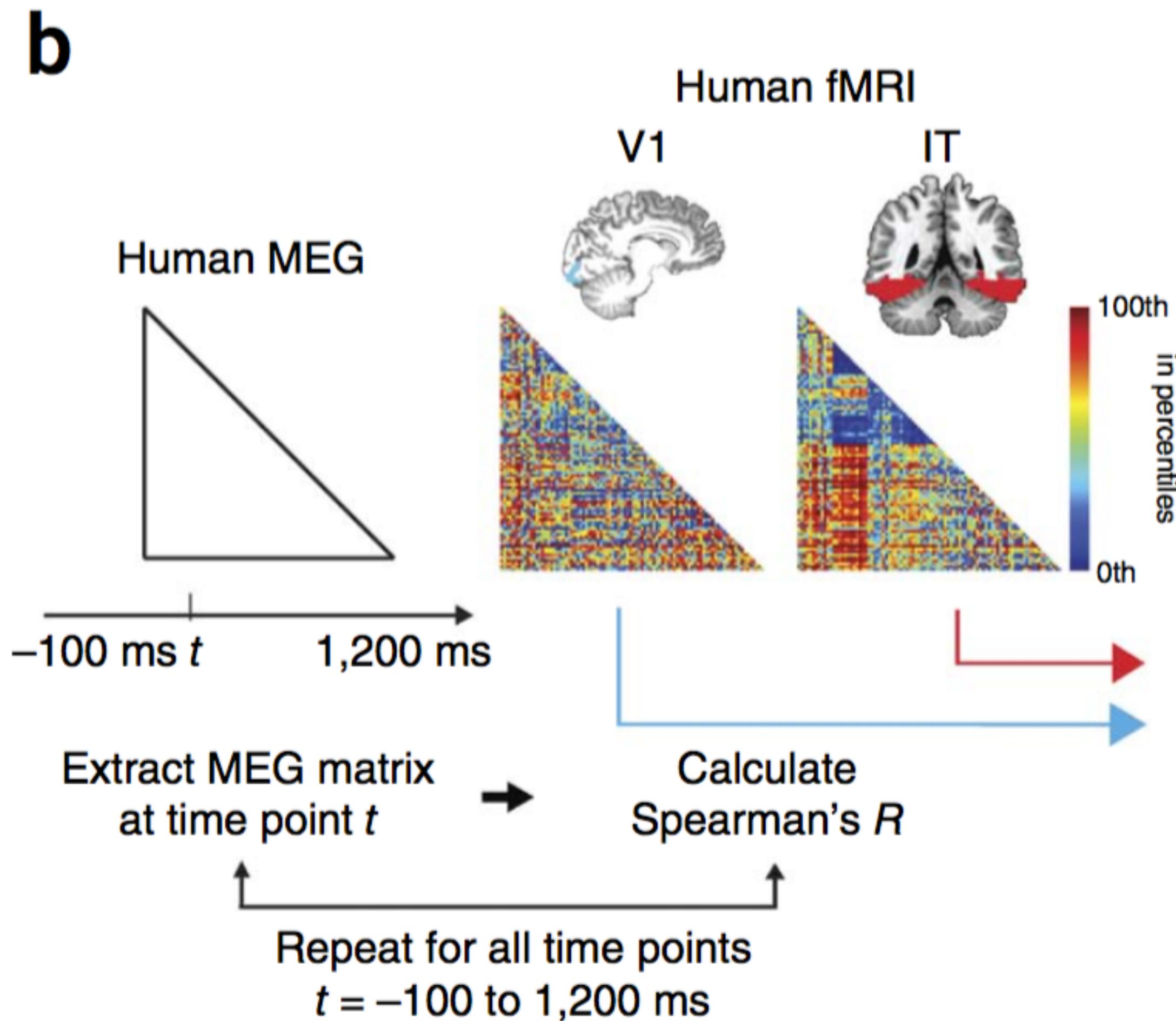
Representational Dissimilarity Analysis



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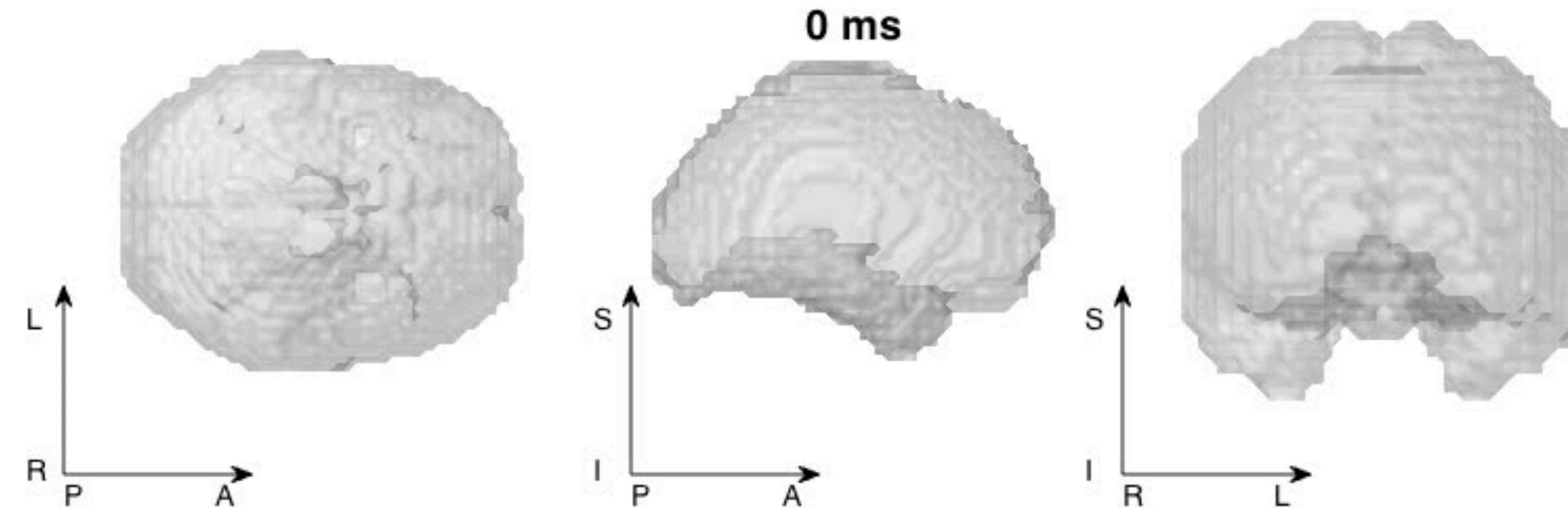
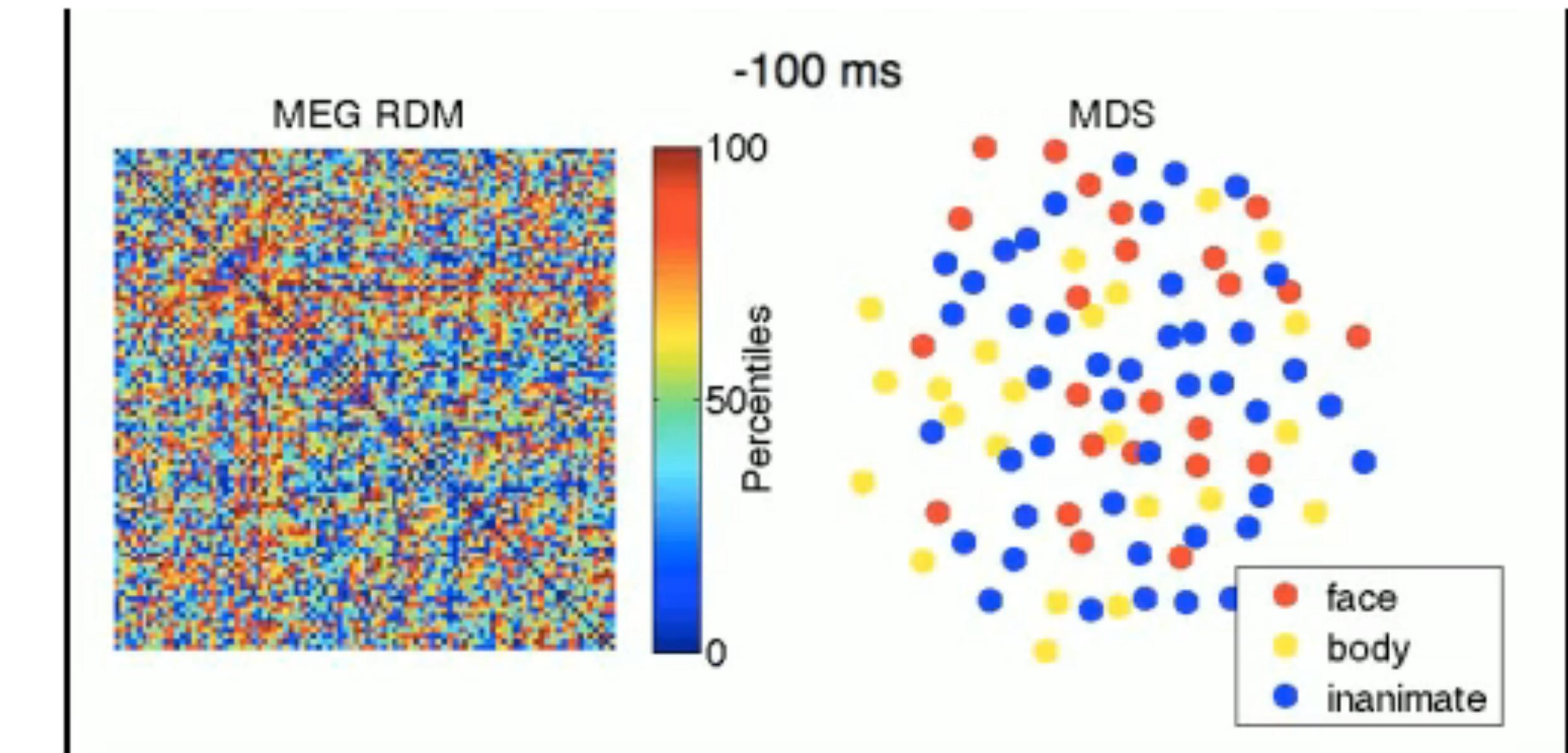


Representational Dissimilarity Analysis



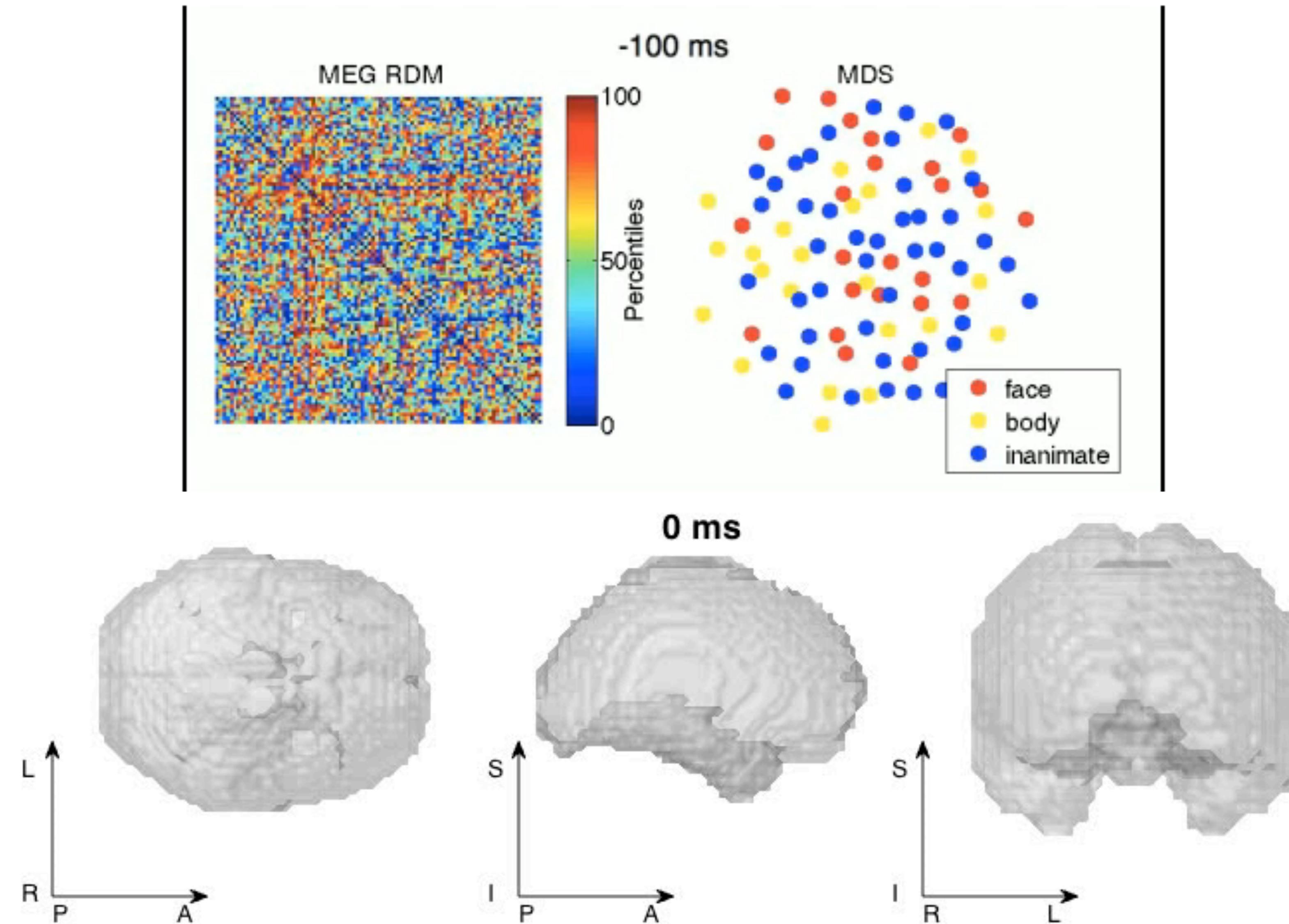
Combining MEG & fMRI

Over time



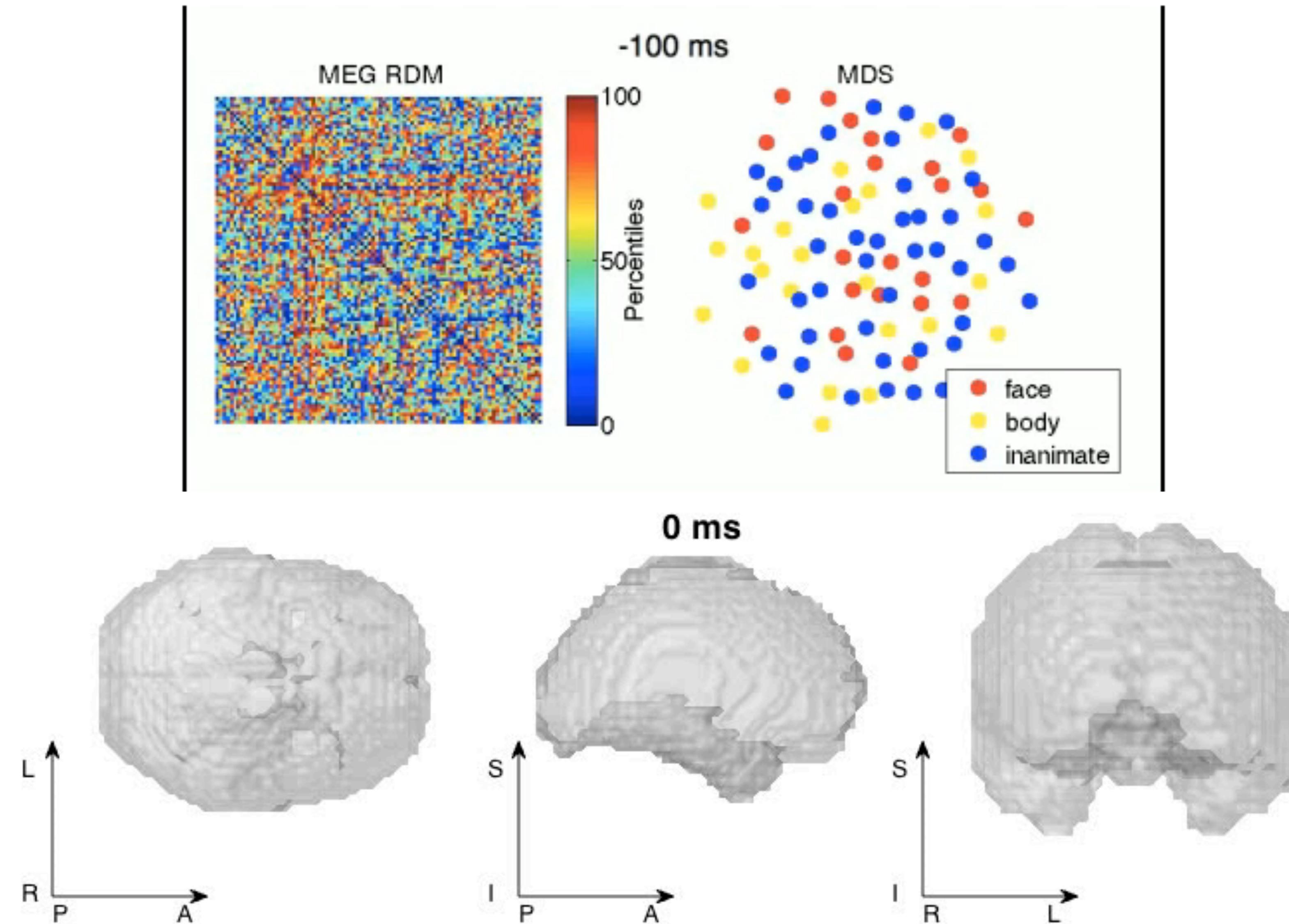
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 - where in the brain can we find information about X?
 - how similar are stimulus X and Y?
- now able to tease apart stimuli that activate the same brain region equally strongly (on average)
- allowed comparison between modalities (MEG - fMRI - behaviour - animal physiology)

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- *Perusall - Kay & Naselaris paper*