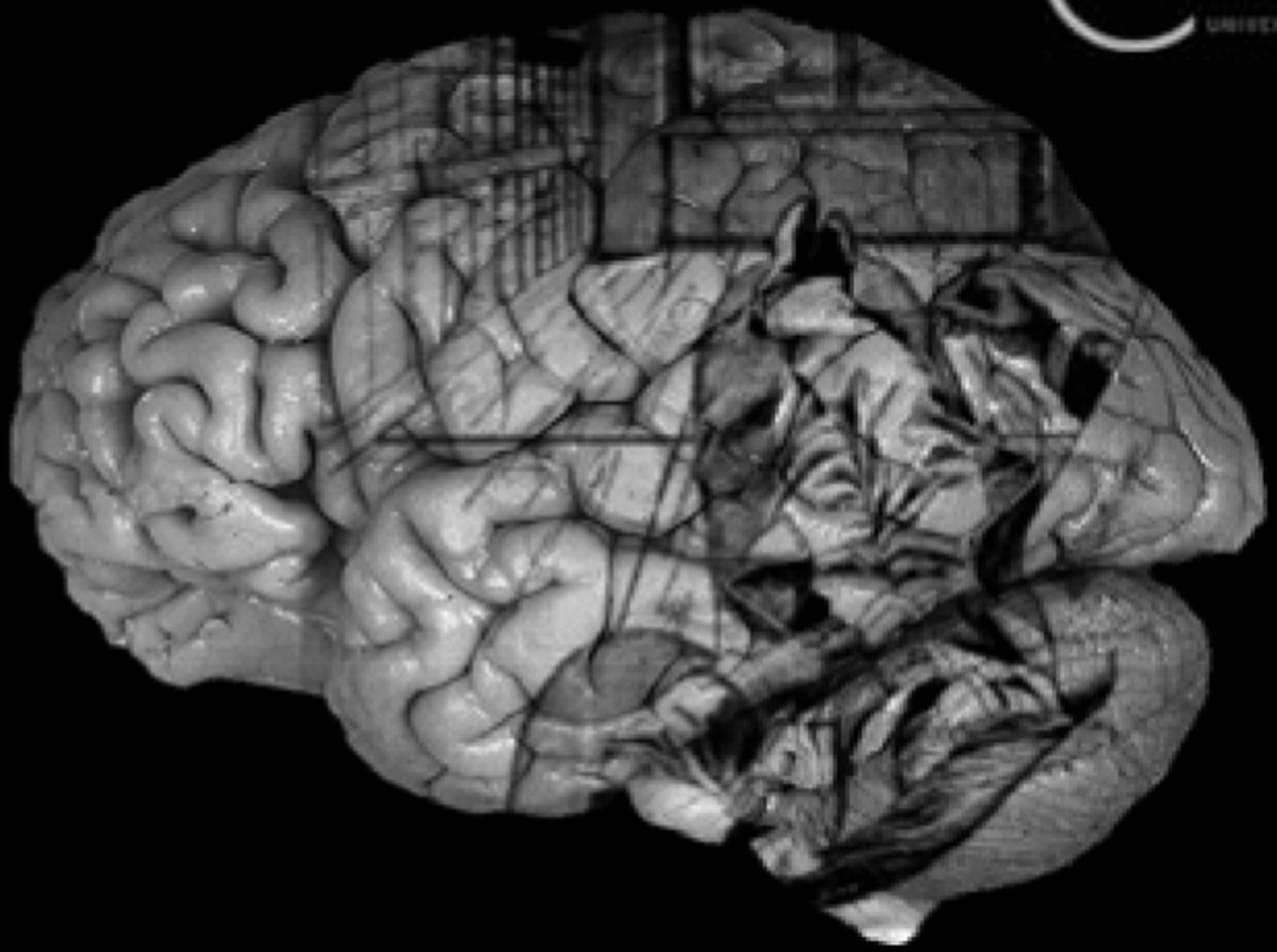
MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Attention and Awareness Group

Bernstein Center for Computational Neuroscience Berlin

CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN



Decoding mental states from human brain activity

John-Dylan Haynes

Everyday thought reading

A general “thought-reading device”?

Mach (1886)

Introduction to “brain-reading”

Limits of brain reading

Technical applications

“Brain reading”

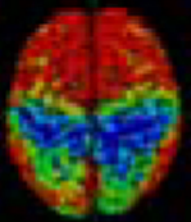
FUNCTIONAL

STRUCTURAL

T1 MRI

CT

DTI fibre tracking



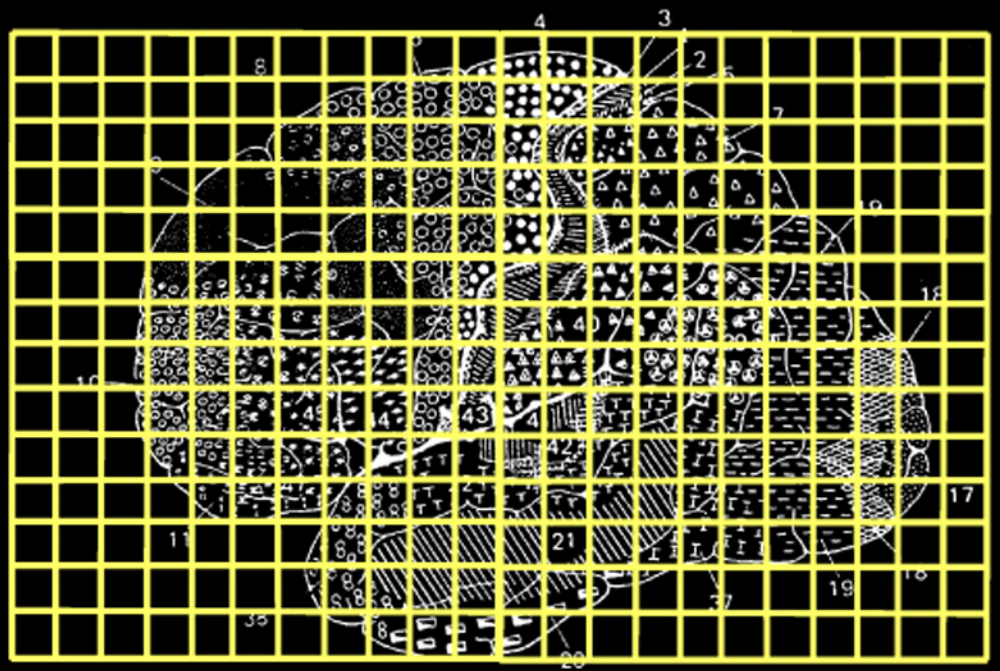
Cortical thickness

MENTAL STATES
Sensations
Memory traces
Intentions
Attitudes
Deception

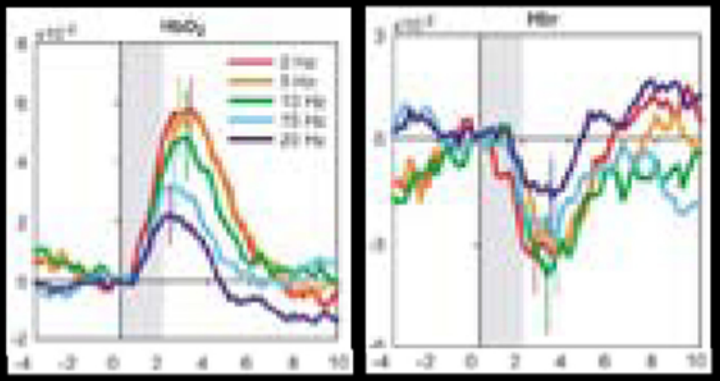
MENTAL TRAITS
Intelligence
Personality

MEDICAL STATE

BOLD - fMRI

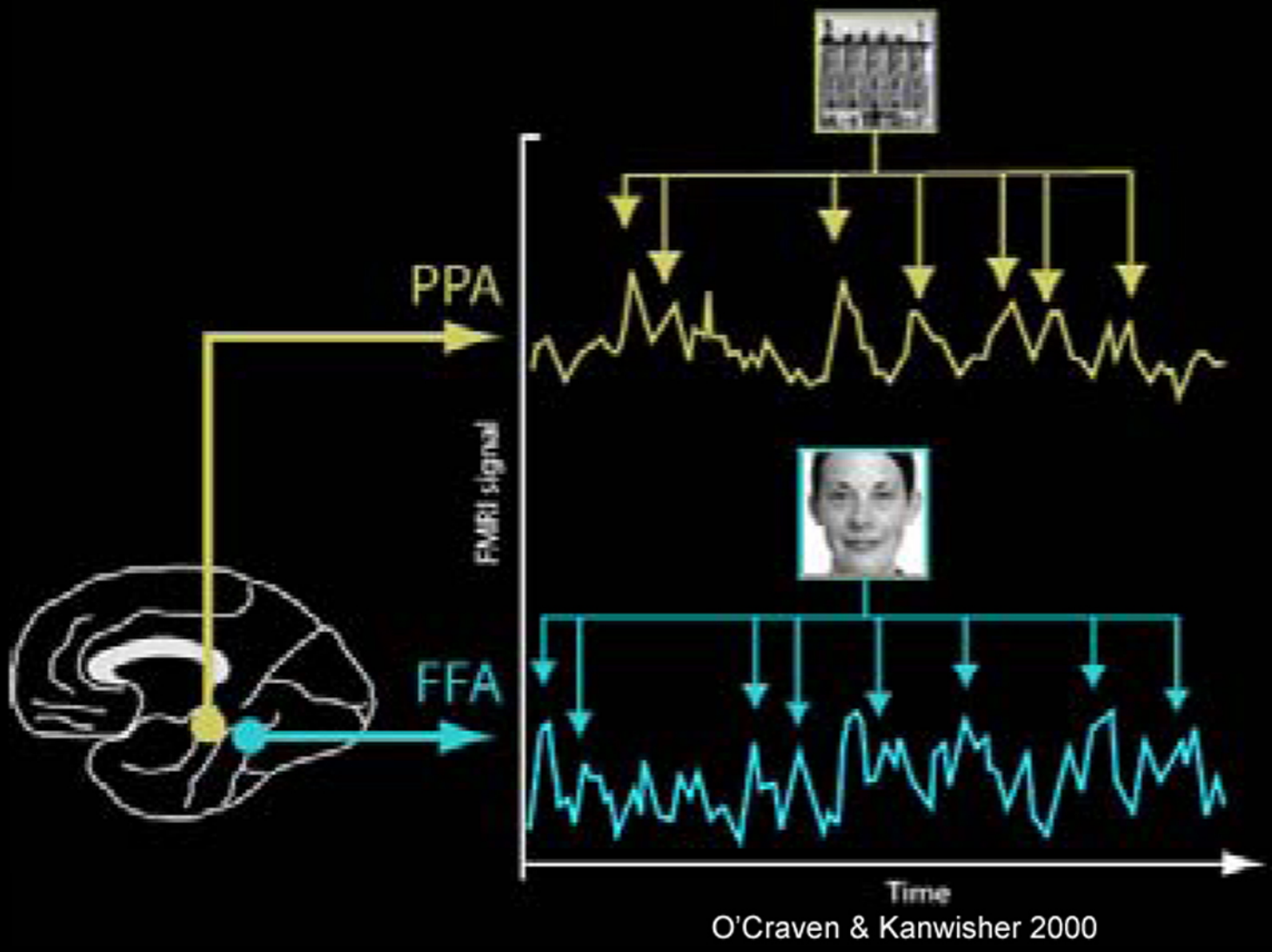


≈3mm



Sheth et al. (2005)

Visuelle Vorstellungen



O'Craven & Kanwisher 2000

85 % korrekt

Trennbare kortikale Module

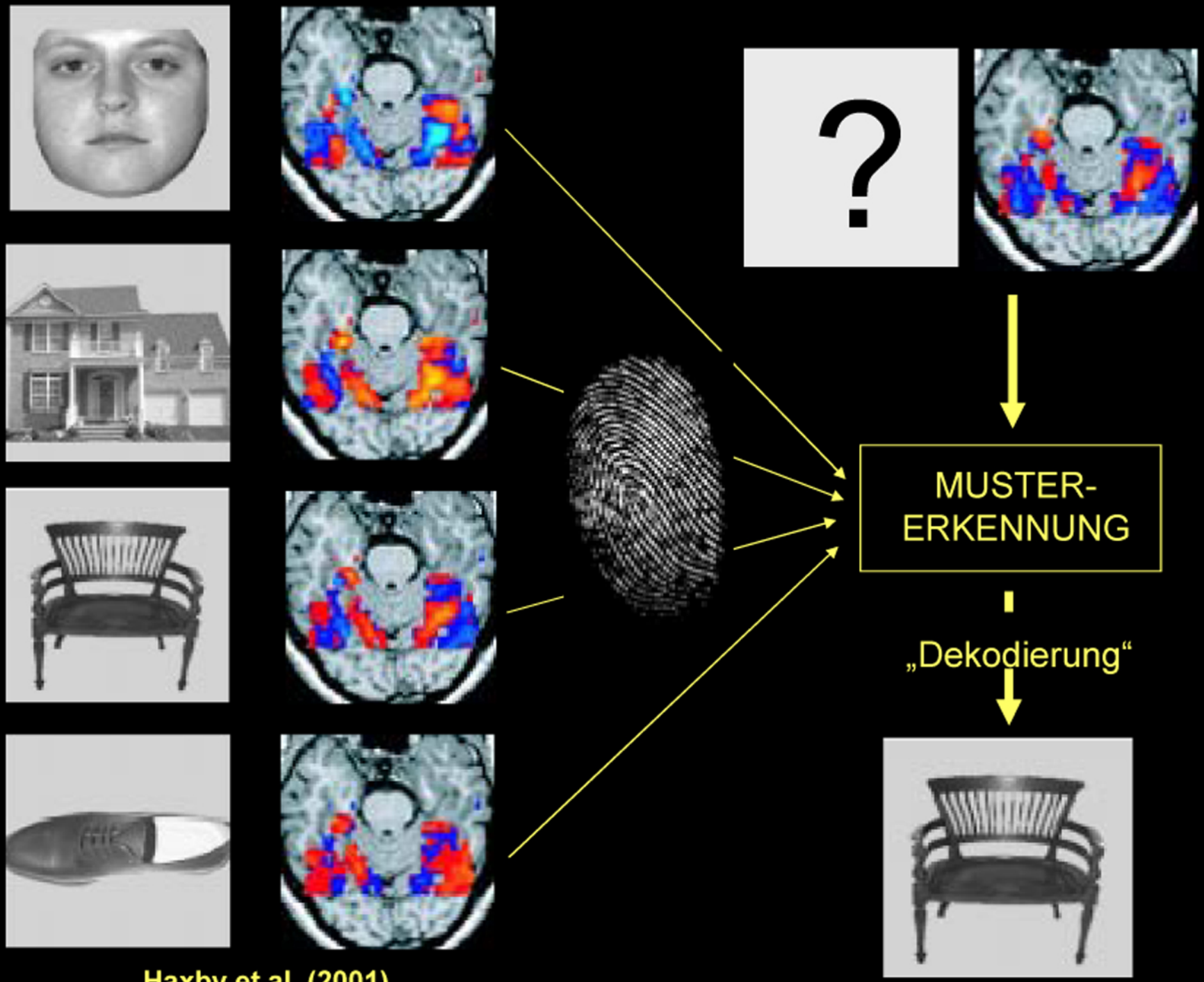
Multiple Objekte?

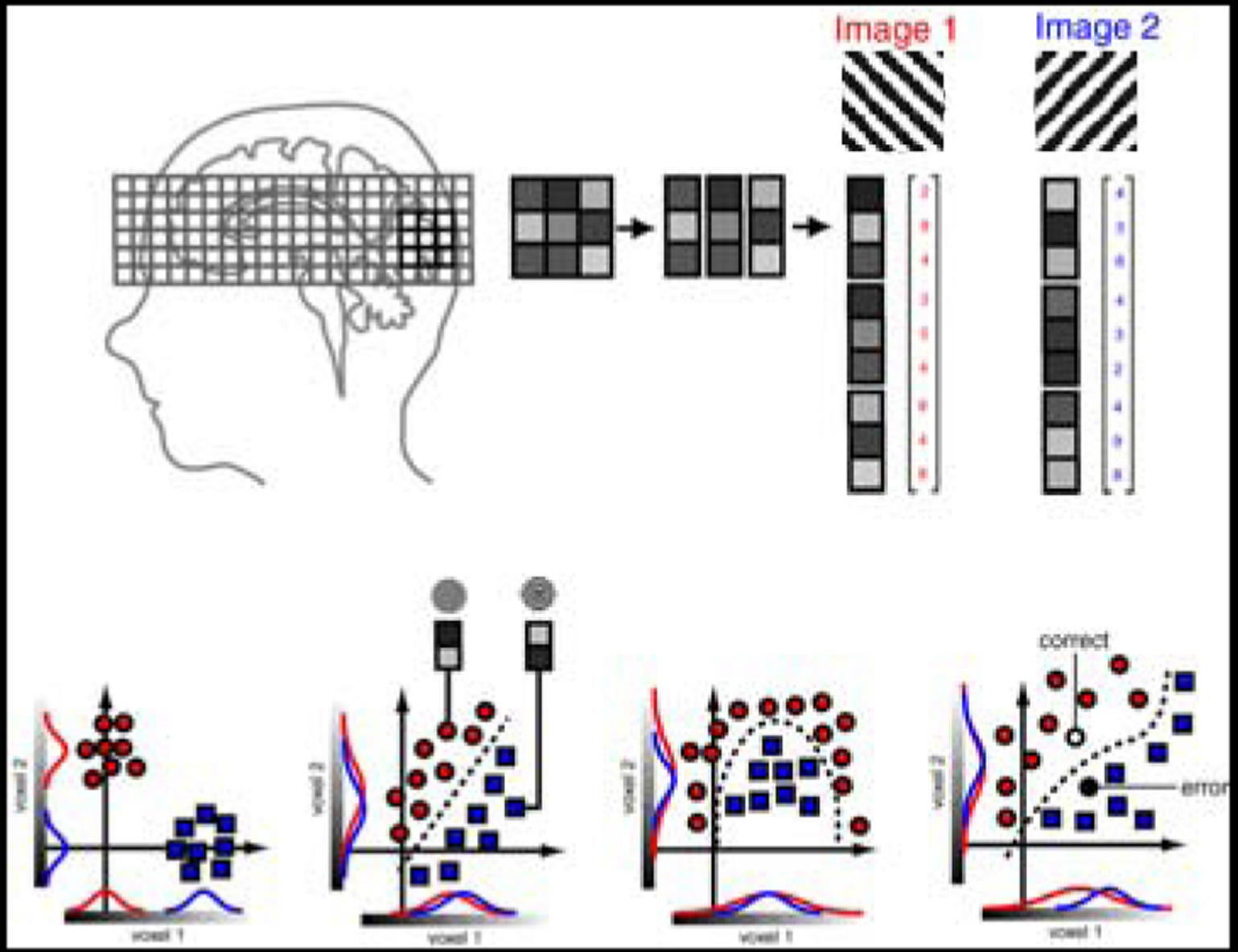




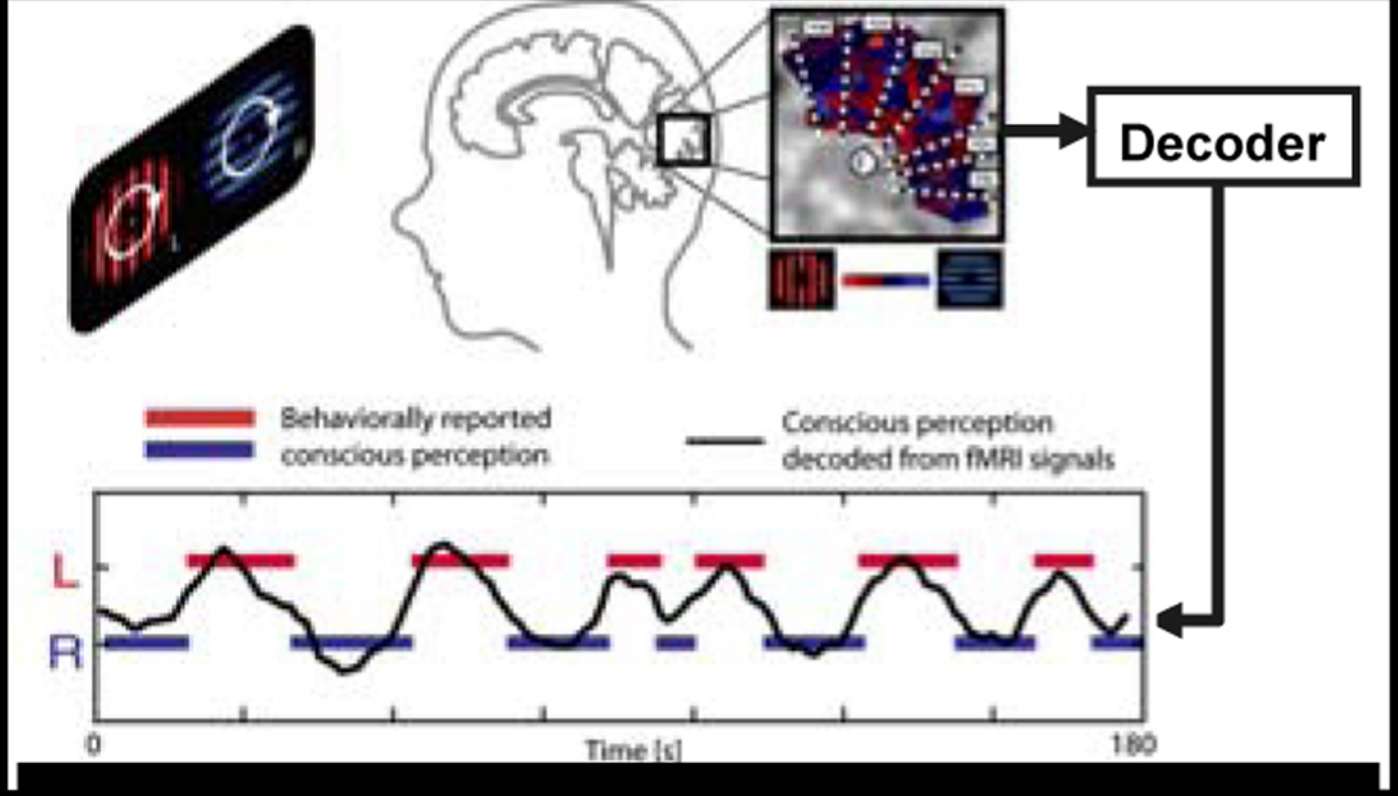


Haxby et al. (2001)


?
MUSTER-
ERKENNUNG
„Dekodierung“
Haxby et al. (2001)



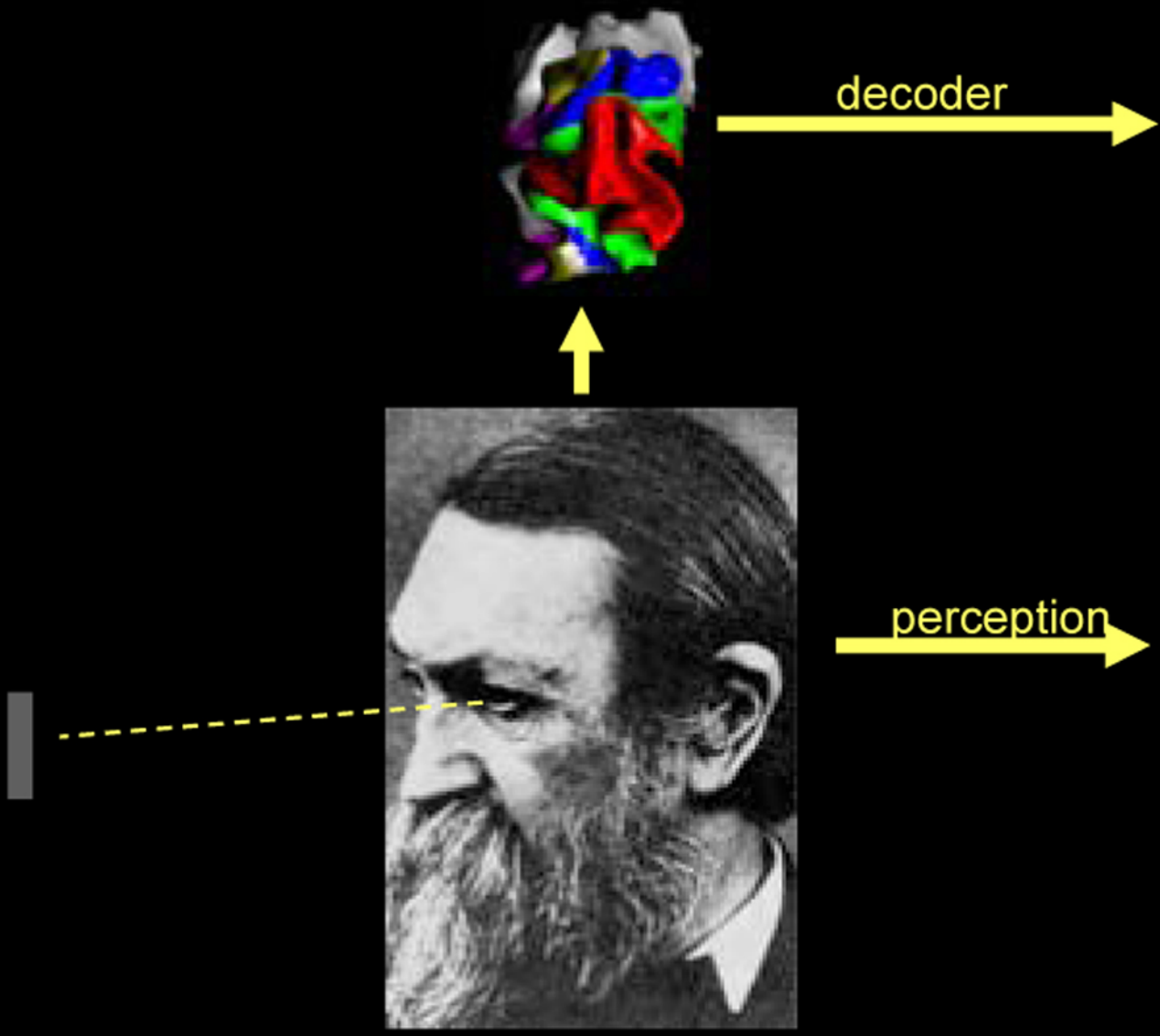
Haynes & Rees. *Nat Rev Neurosci* (2006)



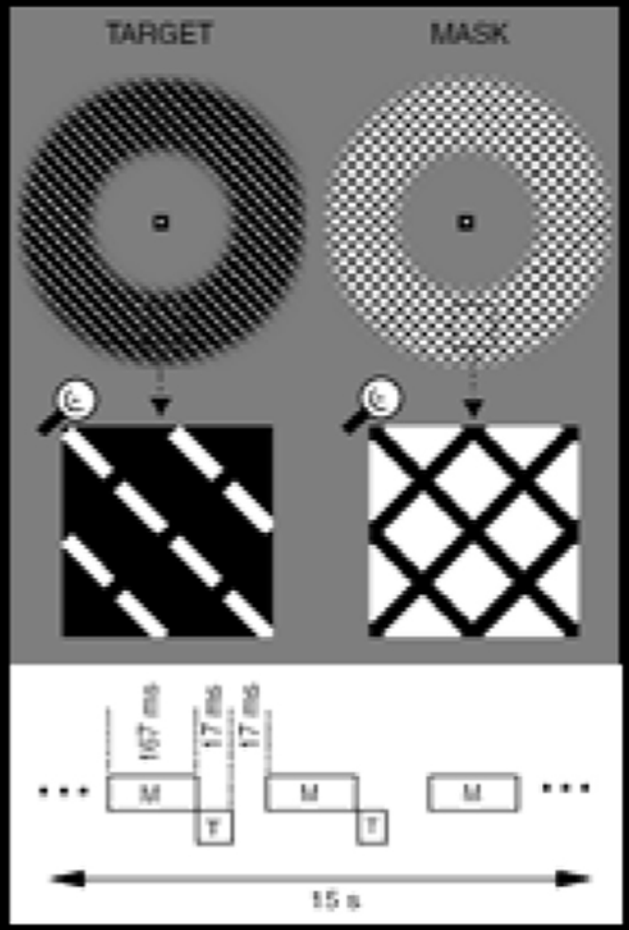
stimulus perception prediction

Haynes & Rees, *Current Biology* (2005); Haynes & Rees *Nature Neuroscience* 2005; Haynes et al. *Nature* (2005)

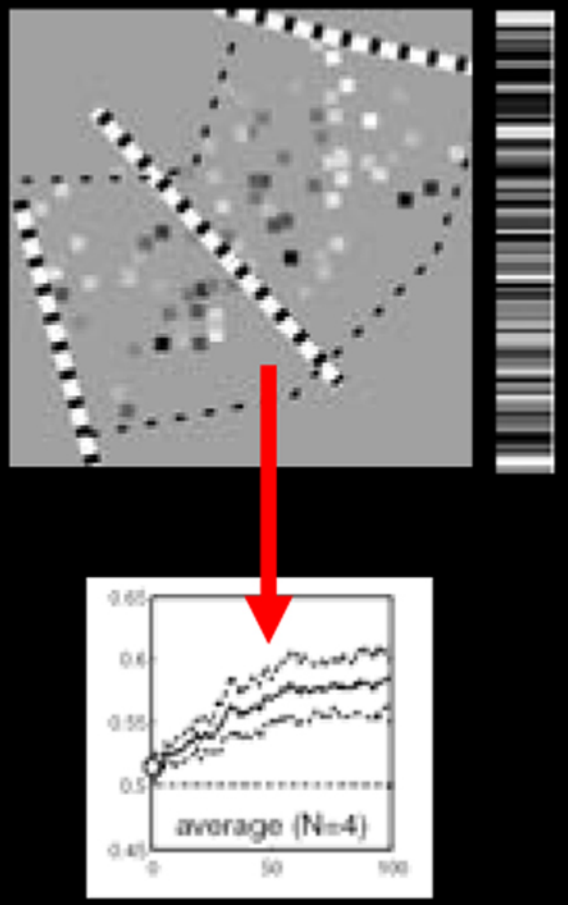
Comparing neural and perceptual information



Responses to invisible stimuli



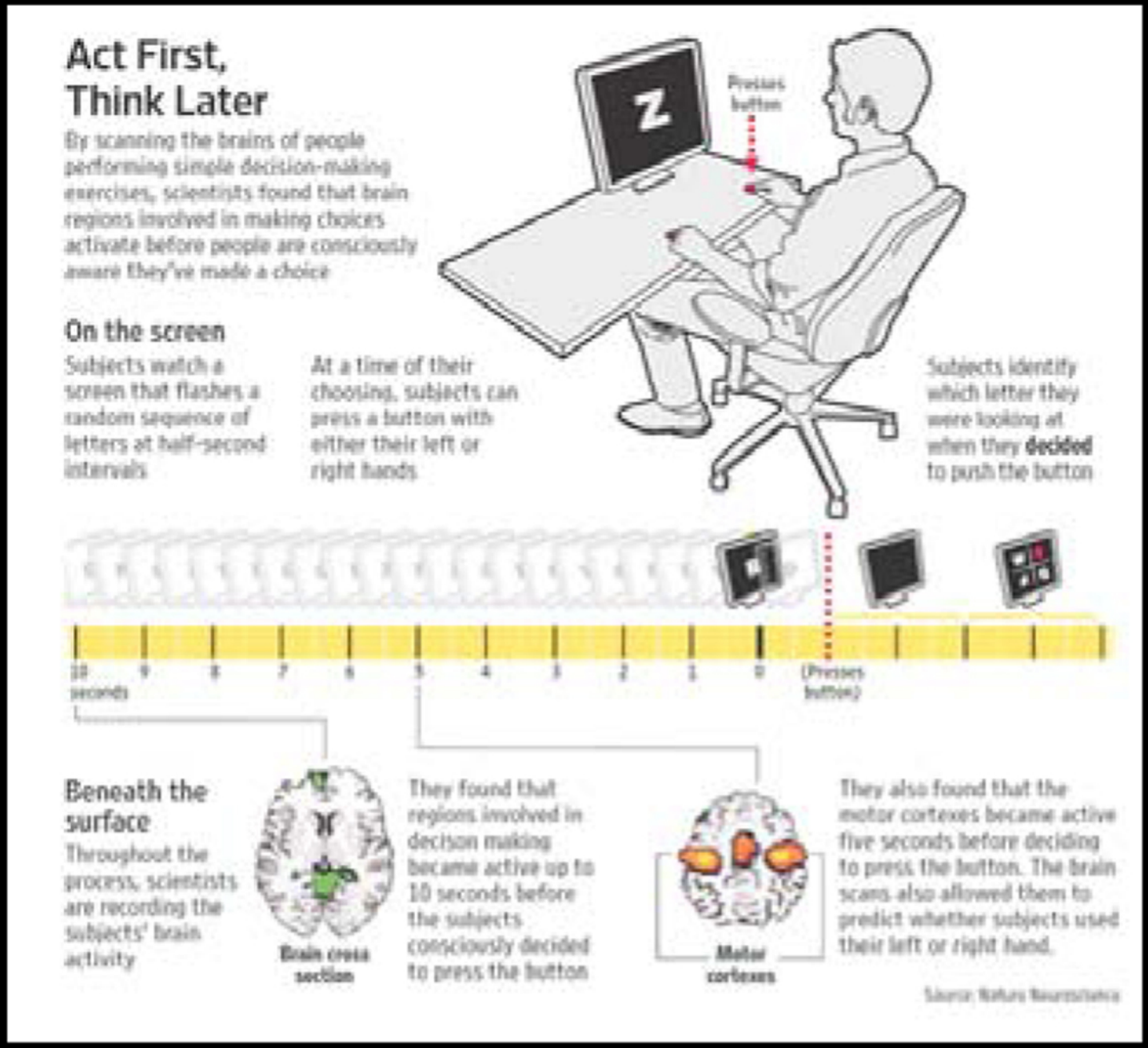
Discrimination performance during scanning at chance (50.3%; SE=0.4)



Single EPI Volumes (TR=1.3s)

Early visual system registers more details of visual stimuli than reach awareness

Haynes & Rees, *Nat. Neurosci.* (2005)

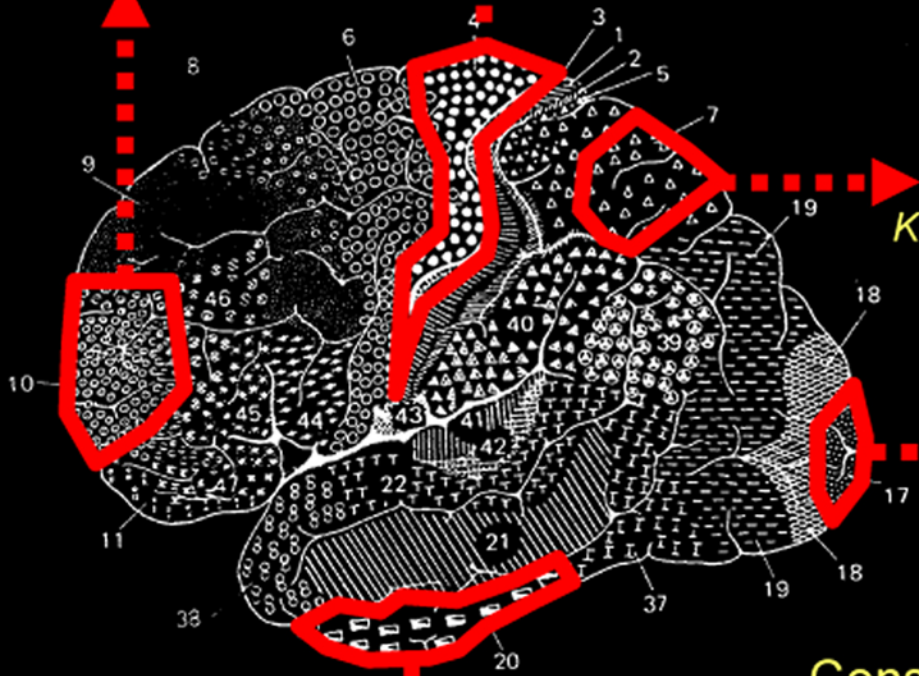


Soon & Haynes (2008) Nature Neuroscience

Other examples

Complex decisions
and action control
Haynes es al. Current Biology 2007
Soon et al. Nat Neurosci 2008

Motor plans
Soon et al. Nat Neurosci 2008
Bode et al. HBM 2007



Attention
Kalberlah et al. HBM 2007

Conscious perception
Haynes et al. Nat Neurosci 2005
Haynes et al. Curr Biology 2005
Haynes et al. Nature 2005
Haynes et al. Neuron 2005

Concepts
Yi & Haynes VSS 2008

Introduction to “brain-reading”

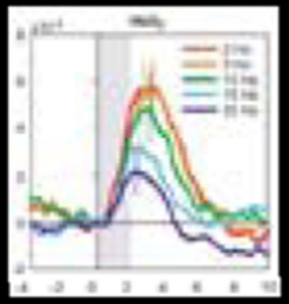
Limits of brain reading

Technical applications

Challenges and limitations

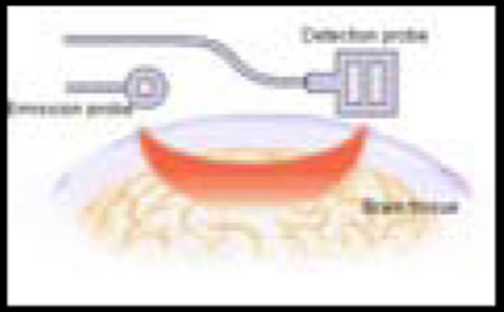
Technical

- Temporal and spatial resolution



- „Mobility“

EEG



NIRS

MRI

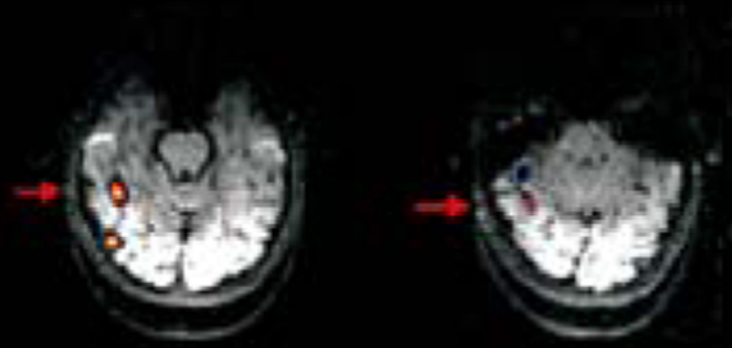
Challenges and limitations

Generalisation and invariance

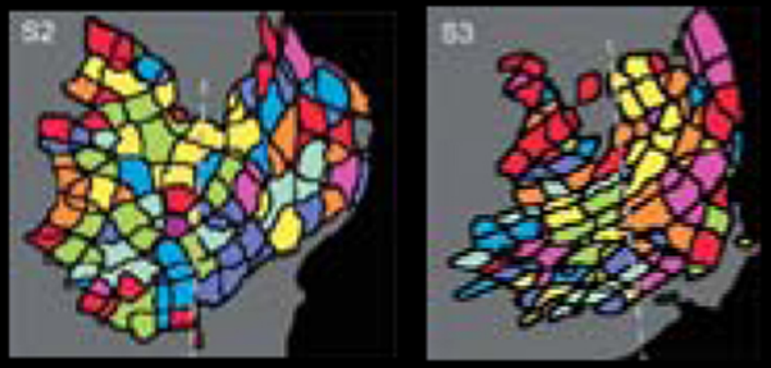
Novel exemplars and contexts

Quiroga et al., Nature (2005)

Novel subjects

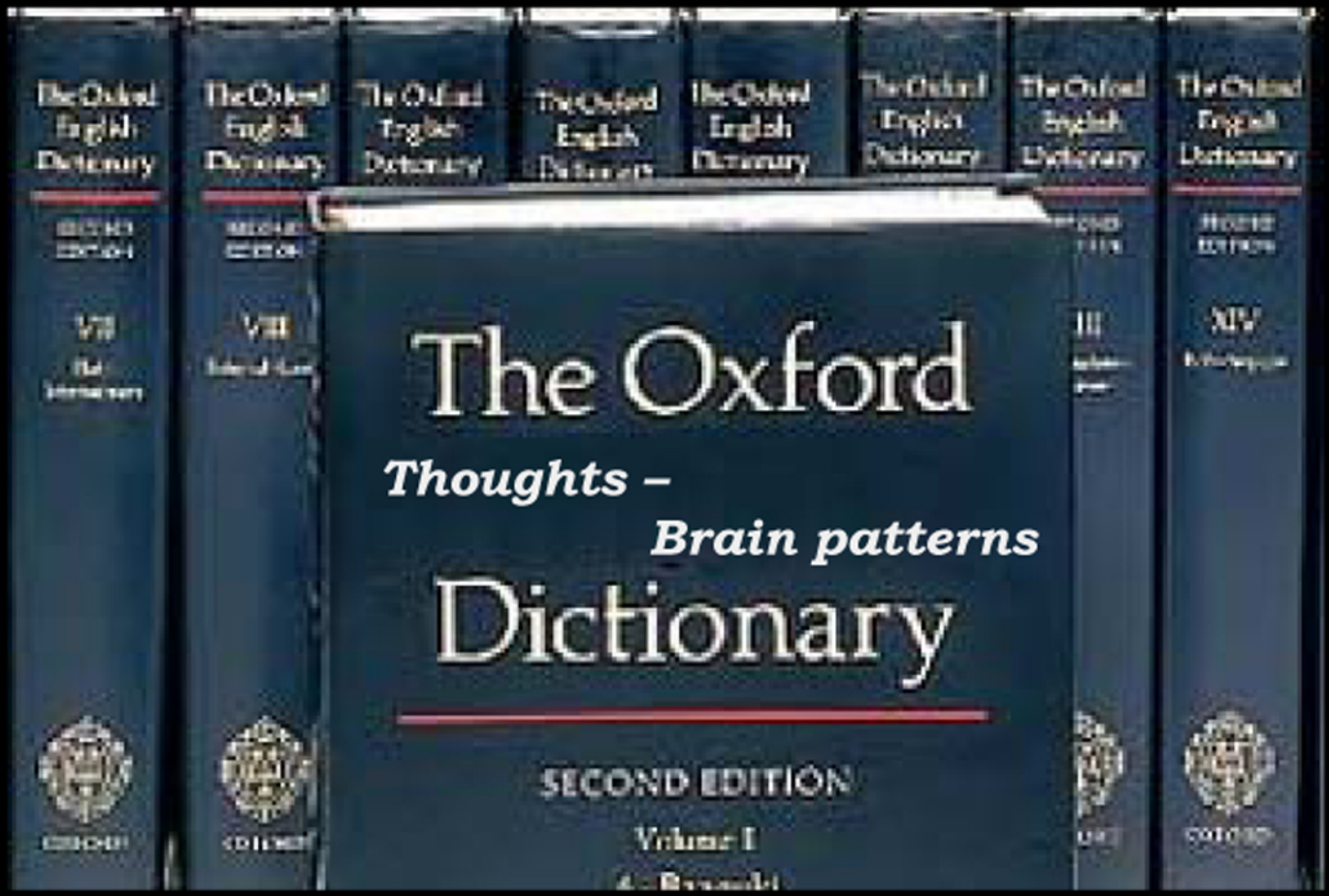


Kanwisher et al., J Neurosci (1997)



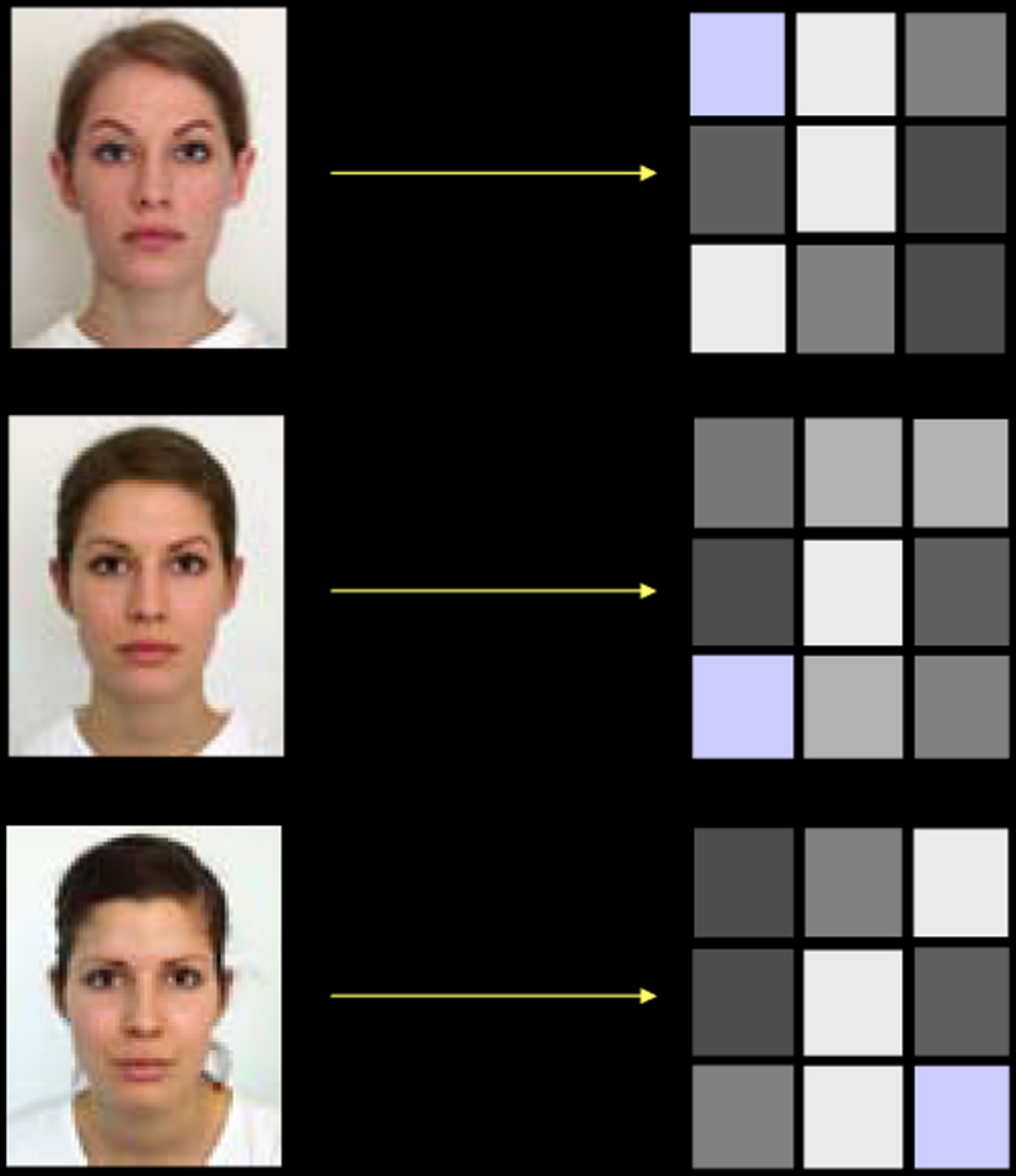
Kamitani & Tong, Nat Neurosci (2005)

Lexicon of thoughts



Superposition of virtual sensors?

Filling up the dictionary

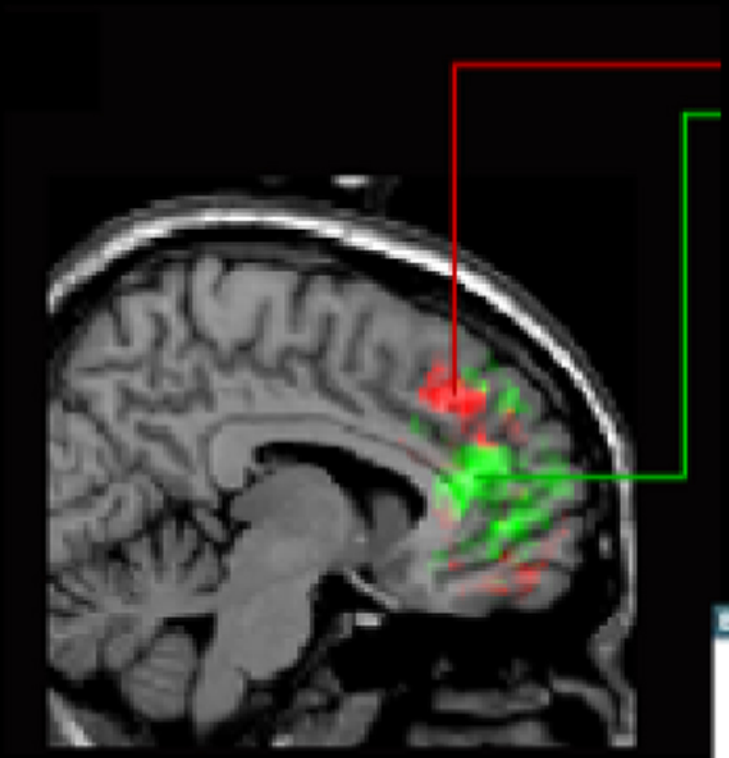


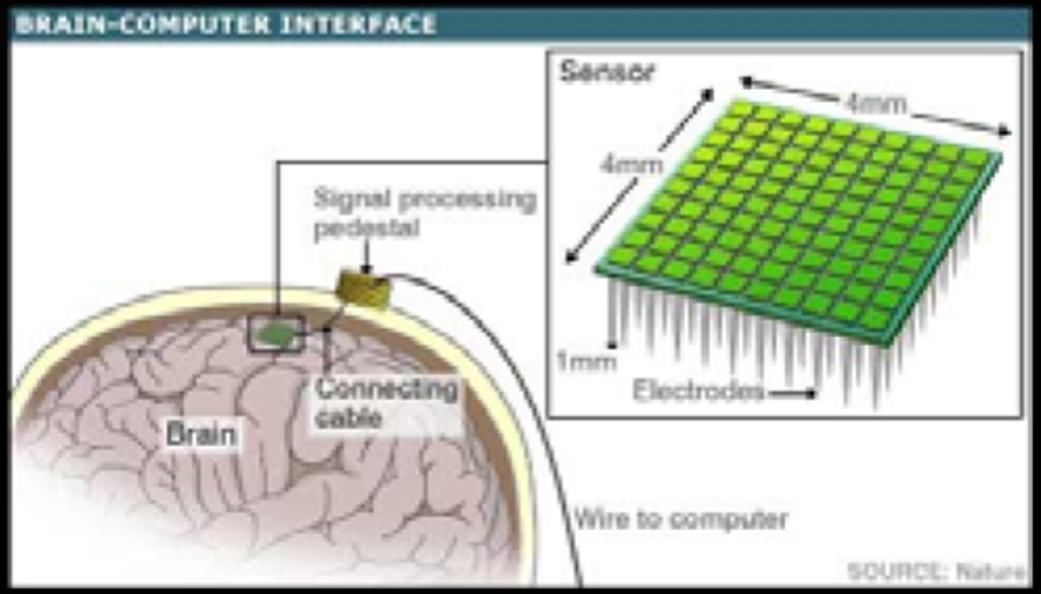
Introduction to “brain-reading”

Limits of brain reading

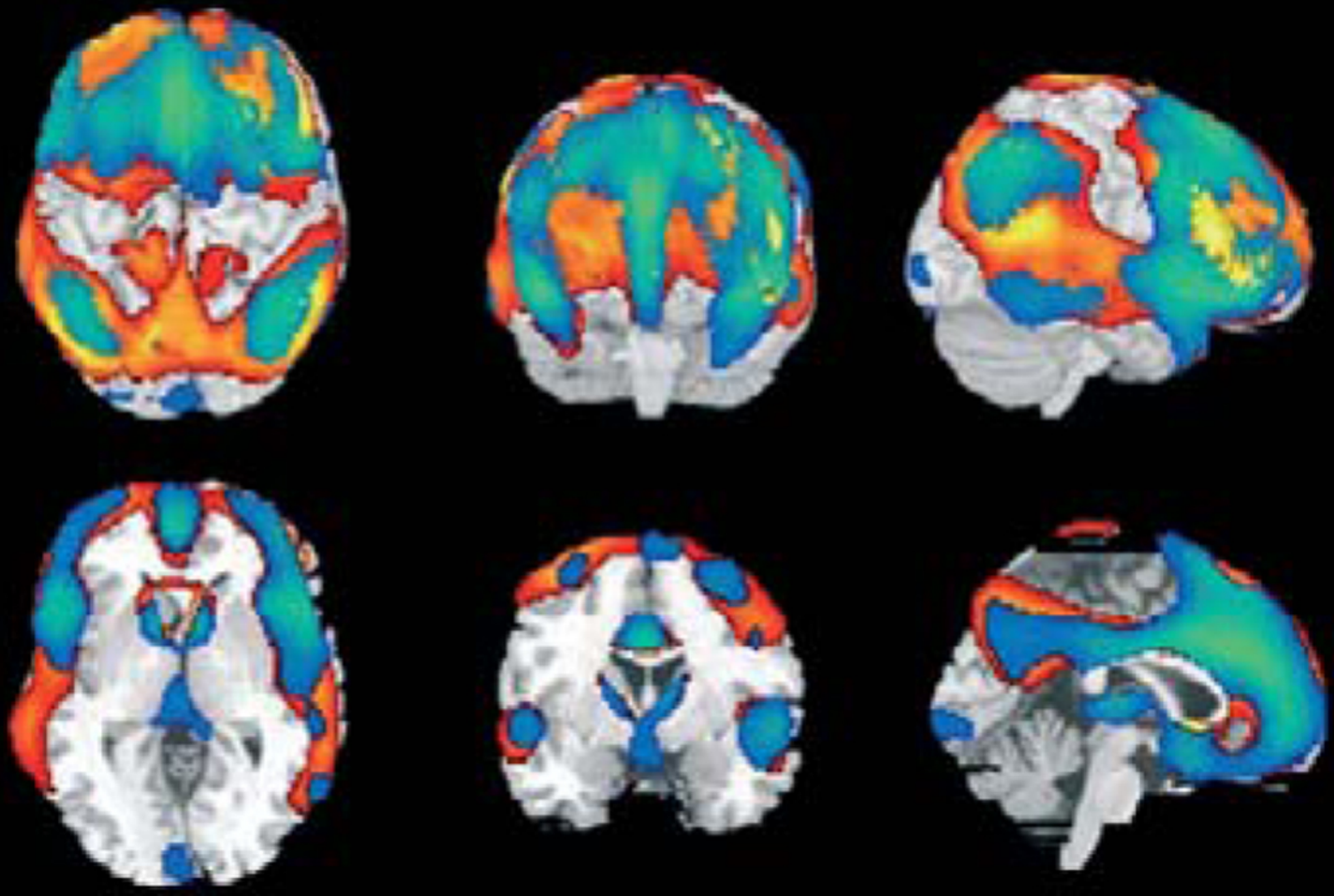
Technical applications

Clinical:
FMRI-guided electrode placement





Clinical diagnostics



Parkinson‘s Dementia < Control

Lewy Body Dementia < Control

Have I been here before?

Design

- Training
  - Explore 4 our of 8 virtual houses

- Experiment
  - 64 videos (8.8 s each)
    - 32 recorded in explored houses
    - 32 recorded in new houses

Seen

Unseen

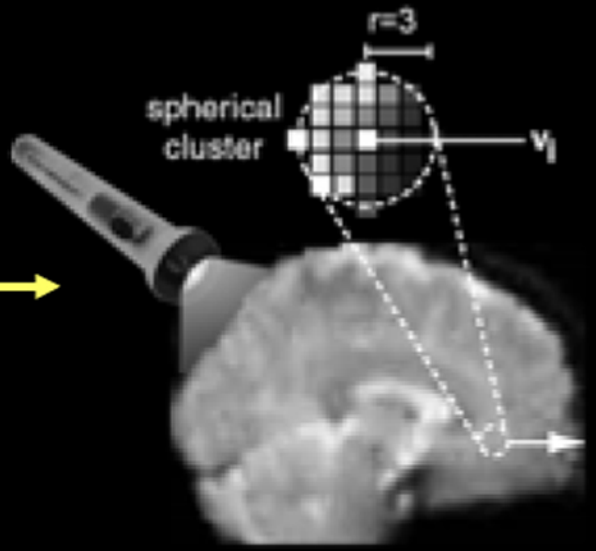
Mart Bles
Postdoc

- 4 runs, 16 videos each (2 per house)
- 8.8 s per video, interspersed with baseline
- 32 slices, 3.5 * 3.5 * 3.5 mm
- Subject's task: count occurrence of tables in videos (assure visual attention

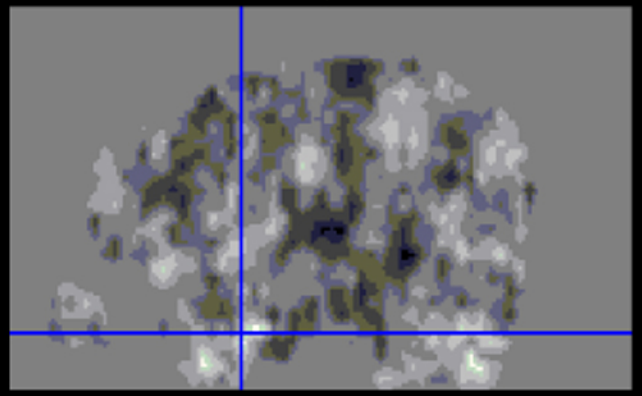
6 houses with known label

seen

unseen



Classifier

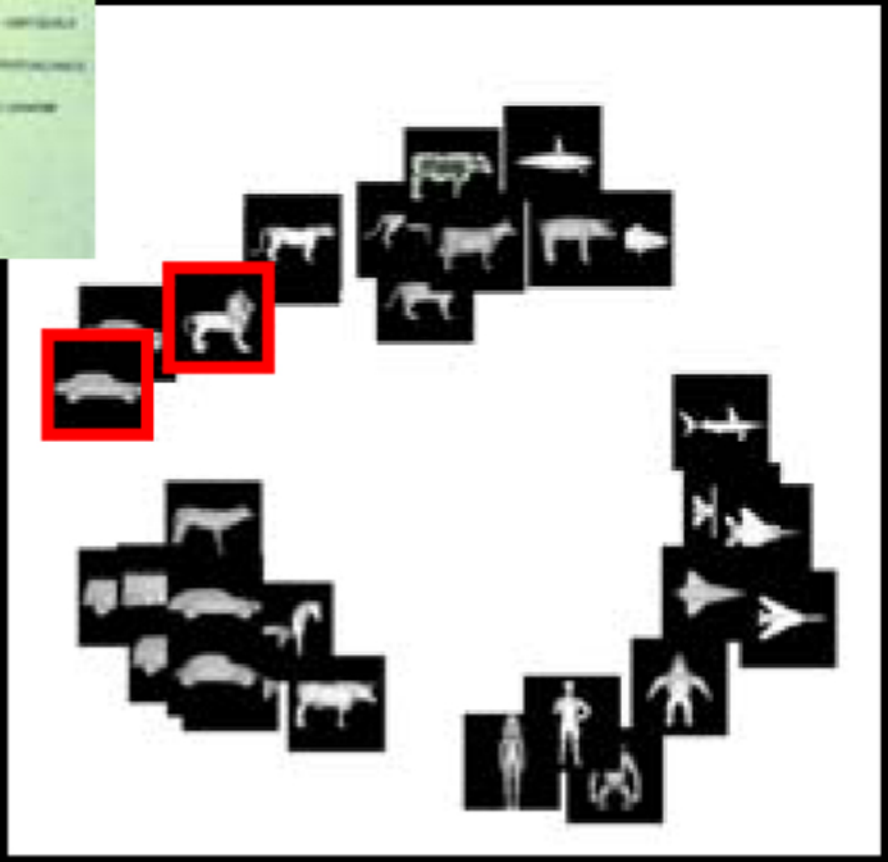


Map of information

92% correct classification

(N=10 subjects)

Market research



Summary

Multivariate decoding allows to non-invasively study the encoding of information in the human brain.

A major limitation is the limited number of mental states that can be decoded.

But even without a „universal thought reading device“ it is still possible to realise powerful applications.

Bernstein Center for Neuroscience

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