Initiative for Synthetic Studies of Awareness (ISSA): Introduction

2017 May 22

AProf Nao Tsuchiya
Monash University, Australia

A map of interdisciplinary studies of consciousness

Theoretical

Philosophy

Zahavi

Psychology

Experimental

Psychophysics

Humans

Tsuchiya, Kanai

Application

Clinical

Traditional → Emerging

A map of interdisciplinary studies of consciousness

Theoretical

Philosophy

Tsuchiya, Albantakis

Integrated Information Theory

Psychology

Neuroscience ***MEG, fMRI***

Experimental

Tsuchiya

Humans

Monkeys

Kanai, Tani

Neural Network

Application

Clinical

Traditional

Emerging

A map of interdisciplinary studies of consciousness

Theoretical

Philosophy

Integrated Information Theory

Psychology

Neuroscience

ASSC

Experimental

Humans

Monkeys

Neural Network

Application

Clinical

Traditional

Emerging

A map of interdisciplinary studies of consciousness

Theoretical

Tsuchiya

Philosophy

Mathematics (Category Theory)

Integrated Information Theory

Experimental

Psychology

Neuroscience

Tsuchiya

Humans

Monkeys

Mice

Flies

Neural Network

Kanai

Artificial Consciousness

Application

Clinical

Robotics

Traditional

Emerging

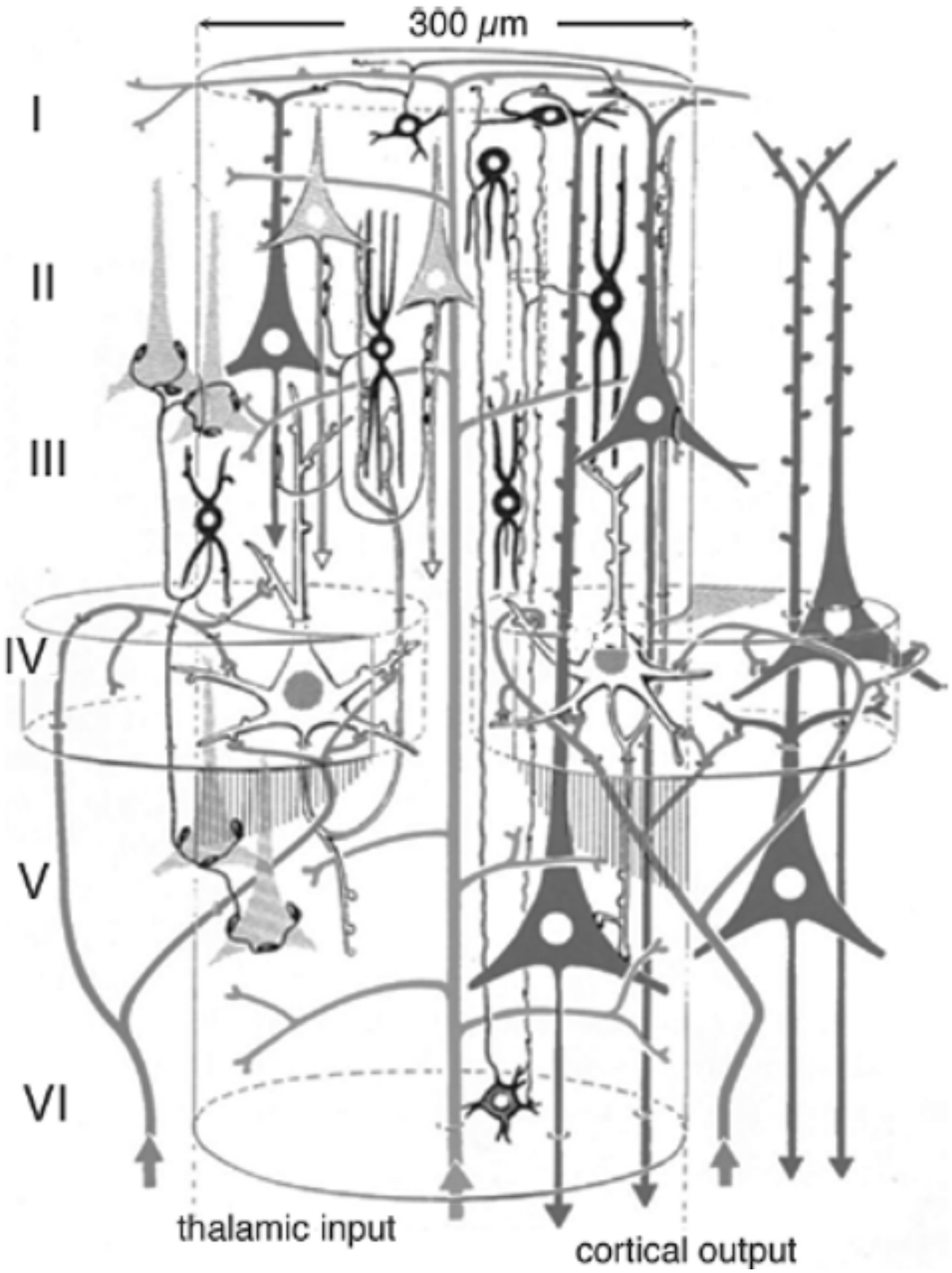
Goals

- To give a common ground on consciousness research (Dehaene 2011, Boly 2013, Tononi 2015)
- basic, important concepts and findings

Topics

1. neurons and their connectivity
2. a brief remark on the history of consciousness science
3. levels of consciousness
4. contents of consciousness = qualia and the Hard problem
5. three key questions in consciousness science
    a. measurement of consciousness
    b. functions of consciousness
    c. unity of consciousness
6. Intro to integrated information theory

1. Neurons

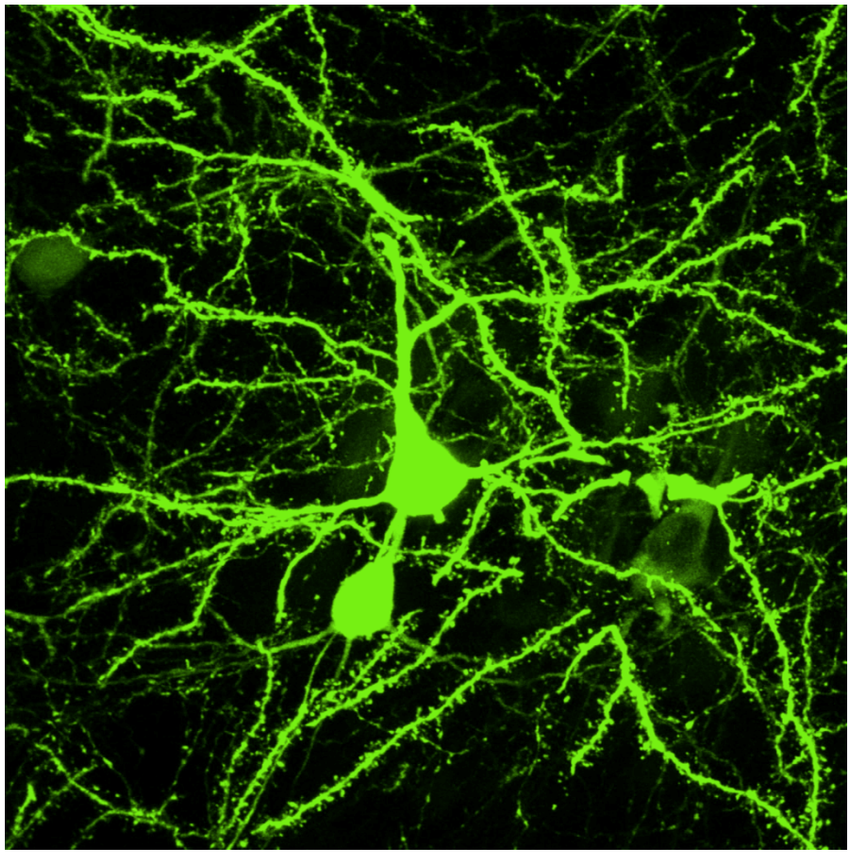


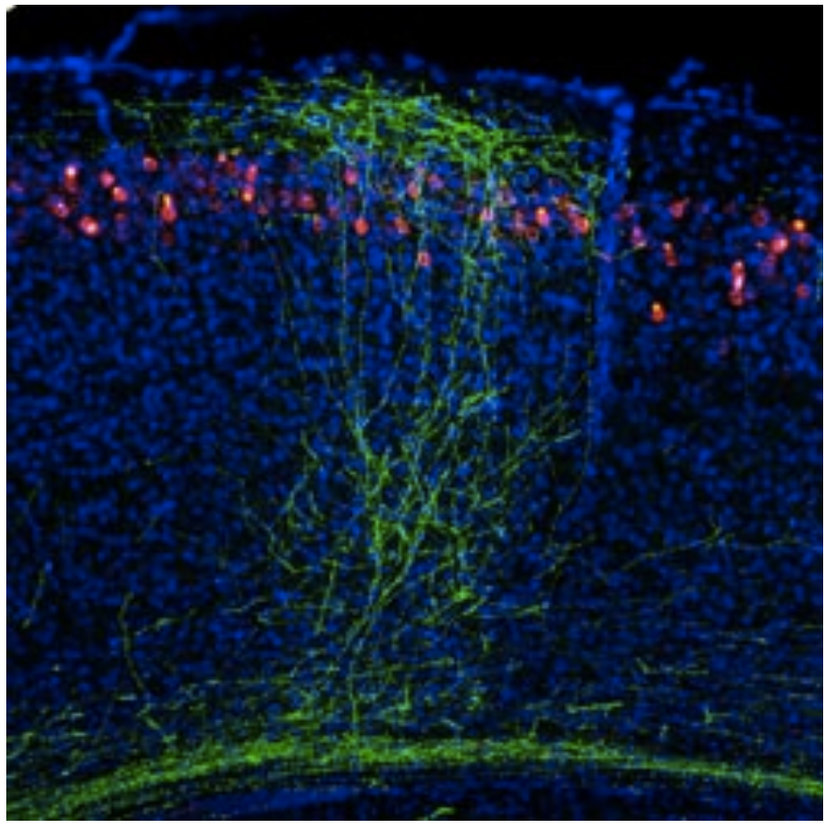
Cell body
  Axon
  Dendrites

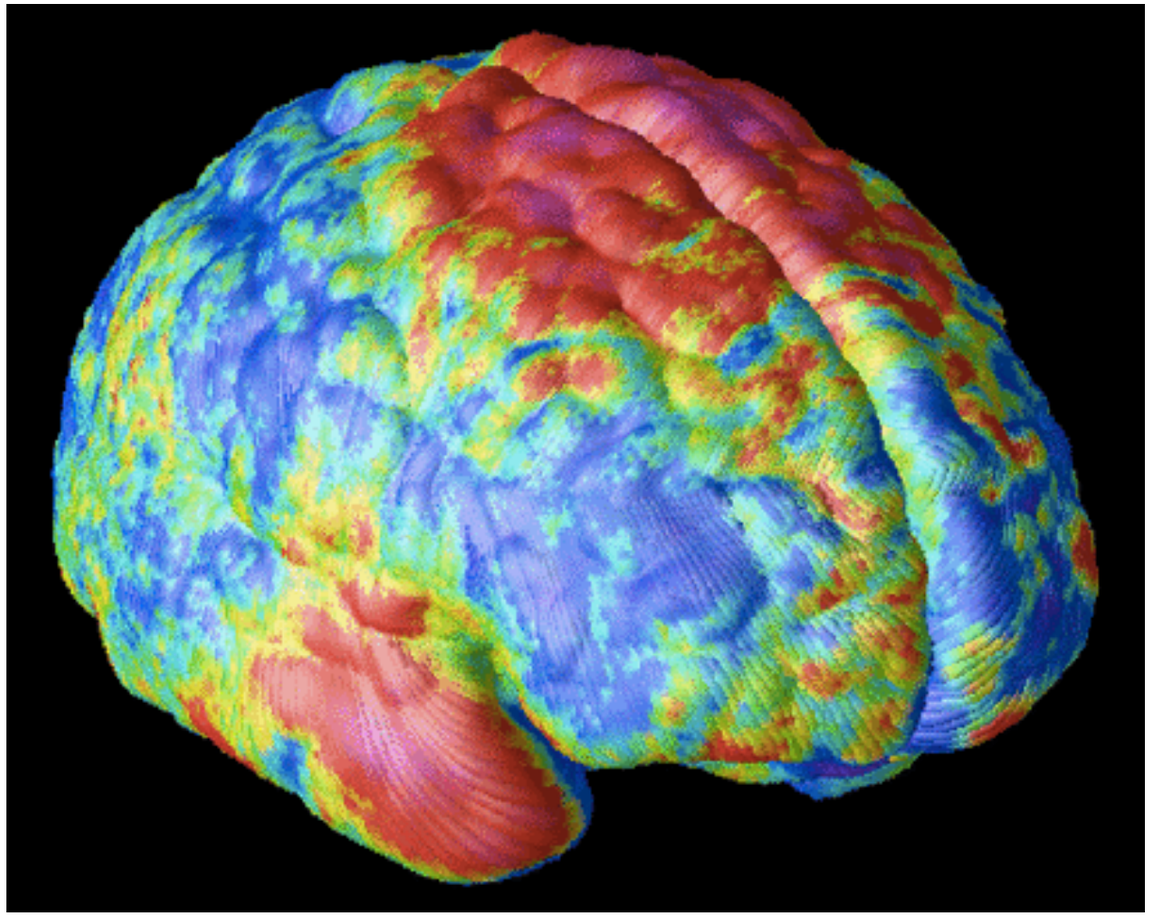
Synapses

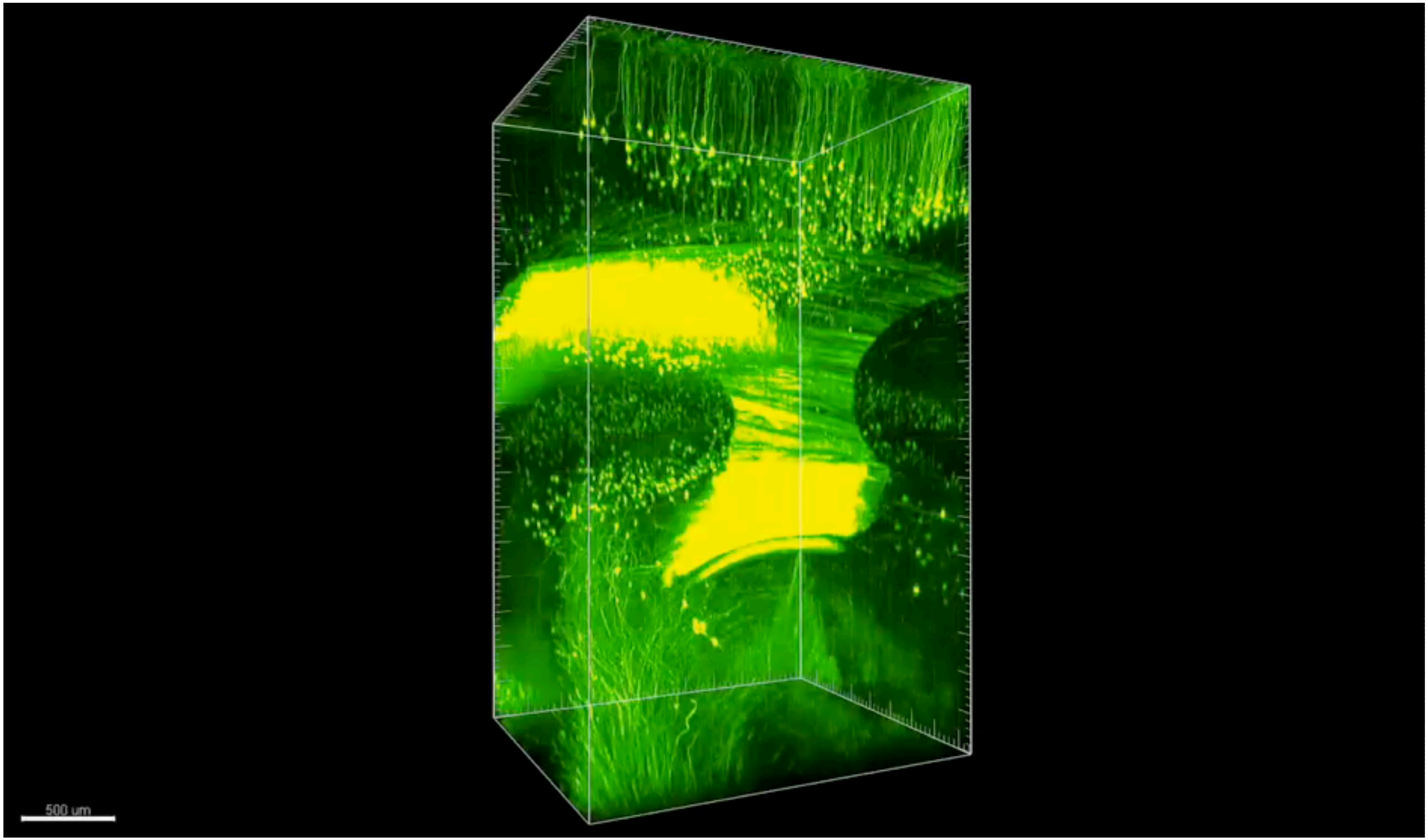
Excitatory vs Inhibitory

Spikes









1. Video 2: 3D visualization of the YFP-expressing neuronal circuit elements from pial surface to the thalamus in the intact Thy-1:eYFP mouse brain (16 weeks old) shown in Fig. 2. (11,386 KB, Download)
   Fly-through animation of the 3D volume data (2,037 Å~ 1,694 Å~ 3,405 µm; step-size=1.976 µm) illustrates visualization of all layers of cortex, the hippocampus, and the thalamus without degradation of resolution at depth. 1p excitation (514nm) and a 10Å~ objective (NA 0.3, WD 3.6 mm) were used.

Important numbers

- In total 10^ neurons.
- One neuron receives inputs from ~10^ other neurons
- Most connections are with neighboring neurons. A minor proportion of axons go outside of the local region
- % of synapses is excitatory (Binzegger et al 2009 Neural Networks)
- Cerebellum — times more neurons than in cerebral cortex (Herculano-Houzel et al 2012 PNAS)

Important numbers

- In total 10^11 neurons.
- One neuron receives inputs from ~10^3 other neurons
- Most connections are with neighboring neurons. A minor proportion of axons go outside of the local region
- 80% of synapses is excitatory (Binzegger et al 2009 Neural Networks)
- Cerebellum — 4 times more neurons than in cerebral cortex (Herculano-Houzel et al 2012 PNAS)

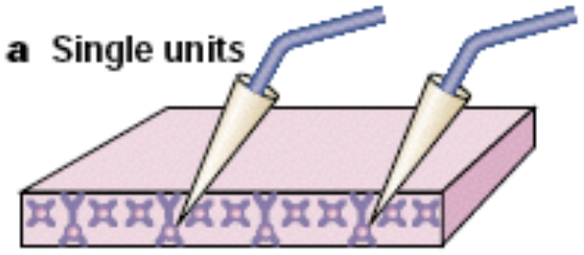
Methods

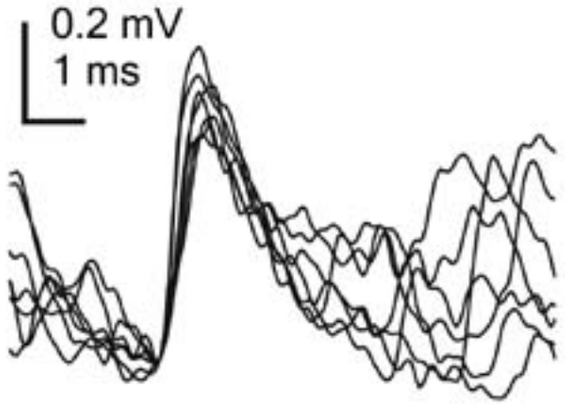
A Local scale

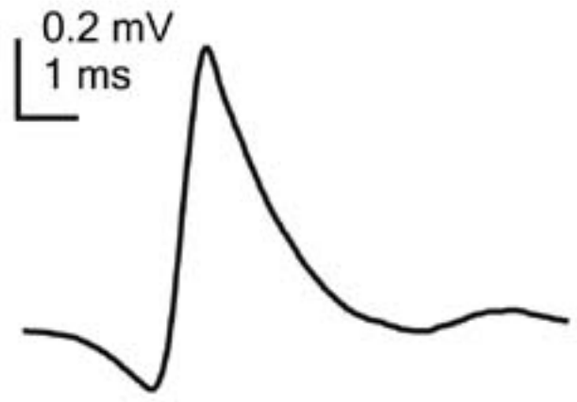
Spatial resoultion

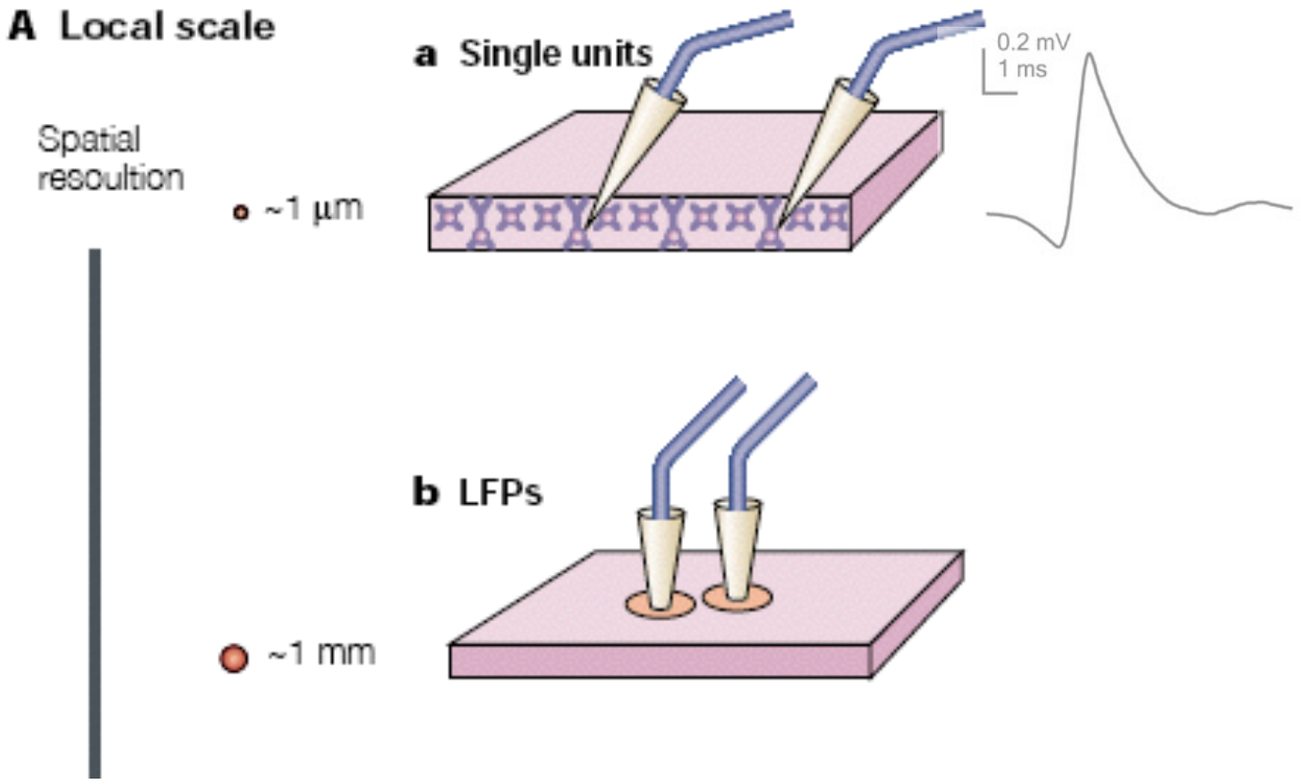
~1 µm

a Single units

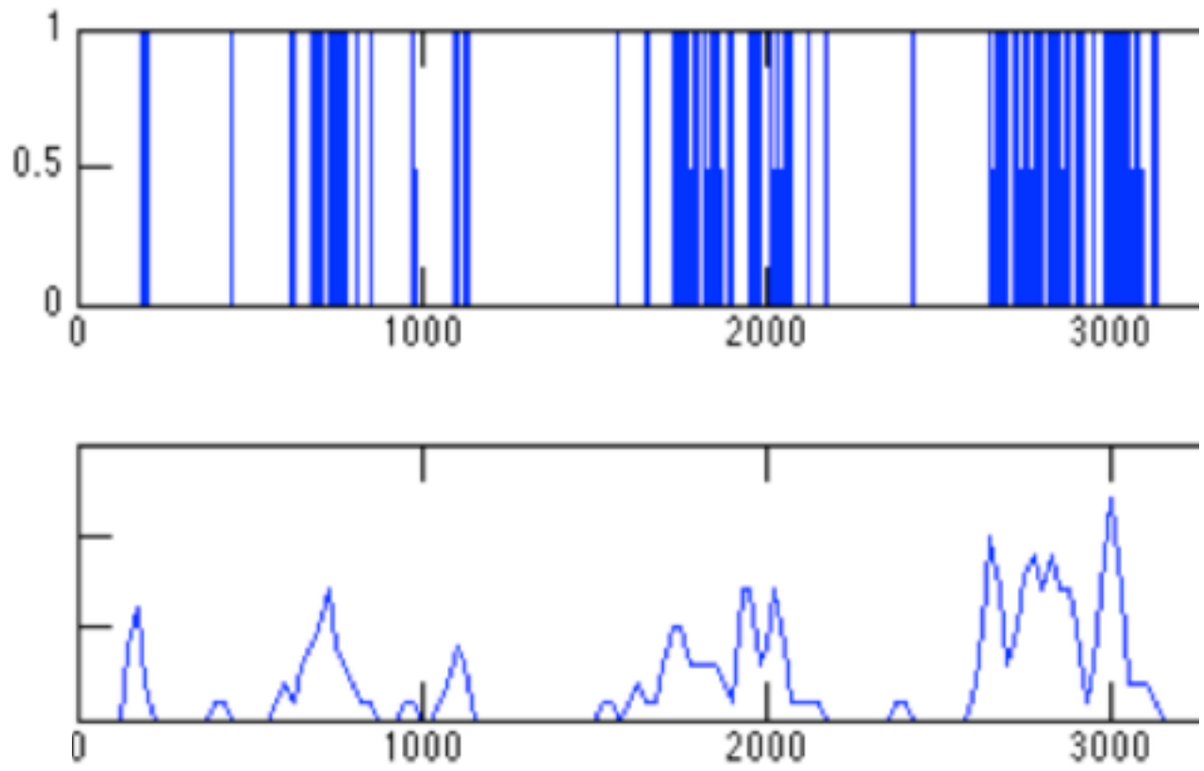






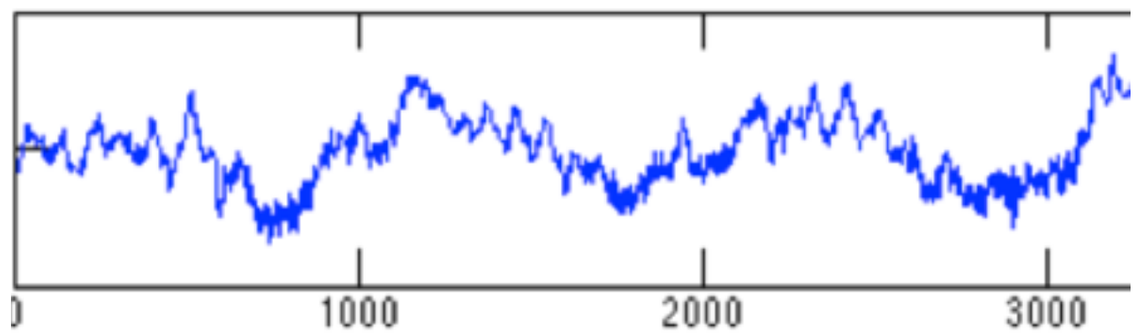


Multi units

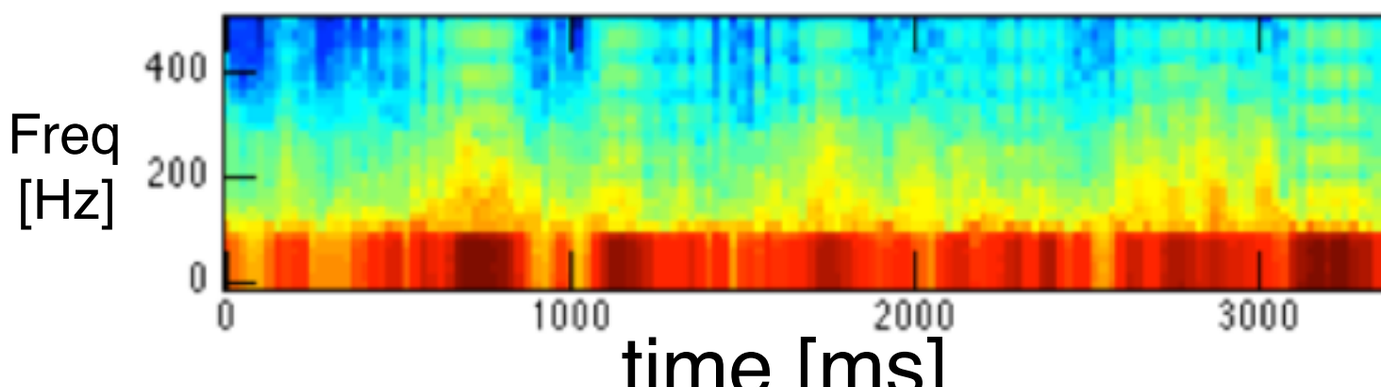


Smoothed MUA

Local field potentials



Spectrogram of LFP

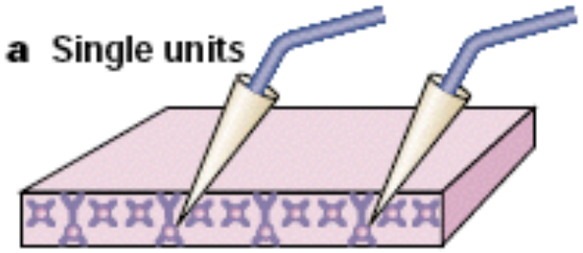


A Local scale

Spatial resolution

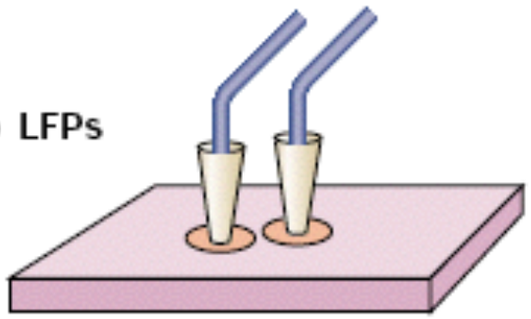
~1 µm

a Single units



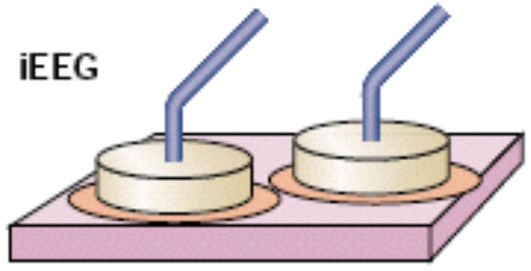
~1 mm

b LFPs



~1 cm

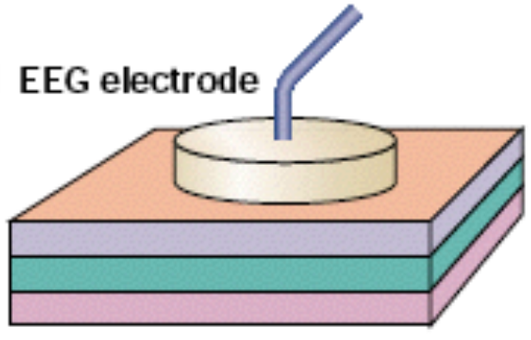
c iEEG

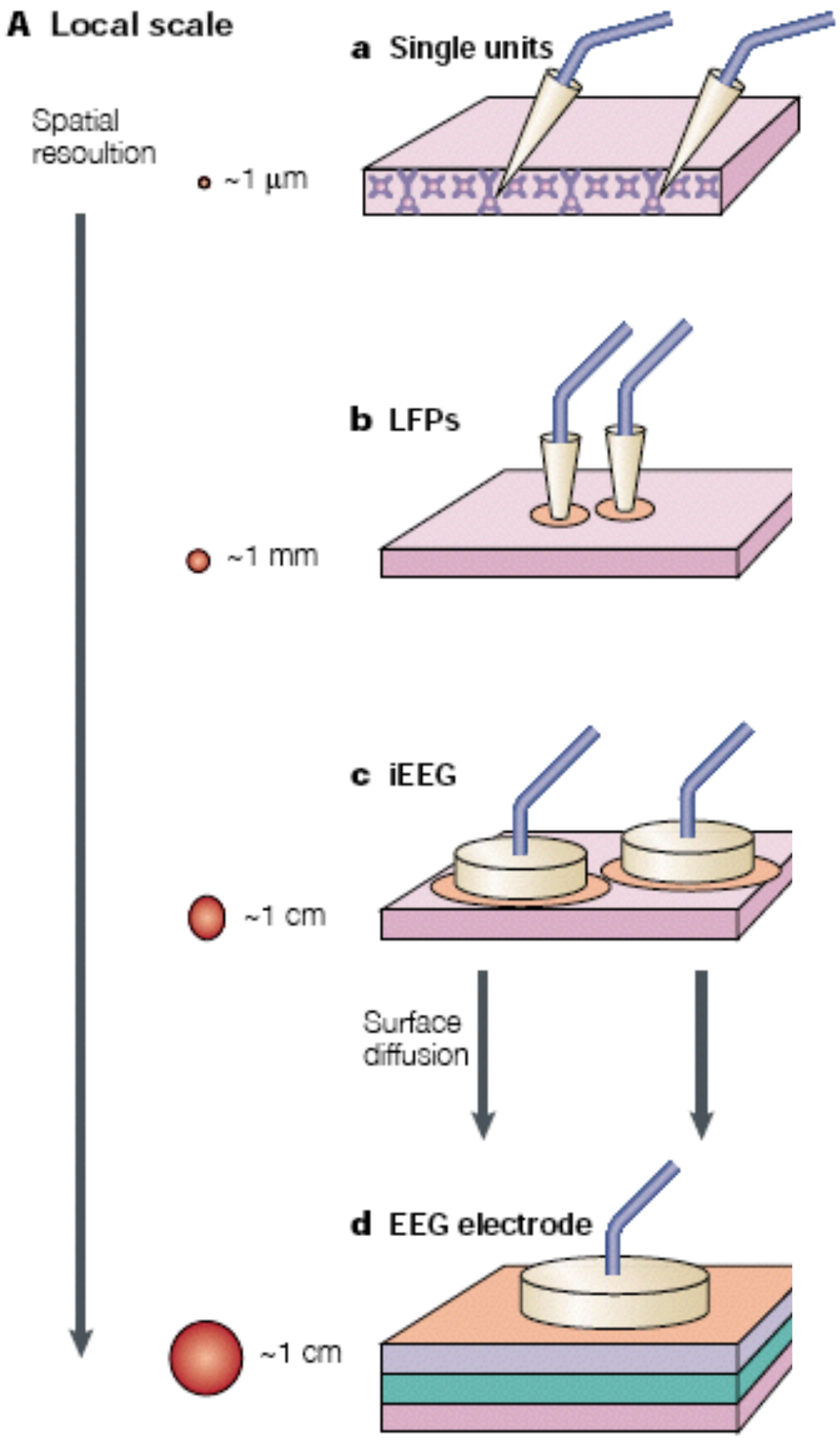


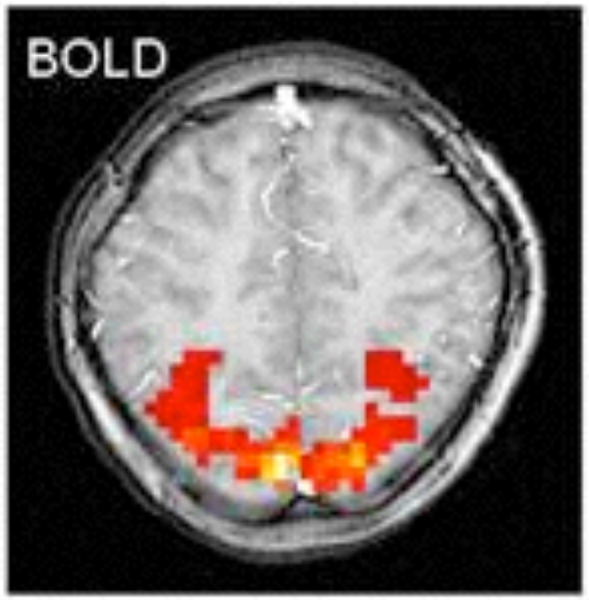
Surface diffusion

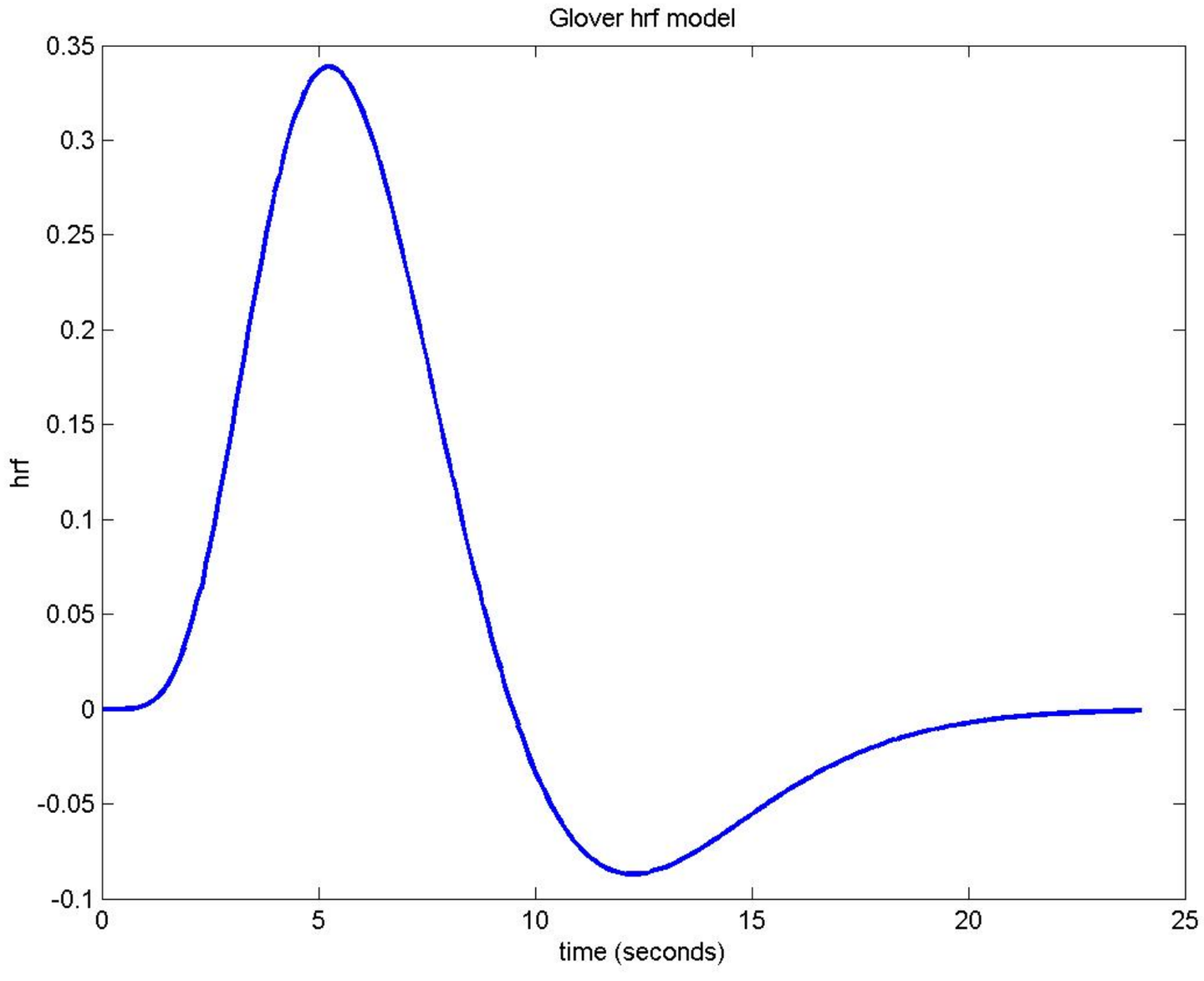
~1 cm

d EEG electrode




A Local scale
Spatial resolution
~1 µm
a Single units
~1 mm
b LFPs
~1 cm
c iEEG
Surface diffusion
~1 cm
d EEG electrode


BOLD


Glover hrf model
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
hrf
0
5
10
15
20
25
time (seconds)

2. A brief history of the consciousness research

~1900

Phenomenology

Gestalt psychology

~1920

Behaviorism

~1960

Cognitive revolution

~1990

Consciousness research

Neural correlates of consciousness

- *A selected list of the breakthroughs in the last 25 years of consciousness research (Boly et al 2013)*

- Understanding of the neural mechanisms that regulates **levels** of consciousness

- Limits and scopes of **non-conscious** processing; its neuronal correlates; and its behavioral consequences

- **Relationship** between consciousness *per se* and cognitive processes that supports it

In what sense do we use the word “consciousness” and “awareness”?

Common definitions of "consciousness"

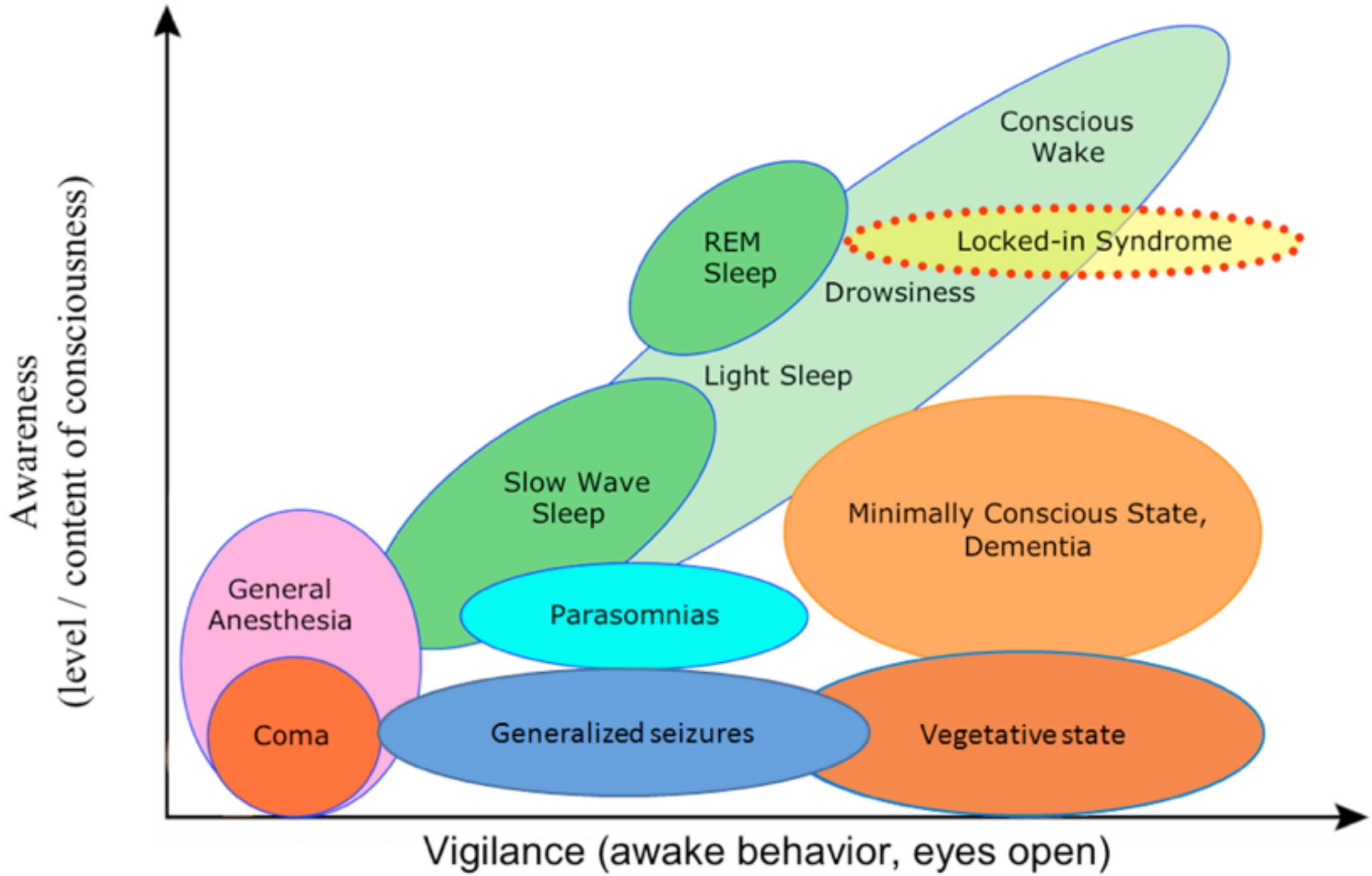
- **Level** of consciousness (as opposed to coma, anesthesia, dreamless sleep)
- **Contents** of consciousness (e.g., redness of red, pain, thoughts)
- (Self consciousness)

Contrastive approach

- Compare the neural activity that accompanies “conscious” and “unconscious” X
- X can be states, perception, motor planning, intention, emotion, ….

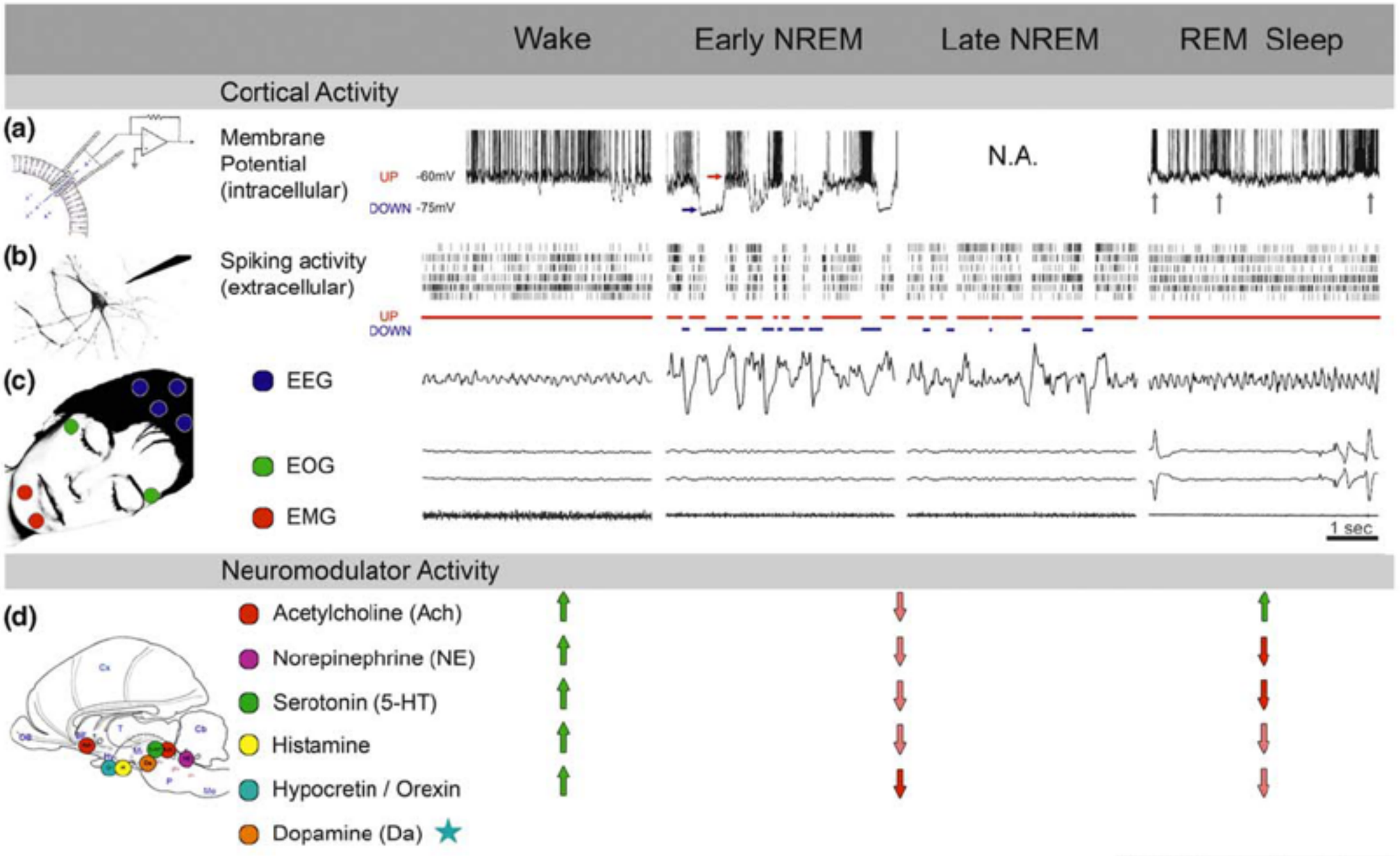
3. level of consciousness

Level and Content of consciousness vs behavioral signs of consciousness



Boly et al 2013 Frontiers in Consciousness Research

During loss of consciousness, brain can be very active!



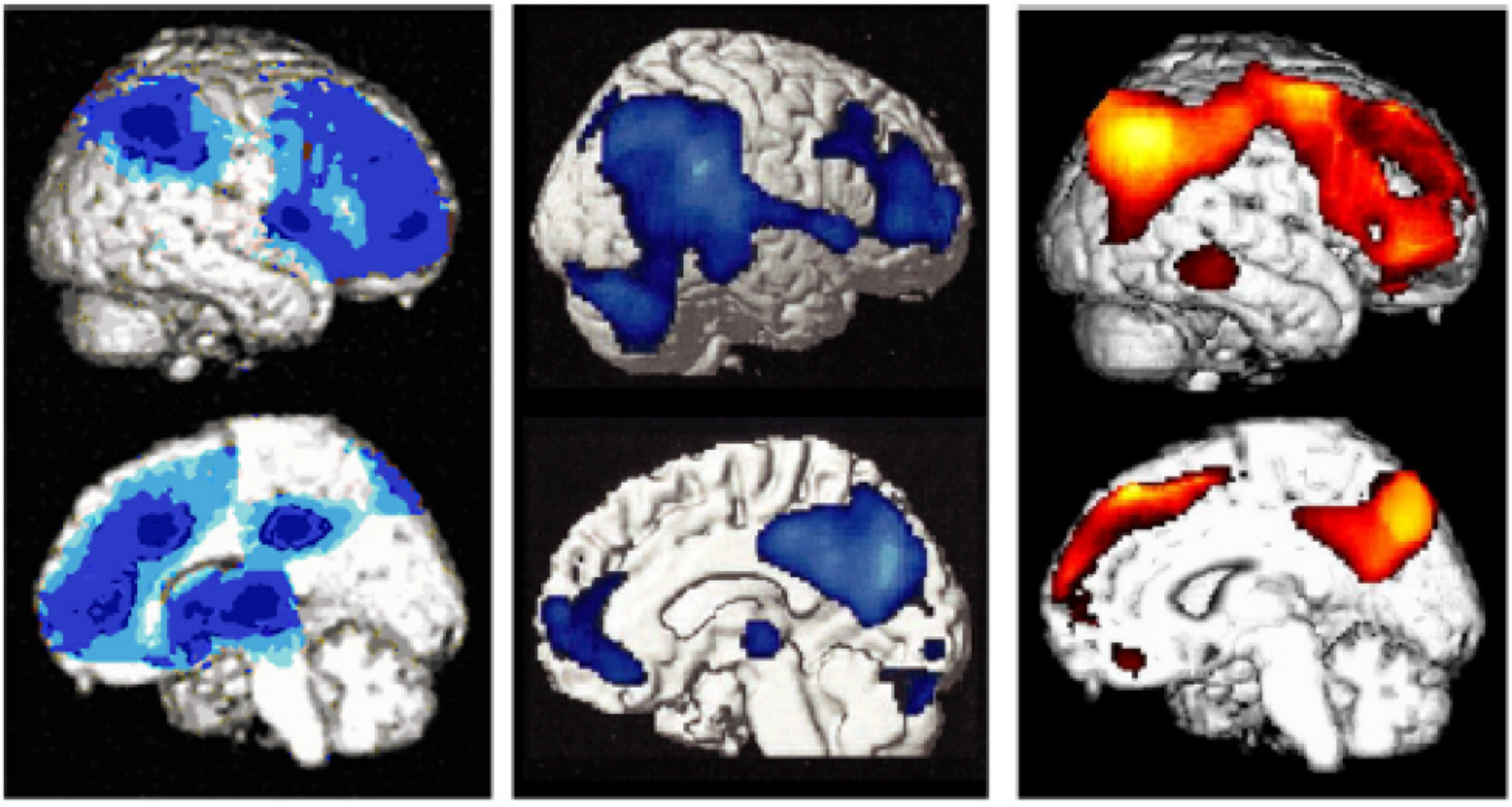
Nir & Tononi 2010 TICS

Reduced metabolism during loss of consciousness

Slow-wave sleep

Anesthesia

Vegetative state



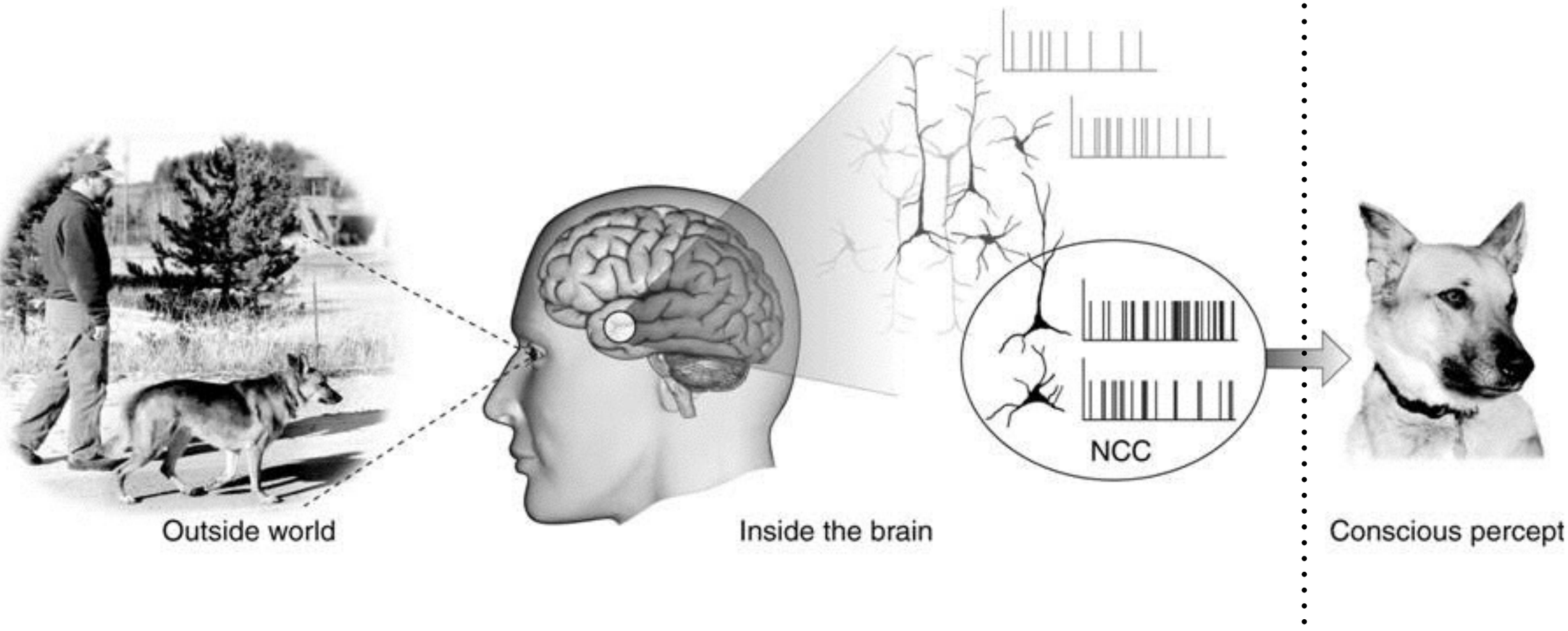
4. contents of consciousness

= qualia

and the Hard problem

physical
electromagnetic
chemical
interactions

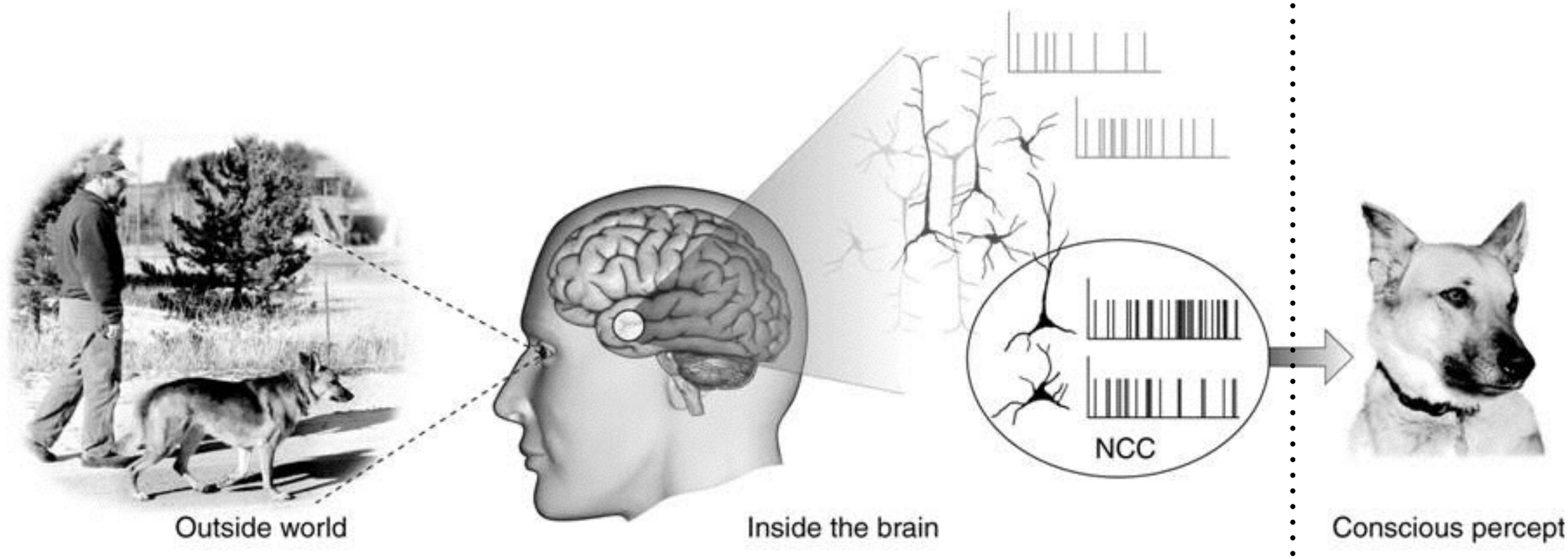
subjective
consciousness,
experience,
phenomenology



Example: Pain

physical
electromagnetic
chemical
interactions

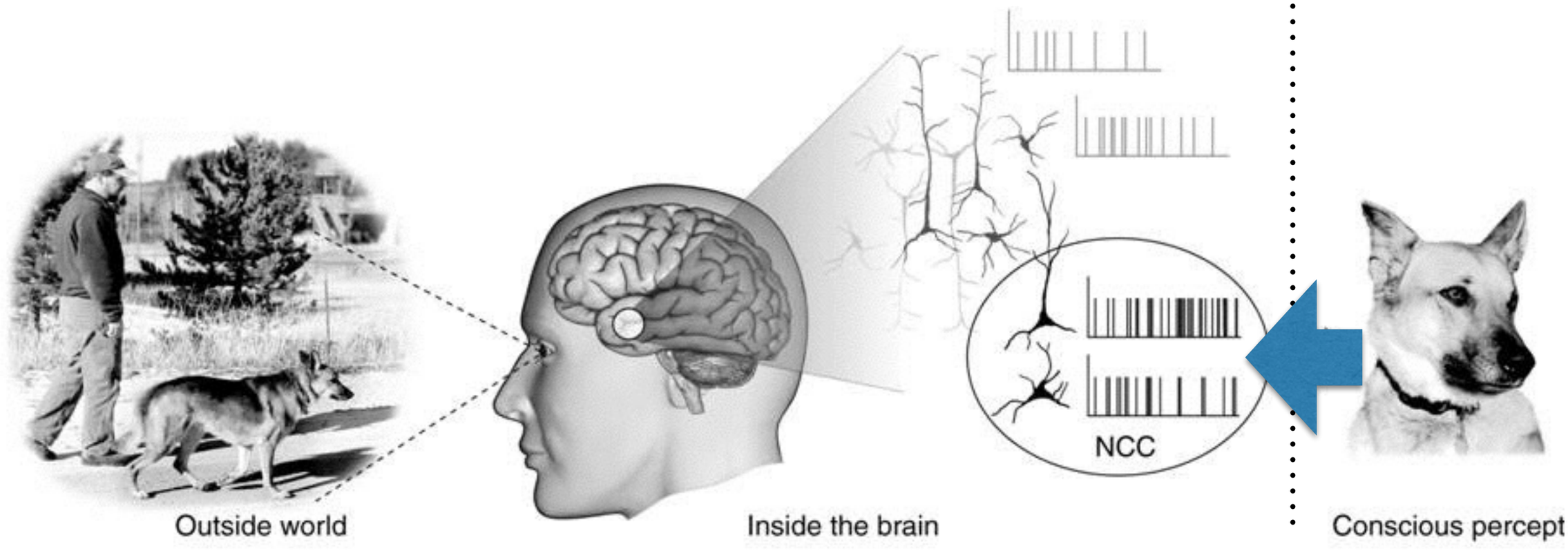
subjective
consciousness,
experience,
phenomenology



Hard Problem of consciousness

physical
electromagnetic
chemical
interactions

subjective
consciousness,
experience,
phenomenology

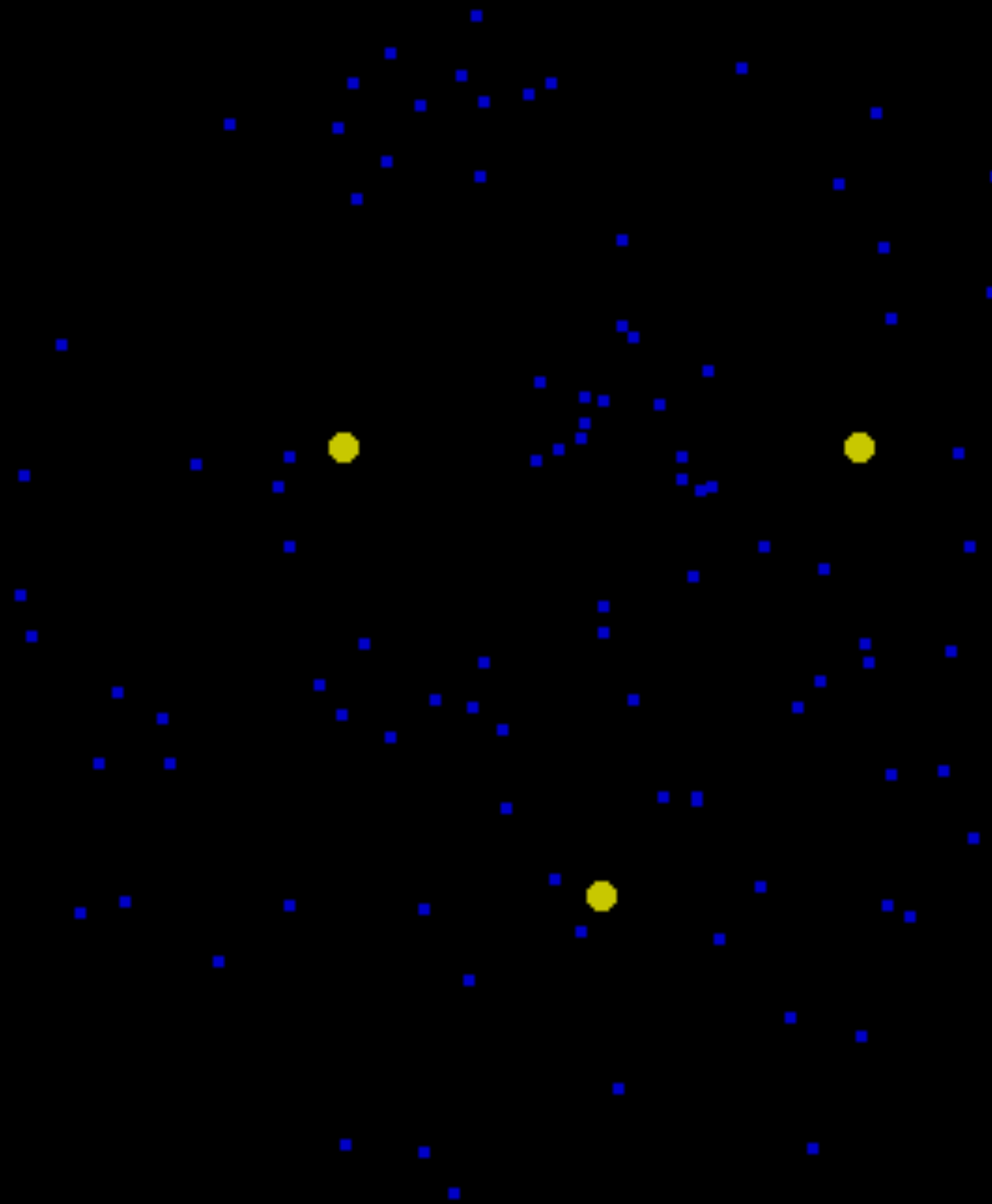


The problem of consciousness:
Is it really Hard?

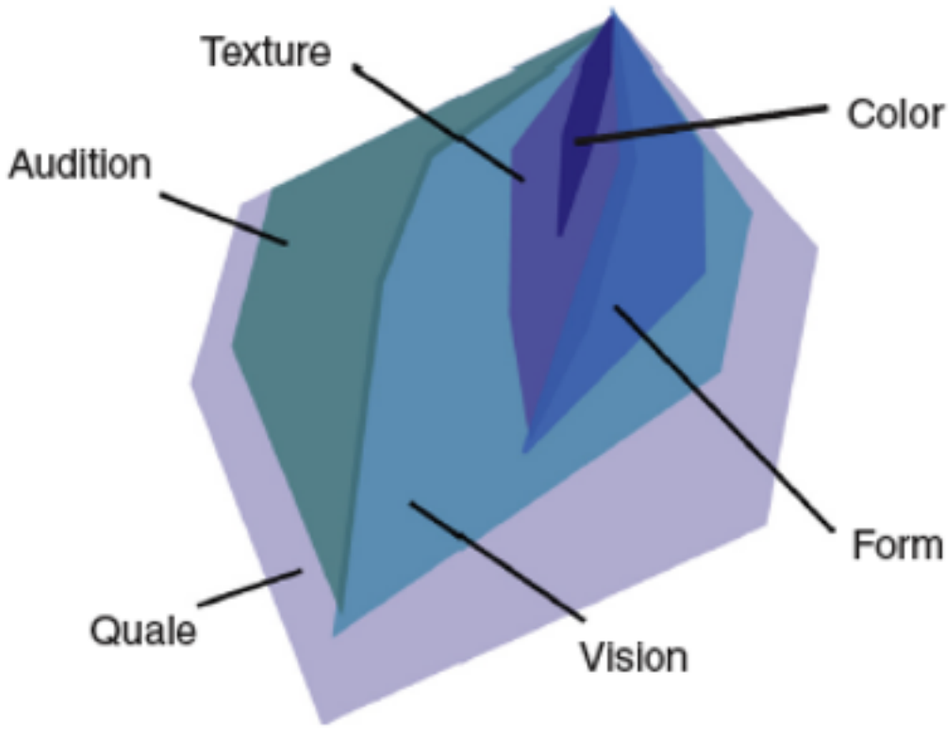
Integrated information theory of consciousness (Tononi 2004 BMC)

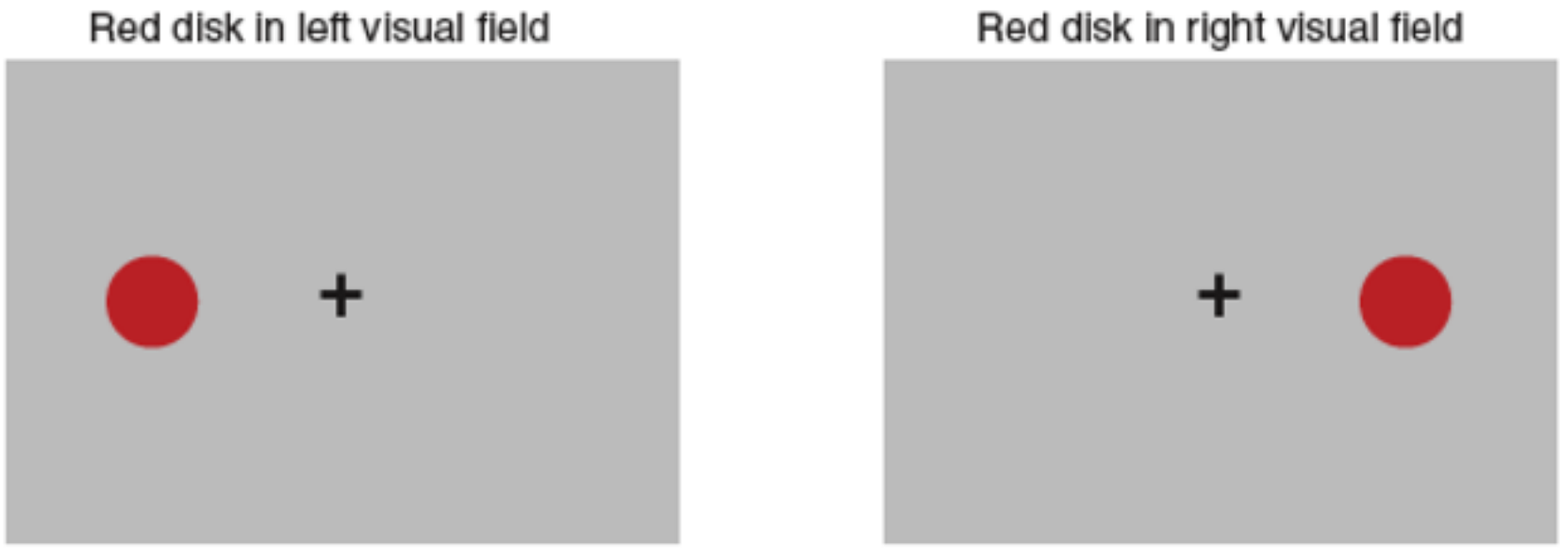
What do I mean by a quale of a yellow dot?

Motion-induced blindness
(Bonneh, Cooperman, Sagi 2001 Nature)



Broad- vs. Narrow- sense qualia





Broad sense: These two experiences are different qualia.

Narrow sense: The redness of the disks refers to the same quale.

Kanai & Tsuchiya 2012 Current Biology

The powerful NCC paradigm

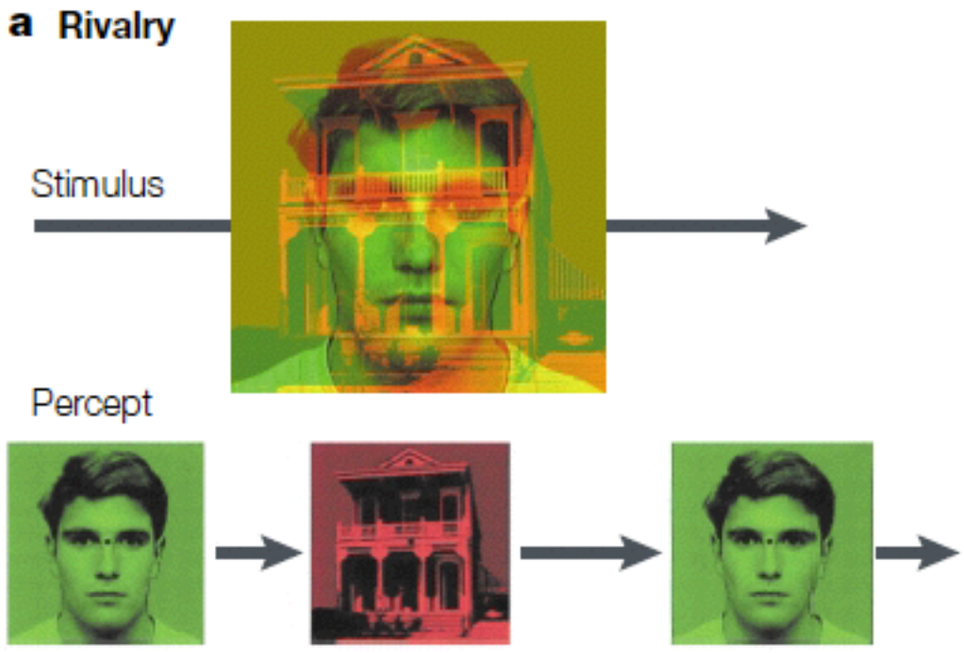
- Keep sensory stimuli **constant;** use perceptual thresholds or ambiguous stimuli

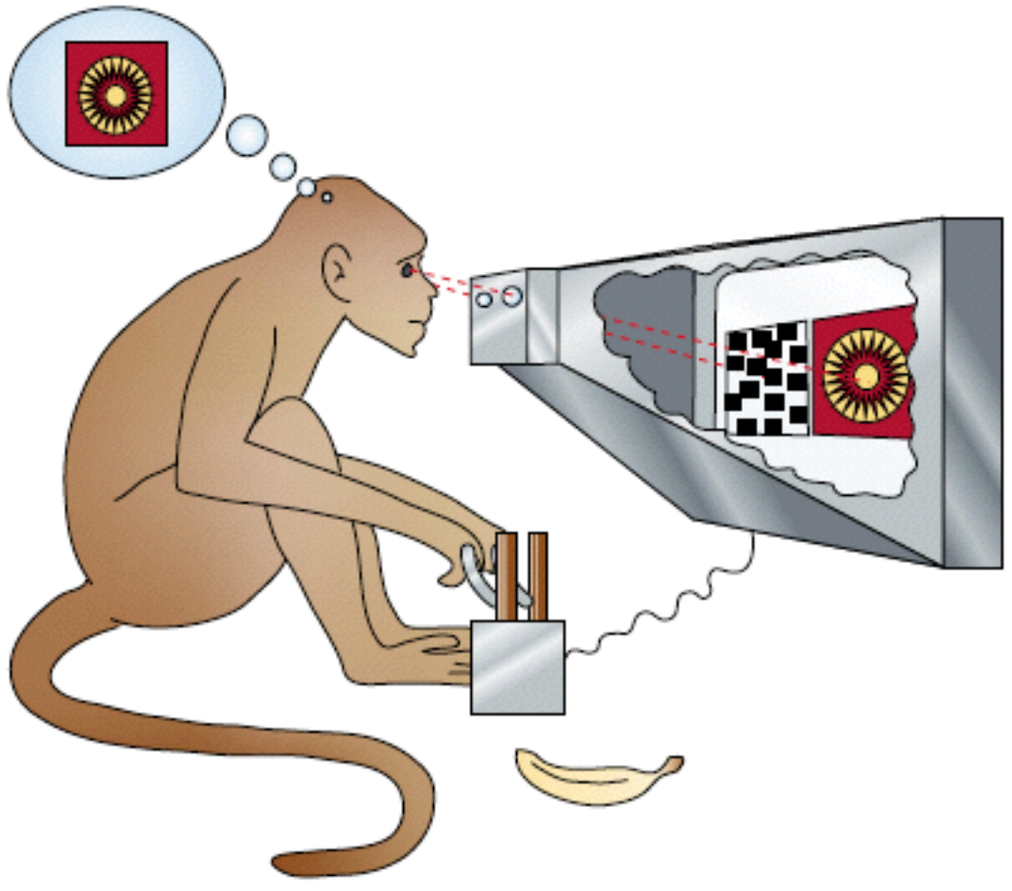
- Manipulate or obtain **variable reports**

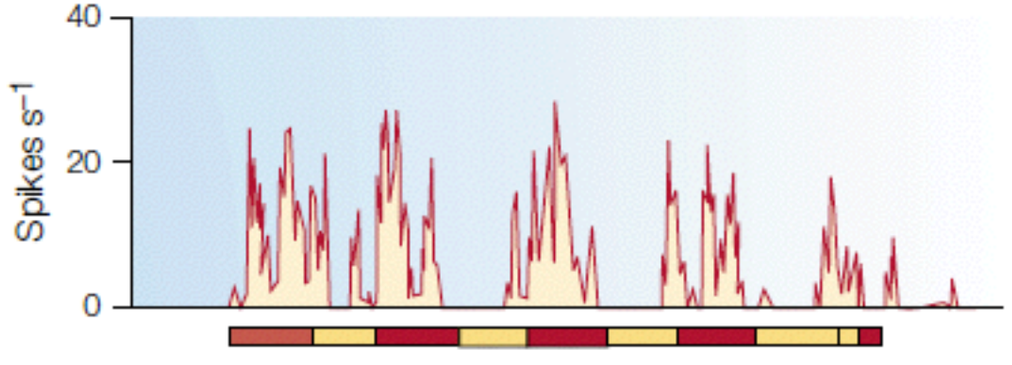
- Find the neural activity that correlates with **consciousness**

  - ***Contingent on reports!***

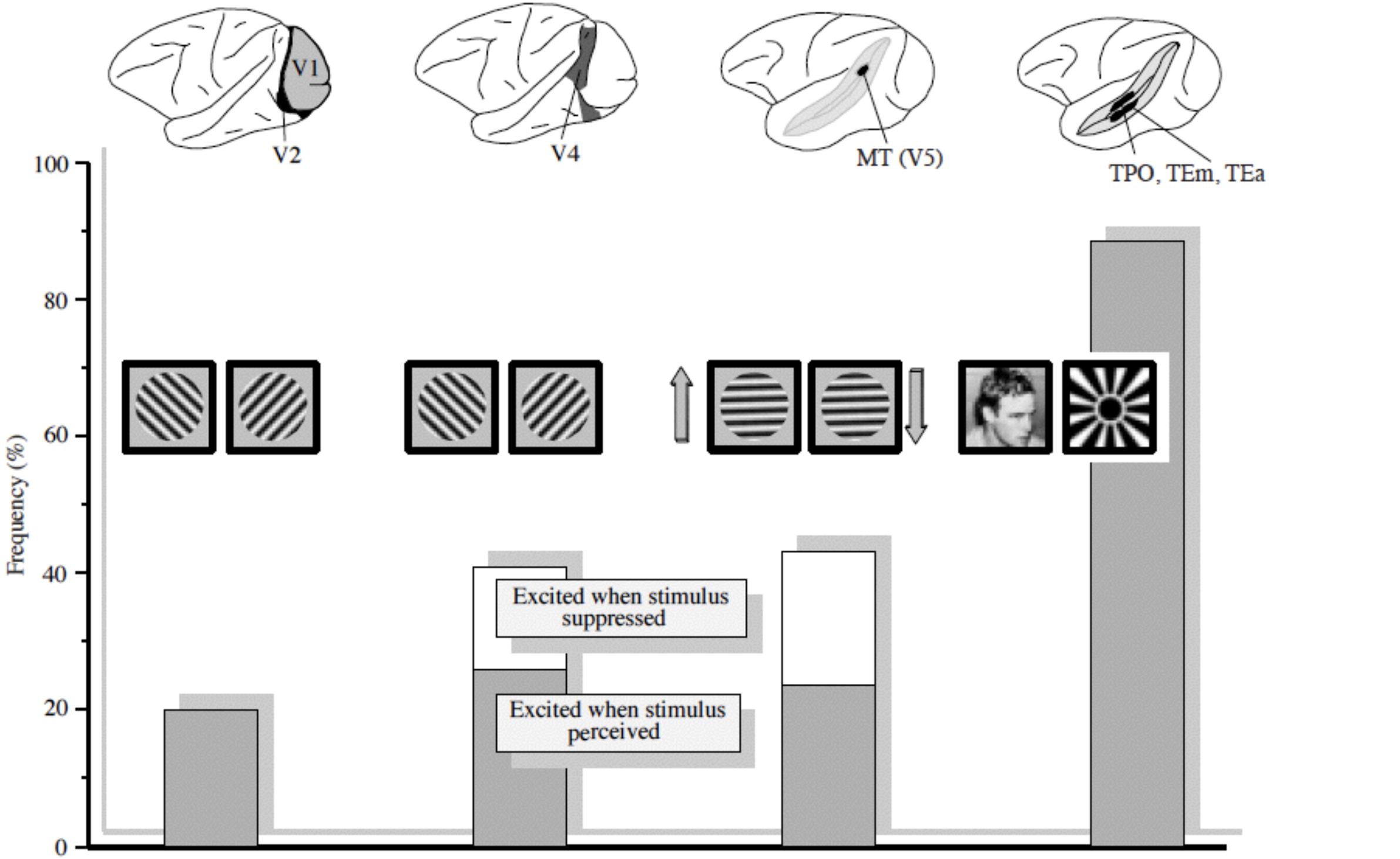
Trying to find the NCC with binocular rivalry



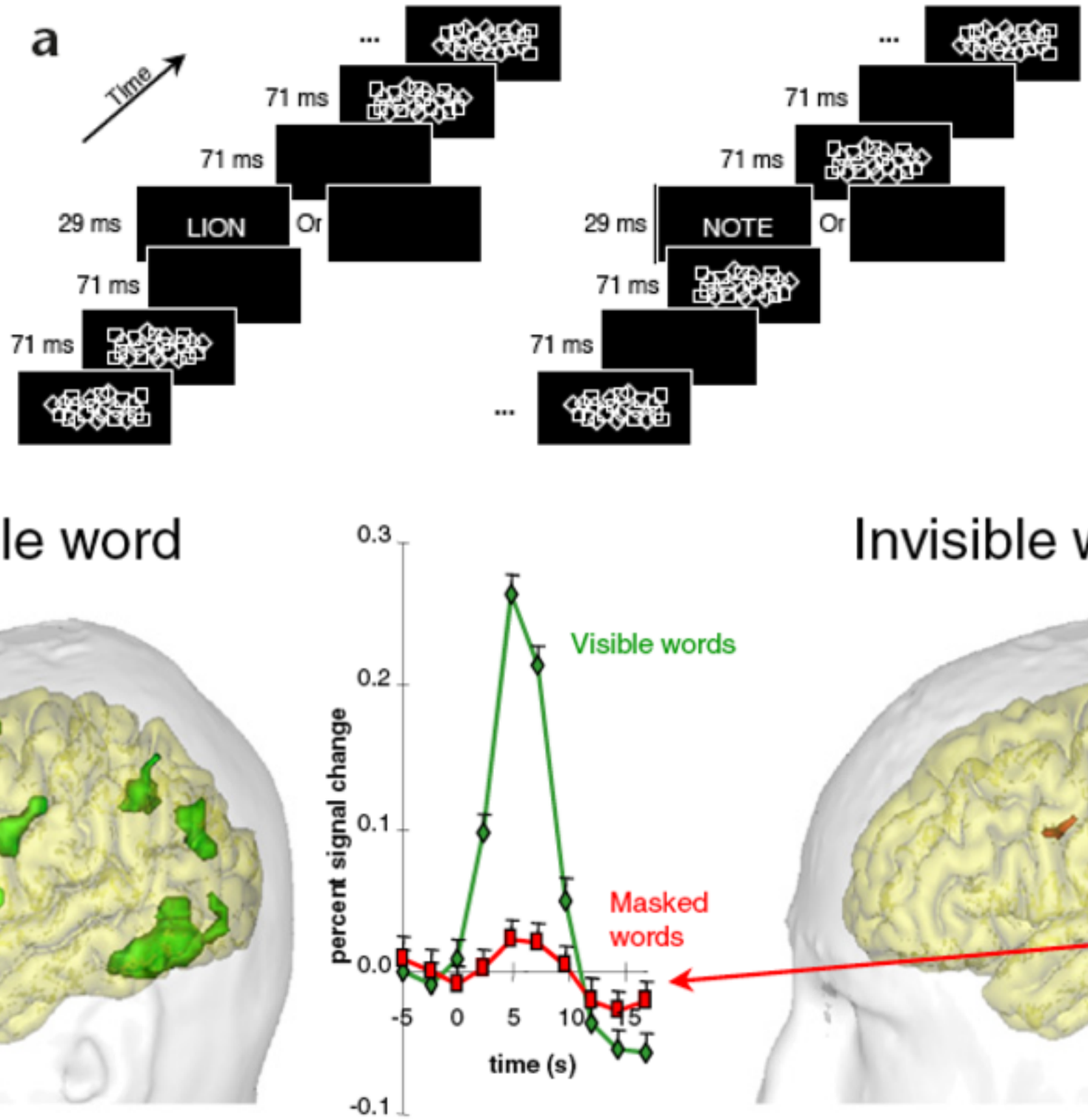




Blake & Logothetis 02 Nat Rev Neuro



Logothetis 98 Phil Trans



Dehaene 2001 Nat Neuro

5. three key questions in consciousness science

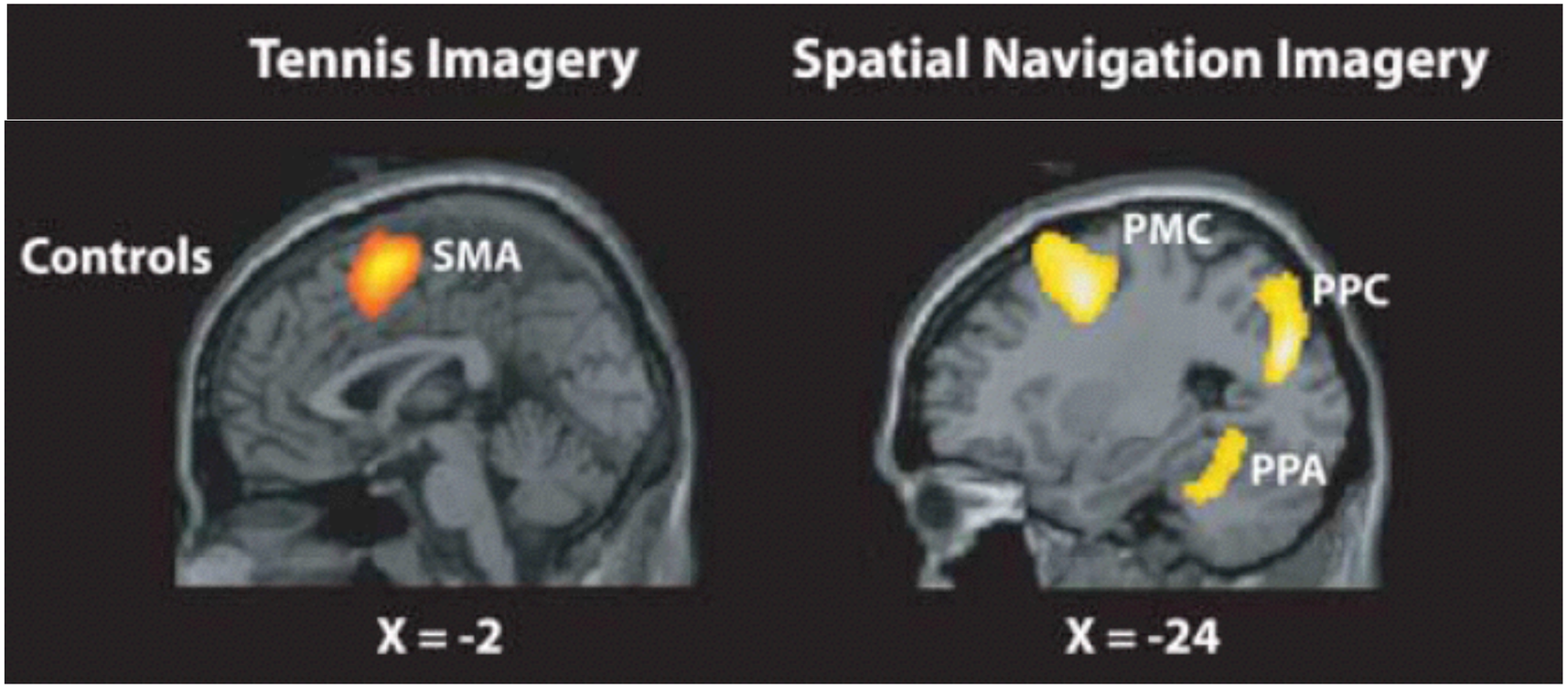
a. measurement of consciousness

b. functions of consciousness

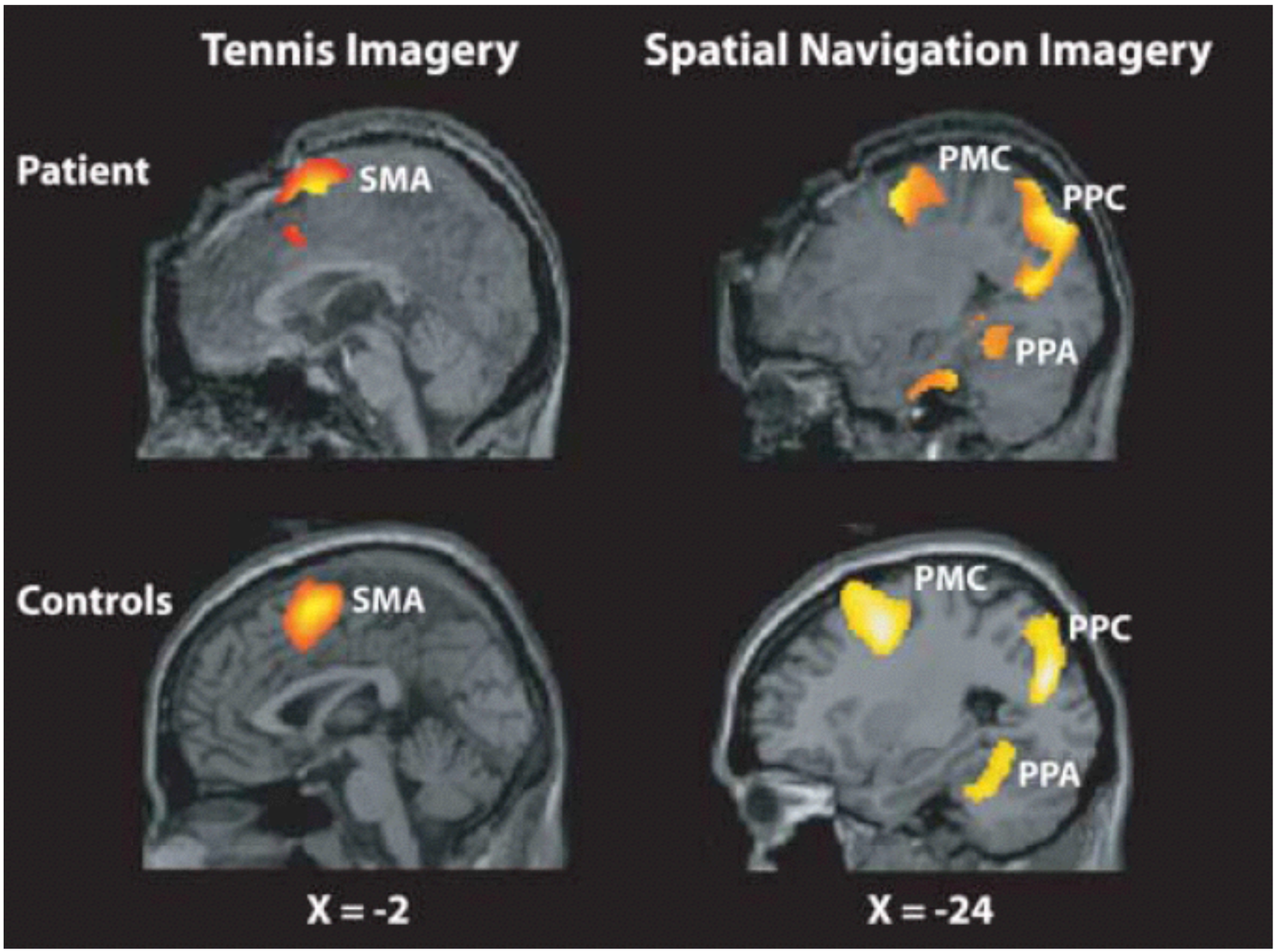
c. unity of consciousness

a.measurement of consciousness

- Can we measure consciousness?
  - in terms of levels and contents?
  - my own, other people, animals, artificial network?
- Levels: Clinical observation - Coma scale



Owen et al 2006 Science



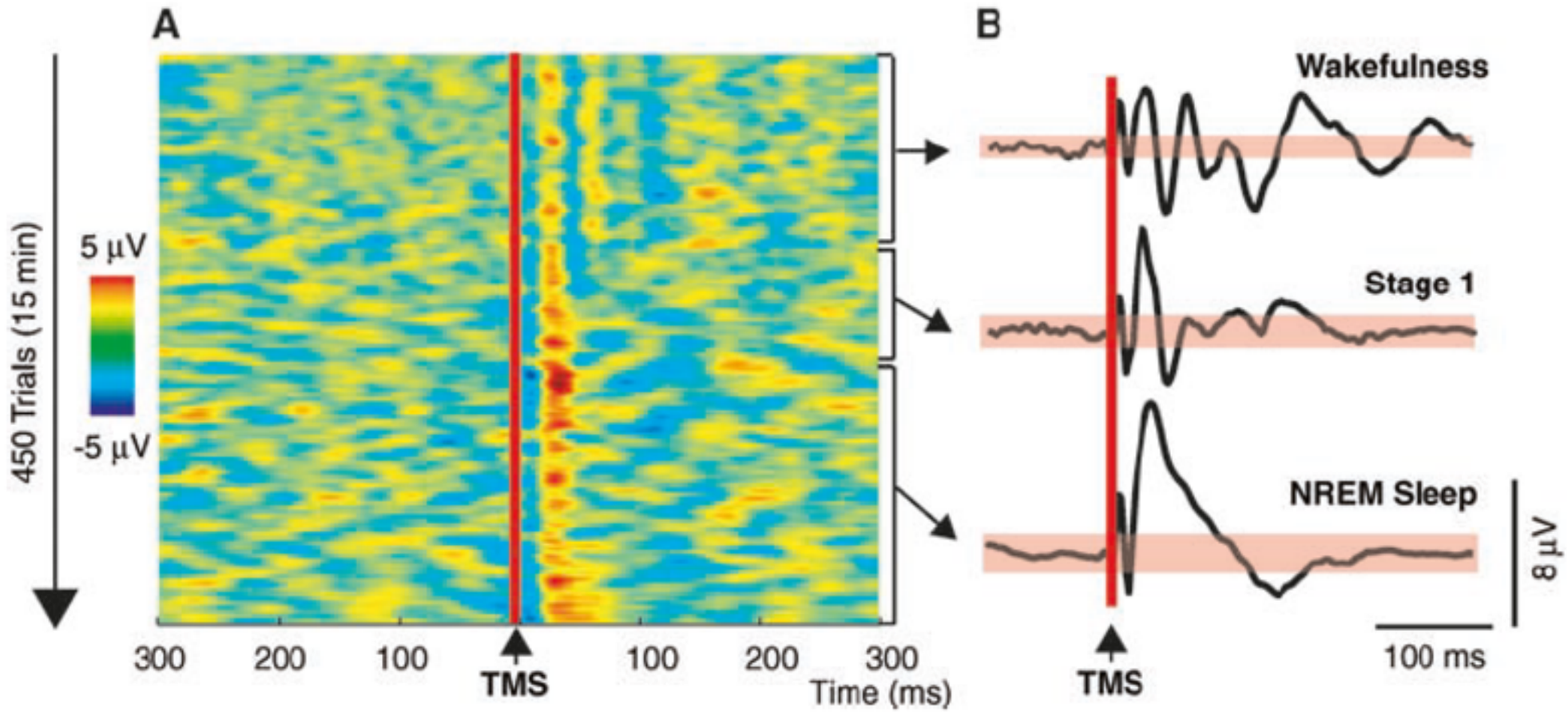
Owen et al 2006 Science

measuring level of consciousness in humans

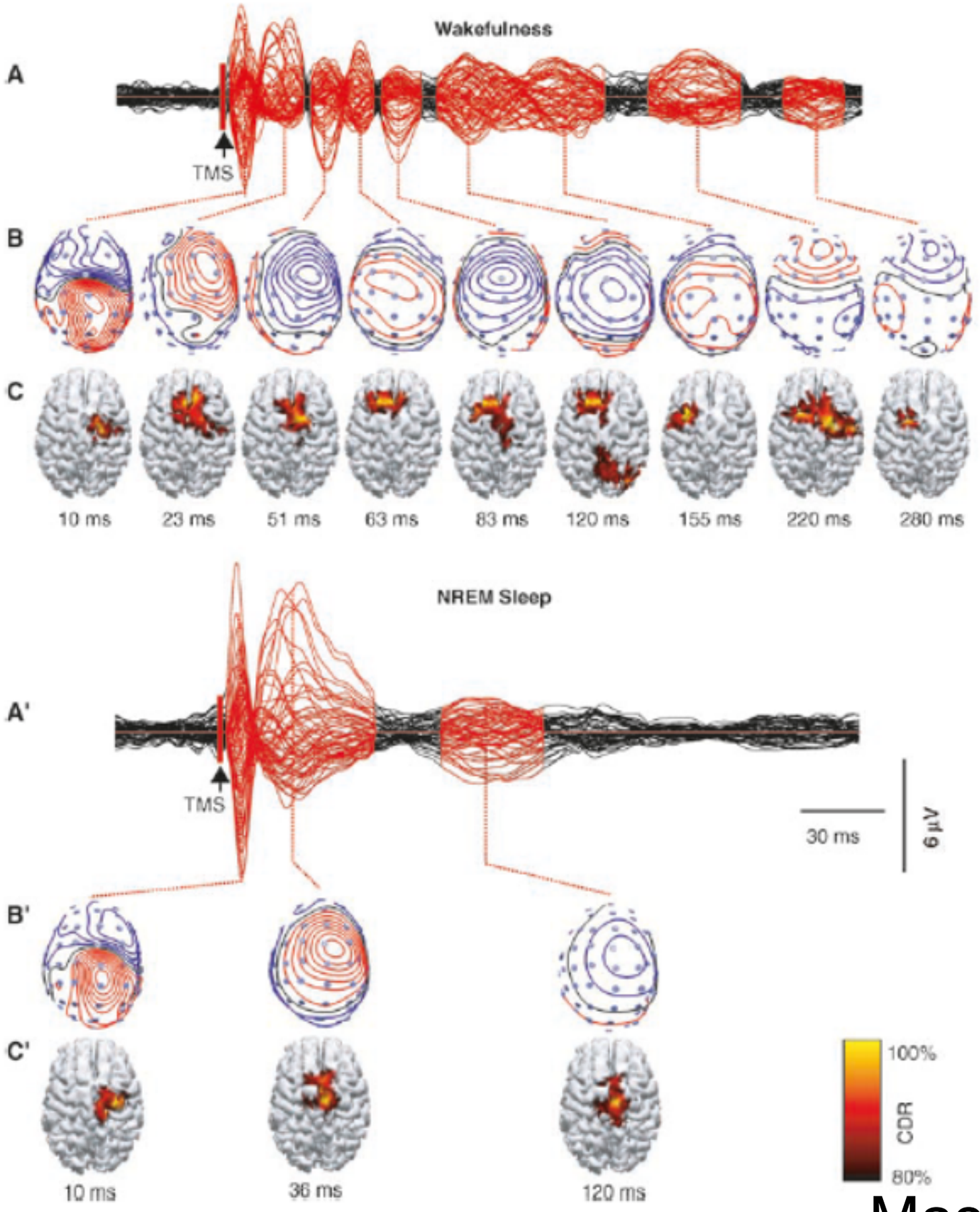
- Challenge - confound due to fallible memory in self-report & behavior based criteria

  - vegetative vs minimally conscious
  - intraoperative awareness during general anesthesia
  - sleep walking
  - drug induced “high”

Breakdown of global connectivity as a key for loss of consciousness

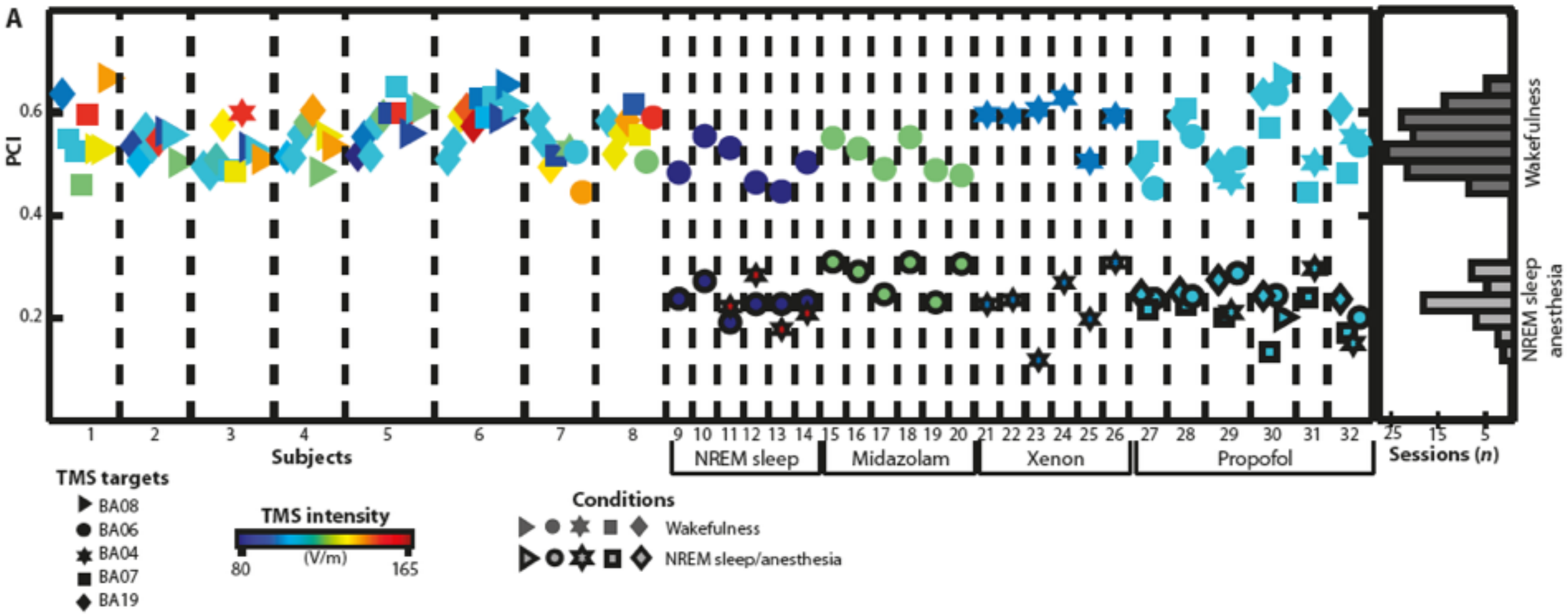


Massimini et al 2005 Science



Massimini et al 2005 Science

Breakdown of global connectivity as a key for loss of consciousness



Casali et al 2013 Science Trans Medicine

Discussion points

- What are the difficulties of measuring level of consciousness? Also contents of consciousness? In yourself? In other people? In animals? In artificial systems?
- Discuss the nature of the difficulties (conceptual, technical, etc)

b. functions of consciousness

- Are there any functions for consciousness?

Levels of analysis (Timbergen)

	Historical explanation	Explanation of current form
Immediate explanation	Development (ontogeny)	Mechanistic and causal explanation
Ultimate or evolutionary explanation	Evolution (phylogeny)	How a species reproduce and survive in the current environment - Function/Adaptation

Levels of analysis (Timbergen)

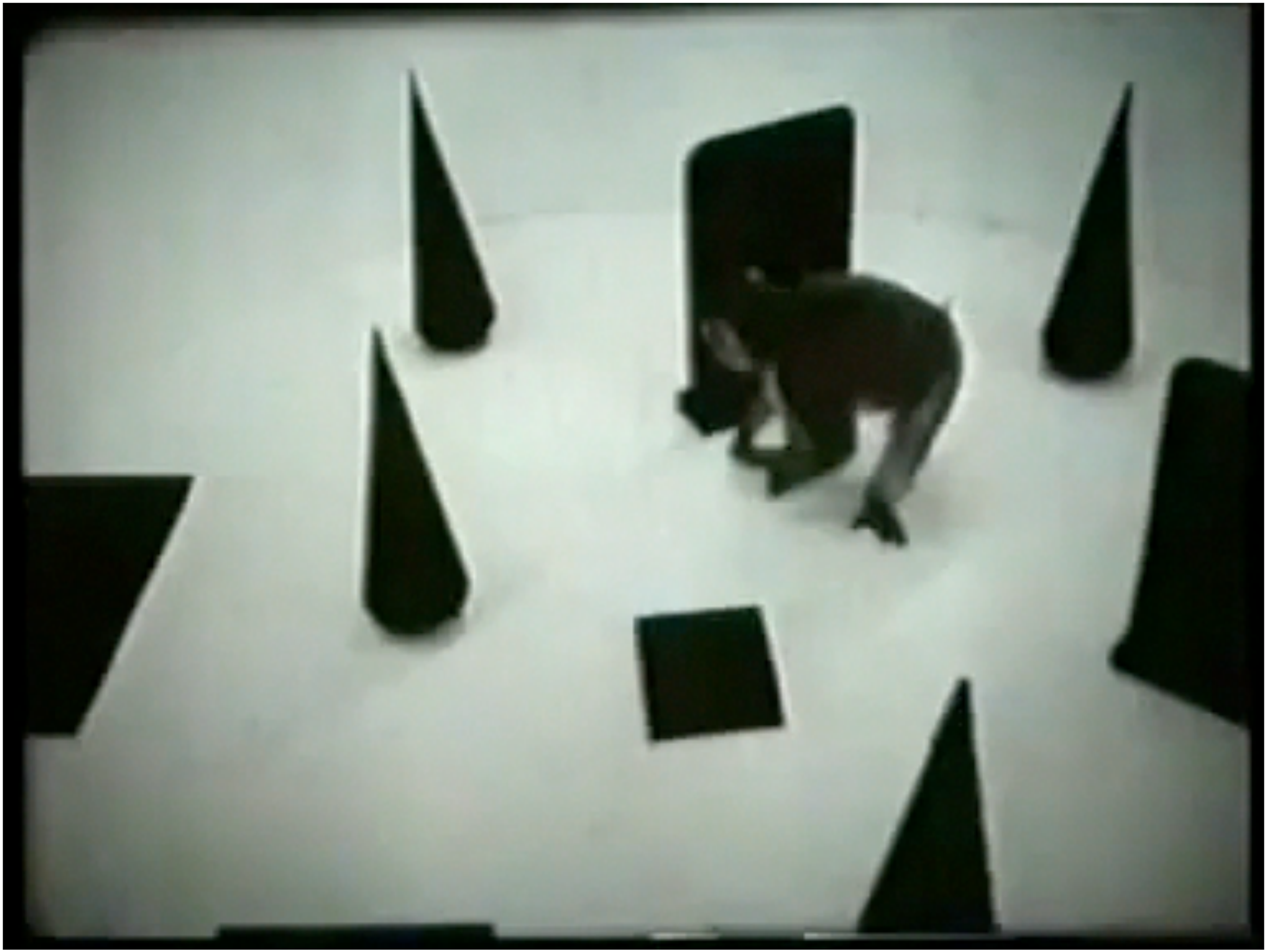
	Historical explanation	Explanation of current form
Immediate explanation	Development (ontogeny)	Mechanistic and causal explanation
Ultimate or evolutionary explanation	Evolution (phylogeny)	How a species reproduce and survive in the current environment - Function/Adaptation

Discussion point : Caveats and usefulness of considering functions of consciousness

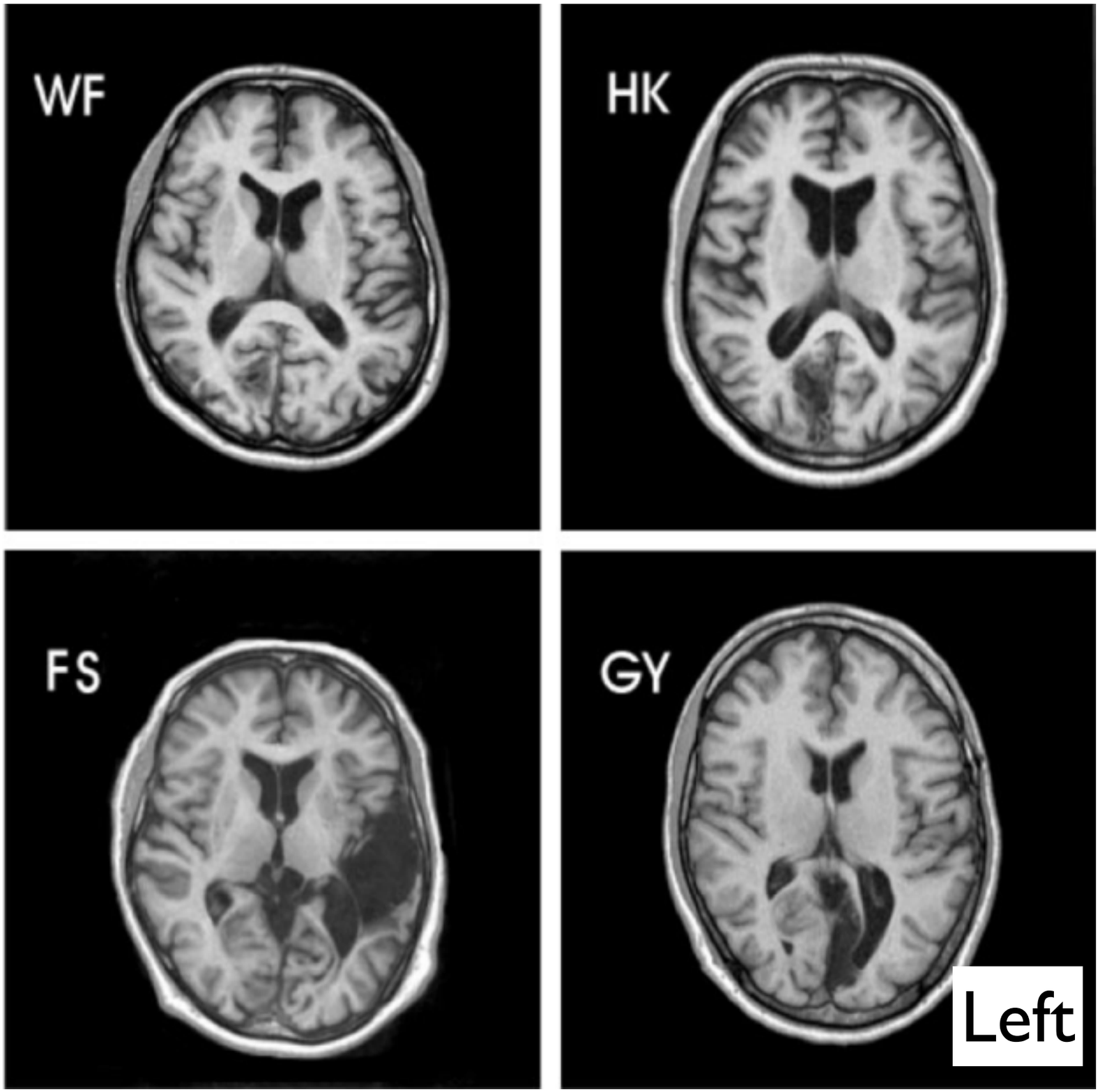
Levels of analysis (Timbergen)

	Historical	Current
Within individual	Development (ontogeny)	Mechanistic and causal explanation
Within species	Evolution (phylogeny)	How a species reproduce and survive in the current environment - Function/Adaptation

Discussion point : Caveats and usefulness of considering functions of consciousness



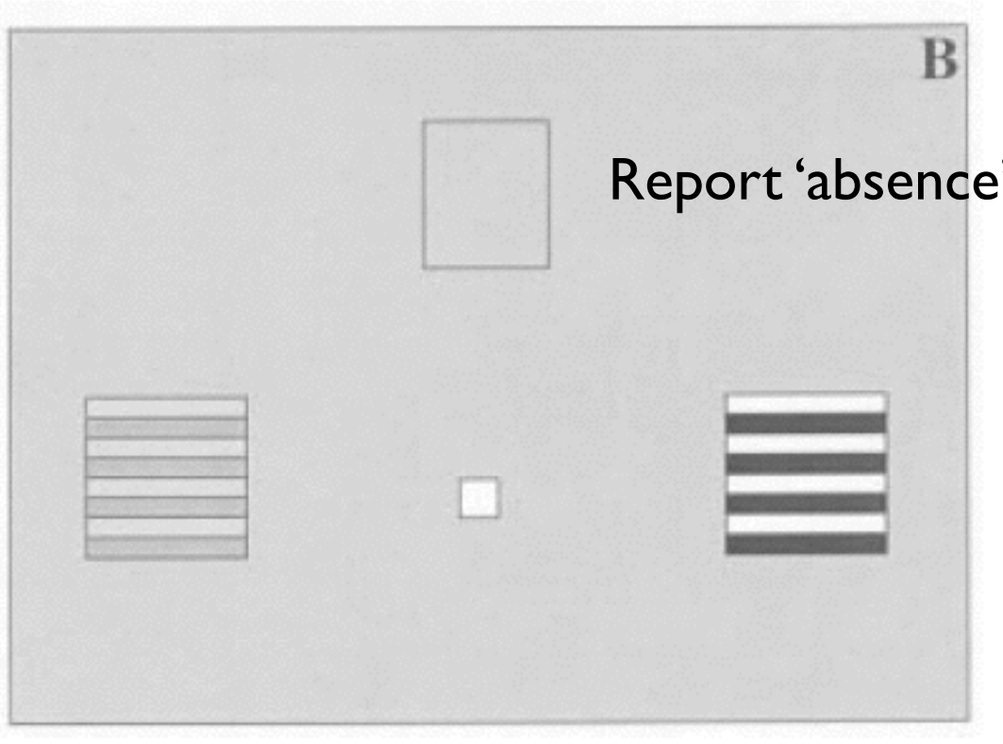
Blindsight: visually guided non-conscious decisions



Stoerig et al 2002 Cereb Cor

Conscious phenomenological experience in blindsight people

Touch response
required



Report ‘absence’ of any stimulus

Faint stimulus
location
in the normal field

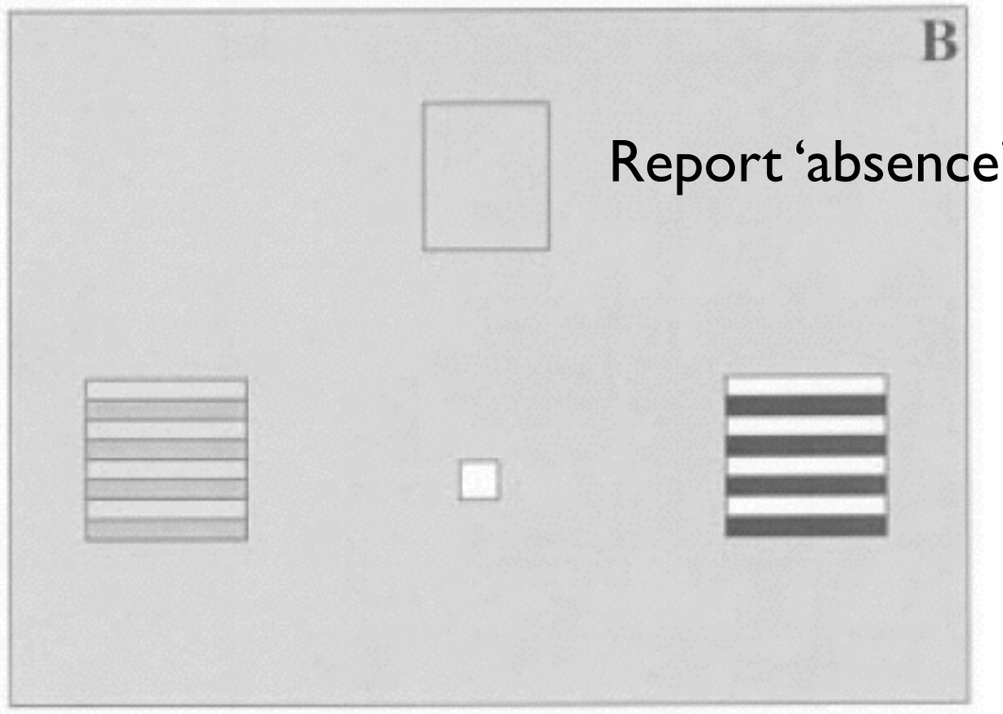
High-contrast stimulus
location
in the damaged field

-3 ways to report
Left, Right, or No stimulus

In 60% of trials, a faint stimulus on the left
In 20% of trials, no stimulus
In 20% of trial, high-contrast stimulus on the right

Stoerig et al 2002 Cereb Cor

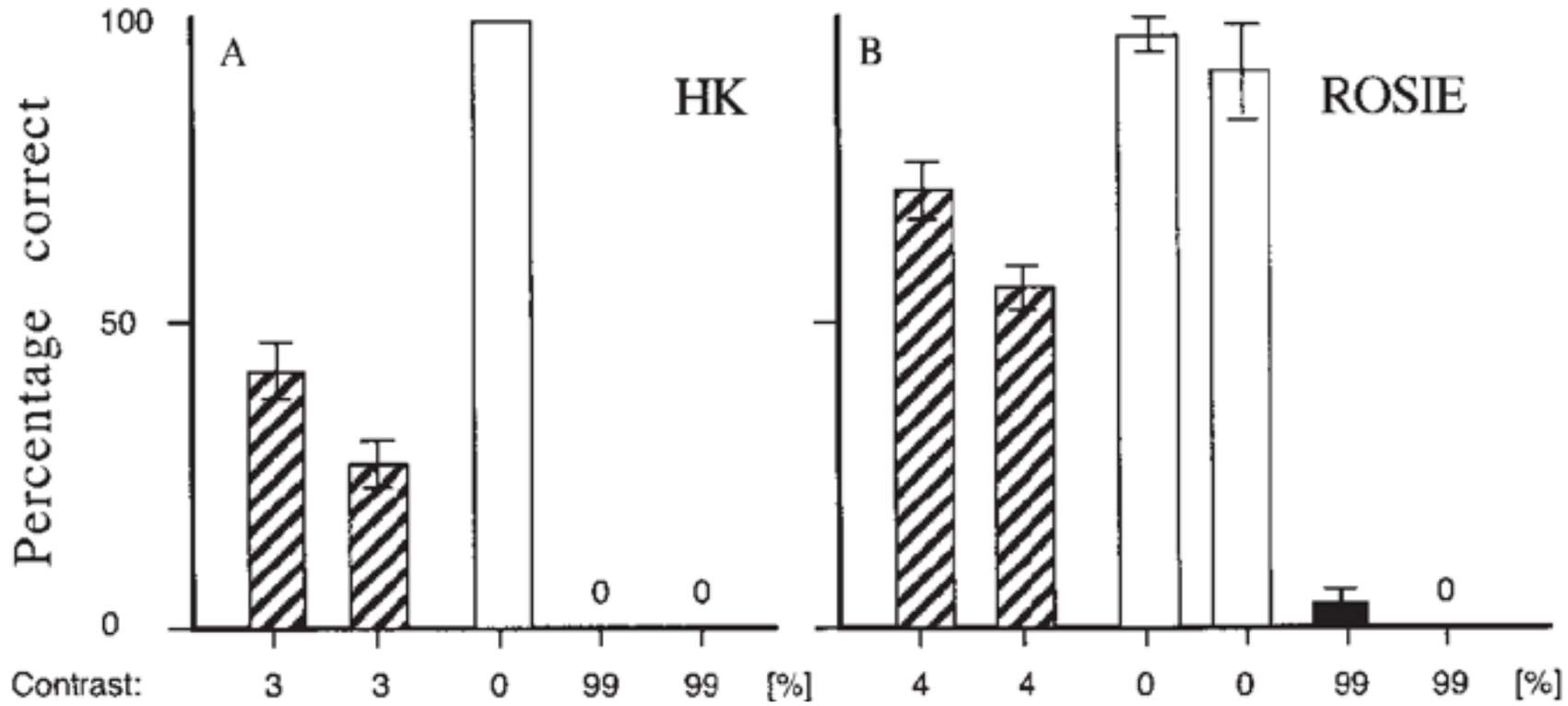
Touch response required



Report 'absence' of any stimulus

Faint stimulus location in the normal field

High-contrast stimulus location in the damaged field



Stimulus frequency (%)												
	Exp 1	60		35	5		60		20		20	
	Exp 2		60	20		20		20		20		60

Stoerig et al 2002 Cereb Cor

Discussion points

- What can we do non-consciously?
- What do we need for consciousness?
- Consideration of evolutionary advantages of having consciousness
- What determines the boundary of conscious and non-conscious processing?

c. unity of consciousness

- Why is consciousness feels to be unified?

- Can we divide consciousness?
- Can we divide attention? Can your mind split and consider two things simultaneously?
- For a given perception of object, can we only see color without seeing its shape? (Binding problem)

Conjoint twins

https://www.youtube.com/watch?v=WKwT1Ol3nY0


And we was little eggs. Yeah.

Discussion points

- Is there a situation when we simultaneously experience two different consciousness at the same time?
- What is it like to be a split brain patient?
- What is it like to be conjoint twins?

Discussion topics

- **Measures**
  - Difficulties of measuring level/contents of consciousness?
  - In yourself, other people, animals, artificial systems
  - nature of the difficulties (conceptual, technical, etc)
- **Functions**
  - What can we do non-consciously?
  - What do we need for consciousness?
  - Evolutionary advantages of having consciousness
  - Boundary between conscious and non-conscious processing
- **Unity**
  - Simultaneous experience of two consciousness at the same time?
  - What is it like to be a split brain patient?
  - What is it like to be conjoint twins?