University of BRISTOL

The neuroscience of consciousness

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Lecturer in Computational Neuroscience

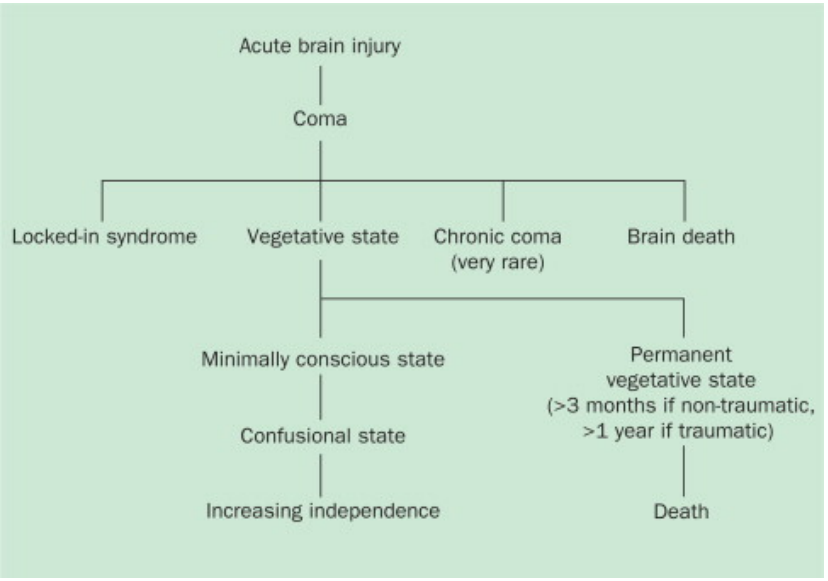
Learning objectives

- To learn about the distinction between levels of consciousness and conscious access
- To learn how the neural correlates of consciousness are studied in the laboratory
- To become acquainted with neuroscientific theories of consciousness
- To study an influential neural circuit model of conscious access

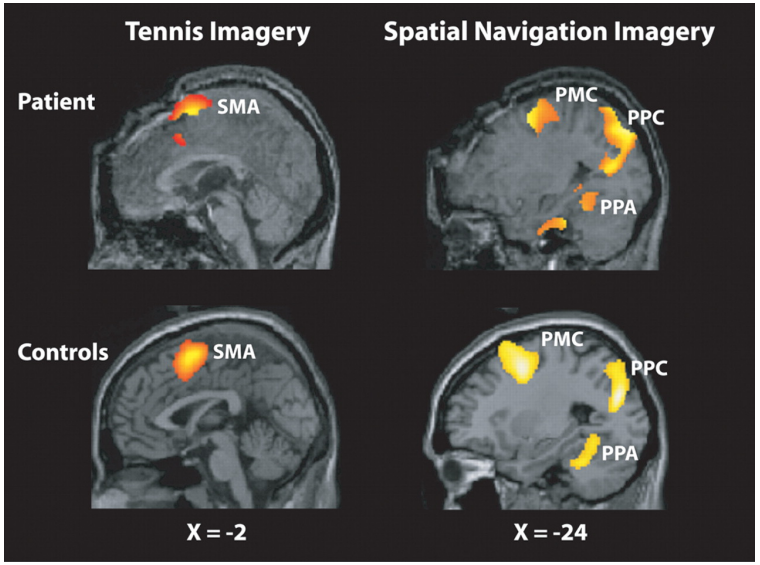
Definition: Levels of consciousness

- The level of consciousness refers to the overall state of awareness/alertness/vigilance of an individual
  - 'how conscious we are'
    - comatose, minimally conscious, asleep, awake
    - wakefulness
  - Differences within the awake state
    - drowsy, alert
    - vigilance
  - Debates
    - Is consciousness binary or graded?
    - Do infants/animals have 'lower' levels of consciousness?
    - Should we consider multiple dimensions (aspects) of consciousness – psychedelic drugs?

Measuring consciousness levels in the lab and the clinc



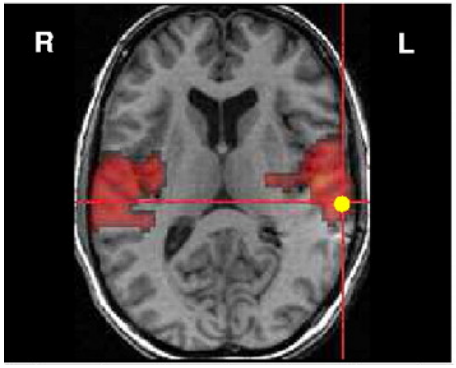
Laureys et al., 2004



Owen et al., 2006
Monti et al., 2010

Large-scale brain activity indicating conscious processing

Local irregularity detection



Early activity (100ms)
remains close to sensory cortex

Global irregularity detection

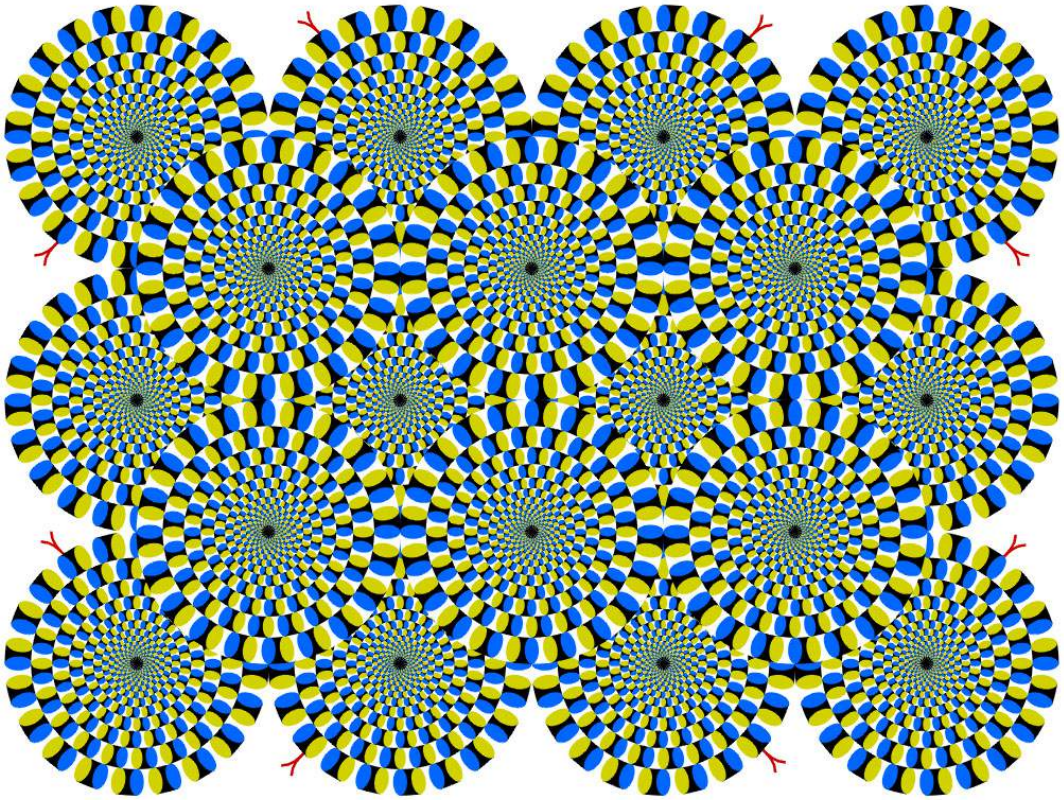
Late activity (300ms)
across distributed networks

Bekinschtein et al., 2009

Definition: Conscious access

- ‘what we are conscious of’
  - When when we subjectively perceive some information from the external world or internal thoughts
  - This enables this information to access other ‘processors’ like working memory, language and motor behavior

physical stimuli vs subjective experience



Kitaoka and Ashida 2003

illusionsindex.org

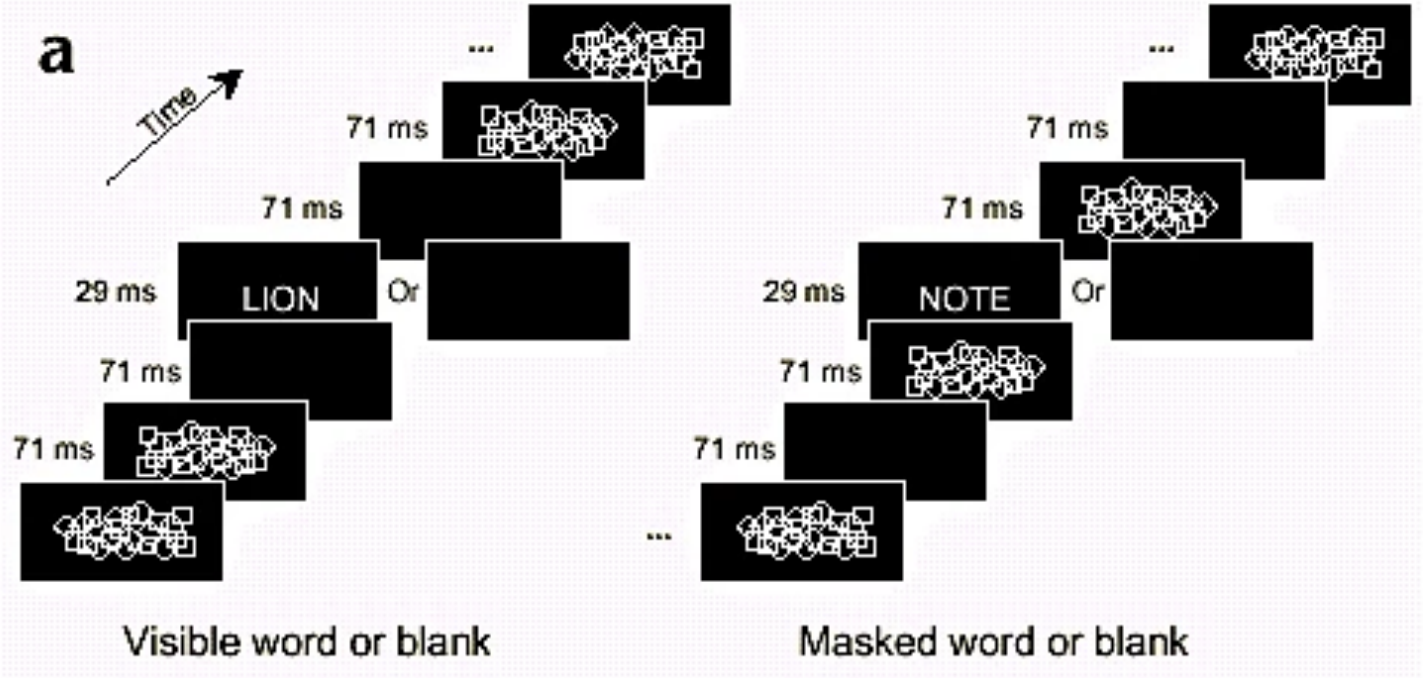
Subjective reports

- The goal of the neuroscience of consciousness
  - Understand the objective neurobiological events that produce a person's subjective experience
- Subjective reports as data
  - "did you see the word?"
- Introspection as a scientific method
  - "quality nylon stockings"

Measuring conscious access in the lab

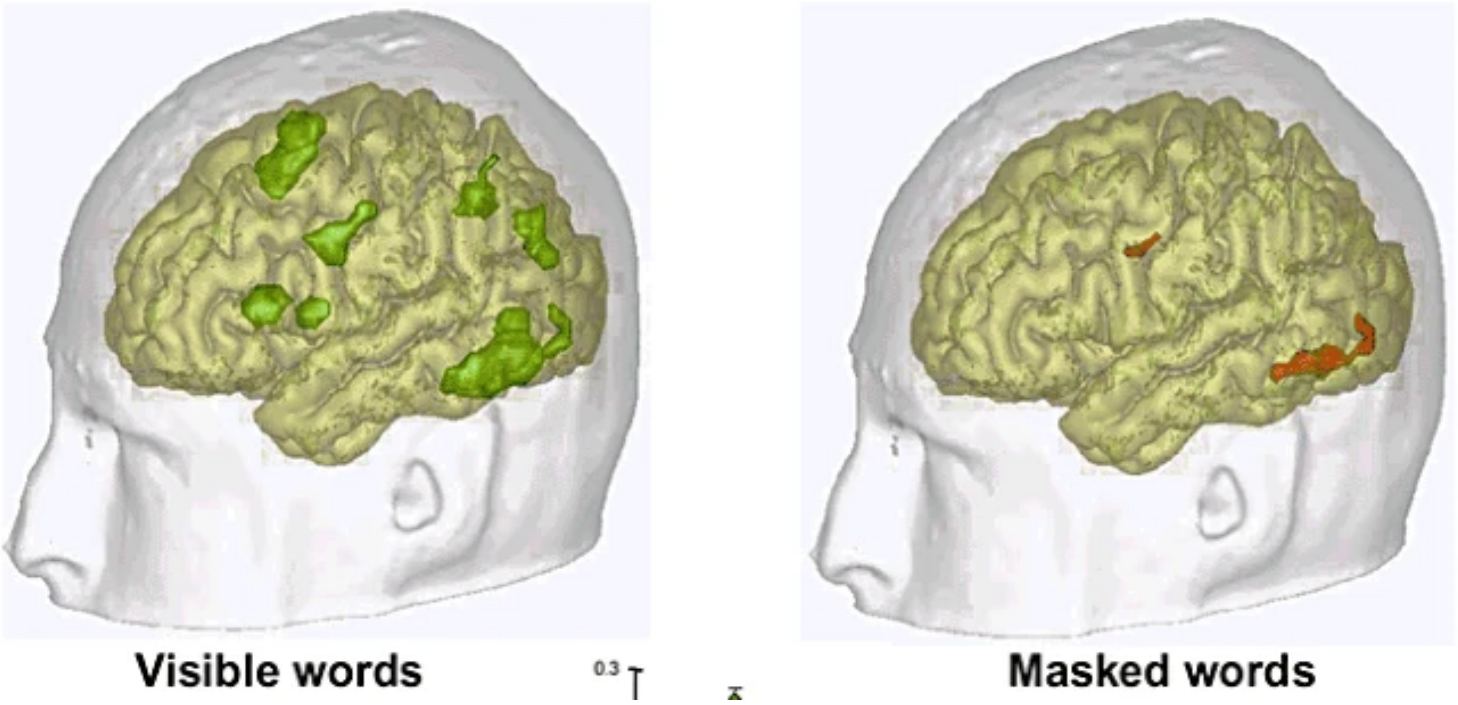
Claire Sergent

Controlling the visibility of stimuli



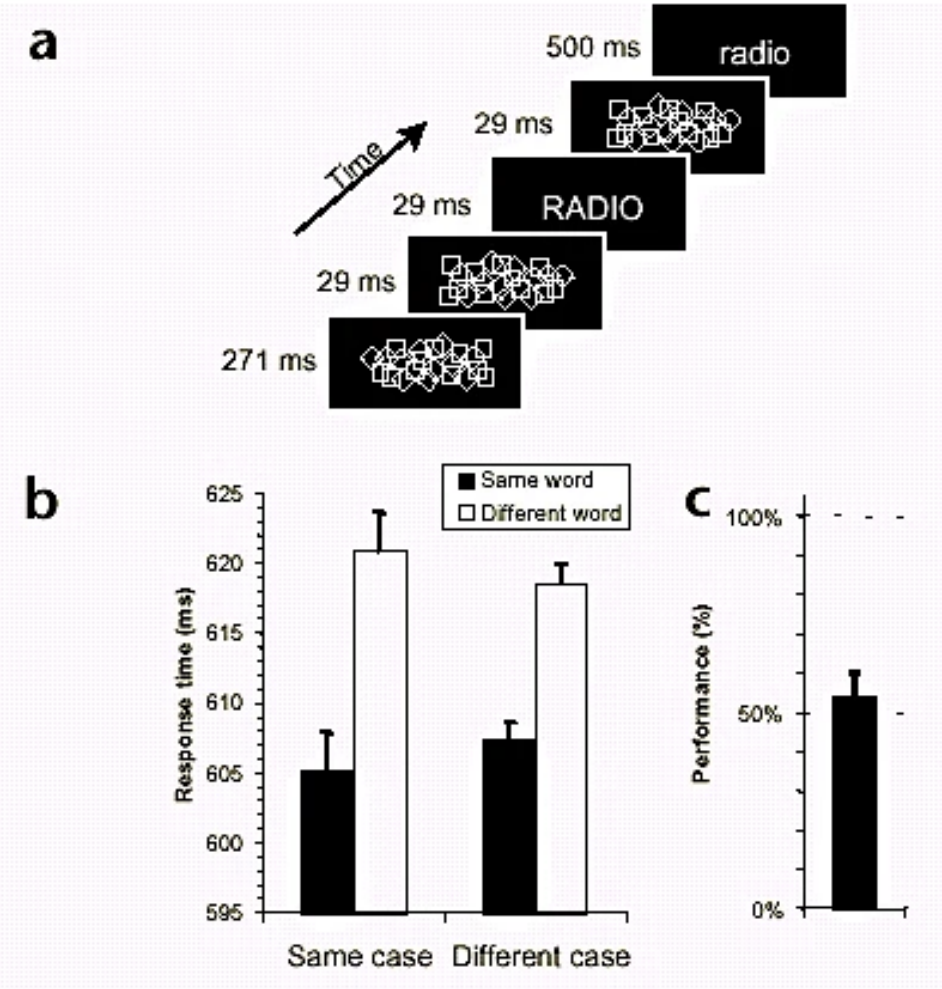
Dehaene et al., 2001

Unconscious processing in the brain



Dehaene et al., 2001

Unconscious processing affects behaviour

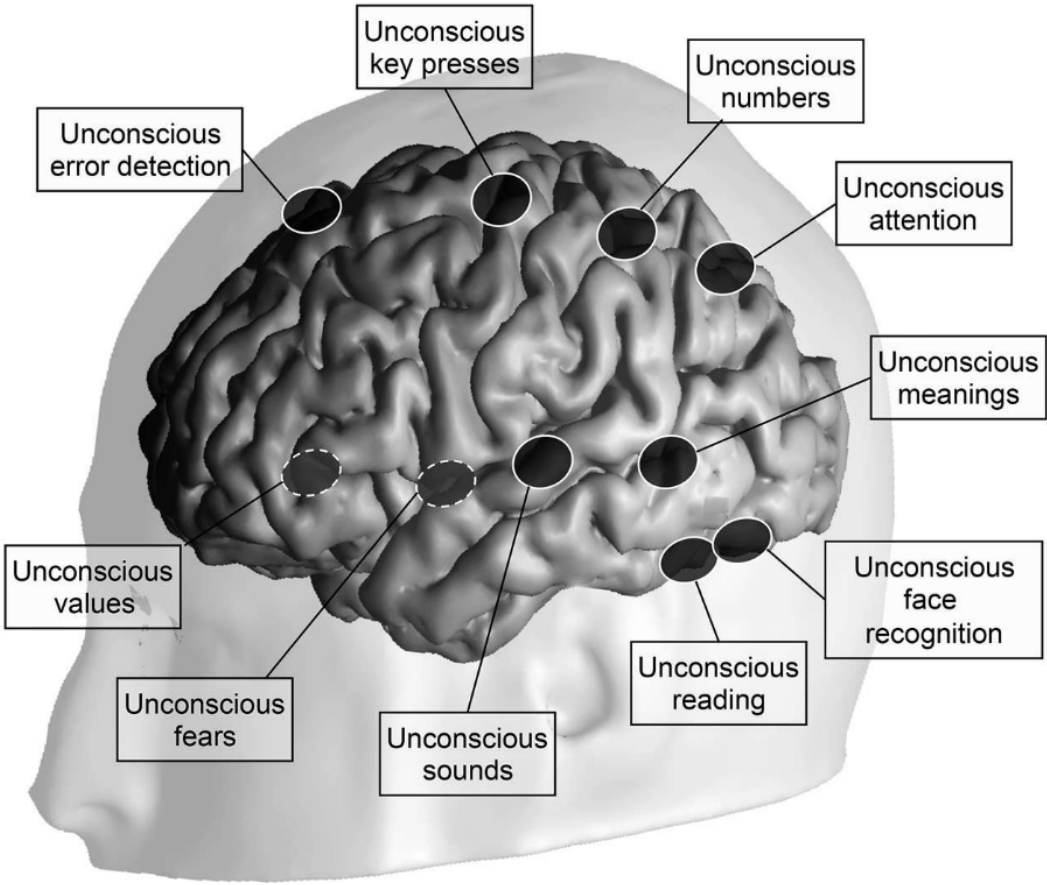


Man-made?

Dehaene et al., 2001

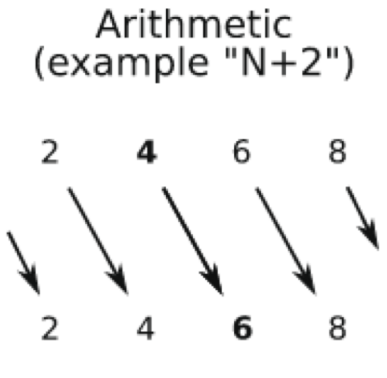
Unconscious cognition

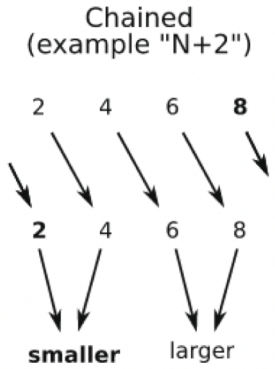
- Dehaene, 2014

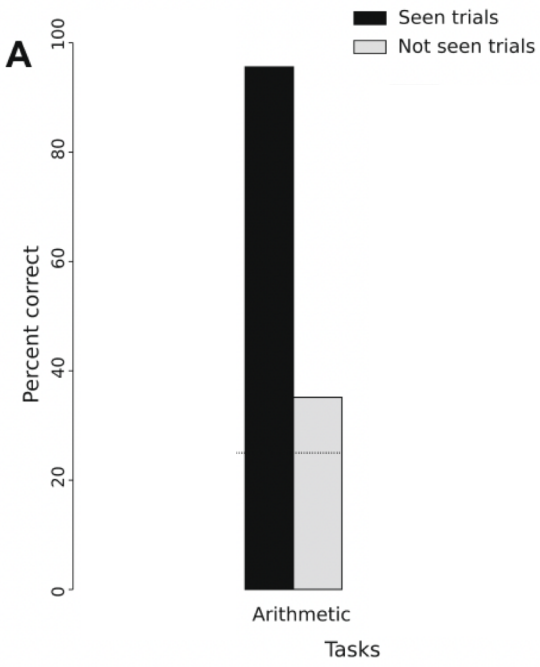


What is consciousness good for?

- Sustaining thoughts
- Chaining operations
- Sharing information with a social network

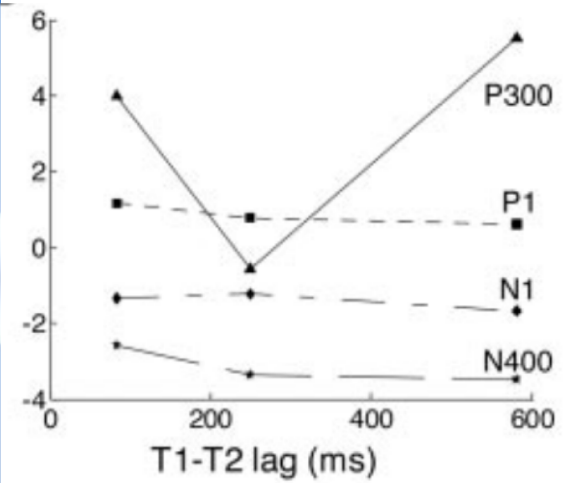






Sackur & Dehaene, 2009

Attentional blink

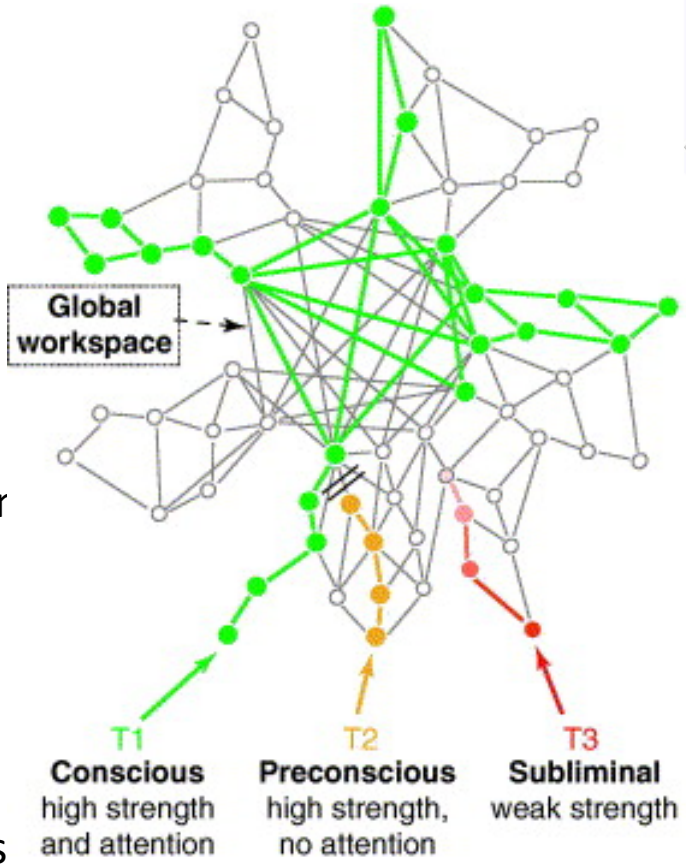


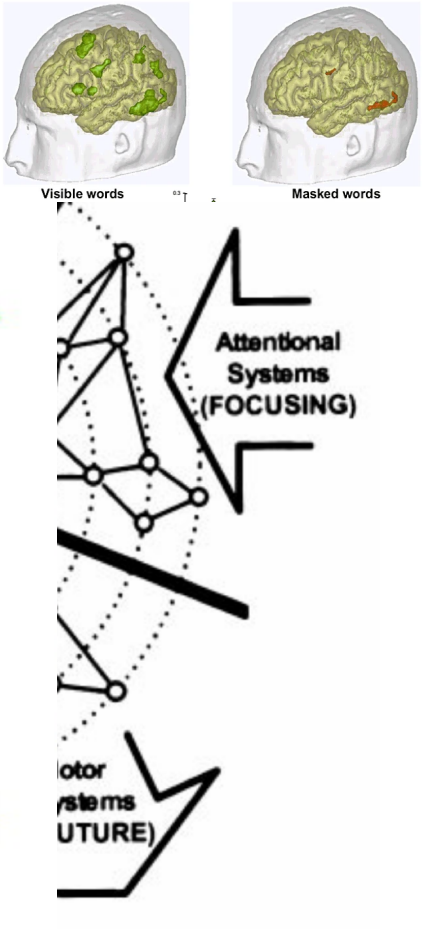
Professor Ross (YouTube)

Vogel et al., 1998

Global Neuronal Workspace Theory

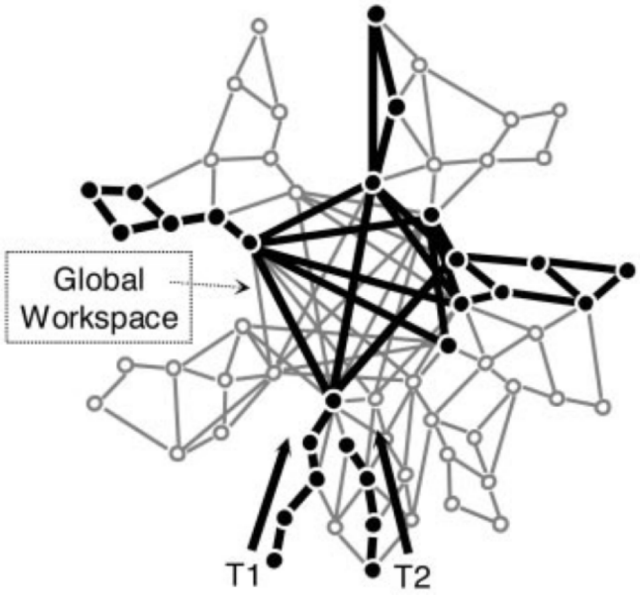
- Information exists in pre-conscious form along independent processors (e.g. sensory streams)
- Information only becomes perceived when it is widely broadcast to other processors ir the brain.
- The widely accessible information constitutes conscious experience
- The broadcast of the information occurs suddenly, as an ignition of activity across frontal and parietal cortex





Baars, 1988
Dehaene et al., 1998

A neural circuit model of conscious access



$$C\frac{dV}{dt} = -g_{leak}(V-V_{rest}) - I_{Na} - I_K - I_{adaptation} - I_{GABA} - I_{AMPA} - I_{NMDA} - I_{stimulus} - I_{neuromodulator}$$

leak

ion channels

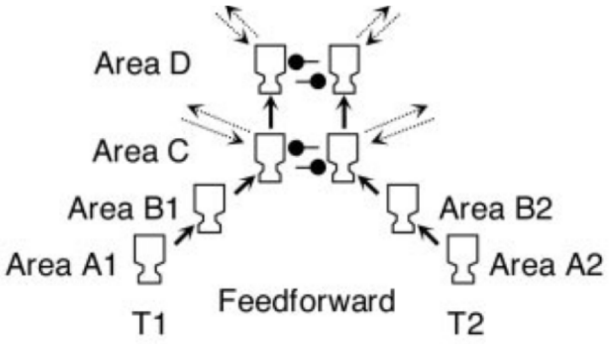
synaptic inputs

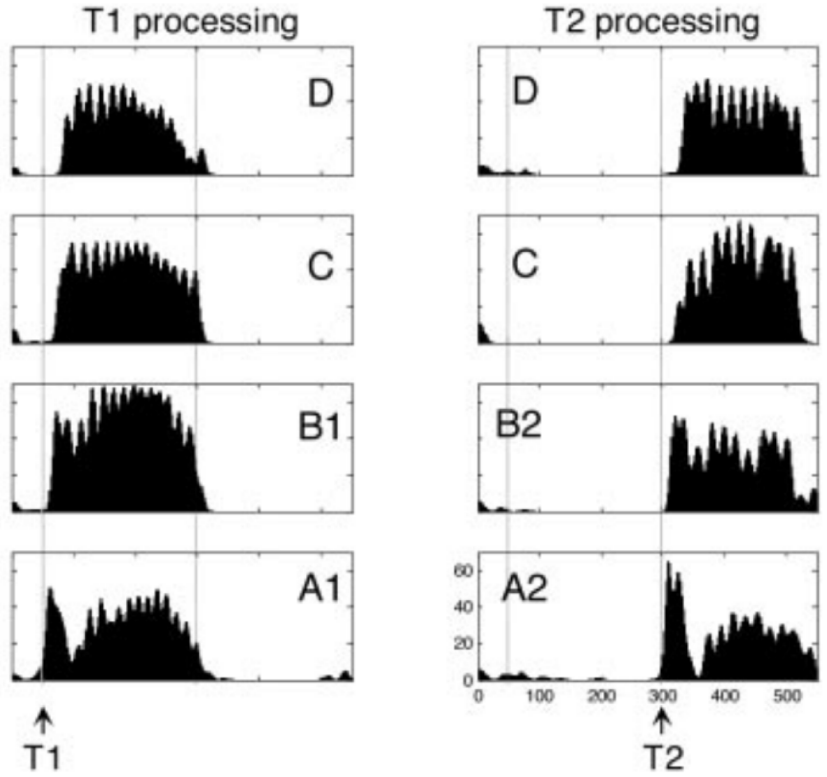
visual stimulus

level of consciousness

Dehaene, Sergent & Changeux, *PNAS*, 2003

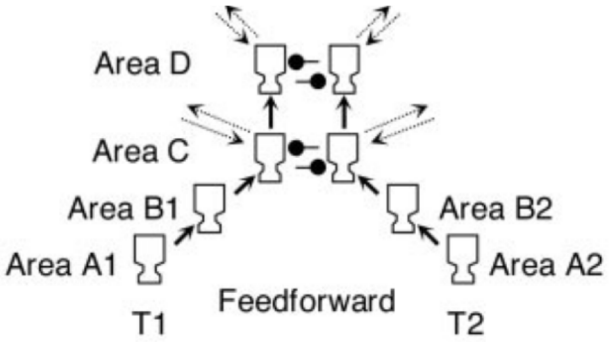
No attentional blink when stimuli are separated by >300ms

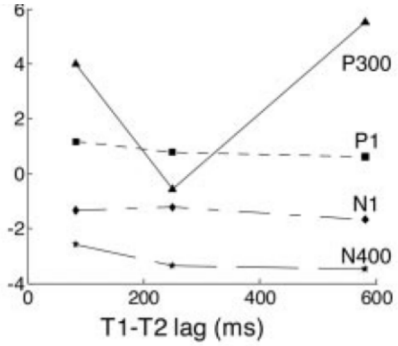


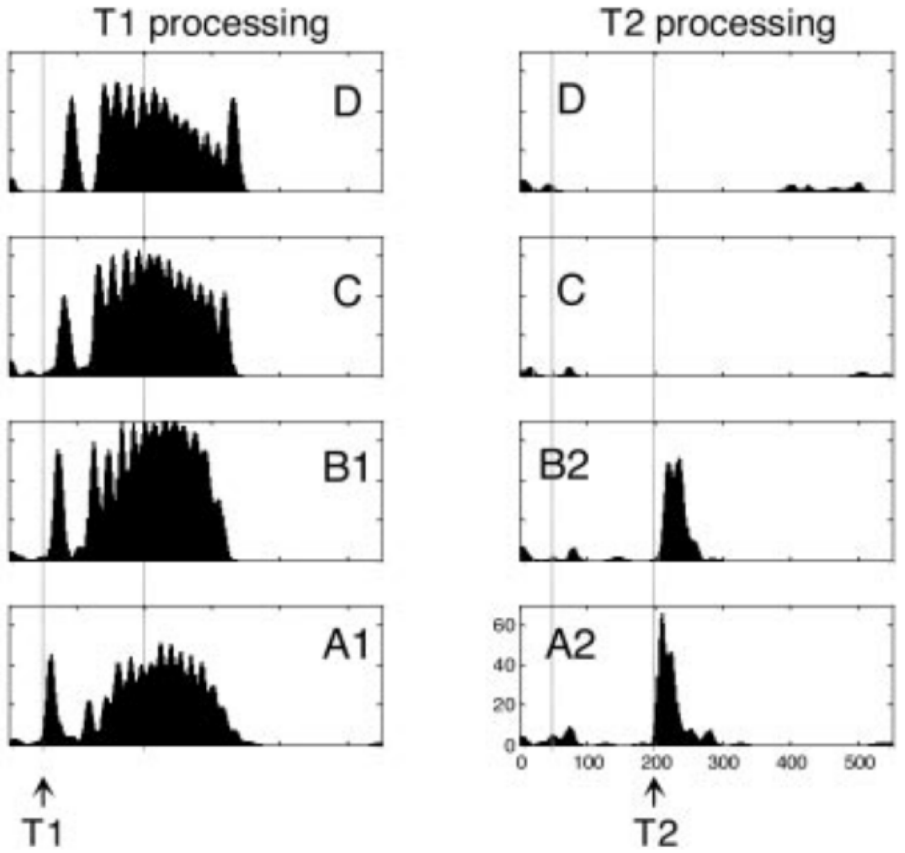


Dehaene, Sergent & Changeux, *PNAS*, 2003

attentional blink when stimuli are separated by 100-200ms

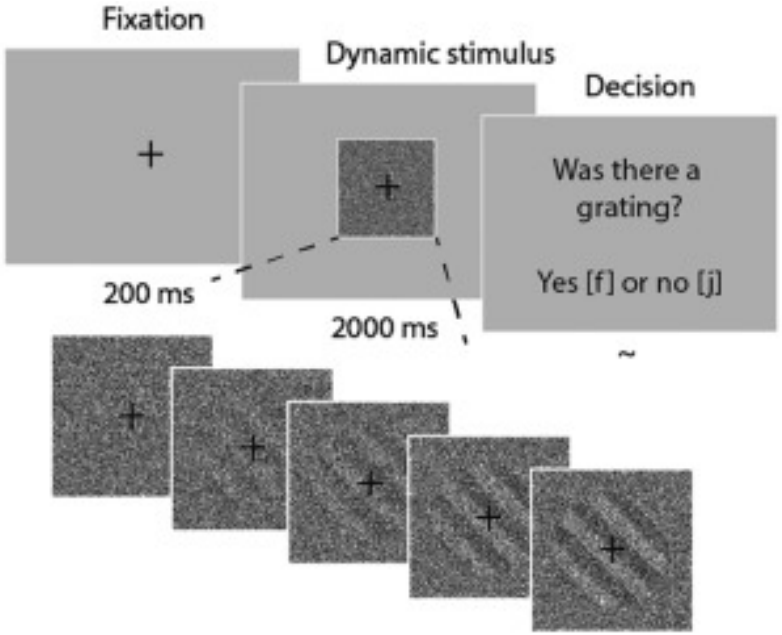






Dehaene, Sergent & Changeux, *PNAS*, 2003

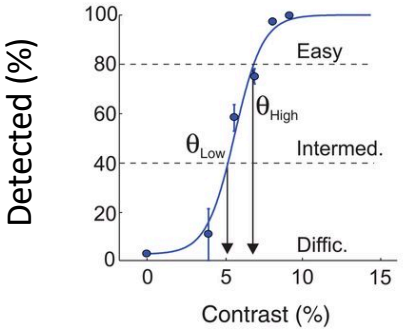
Near-threshold stimulus detection



a weak sensory cue

Dijkstra et al., *Cognition*, 2021

The subject must report if they saw the stimulus

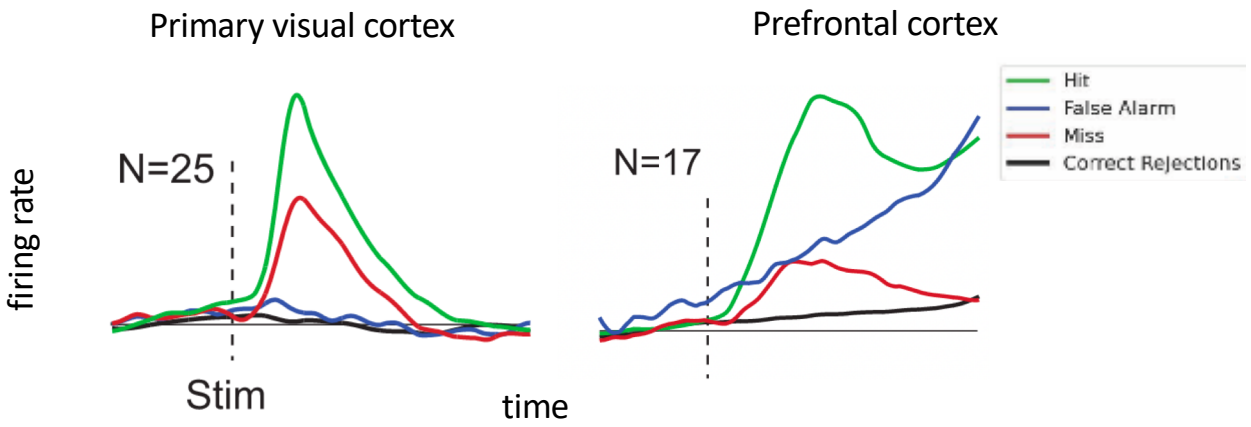


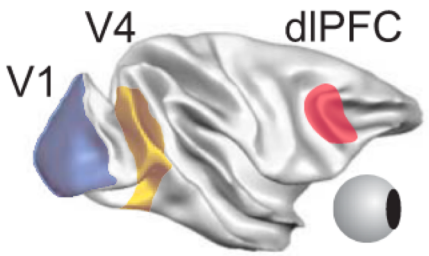
the strength is titrated so that the threshold is detected

Compare brain activity for same stimuli on seen vs unseen trials

Van Vugt et al., *Science*, 2018

Neural correlates of conscious access

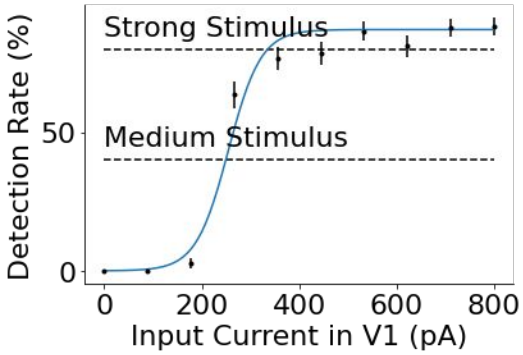


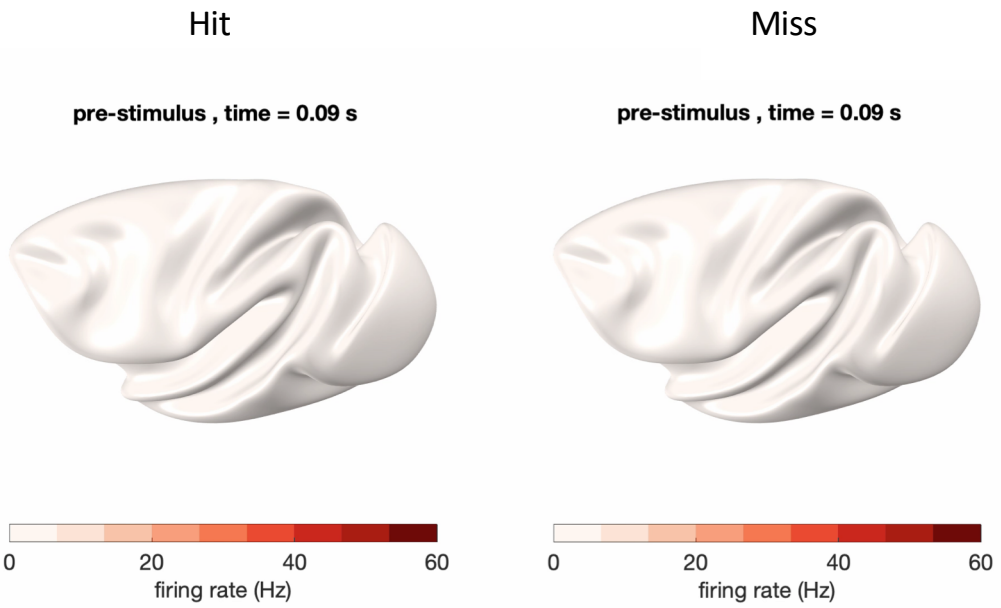


Macaque electrophysiology

Van Vugt et al., *Science*, 2018

A model of conscious access based on the brain's real connectivity

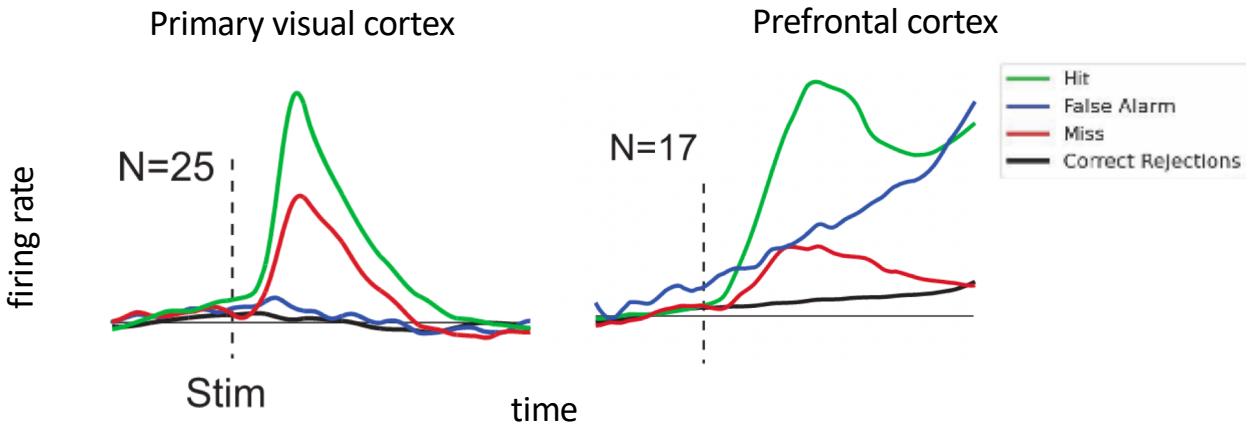




Wong-Wang local circuit model in each brain area
(see lecture on decision-making)

Klatzmann*, Froudist-Walsh* et al., *bioRxiv,* 2022

Inferring mechanisms of conscious access through computational models



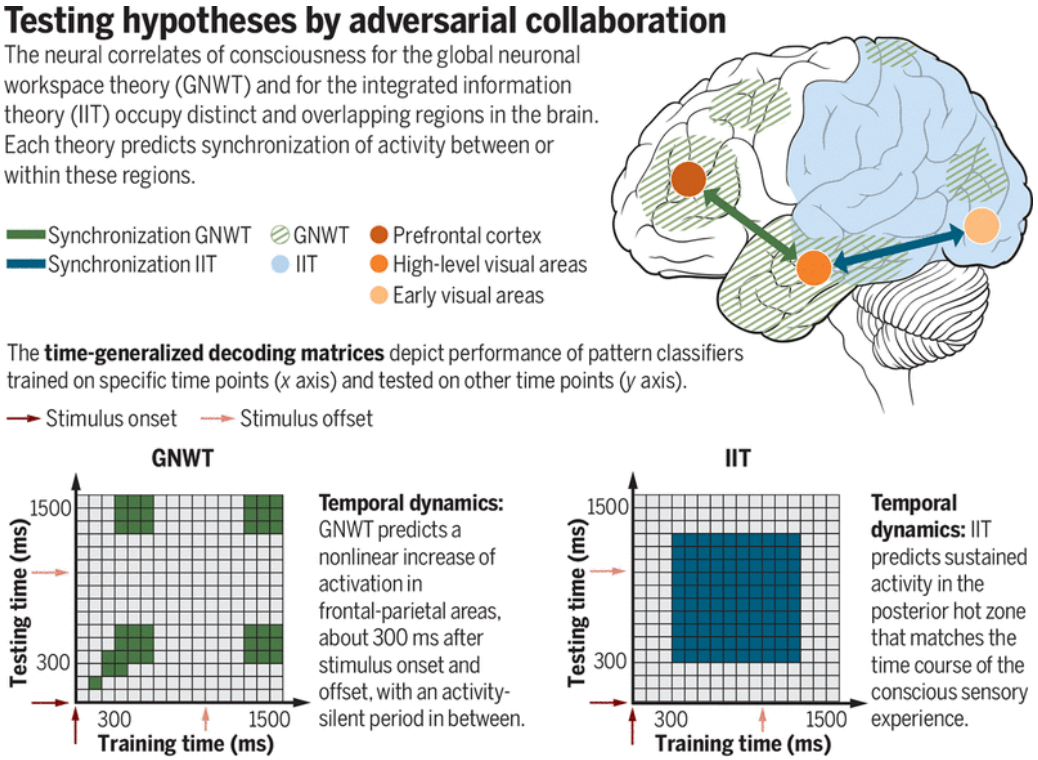
Macaque electrophysiology
Van Vugt et al., *Science*, 2018

Model
Klatzmann*, Froudist-Walsh* et al., *bioRxiv,* 2022

Fast unconscious propagation of information via fast AMPA receptors

Conscious-like ignition of activity via slow NMDA receptors

Adversarial collaborations in consciousness science



Information integration theory: "consciousness is not input-output information processing but the intrinsic ability or power of a neuronal network to influence itself."

Melloni et al., *Science*, 2021

Reviewing learning objectives

- To learn about the distinction between levels and contents of consciousness
- To learn how the neural correlates of consciousness are studied in the laboratory
  - masking, attentional blink, near-threshold stimuli
- To become acquainted with neuroscientific theories of consciousness
  - Global Neuronal Workspace Theory
- To study an influential neural circuit model of conscious access
  - Dehaene et al., 2003

Thank you!

- Contact me on Teams!