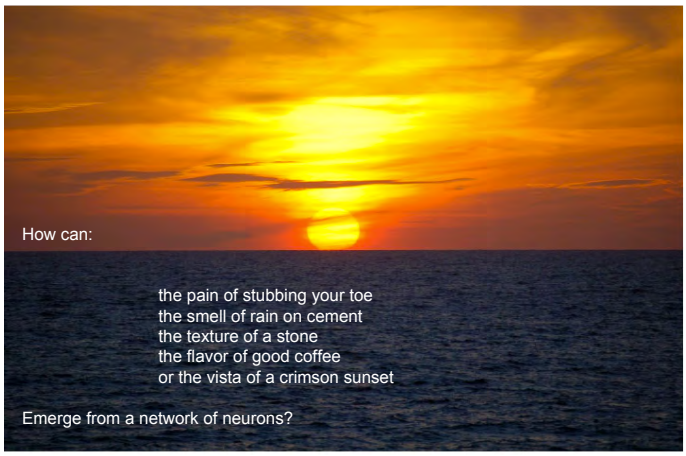
Announcements

- Exam 4 (last exam) is on Tuesday
- Review session is on **Monday, Meliora 203 from 6:15 - 7:30 p.m**

- Class evaluations are now open
  - *www.rochester.edu/registrar/course-evaluations.html*
    - or go to Registrar's home page, and click on Course Evaluations link
  - I will also send a email reminder

www.grand-illusions.com/acatalog/Einstein_Hollow_Face_Illusion.html

Consciousness



Conscious Awareness

- Introduction & Philosophy primer
- Why was it ignored by scientists / psychologists for years?
- What we know from brain damage cases
- Neural correlates of consciousness
- Spirituality and out-of-body experiences

One of the last remaining great mysteries

All the remote, exceedingly complex, abstract things we now understand:

1. DNA and genetics
2. General relativity
3. Expansion of the universe
4. String theory in physics
5. Etc.

But, we still don't have a clue about one thing that is closest to each of us: our own **consciousness**

"*Consciousness poses the most baffling problems in the science of the mind.* ***There is nothing we know more intimately than conscious experience, but there is nothing harder to explain***"

David Chalmers

"I can see that you have explained how information is discriminated, integrated, and reported but you have not explained how it is ***experienced****."*

Many many unsolved sub-mysteries….

How consciousnesses arises from our neural systems?

Does it have a specific physical substrate?

Could a machine have consciousness?

Which animals are conscious?

Is memory a part of consciousness?

How do we perceive present time when our brains live in the past?

Etc.

Approaches

- **Mentalists** – nothing really exists outside the mind
- **Materialists** (*Physicalism*)
  - there is only matter
  - Conscious states *are* physical brain states
  - Unity of conscious experience and the brain
  - Consciousness consists entirely of computational processes
- **Epiphenomentalism** – Consciousness is an illusion
- **Panpsychism** – Everything is conscious
- **Dualism** -
  - Conscious experience distinct from brain activity
  - our experience (e.g. of the color red) cannot be reduced to brain activity.
  - ***An acceptance of inner processes does not entail dualism***
- **Mysterian** - Consciousness is a complete mystery

Can we define it?

- ***Consciousness***: states of *awareness* of the *outside world* **and** of *one's own mental processes*, thoughts, feelings, and perceptions.

- William James (1890):
  - Consciousness is a constantly moving stream of thoughts, feelings, and emotions

Function(s) of consciousness?
- **Monitoring** mental events (introspection)
- **Control**: consciousness allows us to formulate and reach goals
  - Consciousness helps to direct/control behavior in **adaptive** ways

Are there different types of **C**?

- **EXTERNAL SENSORY PERCEPTION**
  - Awareness of sights, sounds, tastes, & touch in the environment

- **INTERNAL SENSORY PERCEPTION**
  - Ability to internally experience sensory information from a remembered event
  - create sensory representations of events we've never experienced
  - Mental imagery

- **ABSTRACT AWARENESS**
  - Abstract ideas (i.e. freedom, love)
  - Emotions (aren't sensory experiences)
  - Symbols we use to represent big ideas

- **AWARENESS OF SELF**
  - Aware of yourself as an indiv. apart from other indiv & objects in your environ
  - Aware of your thoughts & feelings
  - Aware you *have* thoughts & feelings
  - Observe your experiences from the 'outside'

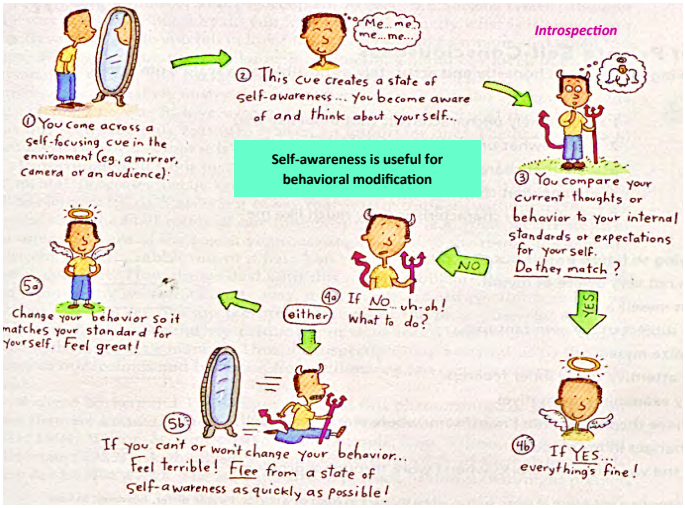
THE BIRTH OF SELF-AWARENESS

Self-awareness

• Self-awareness provides a foundation for emotions like embarrassment, empathy & envy

• When does self-awareness emerge?
  – Mirror Test
  – any problems?

Self-Recognition = Self Awareness?



Why the hard problem is hard

"You can look into your mind until you burst, and you will not discover neurons and synapses and all the rest;

and you can stare at someone's brain from dawn till dusk and you will not perceive the consciousness that is so apparent to the person whose brain you are so rudely eye-balling." (McGinn 1999)

"The problem of consciousness, simply put, is that we cannot understand how a brain, qua gray, granular lump of biological matter, could be the seat of human consciousness, the source or ground of our rich and varied phenomenological lives.

How could that 'lump' be conscious – or, conversely, how could I, as conscious being, be that lump?" (Akins 1993)

"Nobody has the slightest idea how anything material could be conscious.

Nobody even knows what it would be like to have the slightest idea about how anything material could be conscious.

So much for the philosophy of consciousness."

- Jerry Fodor (1992)

'Easy' and 'Hard' problems of C

- Hard problem
  - Phenomenal consciousness
    - Where do feelings come from
    - We can talk about the function of pain and the brain states involved, but why does it *hurt?*
  - Functionalist problem
    - We do not know what its exact function is
  - Materialist problem
    - We do not know what it is made of
  - Experimental problem
    - We cannot measure it directly

'Easy' and 'Hard' problems of C

- **Easy problem**
  - What are the neural correlates of consciousness?
    - Are these specific neurons, brain areas, and/or neural processes that correlate with conscious awareness
      - These need to be distinguished from neural structures that are required for normal brain function (e.g., brain stem)
  - Ultimate goal: identify neural processes that are causally involved in consciousness
  - Essentially an explanation of sensory and cognitive functions
  - The 'easy' problem is quite hard. But the hard problem is even harder!

One solution

Concentrate on the "easy" problems and believe that the answers to the hard problem will come eventually

Francis Crick (in his work about visual consciousness):

"I have said almost nothing about qualia – the redness of red – except to brush it to one side and hope for the best" (Crick 1994)

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Psychophysics

- How to relate mind and matter?
- **Gustav Fechner 1850**: *By quantifying their relationship!*

  - Perceptual thresholds: how strong must a stimulus be for an observer to experience (detect) it?

  - Just Noticeable Difference: how much must two stimuli be physically different for an observer to experience them as different?

Wilhelm Wundt

- The first laboratory for psychological experiments: Leipzig, Germany 1879

- First definitions of psychology as a science:

*"Psychology is the investigation of **conscious** processes in the modes of connection peculiar to them" (Wundt 1874)*

- psychology studies the world of immediate experience
- methods are experimental, objective, like in physiology and physics
- **introspection** or self-observation as the most important method
- highly trained subjects
- highly controlled conditions

Edward Titchener's Definition of "Mind"

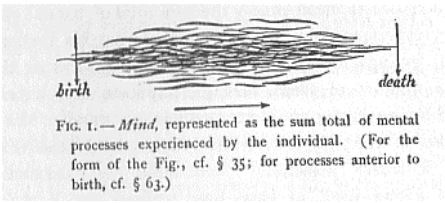

FIG. 1. — *Mind*, represented as the sum total of mental processes experienced by the individual. (For the form of the Fig., cf. § 35; for processes anterior to birth, cf. § 63.)

— so mind is a stream of processes, more or less numerous, which run their course in time together.

My 'consciousness' is the sum of mental processes which make up my experience *now*; it is the mind of any given 'present' time. We might, perhaps, consider it as a cross-section of mind. This section may be either artificial or natural. We may deliberately cut across mind, in order to investigate it for psychological purposes. We

Structuralism (Titchener)

- The tasks of psychology are:

  1) To analyze mind to its basic elements and describe the quality and quantity of the elements of **consciousness**

  2) To discover the laws that govern the combination of the elements to larger wholes in the mind

  3) To discover the **physiological brain events** that correspond to the **psychological elements**

William James (1890)

- "Psychology is the Science of Mental Life"

- "**Introspective observation** is what we have to rely on first and foremost and always…it means the looking into our own minds and reporting what we there discover. **Everyone agrees that we there discover states of consciousness**."

- "No-one ever had a simple sensation. **Consciousness is of a teeming multiplicity of objects and relations**, and what we call simple sensations are results of discriminative attention"

- **The Stream of Consciousness** Consciousness, then, does not appear to itself chopped up in bits. Such words as 'chain' or 'train' do not describe it fitly as it presents itself in the first instance. It is nothing jointed; it flows. A 'river' or a 'stream' are the metaphors by which it is most naturally described. *In talking of it hereafter, let us call it the stream of thought, of consciousness, or of subjective life.* (Vol. 1, p. 239).

John B. Watson

- "The time seems to have come when **psychology must discard all reference to consciousness**. This suggested elimination of states of consciousness as proper objects of investigation will remove the barrier which exists between it and the other sciences"
  (Watson 1913)

- ...the Behaviourist must exclude from his scientific vocabulary all subjective terms such as **sensation**, **perception**, **image**, **desire**, **purpose**, and even **thinking** and **emotion** as they were subjectively defined"
  (Watson 1925)

As a result, psychologists avoided consciousness for most of the 20th century. The central topic in psychological science became a taboo

Conscious Awareness

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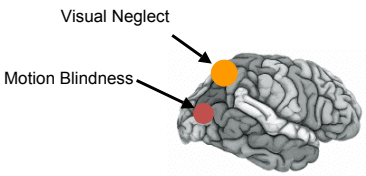
Mike (The Headless Chicken) (April 1945 – March 1947)

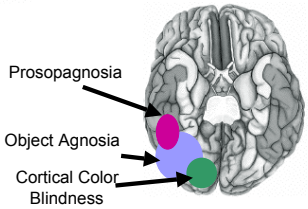



lived for 18 months after his head had been cut off!

http://www.youtube.com/watch?v=LqDjRCHyjTY

When the brain gets damaged





Visual Neglect

- Cause
  - often a stroke that has interrupted the flow of blood to the right parietal lobe that is thought to be critical inattention and selection.
- Symptoms:
  - Failure to acknowledge objects in the field contralateral to the lesion (decreased awareness)
    - Effect stronger when distracting objects are present
  - fail to dress the left side of their body
  - disclaim "ownership" of left limbs
  - not recognize familiar people presented on the left side
  - deny the illness
  - Patients with neglect sometimes have a profound hatred towards the left side and may even physically abuse the left side
- Often no perceptual deficit
  - Neglect patients still activate visual regions in occipital lobes that they claim not to be aware of



Balint Syndrome

- Visual perceptual abilities intact, can describe object features accurately
- No problems with motor movement per se, can move limbs normally
- Able to move their eyes but cannot fixate on specific visual stimuli
- **Field of attention which is limited to one object at a time (simultanagnosia)**
- Activities like reading difficult because each letter is perceived separately
- Severe deficits in reaching under visual guidance (optic ataxia).

Simultanagnosic (Balint Syndrome) patients only attend to one object at a time

Simultanagnosic patients cannot judge the relative length of two lines, but they can tell that a figure made by connecting the ends of the lines is not a rectangle but a trapezoid (Holmes & Horax, 1919).

Blindsight

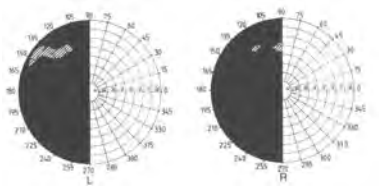
- Ability of certain patients to perform above chance on visual tasks but report that they cannot see
- Blindsight is not very helpful: patient cannot perform spontaneous intentional actions

- **PATIENT DB**
- Had severe migraines due to enlarged blood vessels in the right visual cortex
- The part of the brain containing the blood vessels was removed
- Migraines stopped

- What was the resulting effect on D.B.'s vision?

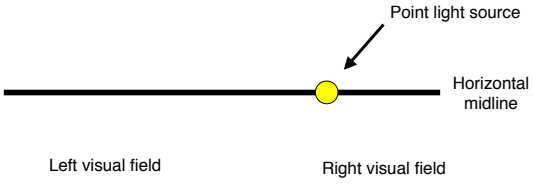
D.B.'s vision

- D.B. was blind in the Left Visual Field
- Tested via point light source in various regions



Weiskrantz et al. (1974)

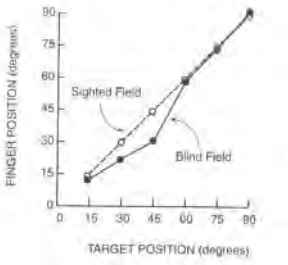
D.B.'s vision



- D.B. was asked to point to the light source, even if we could not see it

D.B.'s vision

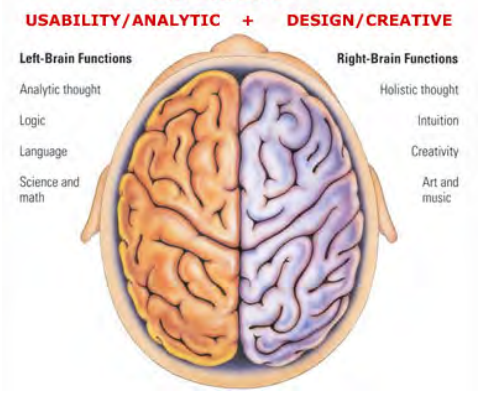
- D.B. performed remarkably well, given that we was "guessing" when the light was in the LVF



- D.B. (in his LVF) could discriminate between:
  - "X" versus "O"
  - Horizontal versus vertical lines
  - Diagonal versus vertical lines
- Performance was improved for larger and longer duration stimuli

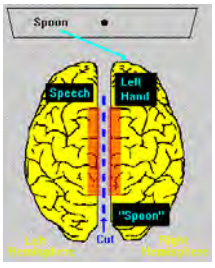
Weiskrantz et al. (1974)

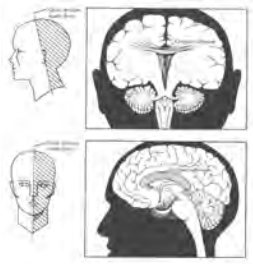
Sperry (1968) Split brain study



Sperry (1968) Split brain study

Brain's 2 hemispheres
- connected by commissural fibres
- lateralisation of function
  - each has different functions
- split to treat extreme epilepsy





Sperry (1968) Split brain study

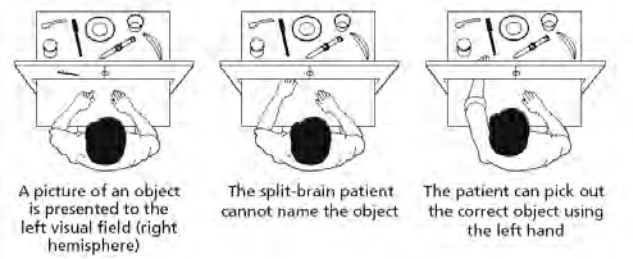
Right visual field (RVF)

Sperry (1968) Split brain study

Left visual field (LVF)

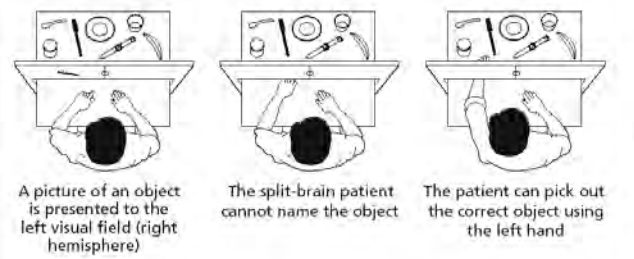
Sperry (1968) Split brain study

- Right-handed subjects shown objects in each field
- could describe object in Right field
- said no object in Left field, or 'just a flash'
- able to respond non-verbally to object in Left field (pick up object with Left hand)



Sperry (1968) Split brain study

- It seems that Left hemisphere (LH) is conscious & visually aware
- Is Right hemisphere (RH) conscious & visually aware?
- Perhaps both LH and RH are visually aware of the object, but only LH can talk about it
- Revisit the problem of other minds: what evidence do we need to believe that something is conscious?



Communicating with someone in a vegetate sate?

Investigators told a vegetative state patient to imagine
1. Playing tennis
2. Moving through there house

Owens et al (2006).

Communicating with someone in a vegetate sate?

Investigators told a vegetative state patient to imagine
1. Playing tennis
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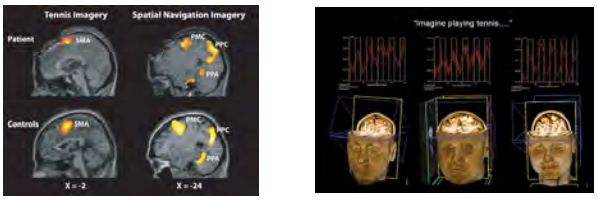
Brain activity showed understanding of instructions!



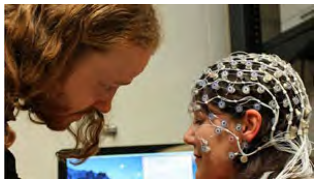
Owens et al (2006).

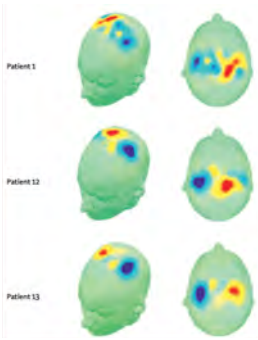
Communicating with someone in a vegetate sate?

Bedside detection of awareness in the vegetative state: a cohort study

Damian Cruse, Srivas Chennu, Camille Chatelle, Tristan A Bekinschtein, Davinia Fernández-Espejo, John D Pickard, Steven Laureys, Adrian M Owen

Patients completed the task in which they were required to imagine movements of their right-hand and toes to command





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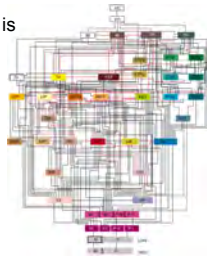
Neural correlates of consciousness (NCC)?

- **Key Assumption**:
  - Many different brain areas are involved in the NCC
    - variety in the content of consciousness likely implies that there will be a variety in NCCs
    - e.g., different NCC for visual awareness of color red and recollection of a favorite song
- **Key Problem**:
  - The distinction between what is necessary & what is sufficient for consciousness
    - e.g., brain stem and a working eye



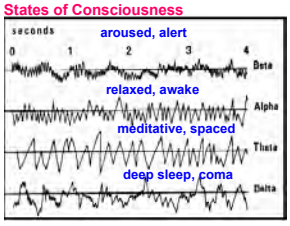
Neural correlates of consciousness (NCC)?

- 40-hertz oscillations in the cerebral cortex (Crick and Koch 1990)
  - Binding Problem: 35-75 hrtz oscillations correlated with awareness. Binds separately represented pieces of information about a single entity are brought together (red + round = apple).
- Intralaminar nuclei in the thalamus (Bogen 1995)
- Re-entrant loops in thalamocortical systems (Edelman 1989)
- 40-hertz rhythmic activity in thalamocortical systems (Llinas et al 1994)
- Extended reticular-thalamic activation system (Newman and Baars 1993)
- Neural assemblies bound by NMDA (Flohr 1995)
- Certain neurochemical levels of activation (Hobson 1997)
- Certain neurons in inferior temporal cortex (Sheinberg and Logothetis 1997)
- Neurons in extrastriate visual cortex projecting to prefrontal areas (Crick and Koch 1995)
- Visual processing within the ventral stream (Milner and Goodale 1995)
- **Brain complexity** (Giulio Tononi)

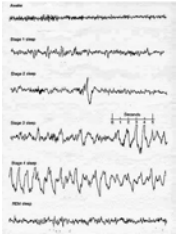
Neural correlates of consciousness (NCC)?

EEG: Measuring potential differences between 128 scalp electrodes

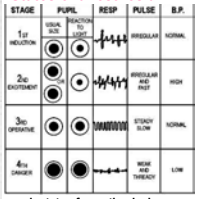
States of Consciousness



States of Sleep



States of anesthesia

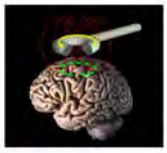


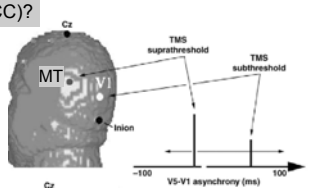
each state of anesthesia has a characteristic EEG state depending on drug

Transcranial magnetic stimulation (TMS)

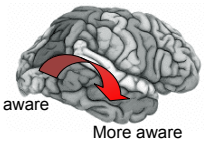
Using a brief change in a magnetic field to disrupt neural activity

1. Create perception
2. Disturb perception

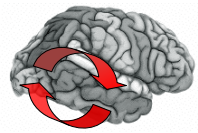




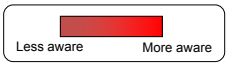
Hierarchical Model



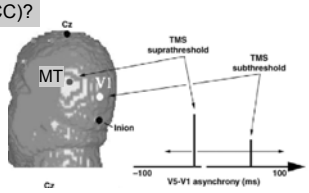
Interactive Model

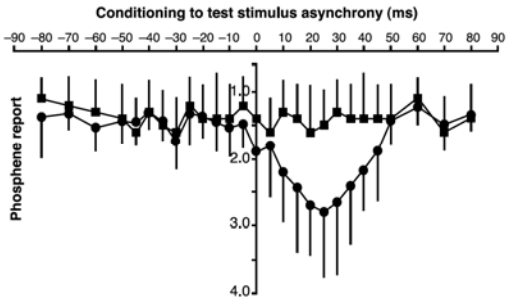


Complete awareness
Requires feedback signals



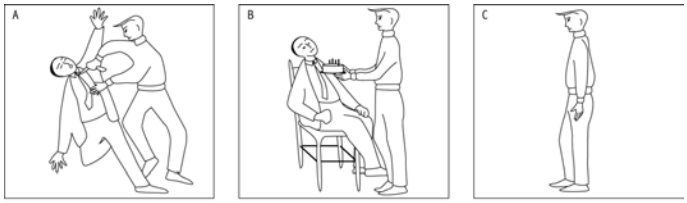
Feedback processing is important for awareness





Subliminal Perception

- Notion that brief exposure to sub-threshold stimuli can influence awareness
- Study: subjects are shown **masked** aggressive (A) or positive (B) stimuli
  - and then rate a neutral stimulus (C)
  - Subjects shown panel A subsequently rated the boy in panel C more negatively



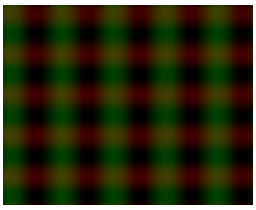
(Figure adapted from Eagle, 1959)

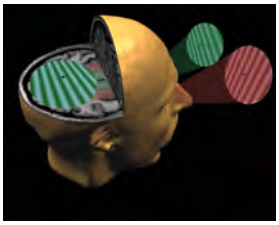
Binocular rivalry

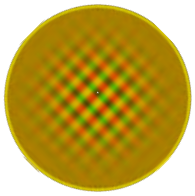
Nothing on the screen is changing

Nothing in your eyes…

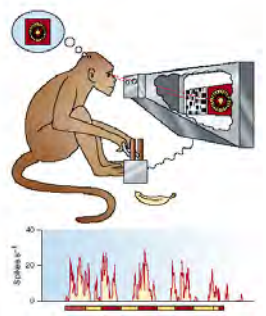
So **where** does something change in the **brain**?







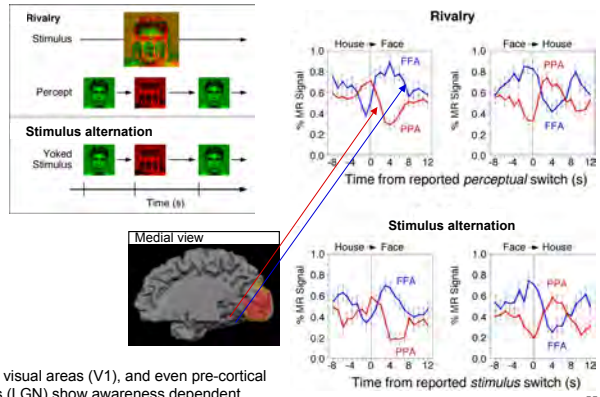
Binocular rivalry & awareness



Question:
Which neurons follow physical stimulation, and
which neurons follow perceptual awareness?

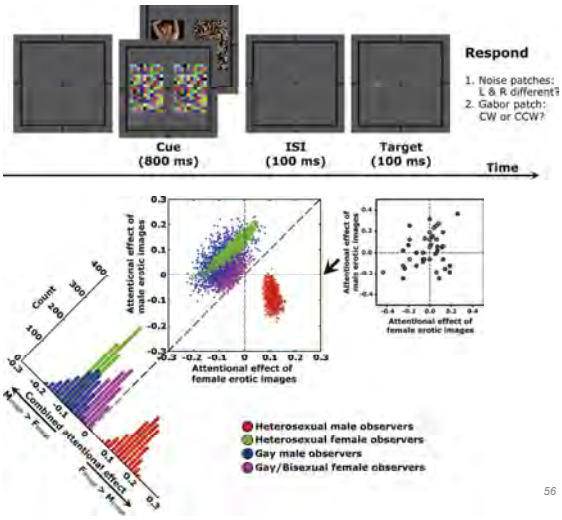
Answer:
Higher level areas care more about perception, while lower level areas care more about physical stimulation.

Binocular rivalry & awareness



Early visual areas (V1), and even pre-cortical areas (LGN) show awareness dependent modulation!

Tong et al (1998)



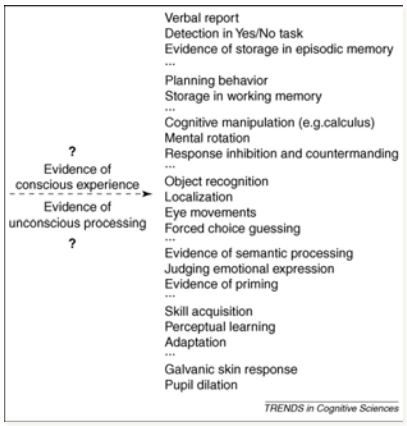
What is **not** in NCC?

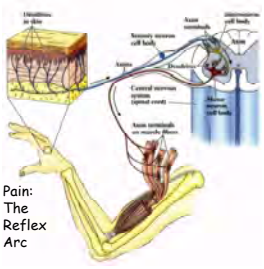
Answer: Most of the brain processes. We are not aware of most things that our brain does!



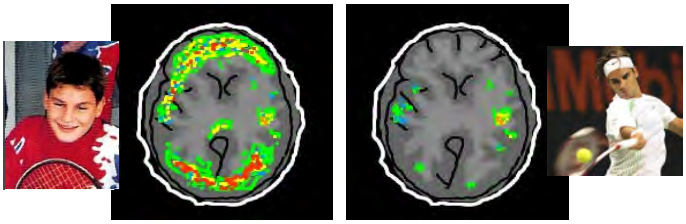
- Many brain mechanisms operate in parallel
  - Most of these mechanisms operate outside of the level of consciousness - oftne called **zombie** agents
- Functional significance of unconscious mechanisms:
  - Are **efficient** and **rapid**
  - Can operate **simultaneously**
  - Operate in the absence of consciousness?

What is **not** in NCC?





Function of Consciousness



Pre-automaticity Automaticity

•Awareness is important during learning (e.g. self reflection)
•Less important (not needed) when the task is well-learned

Conscious Awareness

- Introduction & Philosophy primer
- Why was it ignored by scientists / psychologists for years?
- What we know from brain damage cases
- Neural correlates of consciousness
- Spirituality and out-of-body experiences

Spirituality - A growing field

Work with Buddhist meditation

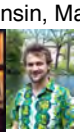
UC Davis

Cliff Saron

Alan Wallace

U Wisconsin, Madison

Richard Davidson



Antoine Lutz

Princeton

Jon Cohen

Brent Field

UCSF

Paul Ekman

U Pennsylvania

Andrew Newberg

Harvard

Stephen Kosslyn

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Spirituality - A growing field

U Pennsylvania

Andrew Newberg

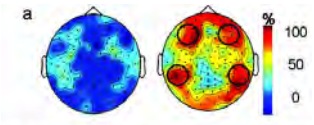
Work with Christian meditation (carmelite nuns)

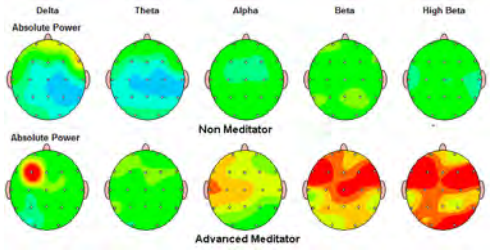
U Montreal

Mario Beauregard

62

Long-term mediators self-induce high-amplitude neural synchrony during mental practice





Lutz et al. (2004)

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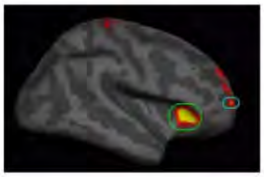
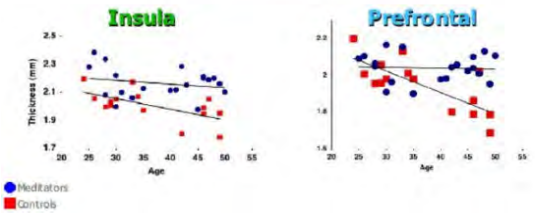
Cortical thickness does not decrease with age in mediators





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Current Biology Vol 15 No 11
R412

Meditation alters perceptual rivalry in Tibetan Buddhist monks

O.L. Carter[1], D.E. Presti[2], C. Callistemon[1], Y. Ungerer[1], G.B. Liu[1] and J.D. Pettigrew[1]

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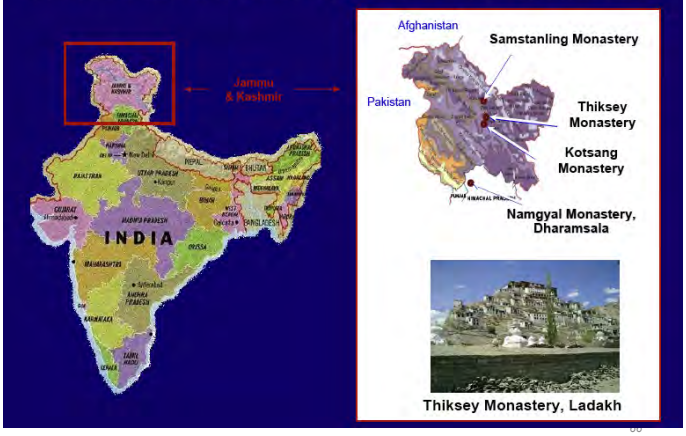
Buddhist monks were tested at 4 monasteries in Northern India.



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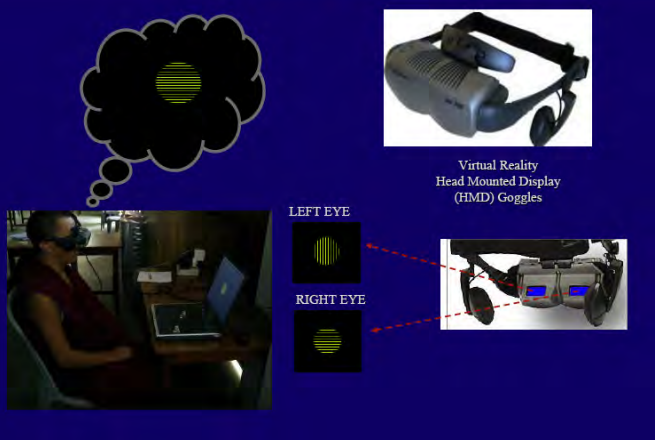
Binocular Rivalry



Methods

76 monks (5-54 years training)
including 3 "retreatest" meditators
- 23 monks tested on binocular rivalry

1st) Familiarization

2nd) Experimental conditions

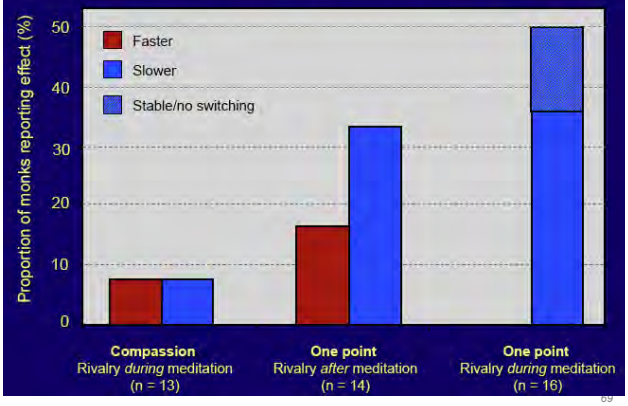
- 1 non-meditation condition & 3 different viewing conditions

Rivalry during meditation
(button-press & verbal report)

Rivalry after meditation
(button-press & verbal report)

Rivalry during meditation
(verbal report only)

Results – Switch Rate



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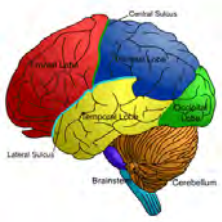
The Spiritual Nature of Man
(Alistair Hardy, 1979)

- Religious Experience Research Unit (RERU), Manchester College in Oxford
- Hardy collected data on spiritual experiences (SEs) for a few decades
- He received over four thousand firsthand accounts of SEs from people of all socioeconomic levels (across UK)
- Hardy and his colleagues identified a variety of "triggers" for SEs
- Most common triggers
  - Depression or despair
  - Prayer or meditation
  - Natural beauty

The **temporal lobe** and spiritual experiences (SEs)

- SEs can occur in conjunction with **temporal lobe epilepsy** (**TLE**)
- **TLE** has been associated with intensification of spiritual and mystical feelings as well as religious conversion



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The "God module" hypothesis
(Ramachandran et al., 1997)

- Study participants
  - Two patients with **TLE**,
  - a group of highly religious volunteers,
  - and a non-religious group
- Four lists of words: sexual, violent, religious, or neutral
- Galvanic skin response (emotional arousal)
- Greater emotional arousal in **TLE** patients in response to religious words
- Conclusion: SEs are mediated by a "God module" localized in the **temporal lobe**

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Michael Persinger

- "Religious belief is an artifact of the brain"
- 'Microseizures' in the **temporal lobes** can generate SEs , i.e., these experiences are "delusions created by the brain"
- It is possible to induce such experiences by stimulating (using TMS) the **temporal lobes**

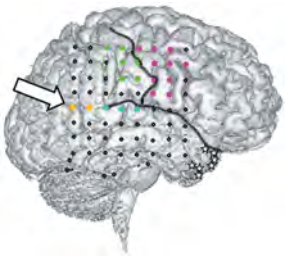
"The God helmet"

Near death experience of Pam Reynolds

- 1991: hypothermic cardiac arrest to remove a giant basilar artery aneurysm in her brain
- "Standstill" : body temperature lowered to 60 degrees, heartbeat and breathing stopped, blood drained from the head, flat EEG, brain-stem activity abolished (loss of the corneal reflex, fixed and dilated pupils, loss of the gag reflex)
- Duration of clinical death: one hour
- Out-of-body experience: description of the surgical tools and procedures associated with the surgery/dialogues between surgeons and nurses
- Sensation of floating out of the operating room and travelling down a tunnel (at the end of it were deceased relatives and friends)
- Presence of a brilliant, wonderfully warm and loving light
- Intense SE that greatly transformed he psychologically and spiritually

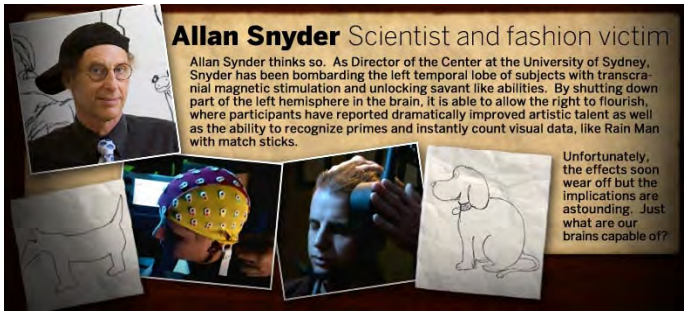
Illusory out-of-body experiences

• stimulation of brain areas shown below
• stimulation of temporoparietal junction (TPJ) resulted in a out-of-body experience

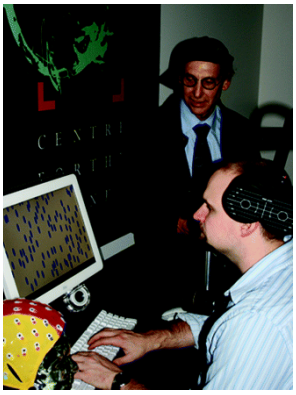


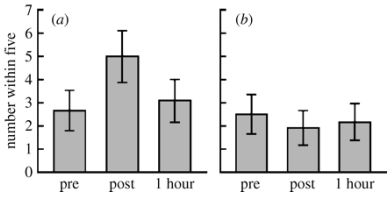
Blanke et al (2002).

Alan Synder's thinking cap



Alan Synder's thinking cap





TMS 'Sham' TMS

Alan Synder's thinking cap