

# Self as a function of the brain

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Soul or brain: what makes us human?

Toruń, 19-21.10.2016

# Steps ...

Brain as a receiver of consciousness, or “radio theory of brains” – thousands of articles and many books.

1. Traditional views.
2. Complexity of the brains.
3. No function for souls.
4. Animal minds.
5. Personal identity.
6. AI and mechanics of cognition.
7. Conclusions.



# Who am I?



Quis ego et qualis ego?

Who am I and what kind of man am I?

**St. Augustin** (400)

What is the self?

Where then is this self, if it is neither in the body nor the soul?

**Pascal** (1670)

How can we answer such questions?

You are nothing else but a bunch of neurons (**Crick**).

You are your synapses (**LeDoux**).

Is that a satisfactory answer? Not for all ...

# Ancient view

Things do not move by themselves, bodies are animated by spirits/souls.  
Egyptians: 7 immortal souls, including shadow and personal name!

Aristotle (*De anima*) and St Thomas (*Summa Theologica*):  
3 souls: vegetative or plant soul (growth), an animal soul (response),  
philosopher's soul (mind) – but these concepts lost their reference.

Michał Heller: we had Galileo case, now Darwin, and sooner or  
later neuroscience case, theologians should not be satisfied with  
ancient times.

Bible: nondualistic, psychosomatic unity of human nature.

Gilbert Ryle, *The concept of mind*, Univ. of Chicago Press (1949)

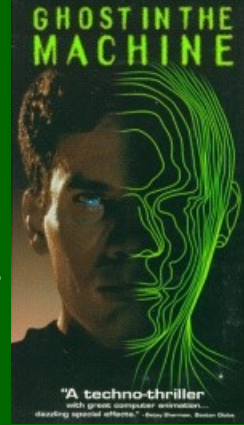
Is there a ghost in the machine?

Is there a horse inside the steam train?

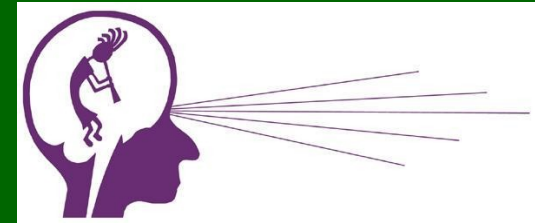
Mind (whole organism) is a process, succession of brain states.

Duch W, Soul & spirit, or prehistory of cognitive science.

Kognitywistyka 1 (1999) pp. 7-38



# Traditional view



Aristotle, Aquinas and others could only speculate, but new little.

The illusion of “ghost in the machine” (homunculus) is strong.

“I” decide in a conscious and free way,  
I am fully responsible for my actions.

Popper & Eccles in “The Self and Its Brain” (1977):  
self can’t be just the brain. Self is primary.

Going back to the idea of souls animating bodies.

**S. Pinker:** Tabula Rasa. The modern denial of human nature (2002)

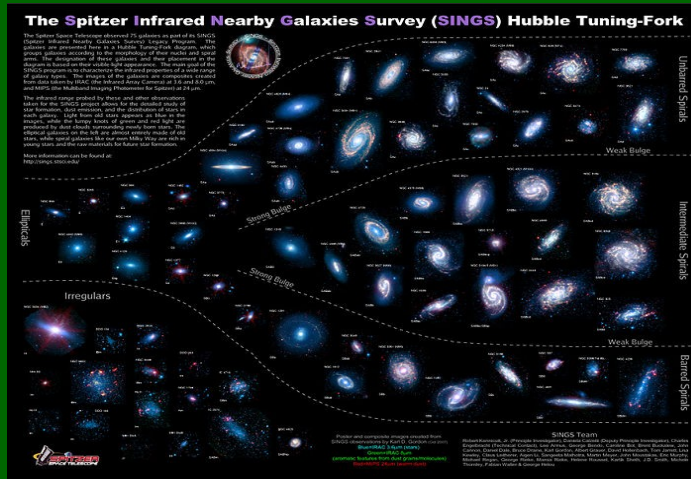
- Tabula Rasa (**J. Locke**) – only environment matters.
- Noble savage (**J.J. Rousseau**) – nature (human) is good.
- Ghost in the machine (**Descartes**) – soul controls body.

The order in which we learn matters!



# Astronomy and neuroscience

Compare ancient views with modern astronomy,  
infinitely more sophisticated - 2 trillion galaxies!



We do not believe in flat earth in the center of the Universe,  
although our direct experience favors such beliefs.

The ancient understanding of a person has not changed much in  
the folk psychology or religious thinking. Faithful simply trust  
their priests ... Neuroscience is at the front of deeper  
understanding of human nature.

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# I. Complexity of brains



Complex processes produce relatively simple functions (worms, insects).  
Everything in biology is incredibly complex.

Human brains are most complex objects in the known Universe.

Human organisms contains:

- $\sim 50 \times 10^{12} = 50$  trillion cells, with 2m of DNA each.
  - $\sim 10^{14} \text{m} = 100$  billion km DNA or 666 x distances to the Sun!
  - Bacteria, viruses, fungi, archaea and other microbes outnumber cells.
  - $\sim 10^{15} = 1$  quadrillion of synapses;  $>1$  mln new synapses/sec formed during infancy; growth controlled by neurotrophic factors
  - $\sim 10^{11} = 100$  billion neurons
  - $\sim 10$  billion proteins in each cell, more than 0.5 mln kinds of protein known
- Cells die after 4 days (gut), but some (neurons) live for 100 years.

**Organism is not a fixed thing, it is an evolving process.**



Mental/biological processes are supported by huge complexity of brains and bodies.

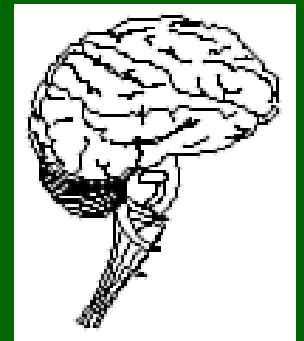
Brains/bodies are substrates in which minds may arise. Environment creates in it a specific form, the self.

Self is not born, self arises in developmental process.

All forms of memory result from physical changes in the substrate of brain matter.

Only a very small percentage of brain processes are consciously accessible.

**Mind is a shadow of neurodynamics.**



# Geometric model of mind

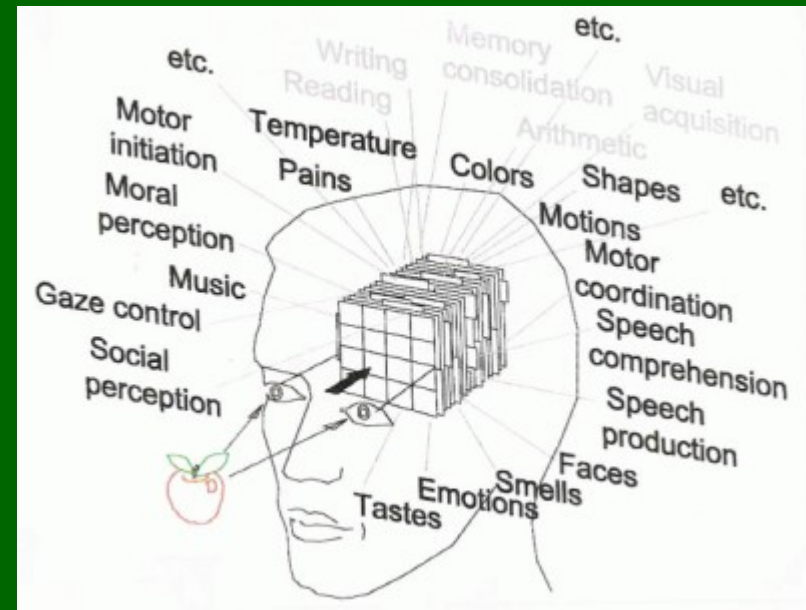
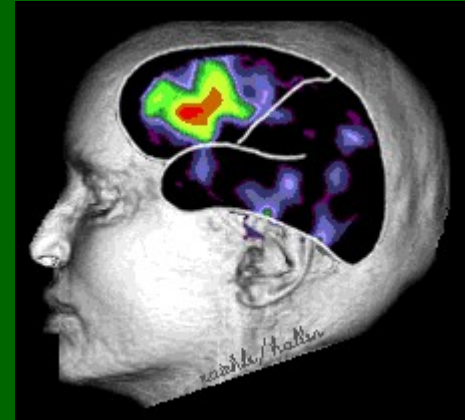
Objective  $\leftrightarrow$  Subjective

Brain  $\leftrightarrow$  Mind

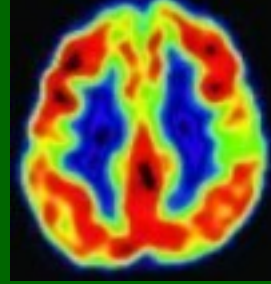
Neurodynamics :neural activity measured using neuroimaging techniques: EEG, ERP, MEG, NIRS, PET, fMRI.

Mental events: represented by qualities recognized in inner experience, hard to describe.  
E. Schwitzgabel, Perplexities of Consciousness, MIT 2011.

Unusual brains states (drugs, dreams, TMS) induce strange experiences, imagery.



# Complexity of cognition



Complex processes  $\Leftrightarrow$  complex changes in the substrate.

Cognition as a physical symbol system:

A. Newell, H. Simon, Computer Science as Empirical Inquiry: Symbols and Search. ACM Journal 19, 113-126, 1976.

- If brains are receiving anything the sending entity must be even more complex than the brain/organism itself.
- Mental states are influenced by the body, so two-way interactions with all structures of the body must take place, not just the brain – could we miss such massive info flows?

Brains working hard on solving problems require more glucose (PET) and oxygen (fMRI). Receiver does not have to work harder to move a chess figure. Brain searching for solution has to work.

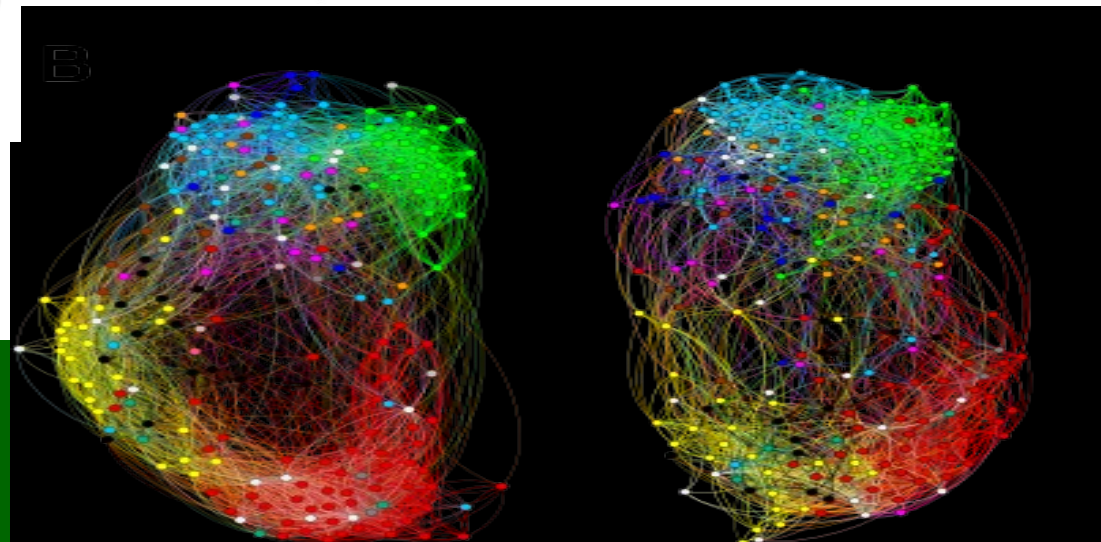
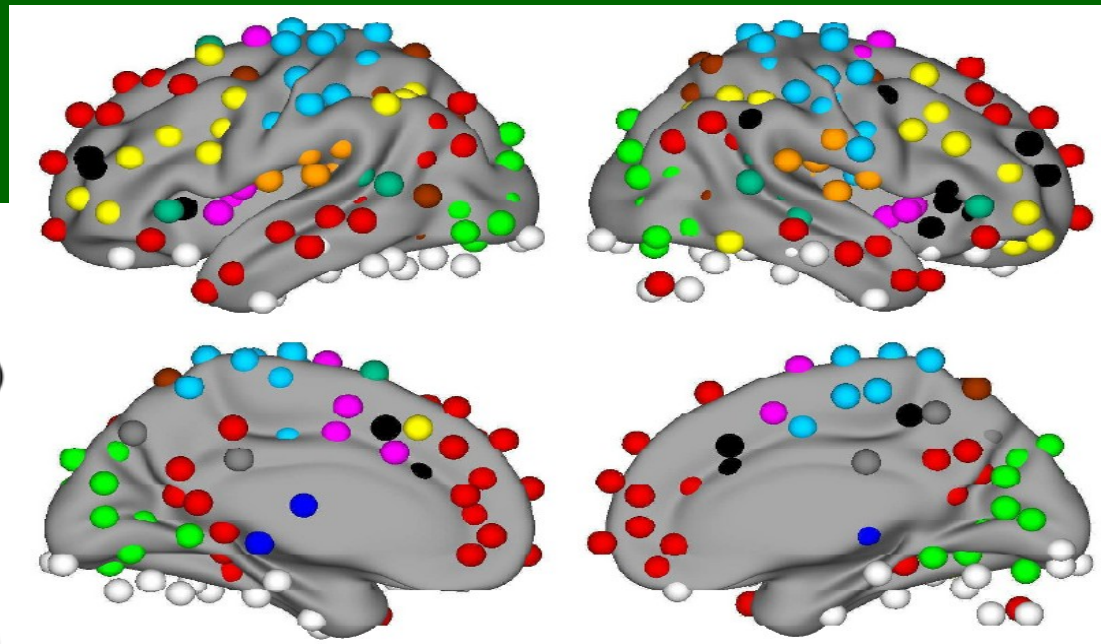
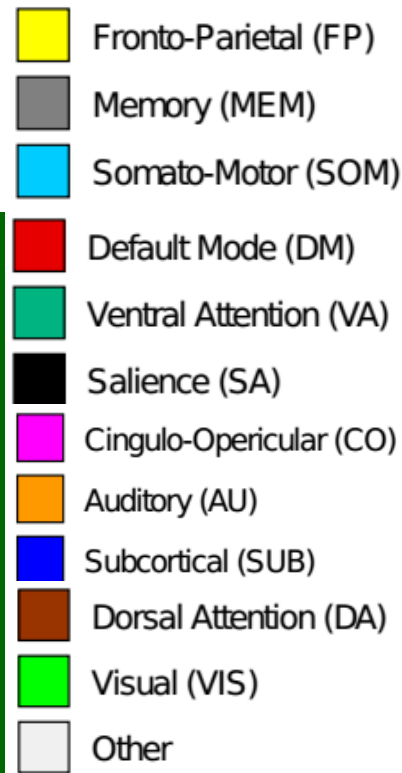
# Brain modules, cognitive processes

Simple and more difficult tasks, requiring the whole-brain network reorganization.

Left: 1-back

Right: 2-back more front to back activity.

Left and midline sections, Average over 35 participants.



1-back  $Q=0.29$

2-back  $Q=0.20$

K. Finc et al (HBM, in rev, with World Hearing Center, MPI for Human Development).

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## II. No function for souls

St Thomas and Aristotle consider 3 souls: vegetative or plant soul (growth), animal soul (sensorimotor responses), philosopher's soul (mind).

Proposed function	Old ideas	Explained by
Animation of bodies	Animism	Metabolic processes
Form of the body	Aristotle	DNA, developmental processes, topobiology
Instincts	Animal souls	Brain stem/limbic system
Dispositions	Phenomenology	Connectome
Passive intellect	St Thomas	Sensorimotor functions
Active intellect	St Thomas	Complex functions, PFC
Will	St Thomas	Basal ganglia, deep brain structures

*Élan vital* (Bergson) has been explained away by modern biology.

What could be received to have conscious brain processes?

# Conscious Perception

Very little of what passes  
In the brain is perceived.

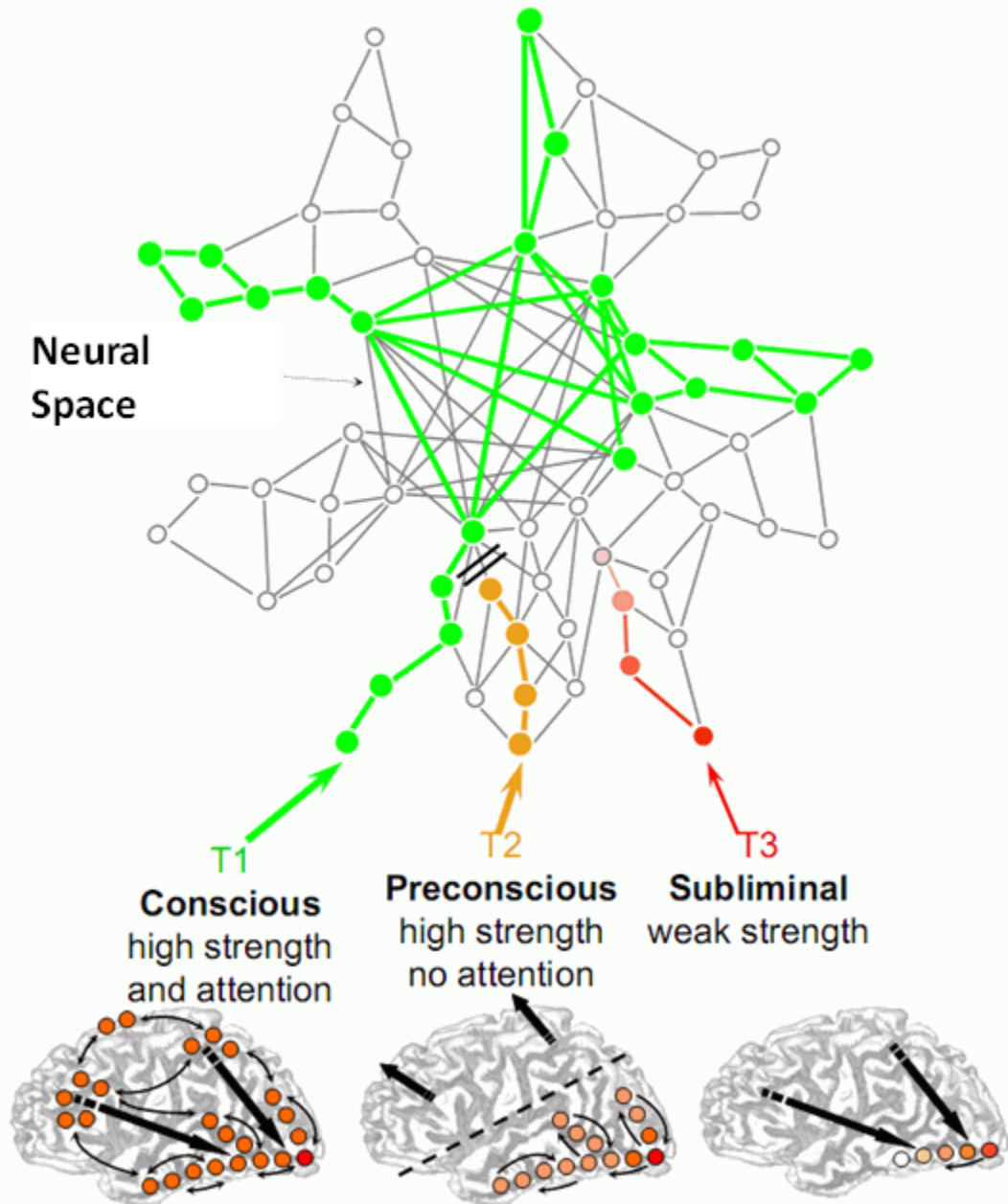
Attention + stimulation  
is needed to create brain  
states that are persistent  
and can be distinguished  
from noise.

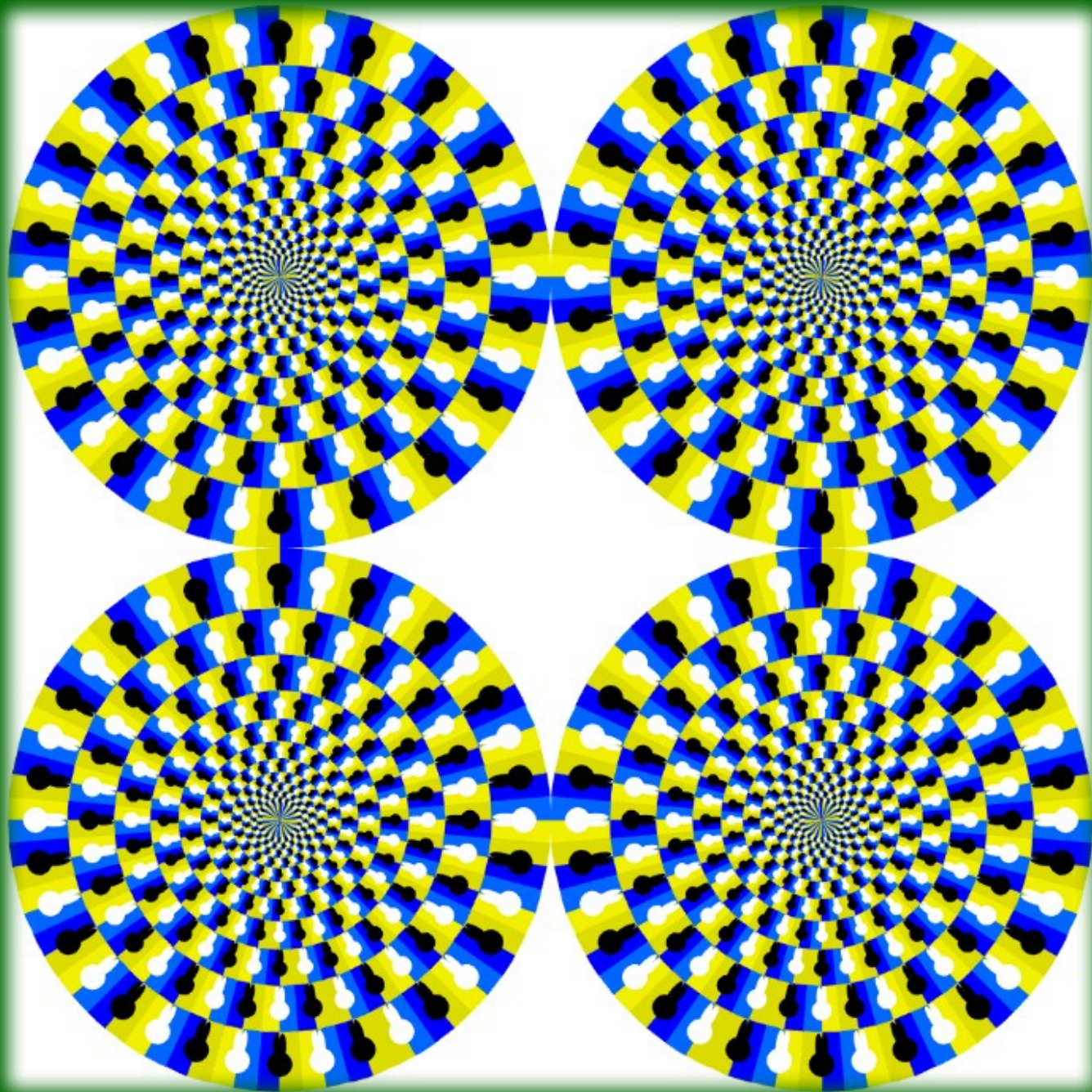
Attention: 20 Hz

Perception: 40 Hz

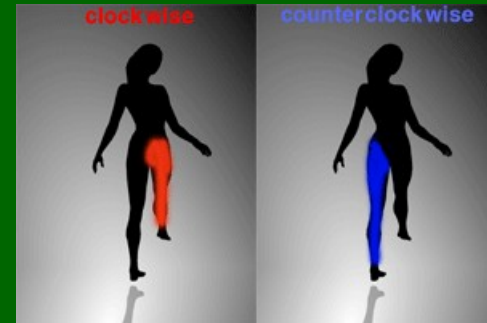
C. Gilbert, M. Sigman,  
Brain States: Top-Down  
Influences in Sensory  
Processing. Neuron 54(5),  
677-696, 2007

Dehaene, Changeux, Naccache, Sackur, & Sergent, TICS, 2006





# It is your mind that moves

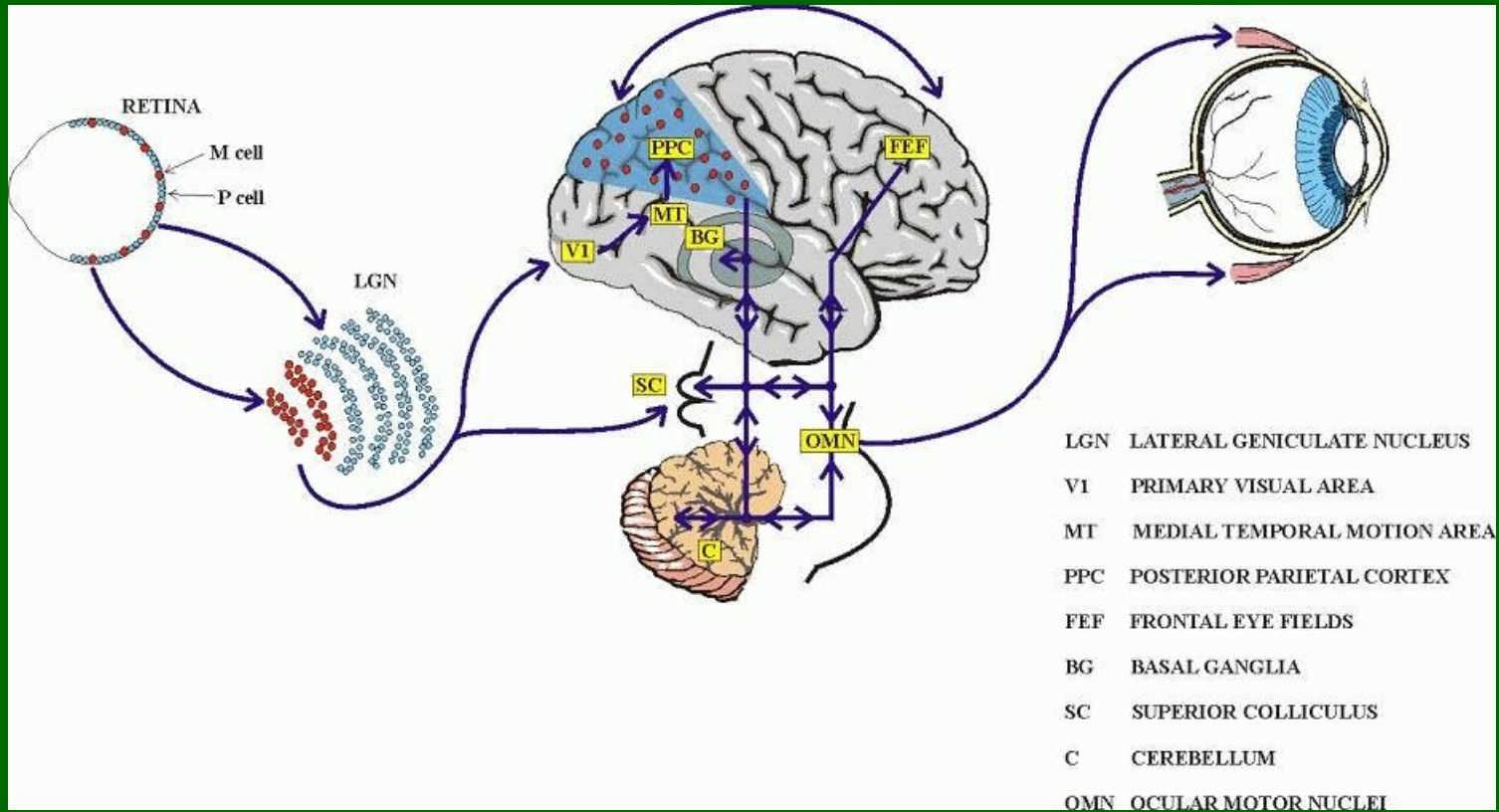


“Whilst part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes out of our own mind.”

William James, *The Principles of Psychology*, 1890



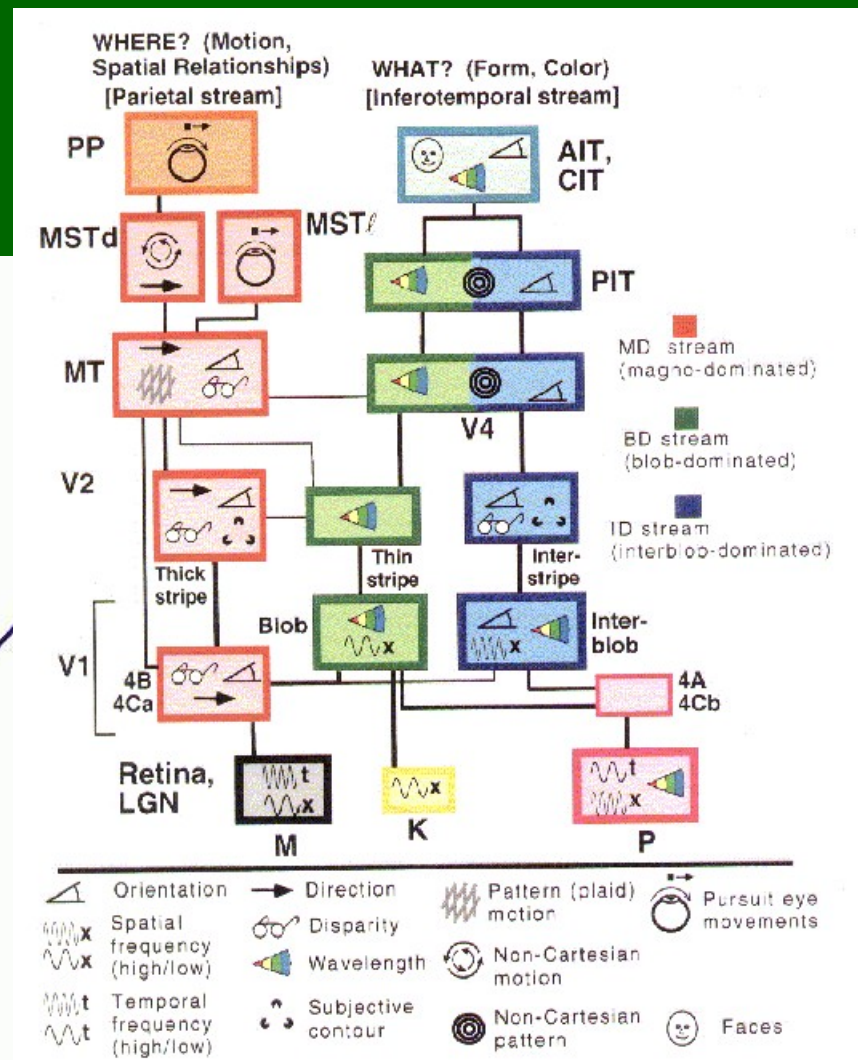
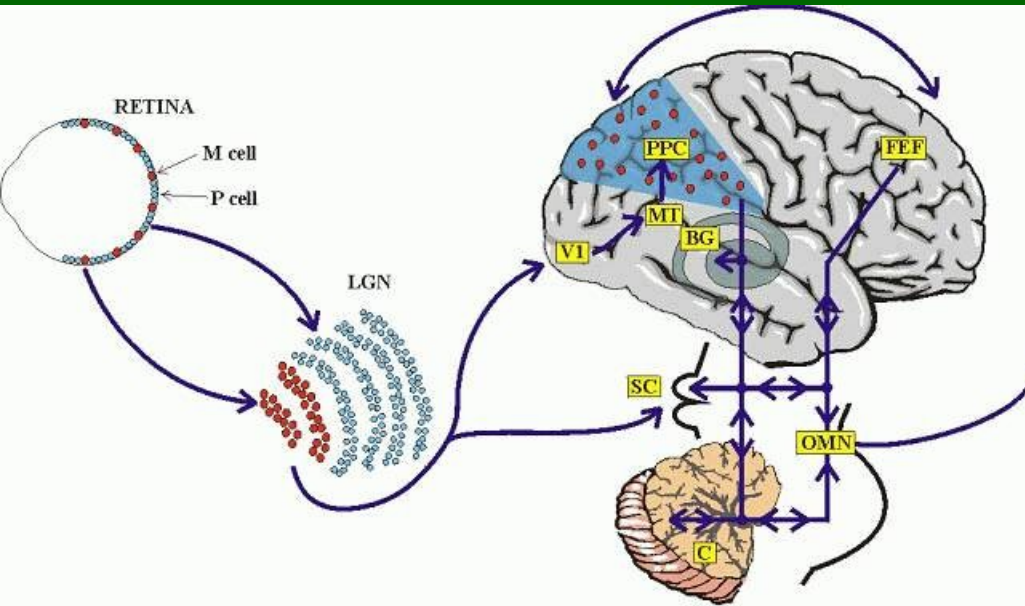
# Vision



Activity of V1 neurons is in 90% controlled top down connections from higher brain areas. Senses do not provide sufficient information, expectations that have been learned are crucial.

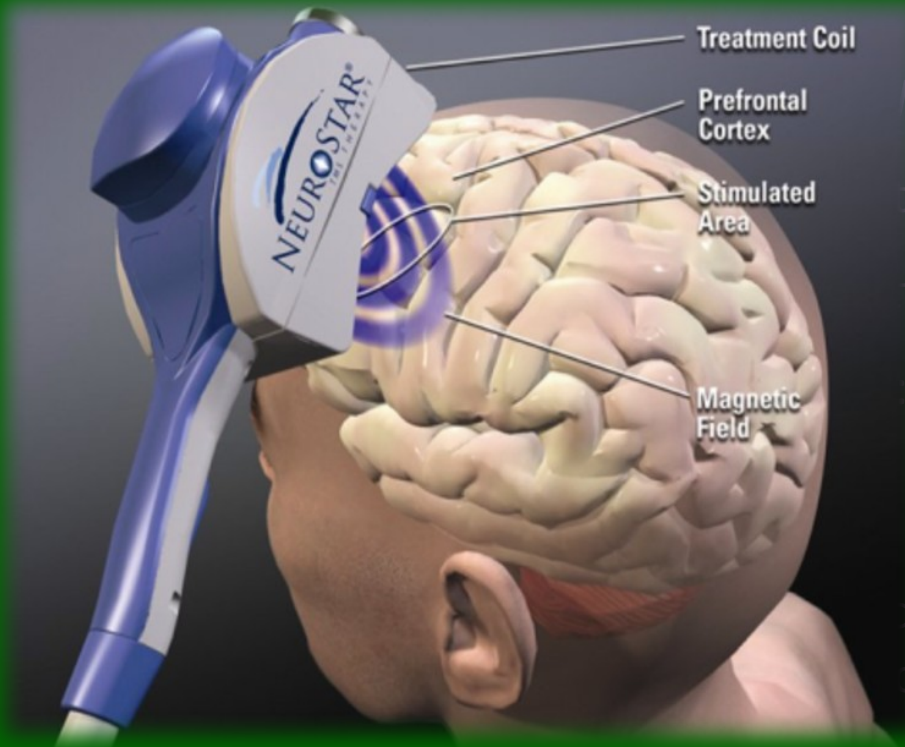


# Vision



Activity of V1 neurons is in 90% controlled top down connections from higher brain areas. Senses do not provide sufficient information, expectations that have been learned are crucial.

# Will is just another feeling



/. MIT Press(2002)

we are: ex: **ouija board**,

ion and hypnotism.

subjects may be induced to believe  
or that their actions are achieving far

t causes of our actions, instead, both  
cts of a common unconscious cause.

**TMS/DCS** stimulation: even if one side is selected 80% of times we will be sure that it is free ... Remote control may become reality in near future.

Brain stimulation may change the will, even induce immoral behavior.

Will is just another feeling resulting from attention to the state of the pre-supplementary motor cortex (**Pre-SMA**).

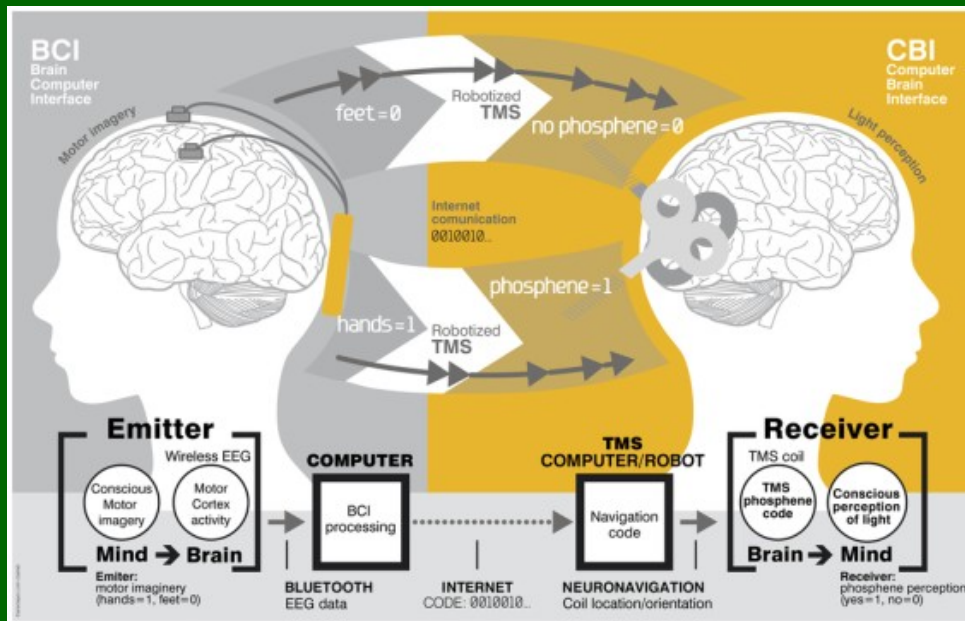
# Direct brain activation

Sony patent for direct streaming of multimedia to the brain.

Method and system for generating sensory data onto the human neural cortex. US Patent 6536440 B1.

It should enable “sensory experiences” by firing “pulses of ultrasound at the head to modify firing patterns in targeted parts of the brain.”

Conscious Brain-to-Brain Communication ?



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# III. Animal minds



The unity of nature is manifested at many levels, from molecules, proteins, genes, signaling pathways, biochemical cycles, body and brain structures, common to most animals.

Reward, fear, arousal, affective, social and cognitive functions in animals are simplified versions of human brain functions.

Animal brains should also be receivers – what could they receive?



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# IV. Personal identity

I am not conscious during deep sleep, in anesthesia, coma, various disorders of consciousness. If consciousness exists but I do not know about it, how can it be linked to my personal identity?

Egyptians thought that everything that moves is alive, shadow was considered to be a kind of soul, capable of independent life.

Should I care about my shadow? Or my neurodynamics?

**Consciousness that is not connected to my self is not me.**

- After heart surgery more blood goes to brain, neurodynamics changes thinking processes and personality.
- **Brain damage** leads to specific impairments of cognition, neuropsychology is full of strange behaviors (phantom limbs, anosognosia ... ) explained by neural information processing.
- One brain may support many behaviors, including multiple personalities, alternative “selves”.

# Do we know ourselves?

We are not aware of most processes that go on in “our” head.

We are unable to describe our mental processes.

Million voices compete for conscious attention (global dynamics).



James C. Christensen

# Development



Nature vs. Nurture – both are important.

Biology => genetic determinism.

Environment => neural determinism.

Person = Body/Mind. What is born? Body and potential for development, limited by genetics, reflexes but not the mind.

Mind develops over time. Potential should not be wasted.

Reflexes => sensory perception => object recognition => speech understanding => formation of concepts => theory of mind.

Evolution needs variability, distribution of all traits has extremes.

Wrong brain wiring => sadist, psychopath, pedophile ... saint.

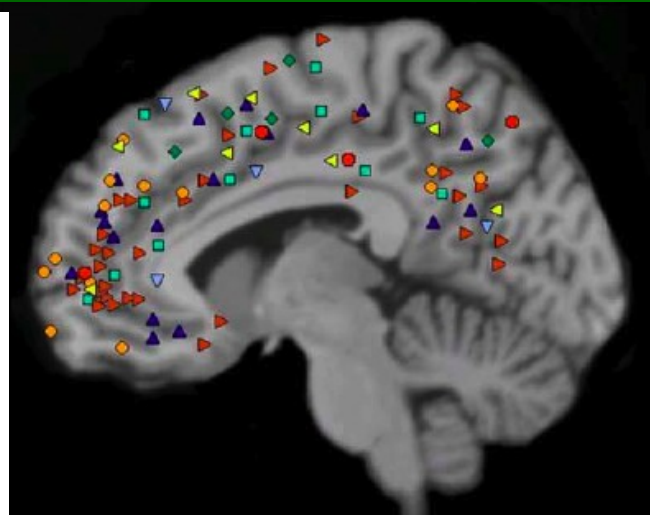
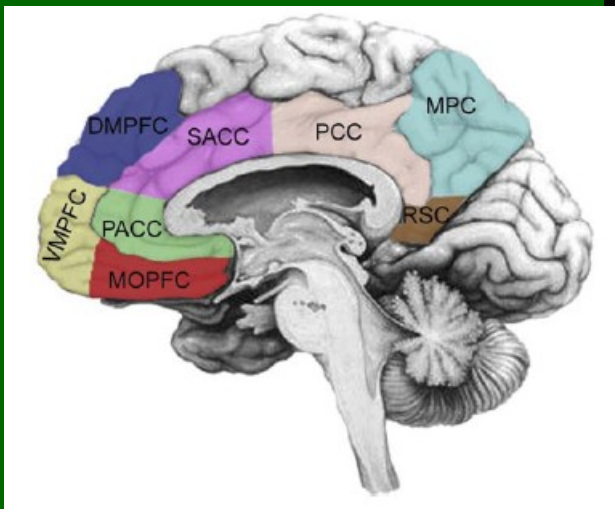
Damage to PFC leads to acquired sociopathy, impulsive affective criminals. Damage to amygdala leads to poor empathy, low fear, typical of psychopathic emotionless criminals.

~25% of all imprisoned in the USA belong to these categories.

Reward system is not functioning properly.

# Various selves

Northoff *et.al*, Self-referential processing in our brain, a meta-analysis of imaging studies on the self. *Neuroimage* 31, 440, 2006



- ▲ emotional domain: self > non-self
- ▼ facial domain: self > non-self
- memory domain: self > non-self
- ◆ motor domain: self > non-self
- ◀ social domain: self ∩ other
- social domain: self > other
- ⊕ spatial domain: self > non-self
- ▶ verbal domain: self > non-self

CMS, **Cortical Midline Structures**, are all involved in the verbal, spatial, emotional and face recognition test when self and others are distinguished. These structures are rarely damaged and are in between the rest of the cortex and limbic/brain stem structures.

Proto-self: body; autobiographical: memory; social: relations.



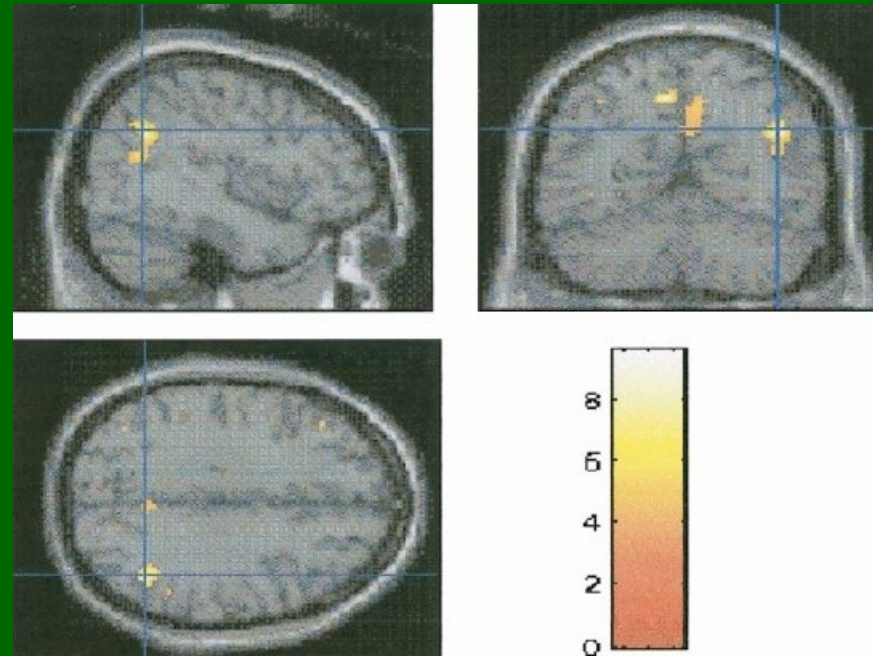
# Who is acting?

**Farrer & Frith**, Experiencing Oneself vs Another Person as Being the Cause of an Action: The Neural Correlates of the Experience of Agency, *Neuroimage* 15, 596, 2002.

Awareness of intentional acting correlates with anterior insular cortex (**AIC**), and passive acting when other person makes the movements with activity of inferior parietal cortex (**IPC**).

**AIC**: integration of multimodal sensory signals associated with voluntary movements.

**IPC**: allocentric coding system for movements that can be applied to the actions of others as well as the self.

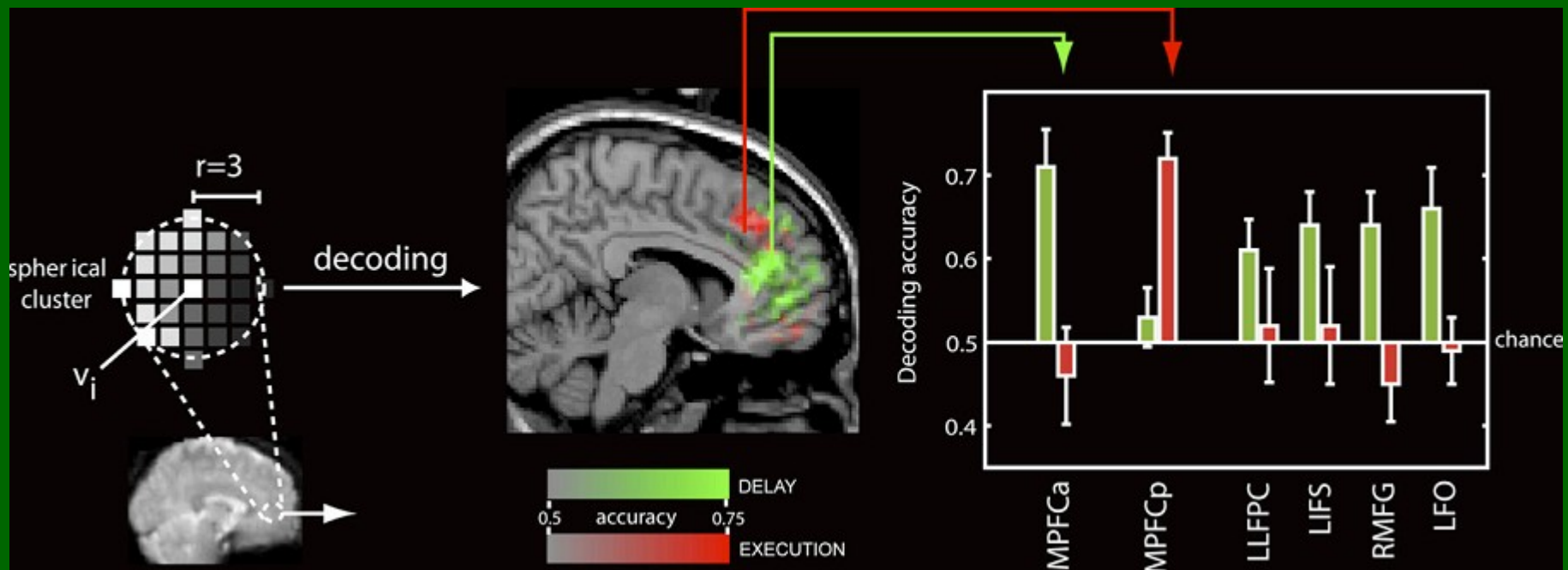


# Intentions in the brain

J-D Hayens et al, Reading Hidden Intentions in the Human Brain. Current Biology 17: 323-328, 2007.

You will see two numbers and you may add or subtract them.

Activity of the medial prefrontal cortex (MPFC) shows what are your hidden intentions (perhaps even before you begin) ...

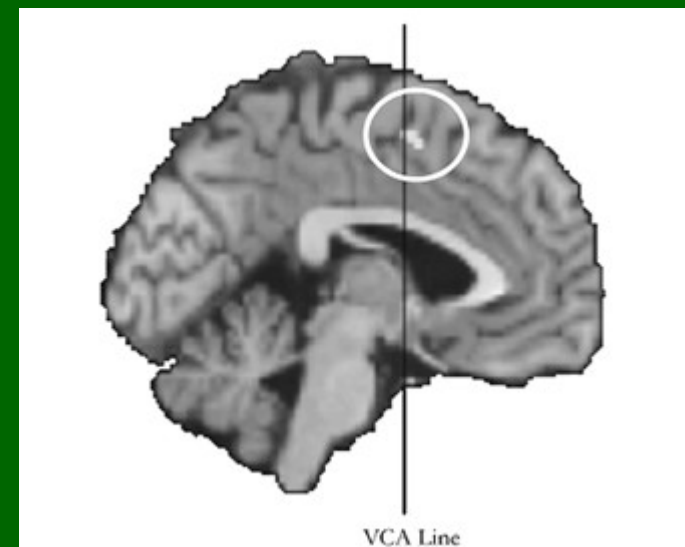
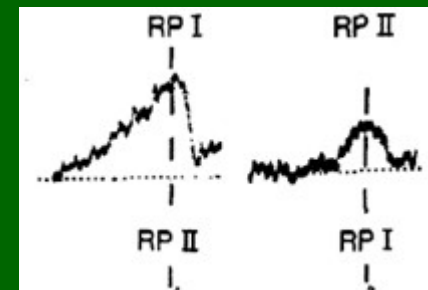
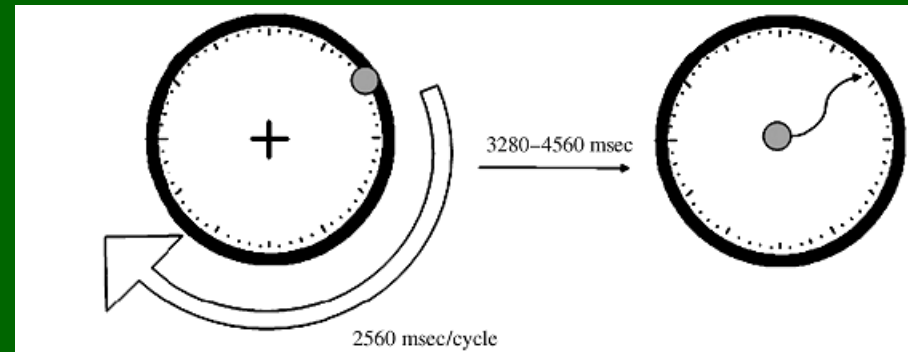


# Observer may know first ...

**B. Libet** et al. *The Volitional Brain: Towards a Neuroscience of Free Will* (2000).

Wait for the urge to act, press the button, and show the moment you have made conscious decision. ERPs show your decisions 300 ms before you became conscious that you have made it.

Newer experiments (H.C. Lau et al., 2006-08), **with TMS in pre-SMA area**:  
“We conclude that the perceived onset of intention depends ... on neural activity that takes place after the execution of action.”



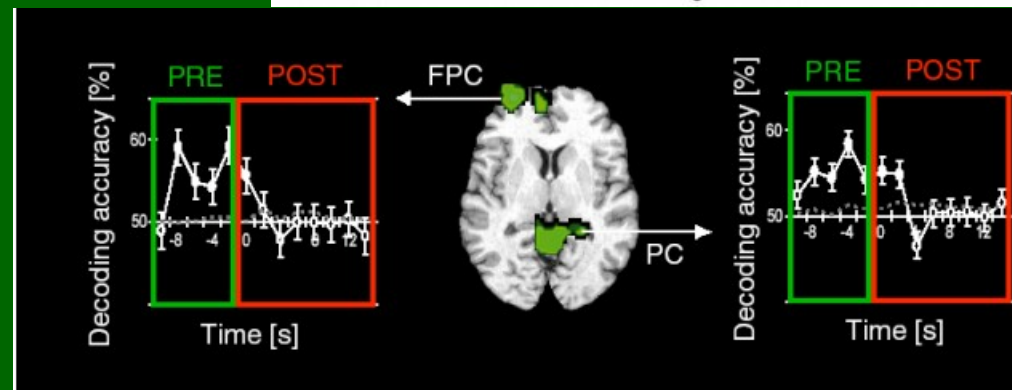
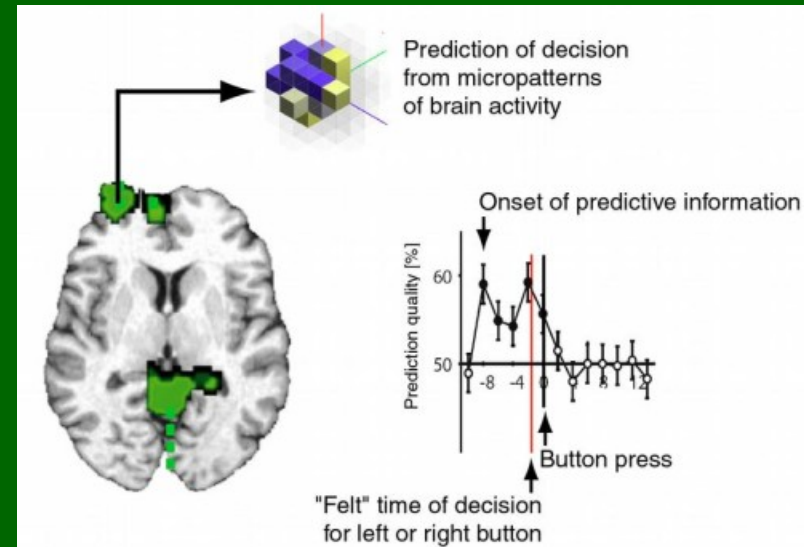
# .. even 10 seconds earlier!

C.S. Soon, M. Brass, H-J. Heinze & J-D. Haynes,  
Unconscious determinants of free decisions in the human brain.  
Nature Neuroscience, April 2008.

We found that the outcome of a decision can be encoded in brain activity of prefrontal and parietal cortex up to 10 sec before it enters awareness.

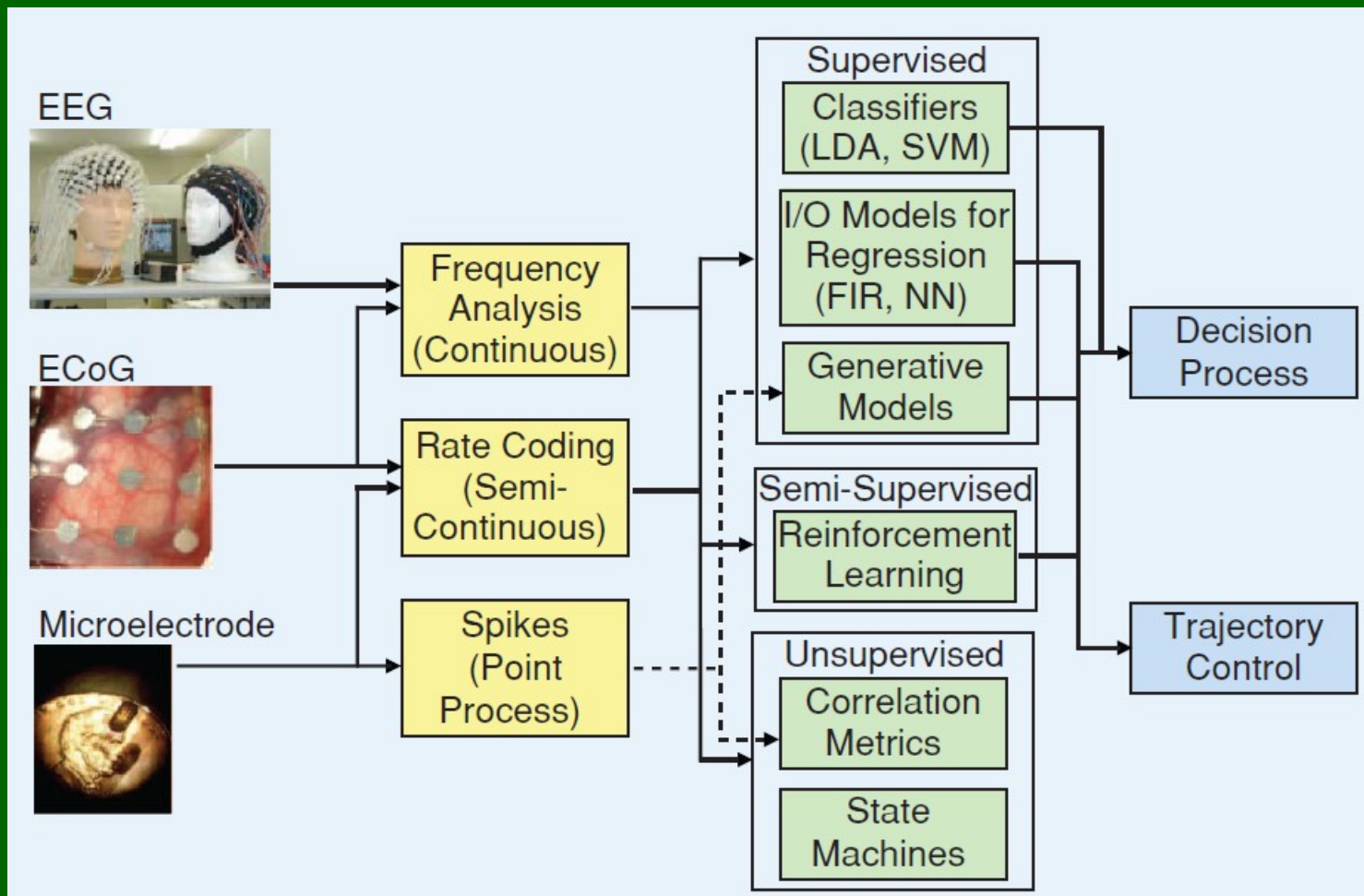
This delay presumably reflects the operation of a network of high-level control areas that begin to prepare an upcoming decision long before it enters awareness.”

Strong motor activation is need to get the feeling that I took decision.



# BCI: wire your brain ....

You must know what to do before you know what you are doing.  
With access to your brain areas that do the planning I may know  
it first! No problem with infinite regress: intention intention in...





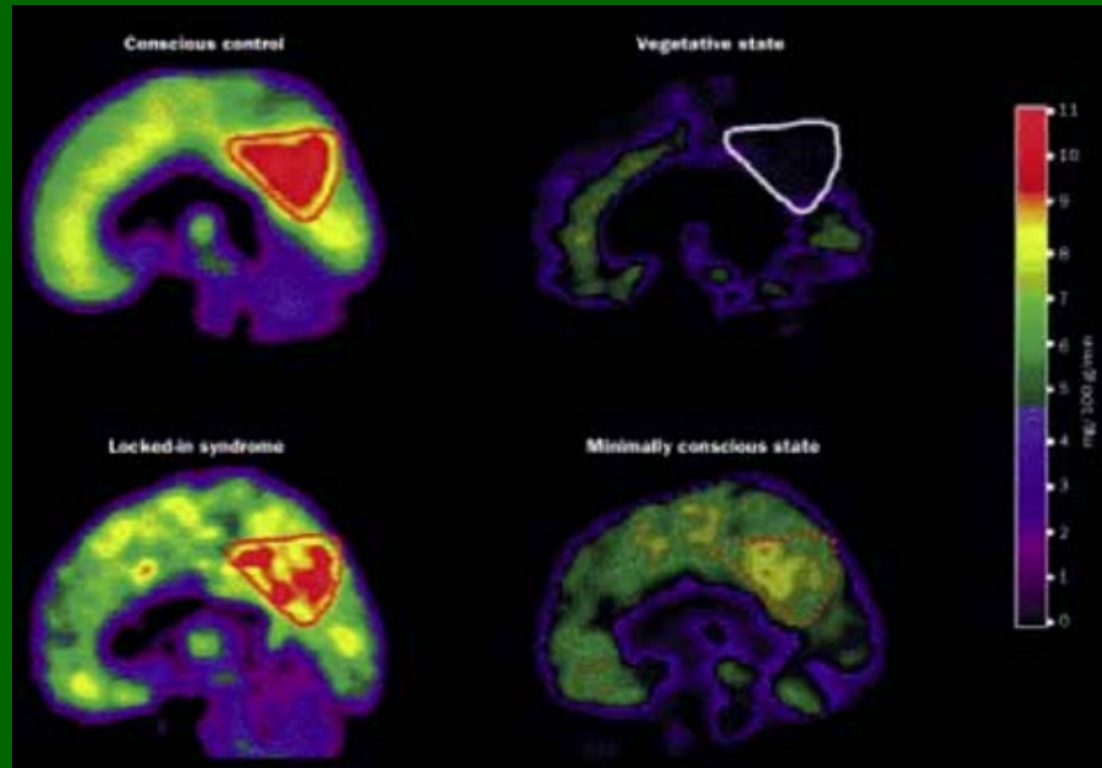
# Measuring consciousness

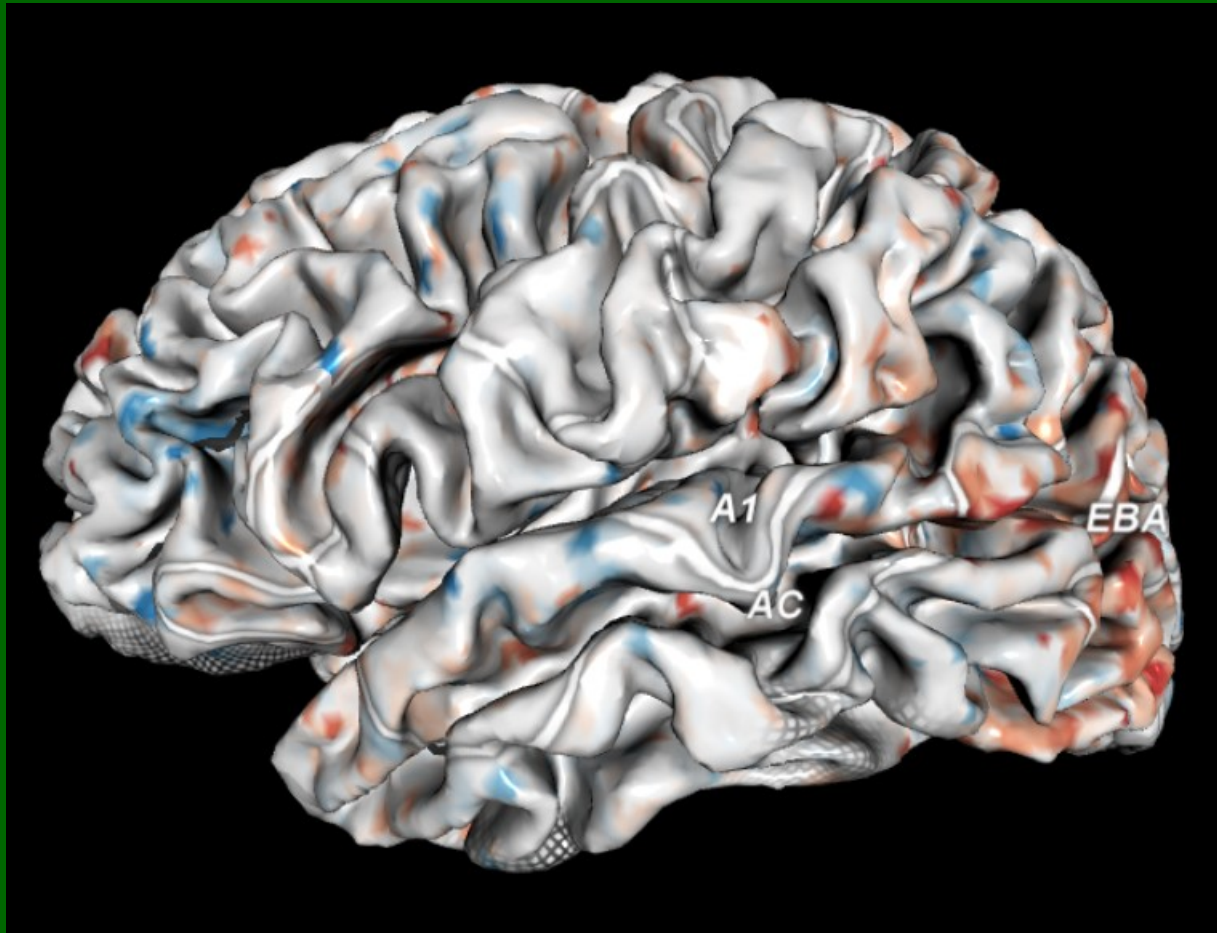
Neural correlates of consciousness?

PET studies show brain activity in normal awake subjects, locked-in subjects, anesthesia, minimal consciousness and vegetative states, and no activity of the dead brain. Normal consciousness requires **distributed integrated brain activity**.

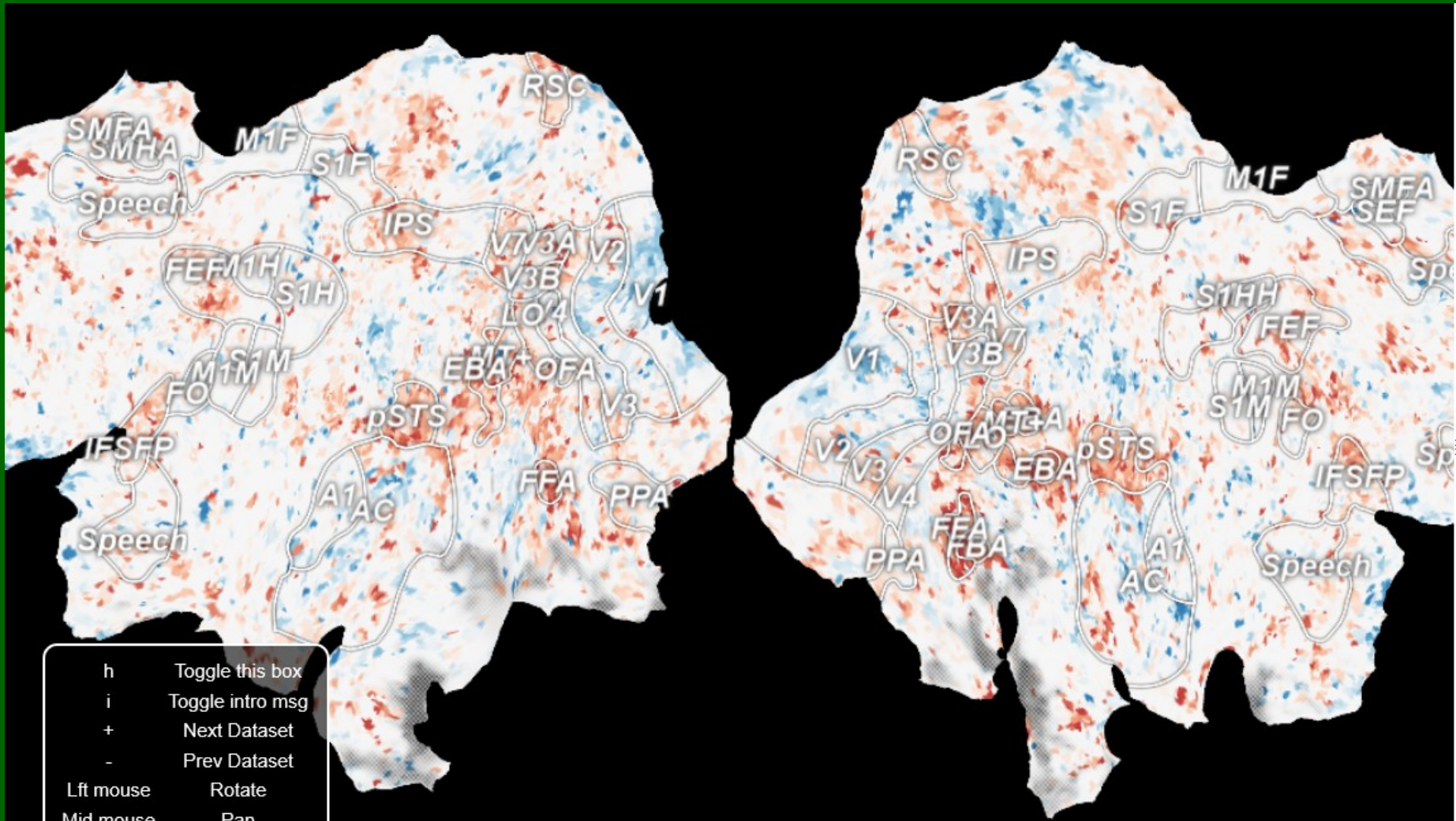
Complexity of structure is not sufficient: cerebellum has 80% of all neurons, and no contribution to conscious states.

Laureys S. et al., Lancet Neurology, 2004;3:537-54.





Activation of specific concept/mental state/musical phrase leads to activation of a network of specific structures in the whole brain, contributing to semantic interpretation of meaning through global brain activity.



This activation is sparse and may be better observed by looking at the flattened cortex:

<http://gallantlab.org/brainviewer/huthetal2012/>

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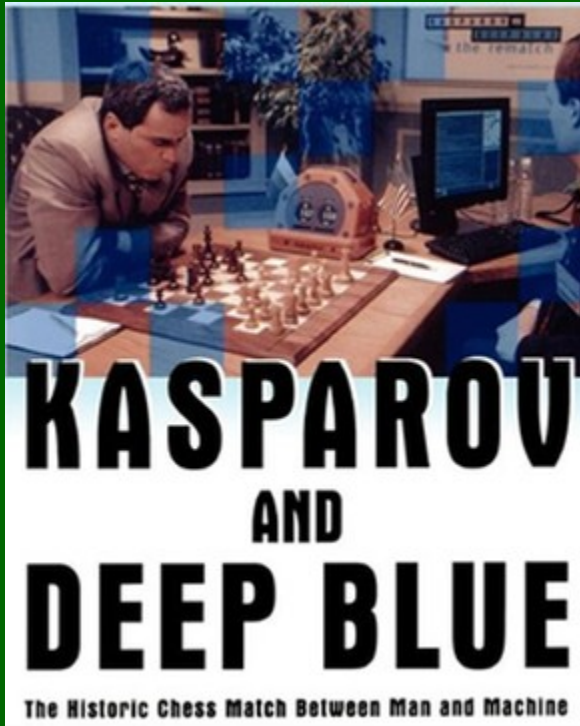


# V. AI and mechanics of cognition

- There are no structures in the brain that receive external commands; the sensory and proprioceptive inputs modulate intrinsic dynamics.
- Neural models of associative, content-addressable memory show all the properties of biological memories, explain various form of amnesia.
- Reward-based learning modifies network structure to reflect environmental events, creates complex internal model of the world and facilitates taking decisions.
- Computational models explain nature of perception, specific qualia associated with sensory experiences, including such strange phenomena as phantom limbs, third hand experience or autoscopic phenomena (illusions of leaving one's own body).
- Computational models help to understand neuropsychological syndromes, psychiatric dysfunctions and cognitive aspects of neurological problems.
- Recent advances in artificial intelligences, nanotechnology and neuromorphic chips point the way to construction of conscious machines.
- Computers are better than brains in many applications requiring thinking.



# AI Progress



1995 – Chinook checkers program wins 6:0 with world champion Dr Tinsley.

1997 – chess, Deep Blue wins with Kasparov.

2011 – IBM Watson wins with two best Jeopardy (Va Banque) players.

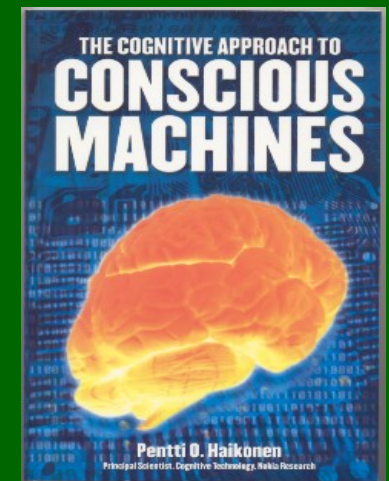
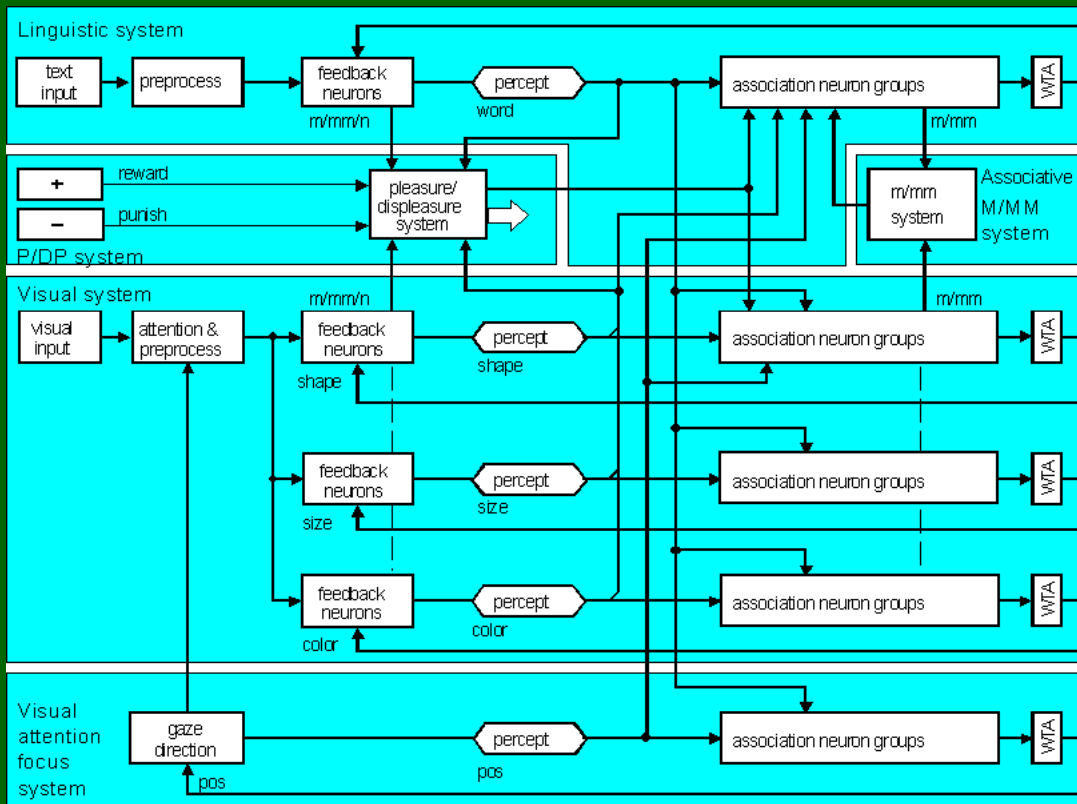
2015 – robotic lab + AI software discovers genetic and signal pathways regenerating flatworms.

2016 – Google AlphaGo wins with Lee Sedolem 4:1



# Conscious machines

Many attempts to create brain-inspired cognitive architecture (BICA) are under way. For example, Haikonen has done some simulations based on a rather straightforward design, with neural models feeding the sensory information (with the Winner-Takes-All associative memory) into the associative “working memory” circuits. Such architecture could have interesting neurodynamics.



# Hector, conscious insect



Holk Cruse, Malte Schilling, Mental States as Emergent Properties. From Walking to Consciousness. In T. Metzinger, ed. Open MIND Project 2015.

Hector: insect that walks, plans its path, imagines alternative actions.

A number of higher-level mental states may be attributed to the control system of Hector. “Inner mental states” include intentions, goal-directed behavior guiding robot actions (find food = charging station).

Body properties are coupled with the environment and used in internal model for planning actions (second-order embodiment).

Emotions are inherent properties of behavior implemented in the control model based on recurrent neural networks (RNN).

Emergent property: phenomenal aspects of emotions.

“Depending on its inner mental state, the system may adopt quick, but risky solutions, [... or] take its time to search for a safer solution.”  
Still too simple? Well ...

# Neuromorphic computers

Synapse 2015: IBM TrueNorth chip

~1M neurons and ¼G synapses, ok 5.4G tranzystorów.

NS16e module=16 chips=16M neurons, >4G synapses, requires only 1.1 W!

Scaling: 256 modules, ~4G neurons, ~1T=  $10^{12}$  synapses < 300 W power!

IBM Neuromorphic System can reach **complexity of the human brain.**



# Conclusions

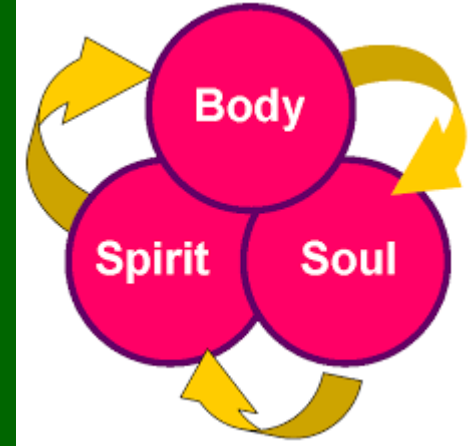


Brain as a receiver of consciousness  $\Leftrightarrow$  we have no idea how it works. This is simply ignorance, because we do know a lot about mechanics of brain processes. Connection to some disembodied entity has always been problematic.

- There are no good arguments against convergence of the neural modeling process in embodied systems and brain-like structure to conscious artifacts.
- Artificial minds of brain-like systems will have to claim qualia; they will be as real in artificial systems as they are in our brains.
- Measures of the level of consciousness based on integrated information theory or its variants are increasingly useful in medicine and AI.
- Scientists do not ask “what is life” anymore, neuroscientists use heterophenomenology, linking experimental conditions with subjective conscious perception, or specific brain reaction.



# Idealist and materialist



## Surprise!

Idealists believing in substantial nature of the soul are materialists.

Mind is truly non-materialistic, although supported by the brain substrate.

Form is not matter, as Aristotle understood. Form in the brain is the dynamical information structure that has potential for creating neurodynamical states.

Dynamical processes in the brain/whole organism are responsible for behavior, body control, conscious perception of brain activity, self and personality.

# Neuropercog - infants, learning, and cognitive development. Toruń, Poland (29-30.10.2016)



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**NeuroMania IV**  
28-29 maja 2016, Toruń

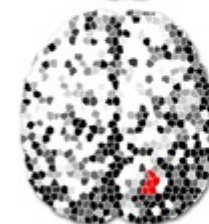
**HOMO COMMUNICATIVUS**  
WSPÓŁCZESNE OBlicZA KOMUNIKACJI I INFORMACJI

Toruń, 24-25 VI 2013 r.

Cognitivist Autumn in Toruń 2011  
**PHANTOMOLOGY:**  
*the virtual reality of the body*  
2011 Torun, Poland

Cognitivist Autumn in Toruń 2010  
**MIRROR NEURONS:**  
*from action to empathy*  
April, 14-16 2010 Torun, Poland

CSW Toruń, 20-21 czerwca 2012

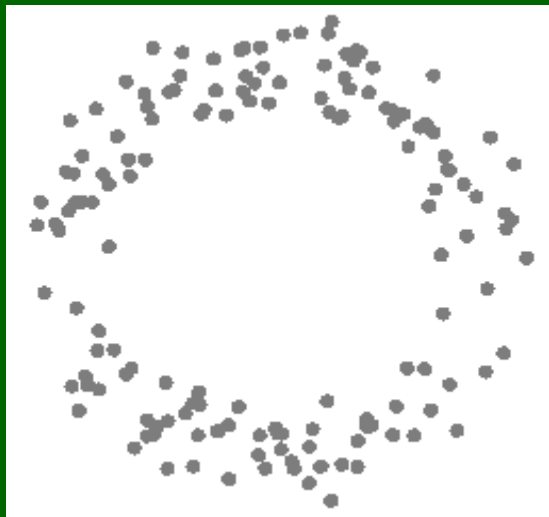


**NEURO**

historia sztuki?

[www.neurohistoriasztuki.umk.pl](http://www.neurohistoriasztuki.umk.pl)

Thank you for  
synchronization of  
your neurons!



Google: Wlodzislaw Duch  
=> papers, talks, lectures ...



# Erosion: neural determinism

Questions of the King Milinda (Milinda Panha, ca. +400).

Nagasena: Water erodes the soil and flows in the same riverbeds, just like neural activation flows in our brains, creating habits and memes.



New things are learned on the canvas of what we already know, the order in which we learn is important (ex. creationist ideas).