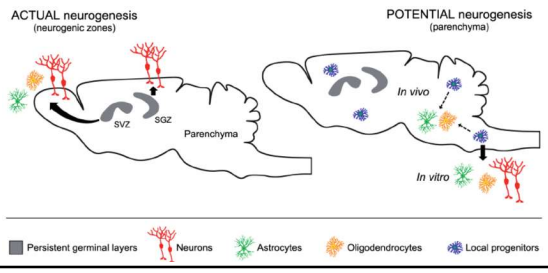
Neuroscience Lectures for MBT

Breaking from Dogma

Once development was ended, the founts of growth dried up irrevocably.
In the aduld the nerve paths are immutable.
Santiago Ramon y Cajal, 1905

AA.VV., *Giulio Bizzozero: cento anni di cellule labili, stabili e perenni*, Vol 3 Notebooks of the Academy of Science of Torino, 1996



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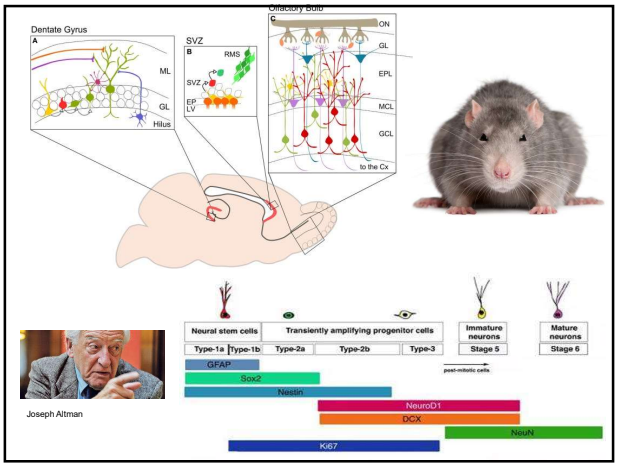
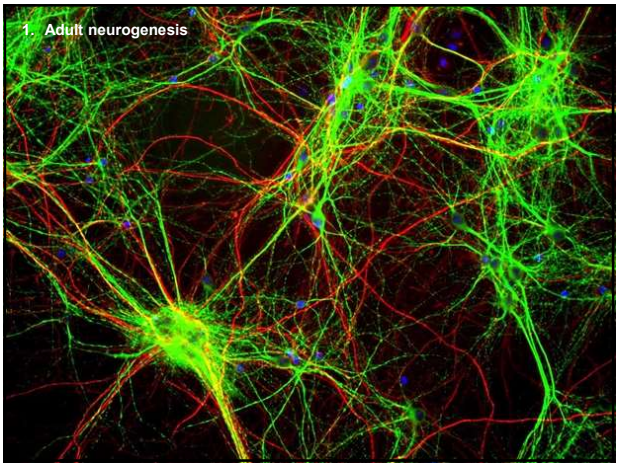
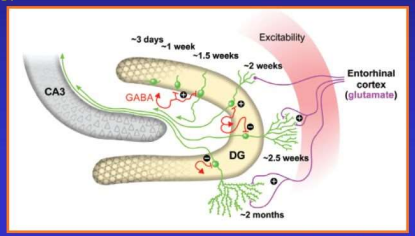


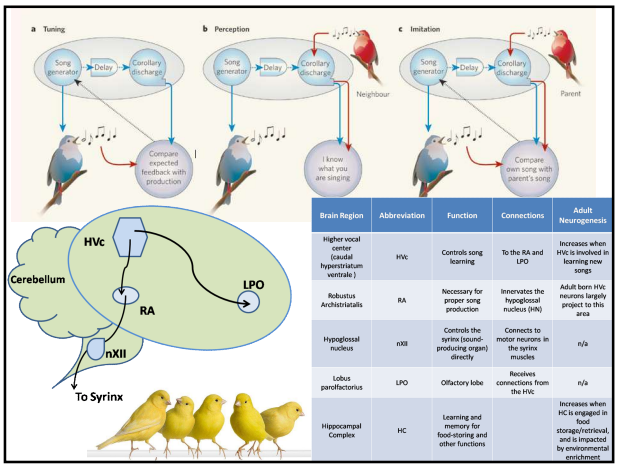


Adult Neurogenesis

1. Proliferation, survival, and differentiation of new neurons from stem cells in adult brain.
2. Occurs mainly in dentate gyrus and sub-ventricular zone.
3. Measured using thymidine analogs (BrdU) or endogenous markers.



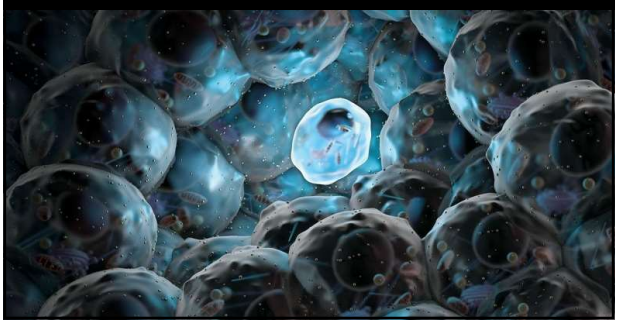
Aimone et al. 2006



Brain Region	Abbreviation	Function	Connections	Adult Neurogenesis
Higher vocal center (caudal hyperstriatum ventrale)	HVc	Controls song learning	To the RA and LPO	Increases when HVc is involved in learning new songs
Robustus Archistriatalis	RA	Necessary for proper song production	Innervates the hypoglossal nucleus (HN)	Adult born HVc neurons largely project to this area
Hypoglossal nucleus	nXII	Controls the syrinx (sound-producing organ) directly	Connects to motor neurons in the syrinx muscles	n/a
Lobus parolfactorius	LPO	Olfactory lobe	Receives connections from the HVc	n/a
Hippocampal Complex	HC	Learning and memory for food-storing and other functions		Increases when HC is engaged in food storage/retrieval, and is impacted by environmental enrichment

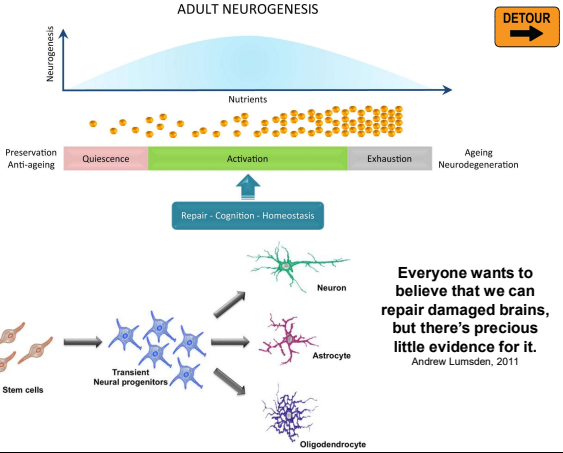
1. Adult neurogenesis

TAKE HOME MESSAGE:
– DOES THE ADULT BRAIN PRODUCE NEW CELLS? –



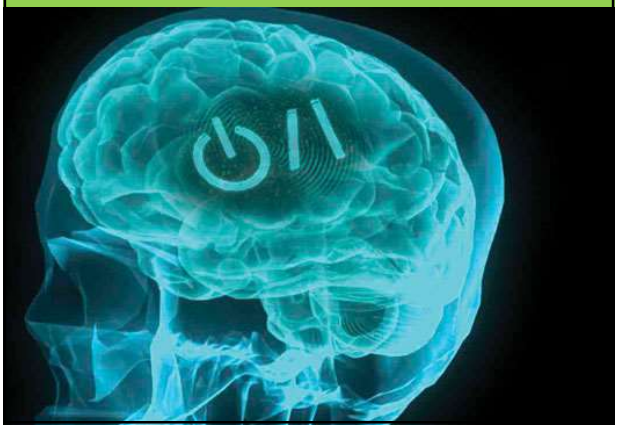
ADULT NEUROGENESIS

DETOUR

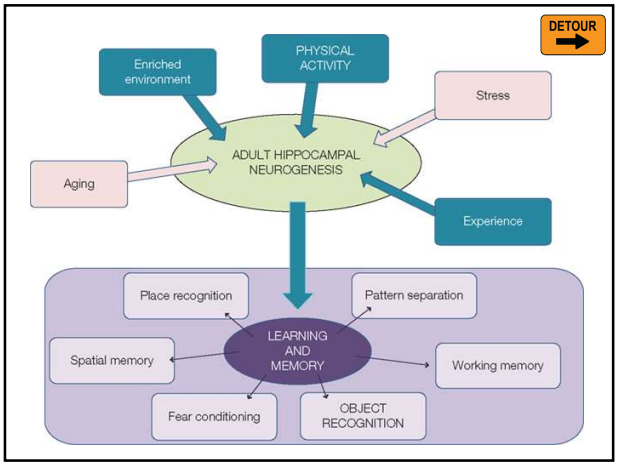


Everyone wants to believe that we can repair damaged brains, but there's precious little evidence for it.
Andrew Lumsden, 2011

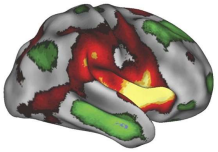
2. Default mode



DETOUR



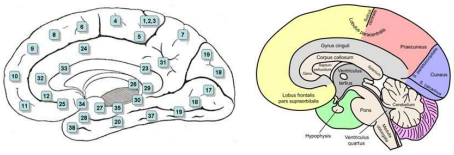
The **default mode network** (**DMN**), also **default network**, or **default state network**, is a large scale brain network of interacting brain regions known to have activity highly correlated with each other and distinct from other networks in the brain.
The default mode network is most commonly shown to be **active when a person is not focused on the outside world and the brain is at wakeful rest**, such as during **daydreaming and mind-wandering**. But it is also active when the individual is thinking about others, thinking about themselves, remembering the past, and planning for the future. The network activates "by default" when a person is not involved in a task.
Though the DMN was originally noticed to be deactivated in certain goal-oriented tasks and is sometimes referred to as the **task-negative network**, it can be active in other goal-oriented tasks such as social working memory or autobiographical tasks. **The DMN has been shown to be negatively correlated with other networks in the brain such as attention networks**.



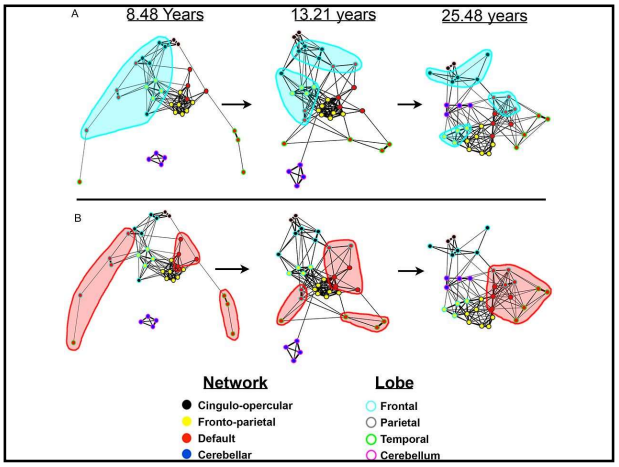
Default Mode Network
Attention/Control Network

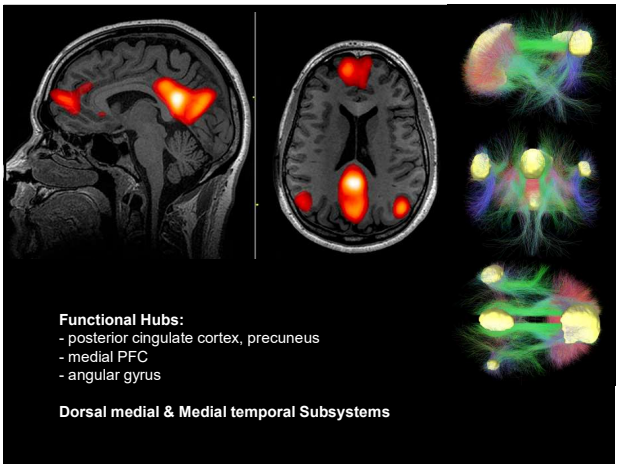
"[Resting state activity is] ... The "brain work" we carry out when left alone and undisturbed
David Ingvar, 1974

What is default mode network?



- The default mode network (DMN) is a network of brain regions that are active when the brain is at rest, which is characterized by coherent neuronal oscillations at a rate lower than 0.1 Hz.
- The DMN includes the posterior cingulate cortex (PCC, 23, 31) and the adjacent precuneus (7), the medial prefrontal cortex (MPFC), and the medial, lateral and inferior parietal cortex, and ITC(20,21).

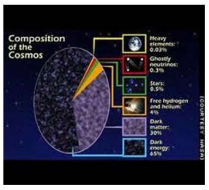




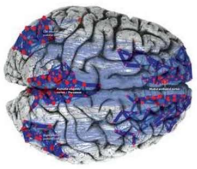
Functional Hubs:
- posterior cingulate cortex, precuneus
- medial PFC
- angular gyrus

Dorsal medial & Medial temporal Subsystems

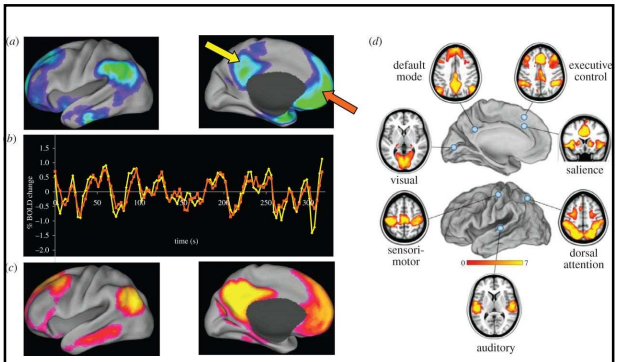
Dark energy and matter: 95% of the universe



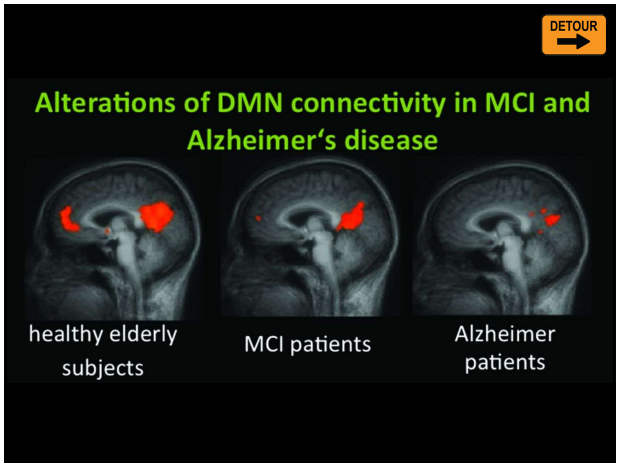
Dark brain energy: DMN



'[O]ur conscious interactions with the world are just a small part of the brain's activity. What goes on below the level of awareness–the brain's dark energy, for one–is critical in providing the context for what we experience in the small window of conscious awareness' (Raichle 2010, 33).

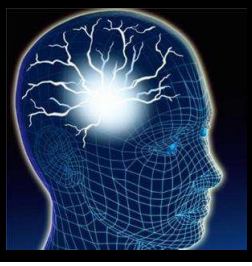


The restless brain

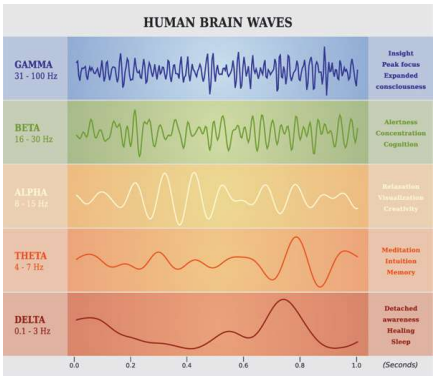


2. Default mode

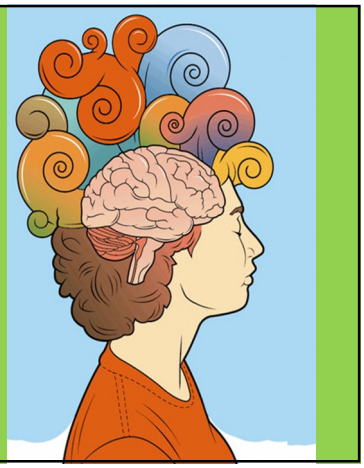
TAKE HOME MESSAGE:
– THE BRAIN "DARK ENERGY" MAY BE AT THE HEART OF ITS CORE FUCNTIONS –

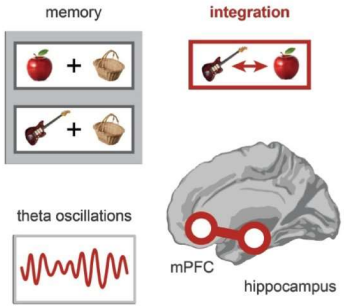


EPiLEPSY

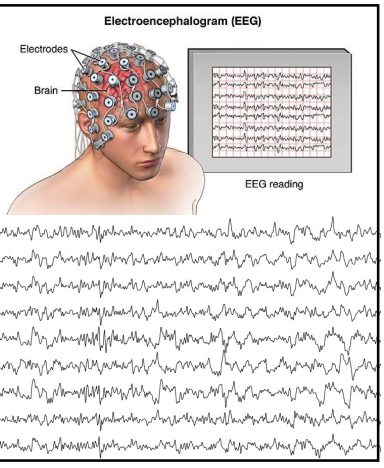


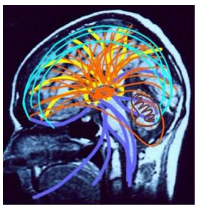
3. Brain-wave oscillations





Hans Berger, 1929

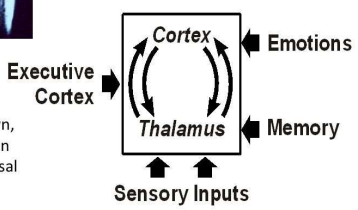




Neuroscientists Baars, Edelman/Tononi, Changeux/Dehaene, Crick/Koch cast thalamo-cortical oscillations as Global workspace for consciousness

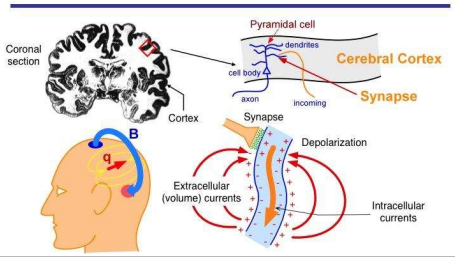
BING!!

Consciousness



Bottom-up, top-down, hierarchical, based on sensory inputs, arousal

Origins of MEG Signals



Opinion TRENDS in Neurosciences Vol.27 No.12 December 2004

The Bayesian brain: the role of uncertainty in neural coding and computation

David C. Knill and Alexandre Pouget
Center for Visual Science and the Department of Brain and Cognitive Science, University of Rochester, NY 14627, USA

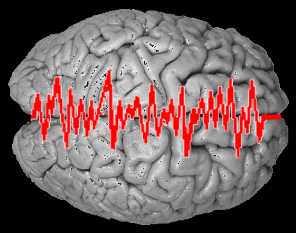
To use sensory information efficiently to make judgments and guide action in the world, the brain must represent and use information about uncertainty in its computations for perception and action. Bayesian methods have proven successful in building computational theories for perception and sensorimotor control, and psychophysics is providing a growing body of evidence that human perceptual computations are 'Bayes' optimal'. This leads to the 'Bayesian coding hypothesis': that the brain represents sensory information probabilistically, in the form of probability distributions. Several computational schemes have recently been proposed for how this might be achieved in populations of neurons. Neurophysiological data on the hypothesis, however, is almost non-existent. A major challenge for neuroscientists is to test these ideas experimentally, and so determine whether and how neurons code information about sensory uncertainty.

Many computational neuroscientists now regard the brain as a Bayesian probability machine that makes inferences about the external world then updates them according to sensory information.
As such, the brain treats ambiguous sensory information **statistically**, **in terms of the probability that a given prediction will turn out to be correct**.

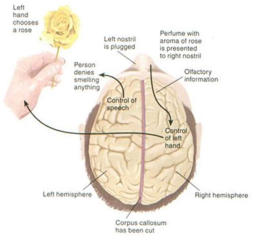
As new information becomes available, it changes the probability that a given prediction is correct, and alters its internal models accordingly.

3. Brain-wave oscillations

TAKE HOME MESSAGE:
– PATHWAYS OF BRAIN-WAVE RHYTHMS CONTRIBUTE TO INFORMATION PROCESSING –



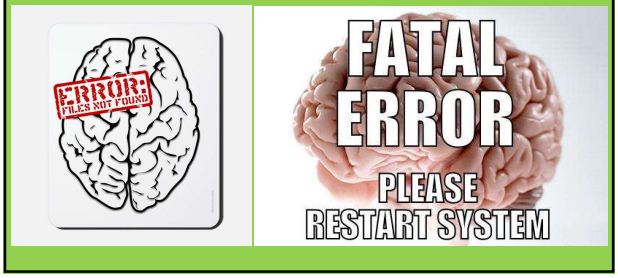
"Bayesian brain" theory



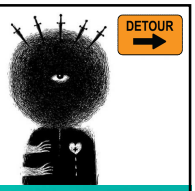
- **Bayesian brain** is a term that is used to refer to the ability of the nervous system to operate in situations of uncertainty in a fashion that is close to the optimal prescribed by Bayesian statistics.

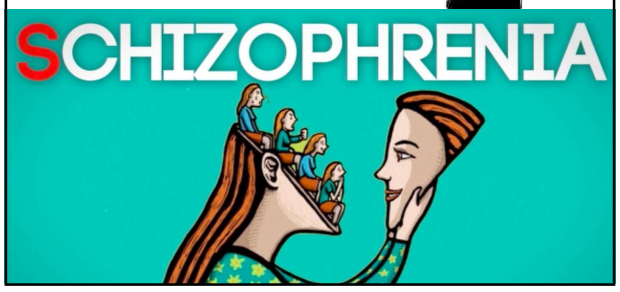
4. Prediction error

'The whole function of the brain is summed up in: error correction.'
British psychiatrist Ross Ashby, 1954



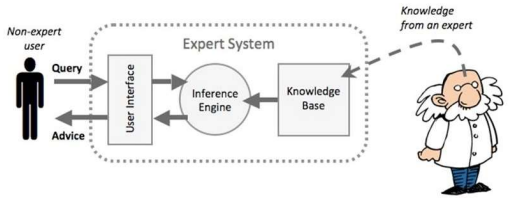
Patients with **schizophrenia** have **difficulty making accurate predictions about the sensory consequences of their actions**, and that the less precise their predictions, the more severe their **delusions of control**. **Delusions and hallucinations are ambiguous experiences that patients explain with implausible beliefs**.





In the field of Artificial Intelligence, **inference engine** is a component of the system that **applies logical rules to the knowledge base to deduce new information**. **The inference engine applies logical rules to the knowledge base and deduced new knowledge. This process would iterate** as each new fact in the knowledge base could trigger additional rules in the inference engine.

Inference engines work primarily in one of two modes either special rule or facts: **forward chaining** and **backward chaining**. Forward chaining starts with the known facts and asserts new facts. Backward chaining starts with goals, and works backward to determine what facts must be asserted so that the goals can be achieved.



4. Prediction error

TAKE HOME MESSAGE:
– THE BRAIN IS AN INFERENCE MACHINE –