22. ožujka 2022. Zagreb

Lokalizacija i narav svijesti

ppt na http://dementia.hiim.hr

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Republika Hrvatska

IP-2019-04-3584 (2020-2024)

KK.01.1.1.01.0007 ZCI-Neuro

Sadržaj

- Otkriće retikularne formacije (RF) i ascendentnog retikularnog aktivacijskog sustava (ARAS)
- Dvije glavne dimenzije svijesti: budnost i svjesnost te njihova disocijacija u različitim stanjima
- Otkriće i uloga mreže temeljnog načina rada (*default mode network,* DMN) u svjesnosti
- Temeljne postavke, prednosti i nedostatci u literaturi najviše spominjanih teorija svijesti
- Teorija dijeljenja informacija u zajedničkom radnom okružju (*global neuronal workspace theory of consciousness*, GNW)
- C0, C1 i C2 svijest i AI

René Descartes (1596-1650)

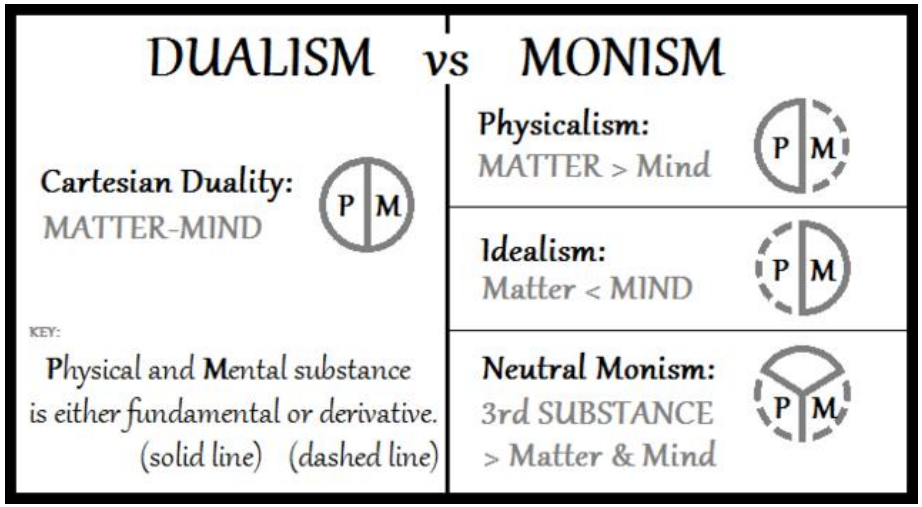
- Jedna od najranijih preteča pokušaja davanja odgovora na pitanje što je svijest uobičajeno se smatra dualnost uma i tijela

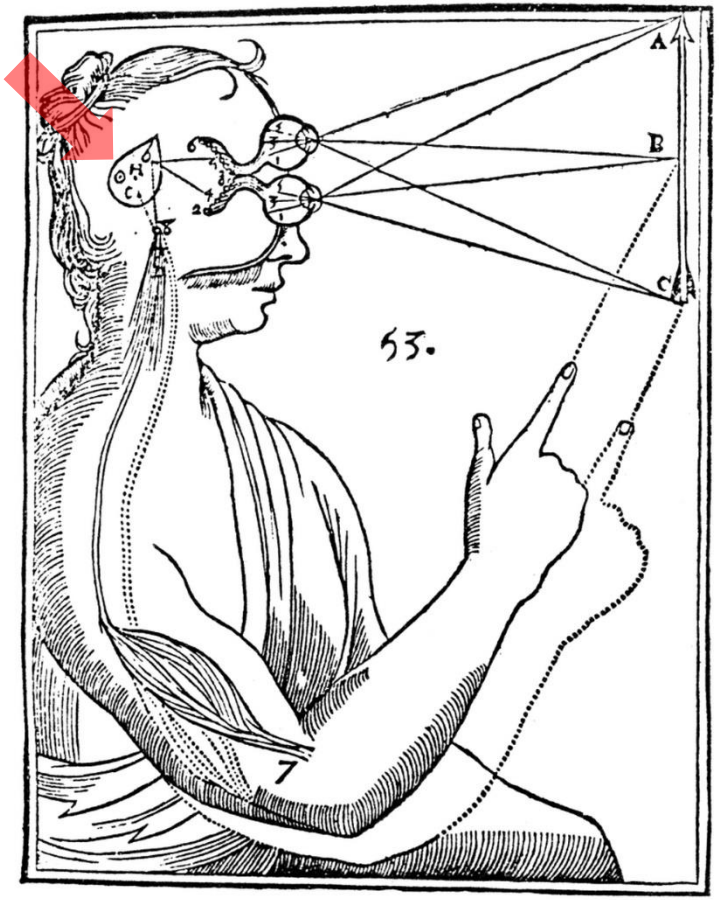
- Prema Descartesu „ja" koje misli zna da postoji dok misli, a ta je „prva i najvažnija istina" sadržana u njegovoj poznatoj izreci: „Mislim, dakle jesam" *(*franc. *„Je pense, donc je suis";* lat. *„**Cogito ergo sum**")*

- Dualistički kartezijanski okvir, u kojemu su um (*res cogitans*) i tijelo/materija (*res extensa*) dva odvojena ontološka entiteta, prema Descartesu su u interakciji samo u epifizi

Ilustracija puta boli iz dijela *Les Passions de l'âme* (*Passions of the soul*) u *Traite de l'homme* (*Treatise of man*, Traktat o čovjeku) Renéa Descartesa (1649.)

René Descartes (1596-1650)





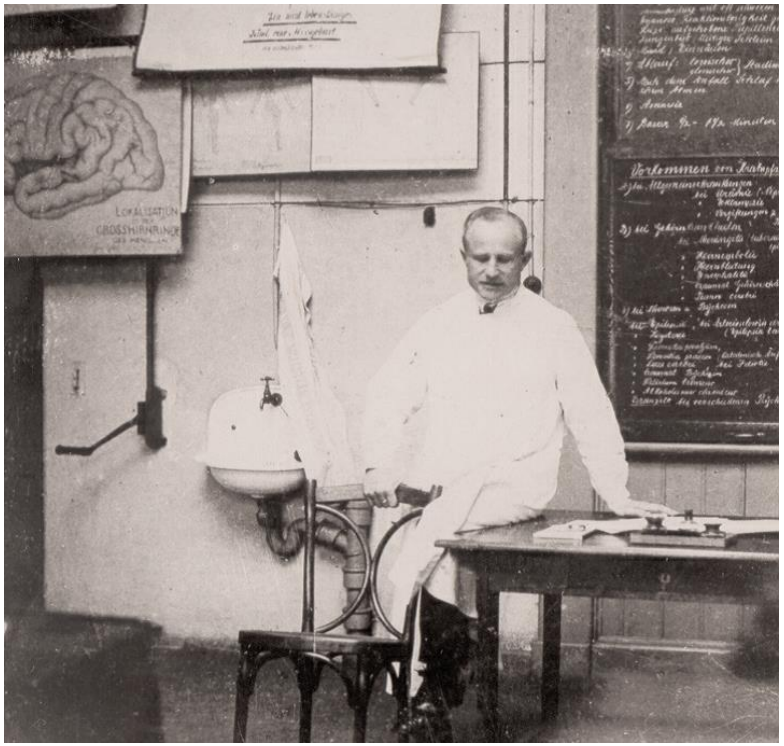
Ilustracija vidnog puta *Principia Philosophiae* (*Principles of philosophy*) Renéa Descartesa (1644. na latinskom, izdanje na francuskom 1647.)

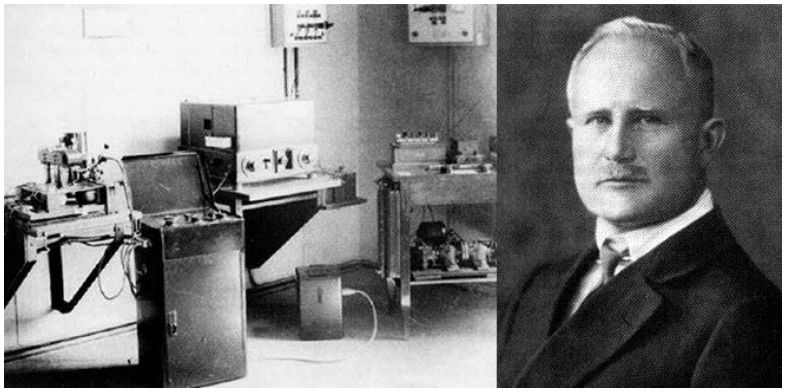
Hans Berger (1873-1941)

- Richard Caton (1842-1926) 1874/75 galvanometrom otkrio električnu aktivnost mozga zeca, psa i majmuna

1924. H.B: „**EEG** je popratni fenomen kontinuiranih procesa koji se odvijaju u mozgu, baš kao što EKG predstavlja popratni fenomen kontrakcija pojedinih segmenata srca."

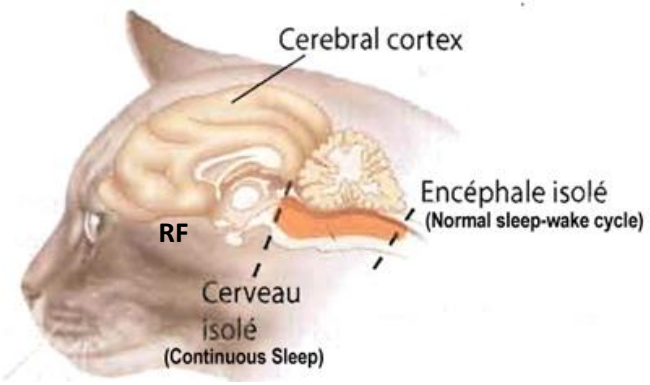
- Edgar Adrian „potvrdio" EEG tek 1934 (+ Charles Sherrington NN1932 za ↑ν AP uslijed ↑I, A=, all-or-none)
- NN: 1936AHfalse1963, 1940o, 1942X, 1947X
- 2005 bilješke iz dnevnika: „*Ich bin gerne bereit, wieder als Gutachter bei zu arbeiten das Gericht für genetische Gesundheit in **Jena**, für das ich Ihnen danke*"





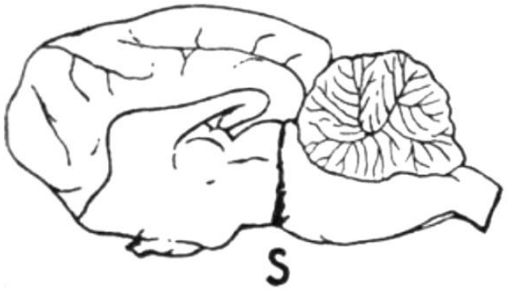
Berger H. Über das Elektrenkephalogramm des Menschen.
Arch. Psychiatr. Nervenkrank. **1929**; 87: 527-570. (+ 12 –II– do 1938.)

Frédéric Bremer (1892-1982)



Nakon što je s Baileyem 1921. otkrio da se oštećenjem hipotalamusa štakora može izazvati dijabetes insipidus, Bremera je zainteresirao nalaz da su navedne životinje nakon navedene procedure, osim simptoma polidipsije i poliurije, bile i izrazito pospane

Stoga je odlučio testirati što bi se dogodilo presjecanjem mozga interkolikularnim transverzalnim presjekom na razini srednjeg mozga (***cerveau isolé*** presjek, „**mezencefalička mačka**”) čime veliki mozak ostaje izoliran od moždanog debla i leđne moždine

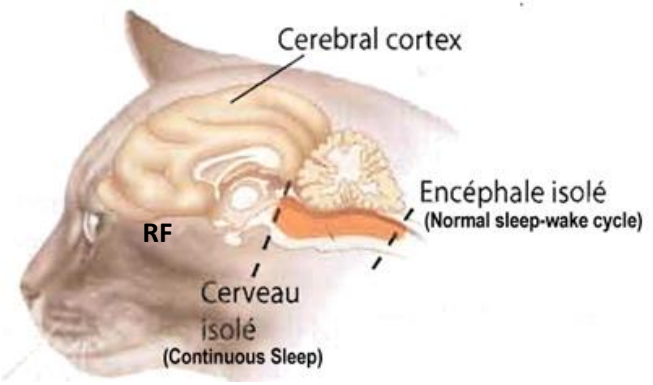


cerveau isolé

Kad je opća anestezija eterom prestala, uočio miozu i spuštanje očnih jabučica prema dolje i medijalno, a u EEG-u alfa valove 7-10 Hz, što ga je navelo na pogrešan zaključak da mačka spava te da je time potvrdio svoju „deaferentacijsku hipotezu” nastanka sna zbog nedostatka osjetnih informacija iz leđne moždine, a zapravo se radilo o trajnoj komi.

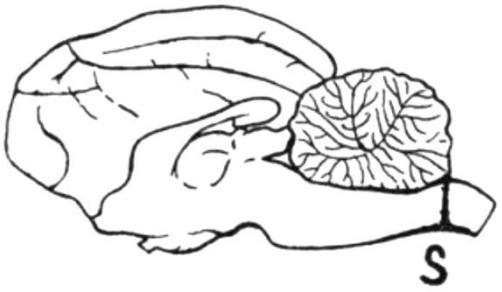
Bremer F. Cerveau "isolé" et physiologie du sommeil. *C. R. Soc. Biol*. 1935; 118: 1235-1241.

Frédéric Bremer (1892-1982)



- U drugoj vrsti pokusa u kojem je presjecanje napravio neposredno iznad mjesta gdje se spajaju moždano deblo i leđna moždina (***encéphale isolé***)

Iako je njime onemogućio pritjecanje osjetnih informacija iz leđne moždine, komunikacija između velikog mozga i moždanog debla ostala je netaknuta, a rezultat je bio potpuno suprotan od prethodnog. Za razliku od stanja trajnog „sna“, odnosno kome „mezencefaličke mačke“ (*cerveau isolé*), ovakvo presjecanje nije doveo do promjena u ciklusu budnosti i spavanja koje bi se razlikovale od onih u zdrave mačke.



encéphale isolé

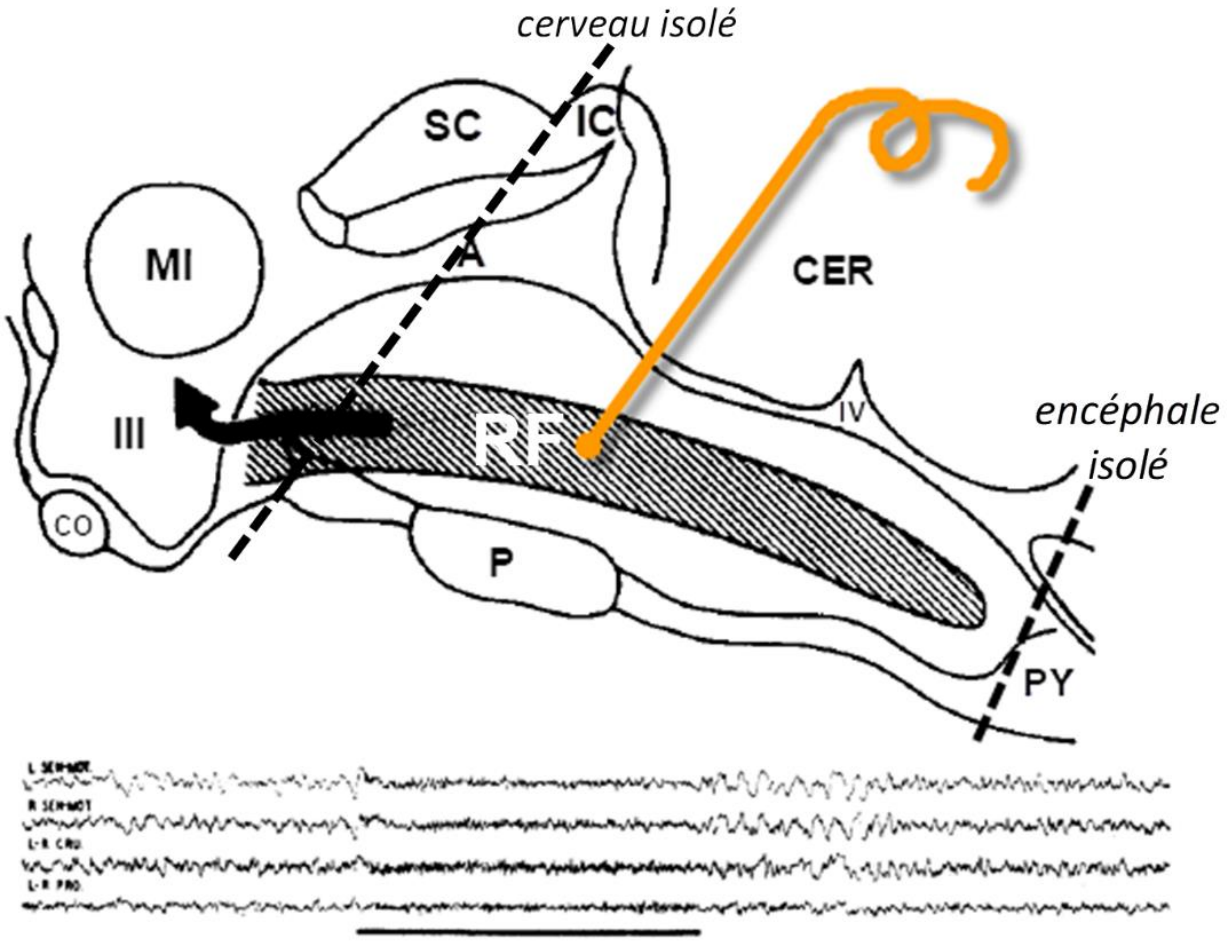
I taj je nalaz Bremer pogrešno protumačio u skladu sa svojim uvjerenjem da san nastaje zbog privremene deaferentacije moždane kore, odnosno da je san manifestacija smanjenja „kortikalnog tonusa“ koji se održava „kontinuiranim dotokom osjetnih informacija u veliki mozak“

Frédéric Bremer 1892-1982: a pioneer in sleep research. *Sleep Med. Rev.* 2000; 4: 505-514

1949: Električno podraživanje RF-a dovodi do razbuđivanja mačke koja spava

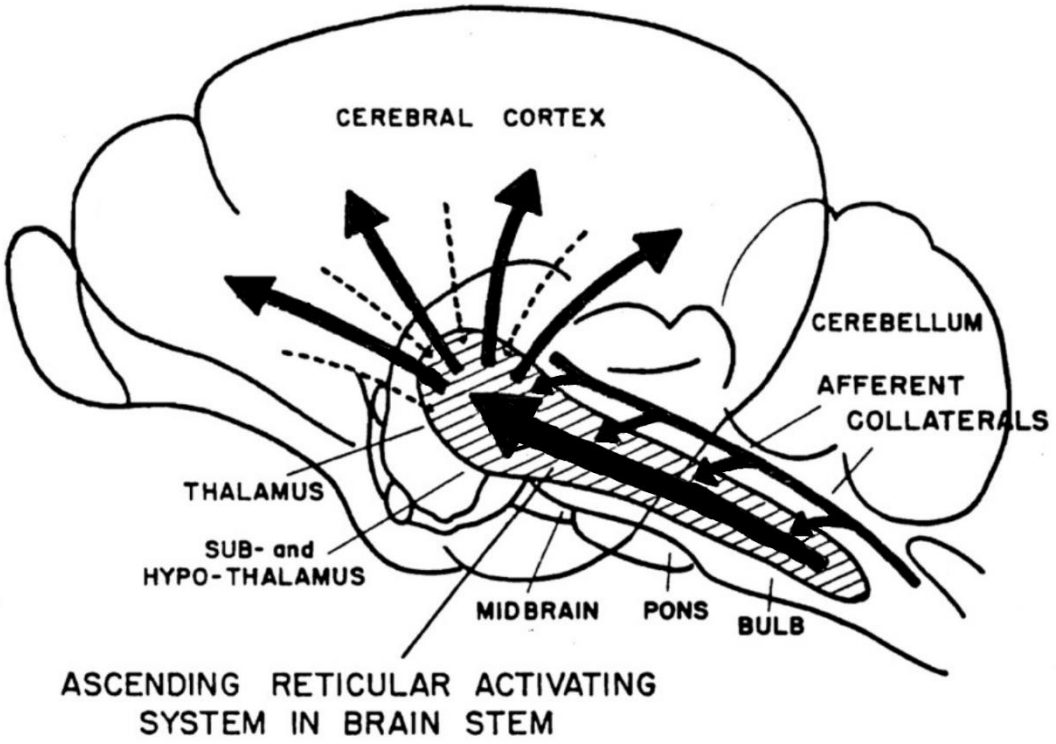
Giuseppe Moruzzi

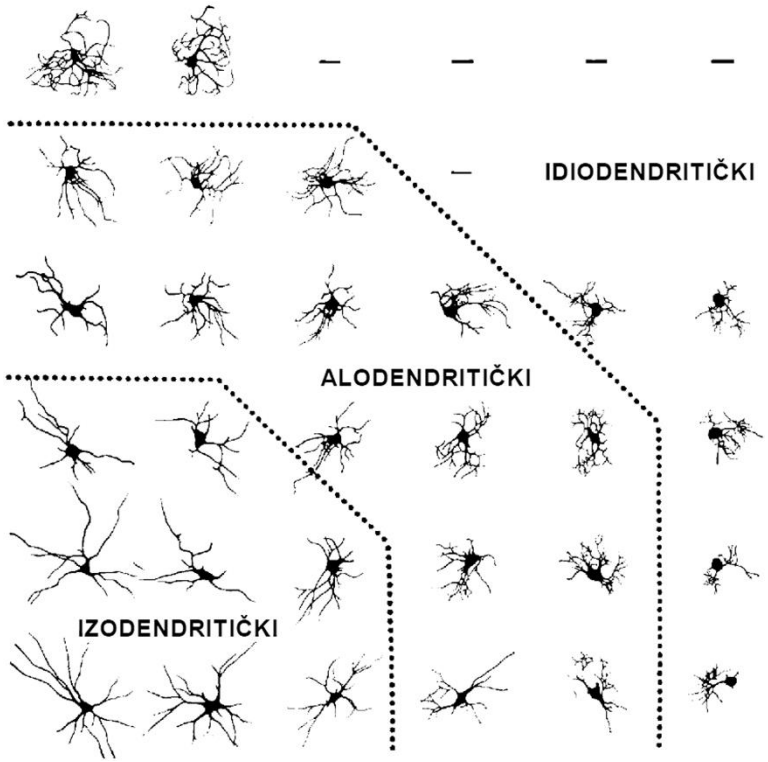
Horace Magoun



Moruzzi G, Magoun HW. Brain stem reticular formation and activation of the EEG. *Electroencephalogr. Clin. Neurophysiol.* **1949**; 1: 455-473.

1951: RF i ARAS

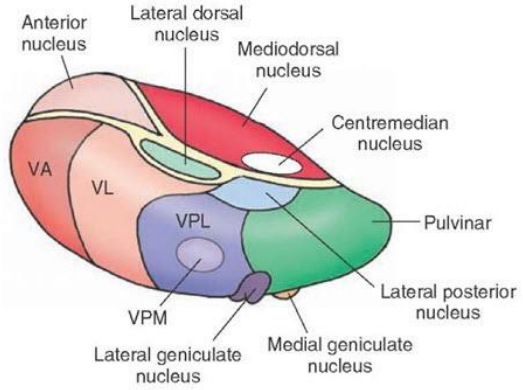


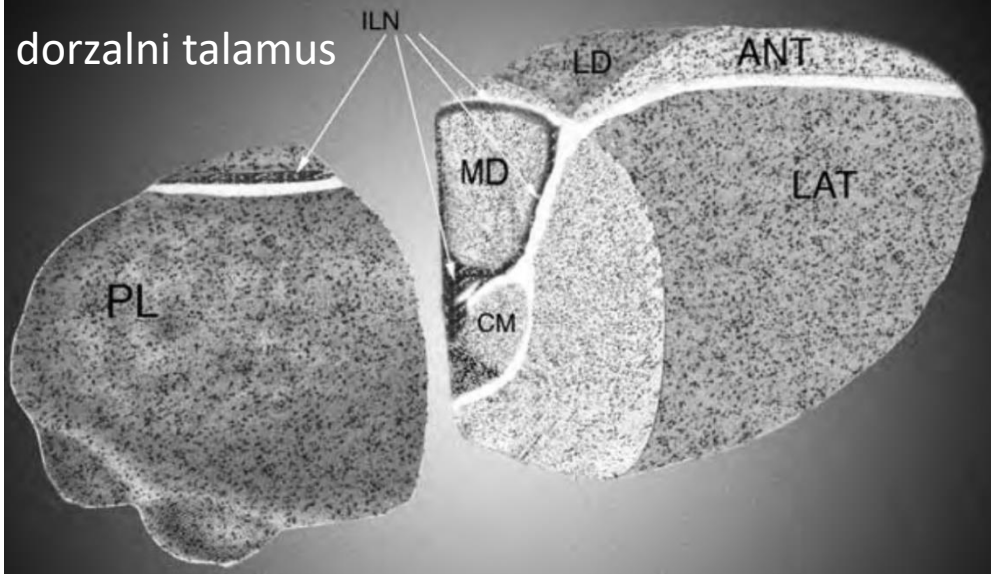


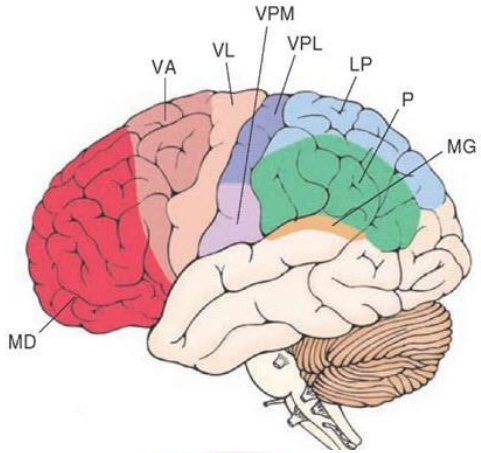
Starzl TE, Taylor CW, Magoun HW. Collateral afferent excitation of reticular formation of brain stem. *J. Neurophysiol.* 1951; 14: 479-496.

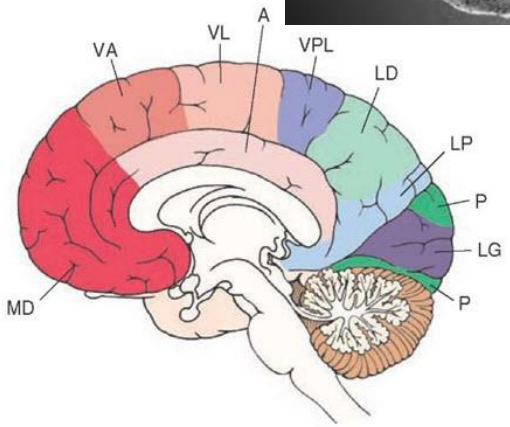
Ramón-Moliner E., Nauta W. J. H. The isodendritic core of the brain stem. *J. Comp. Neurol.* 1966; 126: 311-336.

Intra-laminarne talamičke jezgre

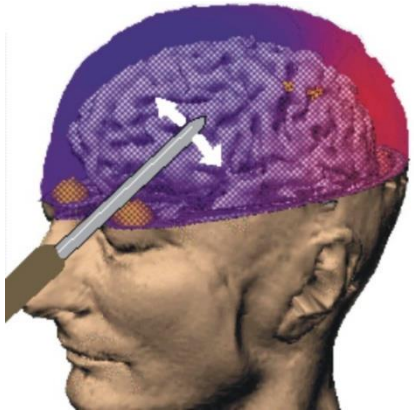




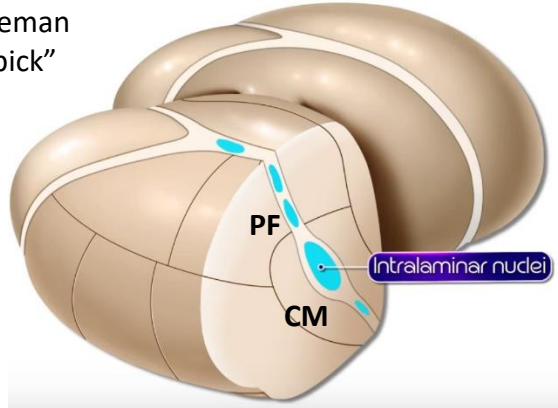




- stereotaksijsko podraživanje IL jezgara dovori do povećane pozornosti (*arousal reaction*)
  Lee B.H. et al., *Acta Anat*. 1985; 123: 1-8
  – 10 squirrel monkeys



Walter Freeman 1945. „icepick” lobotomija



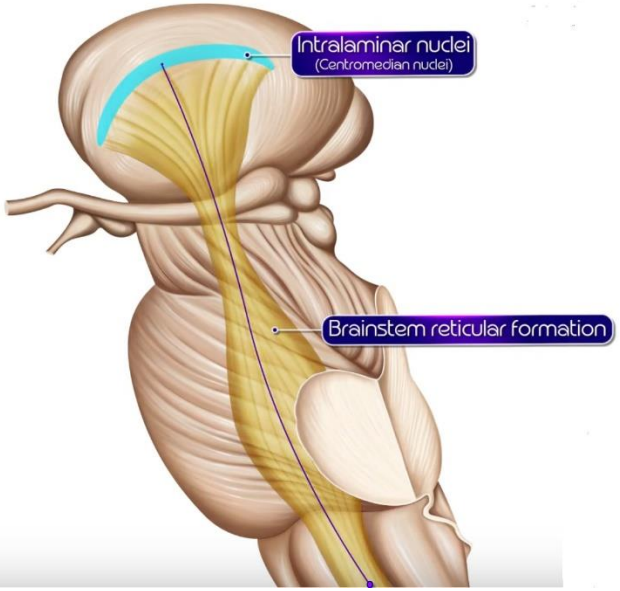
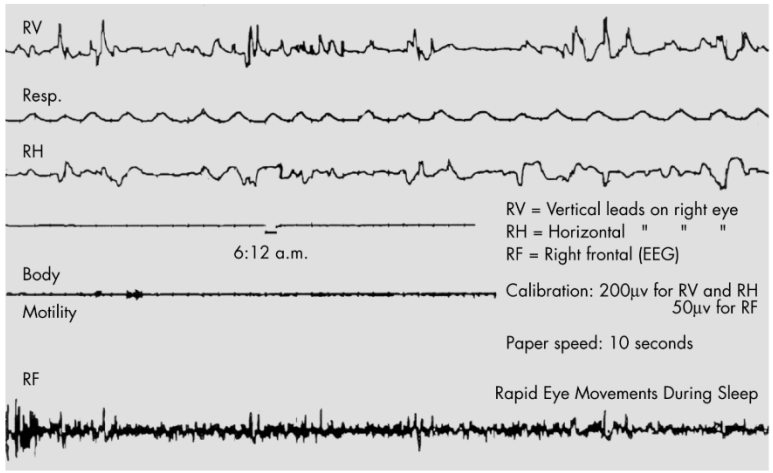


FIGURE 1. **Sample record exhibiting rapid eye movements in a sleeping subject.**

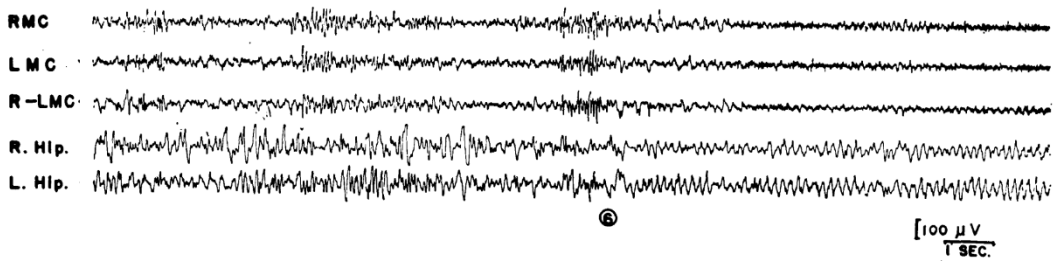


RV = vertical leads on right eyes, RH = horizontal leads on right eye, RF = right frontal (EEG). (Calibration: 200 μv for RV and RH, 50μv for RF; paper speed: 10 sec)

1953: REM san

Aserinsky Eugene, Kleitman Nathaniel. Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. *Science 1953;* 118: 273–274.

1954: theta ritam u hipokampusu



Green John, Arduini Arnaldo. Hippocampal electrical activity in arousal. *J. Neurophysiol*. 1954: 17: 533-557.

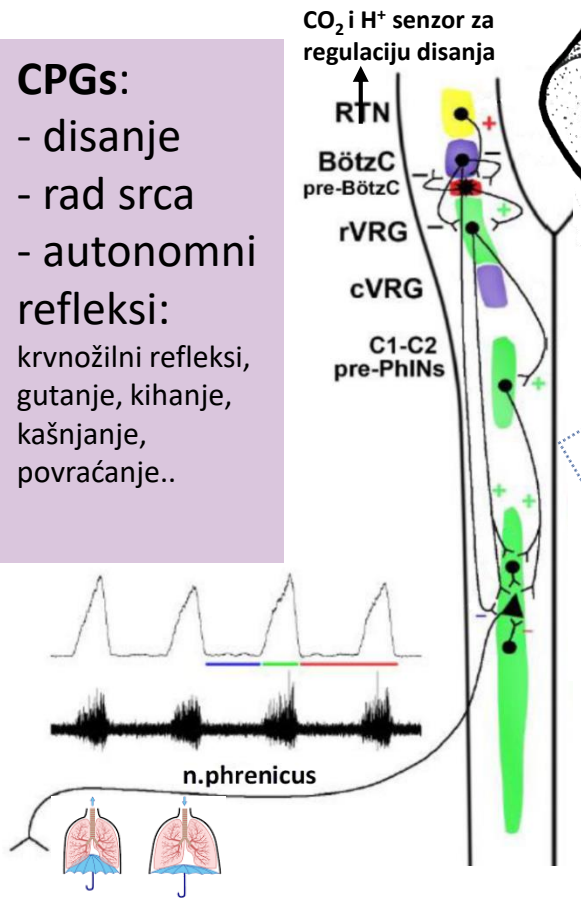
B5-B9 limbičko polje mezencef.
F|F odgovor: motorička imobilnost, hipoalgezija

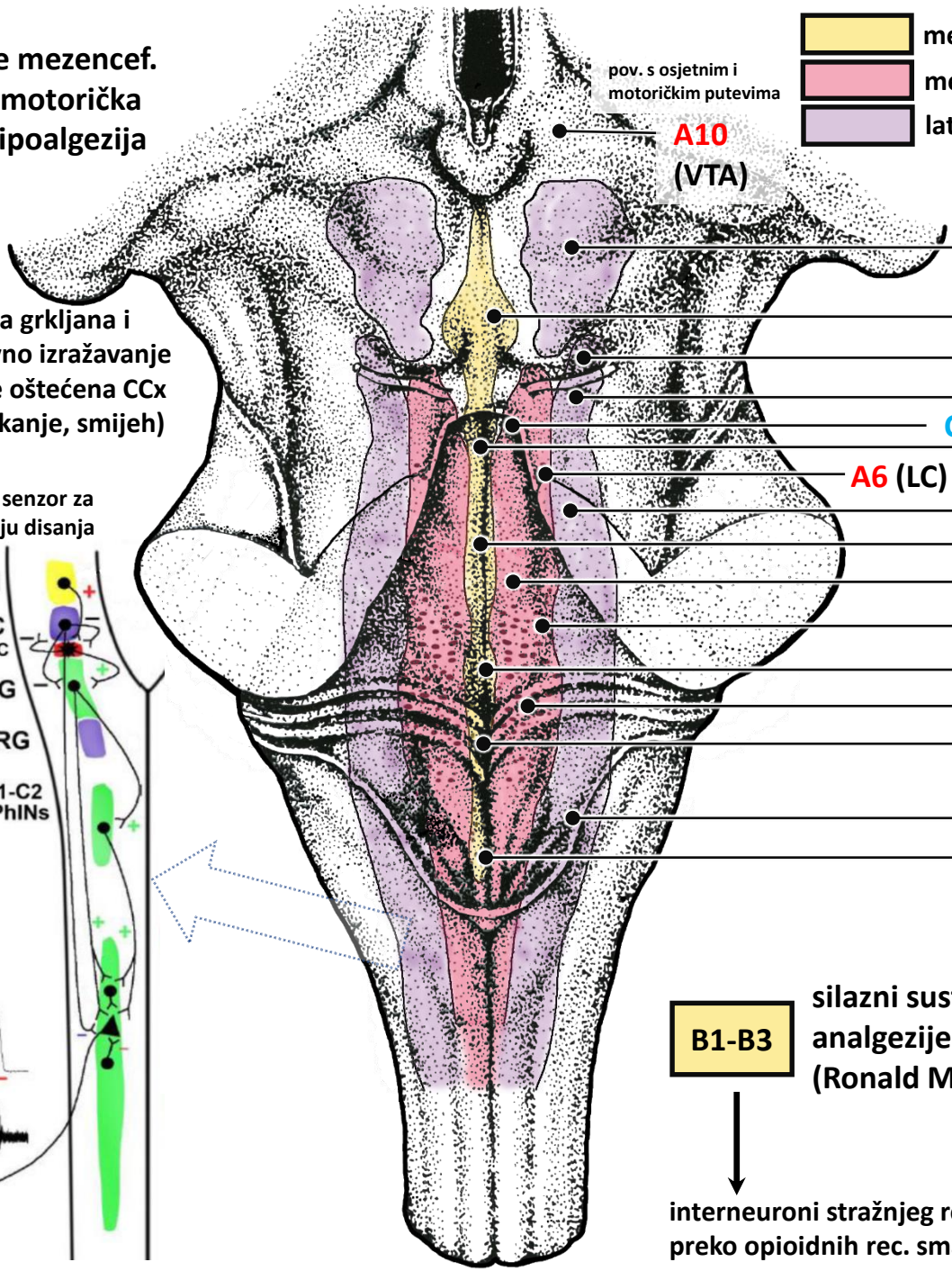
↓ PAG

NAmb inervacija mišića grkljana i glasnica: glasovno izražavanje emocija i kad je oštećena CCx (jauci, krici, plakanje, smijeh)

CPGs:
- disanje
- rad srca
- autonomni refleksi:

krvnožilni refleksi, gutanje, kihanje, kašnjanje, povraćanje..





medijana skupina (*nuclei raphes*)
medijalna (magnocelularna) skupina
lateralna (parvocelularna) skupina (*area tegmentalis lateralis*)

B1-B3 silazni sustav endogene opioidne analgezije – *gate-control of pain* (Ronald Melzack, Patrick Wall, 1965)

↓

interneuroni stražnjeg roga presinaptičkom inhibicijom preko opioidnih rec. smanjuju ulaz bolnih signala u SŽS

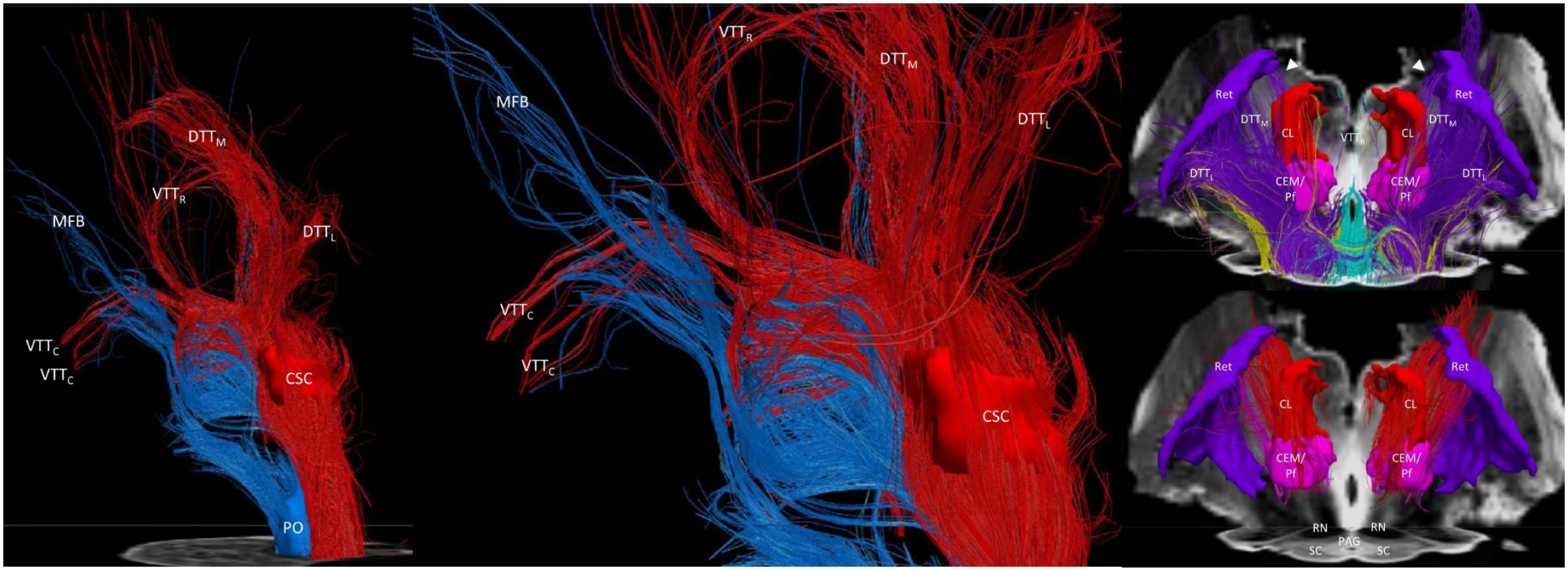


TABLE 1. Neuroanatomic Connectivity of the Human Ascending Reticular Activating System

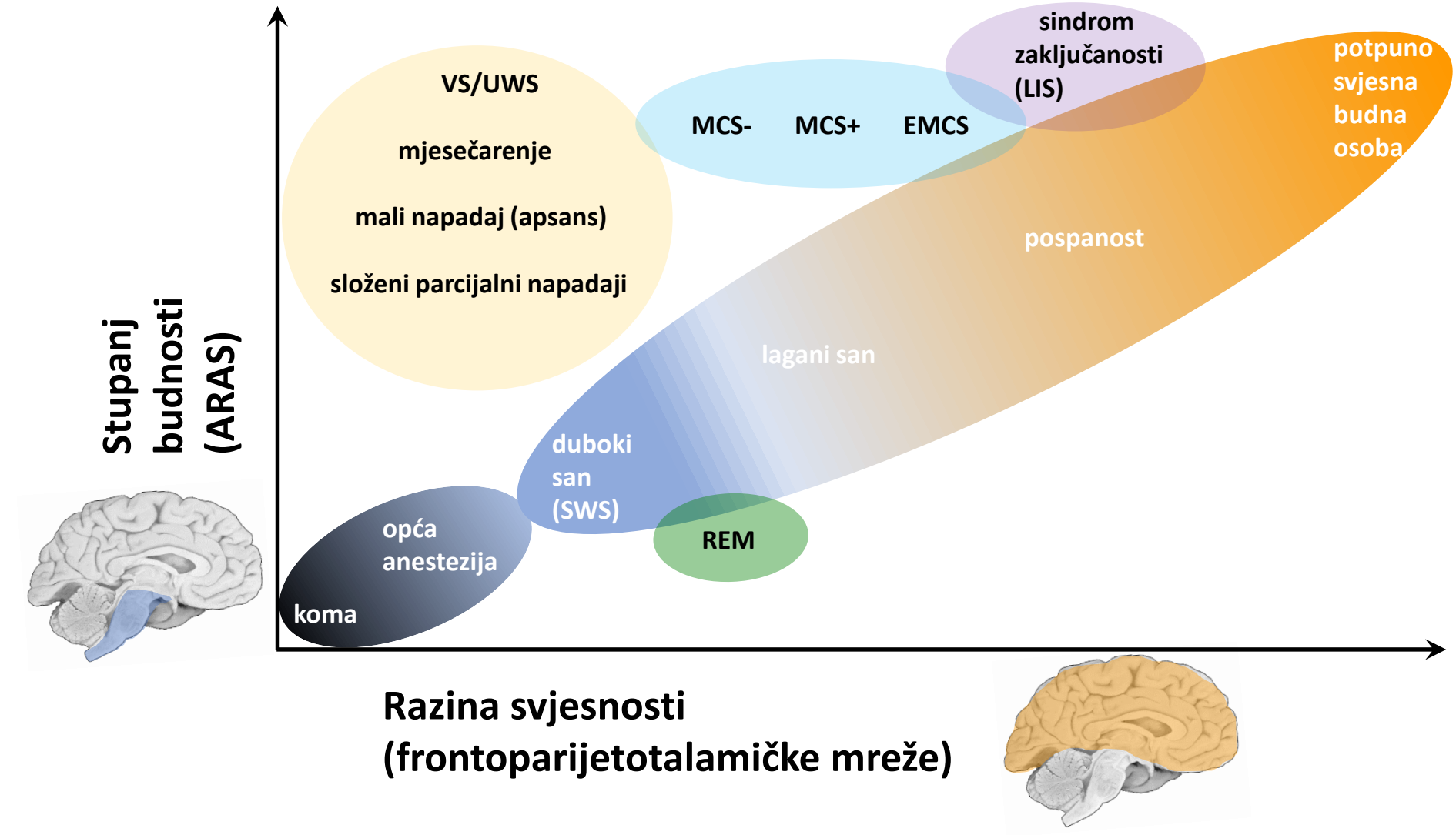
Source Nucleus		Thalamus: IL	Thalamus: Ret	Thalamus: PV	Thalamus: Pul	Thalamus: LGN	Hypothalamus	Basal Forebrain	FF/ZI	Globus Pallidus
CSC	NC&NSC	DTT_M	DTT_L DTT_M	VTT_R	DTT_L	DTT_L	VTT_C	VTT_C DTT_L	VTT_C	VTT_C
PO	NRTPo	DTT_M	DTT_L DTT_M	VTT_R	DTT_L	DTT_L	VTT_C	VTT_C	VTT_C	VTT_C
PPN	Ch5	DTT_M	DTT_L DTT_M	VTT_R	DTT_L	DTT_L	VTT_C	VTT_C DTT_L	VTT_C	VTT_C
PBC	MBPN	DTT_M	DTT_L DTT_M	VTT_R	DTT_L	DTT_L	VTT_C	VTT_C DTT_L	VTT_C	VTT_C
DR	B7	DTT_M	DTT_L	VTT_R	—	—	VTT_C	VTT_C	VTT_C	—
MR	B6	—	—	—	—	—	VTT_C	VTT_C	VTT_C	—
LC	A6	DTT_M	DTT_L	VTT_R	—	—	VTT_C	VTT_C	VTT_C	—
VTA	A10	—	—	—	—	—	VTT_C	VTT_C	VTT_C	VTT_C

The pathways that connect each region are the dorsal tegmental tract, medial (DTT_M); dorsal tegmental tract, lateral (DTT_L); ventral tegmental tract, caudal (VTT_C); and ventral tegmental tract, rostral (VTT_R).

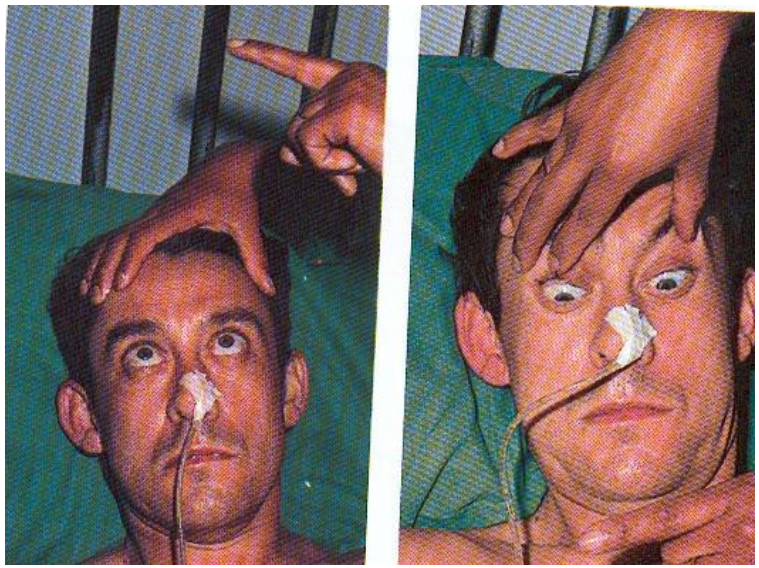
"—," no connectivity.

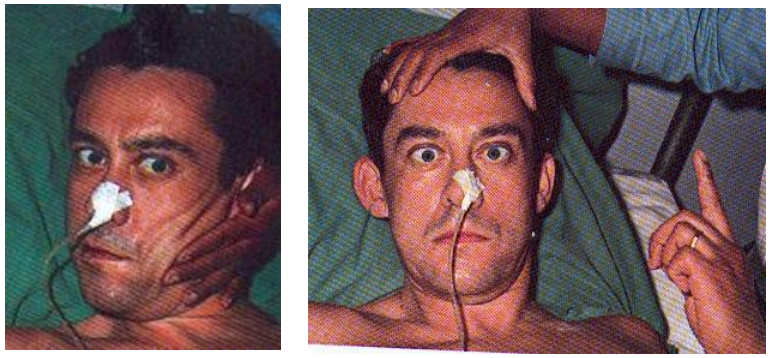
CSC, cuneiform/subcuneiform nucleus; DR, dorsal raphe; FF/ZI, Forel fields/zona incerta; IL, intralaminar nuclei of the thalamus; LC, locus coeruleus; LGN, lateral geniculate nucleus of the thalamus; MR, median raphe; PV, paraventricular region of the thalamus; PBC, parabrachial complex; PPN, pedunculopontine nucleus; PO, pontis oralis; Pul, pulvinar; Ret, reticular nucleus of the thalamus; and VTA, ventral tegmental area.

Dvije glavne dimenzije svijesti

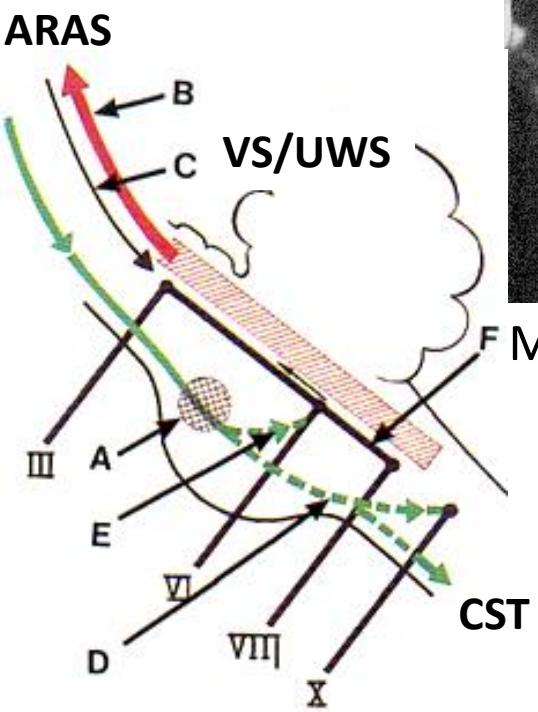


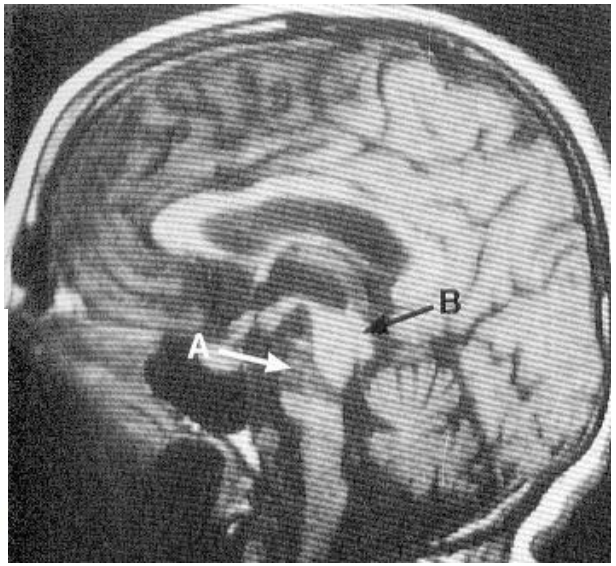
Sindrom zaključanosti (locked-in syndrome)





38-godišnji bolesnik s LIS-om

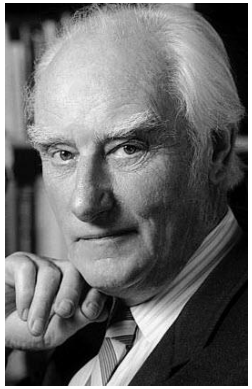




MRI istog 38-god. bolesnika

53-godišnji bolesnik s LIS-om;
transverzalni presjek moždanog debla

Parsons M. 1993. *Clinical atlas of clinical neurology*



1990: Francis Crick , Christoph Koch

Towards a neurobiological theory of consciousness

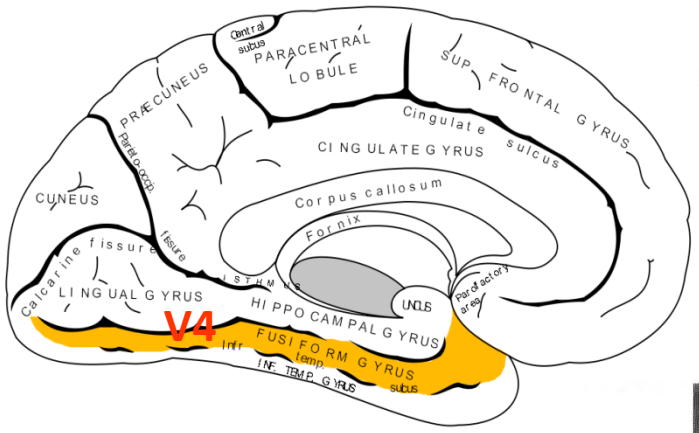
Visual awareness is a favorable form of consciousness to study neurobiologically. We propose that it takes two forms: a very fast form, linked to iconic memory, that may be difficult to study; and a somewhat slower one involving visual attention and short-term memory. In the slower form an attentional mechanism transiently binds together all those neurons whose activity relates to the relevant features of a single visual object. We suggest this is done by generating coherent semi-synchronous oscillations, probably in the 40-70 Hz range. These oscillations then activate a transient short-term (working) memory. We outline several lines of experimental work that might advance the understanding of the neural mechanisms involved. The neural basis of very short-term memory especially needs more experimental study.

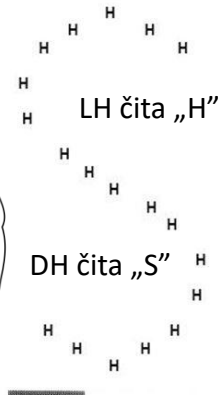
Key words: consciousness / attention / binding / 40 Hz oscillations / short-term memory

Crick F, Koch C. Toward a neurobiological theory of consciousness. *Sem. Neurosci*. 1990; 2: 263-275.

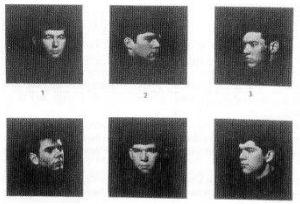
Problem vezivanja vidne pozornosti

→ više epicentra u lat. temp. i temporopolarnoj moždanoj kori, fuziformnoj vijugi…



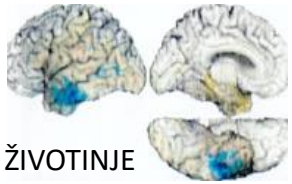


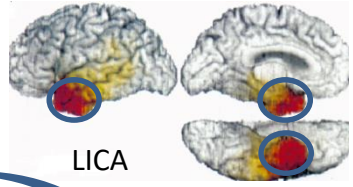
→ BA37 i 20 (prednji i srednji dio fuziformne vijuge – percepcija objekata i lica), granica BA19 i BA37 – percepcija Riječi

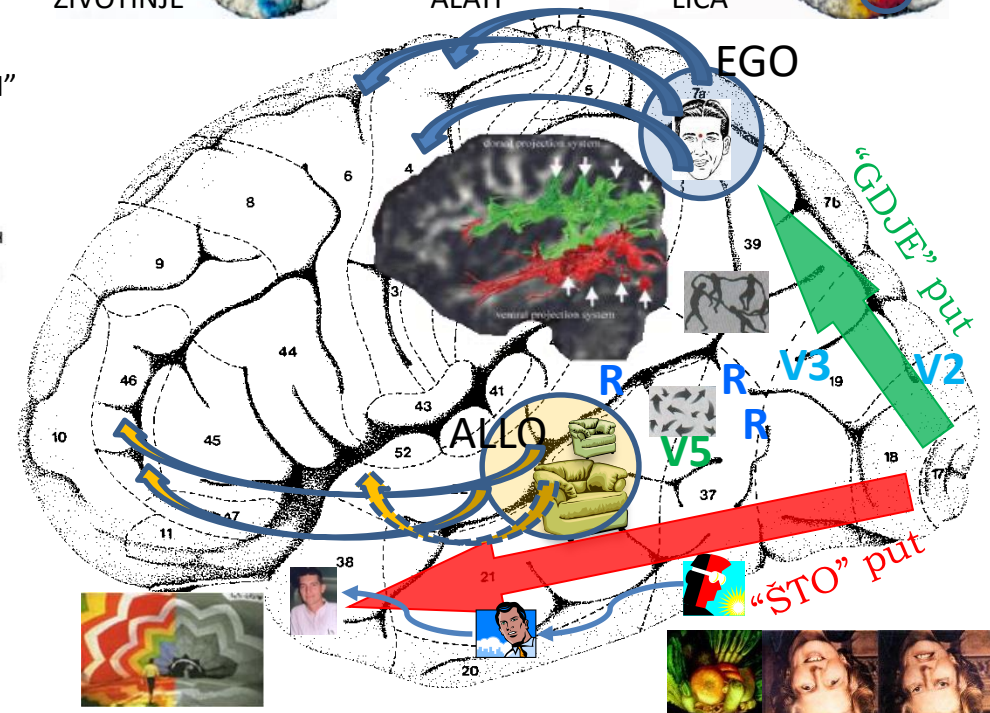


Vidna integracija je stupnjevit proces: nepoznata lica aktiviraju samo unimodalne areje u i oko fuziformnog girusa, dok poznata aktiviraju i transmodalna područja, napose u prednjem dijelu srednjeg sljepooč. girusa

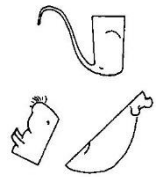

Fregoli sy





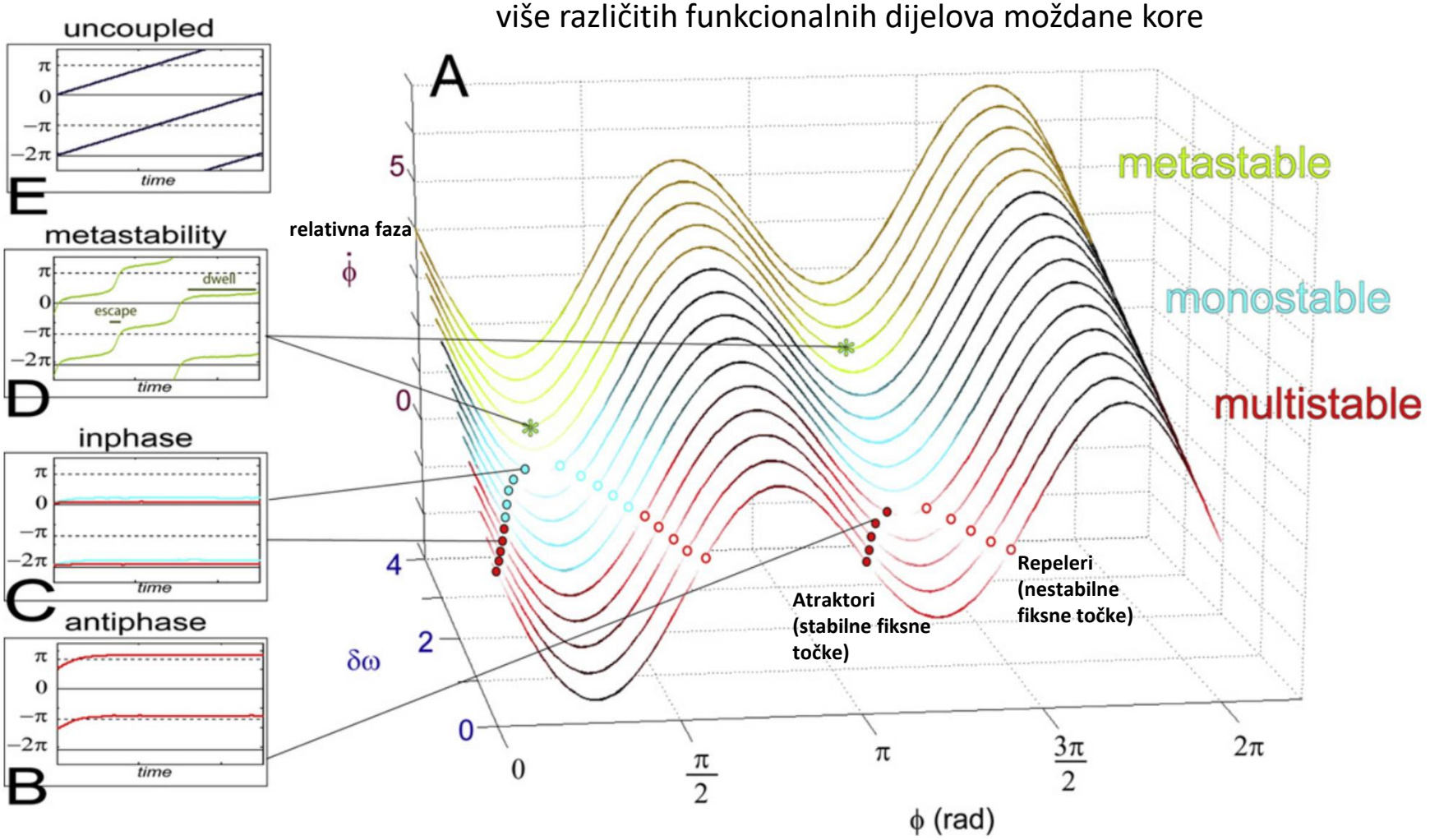


(hemi)akromatopsija (clV4), anomija za boje,
(hemi)akinetopsija (clV5)
vidna objektna agnozija (D), čista aleksija – vidno prepoznavanje riječi (L)
deficit vidne integracije (D) – Hooperov test
asocijativna prozopagnozija (D)
diskonekcijski sindromi: vidna amnezija (L), vidna hipoemocionalnost (D), Capgras sy (D): ”ova mačka izgleda baš kao i moja”
„ti si dvojnik moga prijatelja”



Teorija metastabilnosti

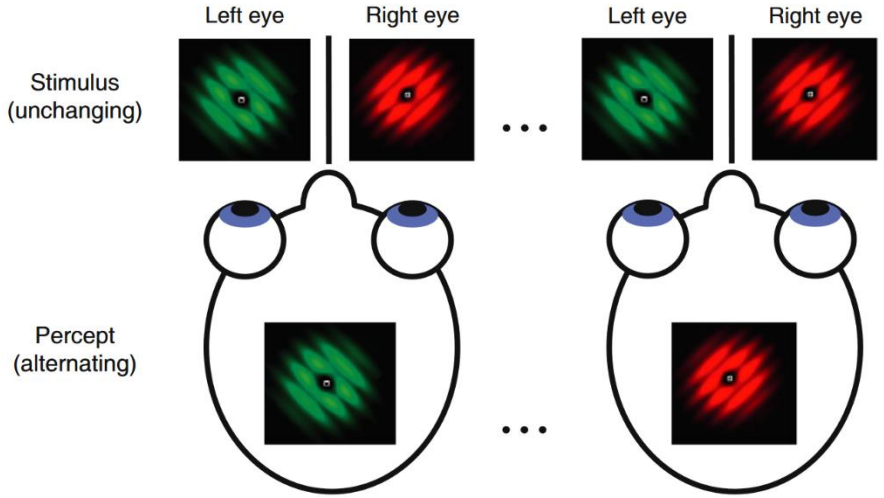
kao temelj za svjesnu aktivnost kroz sposobnost za integraciju više različitih funkcionalnih dijelova moždane kore



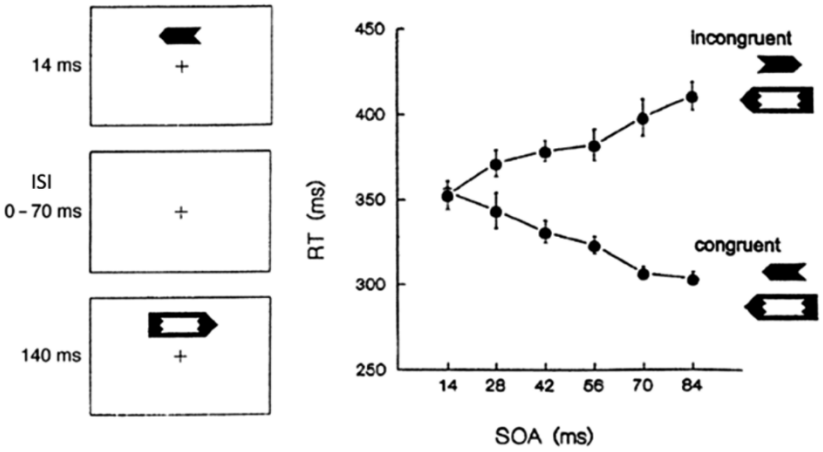
metastabilnost (A) nalazi negdje između potpuno povezanih, integriranih stanja (C, D) i potpuno nevezanih, odvojenih stanja (E)

Tognoli E, Kelso JAS. Brain coordination dynamics: true and false faces of phase synchrony and metastability. *Prog. Neurobiol*. 2009; 87: 31-40.

Binocular rivalry

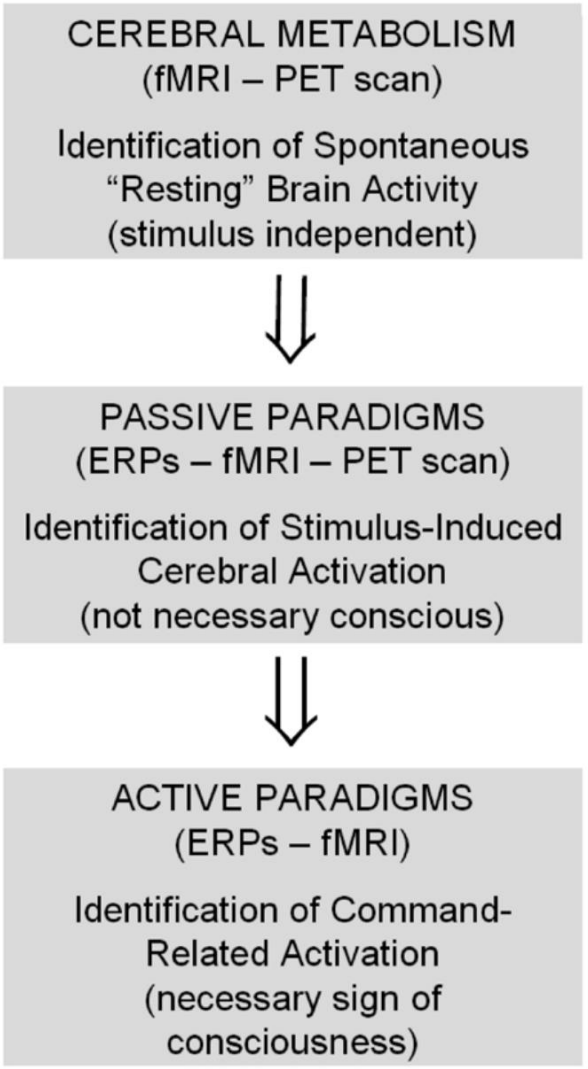


Subliminal priming



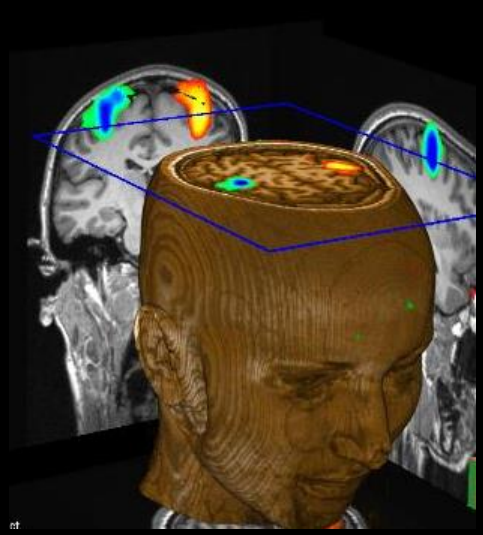
- suparništvo hemisfera za perceptivnu dominaciju
- nakon kraćeg razdoblja „navikavanja" događa je alternacija svakih nekoliko sekundi
- to je umjetno izazvano stanje jer se u normalnim okolnostima slike iz oba oka stapaju
- kad na lijevo i desno uho slušamo različite rečenice, možemo pozornost usmjeriti samo na jednu (što ne znači da ona druga ne biva procesirana)
- **percepciju bez pozornosti (svjesnosti)** vidimo u brojnim fenomenima poput rezidualnog vidnog kapaciteta (***blindsight***), maskiranjem (prekrivanjem) vidnog podražaja dovodimo do njegovog nesvjesnog (subliminalnog) procesiranja (koje utječe npr. na kasnije brže prepoznavanje sličnih podražaja - **priming**; slično se uočava i kod njušnog procesiranja (***blindsmell***, *binaral rivarly – banana - mint*, malo njušimo jedan miris, malo drugi, ako se zamijene na lijevu i desnu nosnicu – to ne možemo razlikovati), kao i kod nesvjesnog procesiranja zastrašujućih lica u slijepom dijelu vidnog polja (***blindfear***) – fMRI pokazuje aktivaciju amigdaloidne jezgre

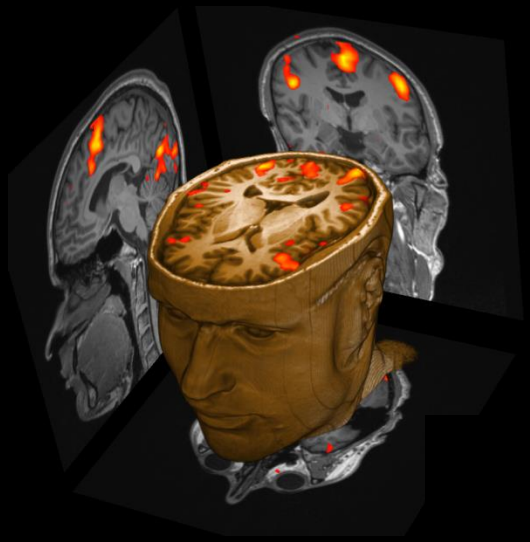
Glavne paradigme u istraživanjima C.



„Zamišljajte da igrate tenis"
„Javite se kad izgovorim vaše ime"

fMRI i otkriće DMN-a





3. VII 1977. – 1. MRI
na živom čovjeku

- non-invasive method to measure brain's activity
- is an indirect measurement of vascular and hemodynamic signals
- most important variant uses BOLD signal
- Seiji Ogawa 1990, AT&T Bell labs, Murray Hill, NJ, USA (1. task-related fMRI)

Proc. Natl. Acad. Sci. USA
Vol. 87, pp. 9868–9872, December 1990
Biophysics

Brain magnetic resonance imaging with contrast dependent on blood oxygenation

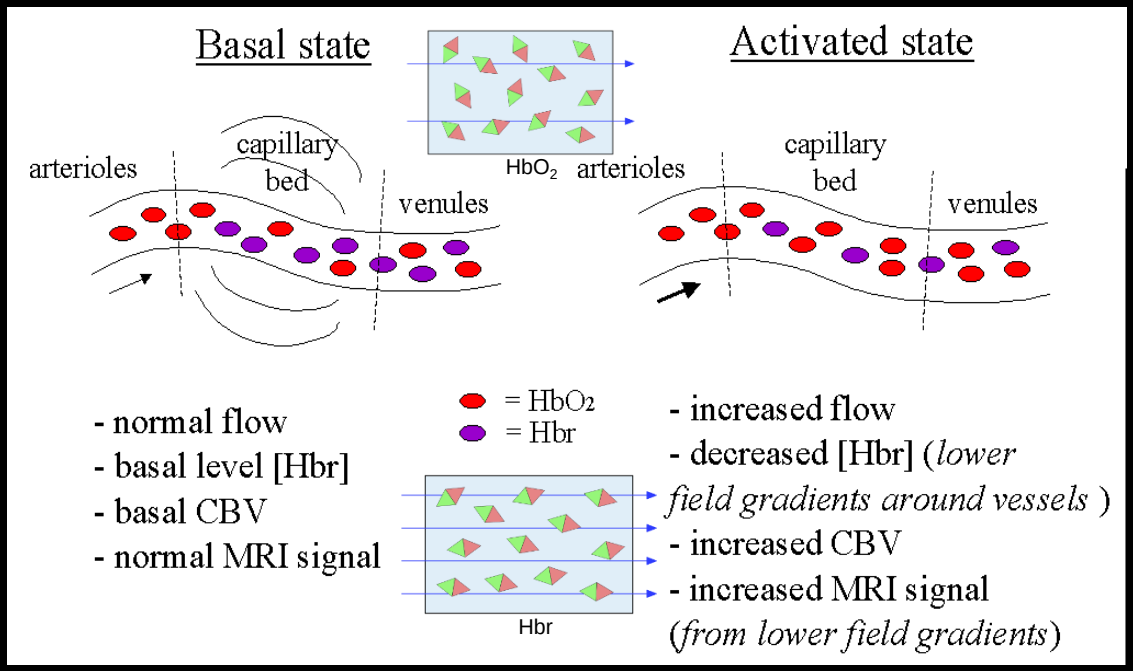
(cerebral blood flow/brain metabolism/oxygenation)

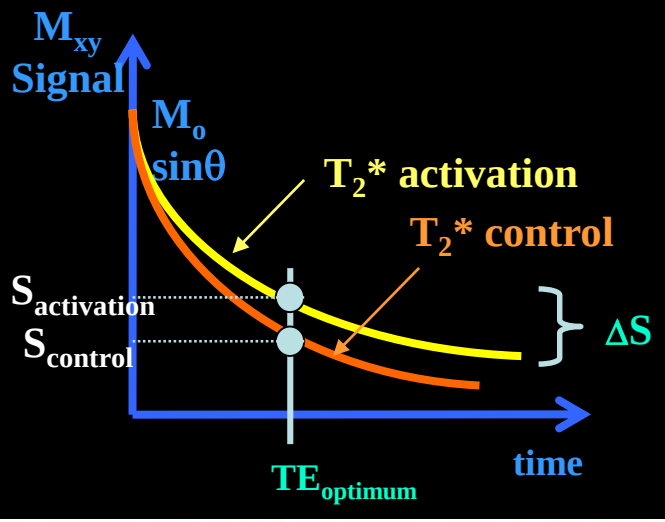
S. OGAWA, T. M. LEE, A. R. KAY, AND D. W. TANK
Biophysics Research Department, AT&T Bell Laboratories, Murray Hill, NJ 07974

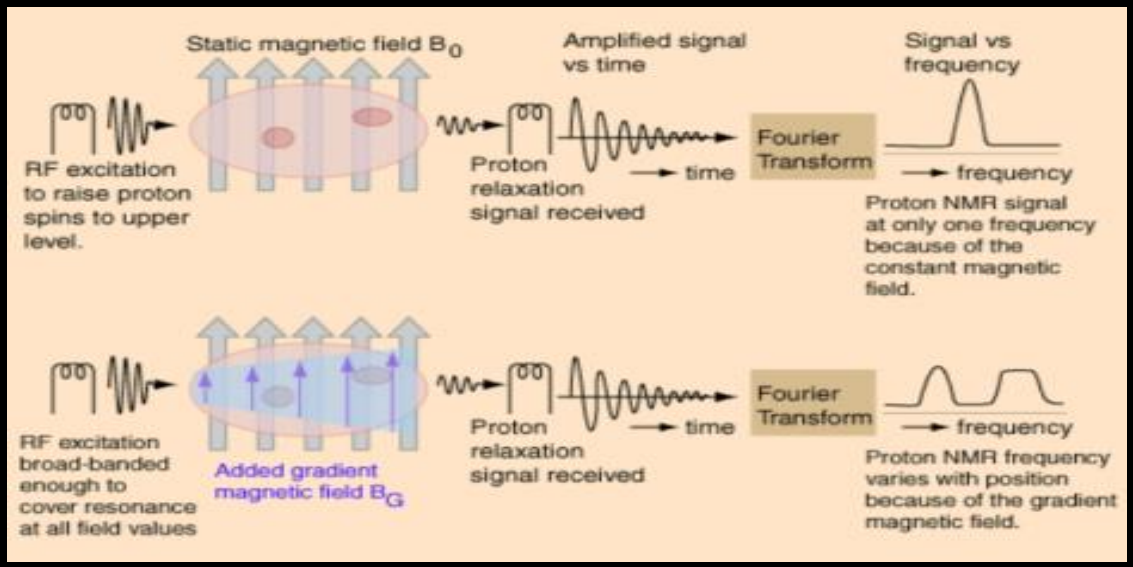
Communicated by Frank H. Stillinger, September 24, 1990 (received for review August 1, 1990)

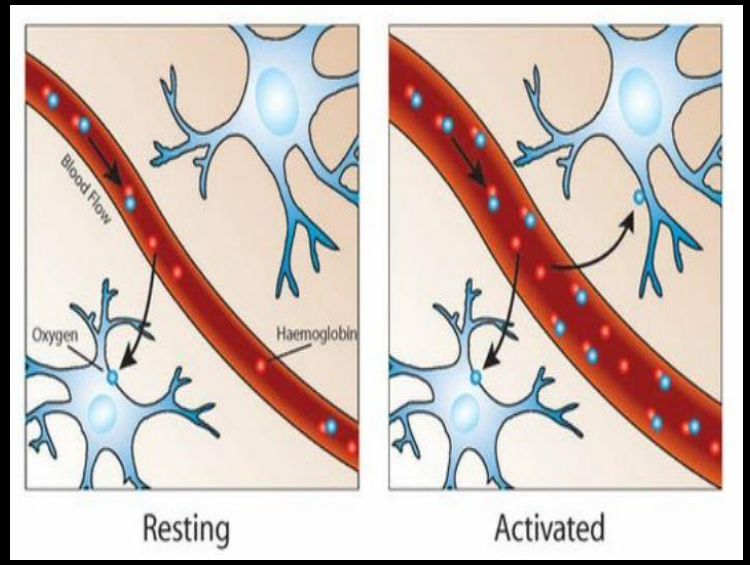
Blood Oxygen Level Dependent signal

oksiHb je dijamagnetičan (kroz magnetno polje prolazi bez deformacija), a deoksiHb paramagnetičan (u magn. polju dobiva dodatni inducirani magnetizam istoga smjera kao i polje)

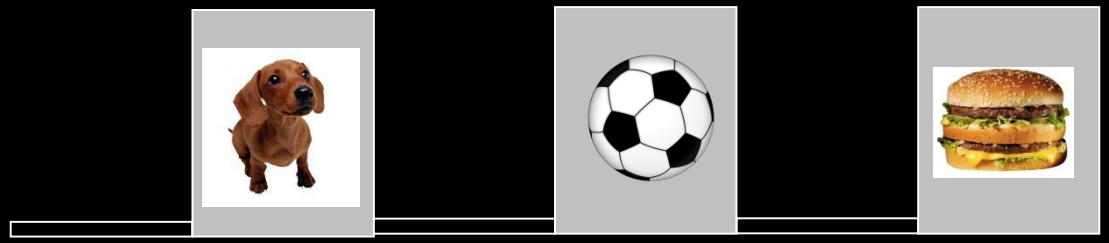




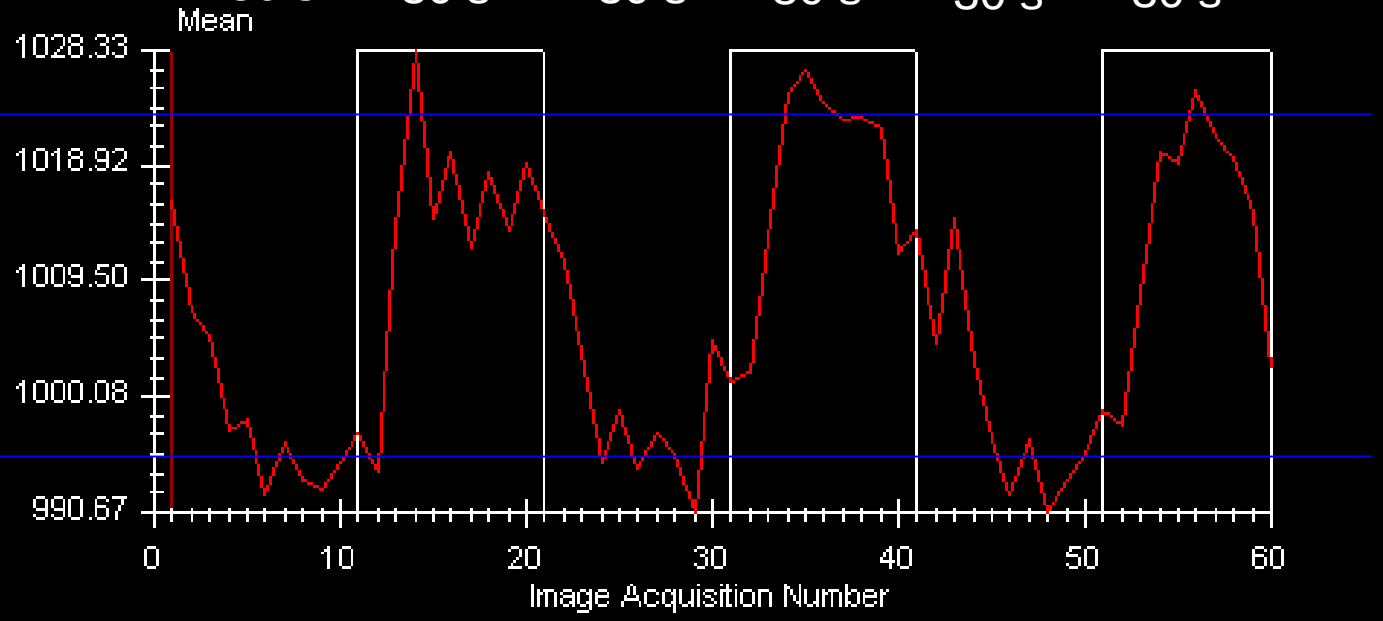




Promjene u intenzitetu BOLD signala (1-5%)



30 s 30 s 30 s 30 s 30 s 30 s



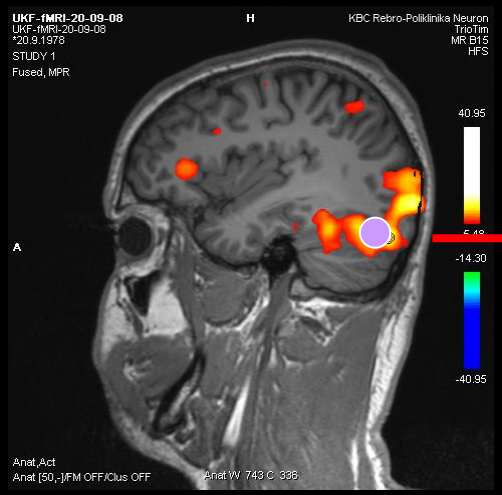
1020

2,5%

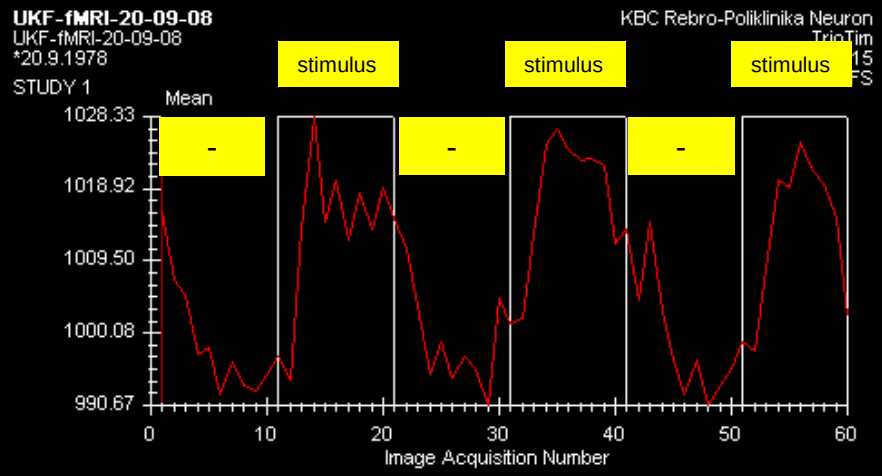
995

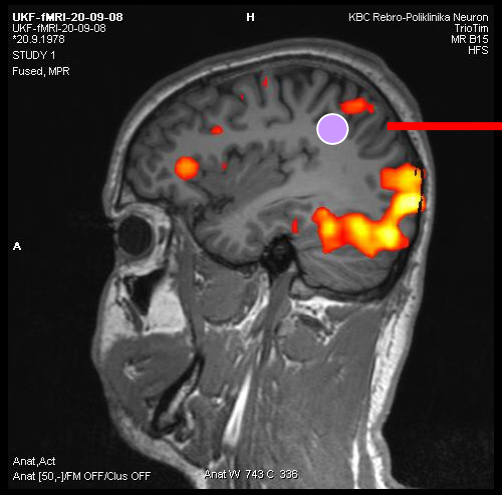
Relativno su male s obzirom na zadatak (npr. ovdje paradigmu imenovanja)

The relationship between baseline BOLD signal and stimulus-evoked BOLD signal

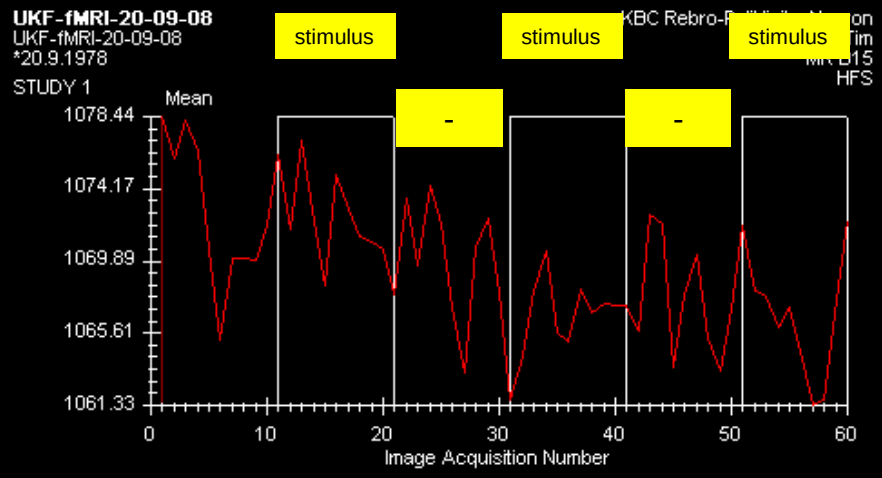


Positive correlation





No correlation



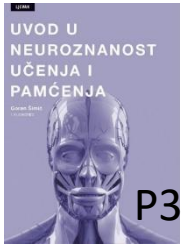
Task-related fMRI

- An experimental task of interest is presented alternately with a control task and the BOLD signal during the experimental task is compared to the BOLD signal during the control task
- The difference between baseline and task-related activation accounts for about 1–5% of the total BOLD signal
- Thus, compared to ongoing 'baseline' brain activity, only a small percentage is needed to respond to an external stimulus
- However, the functions of this vast amount of baseline activity remained unclear

Resting-state fMRI

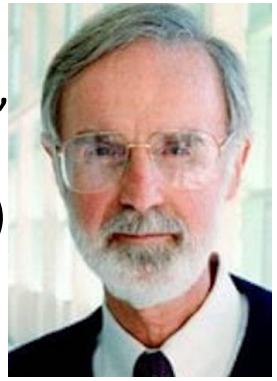
- Focuses on spontaneous, rather than task-induced, fluctuations in BOLD signal
- In the first resting-state fMRI study (Biswal, Magn. Reson. Med., 1995), the time course of a seed region-of-interest (ROI) in the left motor cortex was correlated with the time course of all other brain voxels
- The resulting map demonstrated functional connectivity between the left and right motor cortex even in the absence of a task
- fMRI has since been used to demonstrate that the brain is segregated into a wide array of 8-15 or more functional networks mediating a host of sensory, motor, cognitive, and affective functions (Smith et al., PNAS, 2009; Šimić et al., 2014)

Otkriće DMN-a (the resting state network, the task-negative network)



- DMN je lateralizirana u LH, a DAN u DH

- Inicijalna vizualizacija DMN-a je godinama zanemarivana kao vjerojatni artefakt



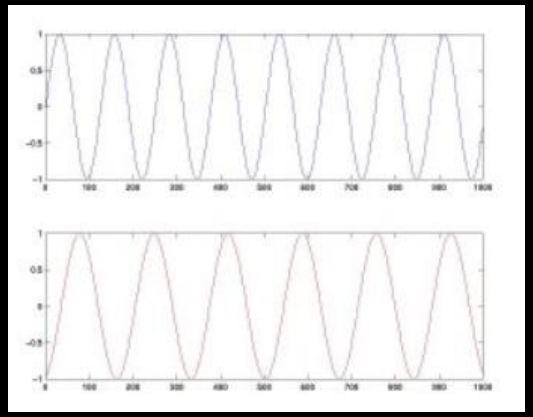
- DMN je pretpostavio **Marcus Raichle** 2001. godine (WU, St. Louis, MO), ali ona nije mogla biti dokazana dok nisu pospješeni algoritmi za ICA matrice 4-dim. BOLD signala (volumen svakog voksela mozga x vrijeme) za „čišćenje" od utjecaja rada srca, disanja, vazomotornih oscilacija i drugih izvora šuma

- U rs-DMN-u je naročito teško odvojiti šum koji nastaje od sporog ritma disanja

- Čvorišta DMN-a se deaktiviraju po obraćanju pozornosti ili izvršavanje bilo koje druge aktivnosti, pa je aktivnost DMN prvi izravno snimio tek 2003. godine Micheal Greicius, a potvrdio Randy Buckner 2004. godine

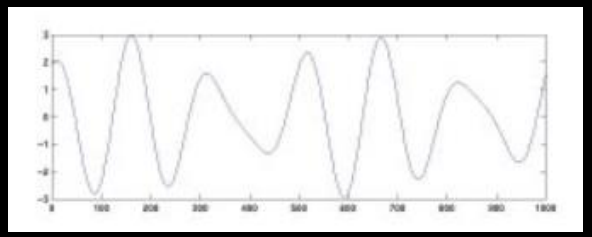
ICA principle

2 independent sources

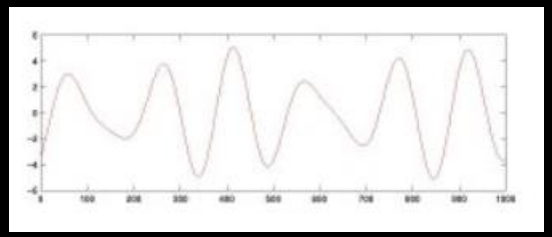


A

B

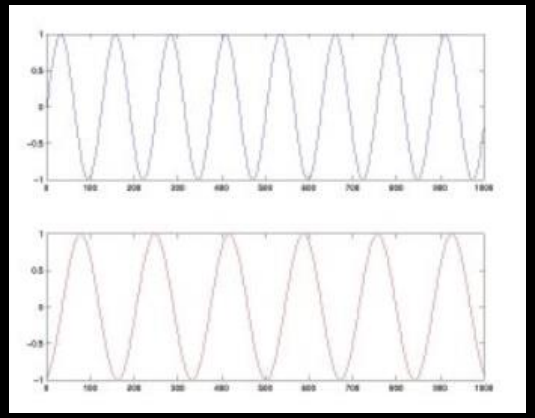


Linear mix: A-2B



Linear mix: 1.73*A+3.41*B

ICA algorithm



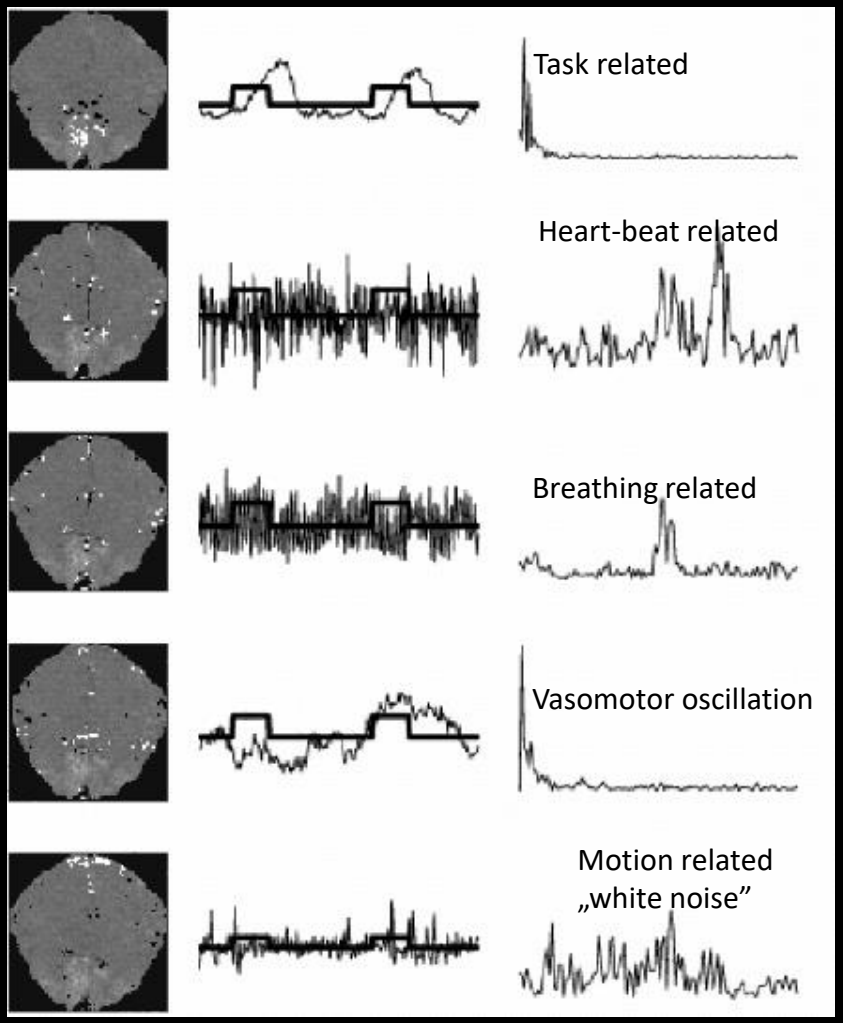
Resting-state fMRI

Limitations: the seed ROI must be selected by the investigator; a preprocessing step of regressing the global signal can induce false negative correlations between brain regions (Murphy et al., NeuroImage, 2009)

To avoid these issues independent component analysis (ICA) decomposes (separates) the 4-dim. (brain volume over time) BOLD signal into a set of spatially distinct maps and their associated time courses (Beckmann et al., Philos. Trans. R Soc. Lond. B, 2005).

A general limitation to resting-state fMRI is that it is very difficult to separate physiological noise, induced by the cardiac pulse and respiration, from the BOLD signal (Birn et al., Hum. Brain Mapp., 2008)

ICA separates linearly mixed sources:



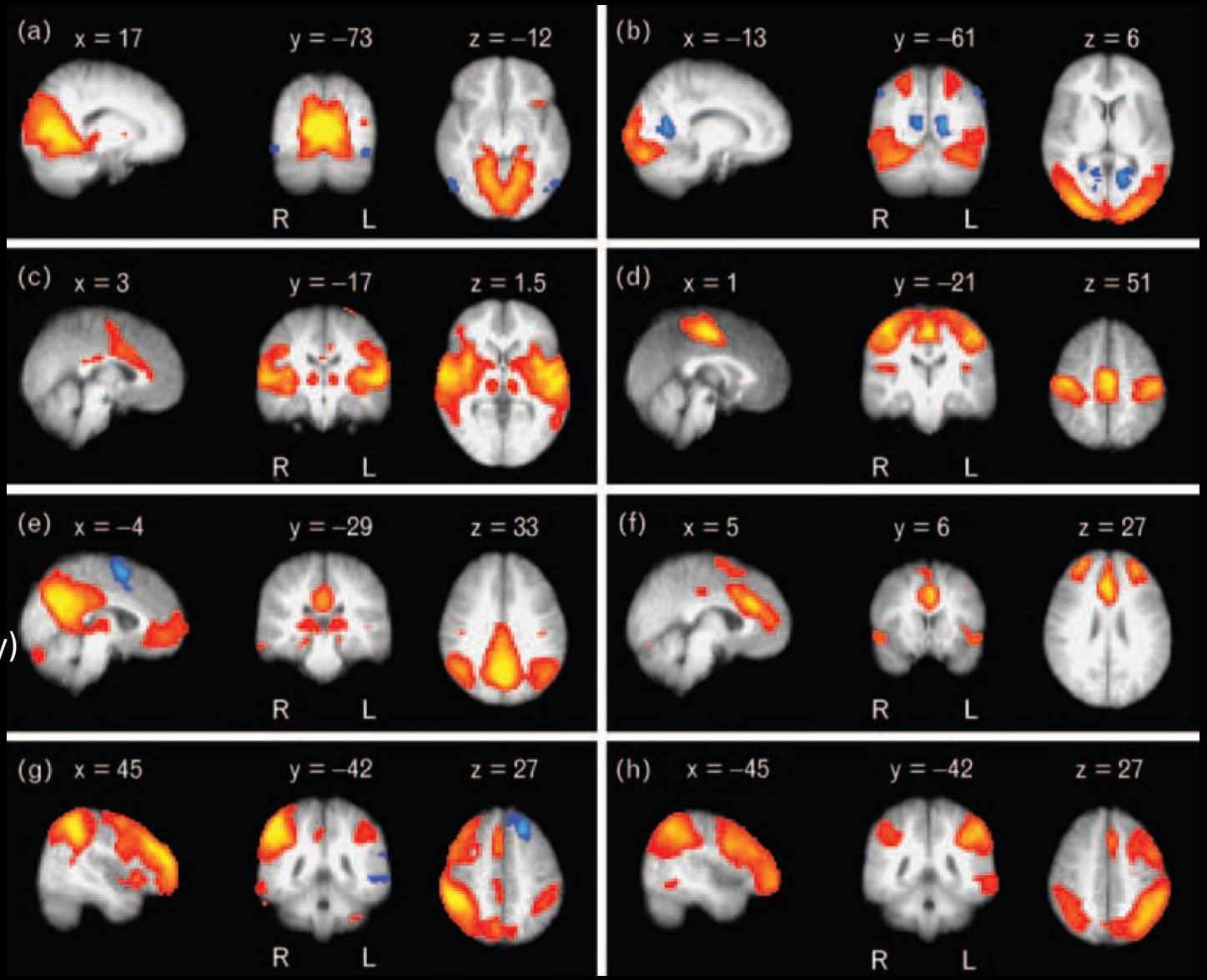
ICA applied to resting-state data identifies 8 main cortical networks

Primary vision

Hearing

DMN (+ memory)

Executive control



Higher order visual processing

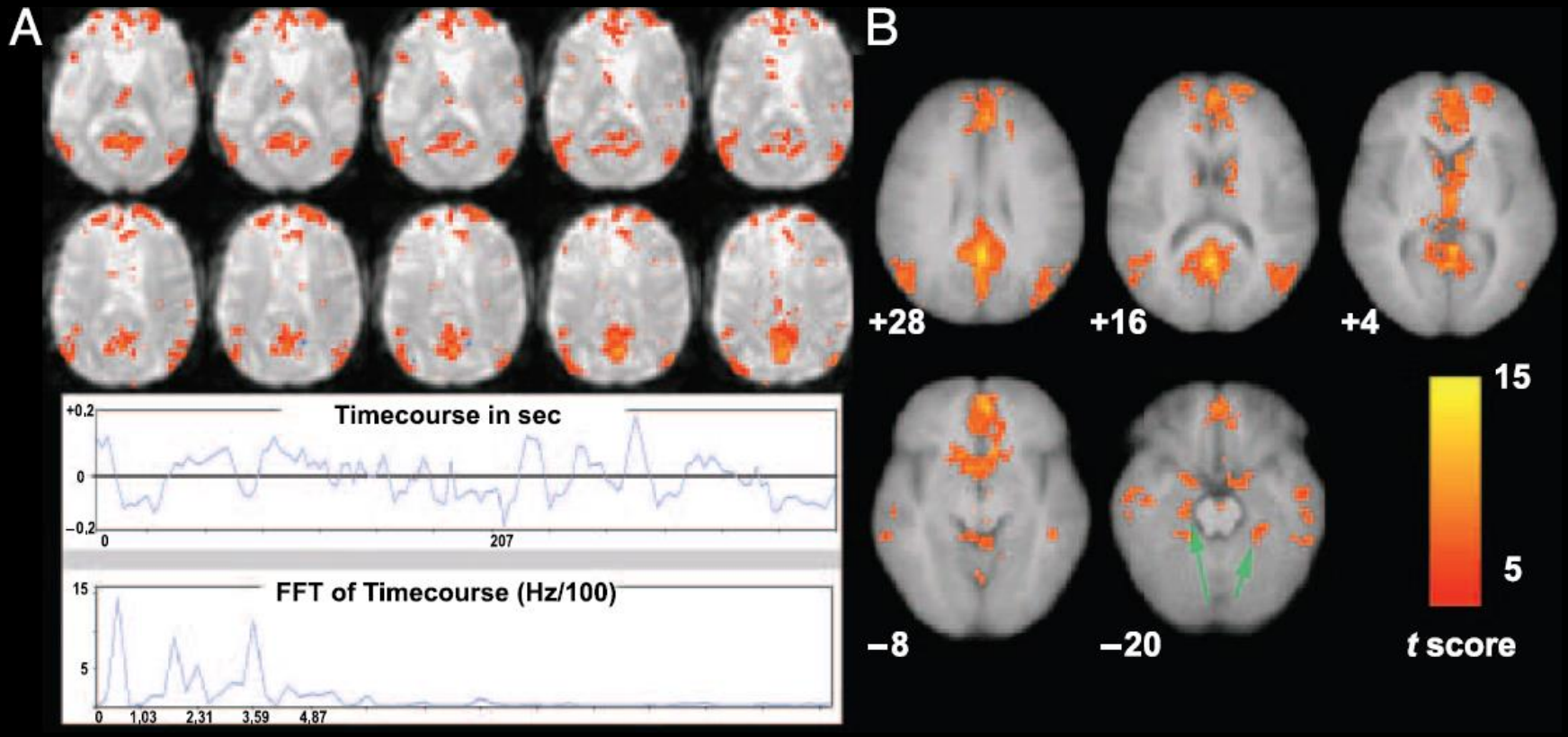
Touch and movement

Salience processing

Executive control

Beckman et al., 2005, Philos. Trans. R Soc. Lond. B, 2005, 360, 1001–1013
Greicius M, Curr. Opin. Neurol., 2008, 21, 424-430

DMN activity at individual and group level

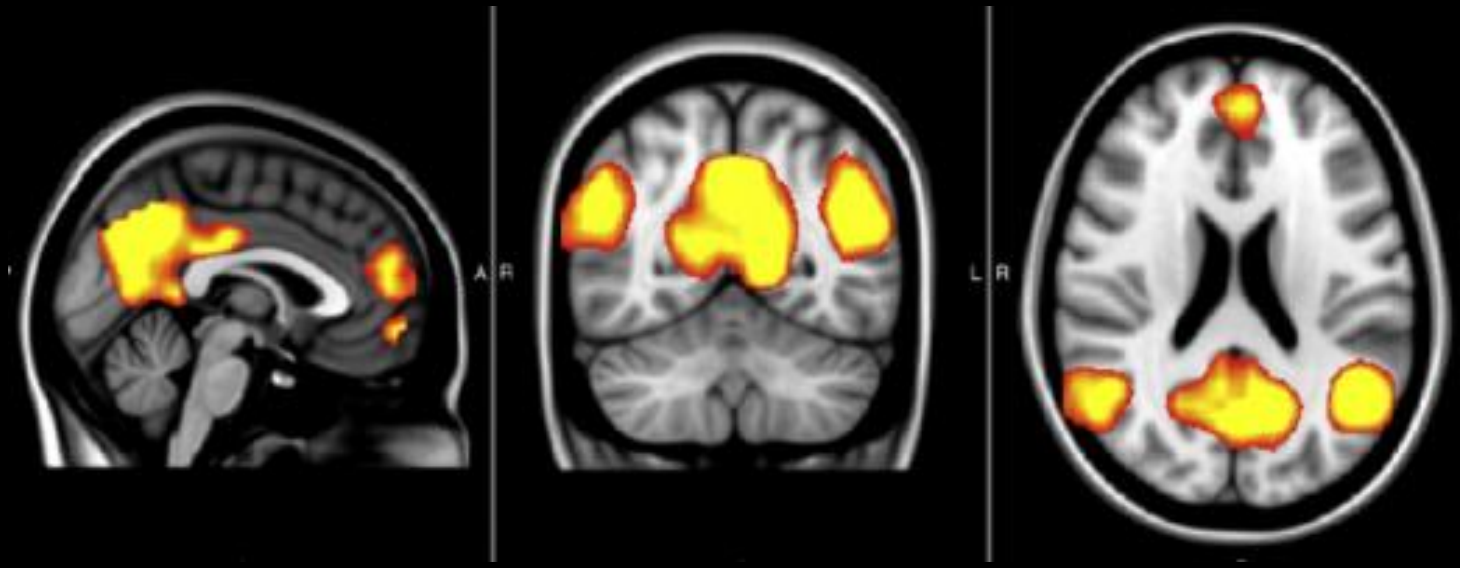


Individual best fit to standard DMN template among 26 components

Computed from 13 mean images

Greicius and Menon, J. Cogn. Neurosci., 2004, 16, 1484-1492

fMRI - default mode network (DMN)

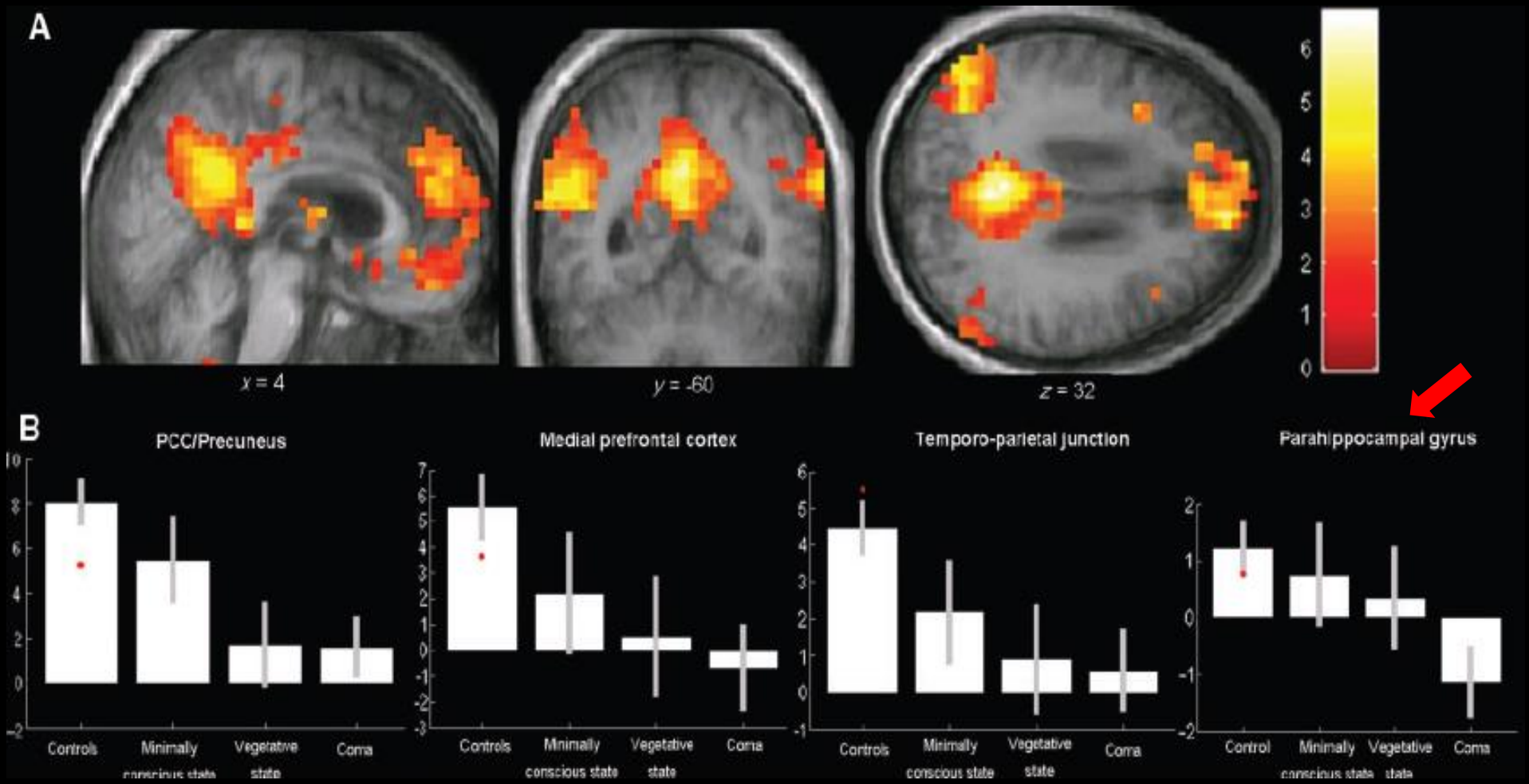


The DMN includes: mPFC, PCC, precuneus, ACC, parietal cortex and in a minority of studies also the hippocampus

Hafkemeijer et al., Biochim. Biophys. Acta, 2012, 1822, 431-441

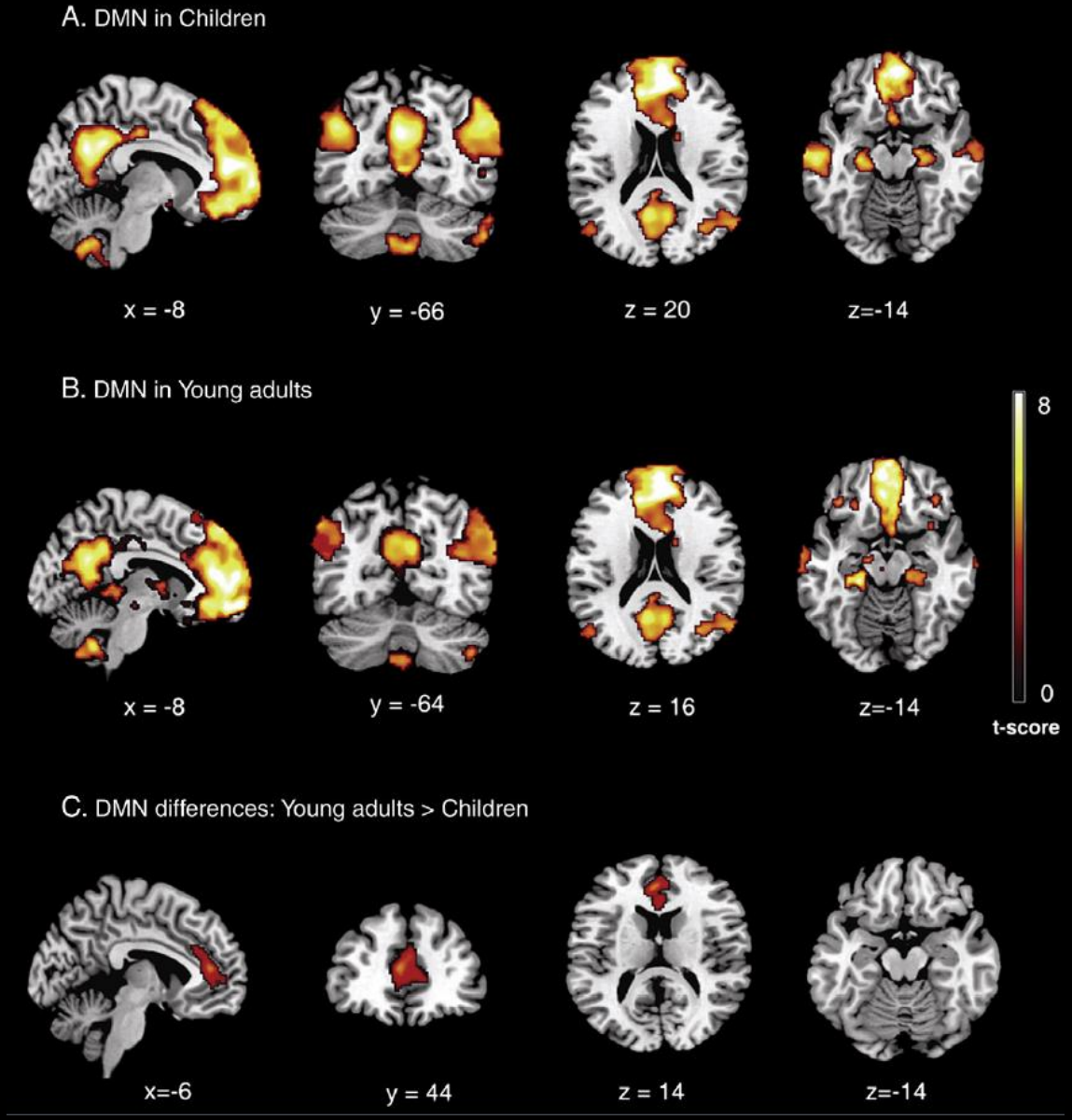
- DMN connectivity reflects the level of consciousness (Greicius et al., Hum. Brain Mapp., 2008; Vanhaudenhuyse et al., Brain, 2010), generates spontaneous thoughts, and preferentially activates when individuals engage in internal tasks such as daydreaming, envisioning the future, and retrieving memories, while it is negatively correlated with brain systems that focus on external visual signals
- In a subject resting quietly for 8 min during an fMRI scan, BOLD signal will fluctuate up and down at a very low frequency (<0.1 Hz) - these low-frequency BOLD signal fluctuations are strongly correlated in time across regions that are known to be functionally connected
- DMN undergoes developmental changes and coherent neuronal oscillations at a rate lower than 0.1 Hz become more consistent in children aged 9-12 years and in older subjects

DMN FC correlates with the level of consciousness



Vanhaudenhuyse et al., Brain, 2010, 133, 161-171

DMN activity is weaker in children (in mPFC)

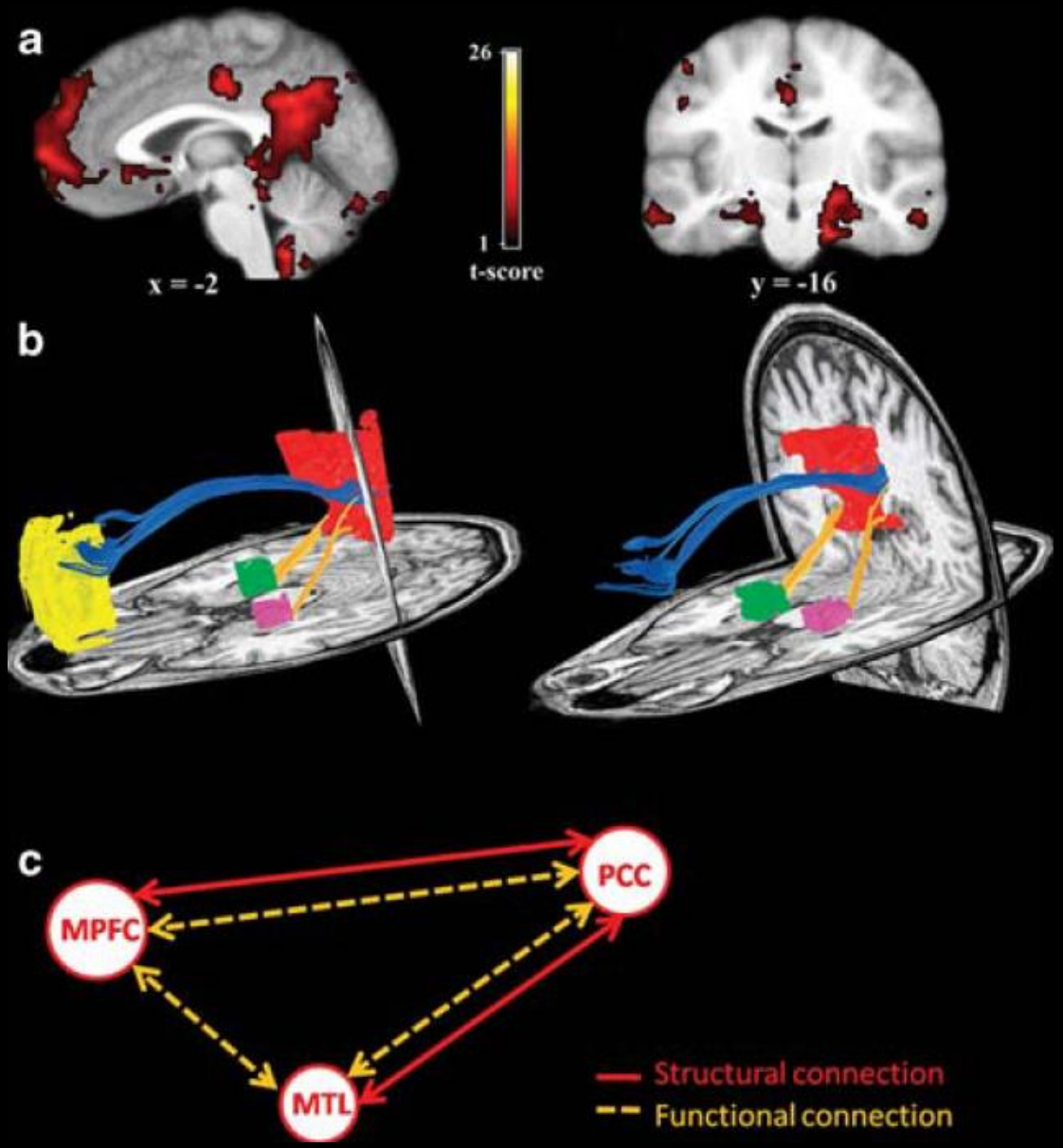


Supekar et al., NeuroImage, 2010, 52, 290-301

DMN fc vs DTI

fMRI

DTI



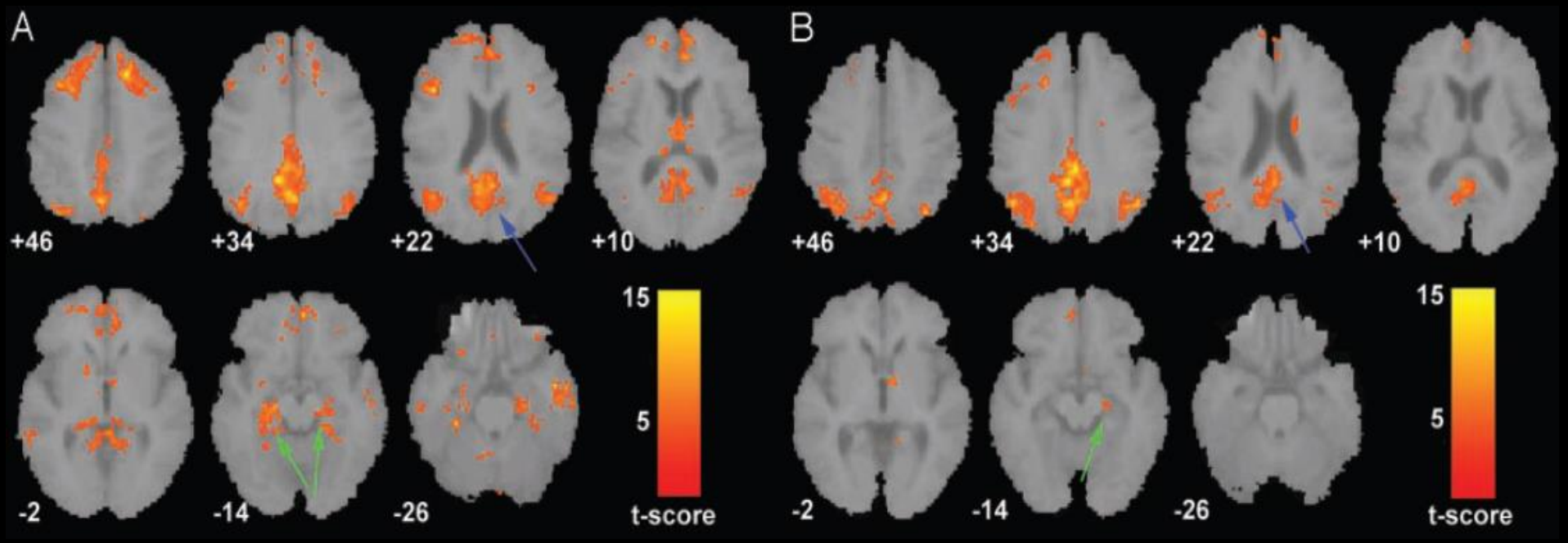
- Most of baseline activity is mediated by neurons that are constantly active and participate in the default mode network (DMN, also known as „the resting state" or „task-negative" network) (Deco et al., TINS, 2013).

Damoiseaux et al., Brain Struct. Funct. 2009, 213, 525-533

DMN in healthy elderly and AD subjects (WashU data)

Healthy elderly subjects

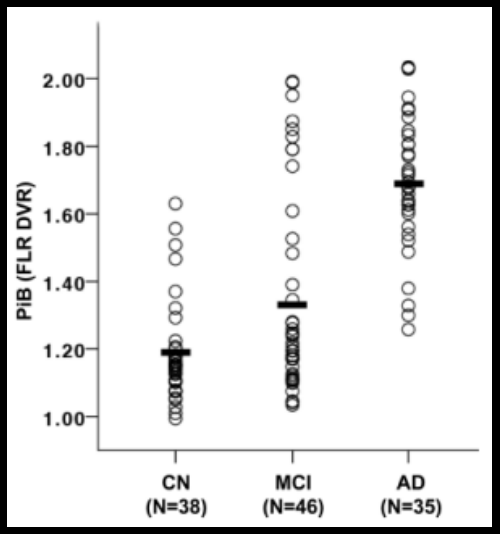
Alzheimer's disease subjects

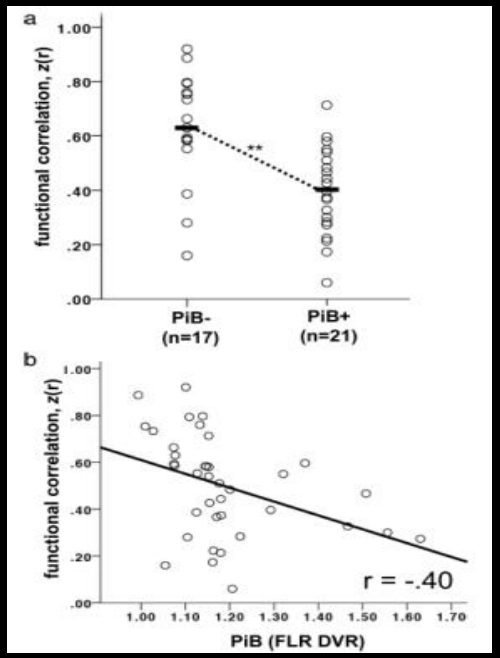


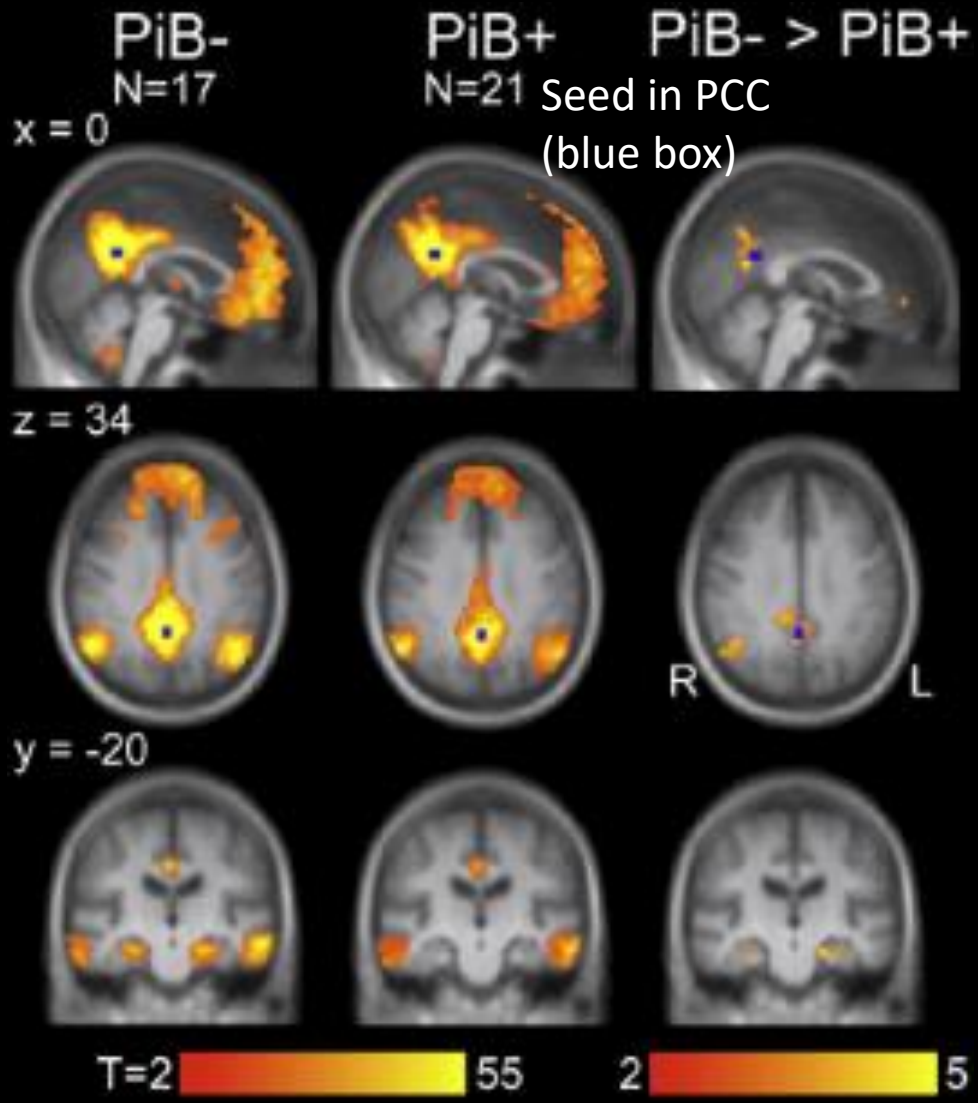
Greicius et al., PNAS, 2004, 101, 4637-4642

AD subjects showed highly significant decreased resting-state activity in PCC (blue arrow), hippocampus and entorhinal cortex (green arrow).

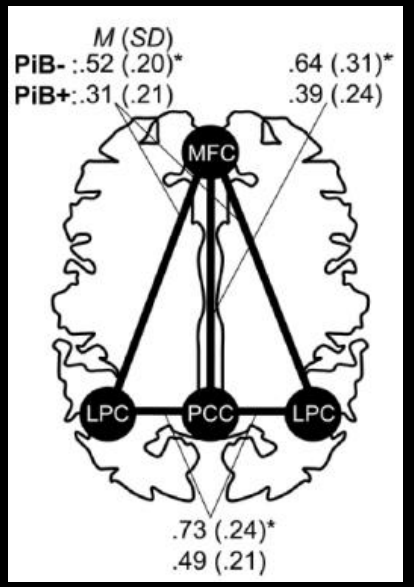
Correlation of β-amyloid deposition (PIB PET) and DMN f-nal connectivity







Clinically normal participants with high amyloid burden displayed significantly reduced f-nal correlations within DMN, including f-nal disconnection of the hippocampal formation relative to participants with low amyloid burden. These reductions were *also observed when controlling for age and structural atrophy*



Hedden et al., J. Neurosci., 2009, 29, 12686-12694;
findings confirmed in Sheline et al., Biol. Psychiatry, 2010, 67, 584-587

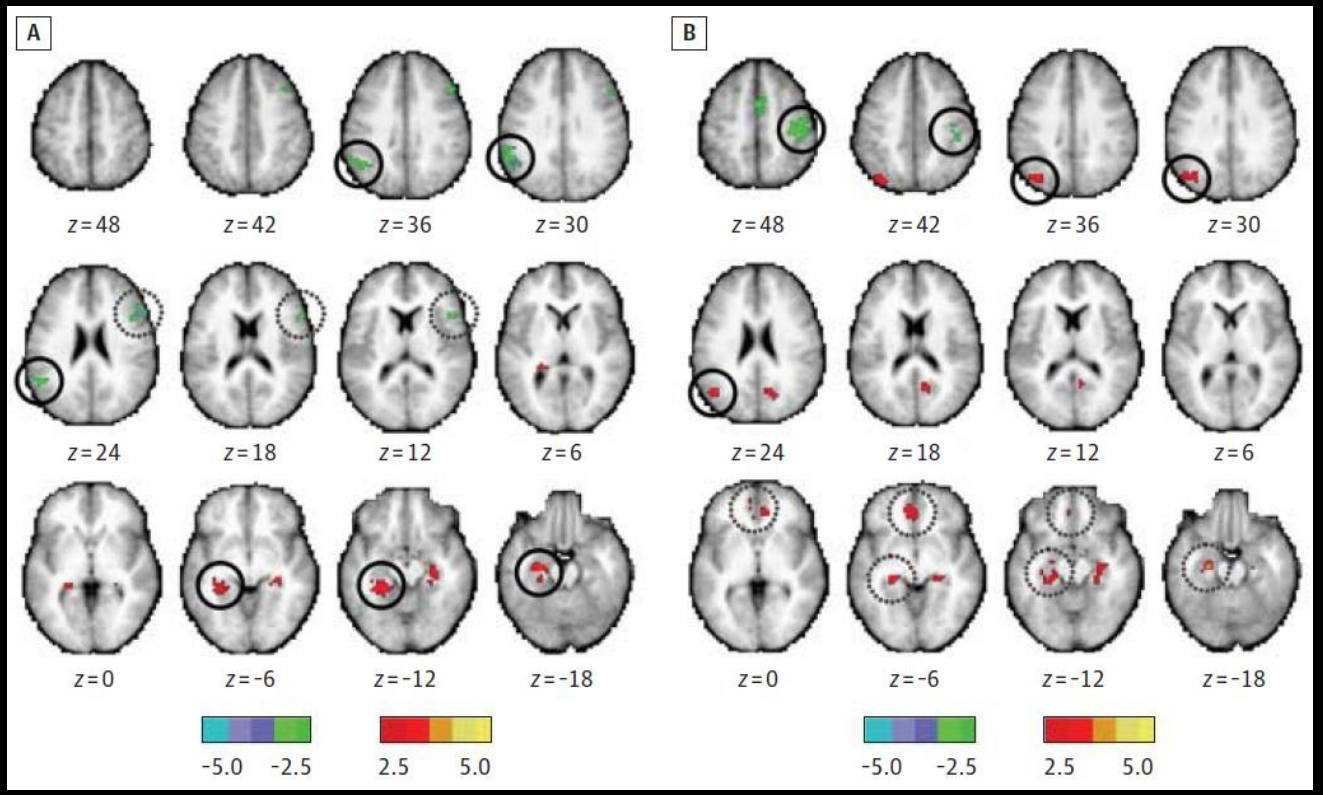
Biomarker correlation

The main opposing network to DMN is the Dorsal Attention Network (DAN): DAN turns off when DMN activates and vice-versa

In participants with low CSF Aβ42 and high p-tau181 (207 cognitively normal participants with preclinical AD), this switching between networks becomes sloppy: in these people, some nodes of the DAN did not turn off when DMN was active

CSF Aβ<500 pg/mL
vs. CSF Aβ >500 pg/mL

CSF p-tau181>80 pg/mL
vs. CSF p-tau181<80 pg/mL



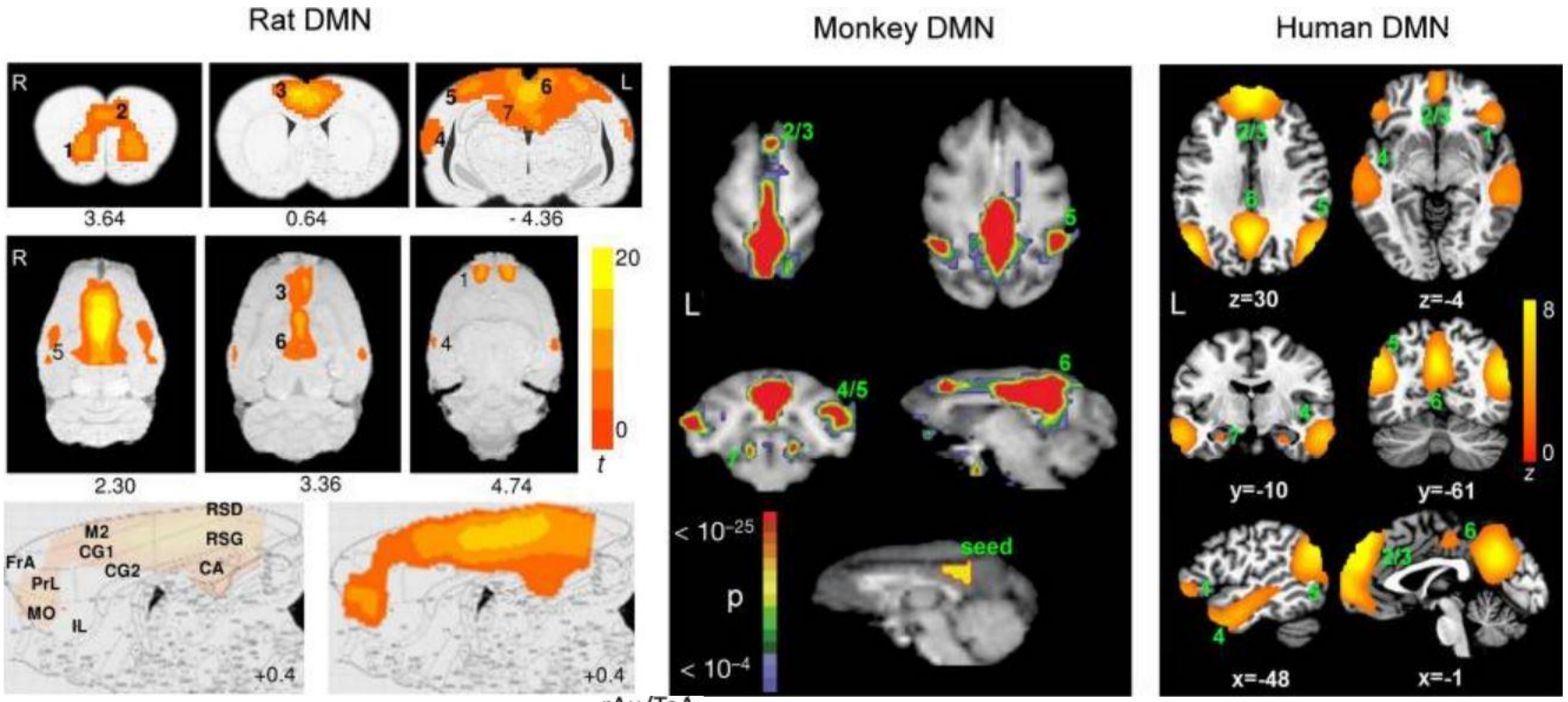
increase decrease in f-nal conn.

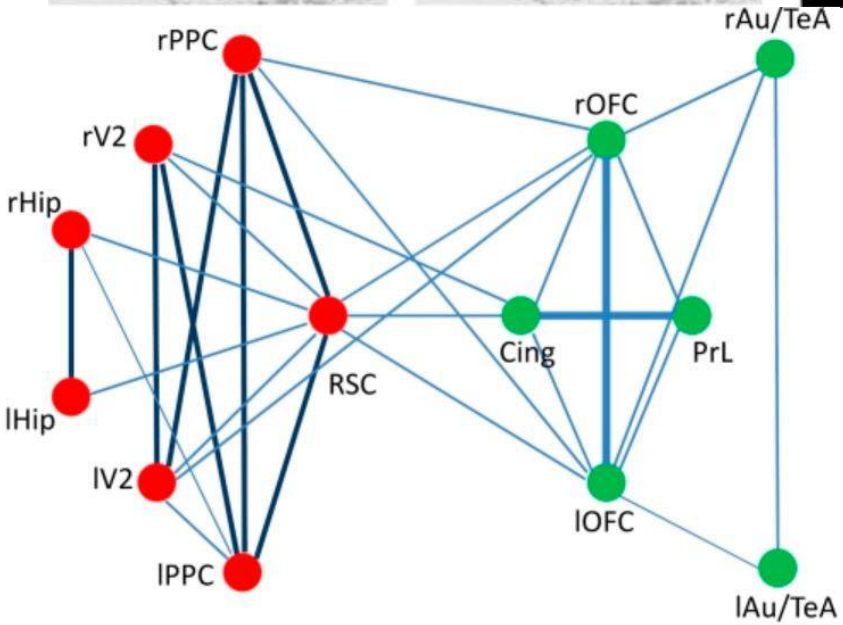
PCC & MTL

increase decrease

MTL & mPFC

Wang et al., JAMA Neurol., 2013; Šimić et al., CNS Neurosci Ther. 2014)

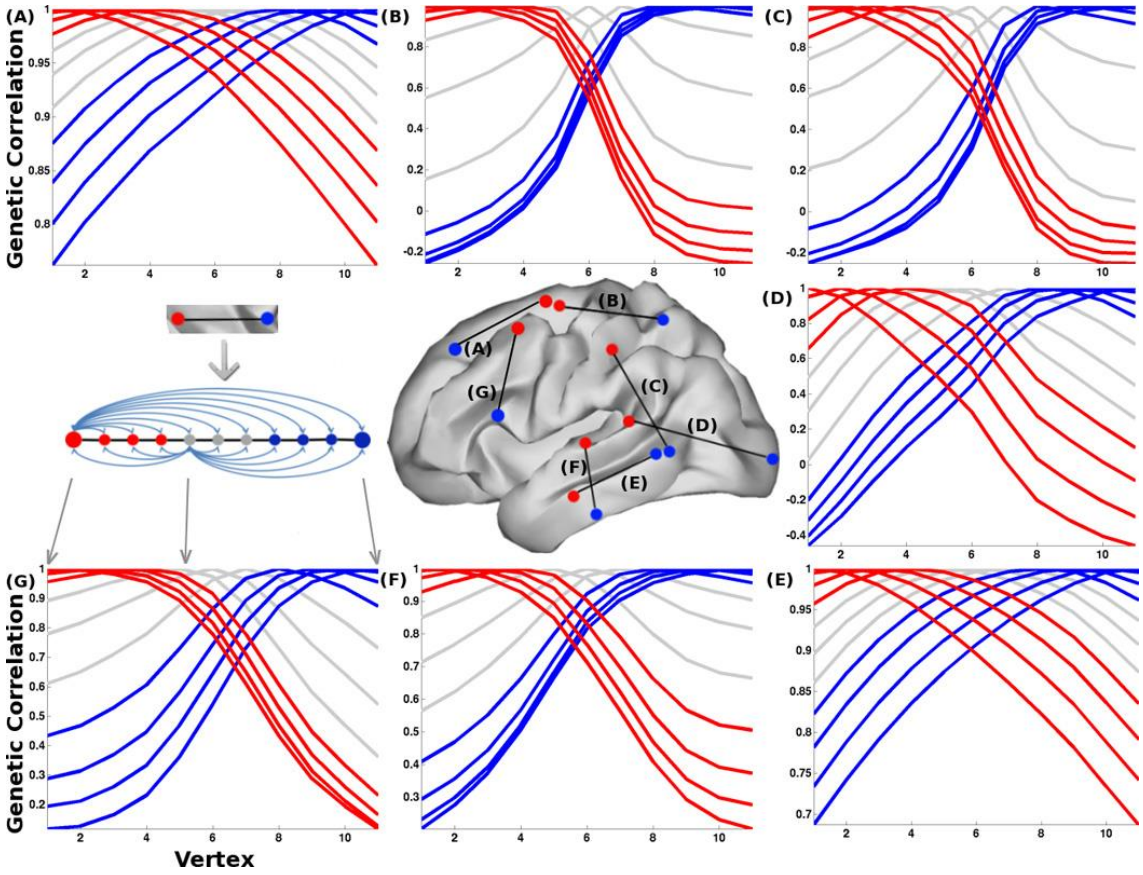


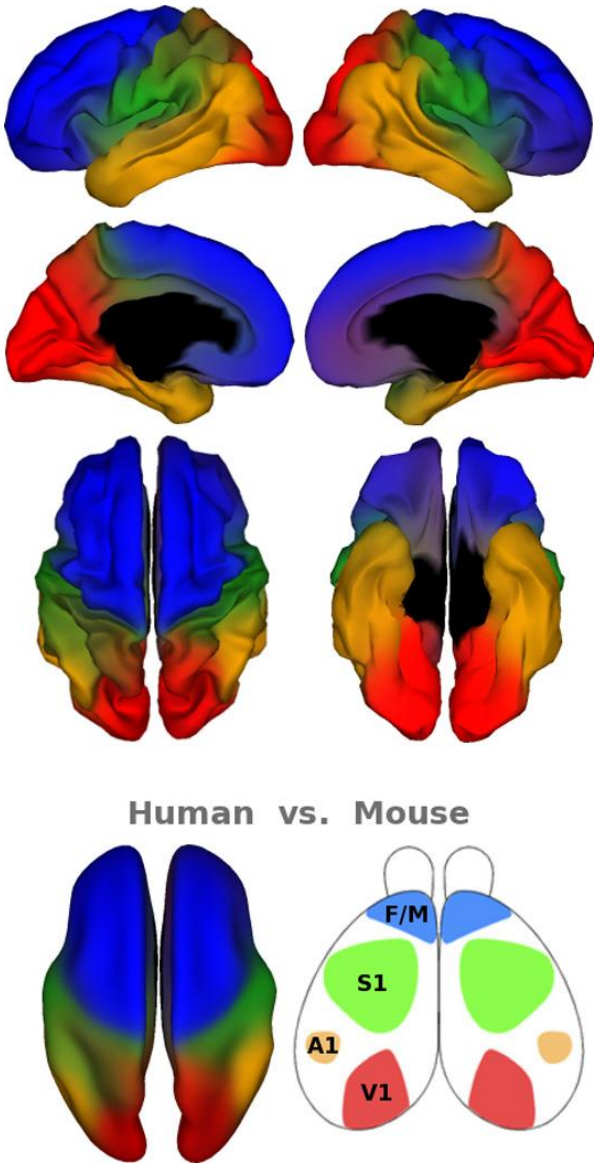


Even rats possess a DMN that is broadly similar to the DMNs of nonhuman primates and humans: despite the distinct evolutionary paths between rodent and primate brain, a well-organized, **intrinsically coherent DMN appears to be a fundamental feature in the mammalian brain** whose primary functions might be to integrate multimodal sensory and affective information to guide behavior in anticipation of changing environmental contingencies.

Lu et al. PNAS USA 2012

Genetički utjecaji na kortikalnu parcelizaciju





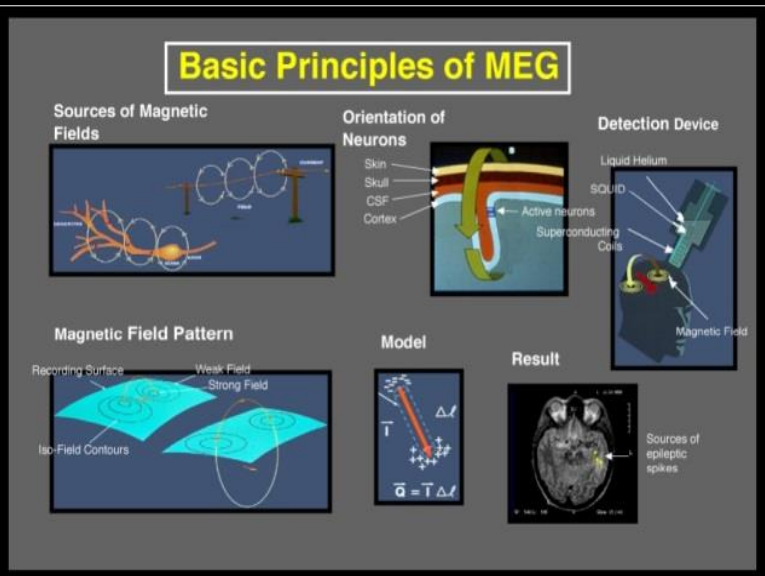
Velike sličnosti u izraženosti gena u glodavaca i ljudi upućuju na očuvanost mehanizama kortikalne parcelizacije, pri čemu različitosti vjerojatno odražavaju funkcionalnosti najvažnije za svaku vrstu

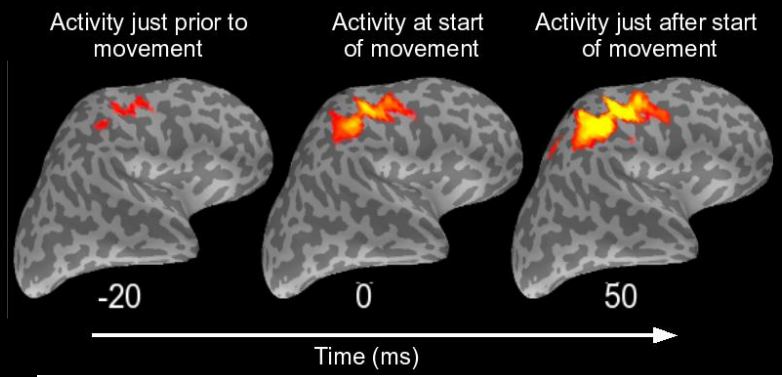
N = 406 blizanaca (110 MZ and 93 DZ)

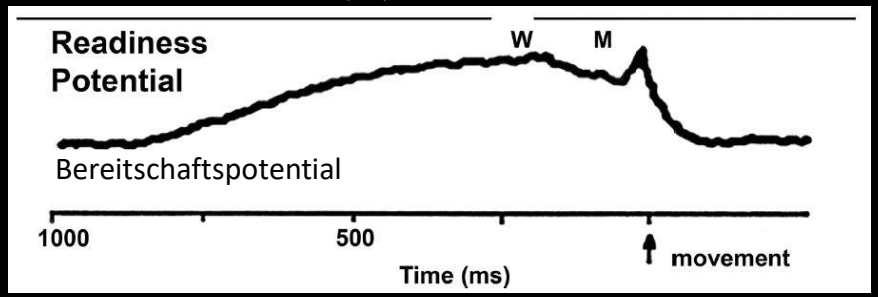
Chen et al. Neuron 2011

MEG i pitanje slobodne volje

To generate a MEG signal that is detectable, approximately 50,000 active neurons are needed



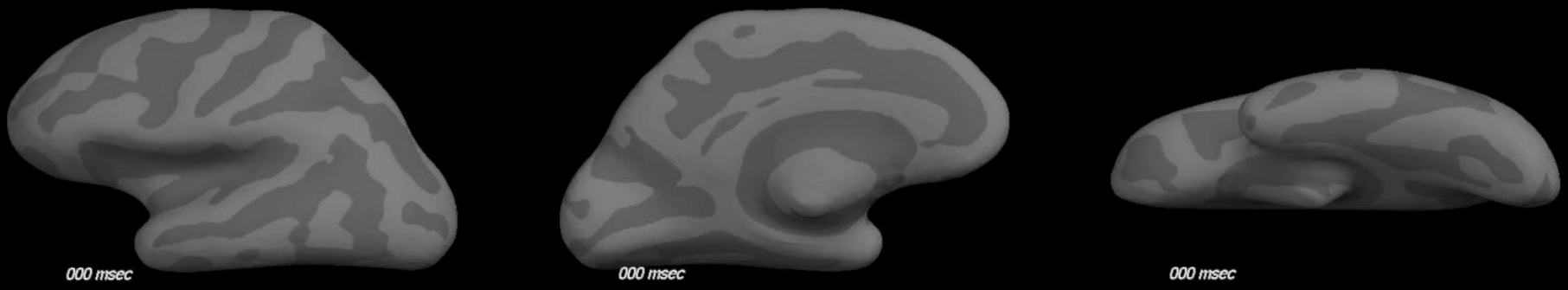




The estimation of the sense of will (signified by “W”) or intent to move occurred well after the beginning of the RP, and the sensation of movement (signified by “M”) occurred even later, and well after the beginning of the RP

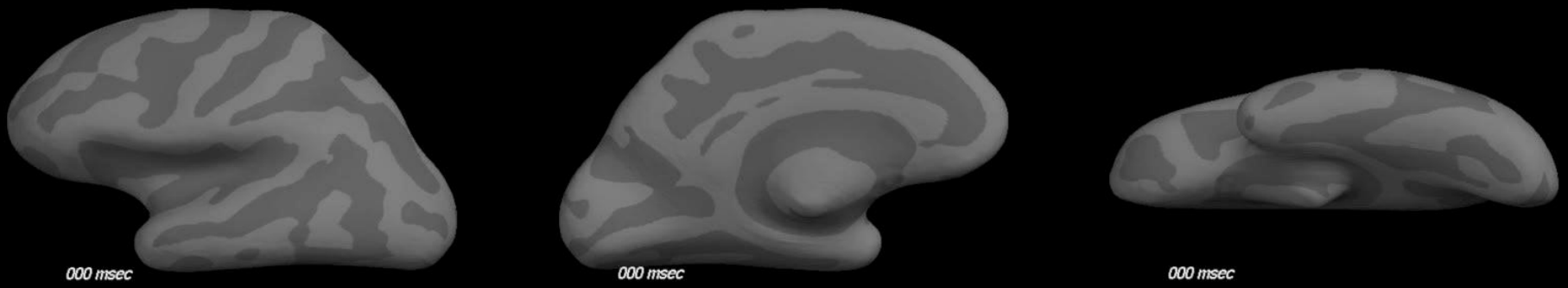
Libet et al., Brain 1983; 106: 623-642

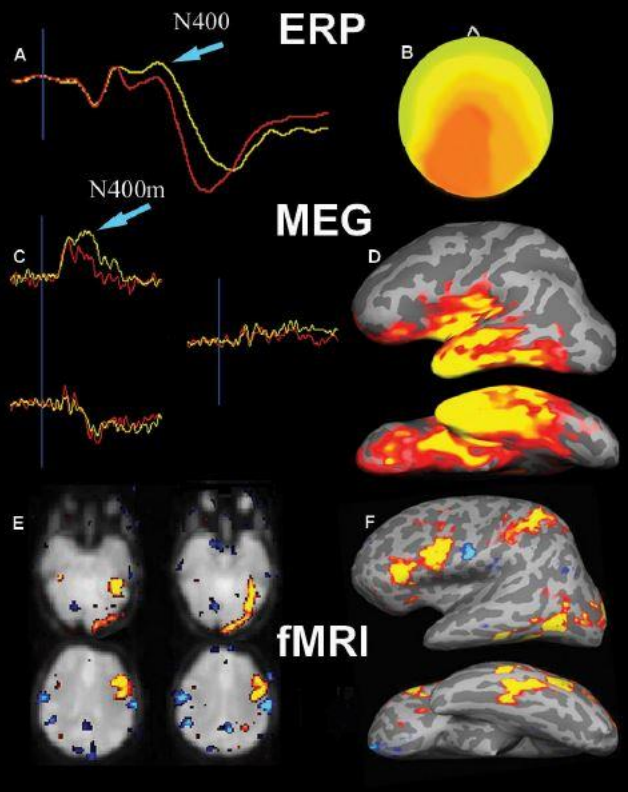
Spatiotemporal dynamics of word processing in the human cortex (fMRI + MEG)

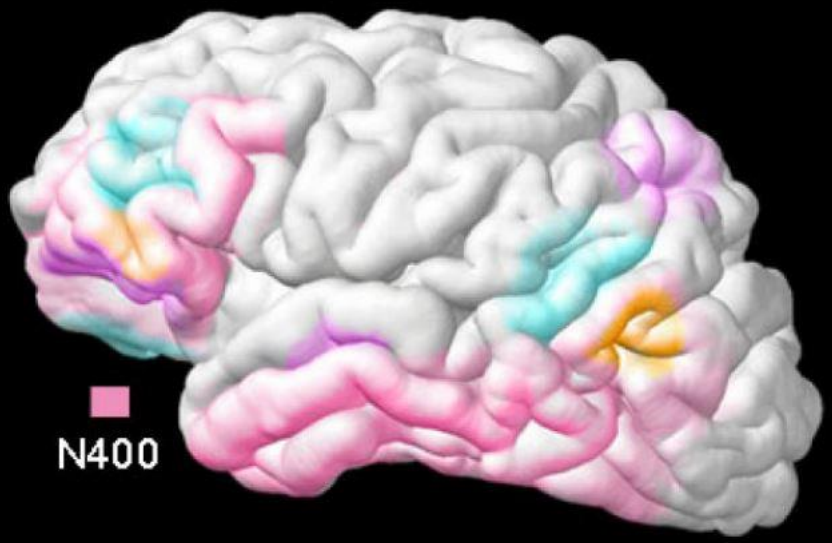


Marinkovic K, Neuroscientist, 2004

Spatiotemporal dynamics of word processing in the human cortex (MEG + fMRI + ERP)



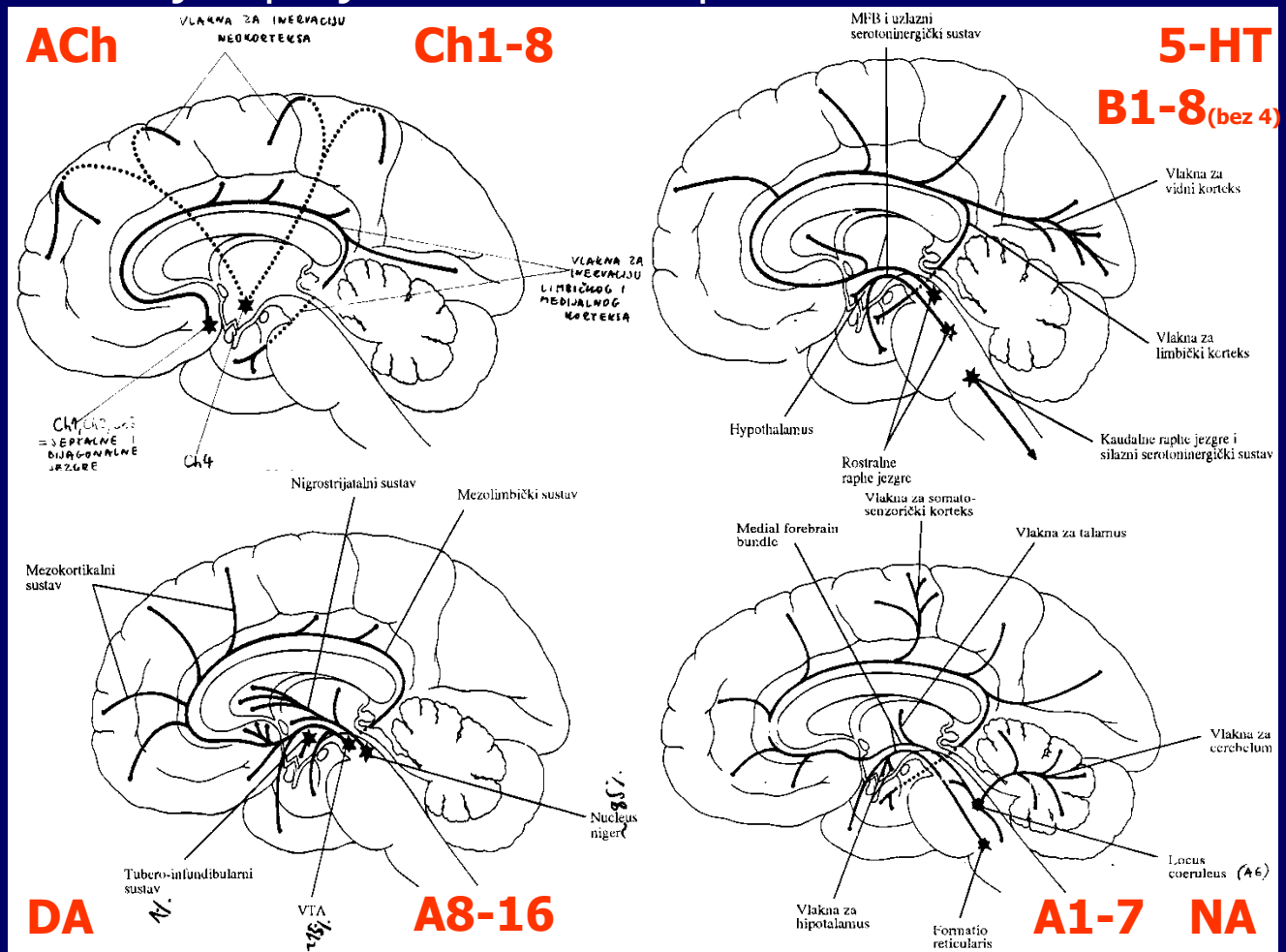




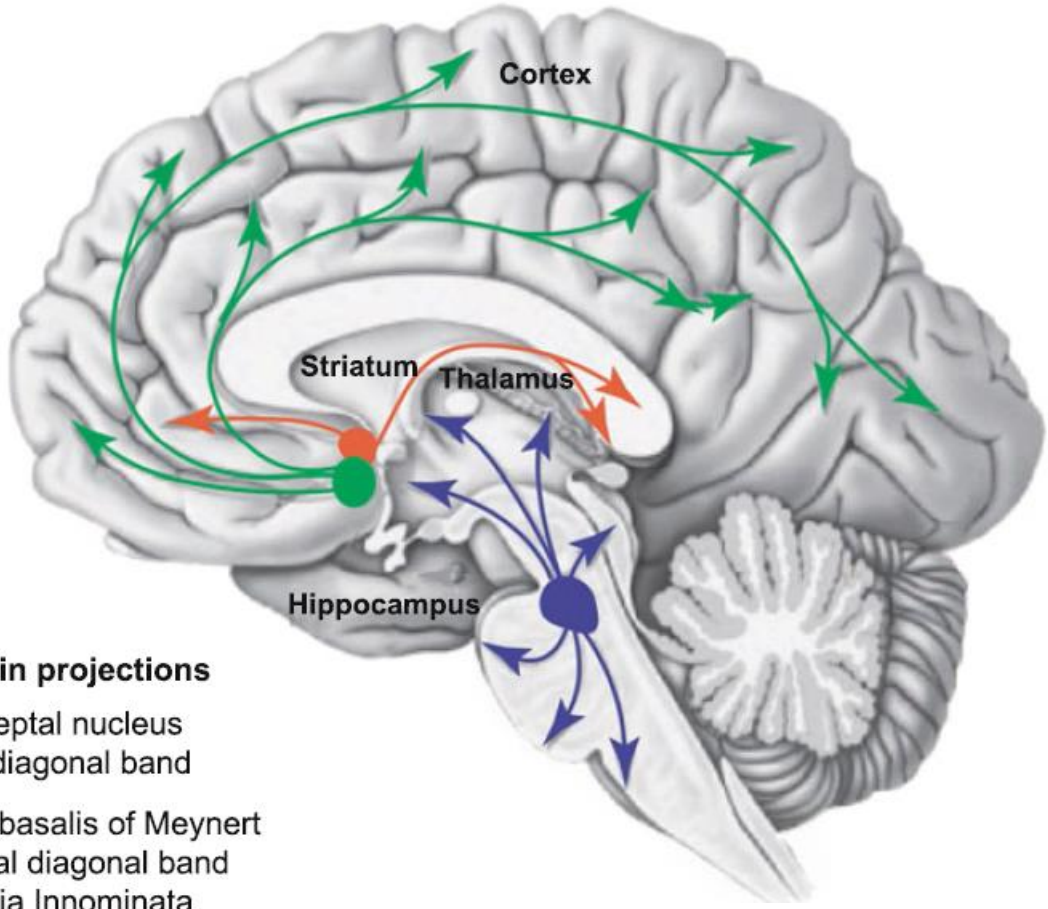
Marinkovic K, Neuroscientist, 2004

Inervacija moždane kore ekstratalamičkim vlaknima

Utjecaj promjene bilo kojeg transmiterskog sustava je izuzetno složen i ovisi o neuroanatomskoj raspodjeli vlakana i receptora u vremenu



Kolinergički sustav



Basal forebrain projections

Medial septal nucleus
Vertical diagonal band

Nucleus basalis of Meynert
Horizontal diagonal band
Substantia Innominata

Brainstem cholinergic projections

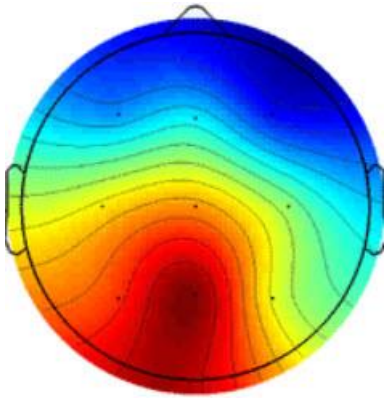
Laterodorsal pontine tegmental nucleus
Pedunculopontine nucleus

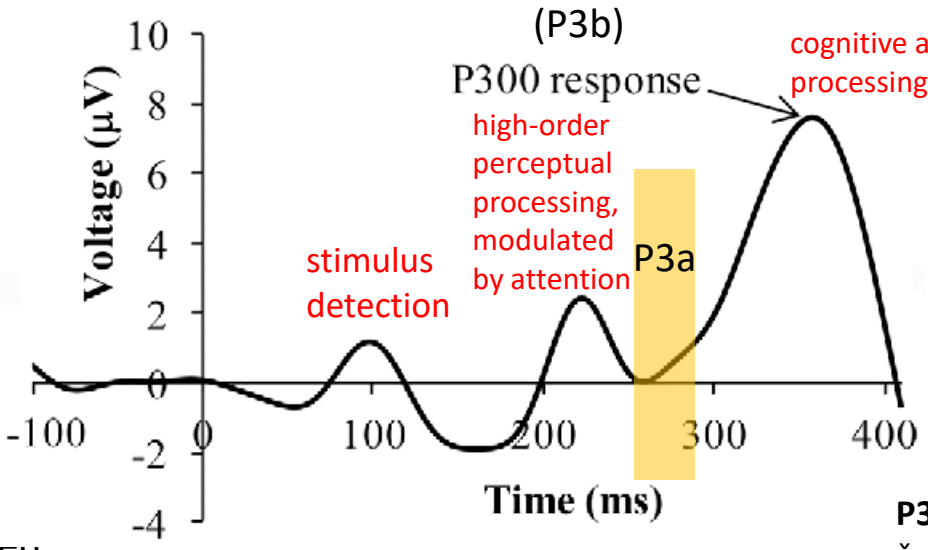
A Review of the Cholinergic System and Therapeutic Approaches to Treat Brain Disorders

Daniel Bertrand and Tanya L. Wallace

Curr Topics Behav Neurosci (2020) 45: 1–28
https://doi.org/10.1007/7854_2020_141
Published Online: 26 May 2020

Pojednostavljena shema glavnih kolinergičkih projekcija u mozgu čovjeka





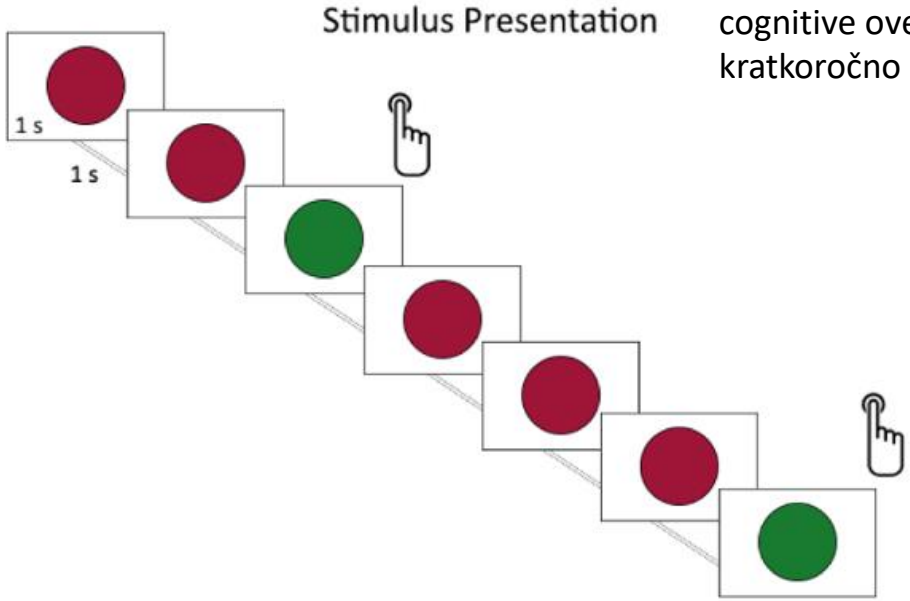
The **P300 wave** (P3b) is a positive deflection in the human event-related potential (ERP).

It is most commonly elicited in an **oddball paradigm** when a subject detects an occasional "target" (novel) stimulus in a regular train of standard stimuli.

Neurons within the basal nucleus are known to respond to novel stimuli triggering the release of ACh within the cerebral cortex, which enhances responsiveness (at psychological level this corresponds to attention) to further excitatory inputs.

These effects are mediated mainly by the **muscarinic M1** receptors.

P3a – pozornost, čeoni/tjemeni režanj – dopamin
P3b – klasični P300 (novel stimulus, cognitive overload, kratkoročno zapamć.)

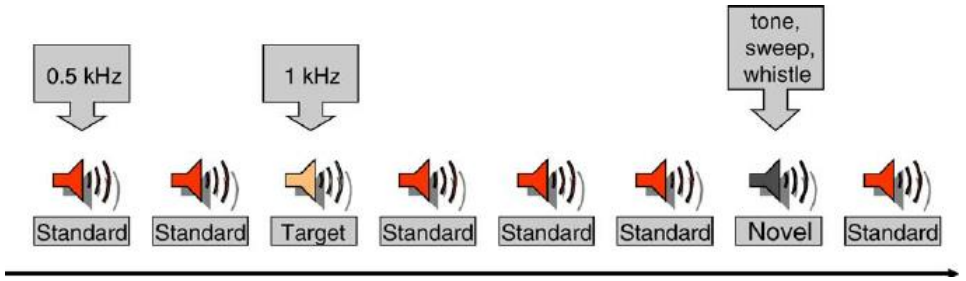


Current Alzheimer Research, 2018, *15*, 1244-1260

RESEARCH ARTICLE

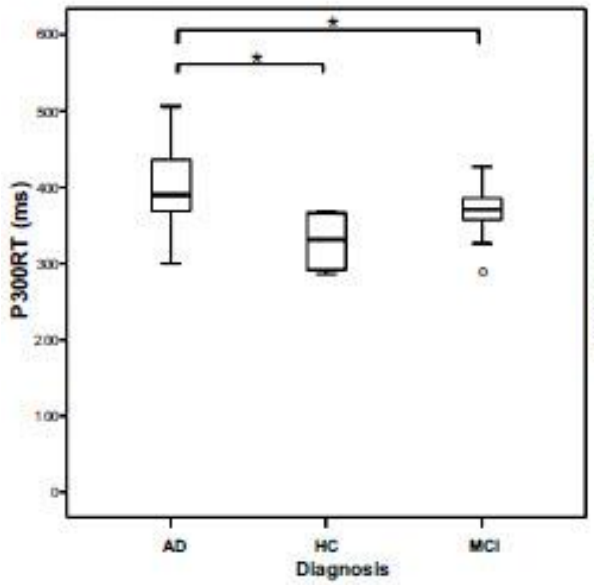
Event-related Potentials Improve the Efficiency of Cerebrospinal Fluid Biomarkers for Differential Diagnosis of Alzheimer's Disease

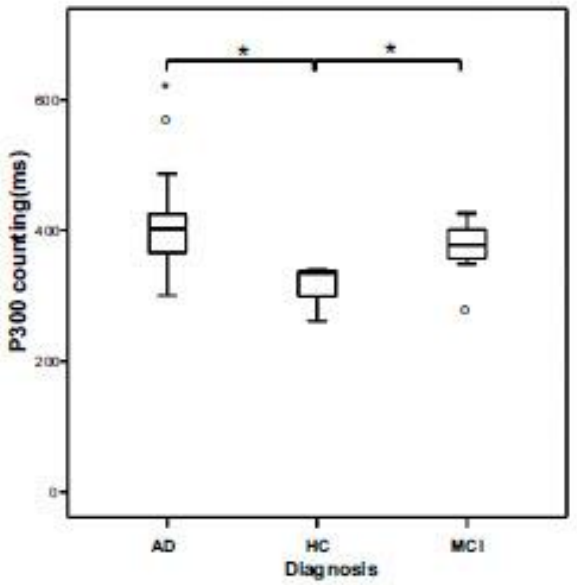
Mirjana Babić Leko[a], Magdalena Krbot Skorić[b], Nataša Klepac[c], Fran Borovečki[c,d], Lea Langer Horvat[a], Željka Vogrinc[e], Zdenko Sonicki[f], Patrick R. Hof[g] and Goran Šimić[a,*]



97 ispitanika

Vrijeme reakcije



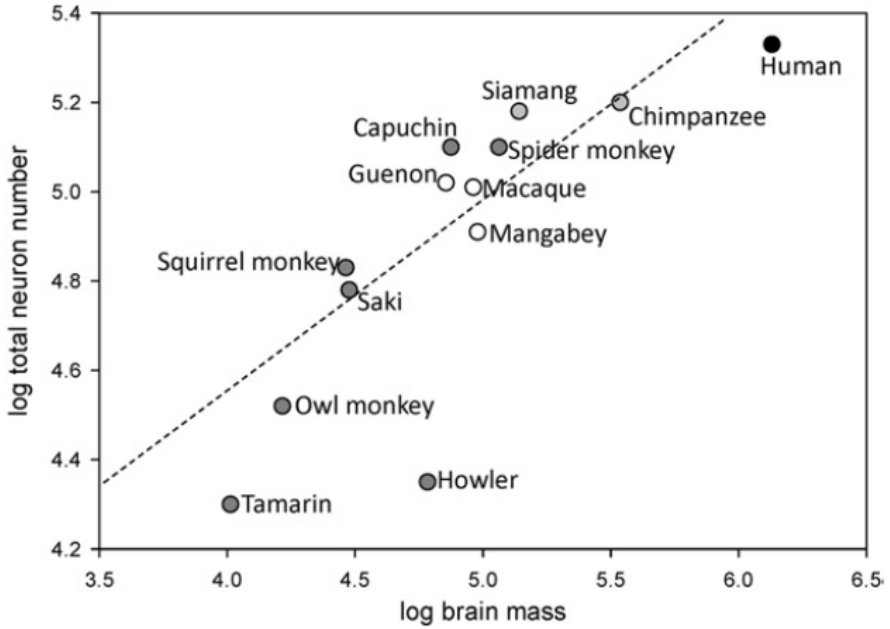


Vrijeme potrebno za prebrojati sve ciljne tonove (među ciljnima i ometajućima)

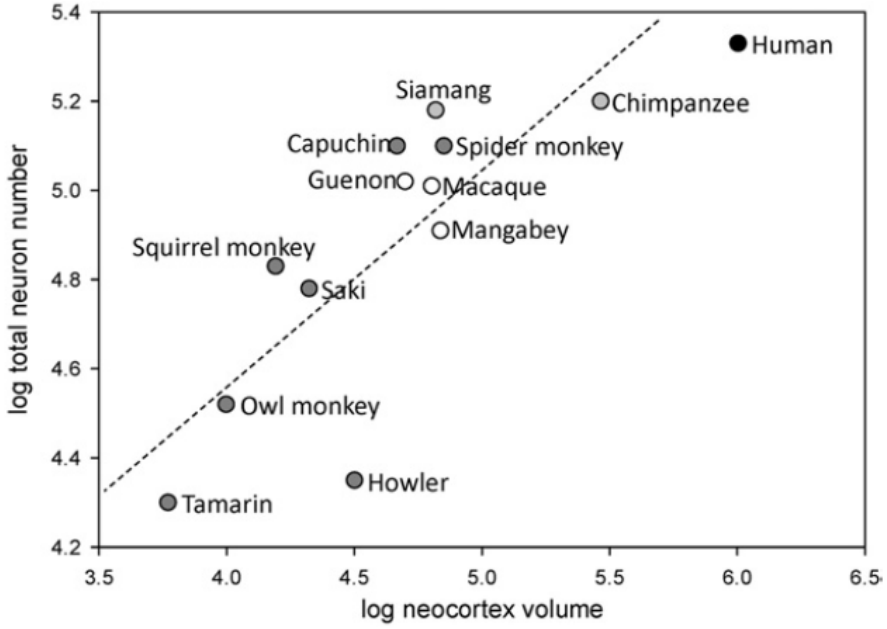
Neuroscience 184 (2011) 1–15

COMPARATIVE ANALYSIS OF THE NUCLEUS BASALIS OF MEYNERT AMONG PRIMATES

M. A. RAGHANTI,[a,b*] G. SIMIC,[c] S. WATSON,[a] C. D. STIMPSON,[d] P. R. HOF[e] AND C. C. SHERWOOD[d]



Total neuron number within the nbM regressed on brain mass. Data points for New World monkeys are dark grey; Old World monkey data points are white; lesser and great ape data points are light grey.



Total neuron number within the nbM regressed on neocortical volume. Data points for New World monkeys are dark grey; Old World monkey data points are white; lesser and great ape data points are light grey.

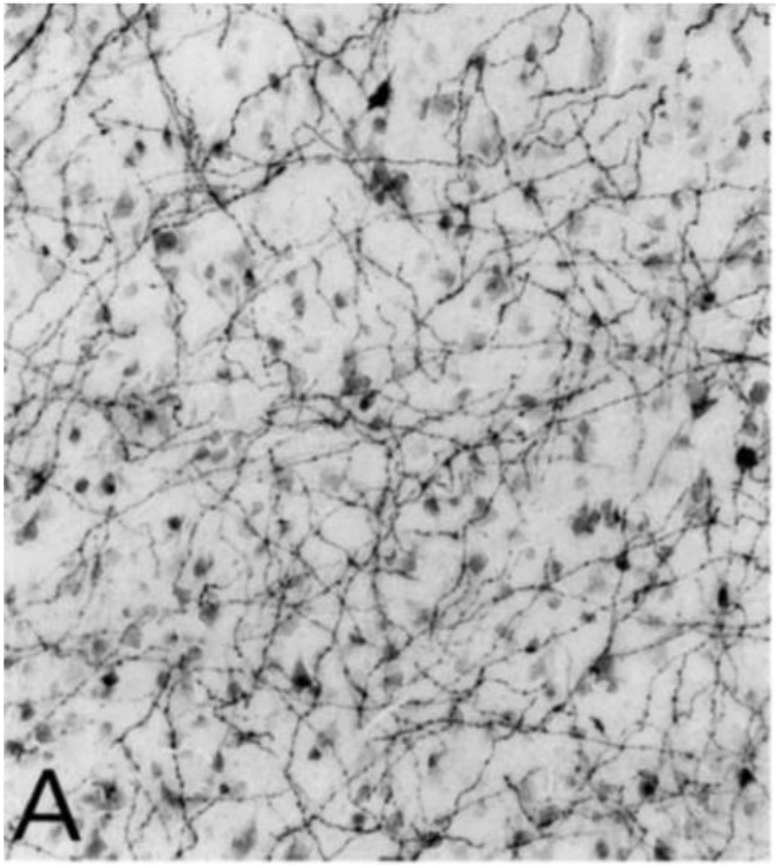
THE JOURNAL OF COMPARATIVE NEUROLOGY 275:216–240 (1988)

Nucleus Basalis (Ch4) and Cortical Cholinergic Innervation in the Human Brain: Observations Based on the Distribution of Acetylcholinesterase and Choline Acetyltransferase

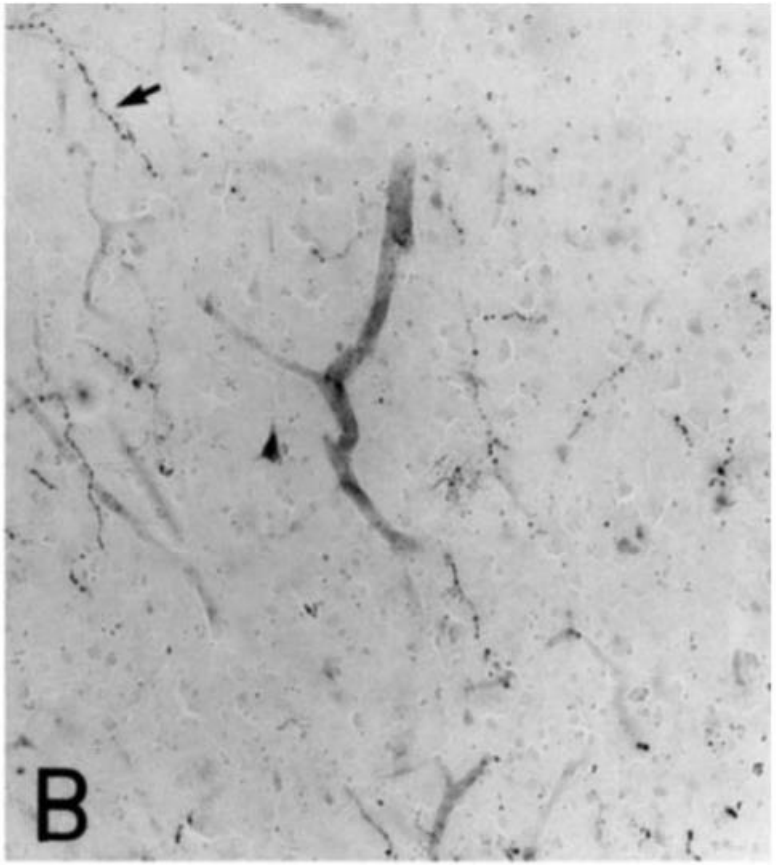
M-MARSEL MESULAM AND CHANGIZ GEULA

AChE ihc

temporopolar cx, CON



temporopolar cx, Alzheimer's disease



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COMPARATIVE ANALYSIS OF THE NUCLEUS BASALIS OF MEYNERT AMONG PRIMATES

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23 individual brains from 12 anthropoid species
ChAT-ihc

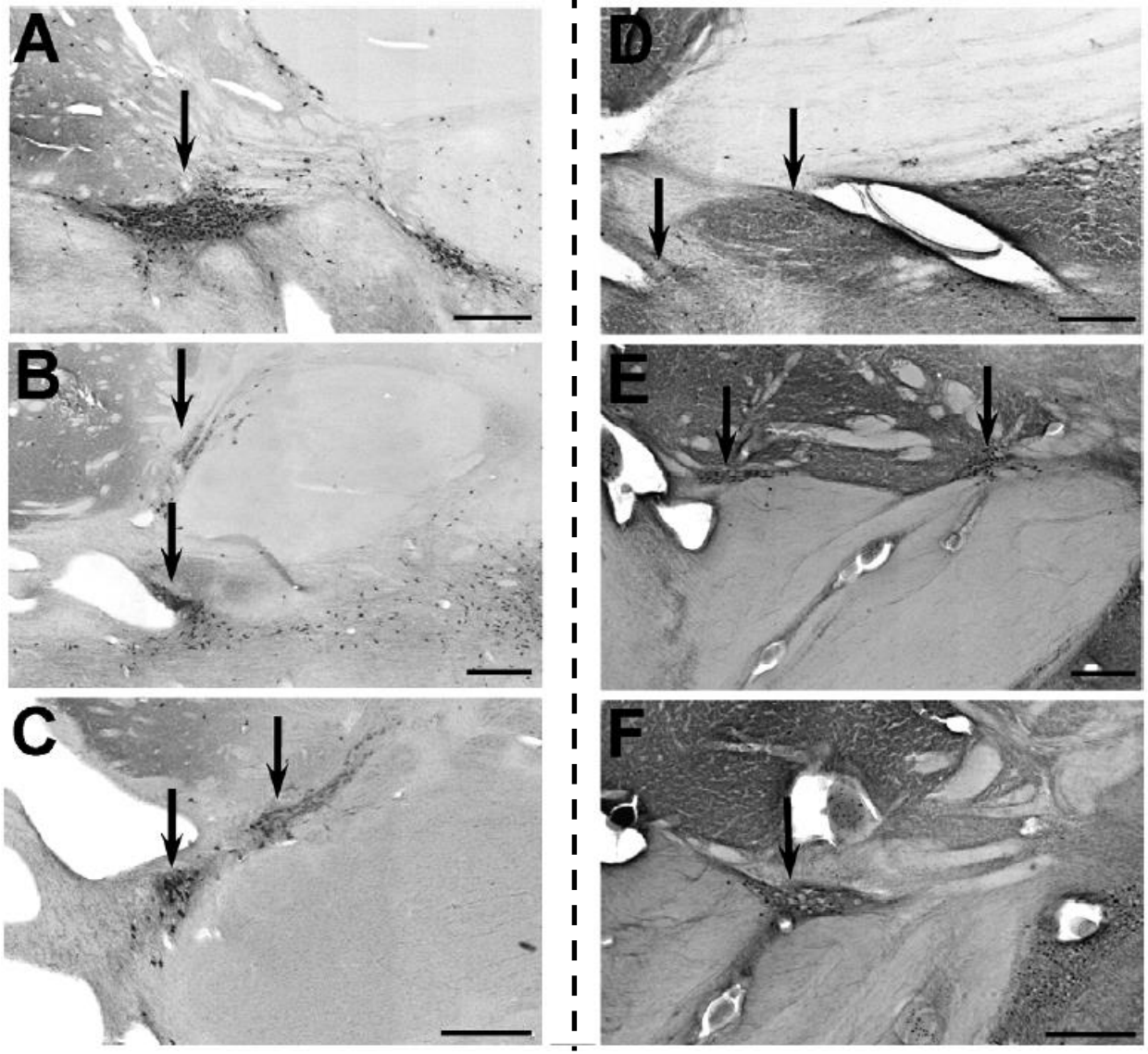
HUMAN NSP

CHIMPANZEE NSP

anterior level

intermediate level

posterior level



Teorije svijesti – 4 kategorije

prema Doering et al., *Cogn. Neurosci*. 2020

Svijest definiraju na temelju:

1. drugih fenomena: **NDT**, **OrchOR**

najprije predlažu da je „njihov" fenomen bitan za svijest ili predstavlja samu svijest, a tek nakon toga rade na detaljima kako bi to dokazali iako ne proučavaju detalje o samoj svijesti

2. struktura koje ju posreduju: **IIT**, **RPT**

ne zadovoljavaju „unfolding" argument, teorija svijesti ne može se temeljiti na karakterizaciji fizičke strukture mozga (tako da locira C. u hardver", a ne govori ništa preciznije o softveru koji na tom hardveru radi)

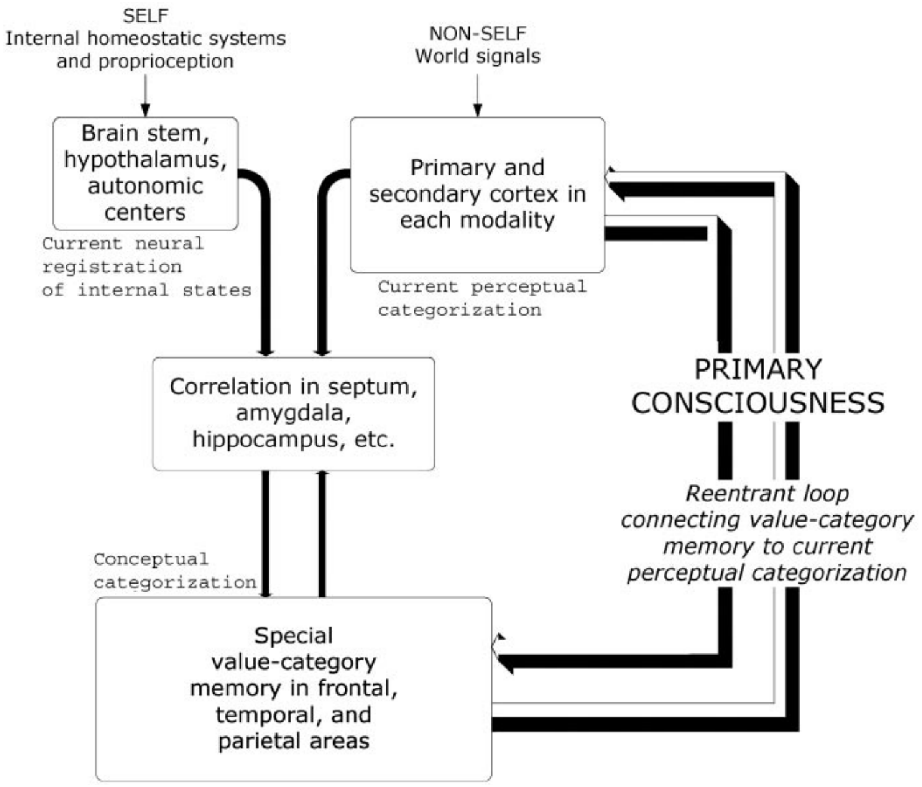
3. procesa obrade podataka koje vrše:
   GNWT, **HOTT**, **PPT**, **ART**

4. bioloških (**TLT**, **NMDA**)
   i kognitivnih procesa (**AST**, **SMT**, **SCMT**)

1. NDT – neural darwinism theory

Edelman ju je nazvao *theory of neuronal group selection* (TNGS)

- primarna C. (jedinstvena percepcija) nastaje u CCx integracijom (*binding*) mnogobrojnih ulaznih signala u razdobljima < 500 ms
- svjesna su stanja uvijek raznolika, ali ujedinjena
- viša C. nastaje putem selekcijskog mehanizma (neuronskog darwinizma) skupina neurona u CCx, a ti su procesi ograničeni i uvjetovani aktivnošću difuznih ascendentnih sustava: NA iz LC, 5-HT iz rostralnih raphe jezgara, kolinergičkih iz NBM, dopaminergički iz VTA, histaminergičkih iz tuberomamilarne jezgre hipotalamusa koji moduliraju i favoriziraju određena za vrstu specifična ponašanja tijekom evolucije tj. odabiru sklopove koji dovode do korisnih percepcija koje se onda ojačavaju epigenetskom i sinaptičkom plastičnošću
- sličnost s teorijom sinaptičkog darwinizma (Jean-Pierre Changeux)

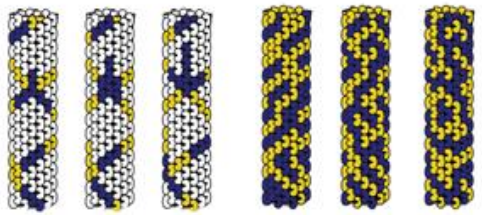


Teorija ne razlikuje svjesno od nesvjesnog procesiranja, pa se može reći da više pokušava poopćiti fenomene percepcije, a ne objasniti svijest

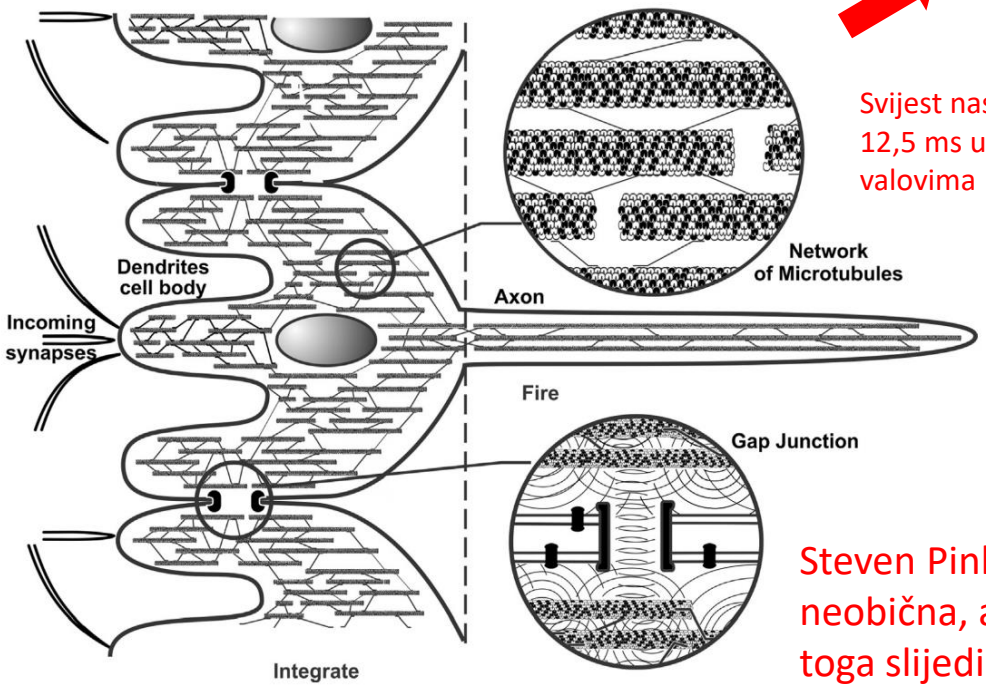
Gerald M. Edelman – (i Rodney R. Porter): NN 1972 za otkriće kem. strukture pt-la

Edelman, G. M. Naturalizing consciousness: a theoretical framework. *Proc. Nat. Acad. Sci. U.S.A.*, 2003; 100: 5520–5524.

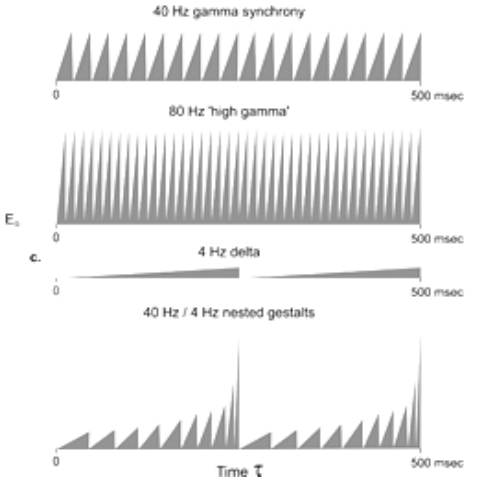
2. **Orch OR** – orchestrated objective reduction theory



- nastanak NFTs u AD dovodi do gubitka informacija i poremećaja svijesti



Svijest nastaje svakih 12,5 ms u 80-Hz-im γ valovima

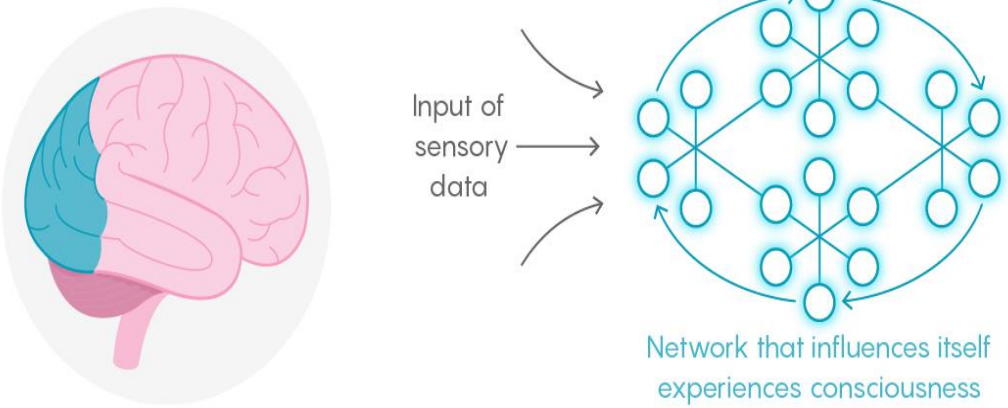


Steven Pinker (2007): „Kvantna mehanika je neobična, a i svijest je neobičan fenomen; iz toga slijedi da se kvantnim mehanizmom može objasniti svijest"

Roger Penrose: NN 2020 za matematičke alate koji su pomogli opisati ponašanje crnih rupa (rad iz 1964.)

Hameroff S, Penrose R. Consciousness in the universe: a review of the 'Orch OR' theory. *Phys. Life Rev*. 2014; 11: 39-78.
Penrose R, Hameroff S. Consciousness in the universe, neuroscience, quantum space – time geometry, and Orch OR theory. *J. Cosmol*. 2011; 14.

Integrated Information Theory



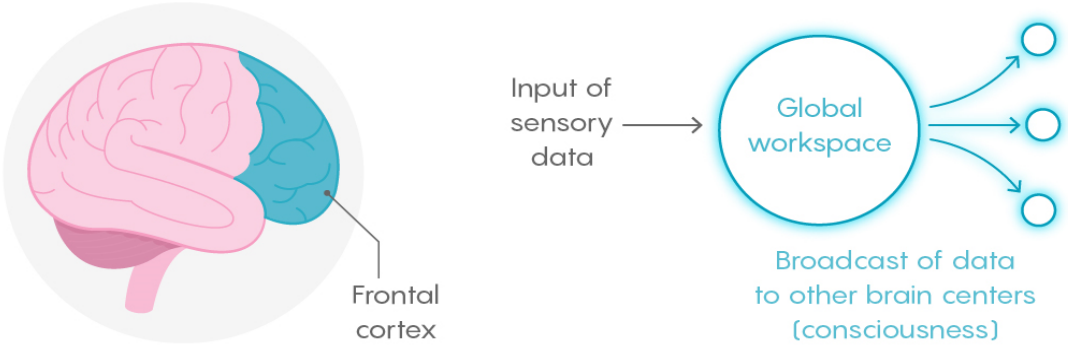
The integrated information theory argues that consciousness is intrinsic to cognitive networks that exert a "causal power" on themselves. The back of the brain might have the right architecture for this capacity.

The John Templeton World Charity Foundation competition 2019:

- natječaj po uzoru na eksperiment iz 1919. u kojem je fizičar **Arthur Eddington** suprotstavio teoriju opće relativnosti Alberta Einsteina s teorijom gravitacije Isaaca Newtona: Eddington je izmjerio kako je Sunčeva gravitacija uzrokovala pomicanje svjetlosti obližnjih zvijezda tijekom pomrčine Sunca (i Einstein je pobijedio)

VS.

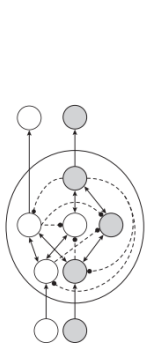
Global Workspace Theory



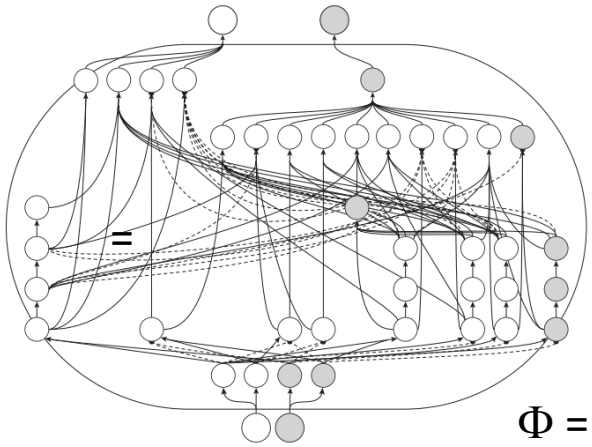
According to one theory, consciousness is a form of information processing. It occurs when sensory data for an experience go to a "global workspace" and are distributed to other centers. The architecture for this process in the brain may be in the frontal cortex .

3. IIT – information integration theory

- C. corresponds to a capacity of a system to integrate information



$\Phi > 0$



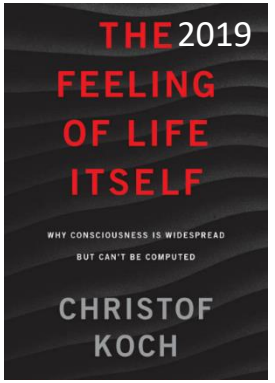
$\Phi = 0$

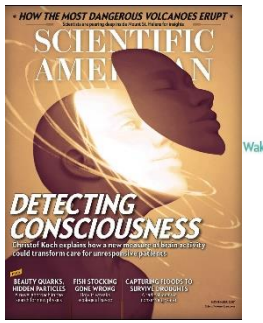
- jedino mreže s povratnim petljama mogu posredovati svijest jer mogu integrirati informacije u mreži; što je veći stupanj integracije – veći je Φ (mjera stupnja svijesti)

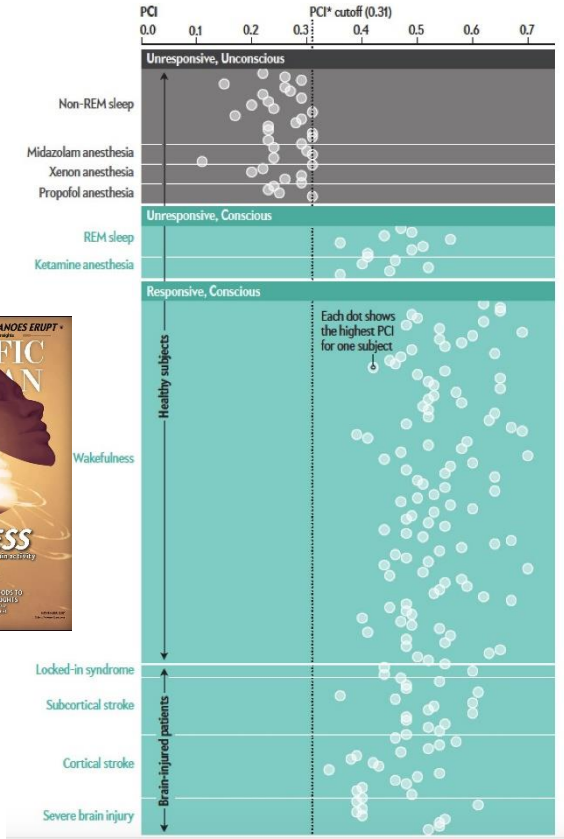
Giulio Tononi

Christof Koch

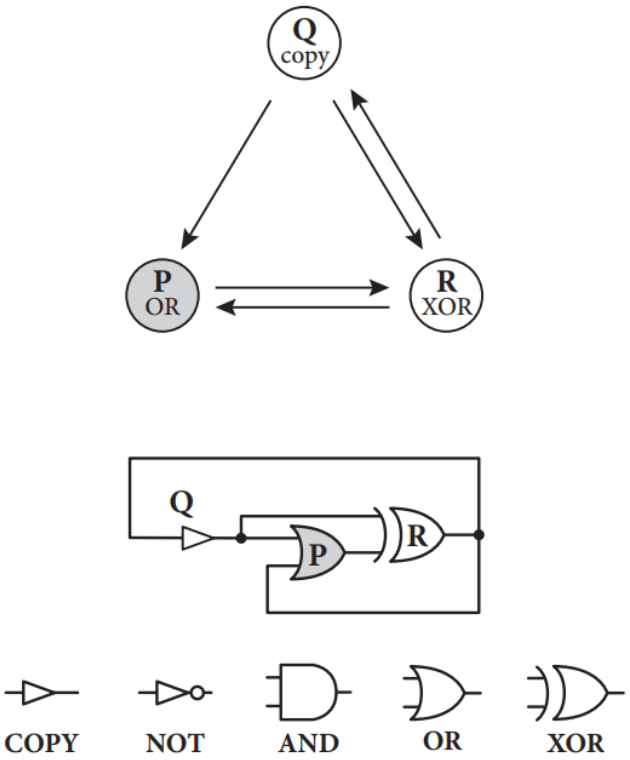
Tononi, G. (2004). An information integration theory of consciousness. *BMC Neuroscience*, 5, 42







„the maximally irreducible cause-effect power of real physical computers is tiny and independent of the software running on the computer”



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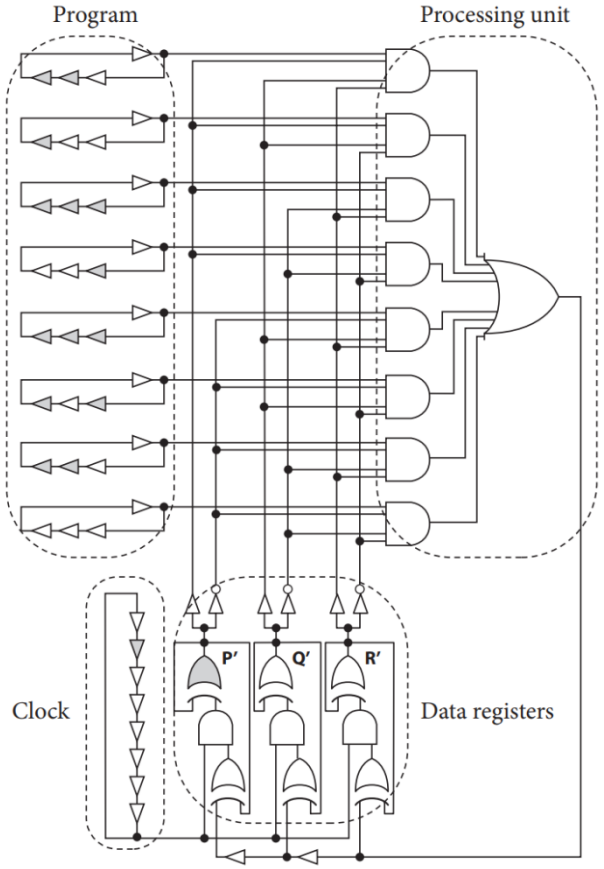
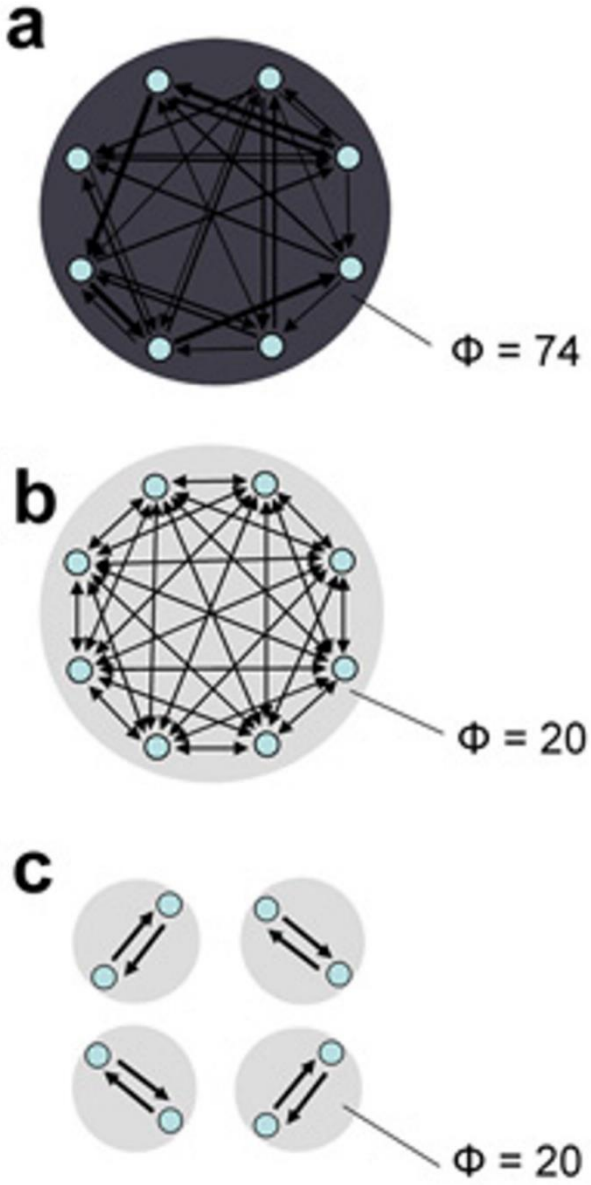


3 logička vrata, $\Phi > 0$

66 elemenata, 3 bita, $\Phi = 0$



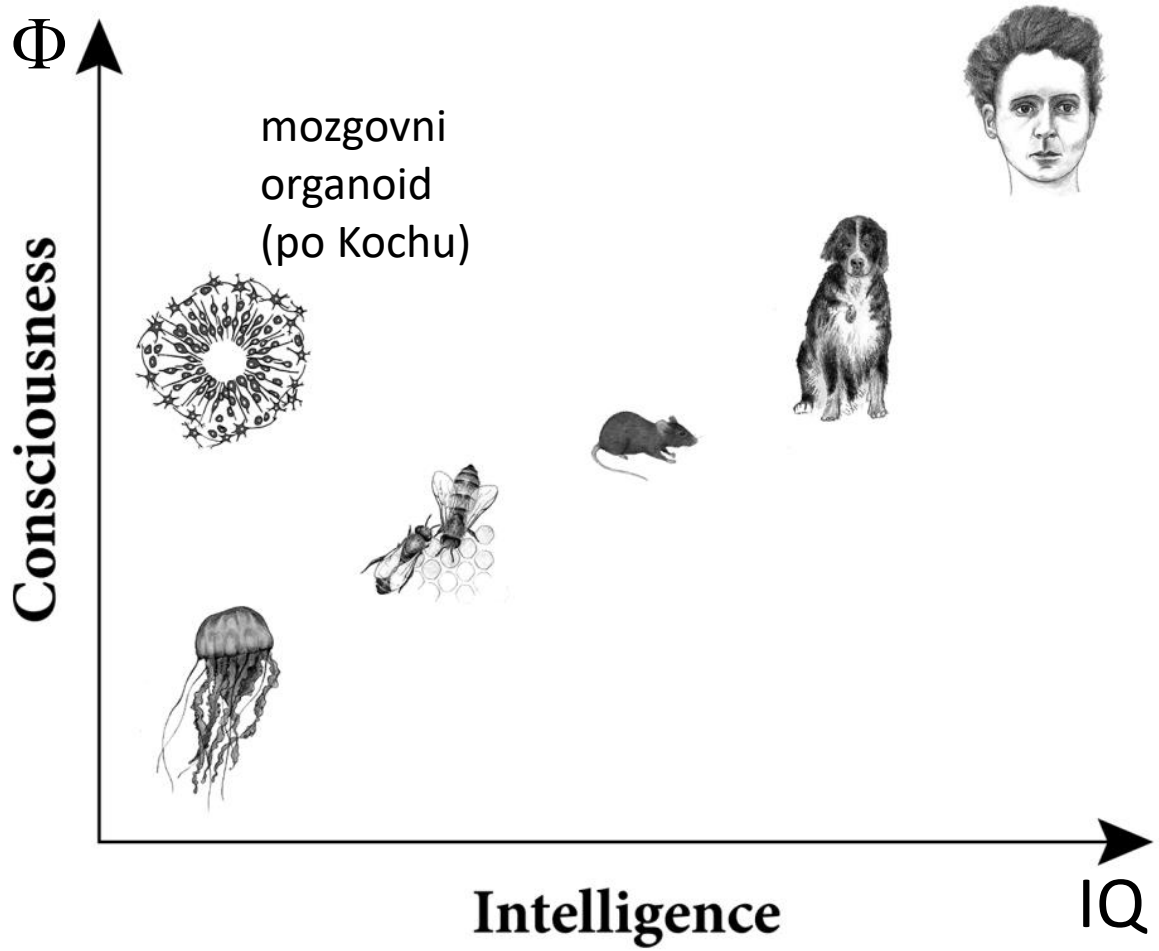
a. Sustav koji je funkcijski specijaliziran i integriran (Φ = 74 bita); svaki element je povezan s različitim drugim elementima, s različitim stupnjem povezanosti (debljina linija). Sustav sliči na talamokortikalnu mrežu.

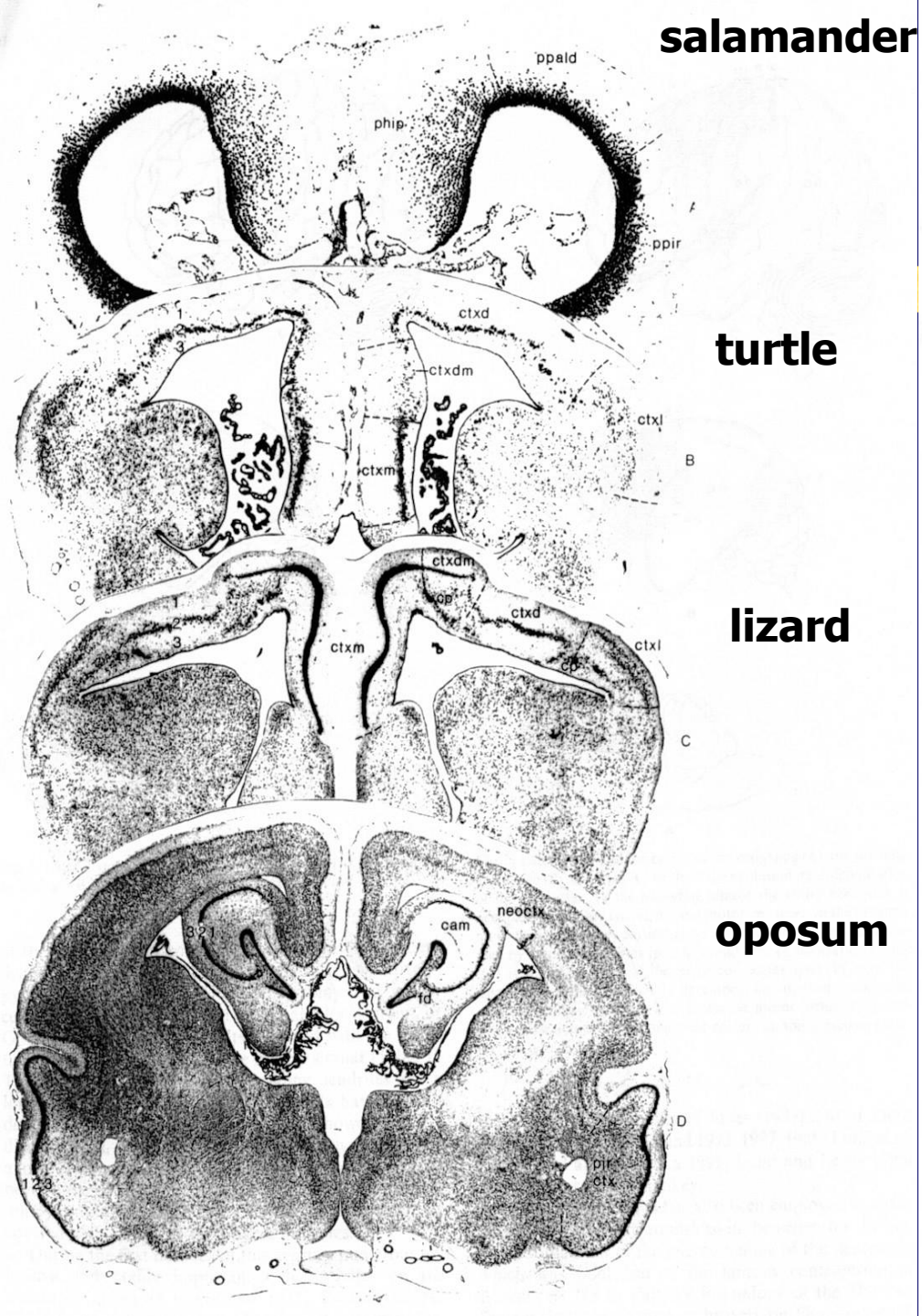
b. Isti stupanj povezanosti, ali je eliminirana funkcijska specijalizacija, povezanost je homogeno raspodijeljena između elemenata, stupanj integriranosti informacija je daleko manji (Φ = 20 bita)

c. Isti stupanj povezanosti, ali je eliminirana integracija jer su 4 modula međusobno odvojena (Φ = 20 bita)

Tononi, G. (2004). An information integration theory of consciousness. *BMC Neuroscience*, 5, 42

Korelacija između stupnja C. i inteligencije jedno je od glavnih obilježja evolucije



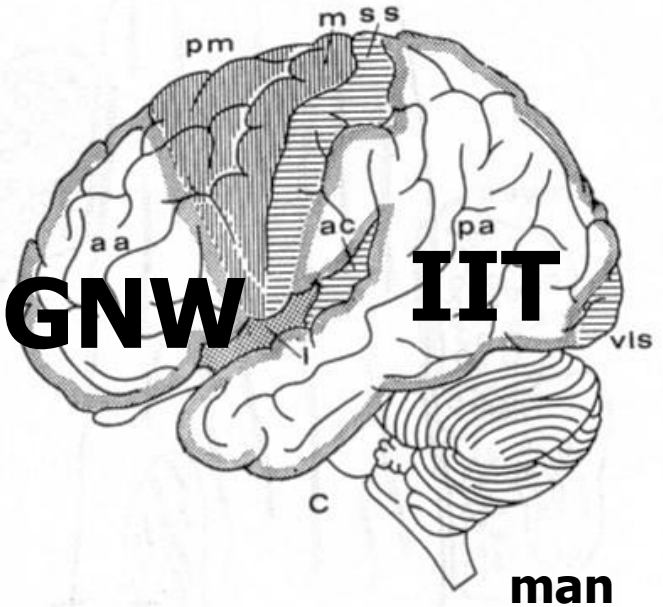


salamander

turtle

lizard

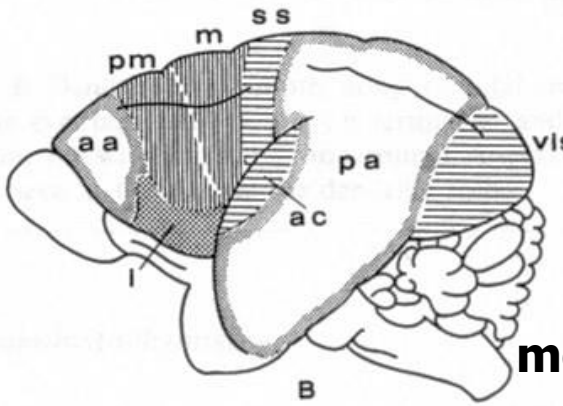
oposum



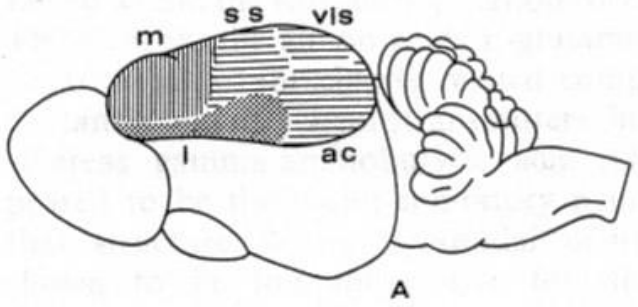
GNW

IIT

man



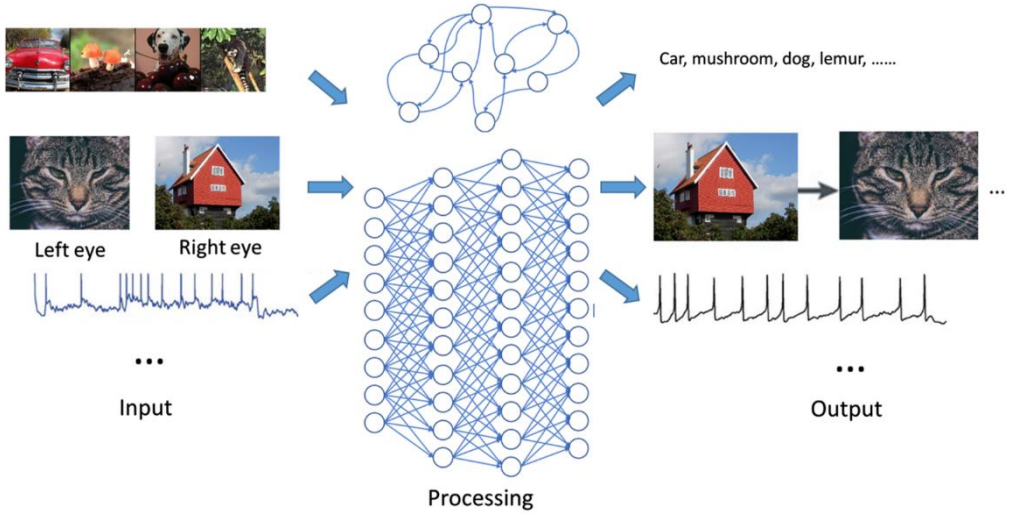
monkey



hedgehog

IIT ne prolazi „unfolding” argument jer sustavi s identičnim I/O f-jama mogu imati Φ=0 ili veliki Φ

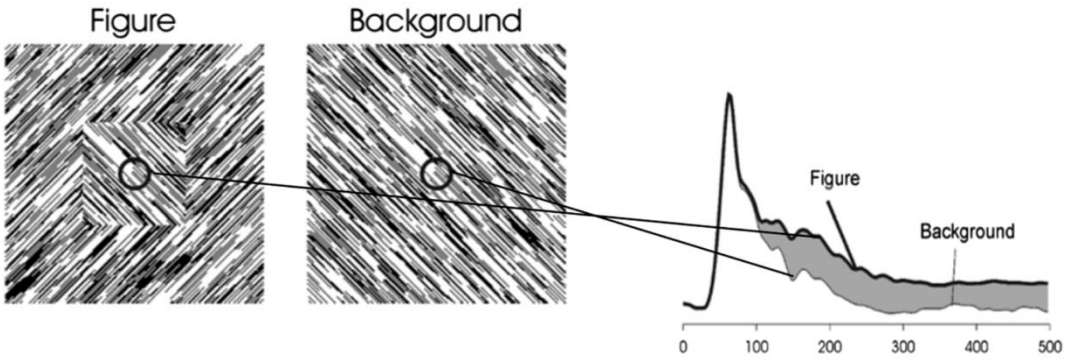
- npr. u pokusu suparničkih podražaja, IIT može „vidjeti” bilo mačku ili kuću, ali „svjesno osjećati” miris šunke (Doerig et al., 2019), tj. sustav može javljati da vidi mačku, ali imati bilo koje stanje svijesti
- ne prolazi argument „male mreže” (panpsihizam)



- i mreže s povratnim petljama, ali i višeslojne konvolucijske mreže mogu biti aproksimatori univerzalnih funkcija, tj. mogu se koristiti za generiranje bilo kojeg željenog I/O i funkcionirati do bilo kojeg stupnja točnosti koristeći konačan broj neurona
- za bilo koju rekurentnu mrežu s danim I/O funkcijama (ponašanjem) postoje odgovarajuće unaprijedne mreže s istim karakteristikama, iako je za te mreže često potrebno puno više neurona nego kod rekurentnih (vidni sustav)

4. RPT – recurrent processing theory

- u vidnom sustavu C. nastaje kad rekurentno procesiranje (masivne povratne veze) omogući da različita specijalizirana vidna područja međusobno komuniciraju
- npr. u primjeru maskiranja podražaja, prema RPT-u svjesno procesiranje nastaje kad se dogodi RP (za što je potrebno određeno vrijeme), a ako ga nema – onda se odvije samo nevjesno, subliminalno procesiranje



Svjesna percepcija središnjeg „kvadrata" očituje se povišenom neuralnom aktivnošću nakon 100 ms, a taj elevirani dio (crtkano) posredovan je rekurenjtnim vezama „viših" područja asocijativnee vidne moždane kore prema nižima („nizvodne veze"). Ako središnjeg „kvadrata" nema (prikazana samo pozadina) ili taj „kvadrat" nije svjesno percipiran, ili je podražaj maskiran, ili je ispitanik anesteziran, povišena aktivnost nije prisutna (nedostaje crtkani dio)

- i računala mogu izvoditi rekurentno procesiranje, pa nisu svjesna (teorija ne prolazi „unfolding" kriterij)
- i u „mreži" od samo 2 neurona može se implementirati rekurentno procesiranje, pa ta dva neurona ne čine svijest (panpsihizam) (teorija ne prolazi kriterij „male mreže")

Lamme V et al., Feedforward, horizontal, and feedback processing in the visual cortex. *Curr. Opin. Neurobiol*. 1998; 8: 529-535.

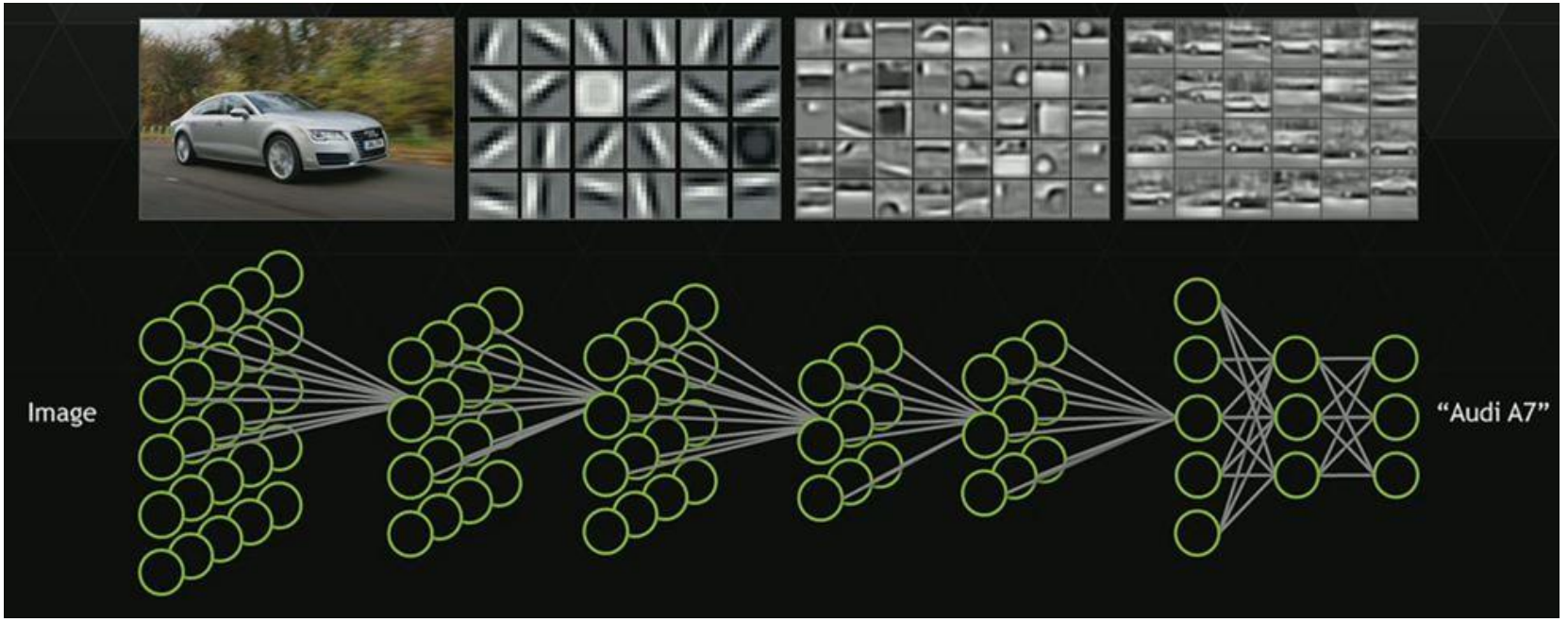


Image
"Audi A7"

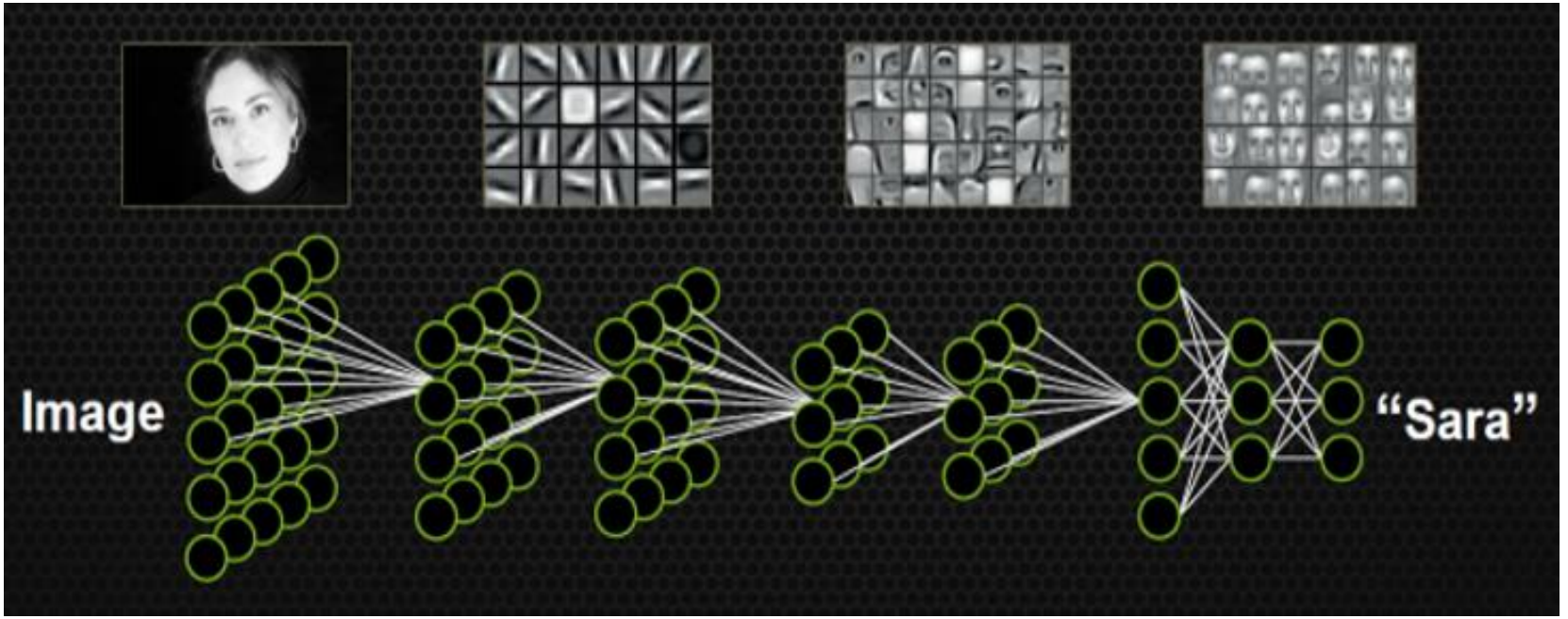
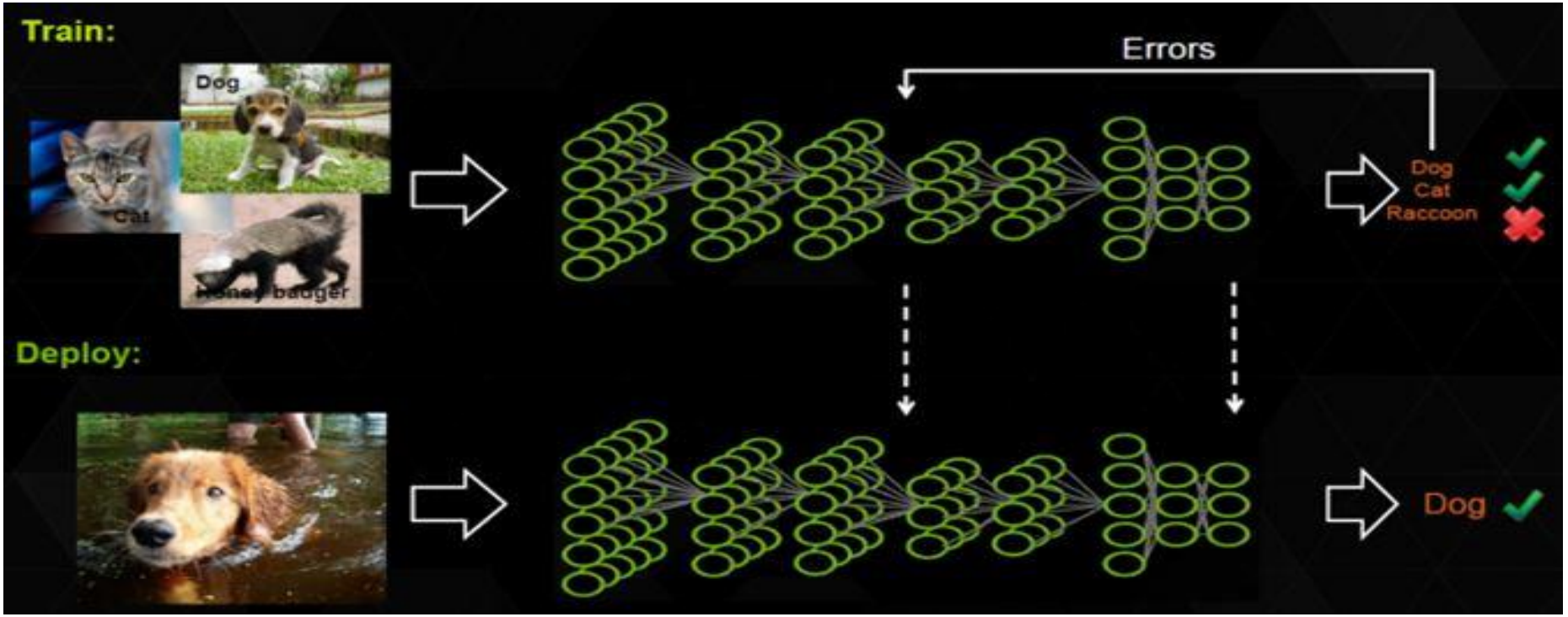
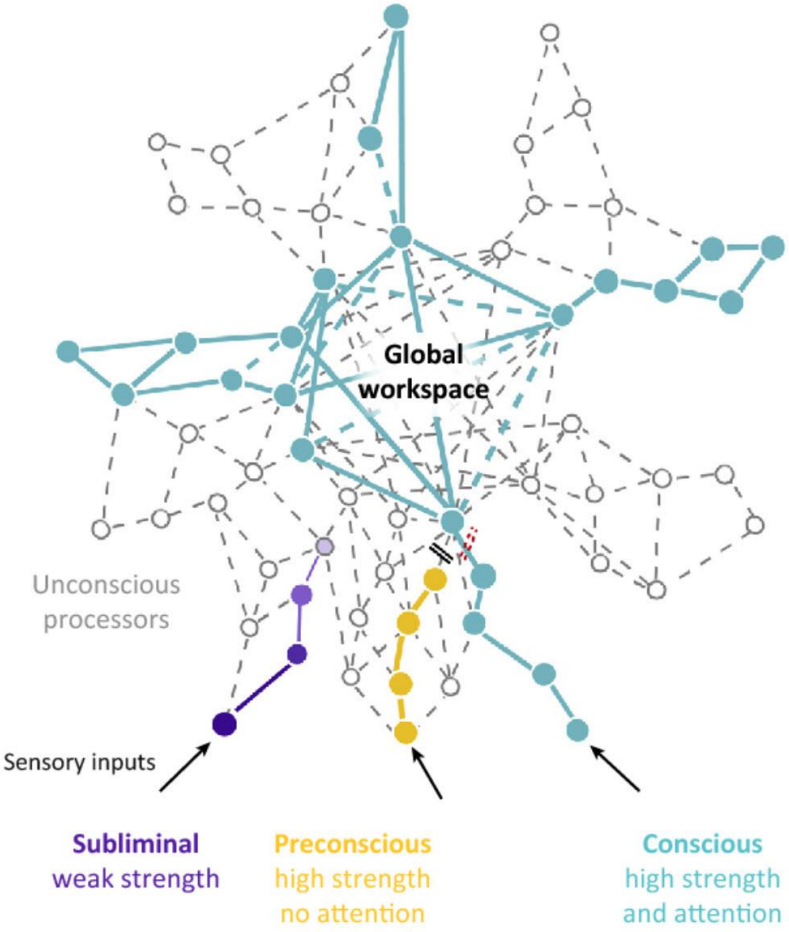


Image
"Sara"


Train:
Dog
Cat
honey badger
Errors
Dog
Cat
Raccoon
Deploy:
Dog

5. **GNWT** – global (neuronal) workspace theory



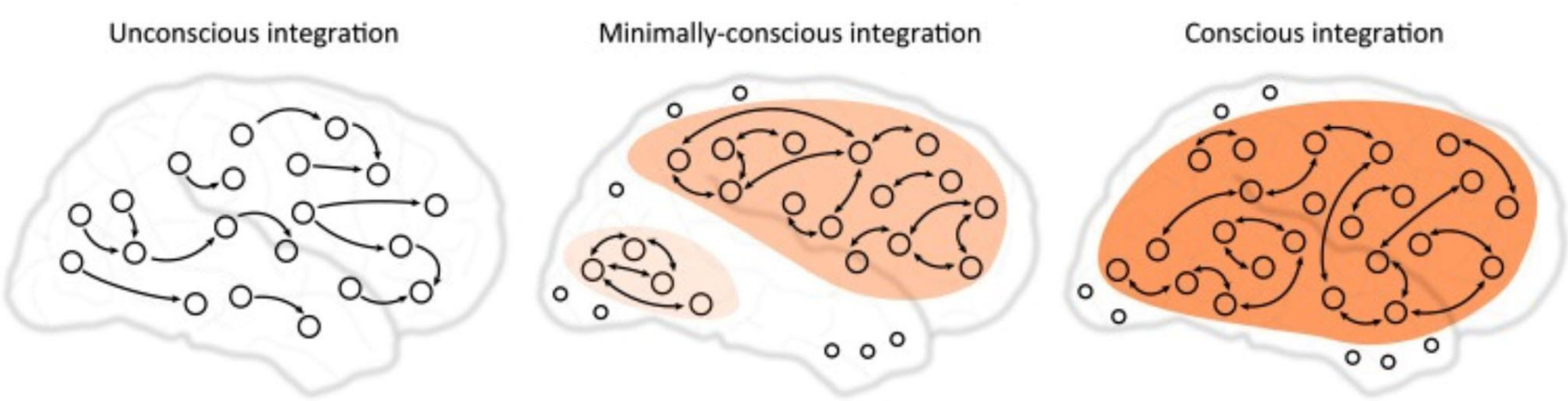
Baars, Bernard. 1993. A cognitive theory of consciousness. Cambridge University Press.

Dehaene, Stanislas (2014). Consciousness and the brain: deciphering how the brain codes our thoughts. Penguin.

Dehaene, S., Lau, H., & Kouider, S. (2017). What is consciousness, and could machines have it? *Science*, 358(6362), 486–492.

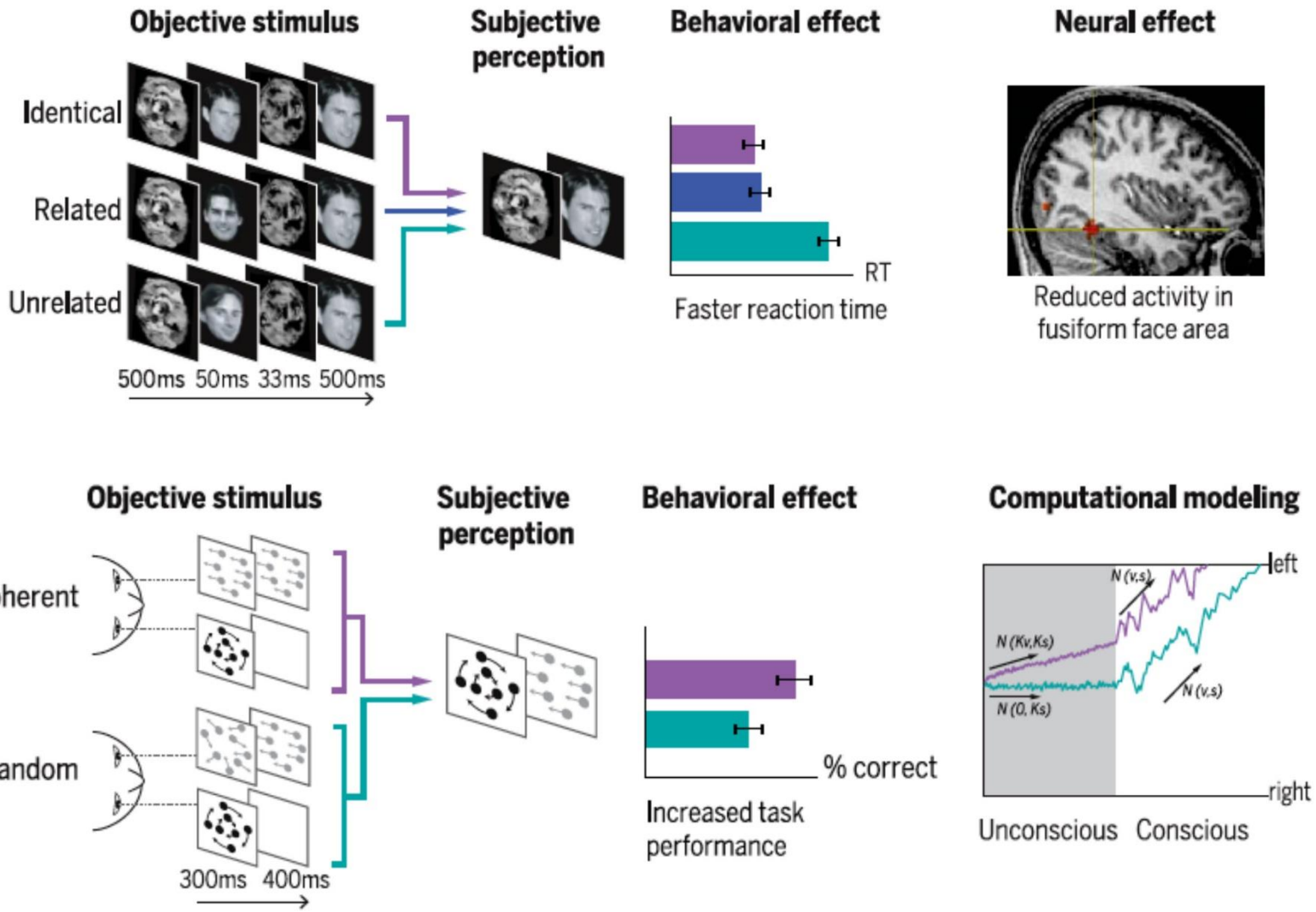
Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition*, 79(1), 1–37.

Dehaene, S., Naccache, L., Cohen, L., Le Bihan, D., Mangin, J.-F., Poline, J.-B., & Rivière, D. (2001). Cerebral mechanisms of word masking and unconscious repetition priming. *Nat. Neurosci.*, 4(7), 752–758.

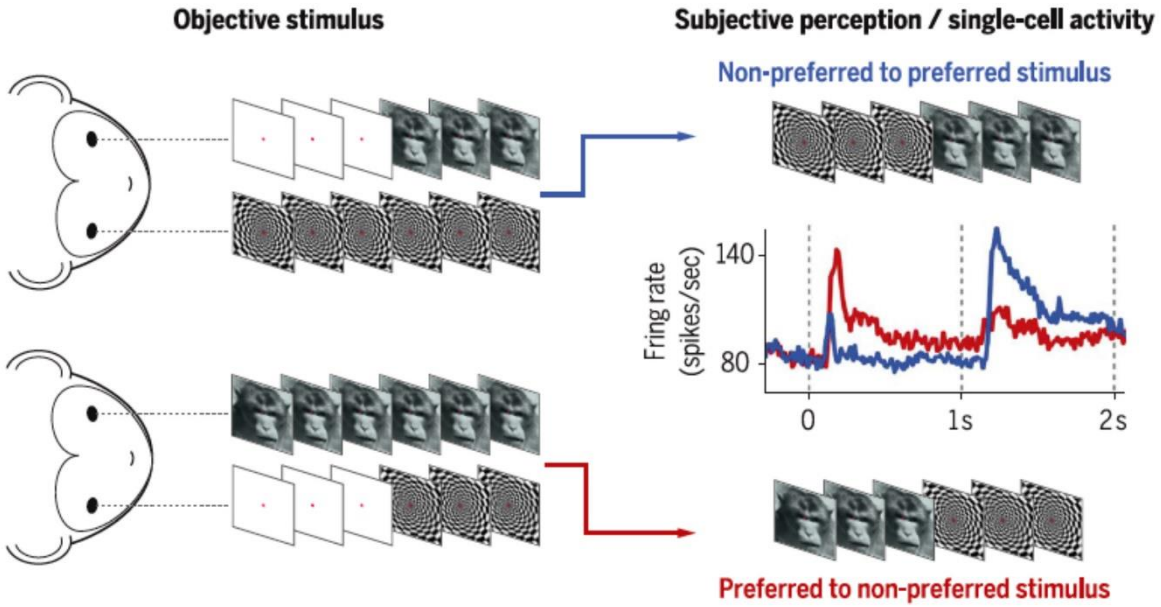


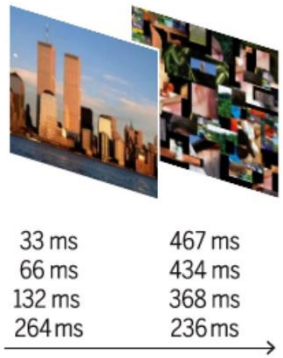
- **Unconscious processing (C0)**
- **Global availability of information (C1)**: The selection of information for global broadcasting, making it flexibly available for computation and report
- **Self-monitoring (C2)** of those computations, leading to a subjective sense of certainty or error

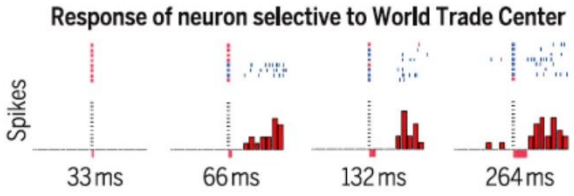
Unconscious processing (C0)

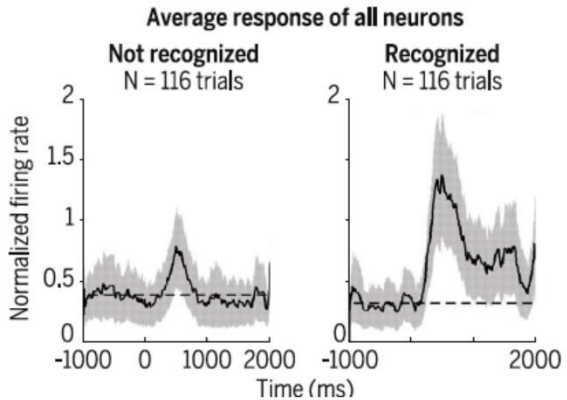


Global availability of information (C1)



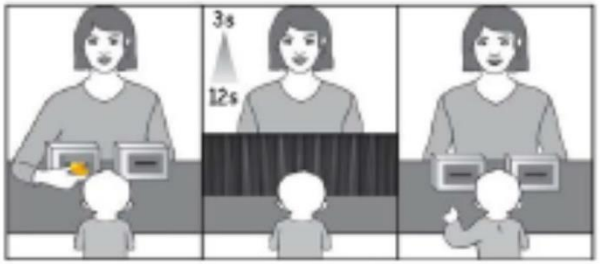






Self-monitoring (C2)

First-order decision
Memory recall



Evidence Toy location | **Delay** Task difficulty | **Pointing** Decision

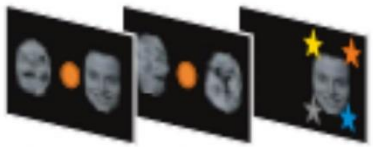
Second-order measure
Manual search persistence

Longer searching time when correct

Second-order measure
Opt-out

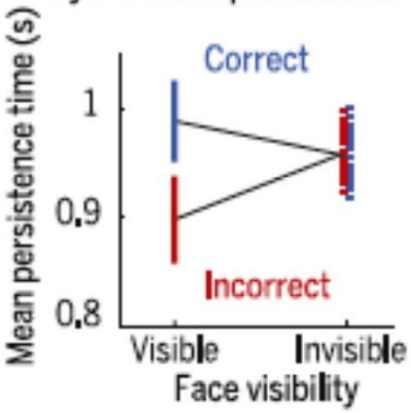
Opt-out by asking for help to avoid errors

First-order decision
Perceptual choice

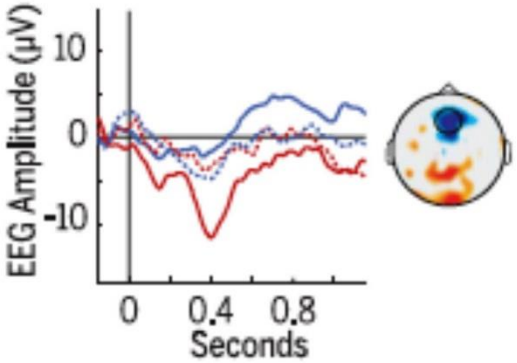


Cue visible/ invisible | **Waiting period** 2500 ms | **Reward** 3000 ms

Second-order measure
Eye fixation persistence



Second-order measure
Error-specific neural signal



Dissociation between C1 and C2

- They are largely orthogonal and complementary dimensions of what we call consciousness
- Self-monitoring can exist for unreportable stimuli (C2 without C1)
- Consciously reportable contents sometimes fail to be accompanied with an adequate sense of confidence (C1 without C2)

Synergy between C1 and C2

- Because C1 and C2 are orthogonal, their joint possession may have synergistic benefits to organisms
  - In one direction, bringing probabilistic metacognitive information (C2) into the global workspace (C1) allows it to be held over time, integrated into explicit long-term reflection, and shared with others
  - In the converse direction, the possession of an explicit repertoire of one's own abilities (C2) improves the efficiency with which C1 information is processed

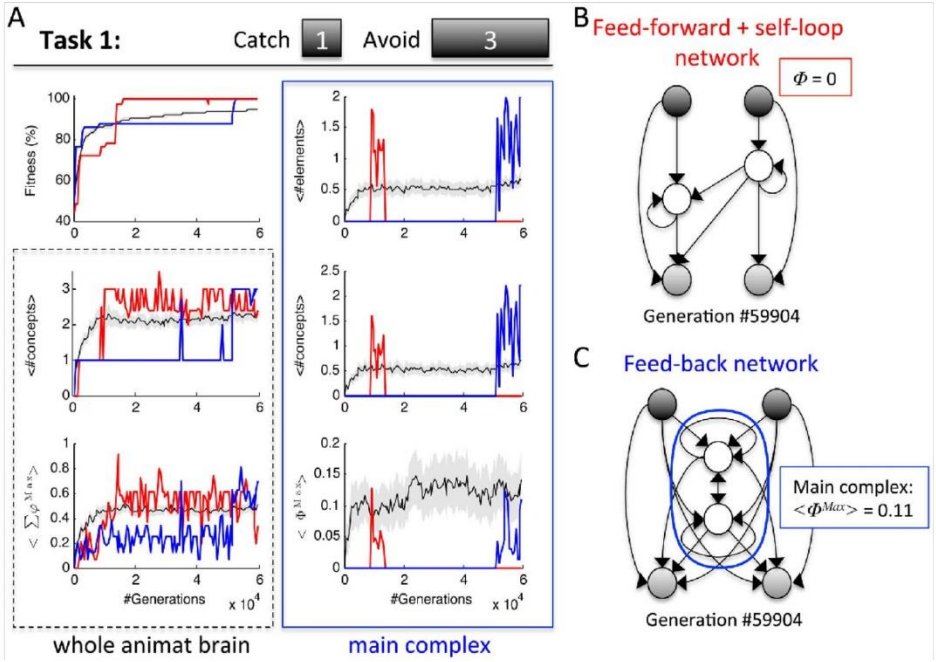
- GWT addresses paradigm cases including the attentional blink (Sergent et al., 2005), masking (Dehaene et al., 2001), and wakefulness vs. sleep (Dehaene et al., 2003); the broadcasting mechanism has conscious and unconscious alternatives.

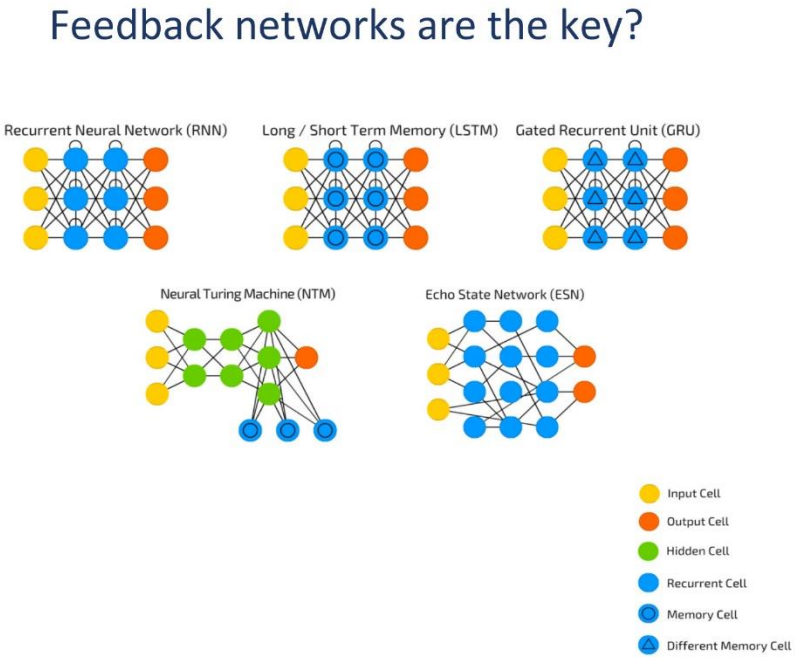
- billions of subsystems in the brain have a GW architecture so GWT faces the large network argument - another additional criterion is needed to decide which one of them gives rise to our seemingly unitary conscious experience, or GWT needs to give up the unity of consciousness
- the need for additional criteria is also highlighted by the existence of systems such as the immune and the vegetative nervous systems, which can also be seen as having a GW structure with broadcasting but are not granted consciousness by GWT
- the main challenge for GWT seems to be that it grants consciousness to too many systems: GWT needs to provide criteria to cope with the small (and large) network argument

Pathways to artificial consciousness

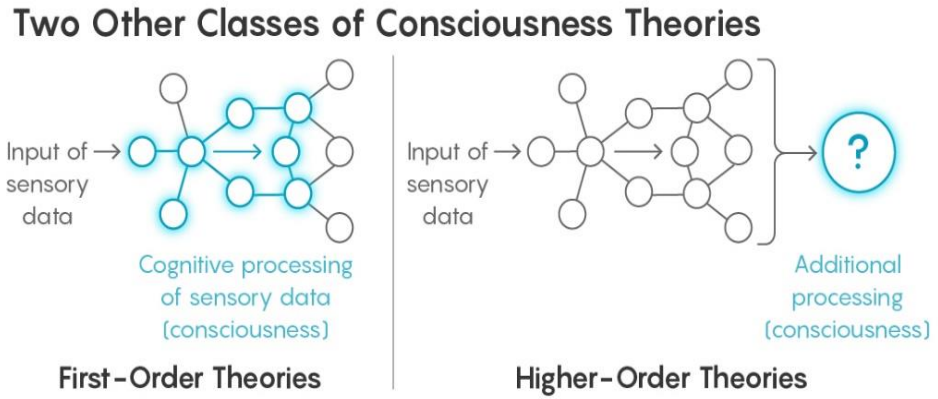
- What makes the difference to the processing related to C0 into non-conscious? What's needed to make it conscious?
- Is C1 sufficient?
- Is C2 sufficient?
- Is there a case of non-conscious processing with C1 AND C2?
- Is there any better alternative to C1 and C2 for AI?
- Current machines are still mostly implementing computations that reflect unconscious processing (C0) in the human brain
- Endowing machines with global information availability (C1) would also allow the different modules to share information and collaborate to address impending problems
- To make optimal use of the information, it would also be useful for the machine to possess a database of its own states. Such self-monitoring (C2) would include an integrated image of itself as well as its internal databases

- Optimizing integration in animats through evolution (IIT)

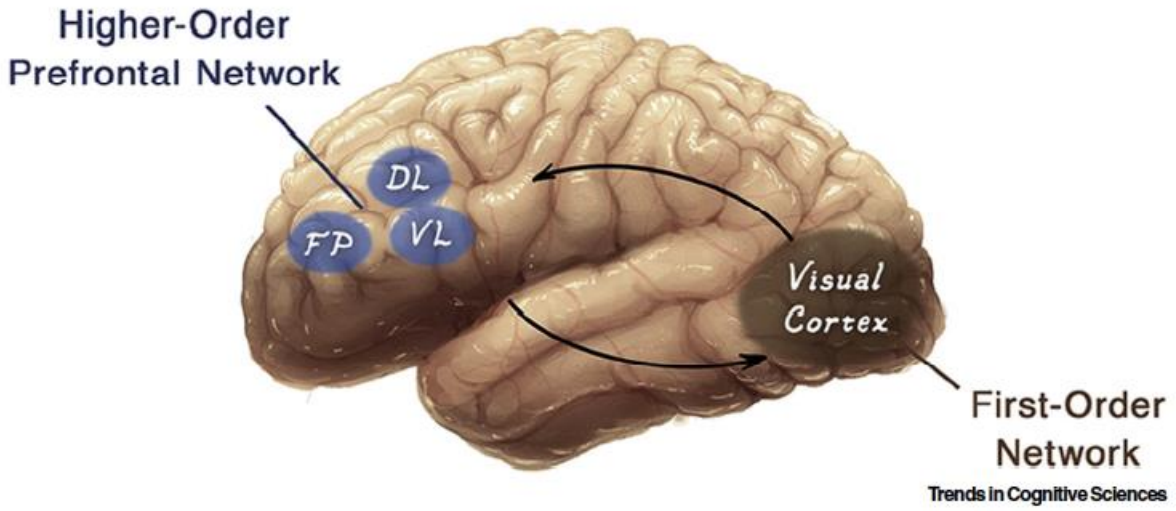




6. **HOTT** – higher order thought theory



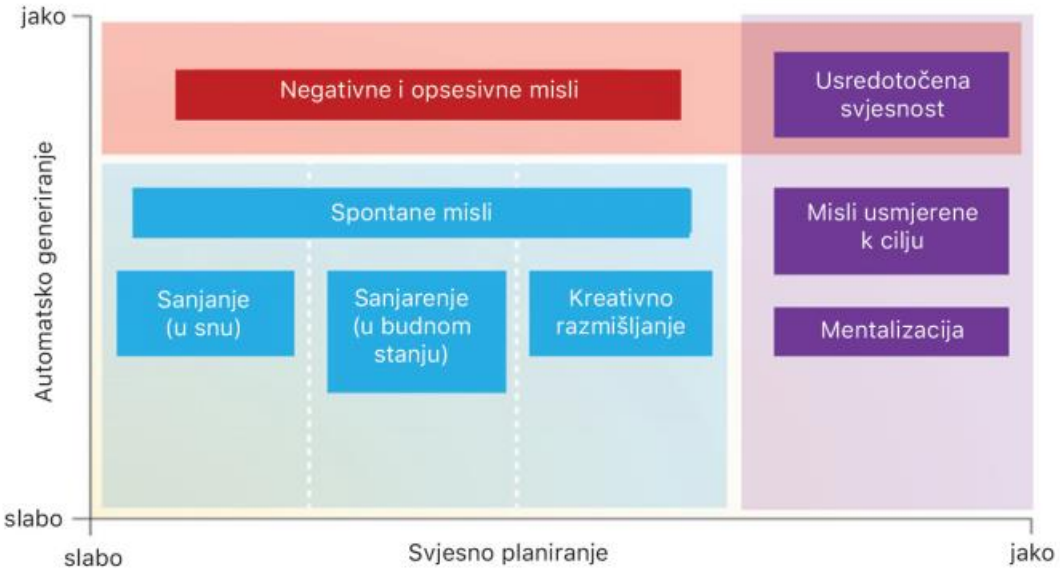
First-order theories maintain that consciousness is simply a product of the cognitive processing of sensory information. Higher-order theories posit that consciousness involves something done to build on that cognitive representation of the sensory experience.



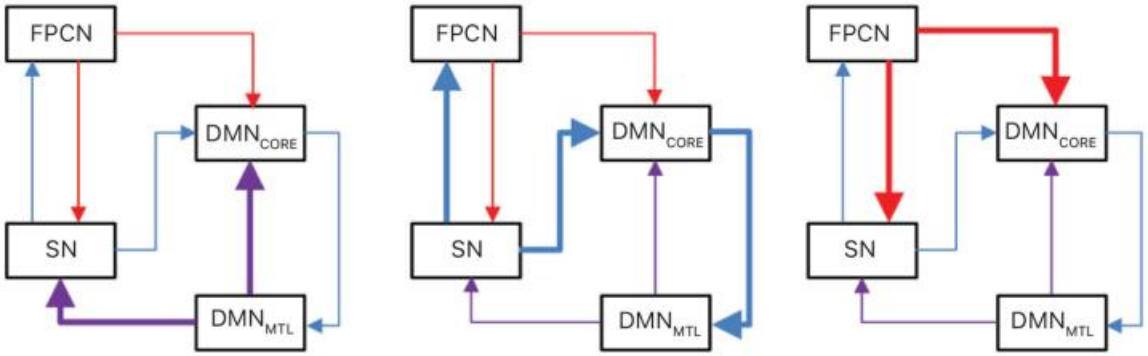
HOTT – nastavak

- ima puno varijanti i tumačenja
- ovisno o tumačenju, mogu se primijeniti argumenti male mreže ili drugih sustava
- u jednoj krajnosti, ako tumačimo misli višeg reda kao jednostavno računanje u 2 stupnja, HOTT podliježe argumentu male mreže jer bi prema tome svaki računalni program s 2 stupnja bio svjestan
- HOTT treba predložiti kriterije za razlikovanje koji su sustavi svjesni i objasniti koji podsustavi mozga doprinose našem ‘naizgled’ jedinstvenom svjesnom iskustvu
- u drugom ekstremu, misli višeg reda mogu se jednostavno odnositi na svakodnevni koncept razmišljanja, pa vrijedi „argument sustava”: HOTT treba objasniti što je ključno da nešto bude 'misao' i koji sustavi mogu proizvoditi ekvivalente 'mislima' i biti svjestni (osim ljudi)

- dodatno, ne predlaže mehanizam putem kojega nastaje C.



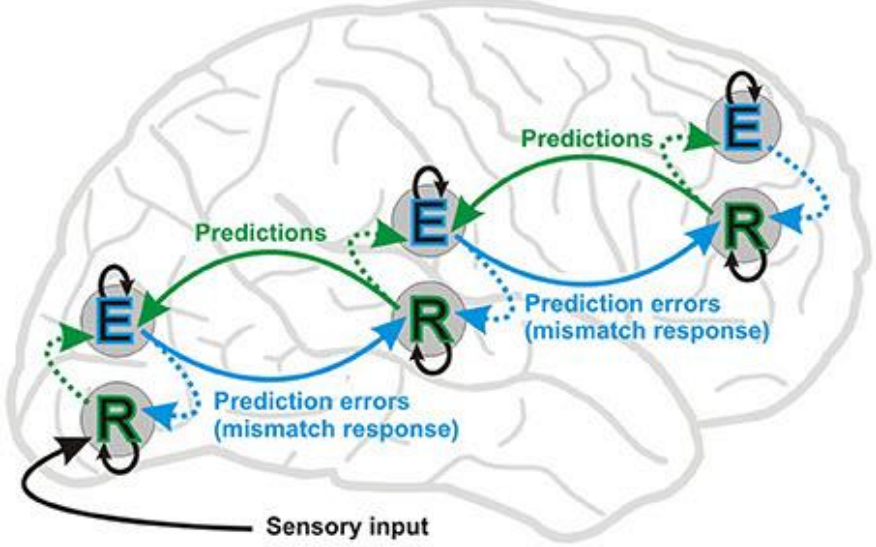
Dok sam hodao prema dućanu, maštao sam o tome što ću sve moći raditi s mobitelom koji sam naručio online...	→	U trenutku dok sam prelazio ulicu, počeo sam se brinuti hoću li stići naučiti za ispit iz neuroznanosti na vrijeme?	→	Počeo sam se zbog toga osjećati jadno... i odlučio misliti o nečem drugom. Ah, da, kud sam krenuo? Trebaju mi kruh i mlijeko...
Spontane misli -lutajuće		Misli usmjerene k cilju -automatske		Misli usmjerene k cilju -planirane



7. PPT – predictive processing theory

- prema PPT-u, mozak od struje ulaznih podataka očekuje samo jednu sliku, da ako mu damo dvije slike istovremeno, moći će obrađivati samo malo jednu pa malo drugu (*binocular rivalry*); u trenutcima dok se jedna obrađuje i dio je svijesti, druga se obrađuje nesvjesno
- svaka interna reprezentacija služi za uzvodno (*top-down*) predviđanje, a svijet oko nas doživljavamo strukturiranim zbog tih internih reprezentacija
- ako zbog bilo kojeg razloga *reality check* moždane kore čeonog režnja ne uspije nastupaju simptomi psihoze (najčešće je to schizofrenija, ali psihoza može biti i izazvana npr. amfetaminima)


https://www.youtube.com/watch?v=sxwn1w7MJvk **iluzija gumene ruke**



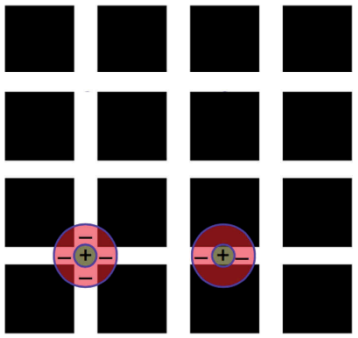
- teorija ne definira koja su ključna obilježja PP-a, tj. zašto drugi sustavi koji implementiraju PP nemaju svijest
- budući da je definirana jednostavnim mehanizmom, ne prolazi argument „male mreže”

Rao Rajesh, **Dana Ballard**. Predictive coding in the visual cortex: a functional interpretation of some extra-classical receptive-field effects. *Nat. Neurosci*. 1999; 2: 79-87.

+ Friston K. 2010
+ Seth A. 2018

8. ART – adaptive resonance theory

- C. nastaje kad su neuroni u stanju adaptivne rezonancije
- ART je temelji na hijerarhijskom procesiranju, gdje adaptivna stanja odgovaraju subjektivnim doživljajima, npr. iluzorne konture kod optičkih iluzija (ti se učinci naravno ne nalaze u samom podražaju, nego su konstrukti svjesnog iskustva)
- ako nakon davanja nekog podražaja neuroni ne dođu u stanje adaptivne rezonancije, taj se podražaj procesira nesvjesno



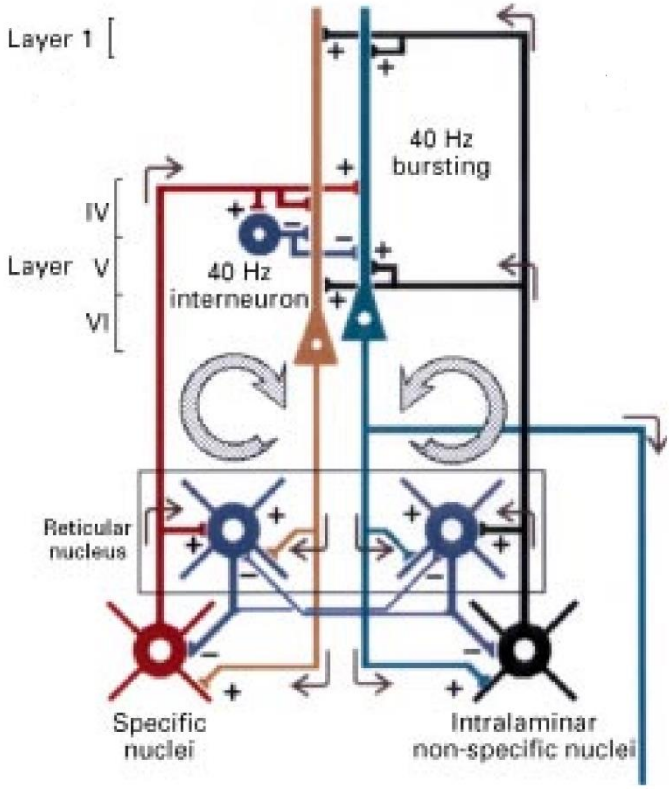
Hermann-Heringova mreža

Sive mrlje na „sjecištima" su subjektivne, pa se zbog toga čine izravno povezane sa C. Nastanak navedenih mrlja se može lako objasniti temeljnim postulatima kortikalne obrade (Blakeslee & McCourt, 2012)

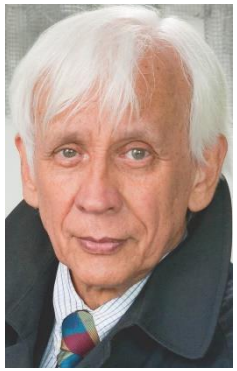
- ne prolazi argumente „male mreže" (čak i s < 100 neurona se može implementirati hijerarhijsko procesiranje) i „unfolding" kriterij
- ne objašnjava kako se svjesna stanja razlikuju od nesvjesnih

Grossberg S. Towards solving the hard problem of consciousness: the varieties of brain resonances and the conscious experiences that they support. *Neural Netw*. 2017; 87: 38–95.

9. TLT – thalamocortical loop theory



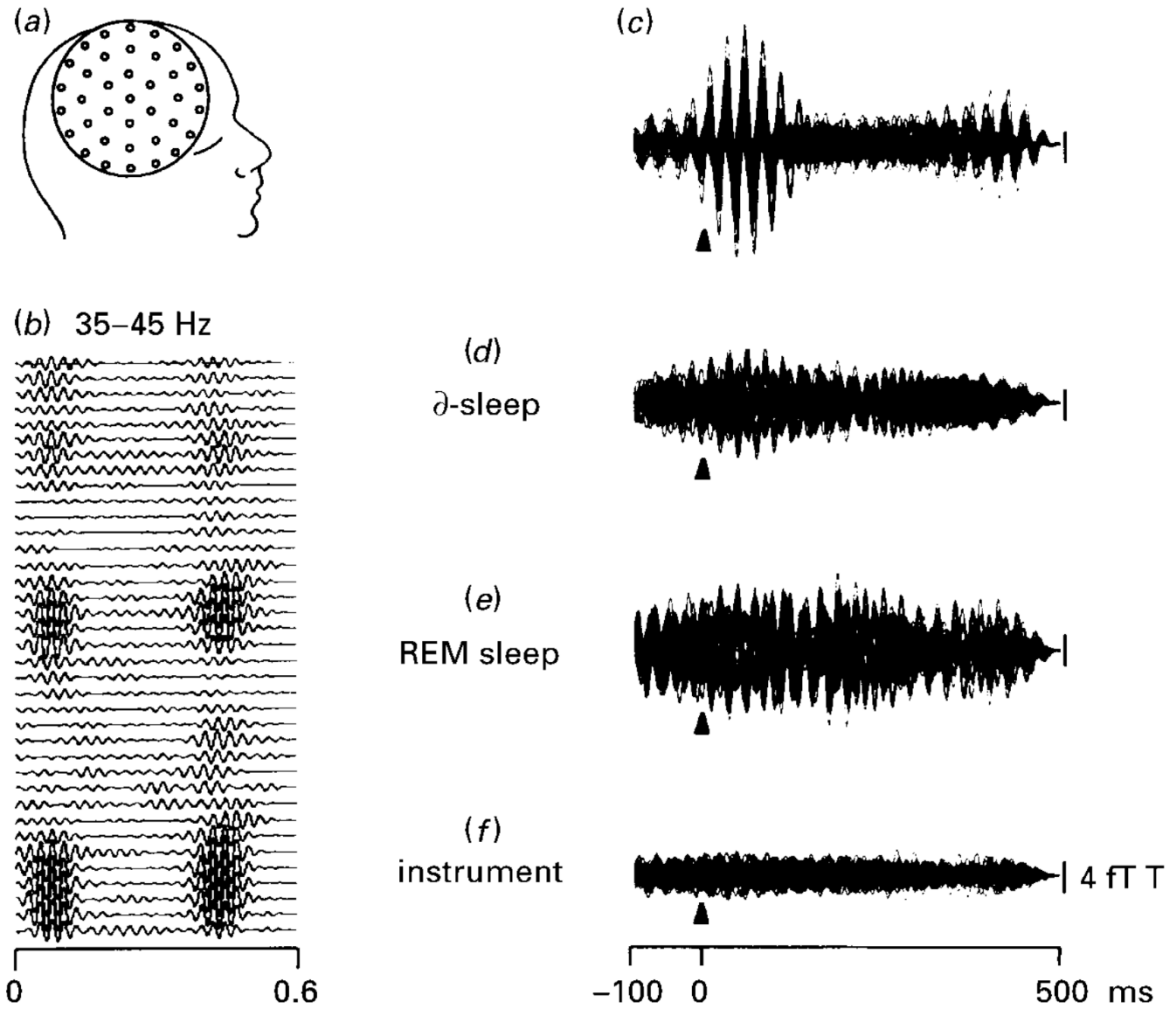
- mehanizam: oscilacije talamokortikalnih petlji pri 40 Hz (gama valovi)
- te oscilacije povezuju informacije iz različitih modaliteta sinkroniziranjem kortikalnih neurona
- različiti sadržaji su vezani u jedinstvenu svijest jer intralaminarne jezgre th sinkroniziraju različita kortikalna čvorišta
- oštećenje IL jezgara dovodi do kome i VS
- svijest je vremenski diskretna varijabla (0.6 s) (Joliot i sur., 1994.)



- i drugi organizmi imaju Th-Cx sustav, pa ih to ne čini jednako svjesnima

Llinas, Rodolfo, Ribary, U., Contreras, D., & Pedroarena, C. (1998). The neuronal basis for consciousness. *Phil. Trans. Roy. Soc. Lond. B: Biol. Sci*. 1998; 353(1377), 1841–1849.

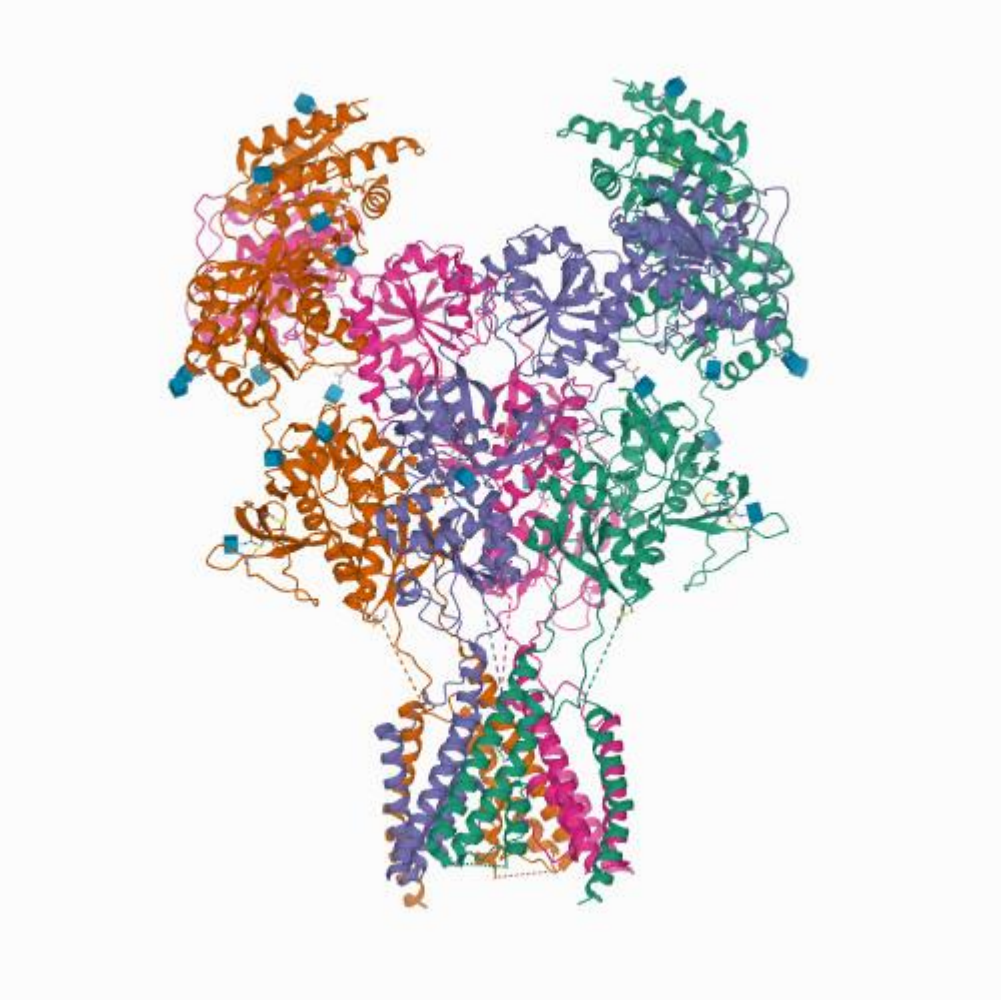
Spontaneous magnetic activity was recorded continuously during wakefulness, slow-wave sleep and REM sleep by using a 37-channel sensor array positioned as shown. Because Fourier analysis of the spontaneous, broadly ¢ltered rhythmicity (1^200 Hz) demonstrated a large peak of activity at 40 Hz over much of the cortex, we decided that it was permissible to ¢lter the data at gamma-band frequency (35-45 Hz). Large coherent signals with a very high signal-to-noise ratio were typically recorded from all 37 sensors as shown in ¢gure 5b for a single 0.6 s epoch of global spontaneous oscillations in an awake individual.



- razliku u stupnju C. u različitim stanjima objašnjava amplitudom delta valova (visoke amplitude – svjesno stanje, niske – nesvjesno)

Figure 5. Oscillation at 40 Hz in wakefulness and a lack of 40 Hz reset in δ-sleep and REM sleep. Recording was with a 37-channel MEG. (a) Diagram of sensor distribution over the head; in (b) the spontaneous magnetic recordings from the 37 sensors during wakefulness are shown immediately below (filtered at 35–45 Hz). (c–f) Averaged oscillatory responses (300 epochs) after auditory stimulus: (c) subject awake and stimulus followed by a reset of 40 Hz activity; (d, e) stimulus produced no resetting of the rhythm; (f) noise of the system in femtoteslas (fT). (Modified from Llinás & Ribary (1993).)

10. **NMDA** theory



Flohr, H. (1992). Qualia and brain processes. In A. Beckermann, H. Flohr, and J. Kim, eds., Emergence or Reduction, 220–238

11. AST – attention schema theory

- eksplicitno kaže da je svijest iluzija percepcije
- odvija se kortikalnim procesiranjem na spoju sljepoočnog i tjemenog režnja

- nedostaje opis mehanizma: što i kako se modulira pozornost da bi nastala svijest
- Ne prolazi argument male mreže
- Ne prolazi argument drugih sustava

12. SMT – sensorimotor theory

- primarno objašnjava takozvanu fenomenalnu svijest (phenomenal C.)
- prema SMT, FC je OSJEĆAJ koji proizlazi iz interakcije s okolinom, npr. osjećaj vida se razlikuje od sluha jer se ulazni vidni podatci ponašaju drugačije kad se krećemo nego slušni
- iako u početku promatrač s TVSS-om locira podražaje na dijelu tijela koji se stimulira, uz vježbu, promatrač lociraju objekte u prostoru, a ne na koži – iako još uvijek može osjetiti lokalni taktilni osjećaj (npr. ako je bolan ili ako svrbi)

Kevin O'Regan
2001, '04, '11

Što definira senzorimotoričke petlje? Kojim se mehanizmom objašnjavaju senzorimotoričke interakcije? Po toj logici je i termostat svjesno biće…

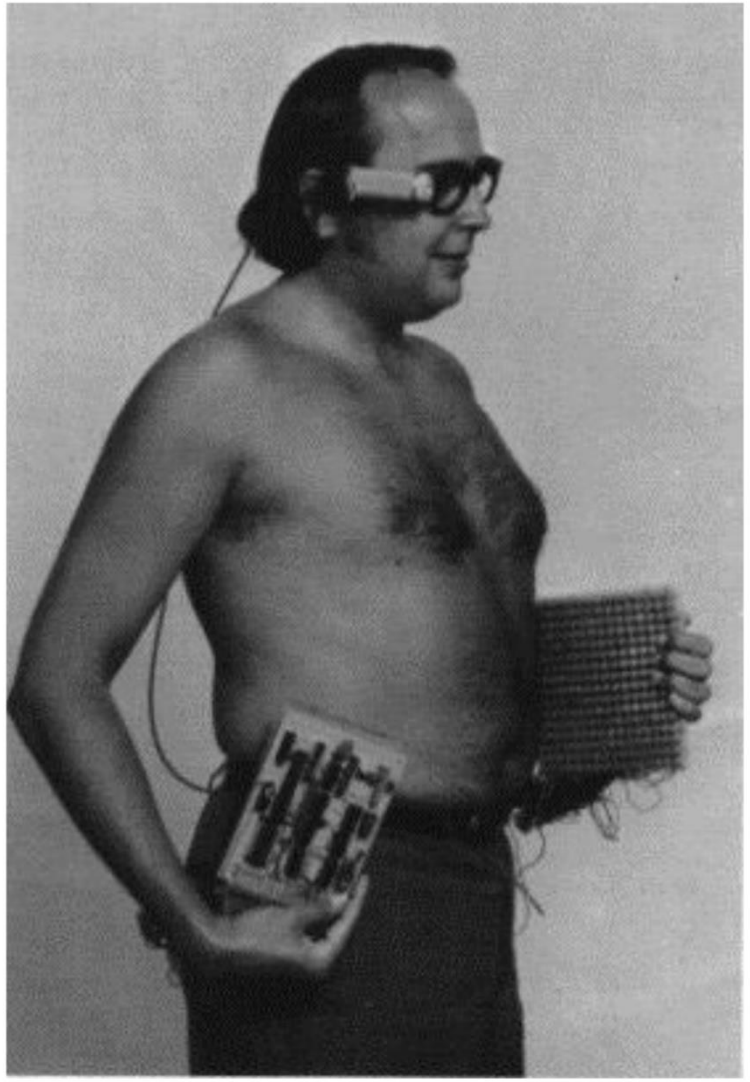
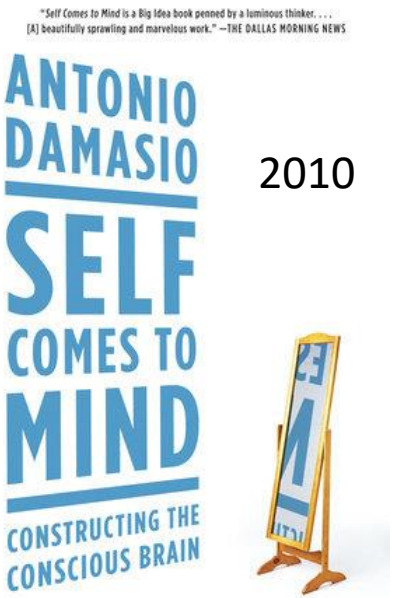


Figure 7. A blind subject with a "Tactile Visual Substitution system" (TVSS). A TV camera (mounted on spectacle frames) sends signals through electronic circuitry (displayed in right hand) to an array of small vibrators (left hand) which is strapped against the subject's skin. The pattern of tactile sitmulation corresponds roughly to a greatly enlarged visual image. (Photograph courtesy of P. Bach-y-Rita). From Morgan (1977).

13. SCTM – self comes to mind theory

- osjećaj **selfa (jastva)** ključan je za nastanak C.
- self čine populacije neurona koji reprezentiraju i monitoriraju stanje tijela
- ključni korak u nastanku C. nije percepcija putem koje se stvara sadržaj C. (ulijevanje vode u posudu) nego je to oblikovanje same posude – tako da znamo da su te percepcije u sadržaju svijesti NAŠE
- self je ključan jer je on „svjedok" našeg uma i jedini način na koji možemo znati da se radi o našim mentalnim stanjima (mPFC)
- postajemo svjesni događaja oko nas tek kad korespodentne reprezentacije tih događaju dođu u interakciju sa selfom
- PROTOSELF – mapiranje vlastitoga tijela u SŽS-u, interakcija s nekim objektom ili bićem dovodi do reprezentacije toga objekta u reprezentacijskim mapama, ali i do promjena u tjelesnim stanjima, čime postajemo svjesni tih objekata →



2010

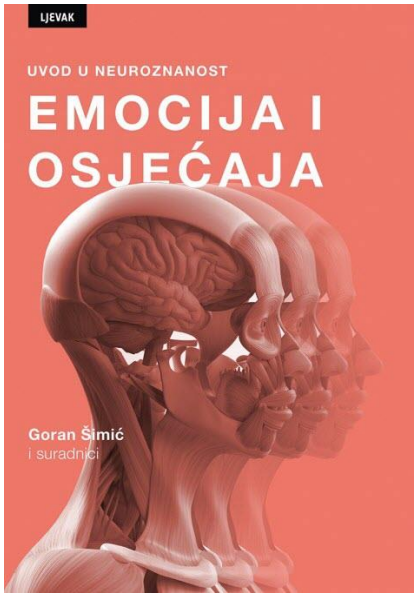
Antonio Damasio

To je Damasijev koncept otjelovljene spoznaje (*cognitive embodiment*); bez tog iskustva (reprezentacije, unutarnje slike) vlastitoga tijela (*self-image*) bi odrasle osobe bile bespomoćne poput novorođenčadi budući da im emocije bez svjesnih osjećaja ne bi bile dovoljne za preživljevanje; no jednom kad su otjelovljene, emocije mogu egzistirati i odvijati se i isključivo unutar SŽS-a, što potvrđuju fenomeni deaferentacijske (najčešće fantomske) boli. SŽŠ mora neprekidno ažurirati informacije o stanju tijela kako bi regulirao procese koji ga drže na životu

13. SCTM – cont.

- u komi i VS je stanje reprezentacije selfa oštećeno
- nesvjesno procesiranje se odvija kad nema interakcije drugih dijelova mozga sa selfom i vlastitim reprezentacijama

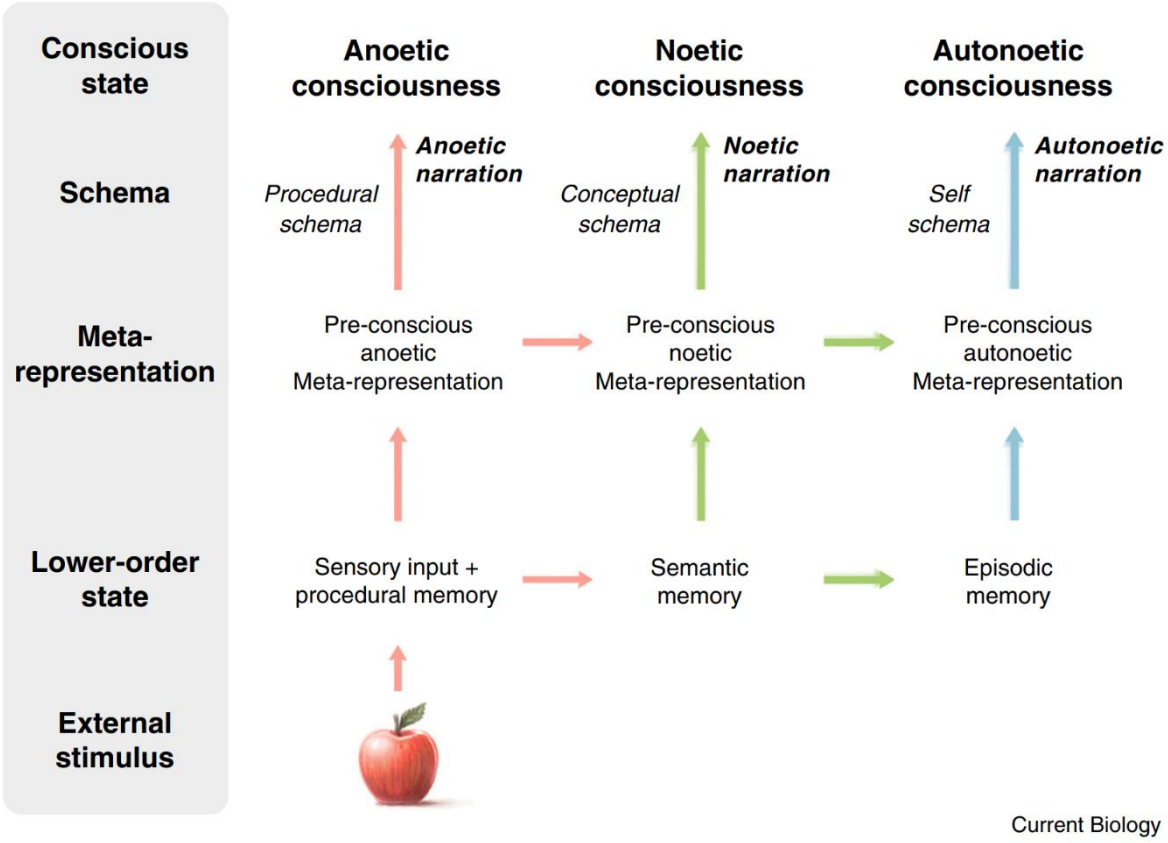
  - ne objašnjava dovoljno precizno mehanizam nastanka da bi se mogla provjeriti
  - ne objašnjava dovoljno dobro zašto je C. čovjeka veća nego kod drugih životinjskih vrsta



-> za detaljan opis otjelovljene spoznaje

Odnos C. i vrsta pamćenja

Core C.
sržna C. kognitivna C. autobiografska C.



LeDoux and Lau, 2020

Savant syndrome

- A rare condition in which a person with serious mental disability and low IQ exhibit remarkable abilities or brilliance in some domains of knowledge

- Such a skill usually emerge spontaneously and is not derived from practice; one of the most incredible manifestations of savant syndrome is that of the "acquired" savant. Here, prodigious skill, especially in art or music, or the enhanced memory capacity, emerges unexpectedly in some people who have suffered a head injury, stroke, and in patients with e.g. FTD with predominant left hemisphere involvement

- Similarly, it can also be induced in normal people by creating a virtual injury (temporary dysfunction) of the left temporal lobe using rTMS

Savant syndrome cont.

- Besides being attracted to numbers, especially prime numbers, and calendars, individuals with savant syndrome are often fascinated by art and music and have extraordinary memory capacity and visuospatial abilities; synesthesia and absolute pitch are also more commonly found in savants than in the general population

- About half of the individuals with savant syndrome have an ASD, while the other half have some other form of CNS damage or disease; only about 10% of the autistic people are savant

Kim Peek

Peek on January 16, 2007

Born	Laurence Kim Peek November 11, 1951 Salt Lake City, Utah, U.S.
Died	December 19, 2009 (aged 58) Murray, Utah, U.S.
Nationality	American
Known for	Megasavant
Parent(s)	Fran Peek, Jeanne W. Buchi

Advances in Pediatrics 55 (2008) 123–170

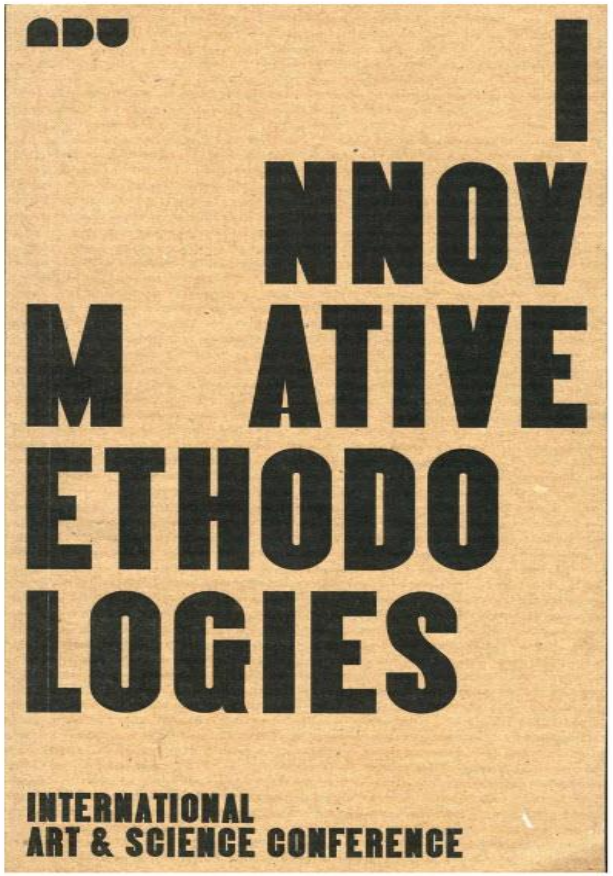
ADVANCES IN PEDIATRICS

The FG Syndromes (Online Mendelian Inheritance in Man 305450): Perspective in 2008

John M. Opitz, MD[a,b,c,d,*], James F. Smith, MD[e,f], Lucia Santoro, MD[g]

Type	OMIM	Gene	Locus
FGS1	305450	*MED12*	Xq13
FGS2	300321	*FLNA*	Xq28
FGS3	300406	*FGS3*	Xp22.3
FGS4	300422	*CASK*	Xp11.4-p11.3
FGS5	300581	*FGS5*	Xq22.3

- At first diagnosed as autistic, later as FG sy (Opitz-Kaveggia sy);
- *Agenesis corporis callosi*, *agenesis of anterior commissure*, *macrocephalia*
- He knew almost by heart the content of > 12,000 books and atlases
- „*Rain man*" (Raymond Babbitt is Dustin Hoffman) https://www.youtube.com/watch?v=DLpCfHH1OVU (the real „Rain man")



Academy of Dramatic Art, University of Zagreb
Trg Republike Hrvatske 5, Zagreb, Croatia
(ADU Velika scena / ADU Big Stage)
9 – 11 April 2019

GORAN ŠIMIĆ
Croatian Institute for Brain Research, Zagreb University
School of Medicine

NEUROSCIENCE OF CREATIVITY: INSIGHTS FROM MINDS OF AUTISTIC GENIUSES

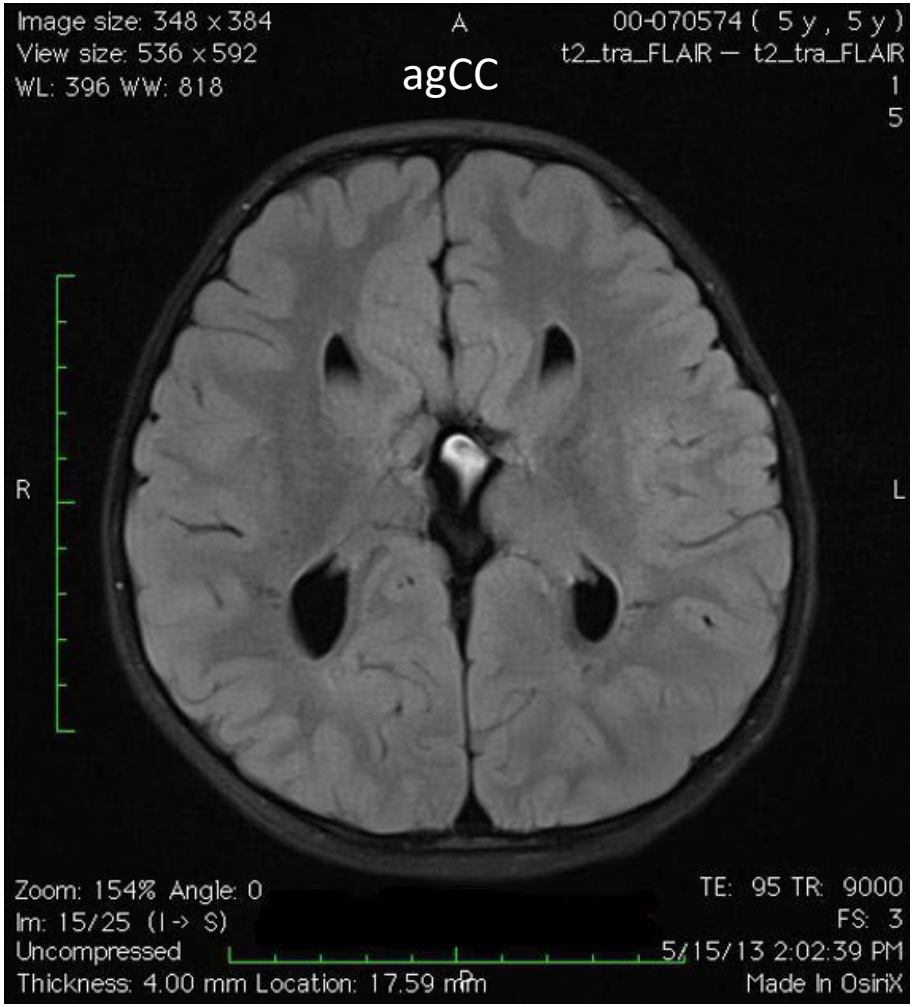
Savant syndrome is a rare condition in which a person with serious mental disability and low IQ exhibit remarkable abilities or brilliance in some domains of knowledge. Such a skill emerges spontaneously and is not derived from practice. Besides being attracted to numbers, especially prime numbers and calendars, individuals with savant syndrome are often fascinated by art and music and have extraordinary memory capacity and visuospatial abilities. Synesthesia and absolute pitch are also more commonly found in savants than in the general population. About half of the individuals with savant syndrome have an autism spectrum disorder, while the other half have some other form of central nervous system damage or disease. Only about 10% of the autistic people are savant.

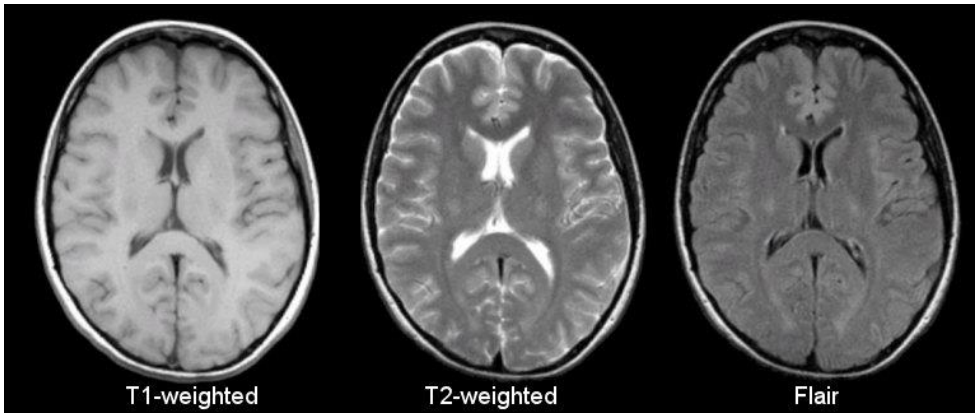
It is believed that savant syndrome is associated with a left-hemisphere dysfunction. Amost all savants are male. The cerebral lateralization theory proposes that due to delayed maturation of the left hemisphere it is more susceptible to prenatal influences such as circulating testosterone in the developing male fetus. In turn, this can trigger recruitment of the right hemisphere, which is compensating the left-hemisphere dysfunction by recruiting lower-level memory capacities as well as automatic and rigid, simple rule-based processing. Consequently, it seems that savants have privileged access to low-level, unprocessed information, before it is "packaged" by meaningful processing of the left hemisphere. Typically, they concentrate more on the parts than on the whole, which is a characteristic of so-called autistic geniuses. This association was raised in a recent movie "Magnus" (2016), chronicling the life of world chess champion Magnus Carlsen, who became a grandmaster at age 13.

One of the most incredible manifestations of savant syndrome is that of the "acquired" savant. Here, prodigious skill, especially in art or music, or the enhanced memory capacity, emerges unexpectedly in some people who have suffered a head injury, stroke, and in patients with e.g. frontotemporal dementia with predominant left hemisphere involvement. Similarly, it can also be induced in normal people by creating a virtual injury of the left temporal lobe using repetitive transcranial magnetic stimulation.

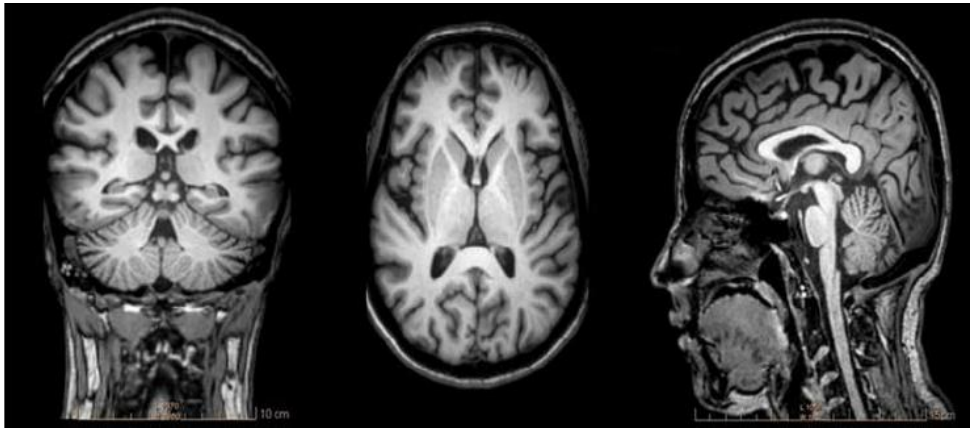
Author's work is funded by the Croatian Science Foundation (IP-2014-09-9730).

„Racing car” znak u agCC

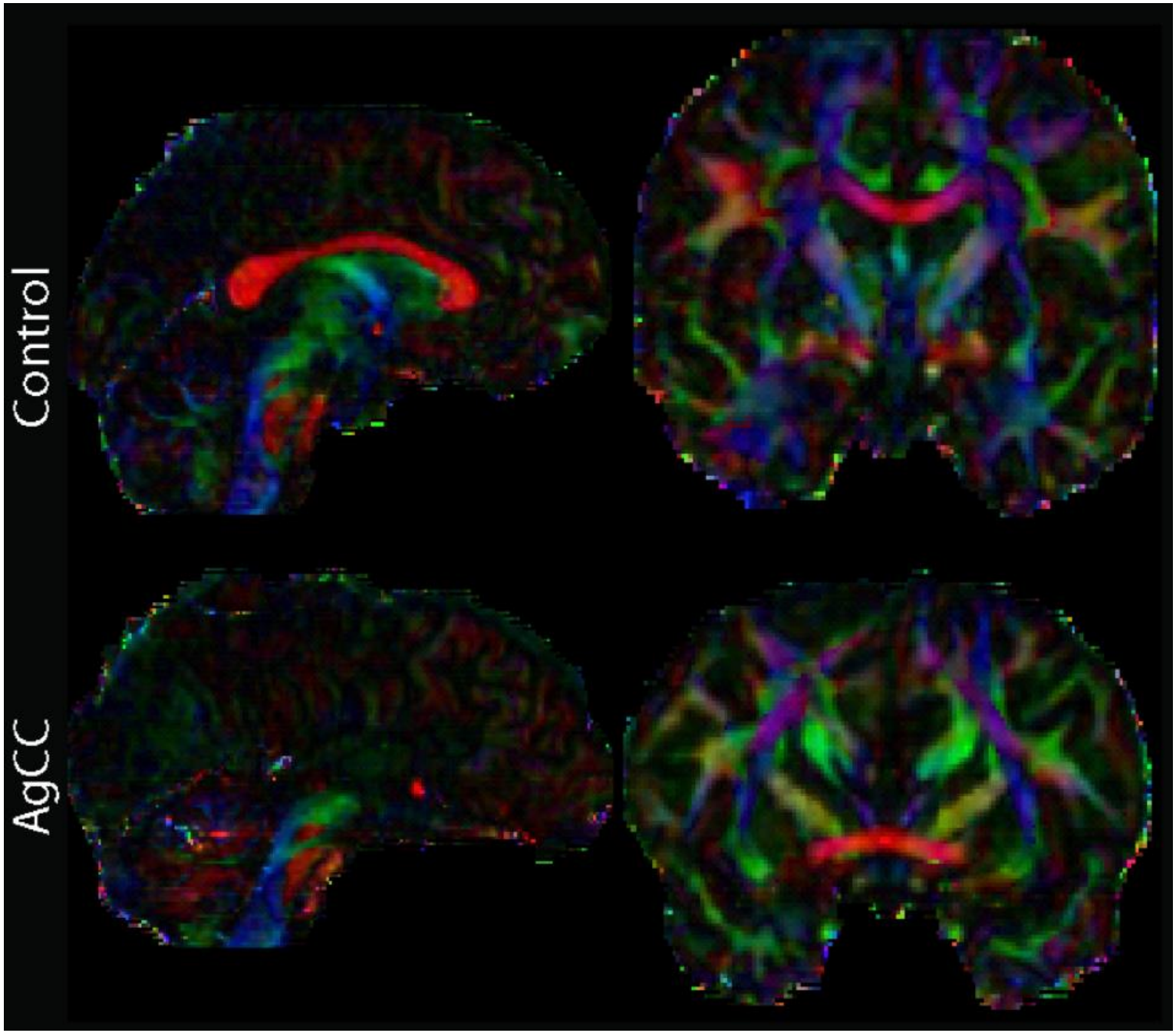




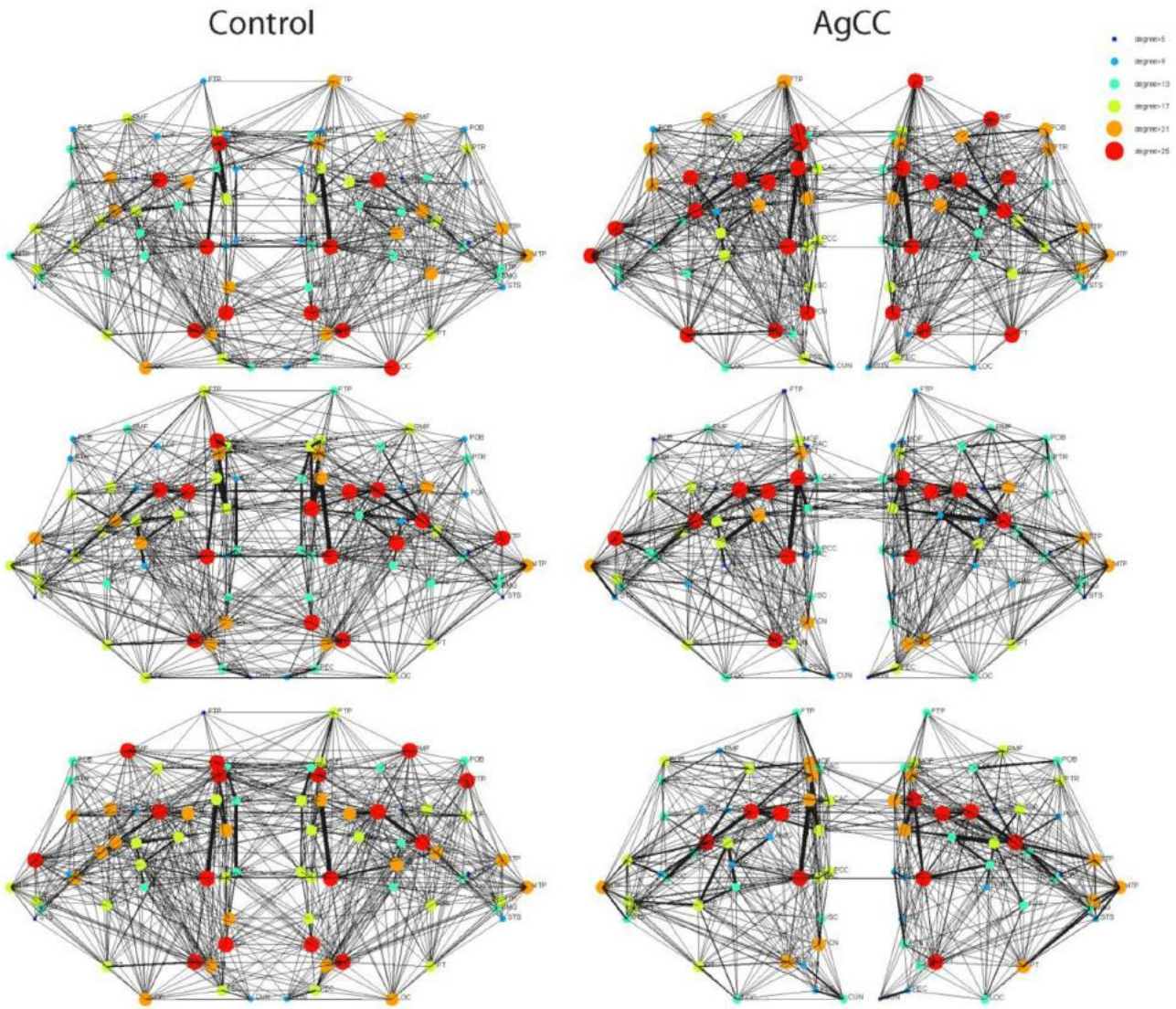
CONTROL



https://radiopaedia.org



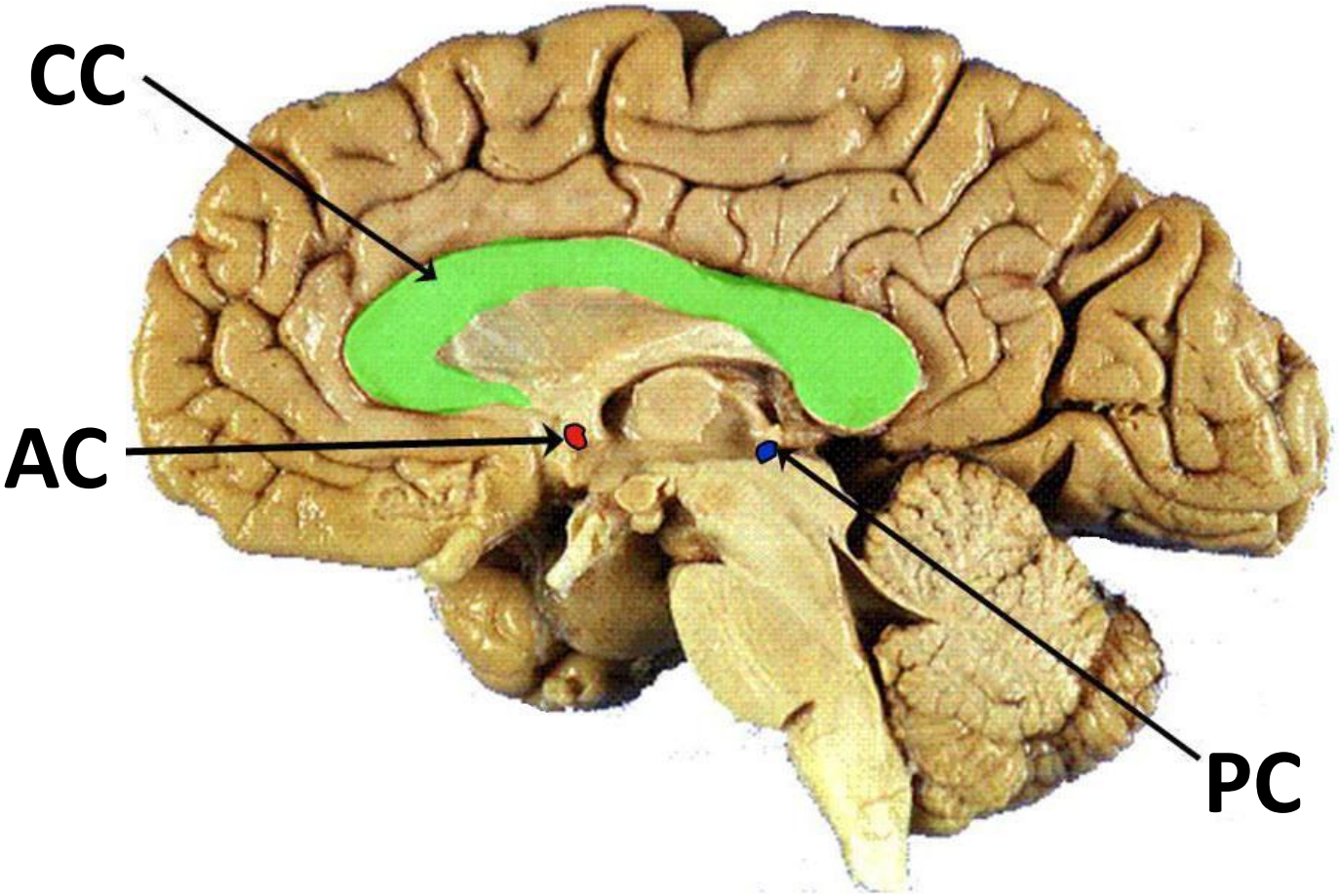
Owen et al., The structural connectome of the human brain in agenesis of the corpus callosum. *Neuroimage*, 2013



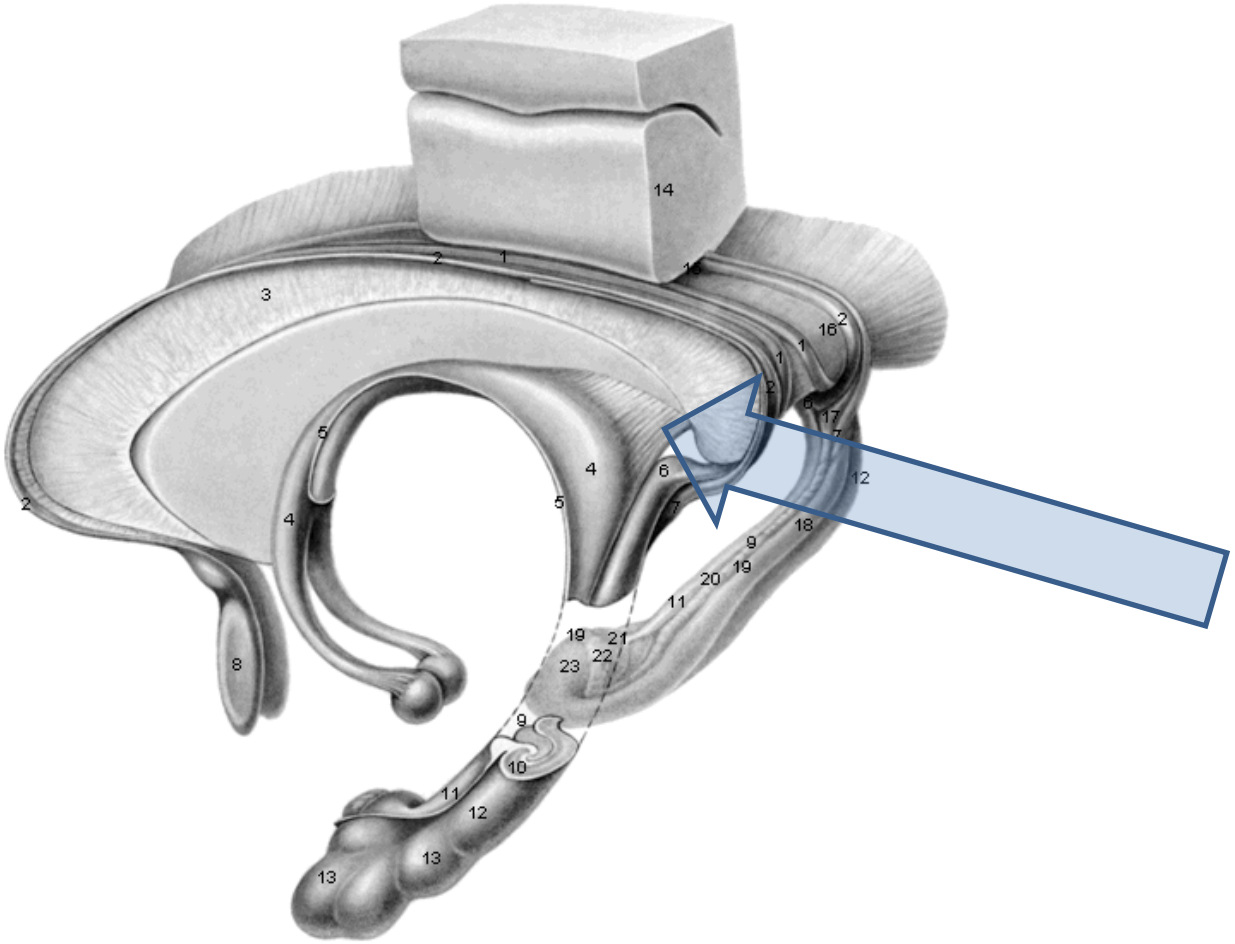
The control brains exhibit some variability, but the overall distribution of degree is constant. The AgCC connectomes demonstrate more variability in the location and number of hub regions

Owen et al., The structural connectome of the human brain in agenesis of the corpus callosum. *Neuroimage*, 2013

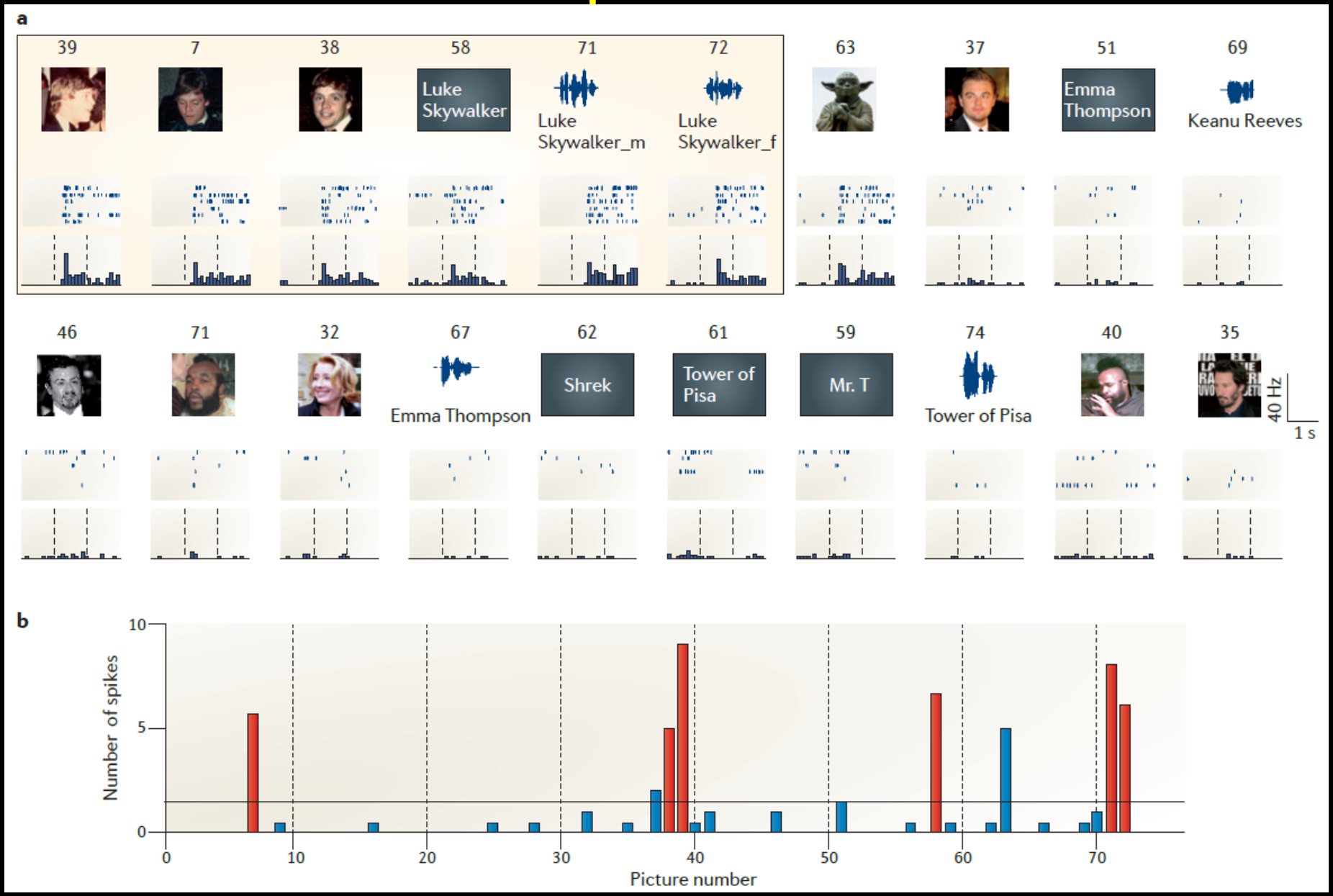
Kalozalna i komisuralna vlakna



Hipokampalna komisura (psalterium)

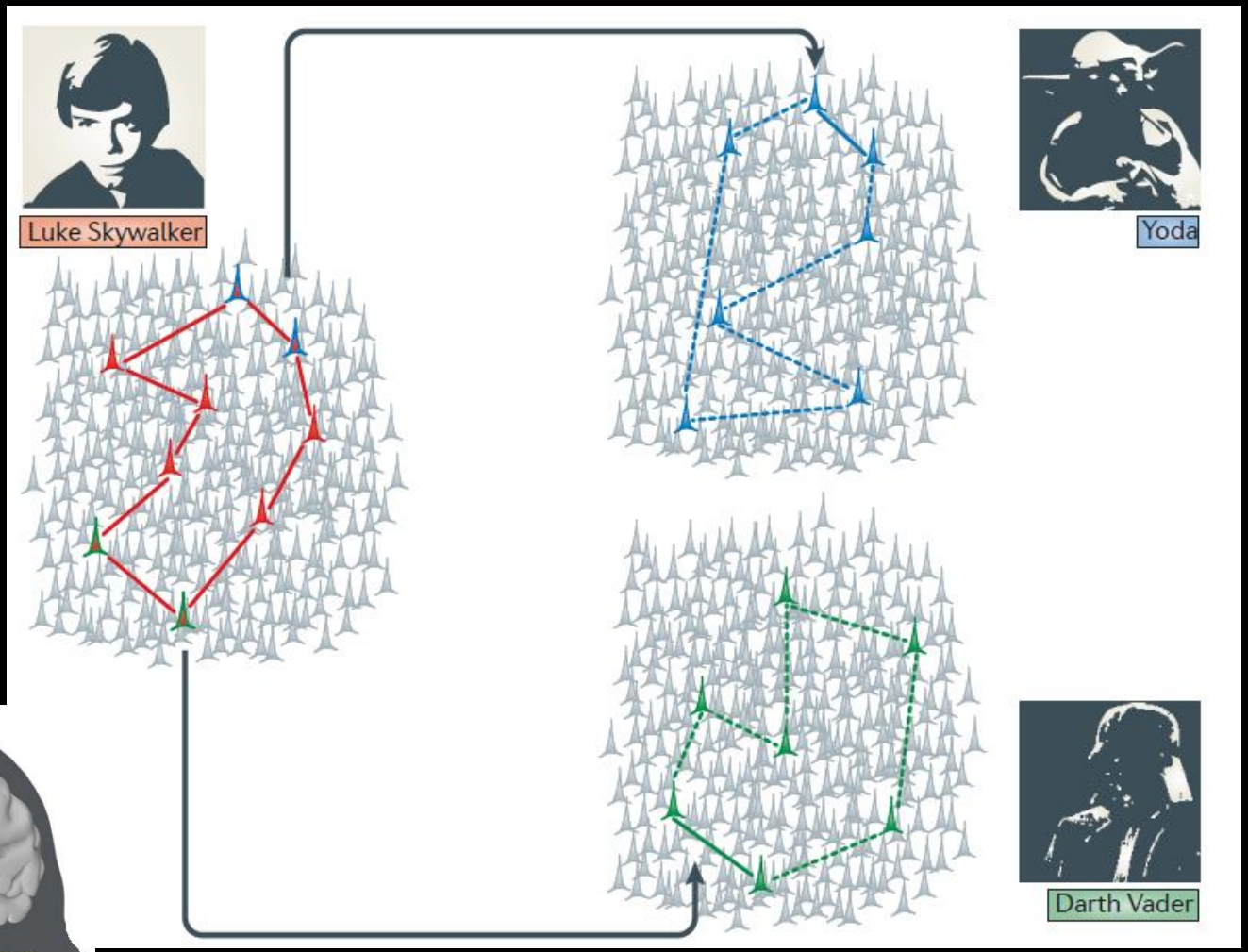


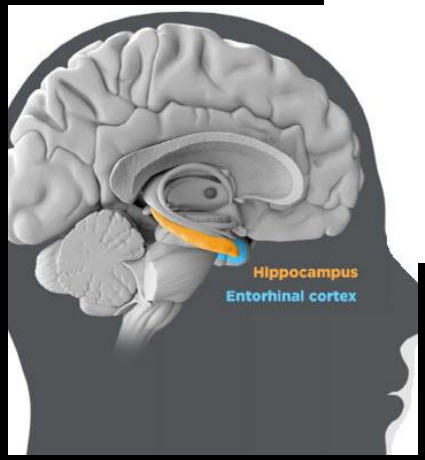
Konceptni neuroni



Quian Quaroga R. (2012) Concept cells: the building blocks of declarative memory functions. Nat. Rev. Neurosci. 13: 587-597

Attractor dynamics of concept neurons from a few visual cues by the activation of a network representing a given concept





Quian Quaroga R. (2012) Concept cells: the building blocks of declarative memory functions. Nat. Rev. Neurosci. 13: 587-597

Neke moguće usporedbe razvoja svijesti s teorijom igara

Kao i kod igranja igara od AI se traži donijeti optimalnu odluku o sljedećem potezu, ali je također potrebno pronaći i optimalnu dugoročnu strategiju

Taj prvi potez kod svijesti čovjeka ovisi o prediktivnom kodiranju

AI je zapravo igra u kojoj je ključ pretraživanje prostora stanja

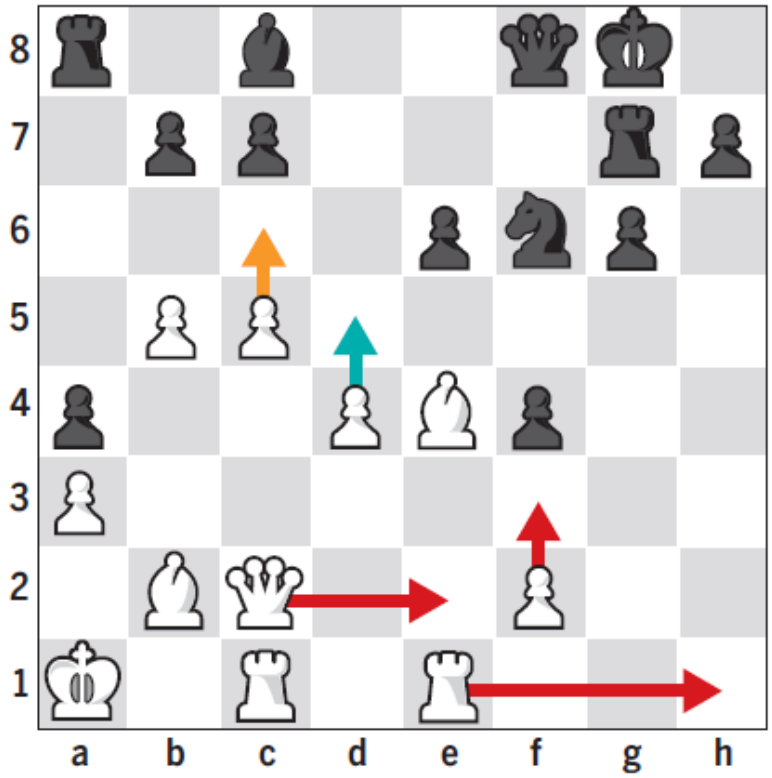
Za razliku od StockFisha, koji se temelji na domenskom znanju (tako su i kod moždane kore odraslog čovjeka parcelizirane kognitivne domene), strojno učenje se AlphaZeroa temelji na Monte Carlo stablu pretraživanja (*tree search*) bez domenskog znanja

Šah, go i šogi su igre s potpunim informacijama, a pravila su fiksna; kod svijesti to nije slučaj (osim ako ne uzmemo skup svih fizikalnih zakona kao pravila)

Chess, a Drosophila of reasoning

Contemplating the next move

In the game between AlphaZero (white) and Stockfish (black), there were several moves that were reasonable for AlphaZero to consider. After 1000 move-sequence simulations, the red moves were rejected, and after 100,000 simulations, AlphaZero chose the blue move over orange.



REPORT

A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play

David Silver[1,2,*,†], Thomas Hubert[1,*], Julian Schrittwieser[1,*], Ioannis Antonoglou[1], Matthew Lai[1], Arthur Guez[1], Marc Lancto...

+ See all authors and affiliations

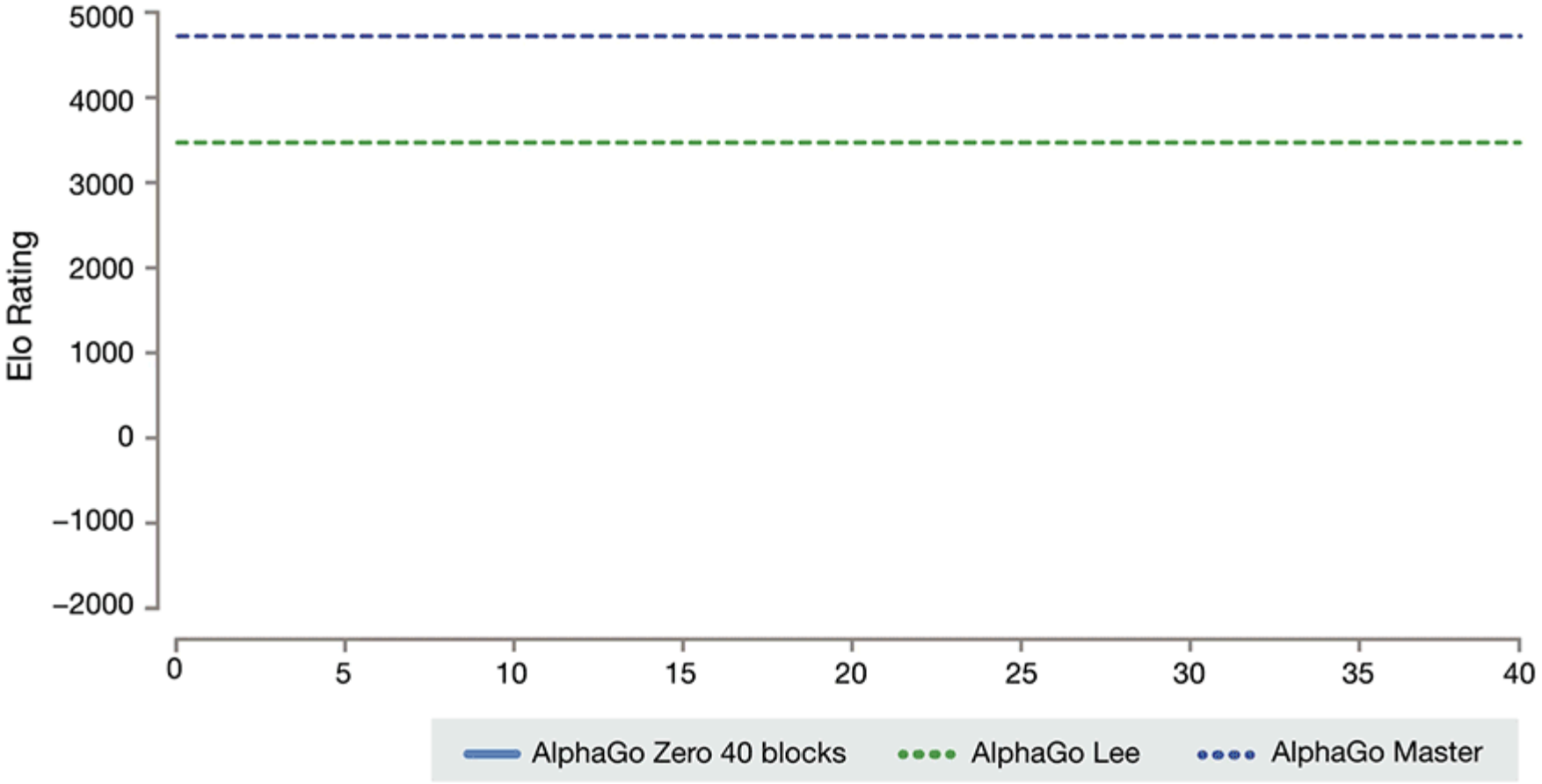
AlphaZero shocked the chess world again with new results today.

AlphaZero Crushes Stockfish In New 1,000-Game Match

pete

Dec 6, 2018, 11:00 AM | 374 | Chess Event Coverage

+155 -6 =839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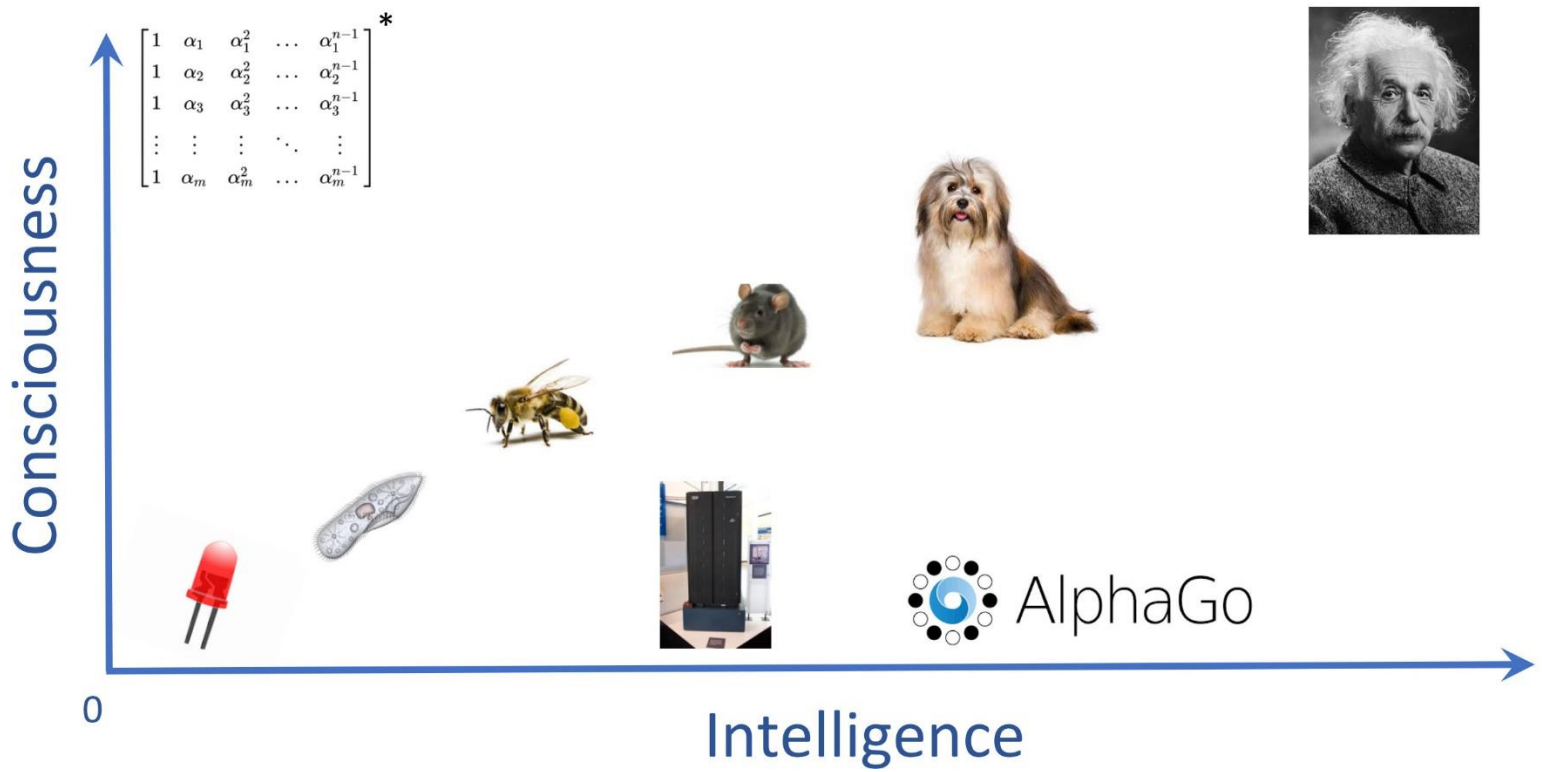
AlphaGo Zero 40 blocks
AlphaGo Lee
AlphaGo Master

- Intelligence vs. Consciousness



(*) According to IIT

Zaključci

Svijest je rezultat biološke evolucije

C. povećava vjerojatnost da će organizam usmjeriti svoju pozornost, a nakon toga i svoje djelovanje na ono što je najvažnije za njegov opstanak i reprodukciju; svaka jedinka želi biti sita i na sigurnom, od jednostaničnog organizma do čovjeka: https://www.youtube.com/watch?v=H6u0VBqNBQ8)

Nijedna teorija zasad ne objašnjava svijest niti zadovoljava sve empirijske uvjete (argumente), ali mnoge od njih doprinose njezinom boljem razumijevanju

March 15th, 2022: Oral/Poster Abstract submission & Travel Grants submission

March 31st, 2022: Poster Abstracts available on the MNS2022 website

May 1st, 2022: Deadline for Early Registration

May 29th – June 2nd, 2022: MNS 2022 & Onsite Registration

Hvala na pozornosti!

IP-2019-04-3584 (2020-2024)

KK.01.1.1.01.0007 ZCI-Neuro

Sažetak

Objašnjenje svijesti jedno je od najtežih pitanja u neuroznanosti, a glavni razlog postojanja brojnih teorija je nedostatak strožih kriterija koji bi se temeljili na iskustvenim podacima i činjenicama. Pojednostavljeno, dvije su glavne dimenzije svijesti budnost i svjesnost. Budnost (*wakefulness*, *arousal*, *vigilance*) ovisi o aktivnosti izodendritičkih neurona retikularne formacije i njihovih ascendentnih projekcija, dok svjesnost (sadržaj svijesti/proživljeno iskustvo sebe i okoline, *awareness/lived experience*) vjerojatno u najvećoj mjeri ovisi o frontoparijetotalamičkim mrežama, napose mreži temeljnog načina rada (*default mode network*). U pojedinim promijenjenim stanjima svijesti te dvije dimenzije mogu biti oštećene u različitoj mjeri. Najveći je stupanj disociranosti prisutan u vegetativnom stanju, budući da ga nakon kraćeg ili duljeg razdoblja kome karakterizira budnost bez svjesnosti o vlastitom postojanju i voljne interakcije s okolinom. U tijeku predavanja pokušat ću iznijeti neke temeljne postavke, prednosti i nedostatke za trinaest u znanstvenoj literaturi najviše spominjanih teorija svijesti. Budući da zasad najbolje zadovoljava većinu empirijskih kriterija, posebno ću detaljno opisati teoriju dijeljenja informacija u zajedničkom radnom okružju (*global neuronal workspace theory of consciousness*). Prema toj teoriji fenomen svijesti obuhvaća dvije vrste procesiranja: odabir informacija za dijeljenje između pojedinih multimodalnih kortikalnih čvorišta (hubs), što ih čini globalno dostupnima za analizu i izvještavanje (C1 svijest) te samonadzorno procesiranje navedenih izračuna, što nam daje subjektivni osjećaj sigurnosti ili pogreške (C2 svijest). Trenutni stupanj umjetne inteligencije strojeva još uvijek se temelji na oponašanju nesvjesnog procesiranja mozga čovjeka (C0 svijest). Na kraju bih otvorio raspravu o, trenutno samo teorijskim, mogućnostima implementiranja C1 i C2 svijesti u strojne i biološke sustave.