India Discovery Center

Mind-Brain-Intentionality

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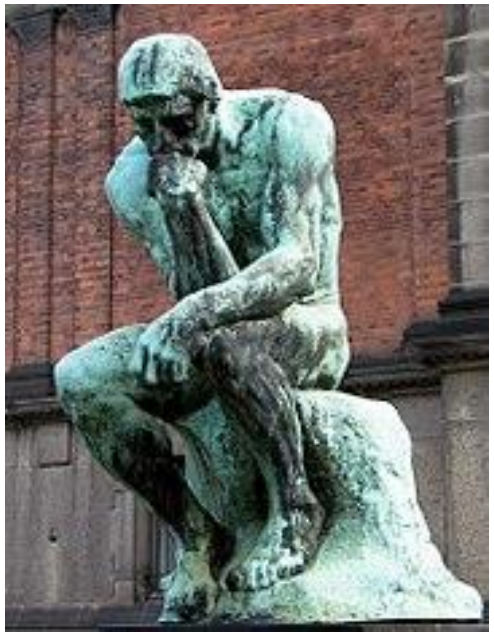
India Discovery Center

Virtual Video Seminar



Concepts of Mind

- The concept of mind (soul, spirit, etc.) is difficult to grasp due to its metaphorical origin [(ψυχή)-psyche] and ontological instability. "Mind" associated with a variety of explanatory theories.
- In Classical Greece ψυχή meant rush of air, blow, breath, and later – by dint of metaphor – was used to name the soul, conscious self, the source of life, etc.

- Soul is that in virtue of which we are alive. Aristotle used nôos for intelligence, immediate awareness, intuitive intellect
  - (Dialogues Clin Neurosci. 2018; 20:5-12)

- **"All men by nature desire to know."** in Aristotle's Metaphysics.

Mind

- **Definition: The "Mind" encompasses sensation and sense perception, feeling and emotion, dreams, traits of character, personality, the unconscious and the volitional aspects of human life, as well as the more narrow intellectual phenomena, such as thought, memory, and belief.**

[The New Encyclopaedia Britannica 1988; 24:116-126]

Mental phenomena of the Mind

consciousness

intentionality

free will

teleology

normativity

Aristotle's five modes of mind

Science-scientific knowledge –epistēmē
Art-technical skill – technē
Prudence-practical wisdom – phronēsis
Intelligence- intuition - nous- nôos
Wisdom -- sophia

The **mind** is intuitively modeled as an **intentional system**, whereas the **brain** is modeled as a **causal system**.
These might both be valid models, even if intentionality is inconsistent with the principle of causality. (Tuomas K. Pernu, 2017)

Connections of mental and physical realms

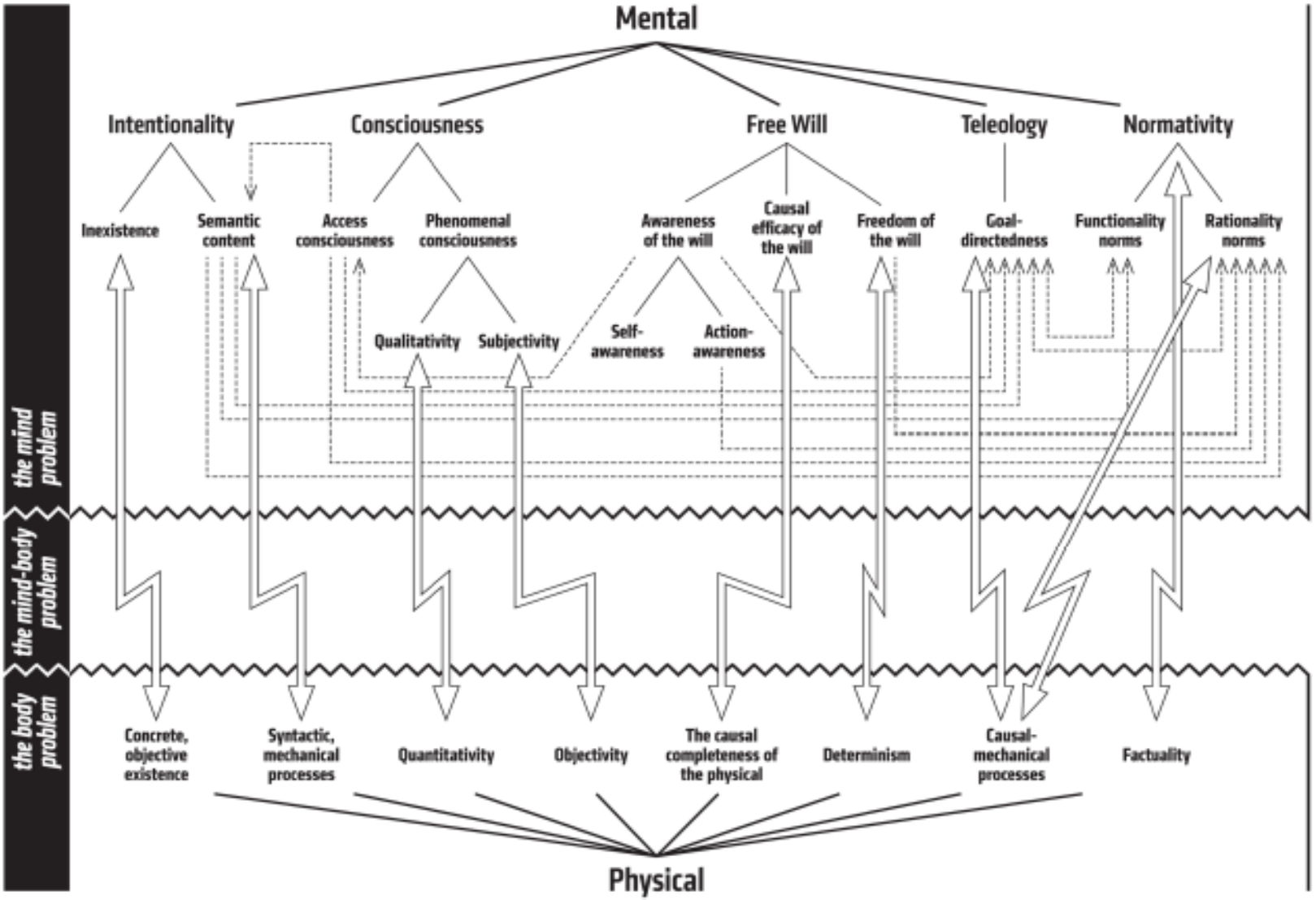
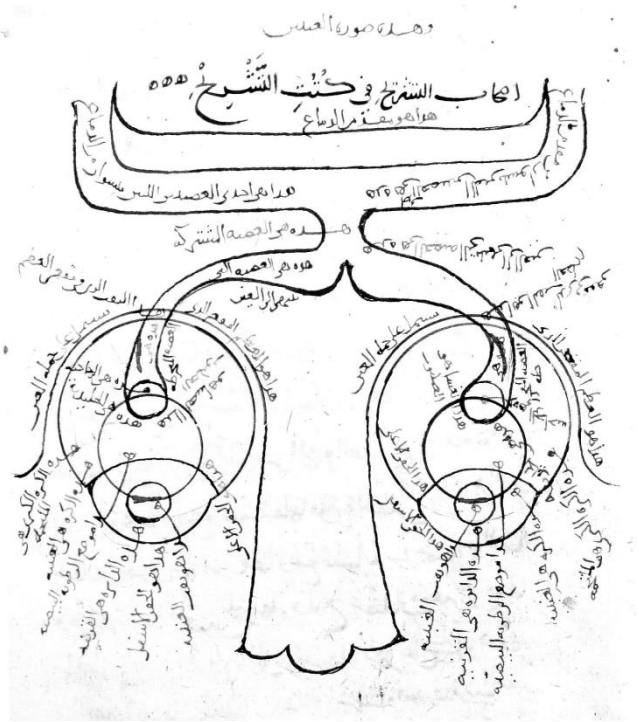


FIGURE 1 | A figure summarizing the various components of the mind-body problem. The vertical lightning arrows represent the different points of tension betwe the paradigmatically mental and physical features. The dashed arrows within the mental realm outline some of the various interdependencies between the separa marks of the mental (the direction of the arrow represents the direction of dependence)

Early anatomical drawings



The visual system

Depicted by Ibn al-Haytham
circa 1027, Cairo, Egypt

(Portraits of the Mind, 2010)

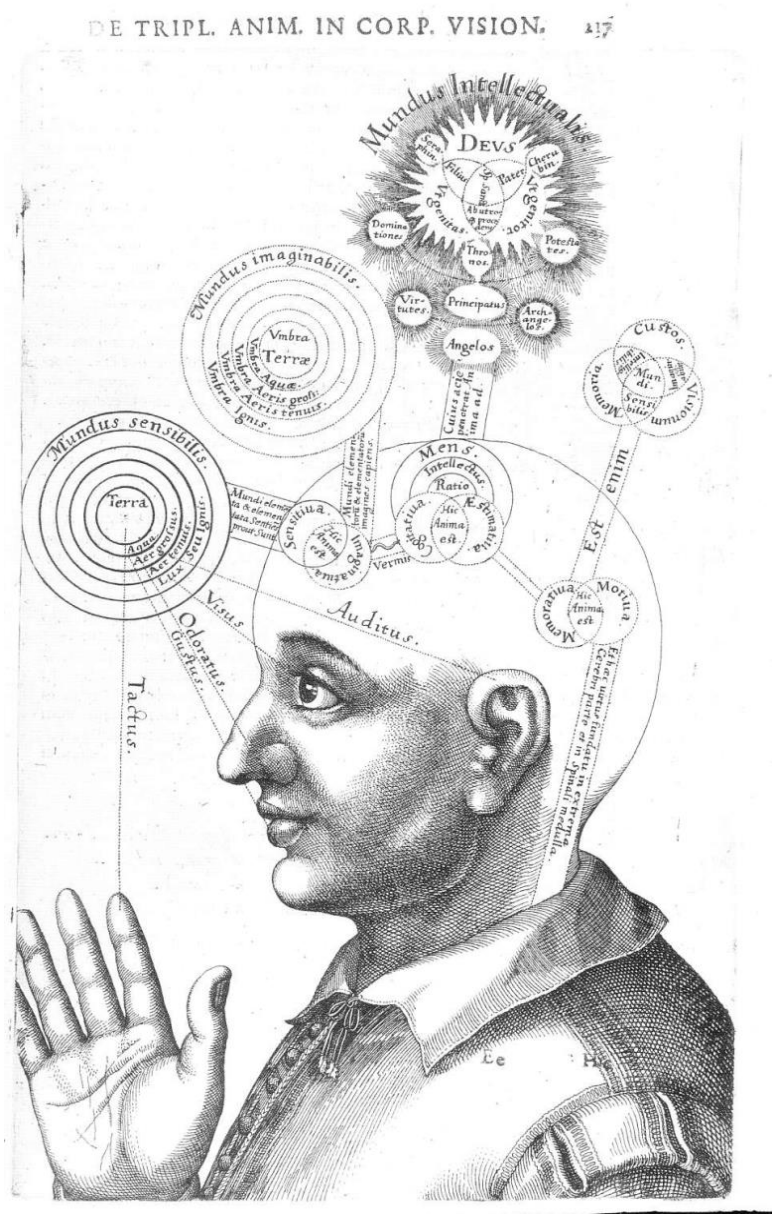
"..the brain is not responsible for any of the sensations, the correct view [is] that the seat and source of sensation is the region of the heart.... the motions of pleasure and pain, and generally all sensation plainly have their source in the heart.." (Aristotle 350 BCE)

"It is only with the heart that one can see rightly; what is essential is invisible to the eye."
(Antoine de Saint Exupéry, 1943)

Woman's head-dress

Anonymous, Saxony, 1441
The band around the woman's neck informs us that "touch is located in all parts of the body."
Aristotle believed the brain served as a cooling unit syphoning off the excess heat from the heart, where the rational soul did its work.
Inclusion of the heart in the mind's function.

Early concept of the Mind and Universe



Mind and Universe

Drawned by Robert Fludd, circa 1621

Mundus sensibilis

auditus
visus
odoratus
Gustus
Tactus

Mundus imaginabilis

Mundi elementoru et elementatoru imagines capiens

Mundus intellectualis

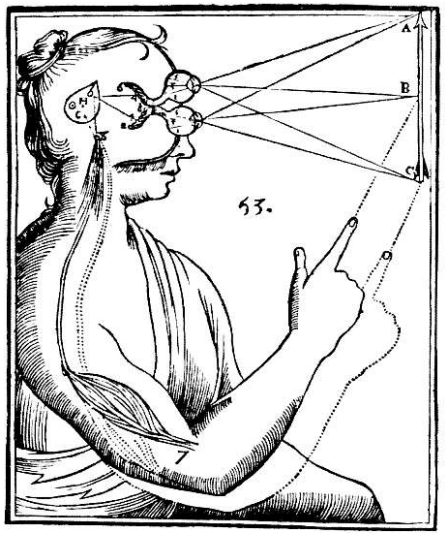
Deus, Pater, Filius, Spiritus Sancti
Seraphin, Cherubin
Dominationes, Potestates
Principatus, Virtutes, Angelos, Archangelos

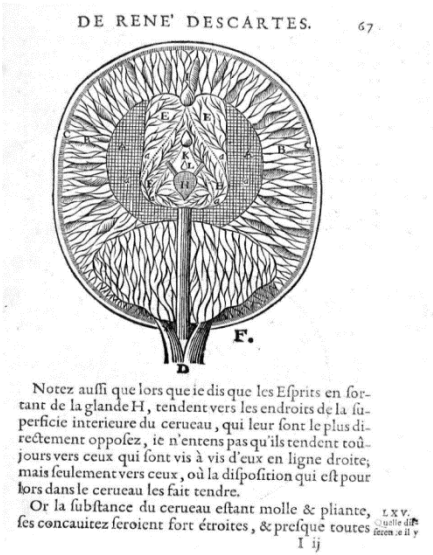
Sensitina	Mens	Memorativa	Custos
Anima	Intellectus	Anima	Memoria
Imaginatuta	Ratio	Motina	Vsionum
	Cogitatina		Mundi sensibilis
	Anima		Intelligibilis
	Aestimatina		imaginabilis

(Portraits of the Mind, 2010)

Descartes' concept of the Mind

"Cogito ergo sum"




DE RENE' DESCARTES. 67

Notez auſſi que lors que ie dis que les Eſprits en ſortant de la glande H, tendent vers les endroits de la ſuperficie interieure du cerueau, qui leur ſont le plus directement oppoſez, ie n'entens pas qu'ils tendent toûjours vers ceux qui ſont vis à vis d'eux en ligne droite; mais ſeulement vers ceux, où la diſpoſition qui eſt pour lors dans le cerueau les fait tendre.

Or la ſubſtance du cerueau eſtant molle & pliante, LXV. ſes concauitez ſeroient fort étroites, & preſque toutes

I ij

In the Dualistic era – Descartes – mind (res cogitans)-body (res extensa)

Mind is nonphysical thing
Body is physical thing
Mind and body interact
Non-physical and physical can not interact

(Dialogues Clin Neuroscience 2018;20:6-12)

Pineal gland

René Descartes, 1664

He brought up the mind-body dualistic view but it was hard to explain the impalpable quality of the mind and its location. He was inspired in part by lifelike statues that were animated by sophisticated hydraulic systems in the royal gardens of the Saint-German palace, he thought to understand all phenomena , including animal and human behavior.

He felt compelled to identify the anatomical interface between the two (body-mind), and he settled on the pineal gland. It is the only single structure in an organ where all others are mirrored on two sides: perfect for interacting with the unitary mind.

(Portraits of the Mind, 2010)

Mind-2

Kant
Hegel, Husserl
Heisenberg, Schrödinger, Wittgenstein and others

Wittgenstein: Philosophy unties the knots in our thinking that we have, in senseless way, put there. The result of philosophical thinking of the right kind is not a truth discovered but a confusion dissolved.

How the mental/mind process was formulated among the researchers?

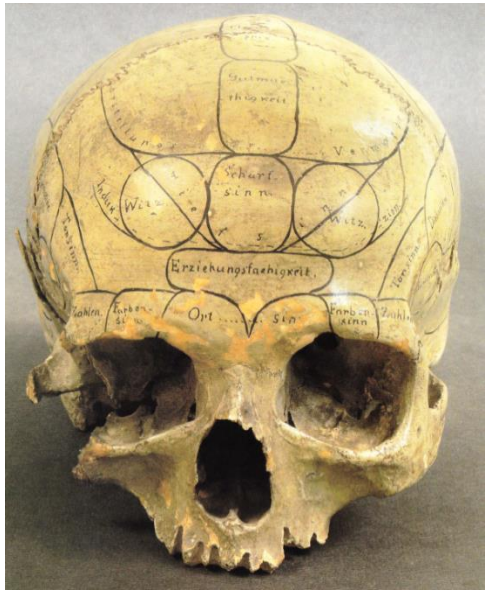
Phrenologists—separatists Dr. Franz Joseph Gall and followers (1810, 1819)

Aggregate field --- Pierre Flourence. He wrote in 1823: "All perceptions, all volitions, occupy the same seat in this (cerebral) organs, the faculty of perceiving, of willing merely constitutes therefore a faculty which is essentially one."

Separatists – Paul Broca (1824-1880; 1872); Carl Wernicke (1848-1905; 1874)

Dr. Paul Flechsig – 1896—The brain is the "Thinking organ"

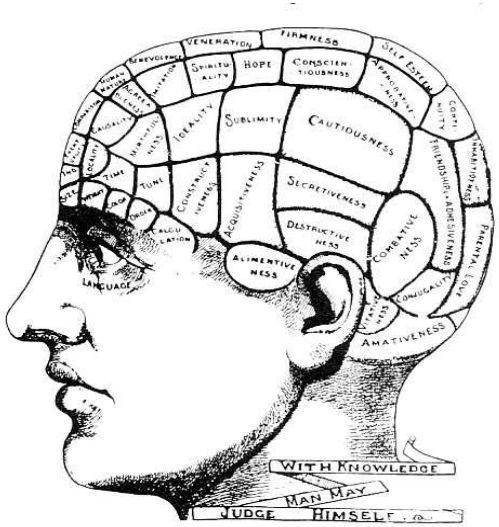
Concepts and Practice of Mind and Characters



Human skull inscribed by a phrenologist
Anonymous, 19th century

Question: Where is the mind located in the human body?

Franz Joseph Gall (1758-1828), neuroanatomist, pioneered in ascribing the cerebral functions to various brain areas. He was the creator of the “cranioscopy” or “phrenology”. He was the first to distinguish between the gray and white matter of the brain.



Phrenological diagram, 1893
BBC Hulton Picture Library

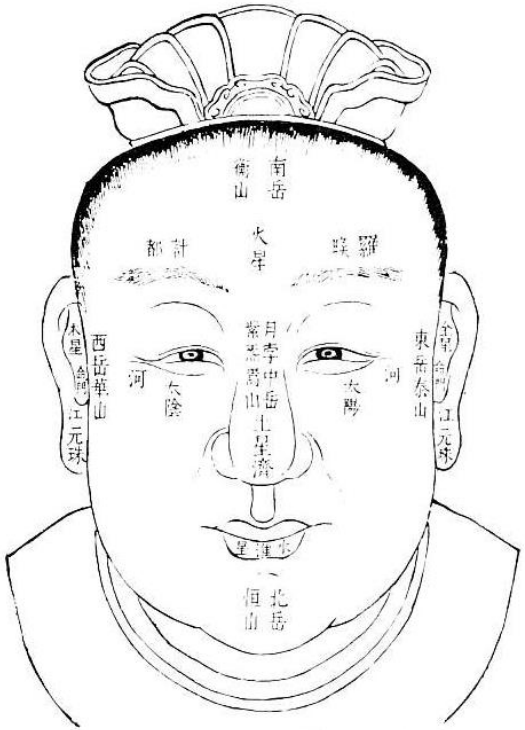
Dr. Gall marked out on model of the head the places of 26 organs. His followers - Drs. Spurzheim and Combe increased the delineated areas up to 37.

Some of them (not the entire list): amativeness, philoprogenitiveness, concentrativeness, secretiveness, adhesiveness, combativeness, destructiveness, self-esteem, love of approbation, cautiousness, benevolence, firmness, hope, wonder, ideality, wit, individuality, form perception, seize perception, weight perception, memory of things, time perception, linguistic perception, comparative understanding, metaphysical spirit.

(Portraits of the Mind, 2010)

Body-mind/intellect correlation

Physiognomy

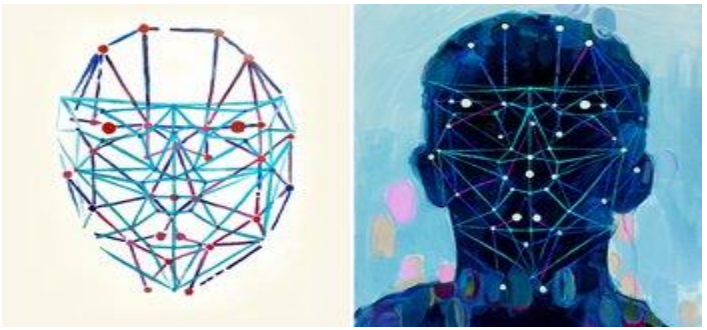


The face explained in terms of five planets, six stars, five mountains, and four rivers; from the *Ku-chin t'u-shu chi-ch'eng*, 1726

New Encyl.Britannica, 1988; 9:414

There is evidence that a number of facial and bodily characteristics are definite correlates of psychological function. Physiognomic signs observed in forms of mental deficiency, abnormal psychosexual behavior and emotional disturbance (e.g. cretinism, hydrocephalus, hermaphroditism, Addison's disease, pellagra, hyperthyroidism.

Cognitec
Clearview
Findface
Pimeyes



Chinese philosophical concept of the mind-body

BOX 1 | Functional theory of mind in early imperial China.
Understanding the mind as a function rather than as a substance has a long and intriguingly cross-cultural history. Here is an excerpt from a Chinese treatise Shên-mieh lun ("Essay on the extinction of the soul") composed by a Confucian Fan Chên in the 5th century, portraying startling similarities to the contemporary discussion (from Balázs, 1964, p. 266):

(1) Someone asked me: You say the soul becomes extinguished. How do you know it becomes extinguished?
Answer: The soul and the body are identical. Therefore while the body survives the soul survives, and when the body perishes the soul is extinguished.

(2) Q. "Body" refers to something that lacks consciousness, "soul" to something that has consciousness. Consciousness and lack of consciousness are two different things, therefore soul and body cannot reasonably be treated as one. I have never before heard it said that body and soul are identical.

A. The body is the soul's material basis; the soul is the functioning of the body. Consequently, since "body" refers to the material basis and soul to the functioning, body and soul cannot be regarded as separate.

(3) Q. But since admittedly, the soul is not the material basis, and the body not the functioning, where is the sense in saying that they cannot be regarded as separate?

A. These are separate names referring to a single object.

(Pernu:Frontiers Psychol. 2017; 8:1-19, Article 1084)

Mind-3

Opinion of ancient researcher:

"..source of our pleasure, merriment, laughter and amusement, as of our grief, pain, anxiety and tears, is none other than the brain....(it) enables us to think, see and hear, and to distinguish the ugly and the beautiful, the bad and the good, pleasant and unpleasant... diaphragm nor heart.. neither take part in mental operations" *(Hippocrates, 400 BCE)*

Opinion of a philosopher:

The world is a construct of our sensations, perceptions, memories. It is convenient to regard it as existing objectively on its own. But it certainly does not become manifest by its mere existence. Its becoming manifest is conditional on very special goings-on in very special parts of this very world, namely on certain events that happen in a brain. That is an inordinately peculiar kind of implication, which prompts the question: what particular properties distinguish these brain processes and enable them to produce the manifestation?

(Schrödinger, 1958)

Opinions of recent researchers:

"You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules." (Francis Crick, 1995?)

"In science , the unknown is our home base, and if you know what you're doing, you shouldn't be doing it. We can rely on the data for answers without prior knowledge."

(Joy Hirsh, 2010)

Physics of the Mind

"Is it possible to turn psychology into "hard science"? Is it possible to describe the mind based on the few first principle as physics does? The mind has its variabilities and uncertainties , the question of perception and elementary cognition to emotions and abstract ideas, to high cognition. Is it possible to turn psychology and neuroscience into "hard" sciences?

What is physics of the mind?

1. The common to all areas of physics is a methodology that first concentrates on finding few fundamental laws and their mathematical formulations.
2. A mathematical theory developed from these few "first principles" that explains a vast area of knowledge without contradicting known facts.
3. It makes unexpected theoretical predictions, which could be verified experimentally, and actual experimental verifications which confirm or disconfirm the theory.

Fundamental principles of the Mind-Brain

1. Concepts
2. Instincts
3. Emotions
4. Behavior
5. Cognitive hierarchy
6. Knowledge Instinct (KI)
7. Aesthetic emotions
8. Perceptions of objects
9. Vague representations (Combinatorial Complexity, CC)
10. Dynamic Logic (DL)

(Leonid I. Perlovsky, Hypothesis and Theory 2016; 10:1-12; Article 84)

Physics of the Mind-2

The beautiful and meaning of Life

The mind mechanisms are organized in an approximate hierarchy of concepts and aesthetic emotions.

Existing science does not understand what is beautiful.

The dual hierarchy, language and cognition

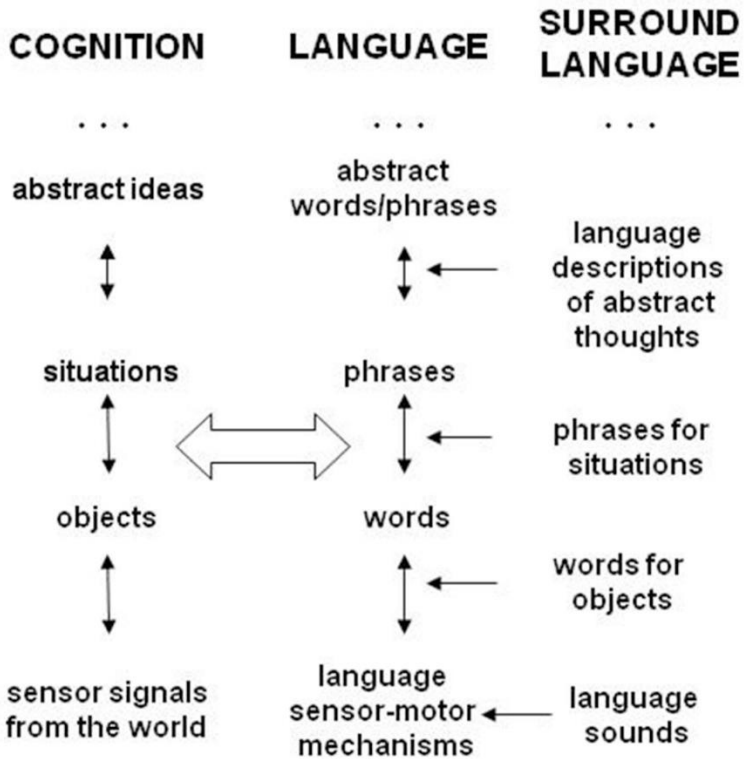
Psycholinguist Chomsky – complete separation

Why children learn language by the age of 5 or 7, but do not think like adults until much later?

(St. Paul, 1 Corinthians 13;11: When I was a child, I spoke like a child; when I became a man, I gave up childish ways.)

What exactly are the changes in neural mechanisms?

Dual model



Every representation has two parts: cognitive and language.

Language is grounded in the surrounding language. Cognitive hierarchy is grounded in experience at the very :bottom"; the cognitive hierarchy is constructed from experience guided by language.

Emotionality of languages and Cultures

English language -- unemotional

Arabic language --- very emotional

Physics of the Mind -3

Dynamic Logic, DL

Dynamic logic is a mathematical technique modeling the knowledge instinct, or more specifically, the brain-mind mechanisms of matching vague top-down signals to bottom-up signals without computational complexity.

The mathematical description, following (Perlovsky et al., 2011) is given below. An index m numbers top representations; an index n numbers bottom representations; an index I numbers BU signals making up the n-th representation. Parameters xni measure the strength of association of the BU signal I with bottom representation, and pmi measure the strength of association of the BU signal I with to representation m. Values of these parameter are limited between 0 and 1. Associations between top and bottom representations are modeled by

$$f(m|n) = r(m)\,\ell\,(n|m) / \sum_{m' \in M} r(m')\,\ell\,(n|m'). \qquad (1)$$

$$\ell\,(n|m) = \prod_{i=1} p_{mi}^{xni}(1 - p_{mi})^{(1-xni)} \qquad (2)$$

Here (n |m) are pdf-like measures, and f(m|n) are probabilities- like measures, similar to a posterior i Bayes probabilities. Under certain conditions, these variables indeed can be interpreted as probabilistic measures. For preserving these probabilistic interpretations (n|m) is defined so that integration over x yields 1. And parameters r (m) are used to model the proportion of signals min top-down representations. These representations model a single level in the hierarchical mental structure; at the lowest level of the hierarchy xni represent sensor signals: If a feature I is present in object or event n,xni = 1,otherwise 0.

Learning in DL processes constitutes adapting parameters pmi and r(m)so that top representations m correspond to patterns in bottom representations xni. This process maximizes a total similarity measure between all bottom patterns and top representations,

$$L(\{n\}, \{m\}) = \prod_{n \in N} \sum_{m \in M} r(m)\ell\,(n|m). \qquad (3)$$

Maximizing this similarity is a model of KI.

The learning process maximizing KI (Perlovsky et al., 2011) can be specified iteratively,

$$p_{mi}^{it+1} = p_{mi}^{it} + dt \sum_{n} f(m|n)[\partial \ln \ell\,(n|m) / \partial\, p_{mi}]^{it}, \qquad (4)$$

$$f^{it+1}(m|n) = [r(m)\,\ell\,(n|m) / \sum_{m' \in M} r(m')\,\ell\,(n|m')]^{it}, \qquad (5)$$

$$r^{it+1}(m) = [(1/N) / \sum_{n} f(m|n)]^{it}, \qquad (6)$$

In equation (4) a parameter dt is an increment of the internal time t of the DL iterations. A fundamental aspect of the DL learning is an initial vague state, which is achieved by specifying the unknown parameter values Pmi near 0.5. This value of Pmi corresponds to maximal variances of I (nlm) and vague representations (mln). This state corresponds to the Aristotelian potentiality. In the process of perception, “mind meets matter.” It is a fundamental principle of the mind describing the process from vague to crisp representations.

Would all of our human characters be stripped off ?

BOX 2 | Physicalism and three kinds of zombies.
A thoroughly physicalistic view of ourselves threatens to make us zombies in at least three distinct senses.

Semantic Zombies. The physical world seems to be governed by wholly syntactic, mechanical processes, leaving the semantic features of our mental states – the content of our desires, beliefs, and perceptions – without any causal role, and transforming us thus into syntactically driven zombies.

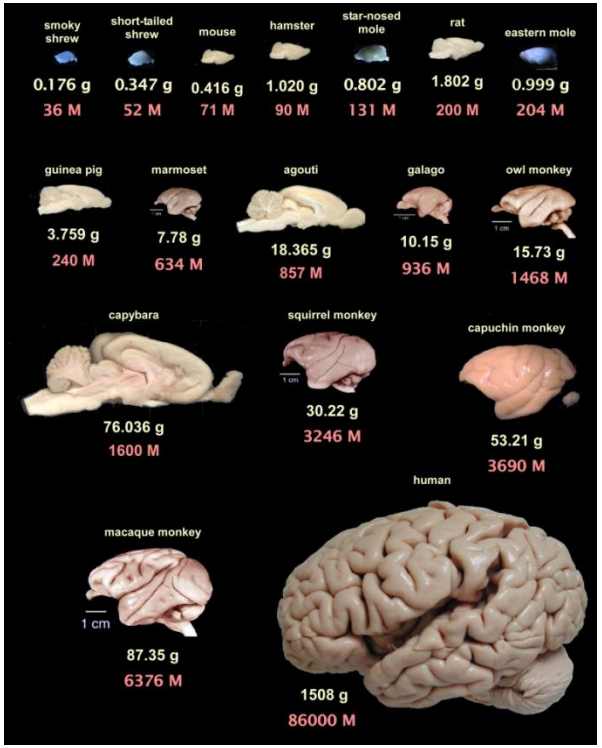
Phenomenal Zombies. Similarly, the subjective qualitative contents of our conscious mental states, the way that things feel and seem to us in our private experiences, seem to be left causally inert from an objective, physicalistic point of view deployed by the sciences, thus prompting us to treat ourselves as phenomenal zombies.

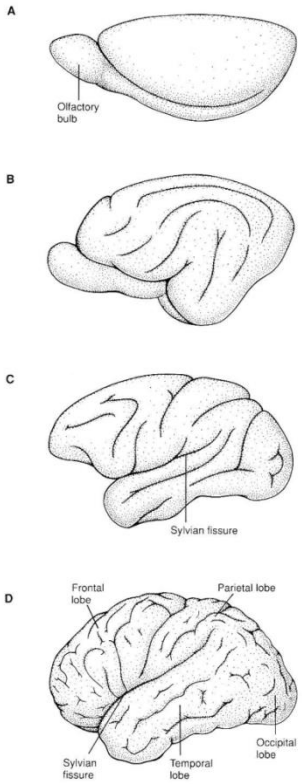
Free Will Zombies. Finally, recent empirical studies on free will have suggested that our conscious decisions do not have a role to play in the initiation of our actions, stripping us of conscious control over our behavior, and making us thus neurobiological zombies, devoid of any true agency and free will. (Pernu:Frontiers Psychol. 2017; 8:1-19, Article 1084)

We are not receptive to physicists trying to apply exotic physics to the brain, about which they seem to know very little, and even less about consciousness. (Crick, F. Nature Neuroscience 2003;2:119-126)

Brain anatomy

Comparative

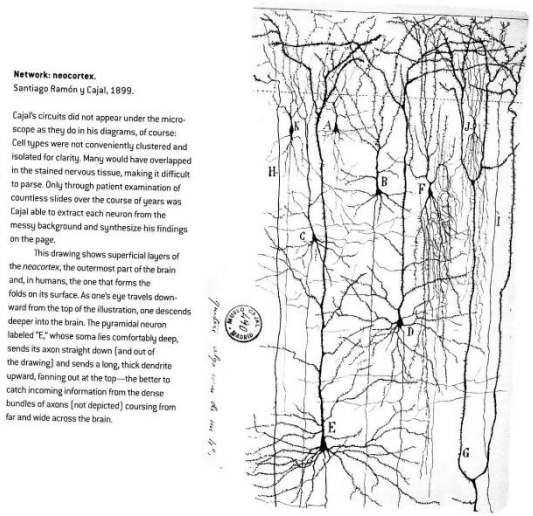




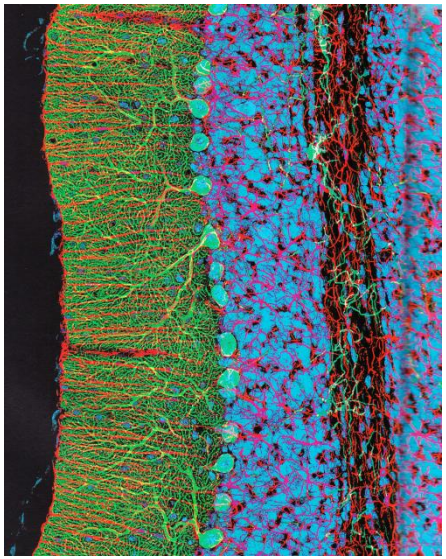
	Neurons in Brain	Neurons in Cerebral Cortex
Caenorabditis elegans	302	
Medicinal leech	10 000	
Anphioxus lanceolatus	20 000	
Fruit fly	250 000	
Honey bee	960 000	
Adult Zebra fish	~10 000 000	
Frog	16 000 000	
House mouse	71 000 000	
Zebra finch	131 000 000	
Guinea pig	240 000 000	
Gray squirrel	453 000 000	
Octopus	500 000 000	
Gray Parrot	1 566 000 000	
Dog	2 253 000 000 -→	530 000 000
Rhesus macaque	6 376 000 000 -→	1 710 000 000
Giraffe	10 750 000 000 -→	1 730 000 000
Chimpanzee	28 000 000 000 →	6 200 000 000
Gorilla	33 400 000 000 →	9 100 000 000
Human	86 000 000 000 →	16 000 000 000
African elephant	257 000 000 000 →	5 600 000 000

(Wikipedia)

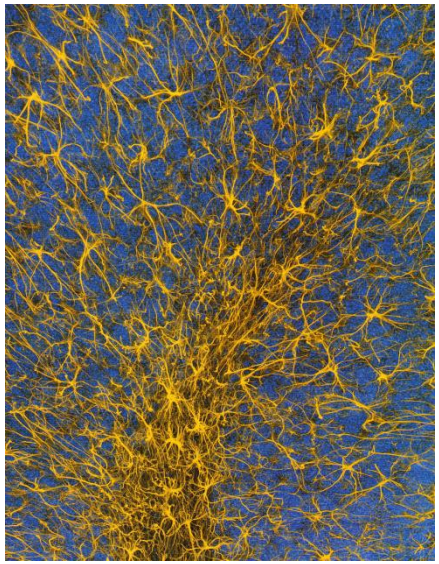
Histology of the Brain



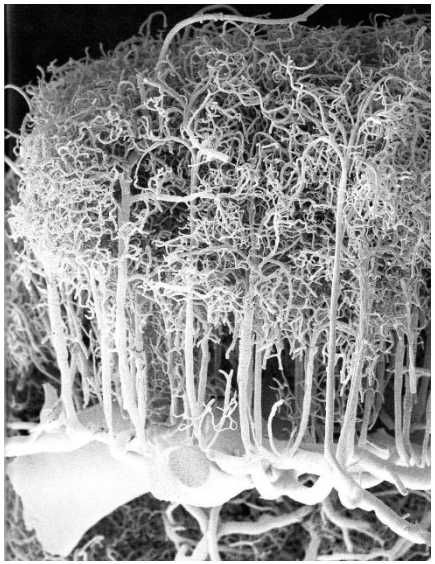
Cerebral cortical neurons, Cajal



Cerebellar cortex

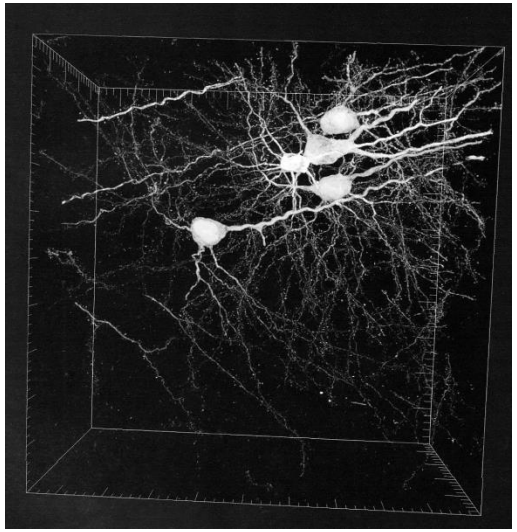


Glial cells in cerebellum

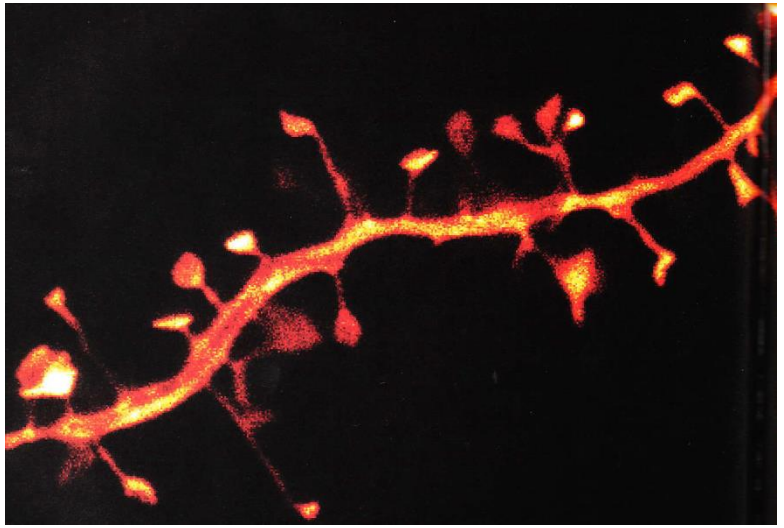


Vasculature in cerebrum

Cerebral cortex

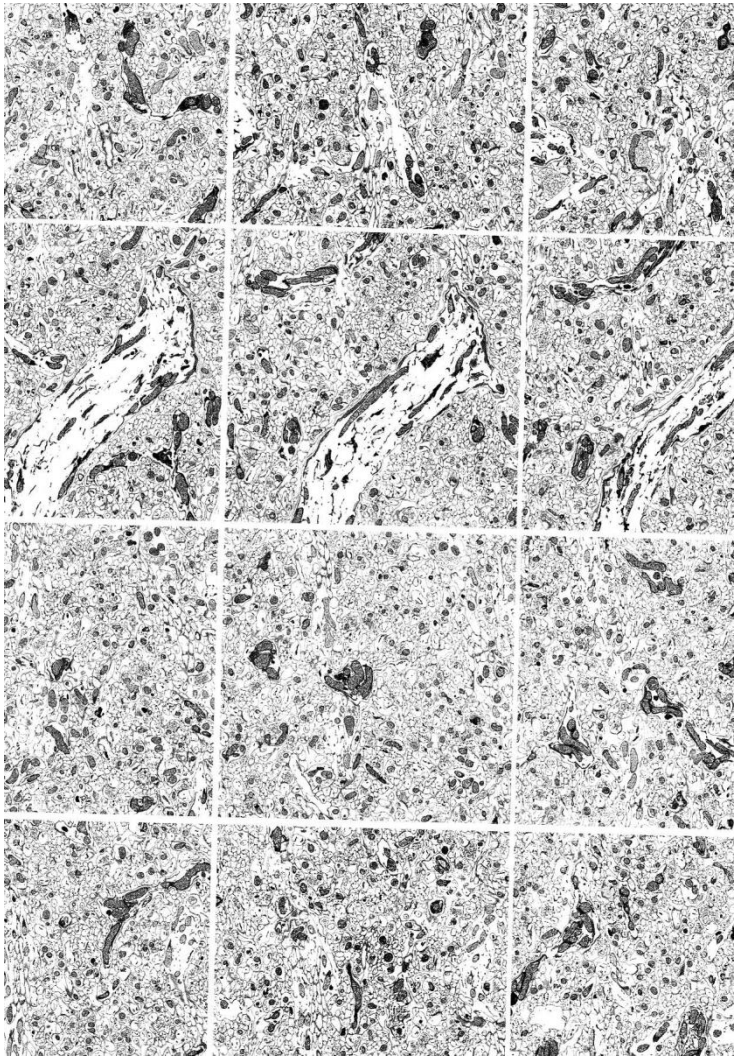


3-D image of cortical neurons

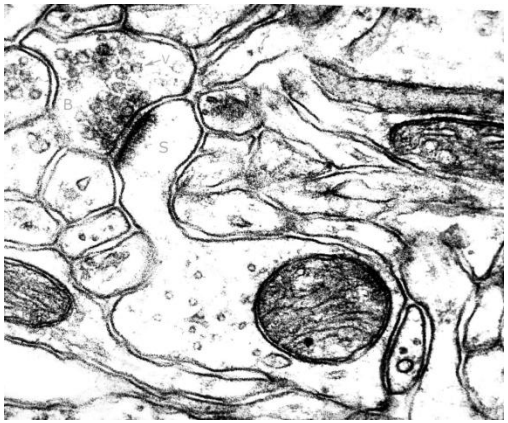


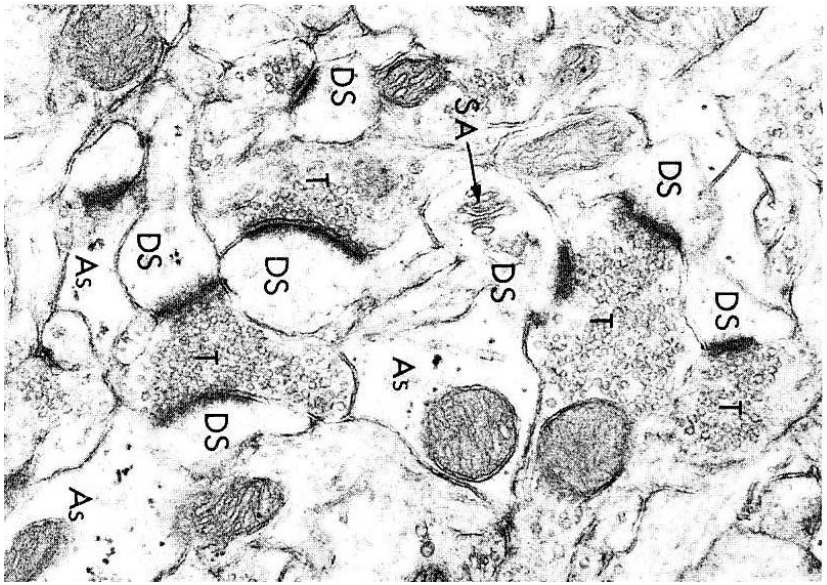
Dendritic spines, confocal microscopic image
(Portraits of the Mind, 2010)

Electron microscopic images of the nervous tissues



Serial images

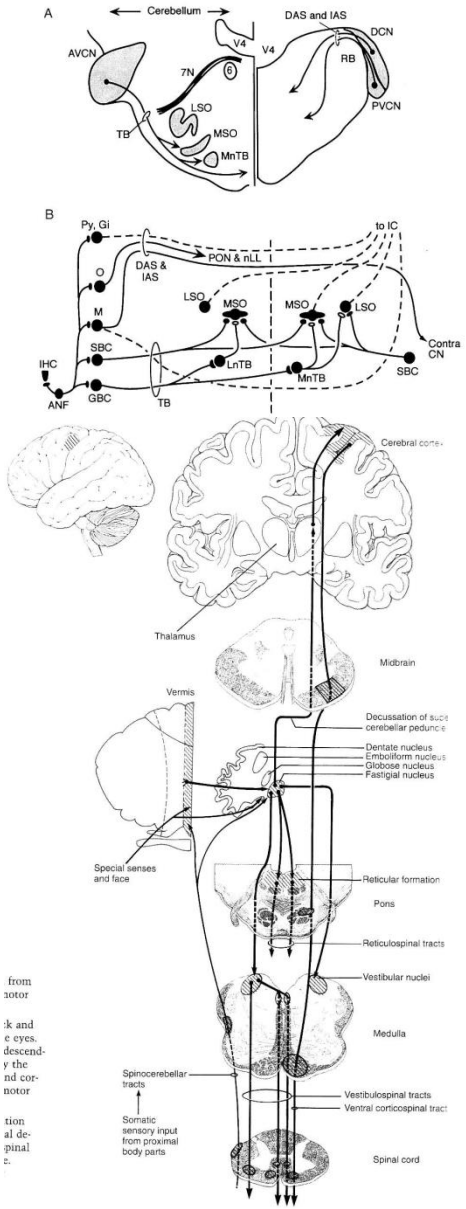




Synapses

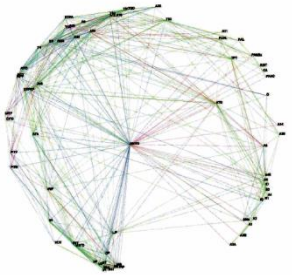
(Portraits of the Mind, 2010)

Brain connection models

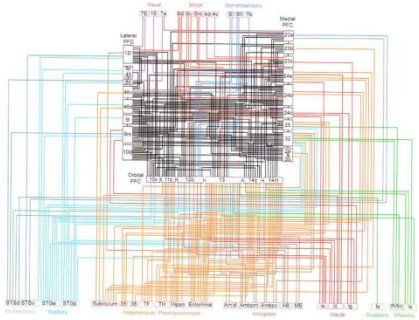


ıronal pathways, diagrams

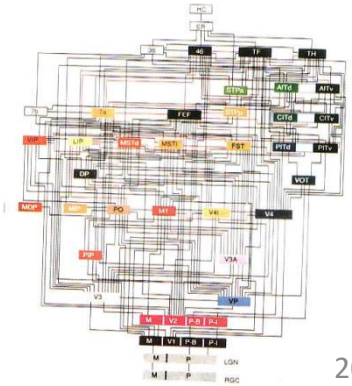
White matter of cerebrum, Tensor image
(Portraits of the Mind, 2010)



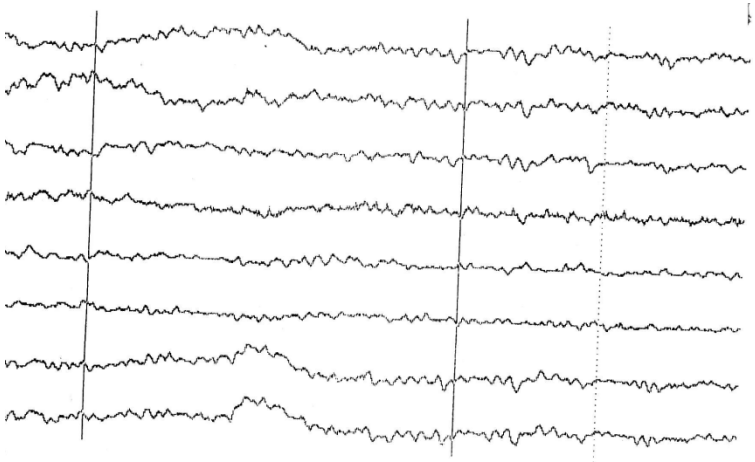
Amygdala connection
Barabási-Albert László:
Science of Networks



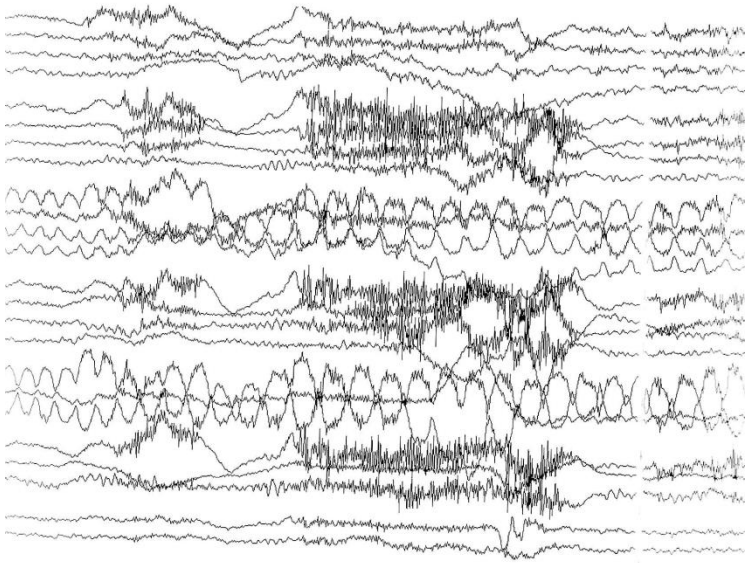
Cerebrum connections



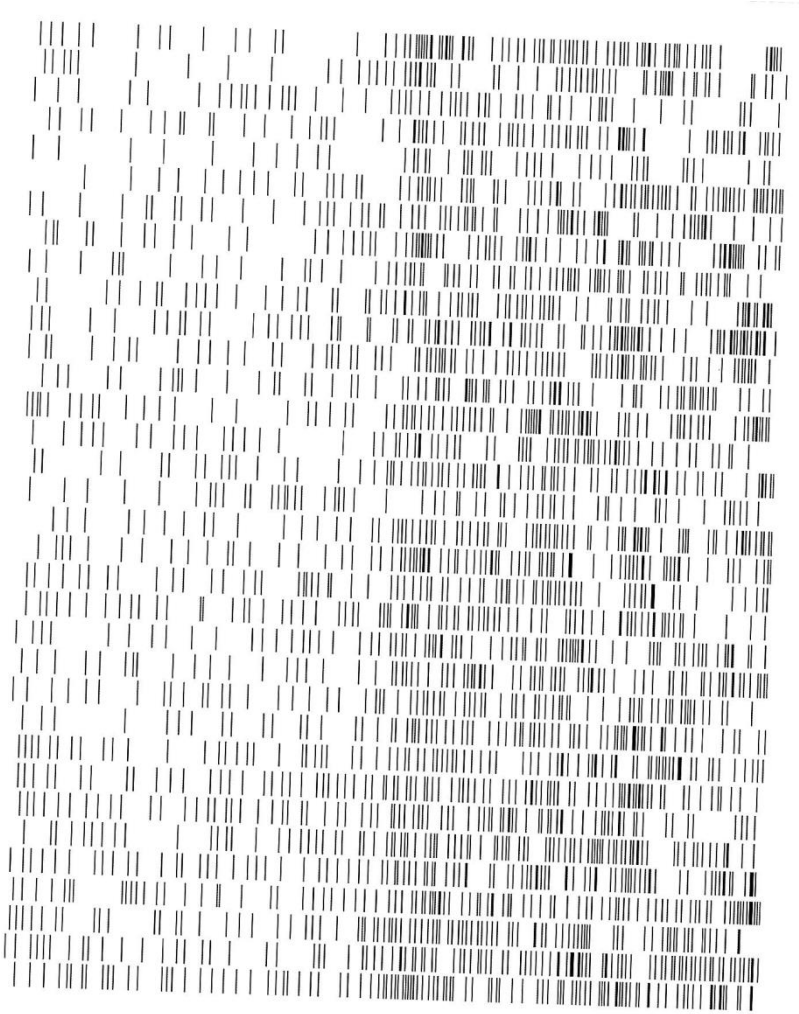
Electrophysiology of the Brain



Normal EEG image



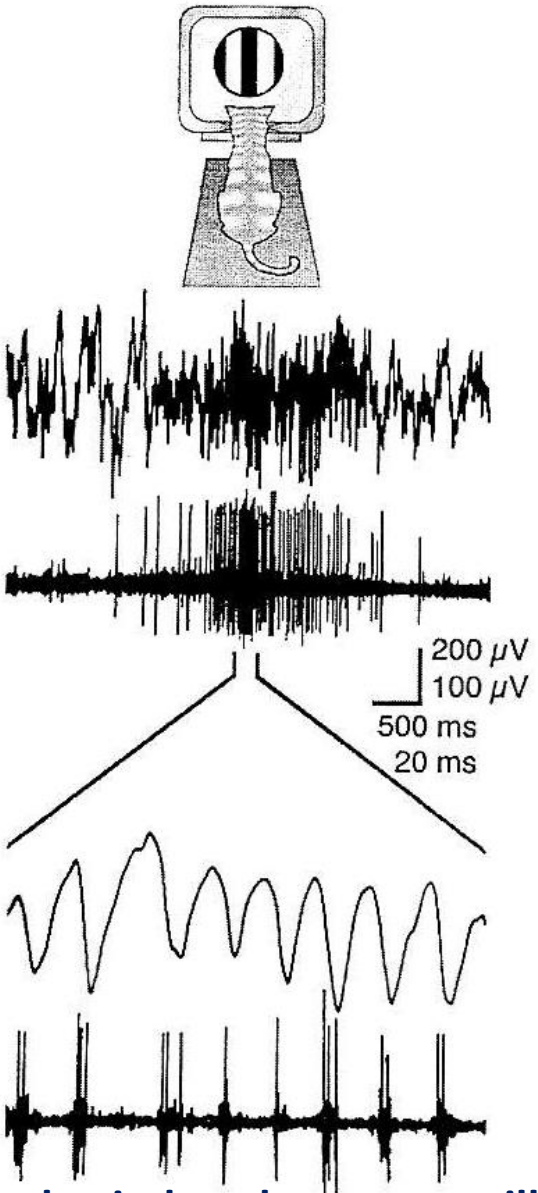
Epileptic seizures image



Multi-electrode recording

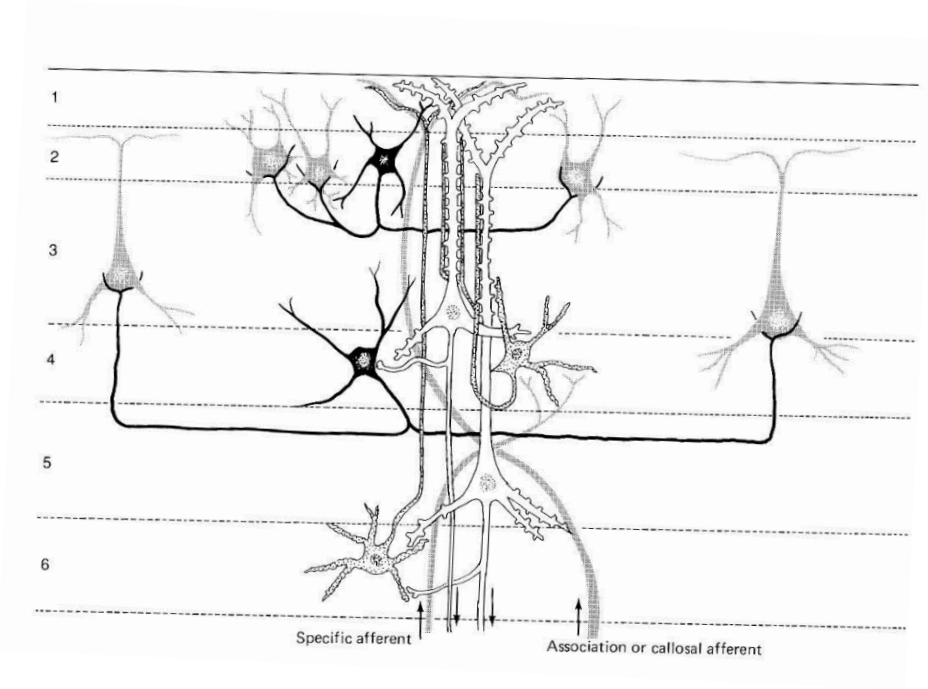
(Portraits of the Mind, 2010)

Encoding of the brain



Stimulus-induced gamma oscillation

(Rhythms of the Bain-Cited by Buzsaki of Gray and Singer, 1989)

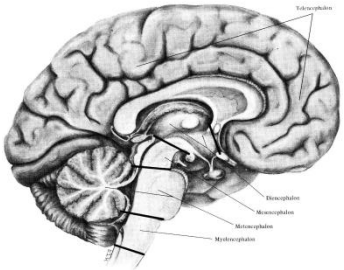


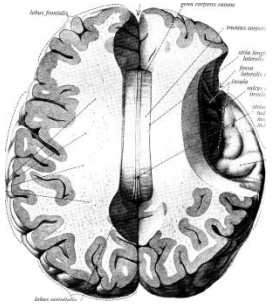
Simplified diagram of the neural connections in the cerebral cortex

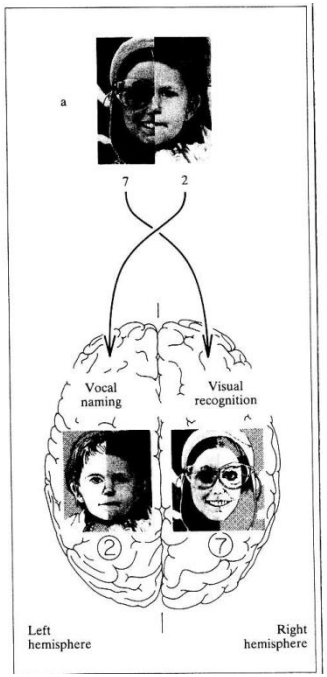
(Principles of Neuroscience, 1998)

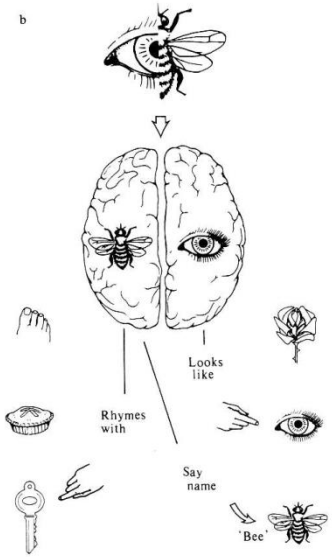
Split Brain Study

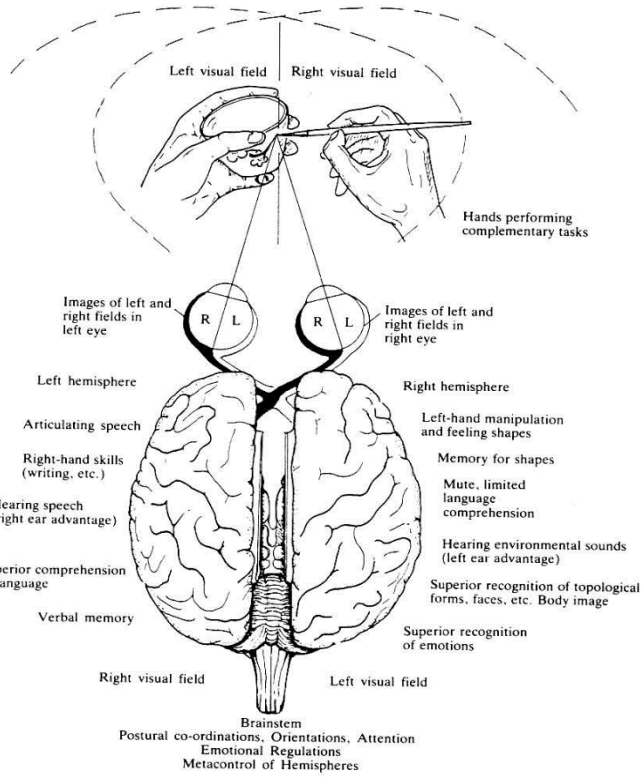
Roger W. Sperry investigated patients with split brain 1960s and published in the 1970s.

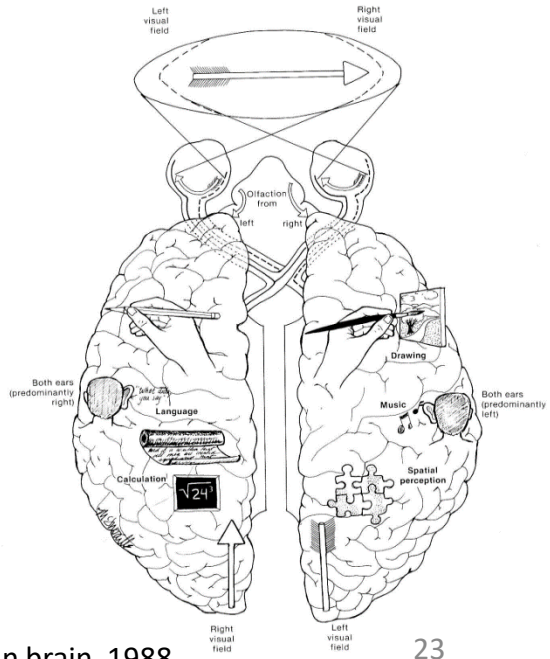












John Nolte: The human brain, 1988

“Three-shell” structure of the Brain

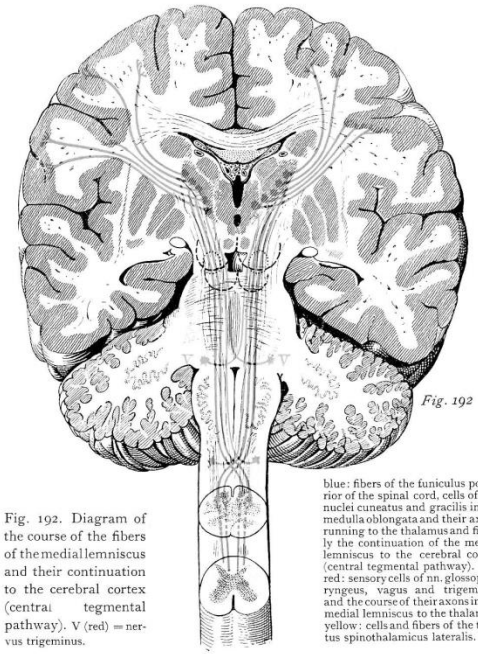
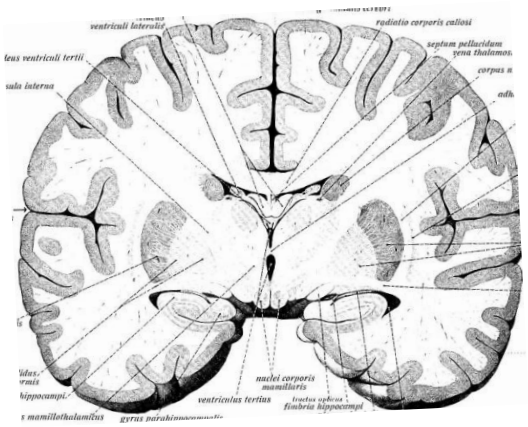
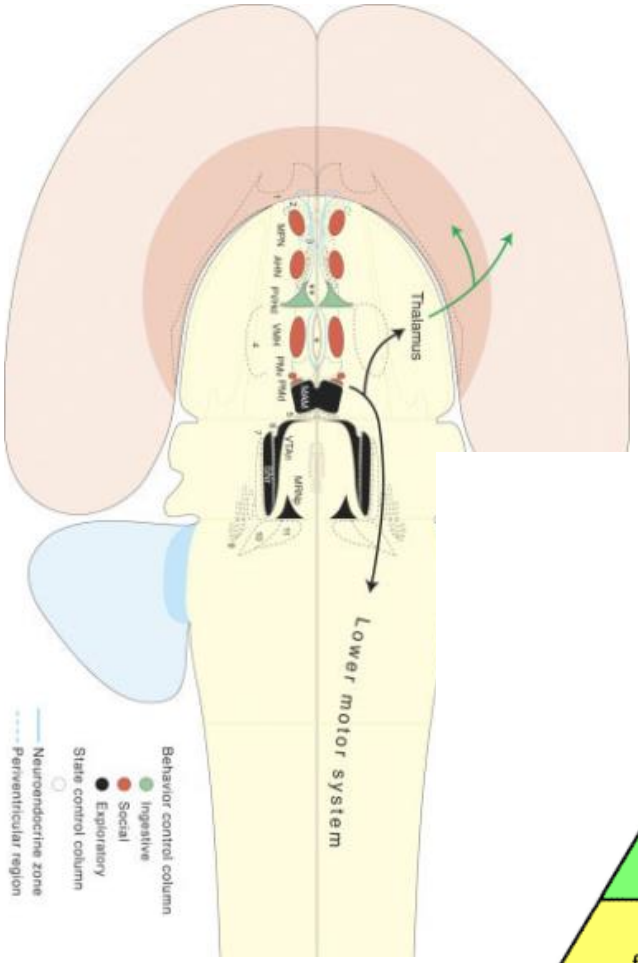


Fig. 192

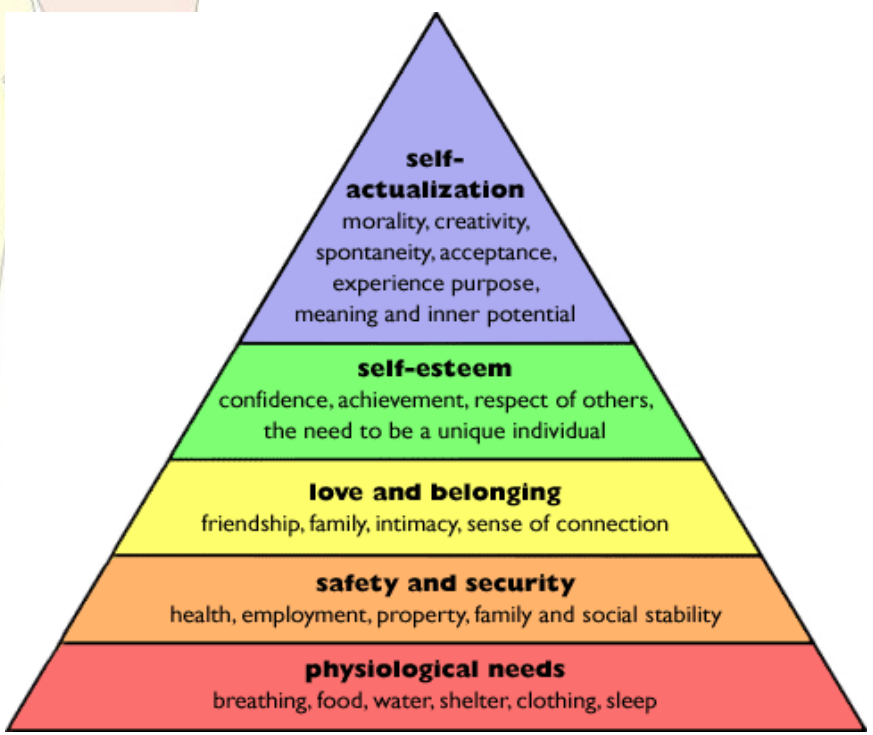
Fig. 192. Diagram of the course of the fibers of the medial lemniscus and their continuation to the cerebral cortex (central tegmental pathway). V (red) = nervus trigeminus.

blue: fibers of the funiculus posterior of the spinal cord, cells of the nuclei cuneatus and gracilis in the medulla oblongata and their axons running to the thalamus and finally the continuation of the medial lemniscus to the cerebral cortex (central tegmental pathway). red: sensory cells of nn. glossopharyngeus, vagus and trigeminus and the course of their axons in the medial lemniscus to the thalamus. yellow: cells and fibers of the tractus spinothalamicus lateralis.





Maslow’s hierarchy



Behavior control

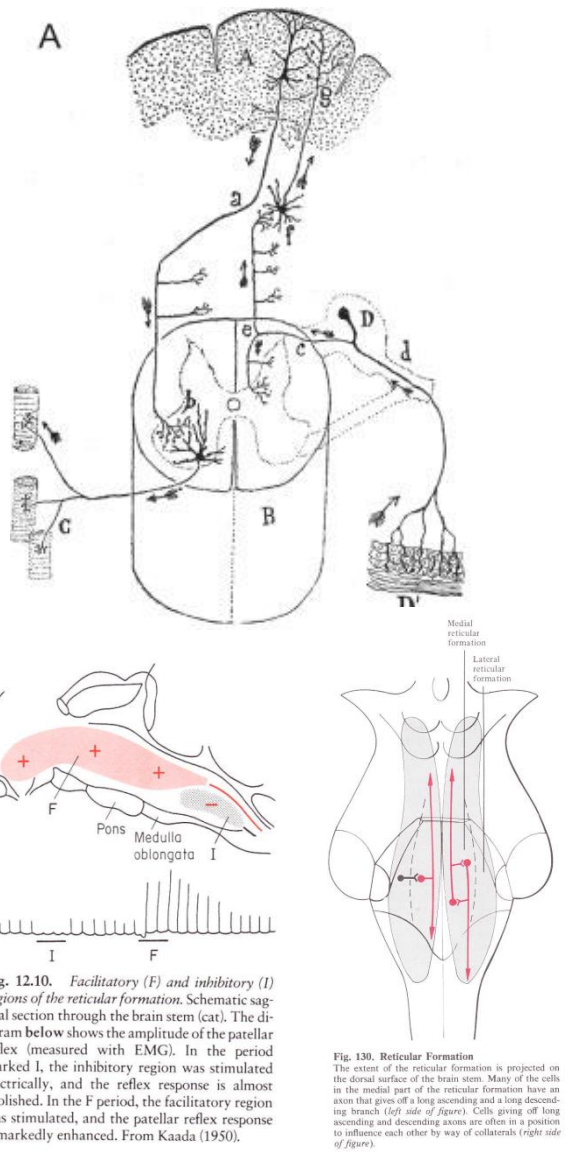
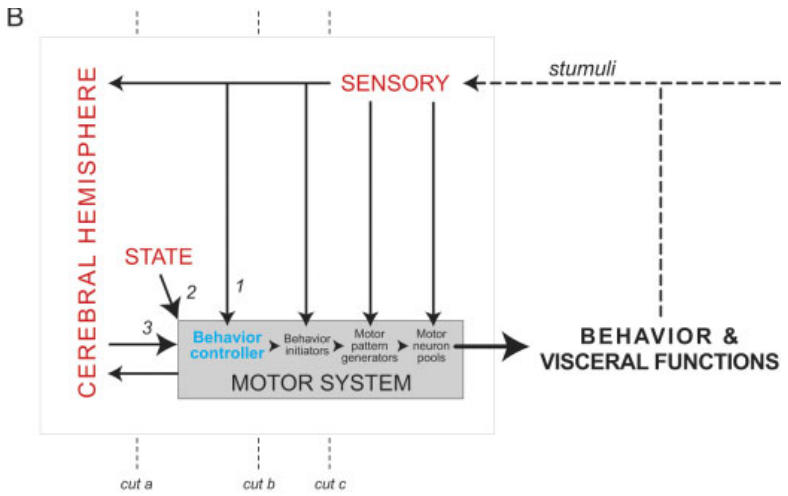


Fig. 12.10. *Facilitatory (F) and inhibitory (I) regions of the reticular formation.* Schematic sagittal section through the brain stem (cat). The diagram **below** shows the amplitude of the patellar reflex (measured with EMG). In the period marked I, the inhibitory region was stimulated electrically, and the reflex response is almost abolished. In the F period, the facilitatory region was stimulated, and the patellar reflex response is markedly enhanced. From Kaada (1950).

Fig. 130. Reticular Formation
The extent of the reticular formation is projected on the dorsal surface of the brain stem. Many of the cells in the medial part of the reticular formation have an axon that gives off a long ascending and a long descending branch (*left side of figure*). Cells giving off long ascending and descending axons are often in a position to influence each other by way of collaterals (*right side of figure*).

Formatio reticularis

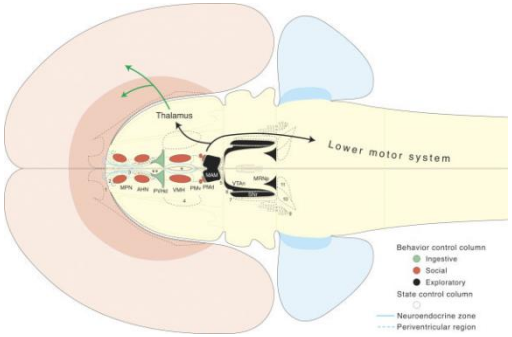
From a broad historical perspective, it could be argued that scientific discussion in antiquity about the soul's nature eventually turned after the Renaissance to the relationship between soul and mind—leaving deep problems that remain today as obscure as ever—the relationship between mind and body, and the possibility that mind survives the body's death. Modern thinking about the mind–body problem in systems neuroscience terms was crystallized just over a century ago by Cajal (1894), who distinguished the reflex branch of incoming sensory information from the branch that proceeds toward cerebral cortex—toward what he called psychomotor or pyramidal neurons, which also profoundly influence motor output or behavior via their descending projections

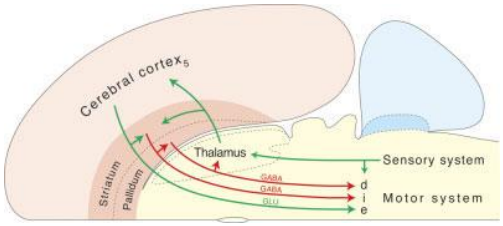


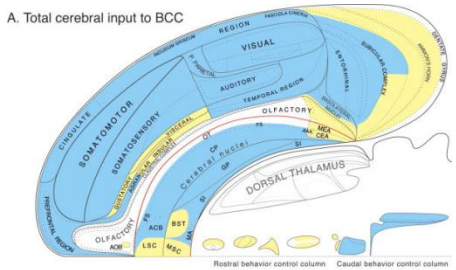
(Swanson, J.Comp.Neurol. 2005;493:122-131)

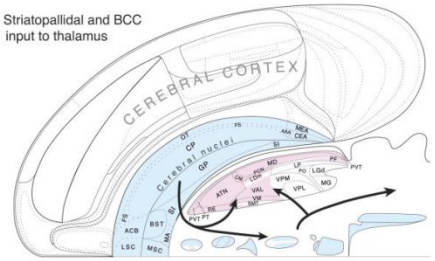
Behavior control column

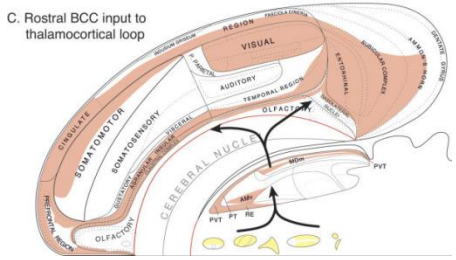
Locomotor pattern generator

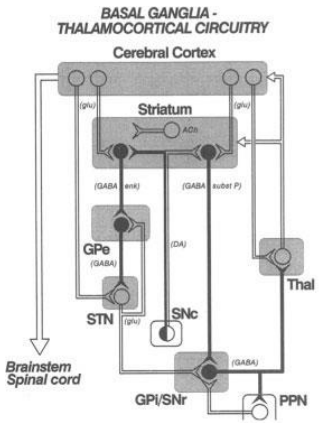




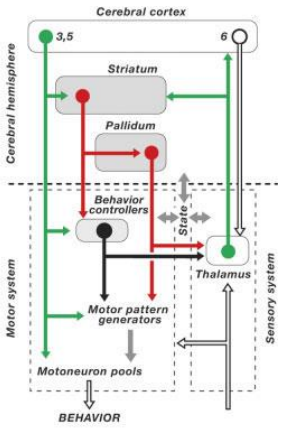








Alexander, Crutcher & DeLong (1990)



Swanson (2000)

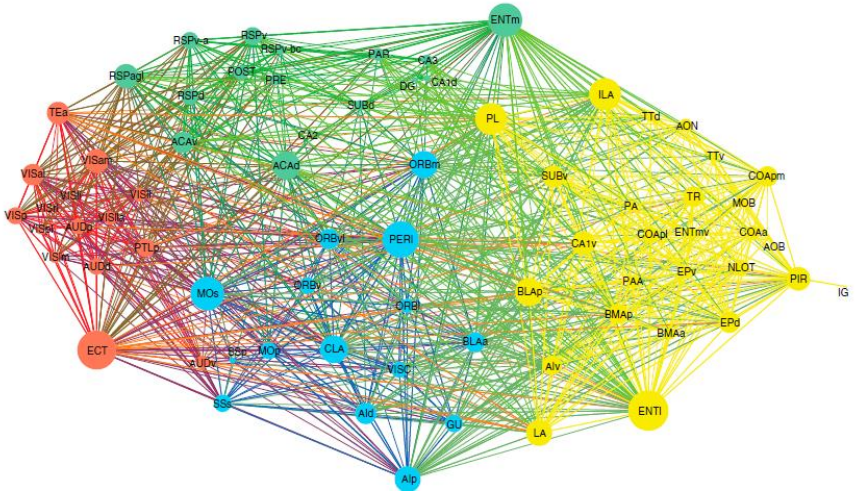
Behavior initiator Midbrain locomotor region

"Who then will deny that the Brayne is the most noble of all the members, seeing it is the seate of all the Animall faculties, Imagination, Reason or discourse & Memory (wherefore Aphrodise(a)us *called it* The Organ of wisdome) *and the beginning or originall of sense and voluntary motion; and beside seeing from it does issue and on it do depend all the instruments of the senses of seeing, hearing, smelling, tasting, touching yea and speech also. And therefore*
Plato did worthily call it, because hee could give it no higher a stile, The divine Member. *For what the Heaven is in the worlde, the same in man is the Braine. The Heaven is the habitation of the supreame* Inteligence, *that is of God; and the Braine is the seate of the* Soule, *that is the* demi-God *of this* Little-world [*the* Microcosm]."—Helkiah Crooke, 1618

There was nothing original about Helkiah Crook's 1618 compendium of human anatomy; he simply borrowed the views of his immediate predecessors. In contrast, the Assessment of Andreas Vesalius—who in his *De humani corporis fabrica* (1543) almost single-handedly founded the modern life sciences with extensive personal observations, descriptive as well as experimental, and a healthy skepticism for authority—still echoes in the final conclusions drawn here, "I can in some degree follow the brain's functions in dissections of living animals [experimental physiology], with sufficient probability and truth, but I am unable to understand how the brain can perform its office of imagining, meditating, thinking, and remembering, or, following various doctrines, however, you may wish to divide or enumerate the powers of the Reigning Soul." (Translated by Singer, 1952).

(Larry L. Swanson, JCN 2005;493:122-131)

Rat cerebral cortex connectome



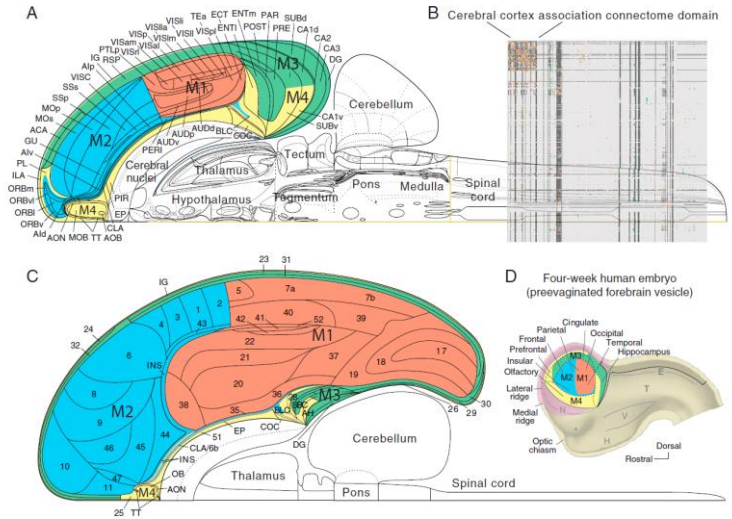


Fig. 4. Spatial distribution of cortical association modules. (*A*) Modules (M1–M4) in Figs. 2 and 3 plotted on a flatmap of right half of rat central nervous system (16); M1, red; M2, blue, M3, green, M4, yellow. See ref. 16 for high-resolution details. (*B*) The cortical association connectome (Fig. 1) shown in the context of the complete rat central nervous system connectome that has just 15% matrix coverage (fill ratio) because most literature outside the cortical association domain is not yet expertly curated (44). Abbreviations are in Fig. S2. (*C*) Histologically defined human cortical regions corresponding to rat cortical regions (correspondence documented in Fig. S2) plotted on a flatmap (45) and color coded as in *A*. AH, Ammon's horn; AON, anterior olfactory nucleus; BLC, basolateral amygdalar complex; CLA/6B, claustrum/layer 6b; COC, cortical amygdalar complex; DG, dentate gyrus; EP, entopeduncular nucleus; INS, insular region; OB, olfactory bulb; TT, tenia tecta; SBC, subicular complex. Numbers correspond to Brodmann's areas (Fig. S2). (*D*) Predicted fate map of major cerebral cortical regions with general location of rat M1–M4 (color coded as in *A* and *C*); illustrated on the right embryonic forebrain vesicle viewed from medial aspect (4-wk human; equivalent to 11-d rat, 9/10-d mouse); adapted from ref. 46. E, epithalamus; H, hypothalamus; N, cerebral nuclei; T, dorsal thalamus; V, ventral thalamus.

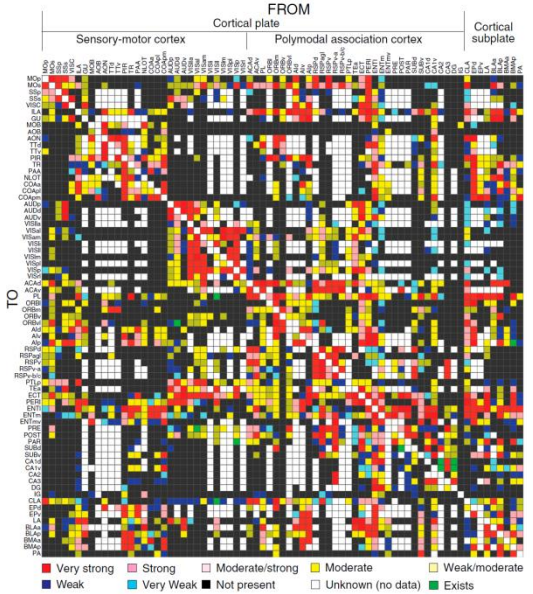


Fig. 1. Rat cortical association connectome. Directed synaptic macroconnection matrix with gray-matter region sequence (top left to right, list of macroconnection origins, from; left side top to bottom, same list of macroconnection terminations, to) in the Swanson-04 (16) structure–function nomenclature hierarchy. The main diagonal (top left to bottom right) is empty because connections within a region are not considered in the analysis. Color scale of connection weight is at bottom; abbreviations are in Fig. S2.

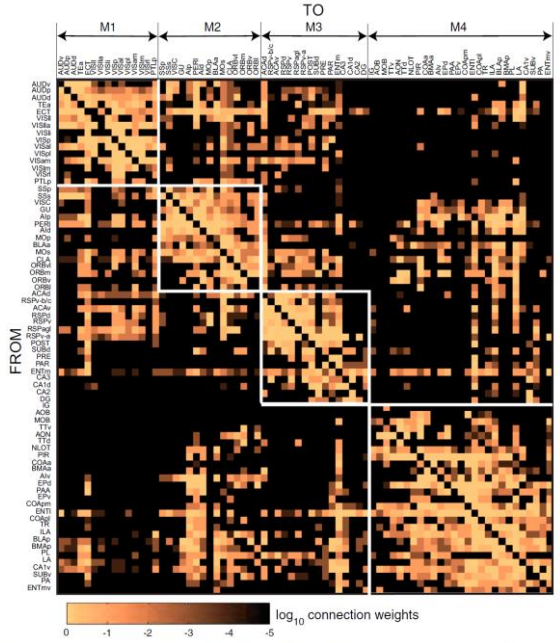


Fig. 2. Four modules of rat cortical association network (M1–M4). Directed synaptic macroconnections are arranged here by connection weight, rather than by nomenclature hierarchy (Fig. 1). The matrix (log-weighted scaled connection weights, bottom) shows four highly interconnected modules (inside white boxes along main diagonal) that together include all 73 regions in the analysis, with intermodular connections shown outside the boxes. "Not present" and "unknown" are black; abbreviations are in Fig. S2.

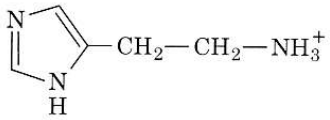
Chemistry of the mind

They play important roles in psychiatric diseases:

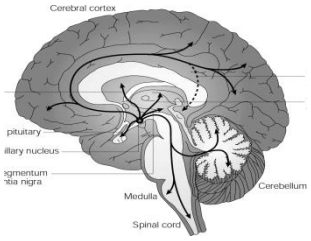
Parkinson's disease

Attention deficit-hyperactivity (ADHA)

Drug addiction



Histamine



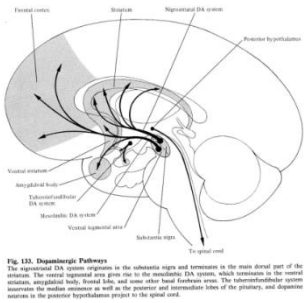


Fig. 133. Dopaminergic Pathways

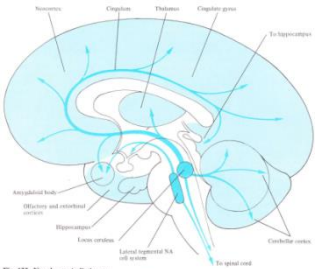


Fig. 132. Noradrenergic Pathways

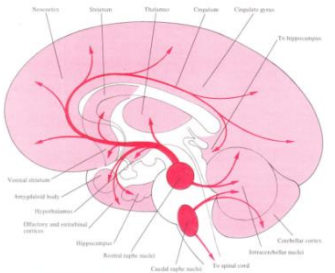
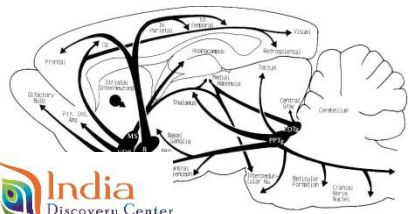


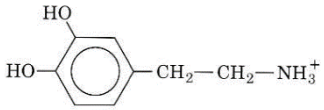
Fig. 131. Serotonergic Pathways



Dopaminergic system (D1-D2 receptors) (Subst. nigra, Ventr.tegm. Tuberoinfundibular syst.)

-improve memory performance

-improve attention



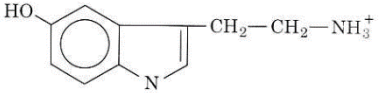
Dopamine

Serotoninergic system controls (Rostral and Caudal Raphé nuclei)

-attention accuracy (dorsal prelimbic, Cg1)

-impulsive behavior (infralimbic, IL)

- perseverative response (latero-orbito-frontal cortex,OFCl)

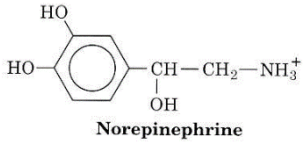


Serotonin
(5-Hydroxytryptamine)

Noradrenergic system (Locus coeruleus, Lat.tegment NA cells) - tonic and phasic effects

-Interaction with the ascending cholinergic and

- noradrenergic system, sustained attention occurs

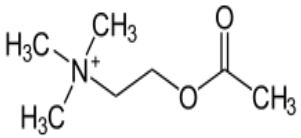


Norepinephrine

Cholinergic system (Basal nucl. Meynert, Diag. band Broca, septum, (Pedunculopontin tegment (Laterodorsal tegmentel n. (Subs.innom., Ventral pall)

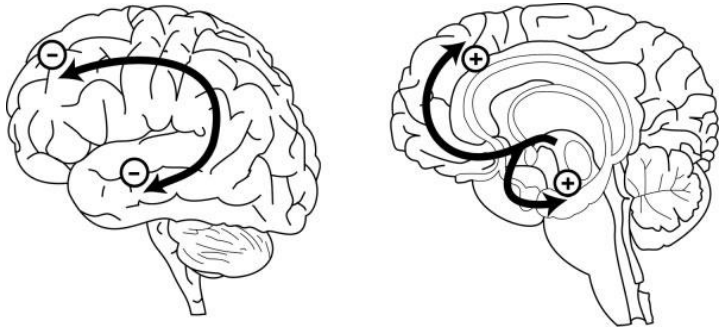
- play a role in arousal, motivation,
- sensory process
- learning, cognition,
- emotion

Acetylcholine

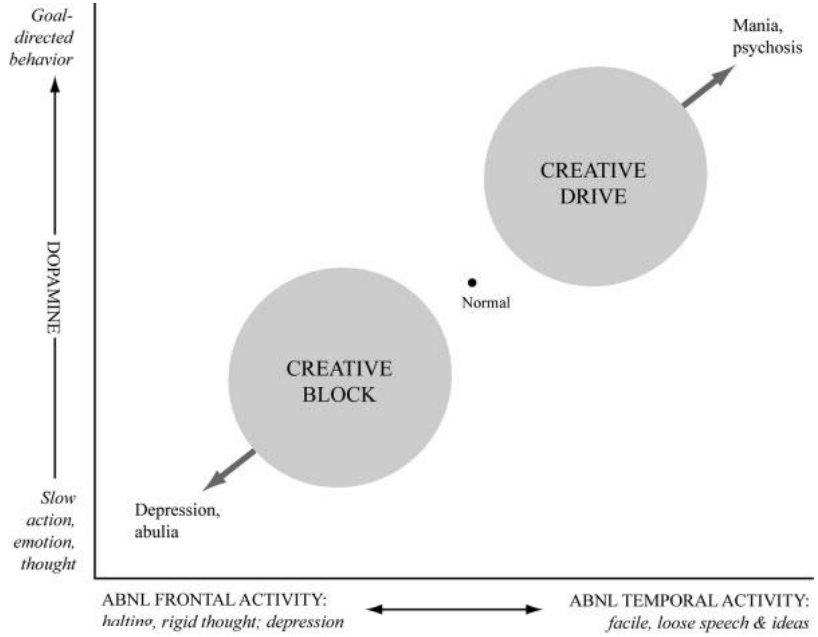


Robbins,J.Comp.Neurol. 2005;493:140-146)

Creativity



Cortico-cortical and mesolimbic dopaminergic projections



"All human accomplishment has this same origin, identically, imagination is a force of nature."

(Saul Bellow, Henderson the rain king)

"Creative idea will be defined simply as one that is both novel and useful (or influential) in a particular social settings."

(Perkins 1988, Csikszentmihalyi, 1999)

Temporal lobe and idea generation

-Hypergraphia- right hemispheric lesion

-Hypergraphia with mania – increase activation on the right anteriror temporal

-Frontotemporal dementia – compulsive artistic /musical interest

-Bipolar disorder with creativity – left or bilateral amygda la enlargement

Limbic system dopaminergic module

- Dopamine decreases latent inhibition
- Dopamine mediates reward-seeking activity

Frontal lobe function

- Hypofunction causes depression, cognitive flexibility declines
- Writer's block – lesion In the Broca's area
- Anxiety- performance anxiety- high arousal level
- Writer's cramp – sensorimotor-premotor cortex lower activity
- Amotivational, abulic states decr. creative drive- medial prefrontal
- Working memory, flexible problem-solving – dorsolateral prefrontal
- Performance, skill – motor, premotor area

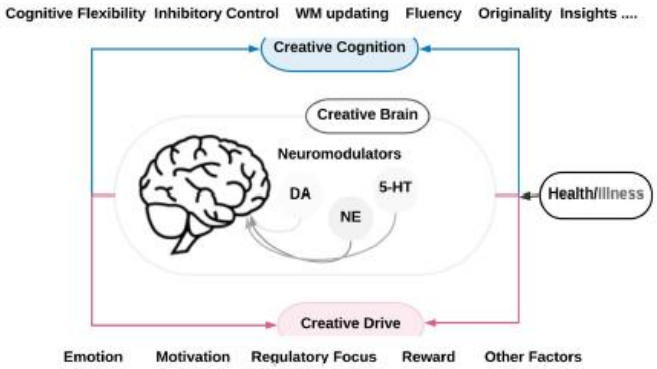
Alice W. Flaherty, J.Comp.Neurol. 2005;493:147-153

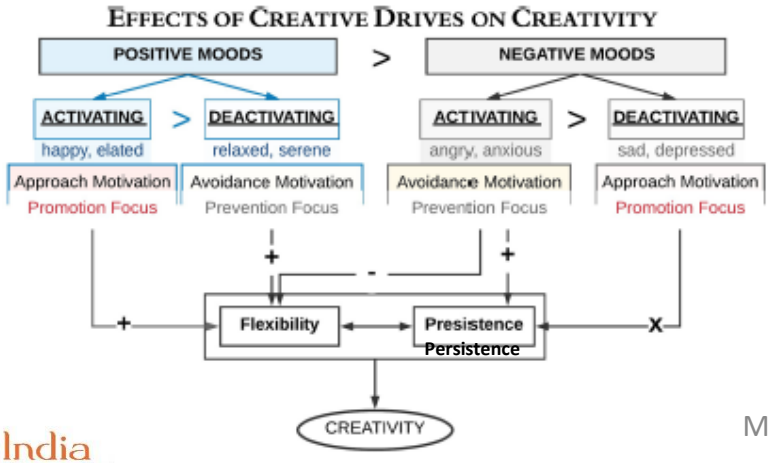
Creativity-2

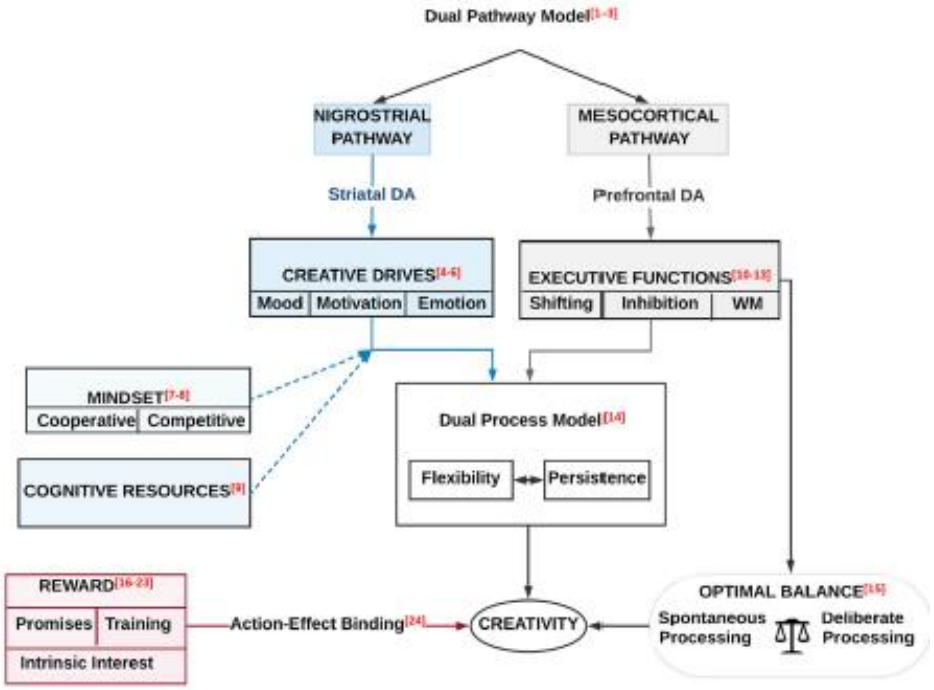
Having a creative mind is one of the gateways for achieving fabulous success and remarkable progress in professional, personal and social life.

Creativity is an essential psychological and cognitive process. (Csikszentmihalyi, 1999)

Creative cognition
Creative drive—motivation, mood states, reward







(Radwa Khalil et al. Frontiers Neurol.Circ. 2019;13:1-16; Article 18)

Creativity-3

It reflects the representation of conceptual content in the absence of external input.

Mental Imagery (perceptual/motor)	Intentionality (recollective)	Novel Combinatorial (generative)	Phenomenology (emotion)
Visual Imagery Mental Rotation Auditory Imagery Musical Imagery Motor Imagery ...	Mental State Reasoning/Theory of Mind Moral Decision Making Mental Time Travel/ Future Thinking Autobiographical/ Episodic Memory ...	Creativity Hypothetical Reasoning Counterfactual Thinking Hypothesis Generation ...	Aesthetic Engagement Visual Art-related Aesthetic Response Music-related Aesthetic Response ...

Altered States:
Dreams, Hypnosis, Meditative States, Hallucinations, Out of Body Experiences, Delusions ...

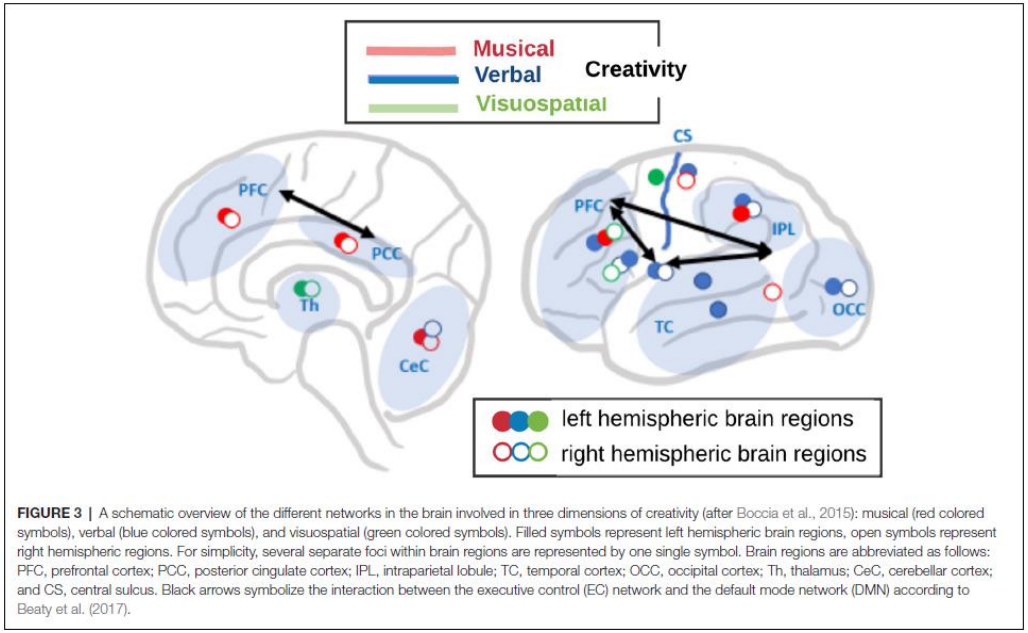


FIGURE 3 | A schematic overview of the different networks in the brain involved in three dimensions of creativity (after Boccia et al., 2015): musical (red colored symbols), verbal (blue colored symbols), and visuospatial (green colored symbols). Filled symbols represent left hemispheric brain regions, open symbols represent right hemispheric regions. For simplicity, several separate foci within brain regions are represented by one single symbol. Brain regions are abbreviated as follows: PFC, prefrontal cortex; PCC, posterior cingulate cortex; IPL, intraparietal lobule; TC, temporal cortex; OCC, occipital cortex; Th, thalamus; CeC, cerebellar cortex; and CS, central sulcus. Black arrows symbolize the interaction between the executive control (EC) network and the default mode network (DMN) according to Beaty et al. (2017).

Five-part of classification
Of the human imagination
-spontaneous
- stimulus-independent
- imaginative

Is the S-O-R route relevant?

Default-Mode-Network (DMN)

1. Musical creativity expressed activation in a bilateral network consisting of the bilateral medial frontal gyrus (MeFG) and posterior cingulate cortex (PCC), left middle frontal gyrus (MFG) and inferior parietal lobule (IPL), and the right postcentral gyrus (PoCG) and fusiform gyrus (FG), as well as bilaterally the cerebellum.
2. The network for verbal creativity was left-hemispheric dominated and comprised of several activation foci in the left MFG, inferior parietal lobule (IPL), SMG, occipital gyrus (MOG), and middle and superior temporal gyrus (MTG and STG), and the bilateral inferior frontal gyrus (IFG) and insula, and the right lingual gyrus (LG) and cerebellum.
3. Visuospatial creativity relied on a slightly right-hemispheric dominated network including activation foci in the right MFG and IFG, the left precentral gyrus (PrCG), and the bilateral thalamus.

(Radwa Khalil et al. Frontiers Neurol.Circ. 2019;13:1-16; Article 18)

Intentionality

Franz Clemens Brentano (1838-1917) German philosopher wrote 1874:
"All and only mental phenomena are intentional, no physical phenomenon exhibits intentionality."

''Intentionality is the directed property of certain mental states, as described previously; intentions are the causal antecedents of actions and, as such, are only one type of Intentional mental state'' (Chapman, Psychological Inquiry 1990;1:251

Traditionally intentionality is regarded as that feature of all and only mental states – paradigmatically beliefs and desires – in virtue of which they are directed at or are about something.
Intentionality as a feature of whole embodied agents (paradigmatically organisms)who can be directed at objects and states of affairs in various ways, while representation should be regarded as a feature of mental states (and their respective vehicles or underlying mechanisms).

(Tobias Schlicht, Frontiers of Psychol. 2018;9:1-14)

Cognitionism

Sensory inputs ---→cognition -→motor outputs ("sandwiched model")

Enactive and embodied approach: Cognition as primary or bodily activity of a whole organism (or more generally, embodied agent) that can be explained without appeal to mental representation. How one can consolidate/naturalize the concept that intentionality involving mental representation?

-**radical enactivist** → basic cognitive capacity – intentionally directed w/o representational or content-involving

-mental representation- cognition

- **predictive processing** →claims the unifying model of perception, cognition and action

The Brain is a "prediction machine" constantly testing hypotheses about the incoming sensory stimulation based on hierarchical generative model.

Intentionality-2

Equivalence thesis ET) ←-→ Separation thesis (ST)

Intentionality and mental representation is equivalent and coextensive or separate

Phenomenal representation

"We can separate the issue of consciously experienced intentionality from the more general problems of how something like representational content could evolve in the minds of human beings and other animals at all." (Metzinger 2003)

The homeostatic basis of phenomenal subjectivity

Self-organization-"feel itself as itself"

All intentionality involves a self-other distinction, since understood as directedness it implies that something reaches beyond itself, transcends itself.

Autopoesis and Nano-Intentionality

Intentionality is conceived as a basic feature of an organism's embodied interactions with the environment, not as a feature of mental states.

(Kant-the part and the whole relation!)

Intentionality and mind-wandering

Intentional mind wandering

Non-intentional mind wandering

Meta-awareness

Morality-Intentionality- Group and Intergroup attitudes

Intentionality-3

The theories or models of the physical sciences, including neuroscience, are all consistent with the principle of causality. Their explanation is value-neutral, that is a What-Is model.

Dennett calls the brain a syntactic (procedure-based) engine, so that you cannot get to a semantic (meaning-based) engine, which is the mind, from brain.

The principle of intentionality is that it opens up the door to value, this could lead a What-Matters models.

Brentano, 1874, proposed that an intentional relation is an "aboutness" relation between a meaning and whatever it is about (whatever it points at). The model is: **"I intend it"** an **"I-it"** (subject-object relation that is mediated by the mental meaning by which the subject points at (characterizes and values) the object.

Denettian model (1987): People are rational agents who choose in conformance to their beliefs and desires. So, they know what ought to do to carry out a rational behavior.

He distinguishes the brain as a "syntactic engine" (a kind of organic computer) from the mind as a "semantic engine", operating more by meanings (and purposes) and their complex interconnections than by automatic procedures.

"All actions are emotional and at the same time they have their reasons and explanations. This the nature of intentional behavior." (Freemann, 2000) (Charles Turner, 2017)

Intentionality-4

How and what is needed to these actions and behaviors that they are going to be appropriate, good, correct?

Wisdom: is **a measure of the practical understanding and rationality of intentional being**
(or believing what you ought to believe and what you ought to want).
is an **objective standard for the reality, rationality**
is a **measure of conformity of a subject's beliefs**

Intentionality has a practical function in life just because some intentions are objectively more adequate (wiser, more rational, and more adaptive) than others.

When the intended or executed actions are or going wrong?

1. Ignorance

Deficit in a subject's baseline wisdom when compared to objective wisdom

a. lack of knowledge
b. misunderstanding of actual interests
c. defective reasoning processes

2. Foolishness --→ **deficit in a subject's temporary distorted wisdom when compared to the baseline wisdom.**

Morality--- Intra-, inter-group attitude, social interaction

Intentionality-5

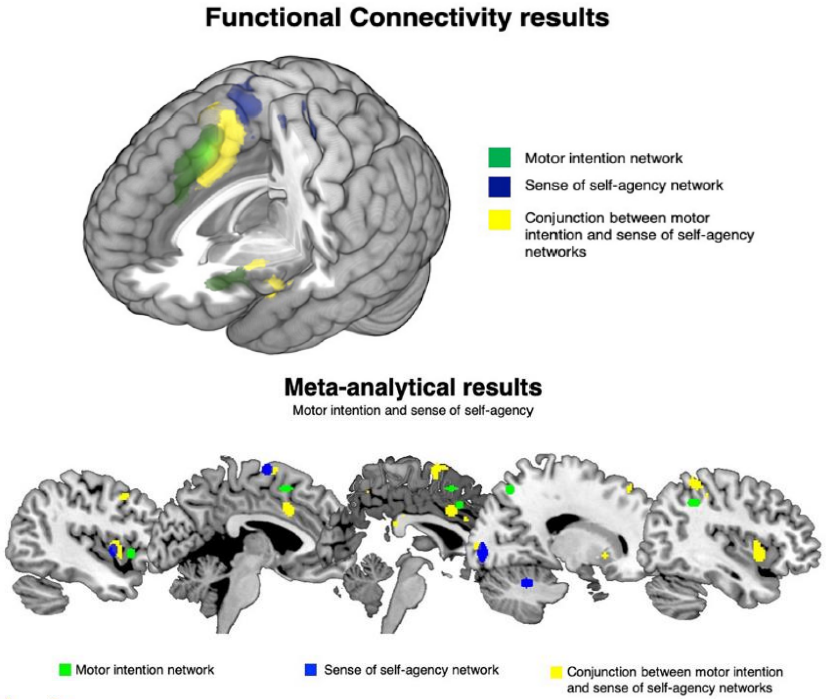
Intentionality which controls the voluntary actions has two phenomena:

- the emergence of intentions
- the ensuing motor plans and actions

There are two networks underlying the processes:

1. **"intentionality network":** involving – the rostral area of the mesial frontal cortex (middle cingulum and pre-supplementary motor area)
– the anterior insula

2. **"self-agency network":** involving -- the posterior area of the mesial frontal cortex (the SMA)
the posterior insula
the occipital lobe
the cerebellum



Theory of apparent mental causation;

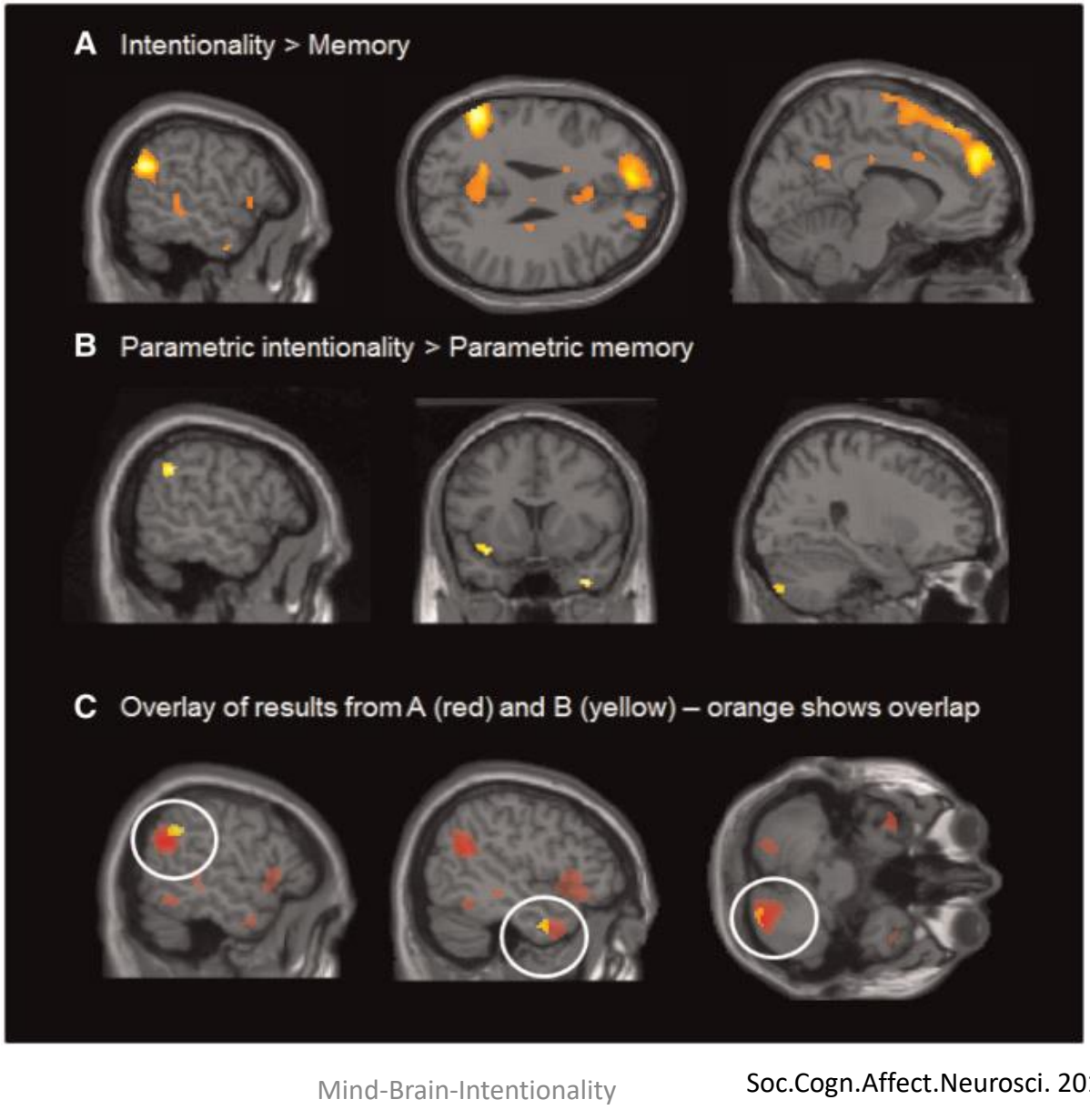
priority-thought conscious before action
consistency- thought consistent with action
exclusively – only the person involved

Comparator model

inverse model –compute motor commands
forward model –represents the causal flow
prediction, adjustment

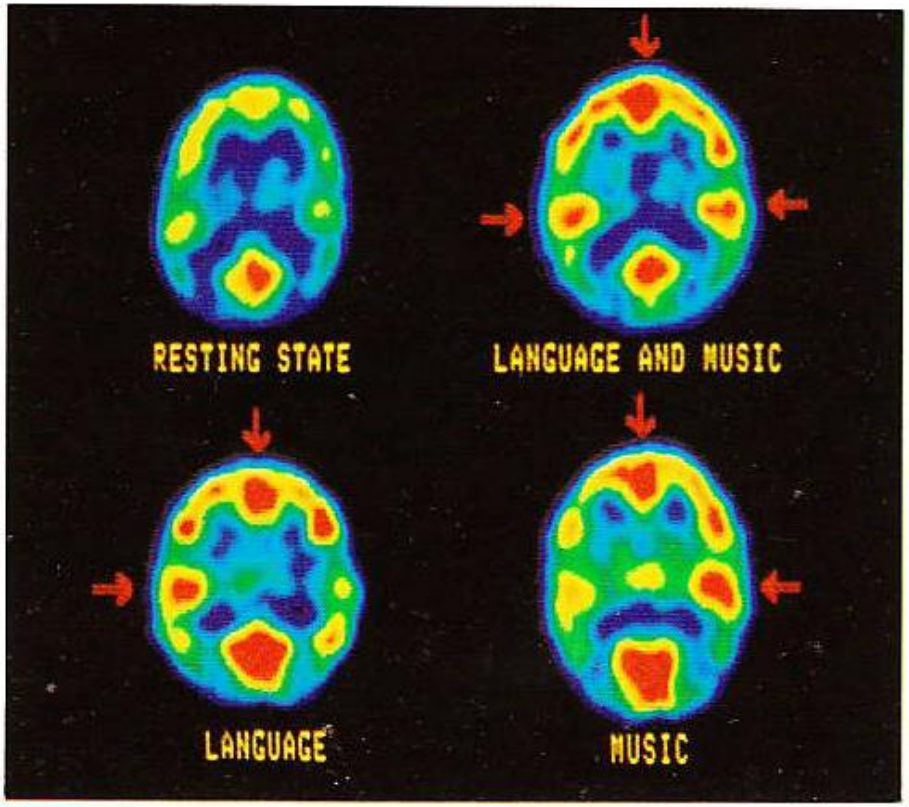
(Frontiers Psychol. 2019;10:1-14; article 804)

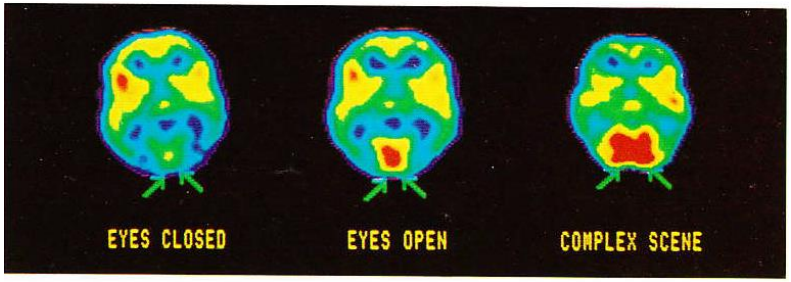
Intentionality – Memory shown in fMRI images

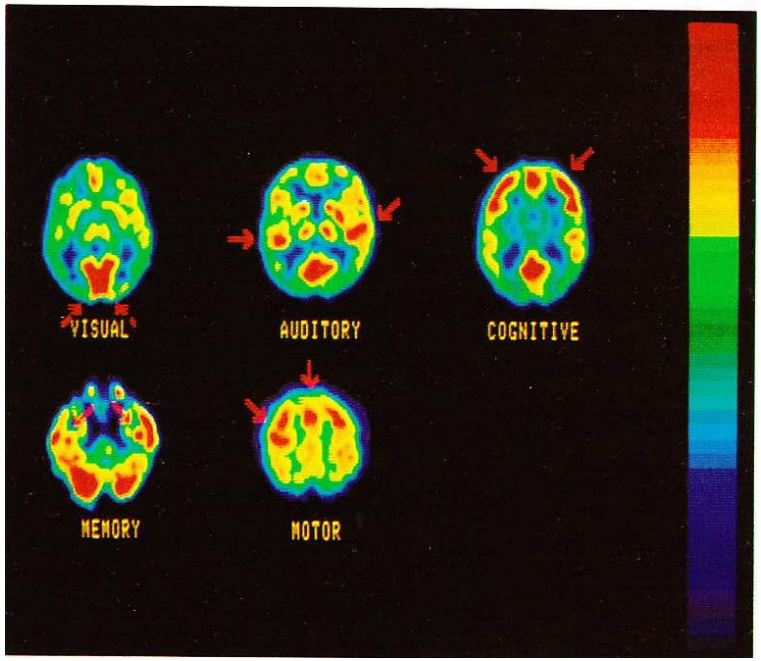


Soc.Cogn.Affect.Neurosci. 2017; 12(7): 1063-1071)

Brain activities shown in PET images



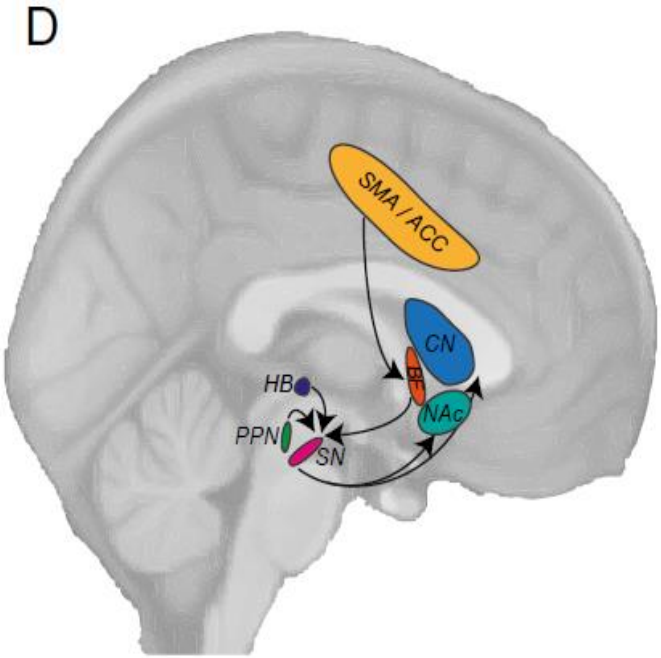


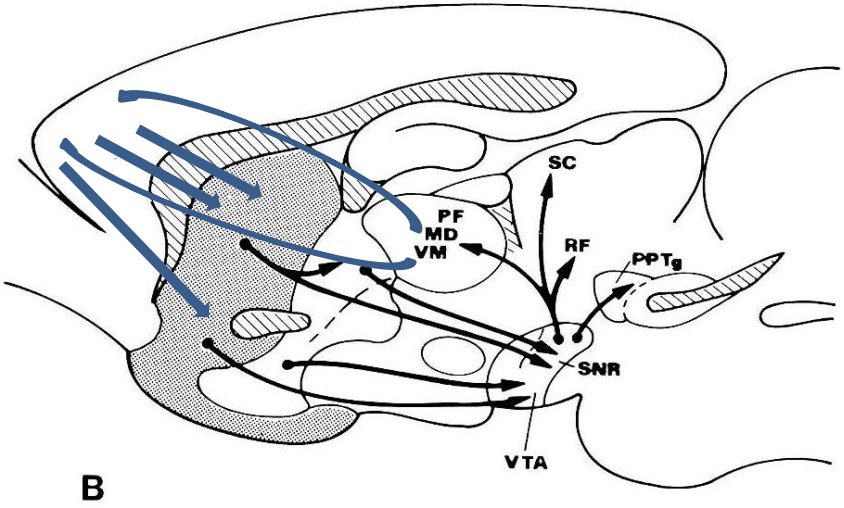


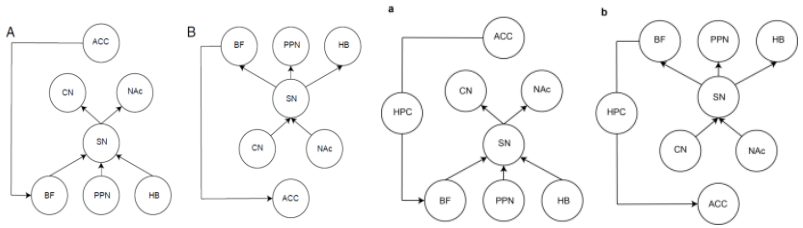
John Nolte: The human Brain, 1988

Decision making

Decisions about when to act are critical for survival in humans as in animals. Anterior cingulate cortex within medial frontal cortex, a group of subcortical structures including striatum, substantia nigra, basal forebrain (BF), pedunculo-pontine nucleus (PPN), and habenula (HB) encode trial-by-trial variation in action time. BF integrates contextual information that will influence the decision about when to act and communicates this information, in parallel with PPN and HB influences, to nigrostriatal circuits. It is then in the nigrostriatal circuit that action initiation per se begins.







Ventromedial thalamic nuclei (VM) axons make synaptic contacts on the pyramidal cells' dendrites and interneurons in layer I in the prefrontal (prelimbic) cortex of the rat. The pyramidal neurons are residing in the cortical layers II-III&V which are mostly project to the striatum. These cortico-striatal neurons in the prelimbic cortex seem to play role in the cost-benefit-decision making in rats.

Brain Structure and Function 2020; 1-20

PNAS, 2020:117(21):11799-11810

"As with any tool in science, fMRI and complementary imaging techniques such as PET, EEG, and optical imaging are subject to limitations. Some of the hardest questions - How do neurons transform energy packets captured from the environment into conscious experience? – Still remain far out of our reach."

(Joy Hirsh, 2010)

Thank you for your attention!