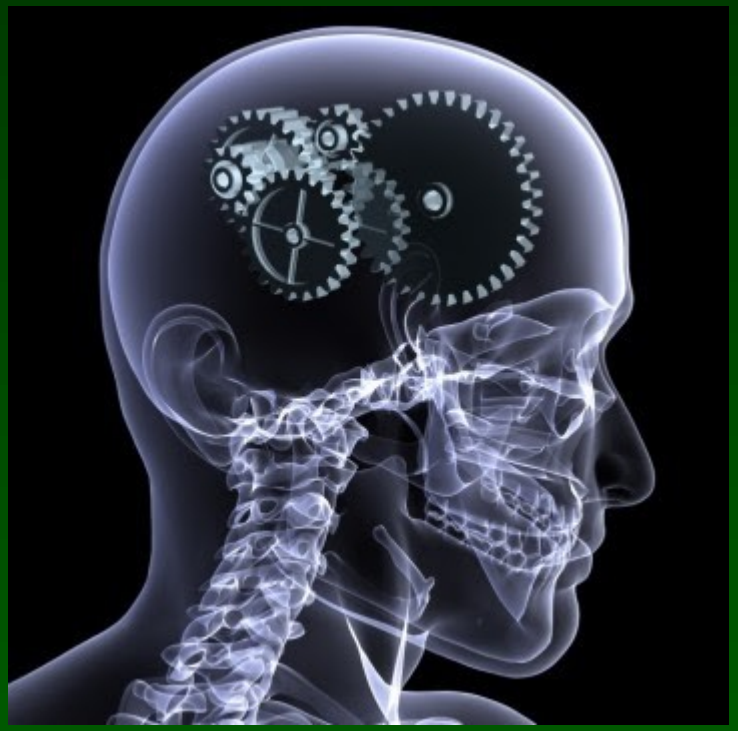
Selected topics in cognitive science and biomodeling



L6: Information flow in the brain

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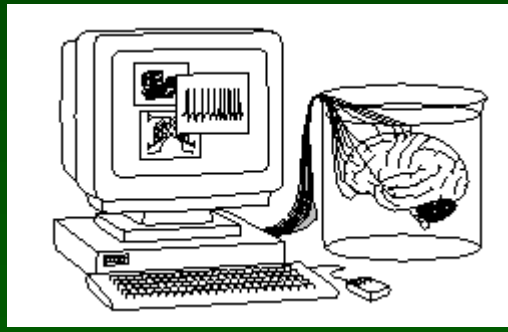
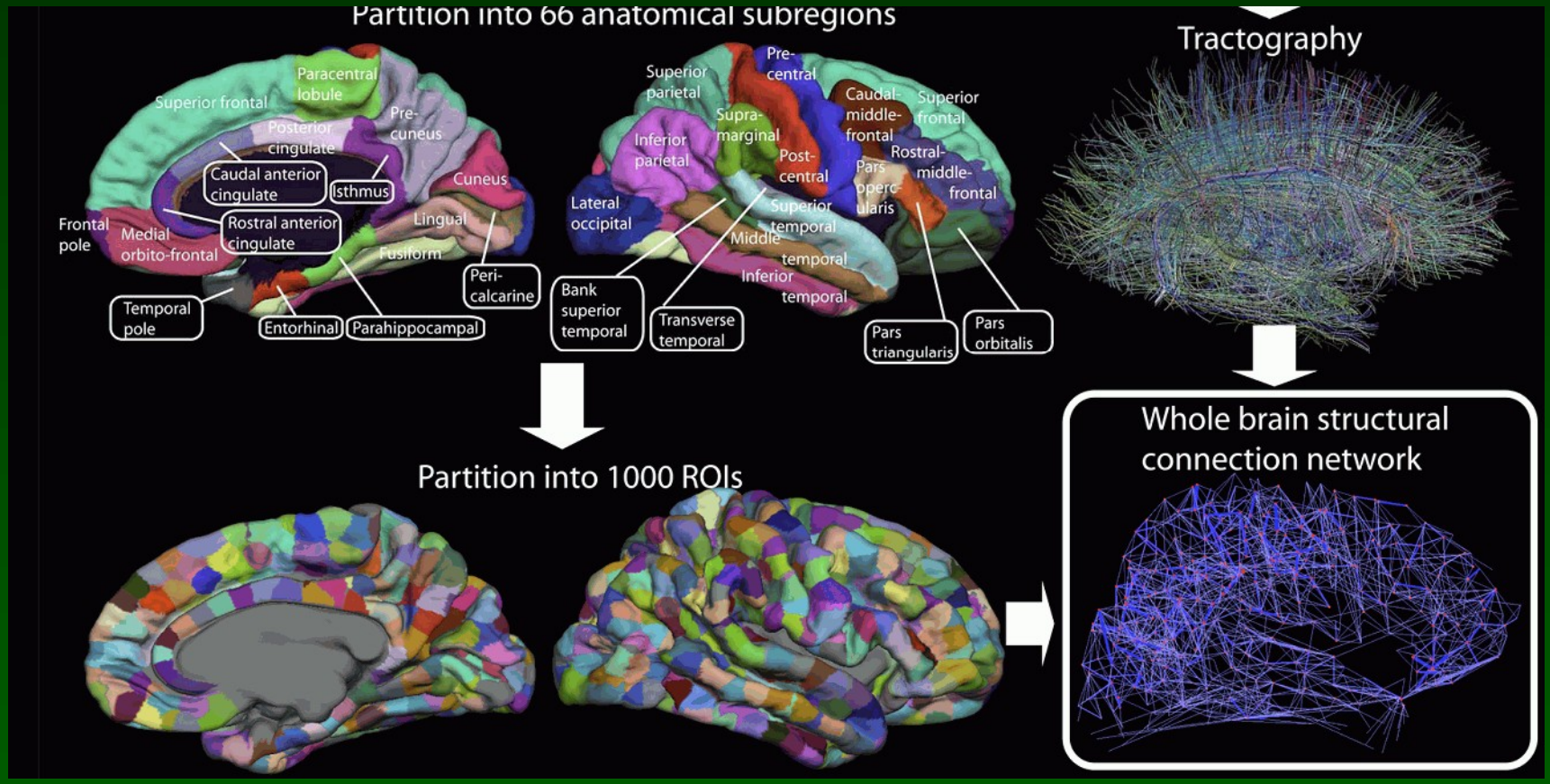
What it will be about

1. Information flow in the brain.
2. Delusions: examples of communication breakdown.
3. Functions of the brain stem and states of consciousness.
4. Limbic system and emotions.
5. Sensory input coding - receptors.
6. Topographical maps.
7. Population coding – active perception.
8. Senses and pathways.
9. Vision.



Connectome Project



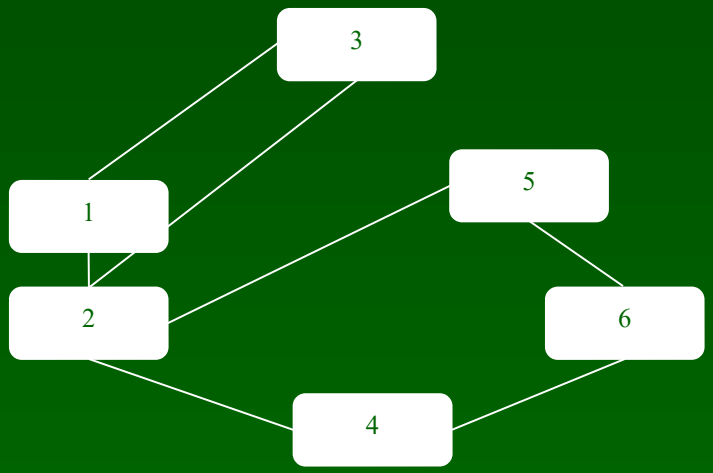
We do not know the details of information flow, the human connectome project should construct maps of structural and functional neural connections. But rough connectivity is already known. Check this gallery of the HCP.

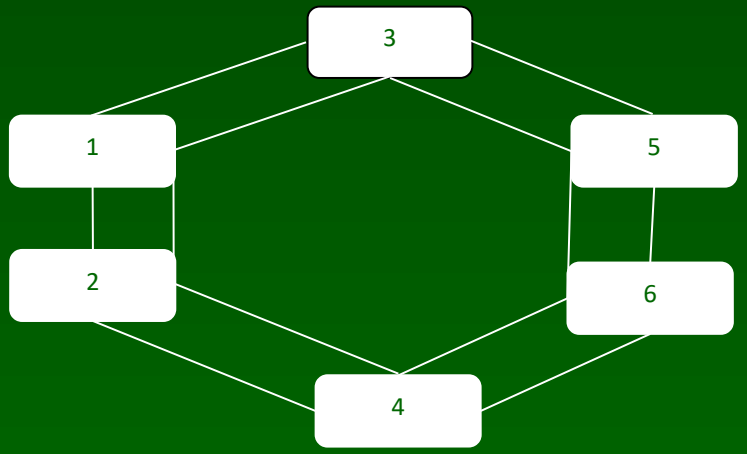
Functions and regions

Localized or holistic information flow?
Holistic theories in 19th century have been replaced by localization of some functions, now neuroimaging shows that each region has many functions.

Localized:
each brain area has a fixed function, and each task is implemented by cooperation of active regions.

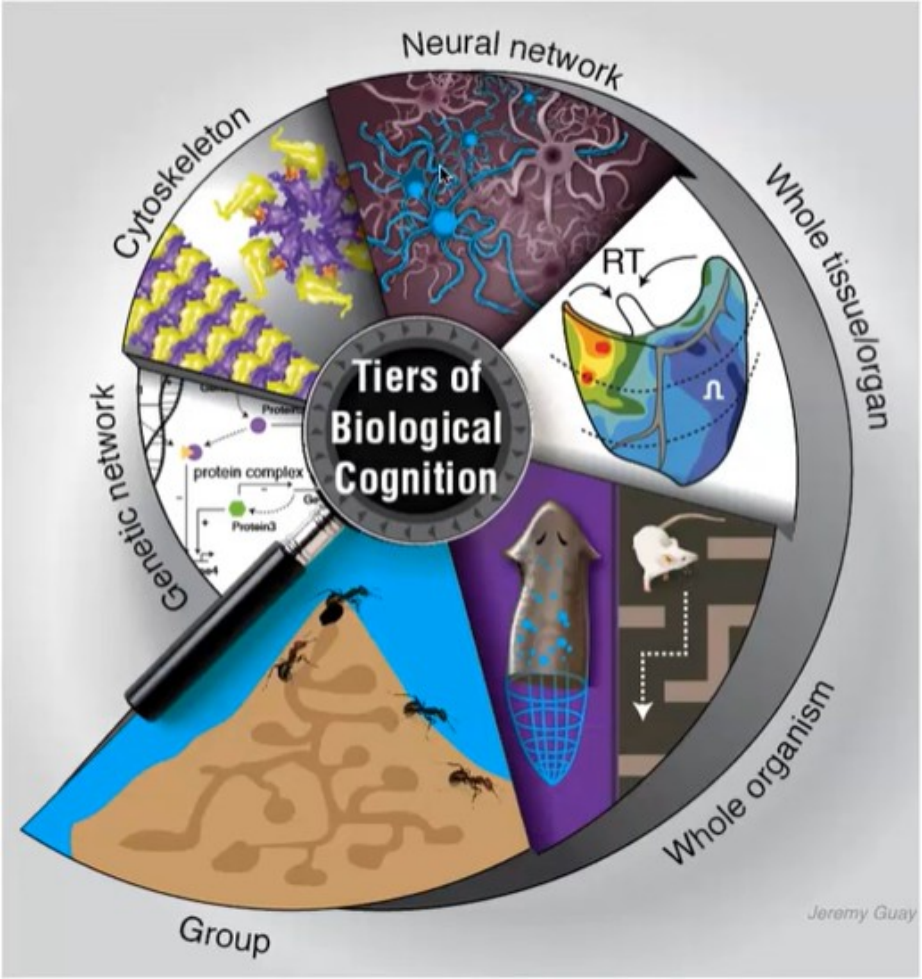
Holistic:
the whole brain works on each task, regions have functions that may in large degree be exchangeable.





Many levels of organization

Michael Levin, Tufts University. Thoughtforms.life



Multi-scale Competency Architecture

each level of organization solves problems in its own space (morphospace, transcriptional space, physiological space, 3D behavioral space, etc.) using some of the same tricks, at various levels of sophistication

Many levels of organization

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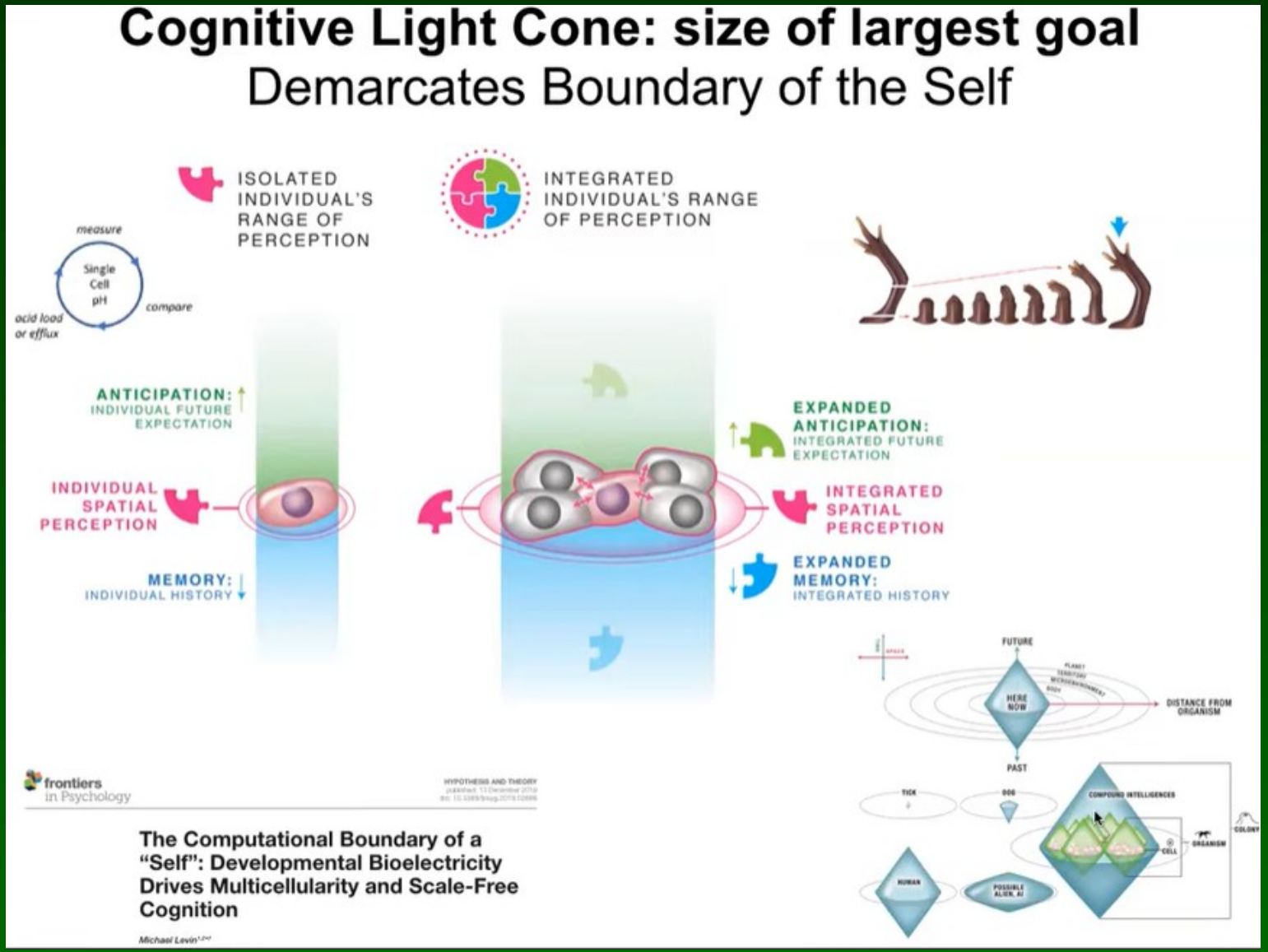

Many levels of organization

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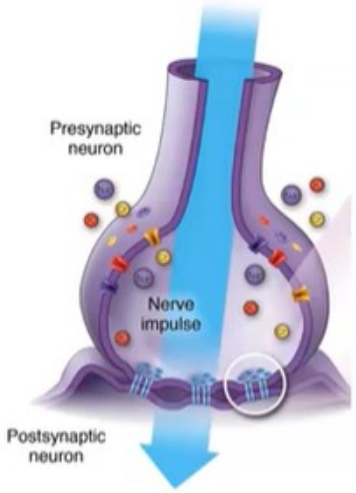
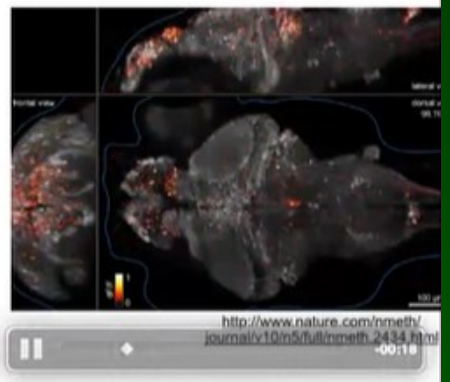
Bioelectricity as Cognitive Glue Beyond Brain

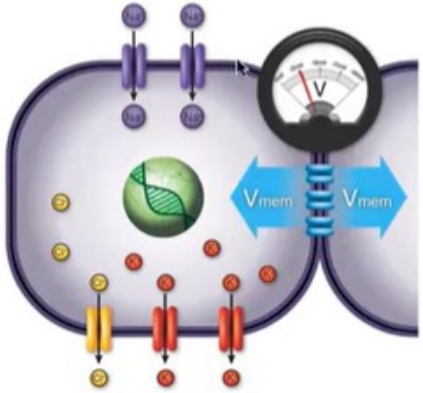
ion channels, electrical synapses



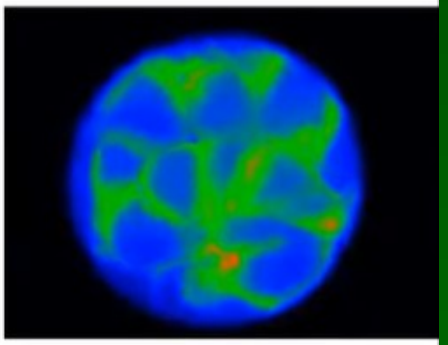
neural



ion channels, electrical synapses



developmental

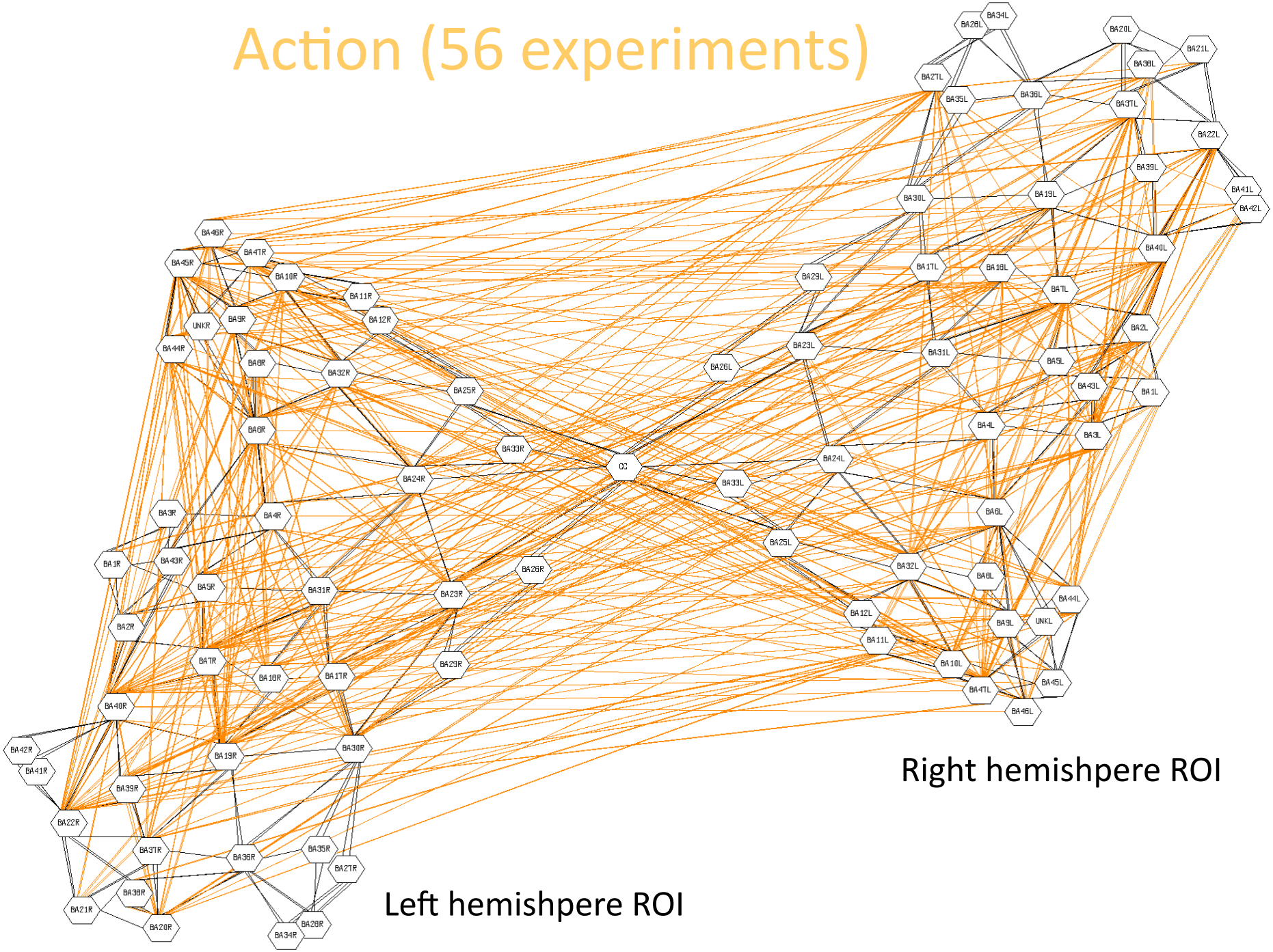


Neural recycling ?

M. Anderson, Neural reuse: a fundamental organizational principle of the brain. Behavioral & Brain Sci 33, 245 (2010)

- Central organizational principle: reuse of the same neural circuitry for various cognitive purposes.
- Brain has a heterarchy of semi-autonomous subsystems, no permanent "supervisor" population of neurons, any subsystem may take the lead
- Neural circuits were exapted (exploited, recycled, redeployed) during evolution for different uses, often without losing their original functions.
- Brain circuits can continue to acquire new functions without significant local change to circuit structure, functional connections to new partners.
- This gives new perspective on brain evolution/development, tool use, human language; modularity/localization of cognitive functions.
- It has practical implications in neurorehabilitation, BCI design, cognitive architectures, a bit like object/module reuse in programming.
- Based on meta-analysis of 665 experiments in 20 cognitive domains.

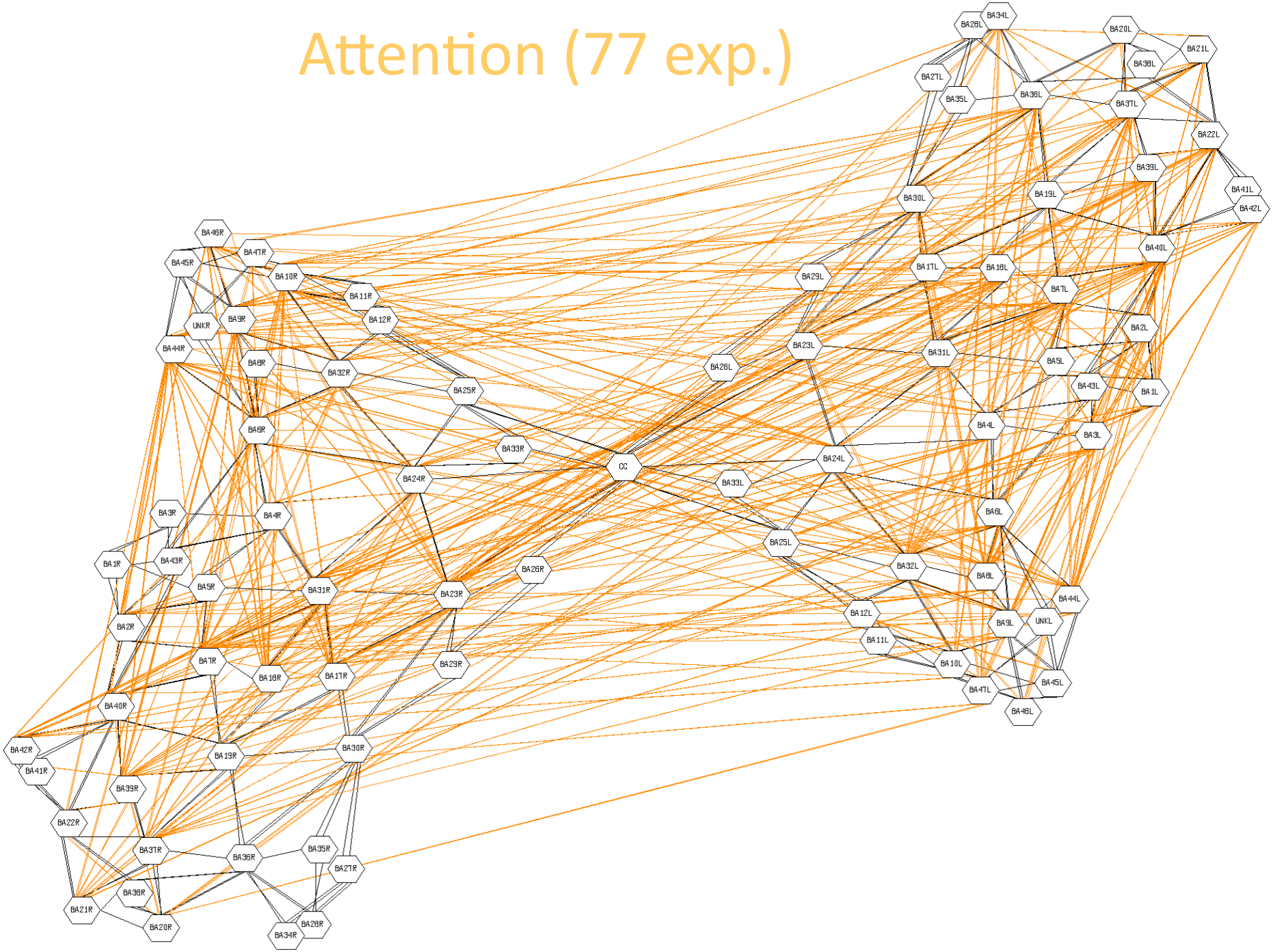
Action (56 experiments)



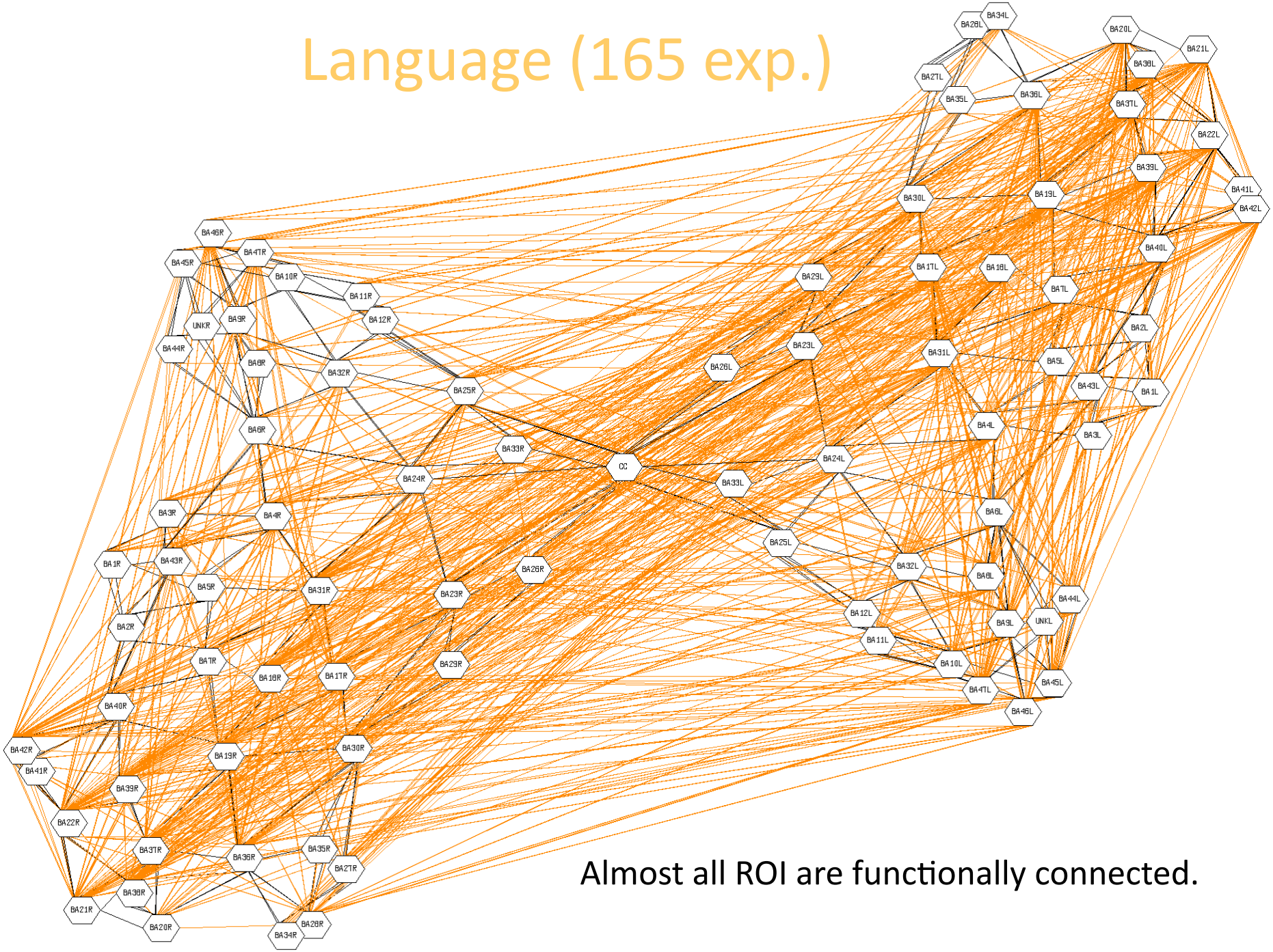
Right hemishpere ROI

Left hemishpere ROI

Attention (77 exp.)

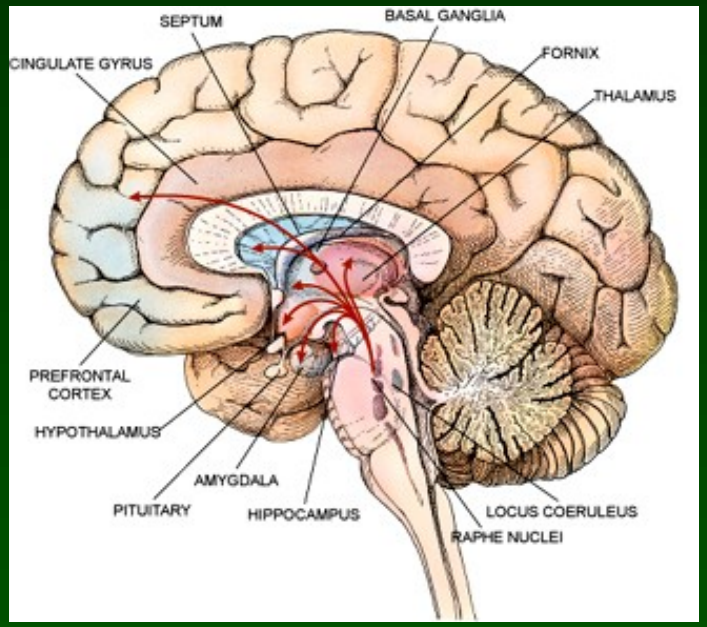


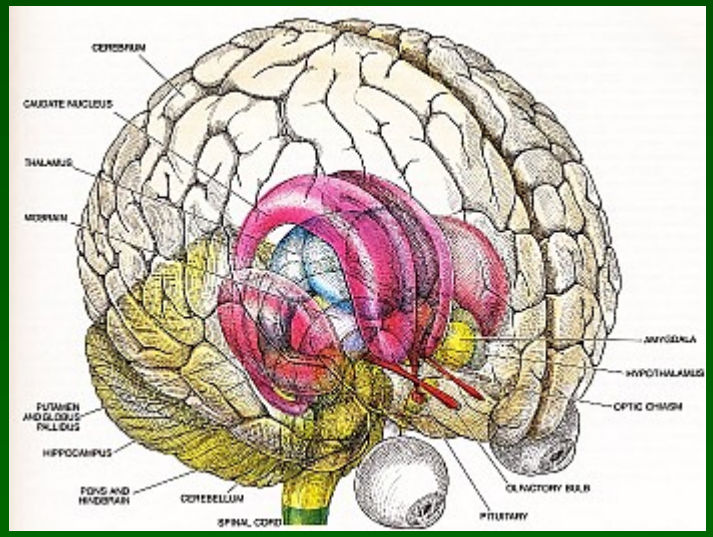
Language (165 exp.)



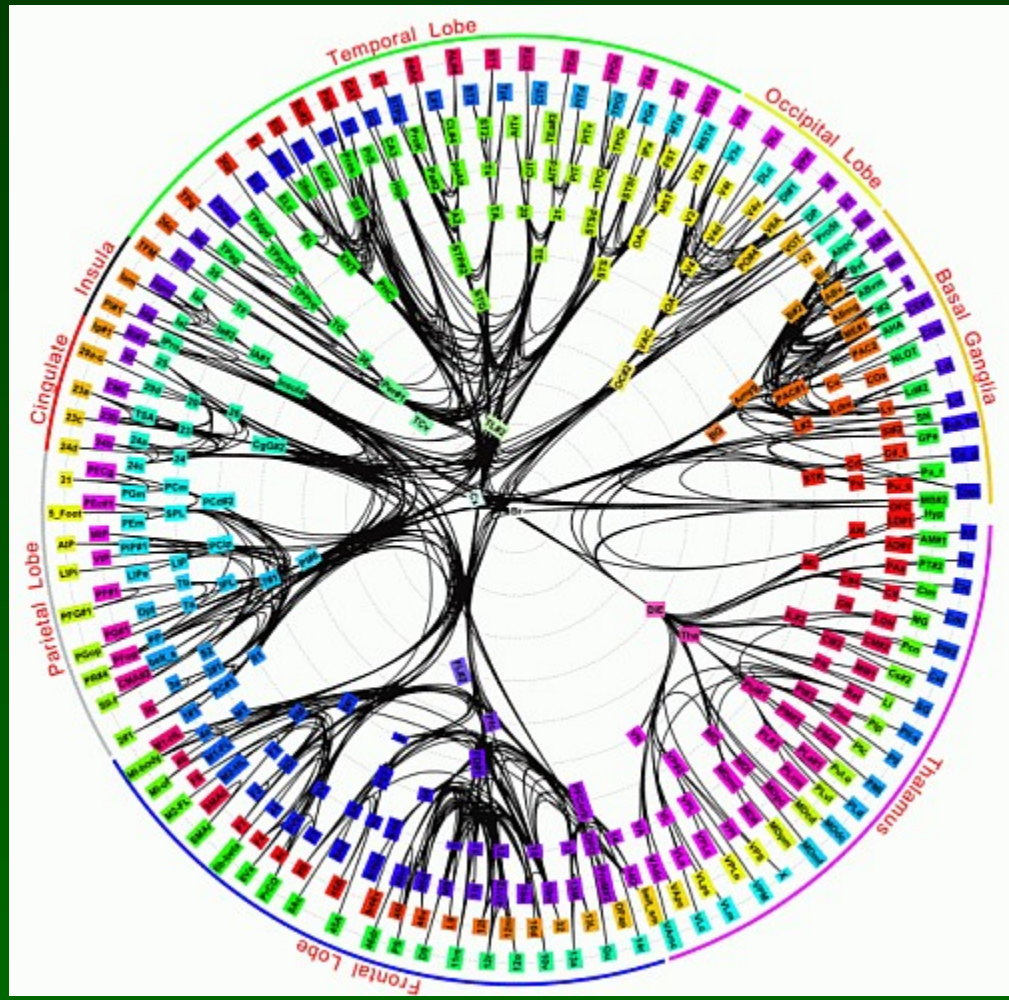
Almost all ROI are functionally connected.

Modules





Connectivity of 383 regions in macaque brain; Modha & Singh, PNAS 2010.



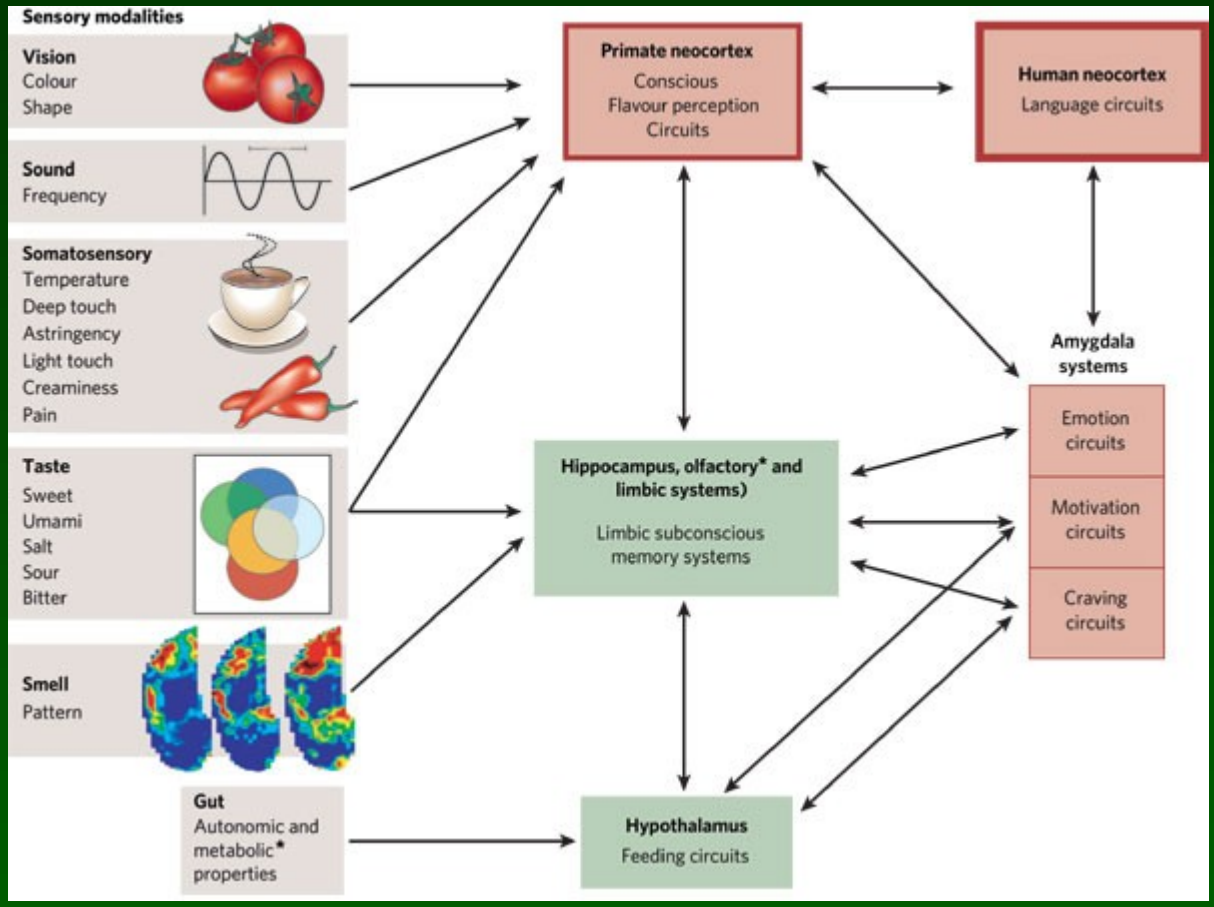
Flavor inputs

Even flavor perception is very complex.

Areas involved in the perceptual, emotional, various memory, motivational and linguistic aspects of food evaluation are mediated by flavor inputs.

Conclusion: all real perception is complex!

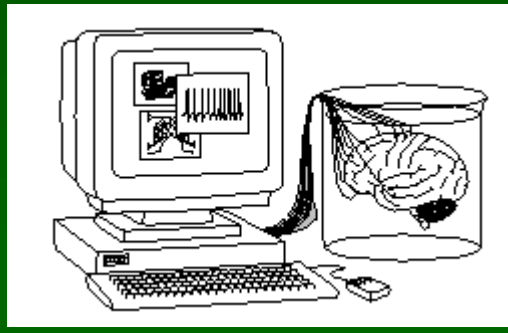
It should extract useful information from signal.



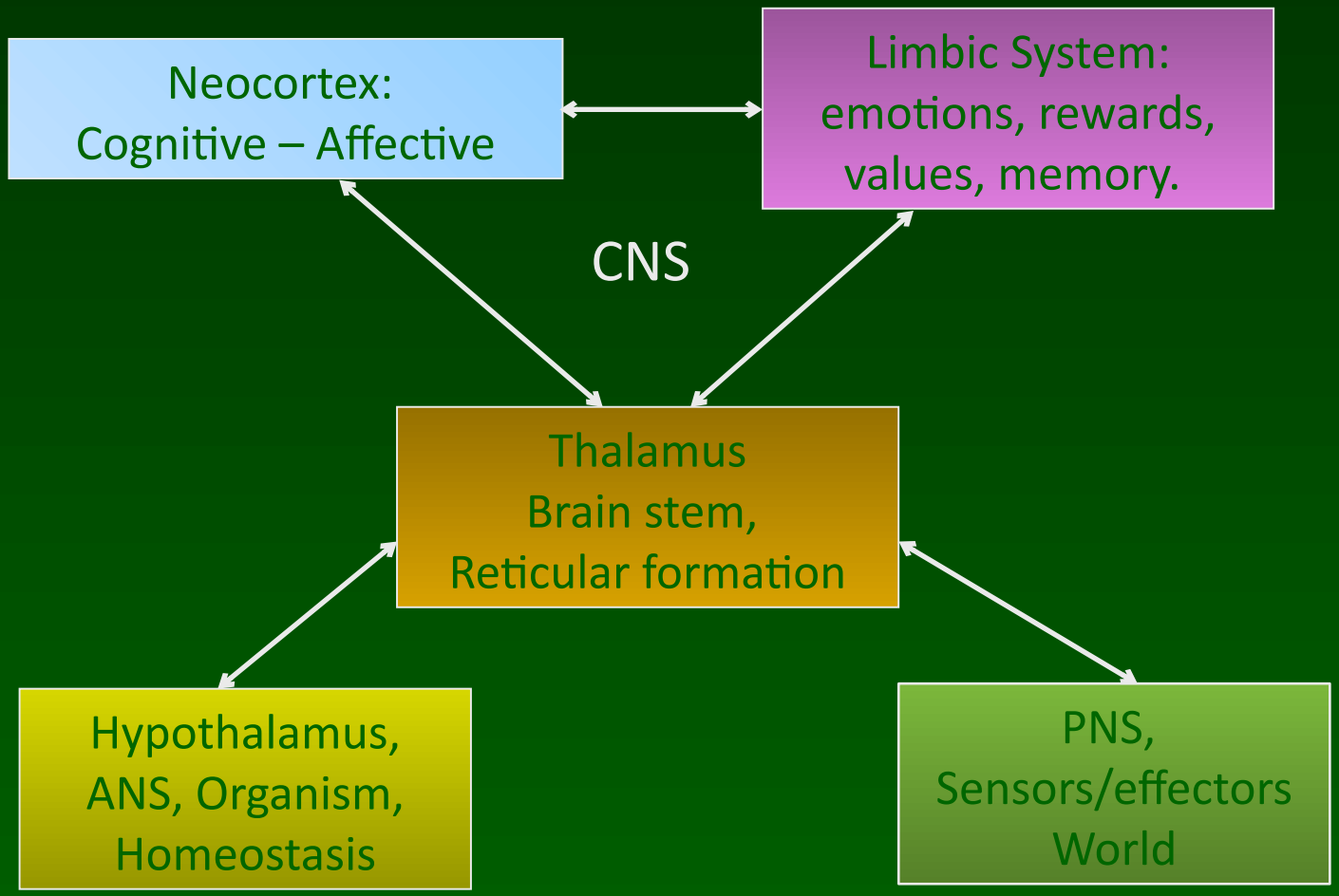
From G.M. Shepherd, Smell images and the flavour system in the human brain. Nature 444, 316-321 (2006).

What it will be about

1. Core ideas and cybernetic explanations.
2. Basic brain architecture.
3. Information flow in the brain.
4. Examples of communication breakdown.
5. Functions of the brain stem and states of consciousness.
6. Limbic system and emotions.

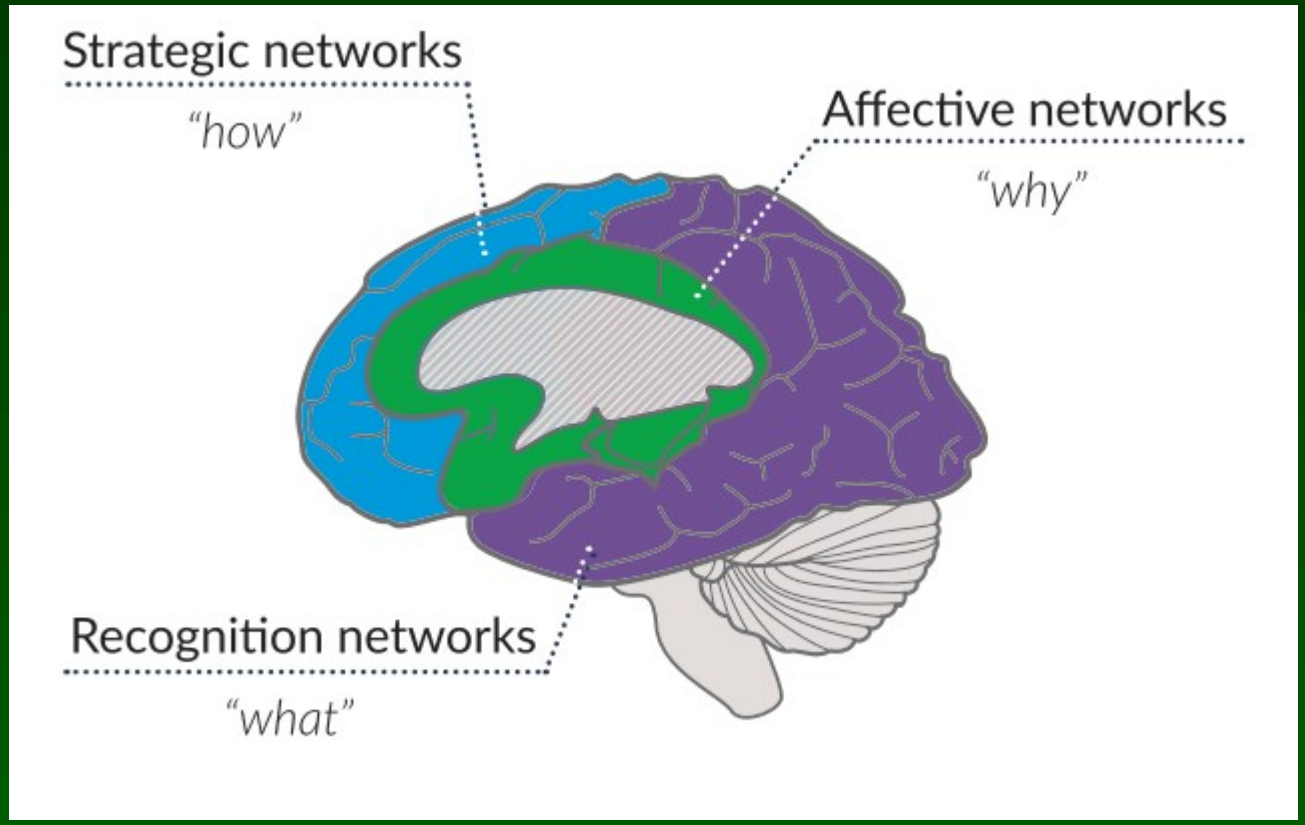


Basic modules



What may happen if one of the connections is broken or miswired?
For example neocortex-limbic connection?

Basic modules



What may happen if one of the connections is broken or miswired?
For example neocortex-limbic connection?

Delusional syndromes

What happens if the affective-cognitive link is broken? Values are lost.

Sometimes we recognize a place, person, object but feel strange about it, or sometimes we feel we know but cannot recognize.
DMS, delusional misidentification syndrome: a belief that the identity of a person, object or place has somehow changed or has been altered.

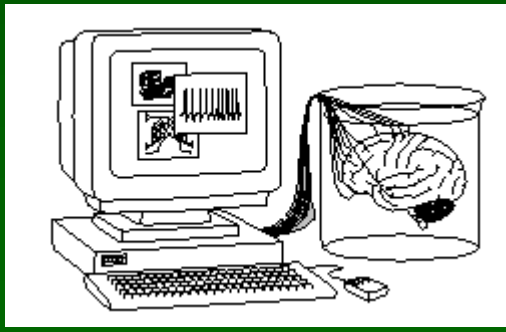
- Capgras delusion: delusion that a close relative/spouse has been replaced by an identical-looking impostor.
- Reduplicative paramnesia: familiar person, place, object or body part has been duplicated.
- Fregoli delusion: delusion that various people met are actually the same person in disguise.
- Intermetamorphosis: delusion that people swap identities with each other whilst keeping the same appearance.
- Subjective doubles, delusion of a doppelgänger, a double of the person carrying out independent actions.
- Mirrored self-misidentification: delusion that one's reflection in a mirror is some other person.

It may happen to you!

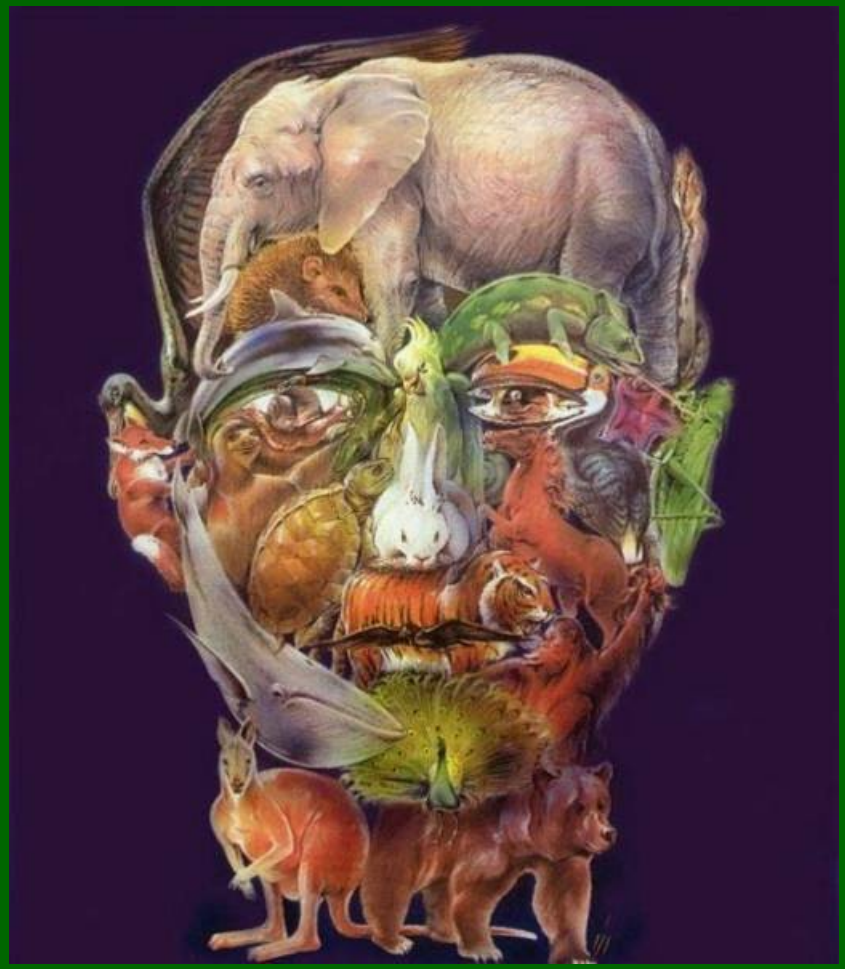
What it will be about

Next:

- Homeostasis and brain stem
- Perception
- Learning
- Memory
- Language
- Volition
- Consciousness



Thank you for
synchronization
of your neurons



Google: Wlodzislaw Duch
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