Visualization of mind inside the brain

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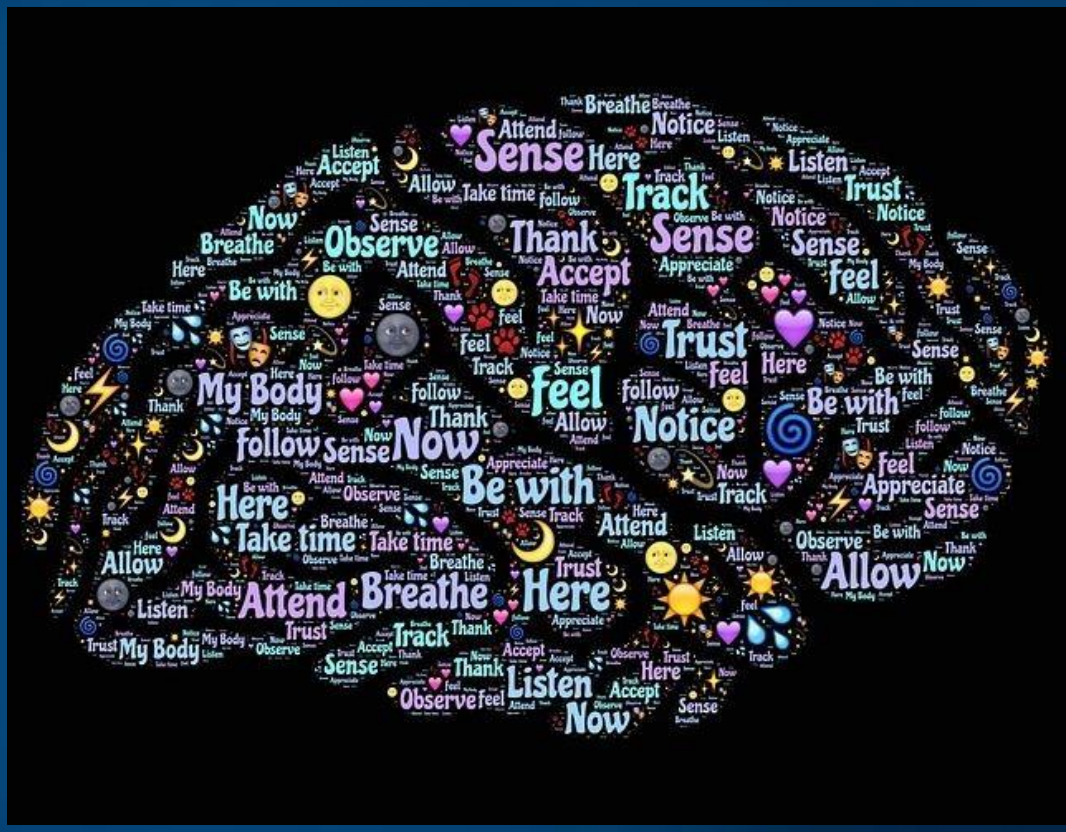
Information Visualization in Humanities, 23.03.2017

Questions

Cognitive InfoCommunication

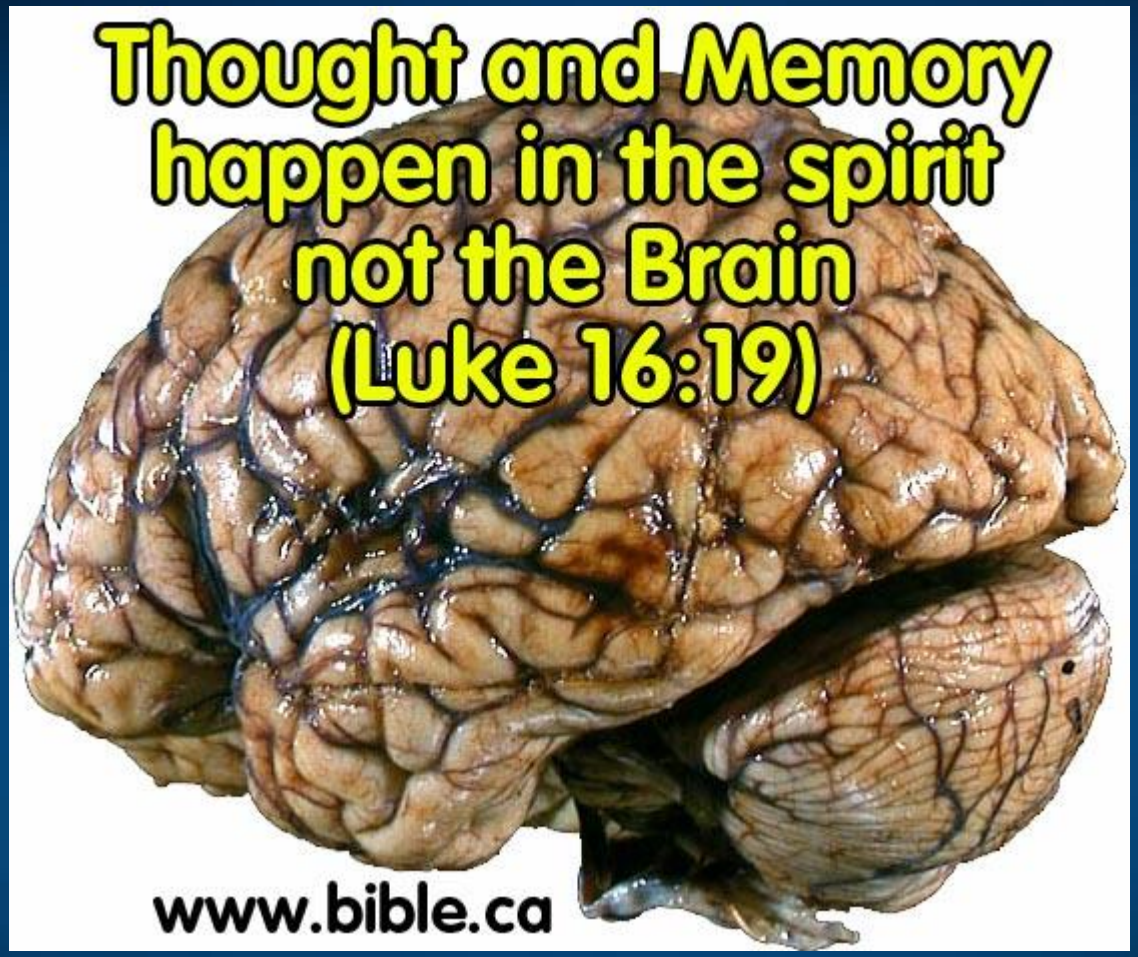
- Can we see minds in our brains?
- Can we see culture?
- Is the inner world really private?
- Are my dreams private?
- How are deep beliefs, conspiracy theories formed?

Previous talks on many approaches to visualization are on my page.



My favorite organ! Where is mind?

Soul or brain?

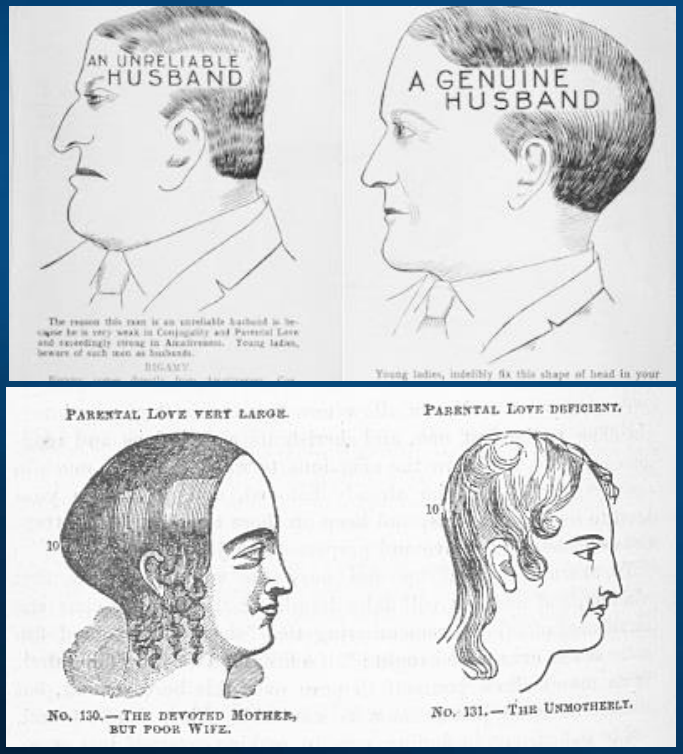


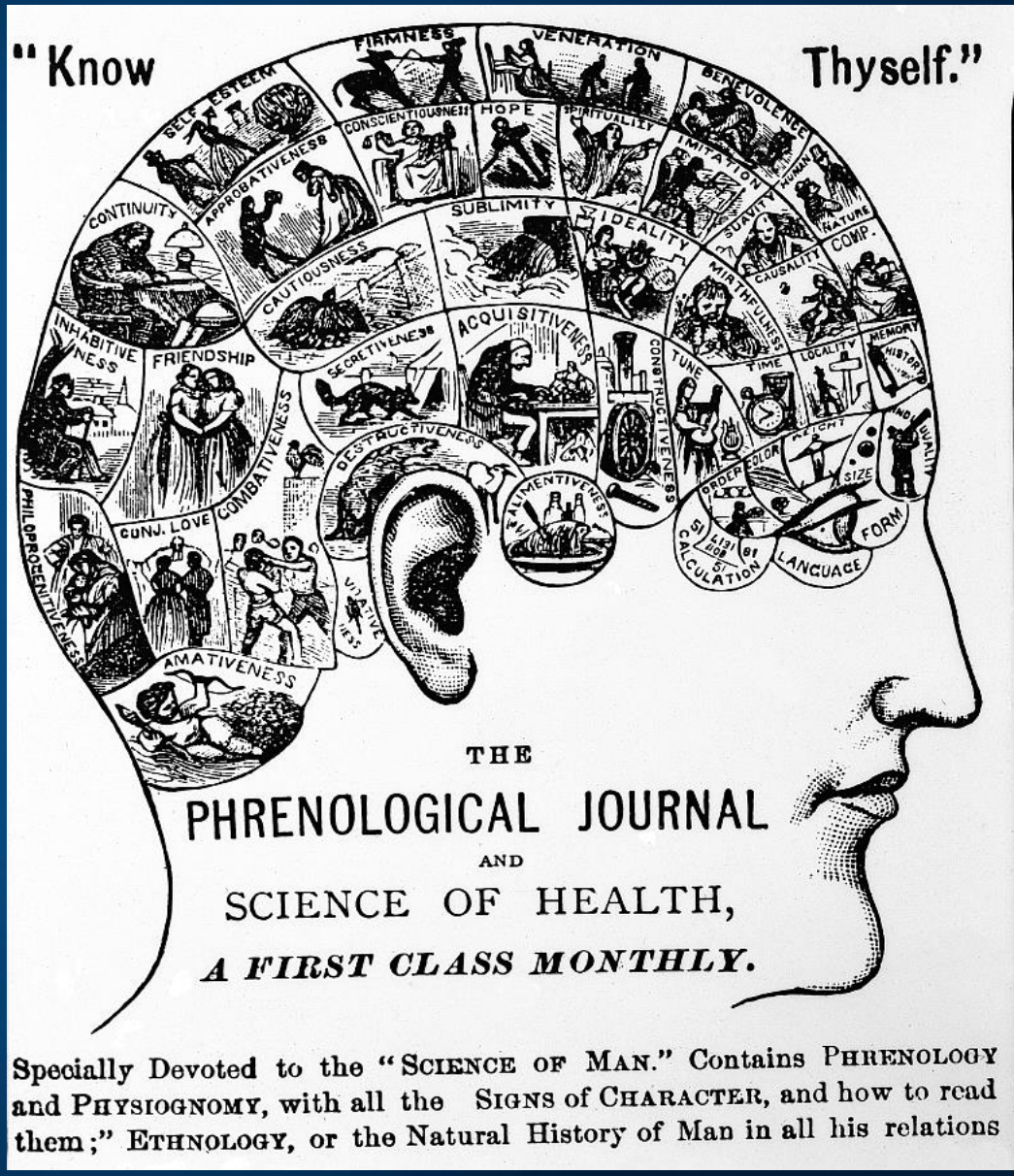
Soul or brain: what makes us human? Interdisciplinary Workshop, Faculty of Theology, Nicolaus Copernicus University + Insbruck + Pampeluna (10/2016). Almost no dualists are left even among theologians.

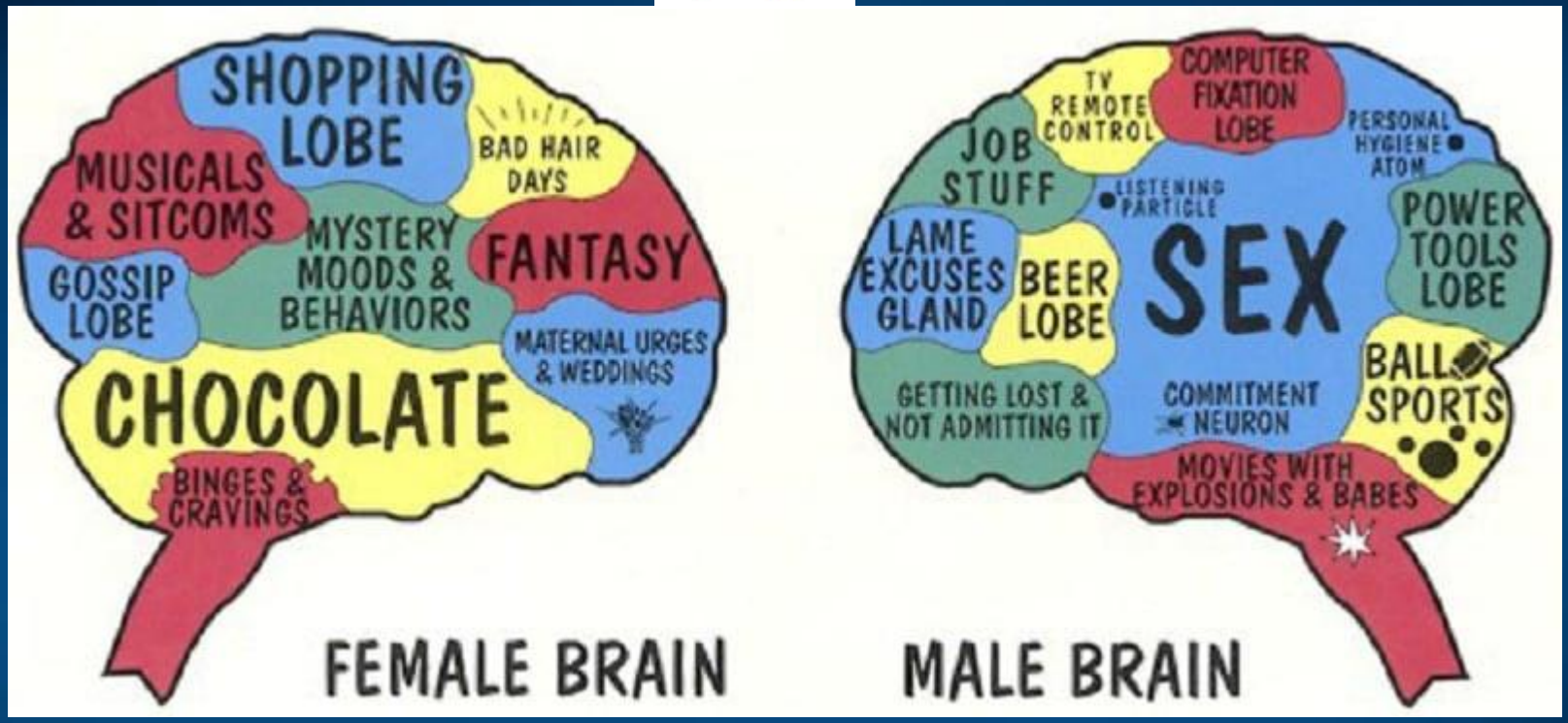
Phrenology

Phrenology was popular in 19 century. The scull was divided in 35 areas with specific functions.

Amativness, friendship, self esteem, hope, wit, veneration …







This is also not what we have in the brain …

But there are many neuromyth and pseudo-scientific organizations that promote ideas at this level.

Ex: Structogram Training System, Genetic Code for Personality.

Real demons in our brains …

Can we see what goes on in human brains?

Psychological spaces

Psychological spaces:

K. Lewin, The conceptual representation and the measurement of psychological forces (1938), cognitive dynamic movement in phenomenological space.

George Kelly (1955), personal construct psychology, geometry of psychological spaces as alternative to logic.

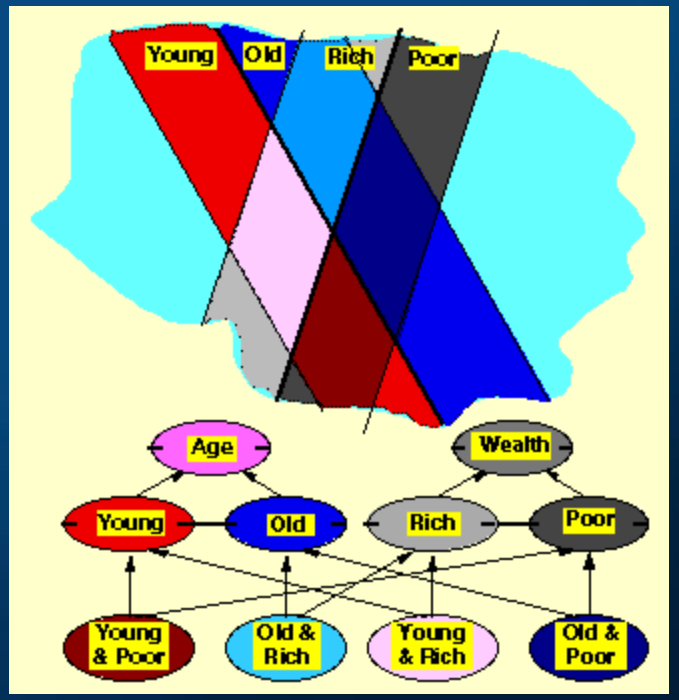
A complete theory of cognition, action, learning and intention.

P-space: region in which we may place and classify elements of our experience, constructed and evolving, „a space without distance", divided by dichotomies.

P-spaces (Shepard 1957-2001):

- minimal dimensionality
- distances that monotonically decrease with increasing similarity

(multi-dimensional non-metric scaling).



Some connections

Geometric/dynamical ideas related to mind may be found in many fields:

Philosophy: Mind as motion, ed. R.F. Port, T. van Gelder (MIT Press 1995)

Linguistics: G. Fauconnier, Mental Spaces (Cambridge U.P. 1994).
Mental spaces and non-classical feature spaces.

J. Elman, Language as a dynamical system (San Diego, 1997).
Stream of thoughts, sentence as a trajectory in P-space.

Psycholinguistics: T. Landauer, S. Dumais, Latent Semantic Analysis Theory, Psych. Rev. (1997) Semantics requires about 300 dim. to capture associations.

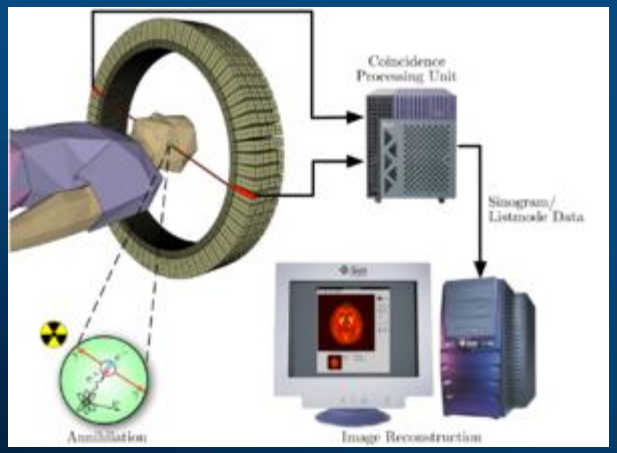
M.J. Spivey, The Continuity of Mind (OUP 2007)

Neuroscience: Anderson, van Essen (1994): Superior Colliculus maps as PDFs

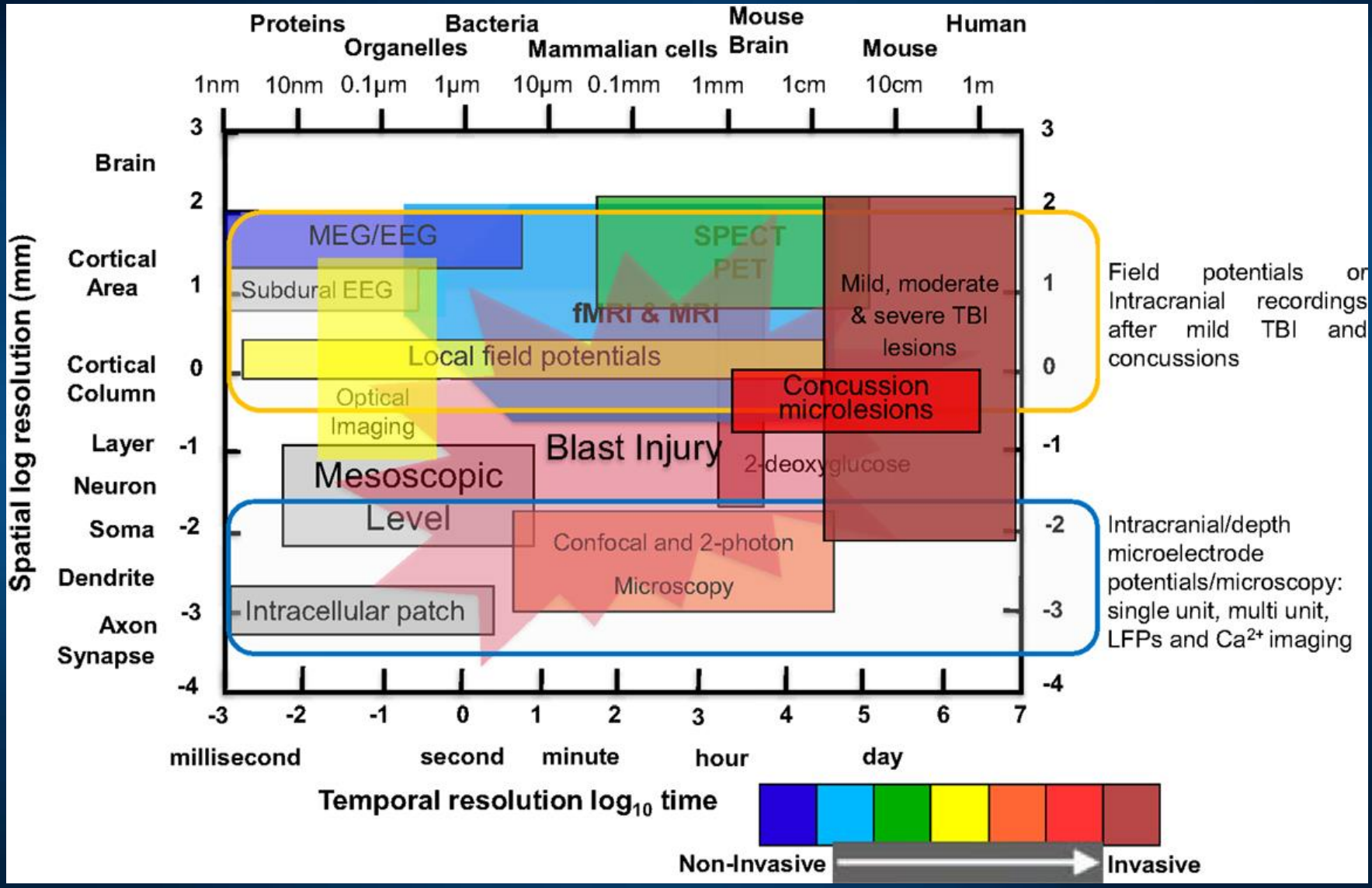
AI: problem spaces - reasoning, problem solving, SOAR, ACT-R

Folk psychology: to put in mind, to have in mind, to keep in mind, to make up one's mind, be of one mind ... (space).

Neuroimaging



Neuroimaging techniques



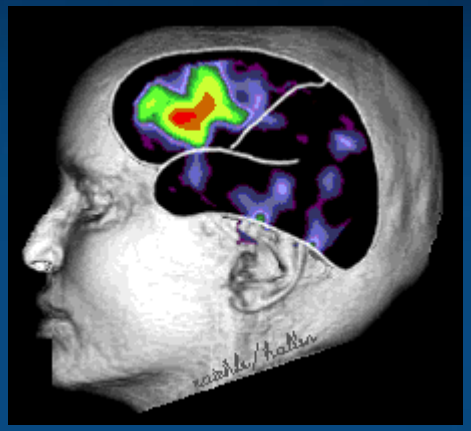
ICNT: scanner GE Discovery MR750 3T

Geometric model of mind

Brain ⇔ Psyche

Objective ⇔ Subjective

Neurodynamics: bioelectrical activity of the brain, neural activity measured using EEG, MEG, NIRS-OT, PET, fMRI, other techniques.

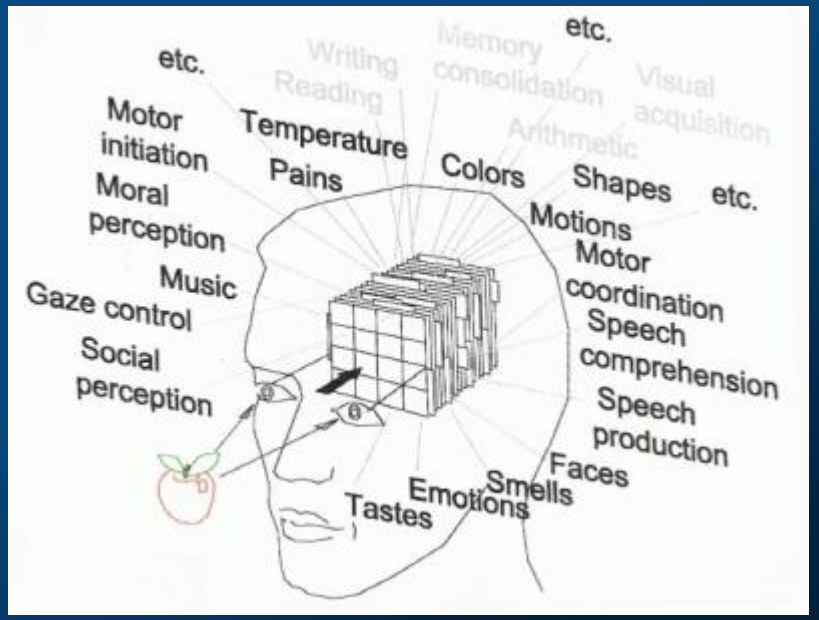


Mapping S(M)⇔S(B) but how do we describe the state of mind?

Verbal description is not sufficient. A space with dimensions that measure different aspects of experience is needed.

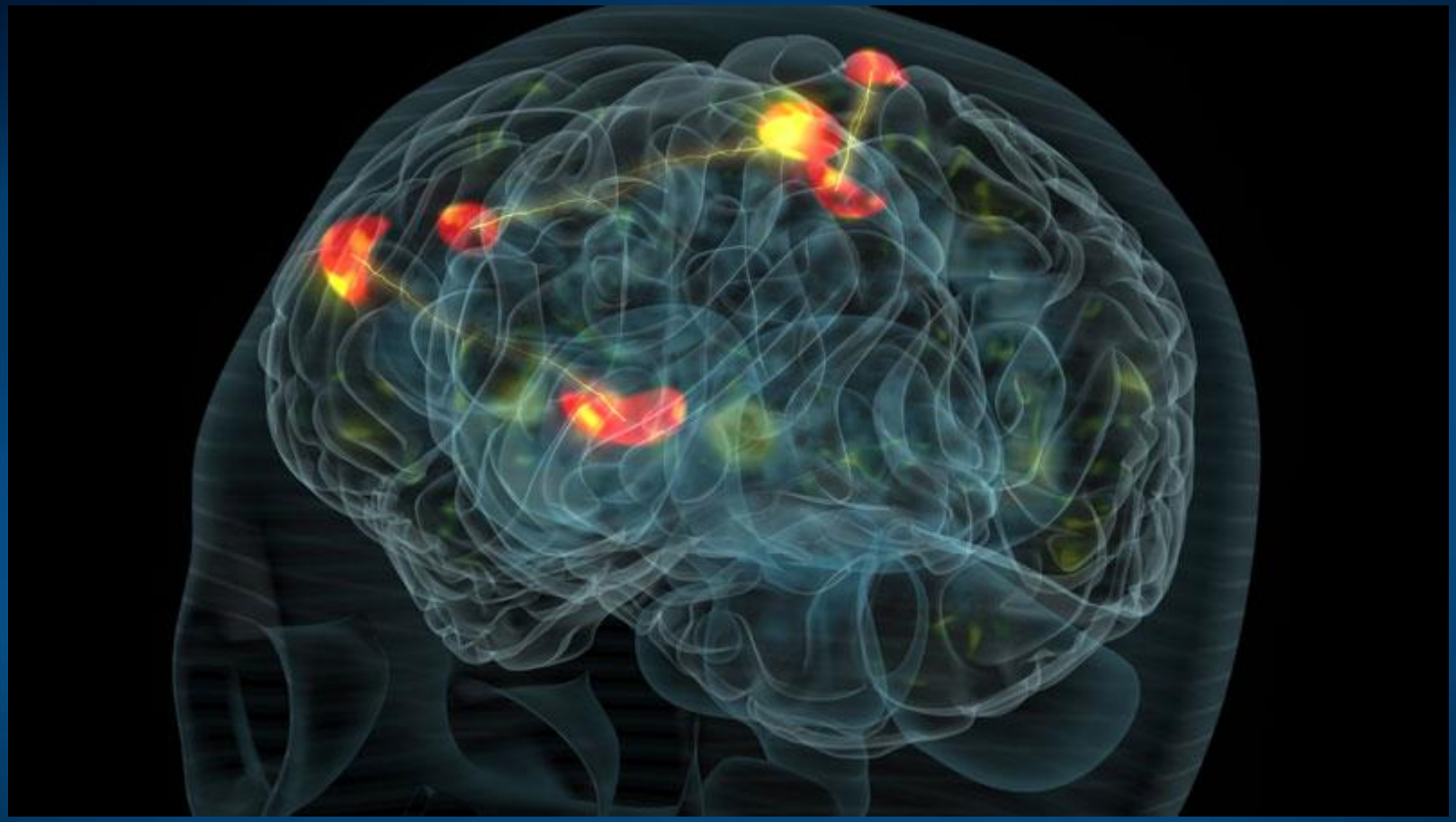
Mental states, movement of thoughts ⇔ trajectories in psychological spaces.

Problem: good phenomenology. We are not able to describe our mental states.



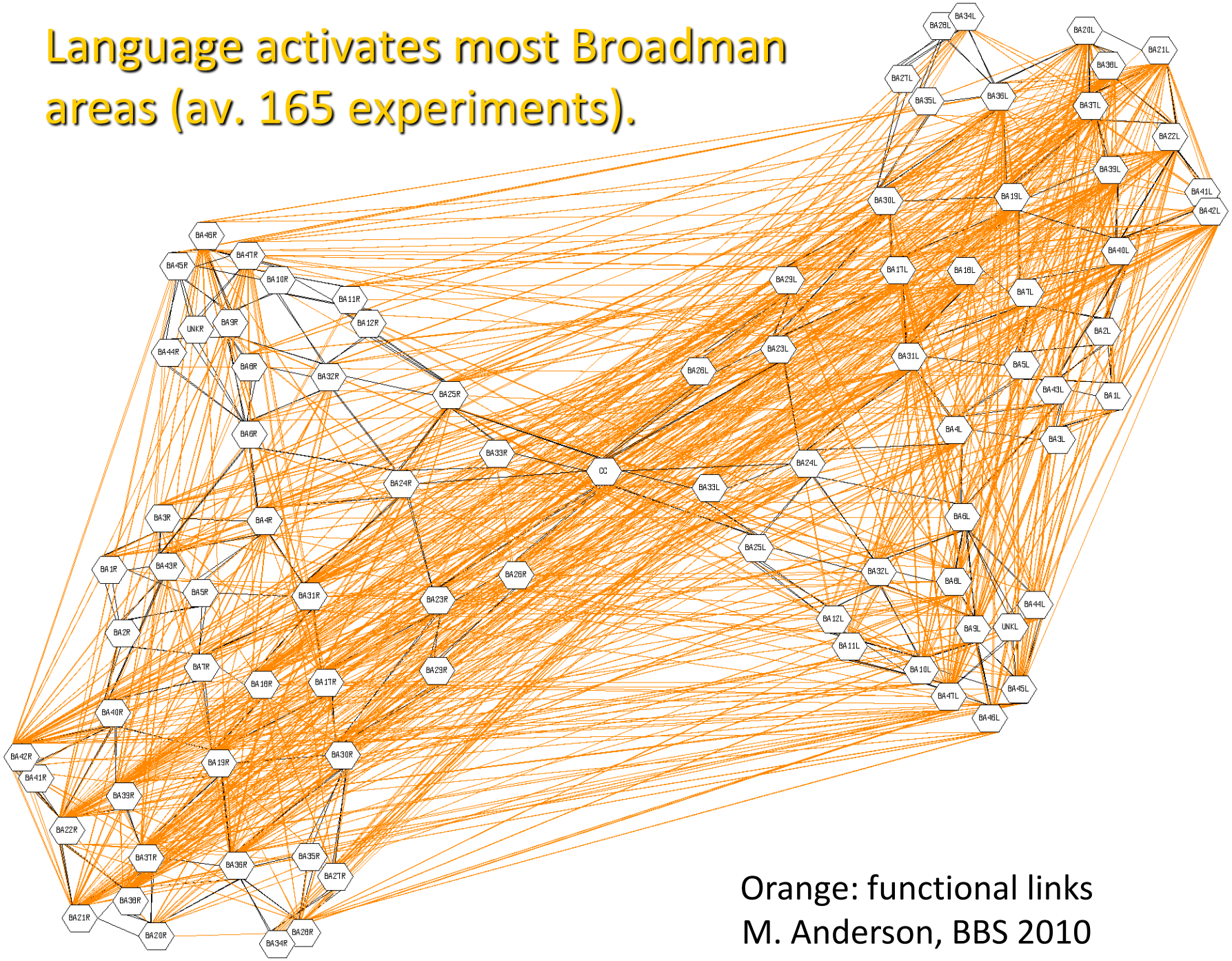
Hurlburt & Schwitzgabel, Describing Inner Experience? MIT Press 2007

Thought: strong, coherent activation



Many processes go on in parallel, controlling the state of our bodies.
Most are automatic, hidden from our Self.
Processes implemented by subnetworks compete for access to the highest level of control, consciousness, using the winner-takes-most mechanism.
Such processes may activate representaiton of Self in the brain.

Language activates most Broadman areas (av. 165 experiments).



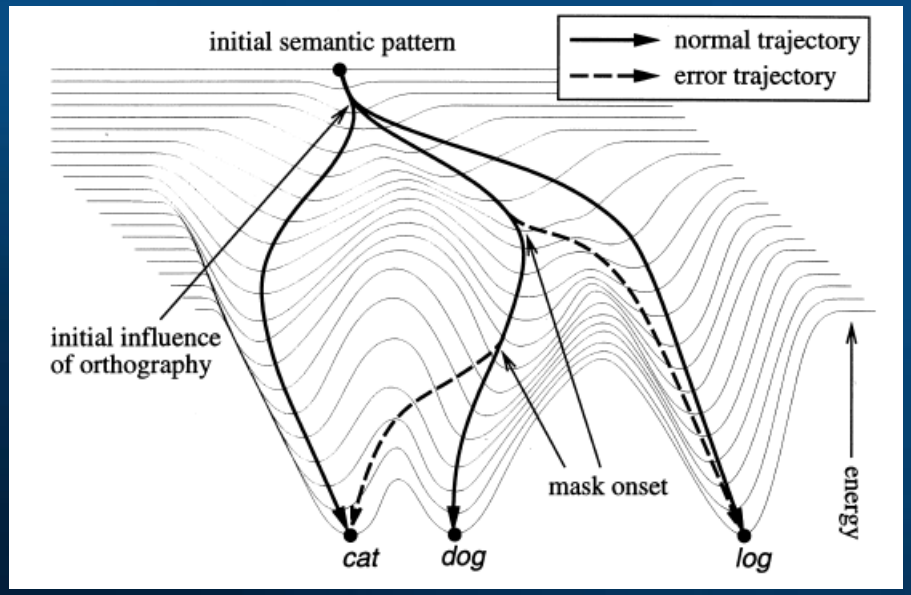
Orange: functional links
M. Anderson, BBS 2010

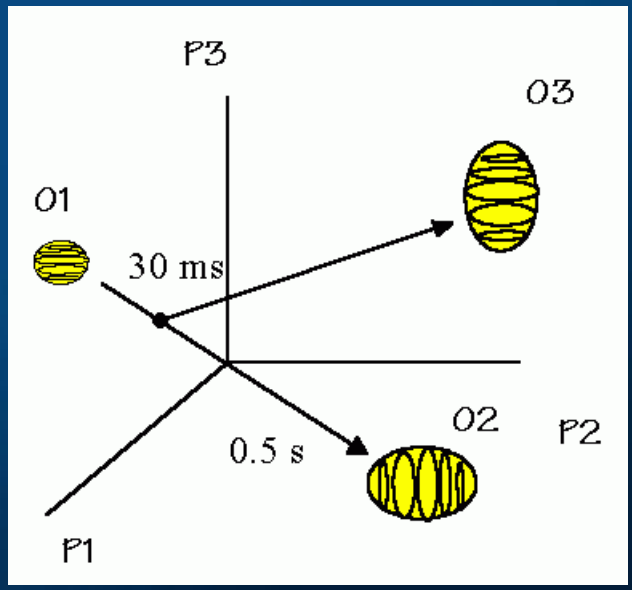
Energies of trajectories

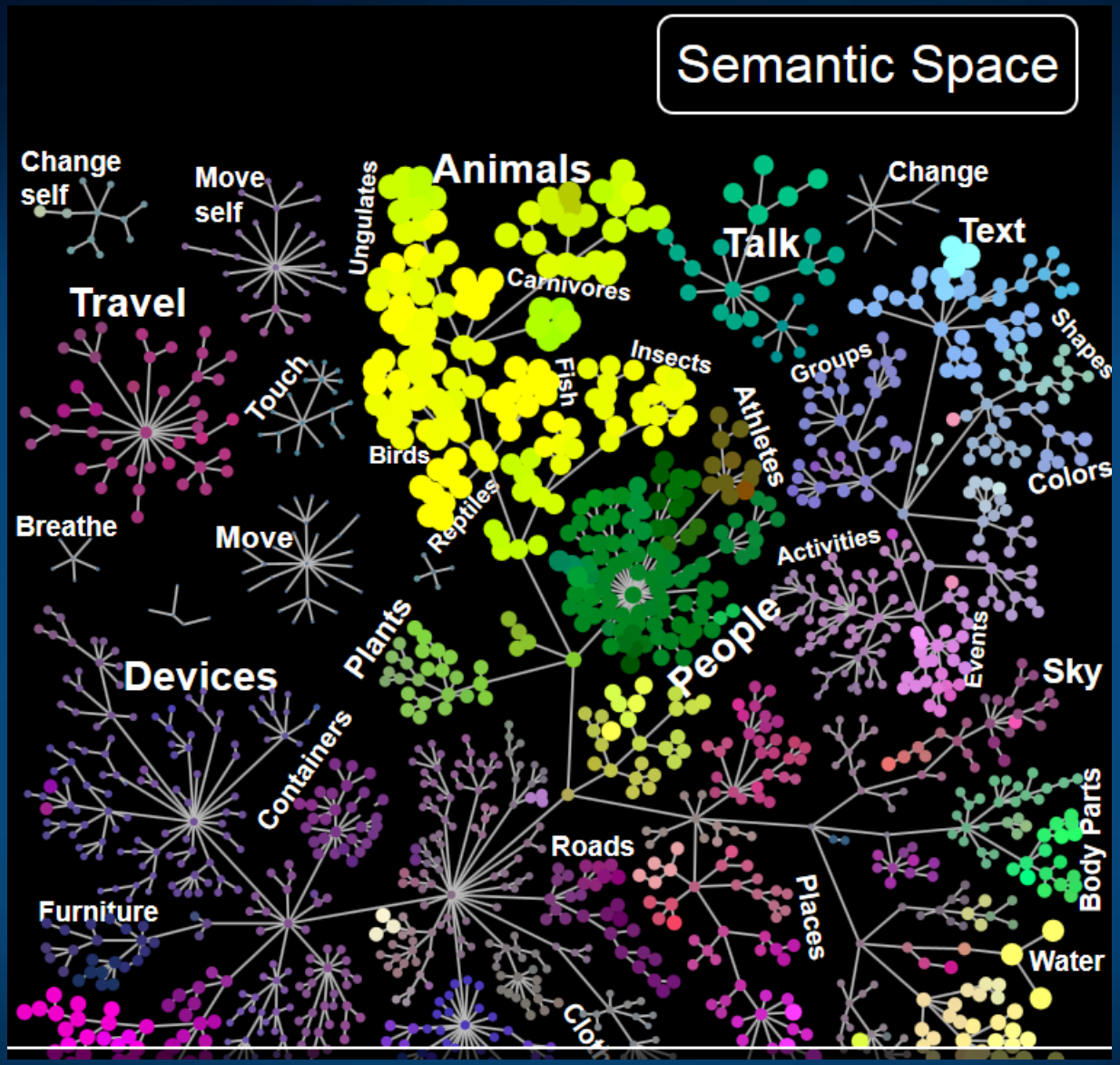
P. McLeod, T. Shallice, D.C. Plaut, Attractor dynamics in word recognition: converging evidence from errors by normal subjects, dyslexic patients and a connectionist model. Cognition 74 (2000) 91-113.

M.J. Spivey, The Continuity of Mind (OUP 2007)
New area in psycholinguistics: investigation of dynamical cognition, influence of masking on semantic and phonological errors.

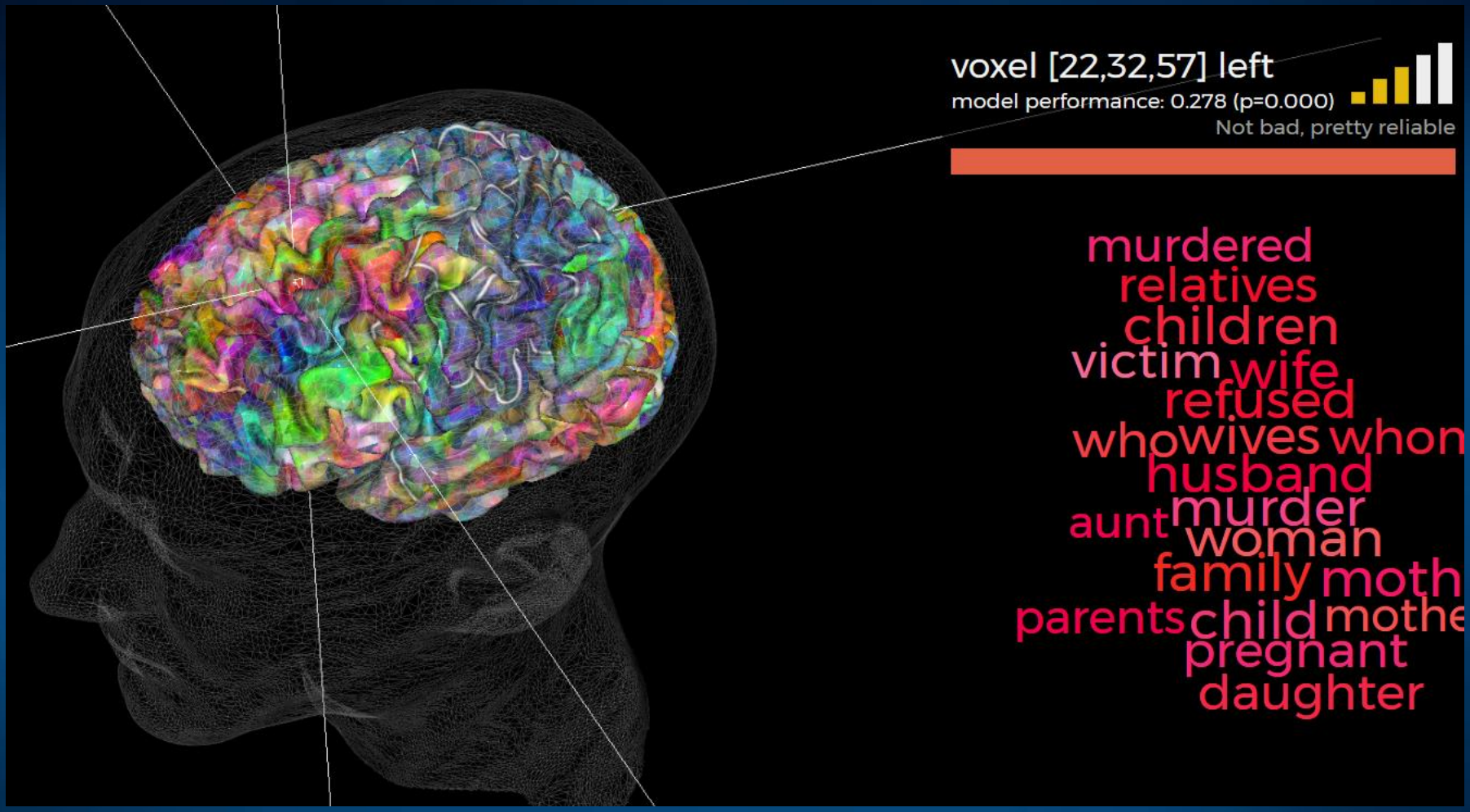
Brain is a substrate in which mental processes take place.



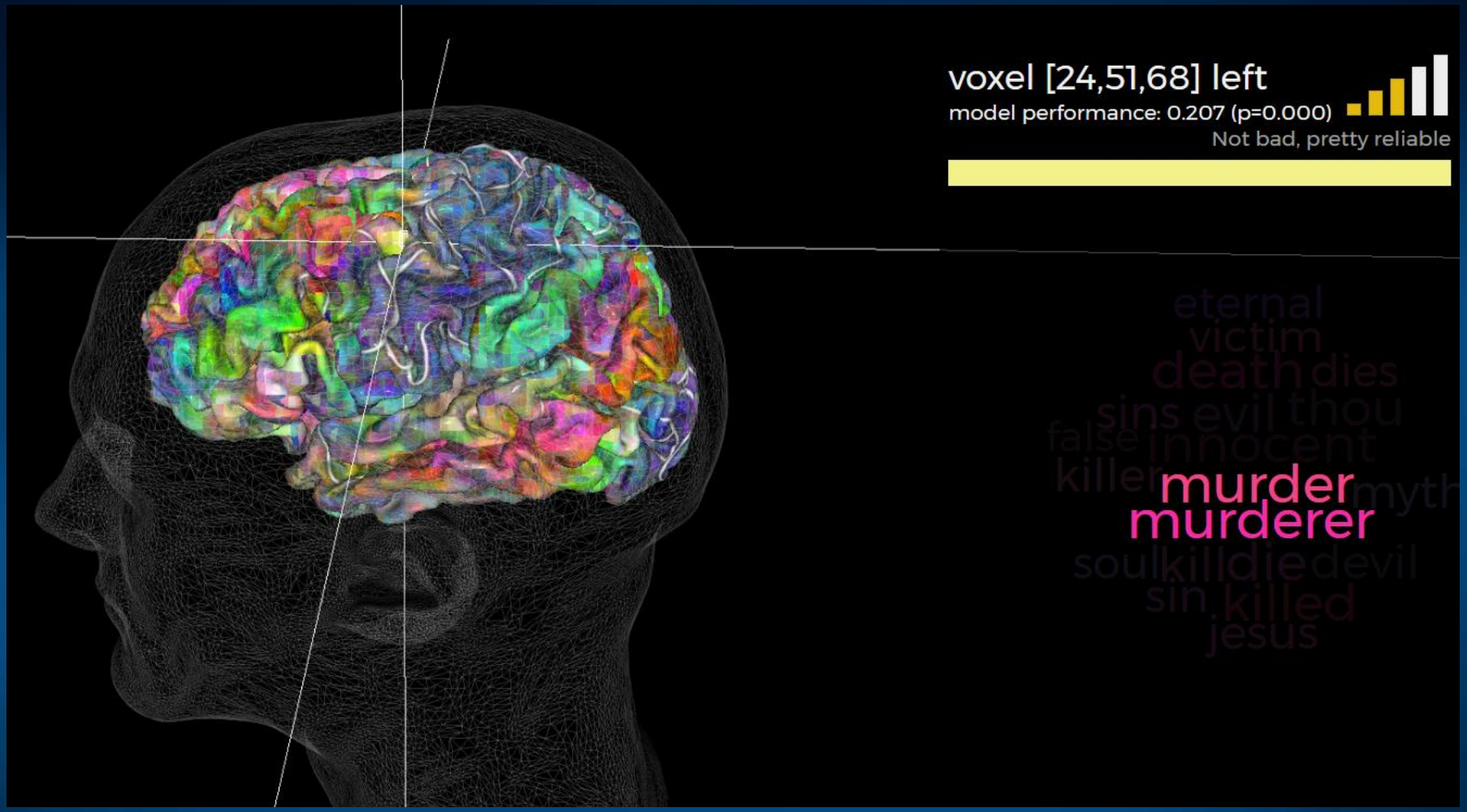




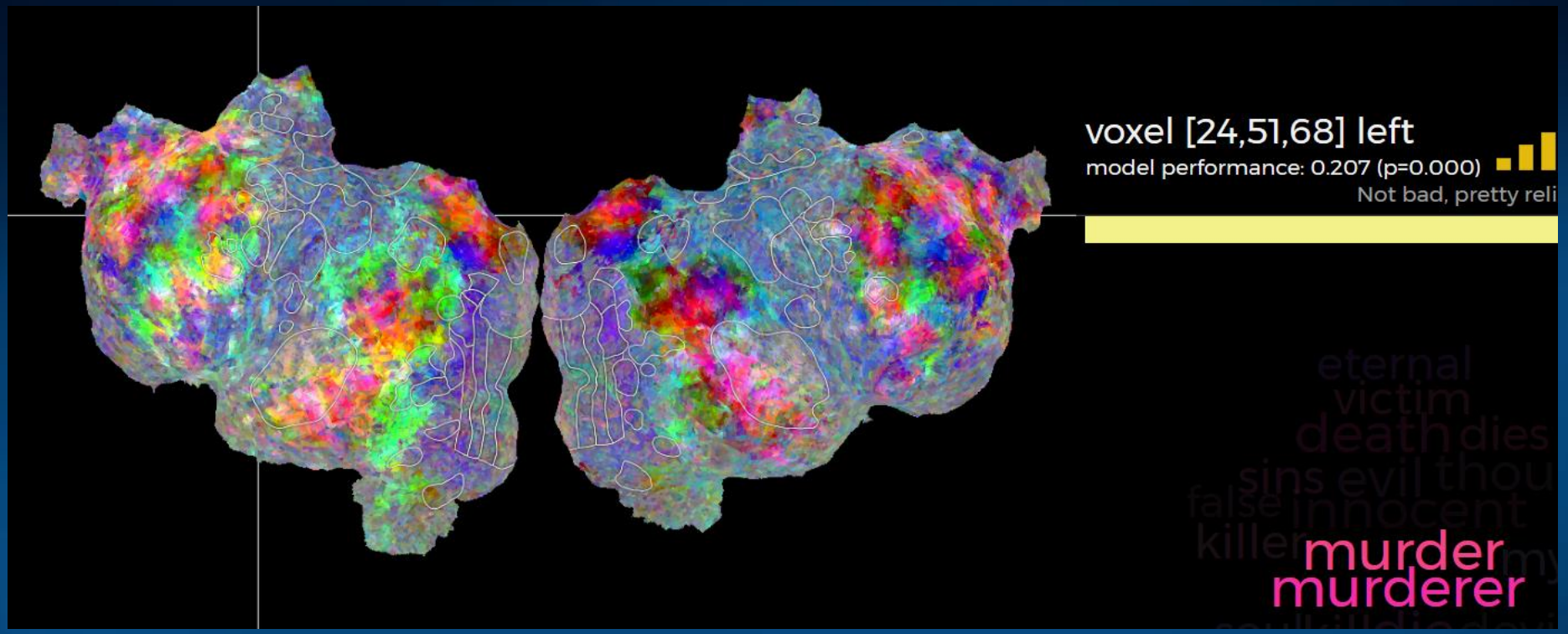
Words in the semantic space are grouped by their similarity.
Words activate specific brain maps, similar words create similar maps.
Each pixel may be activated by many words.



Each voxel responds usually to many related words, whole categories.
http://gallantlab.org/huth2016/



Voxel may also responds in quite specific way.
http://gallantlab.org/huth2016/

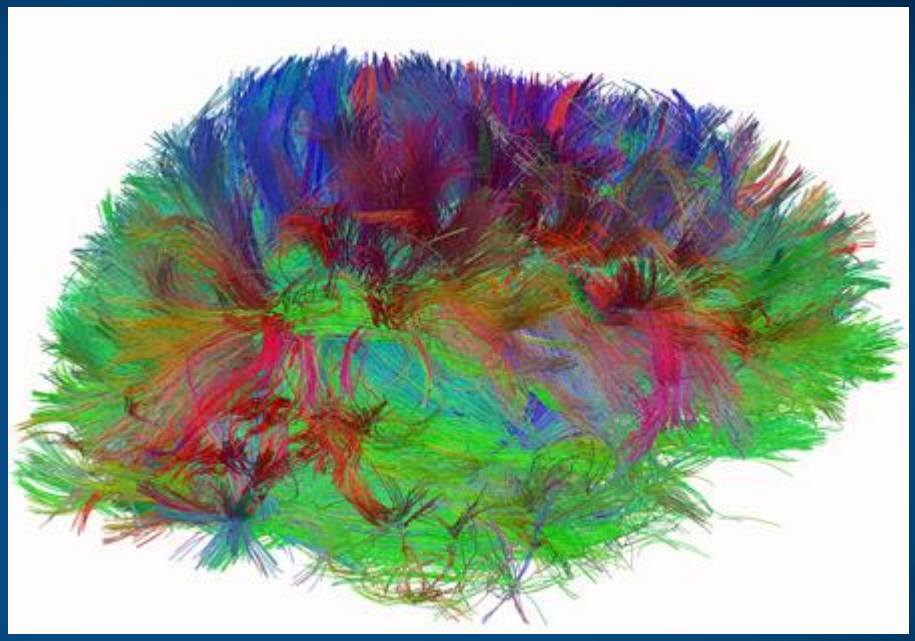


Each word activates a whole map of activity in the brain.
Whole map for the word “murder” shown on the flattened cortex.

Why such activity patterns arise? Brain subnetworks connect active areas.

http://gallantlab.org/huth2016/ and short movie intro.

Neural determinism



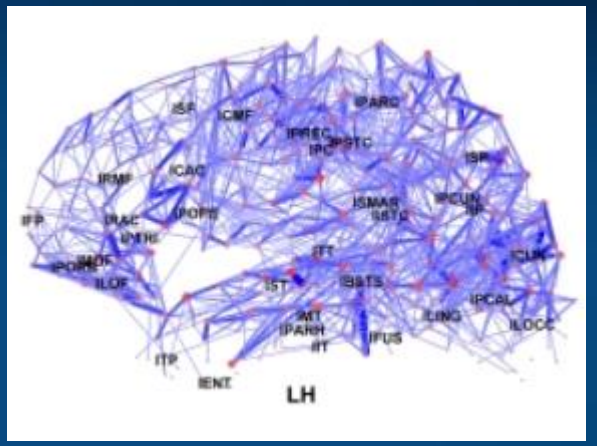
Genetic determinism: general anatomy and functions of the brain.

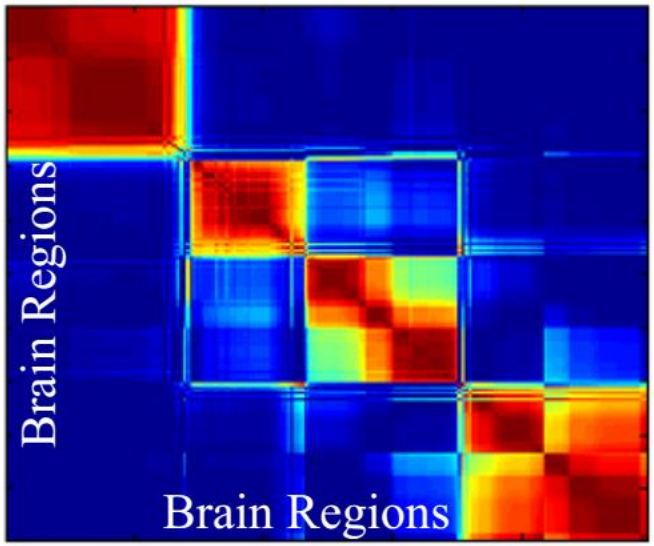
Neural determinism: connections are formed by interactions with the environment, individual experiences and culture.
We can only think in a way that is determined by neuronal activity!
Neurodynamics is the true source of our thoughts, we confabulate in search for explanations. Understanding = activation of maps through connections.
Metaphor: mind is the shadow of neurodynamics.

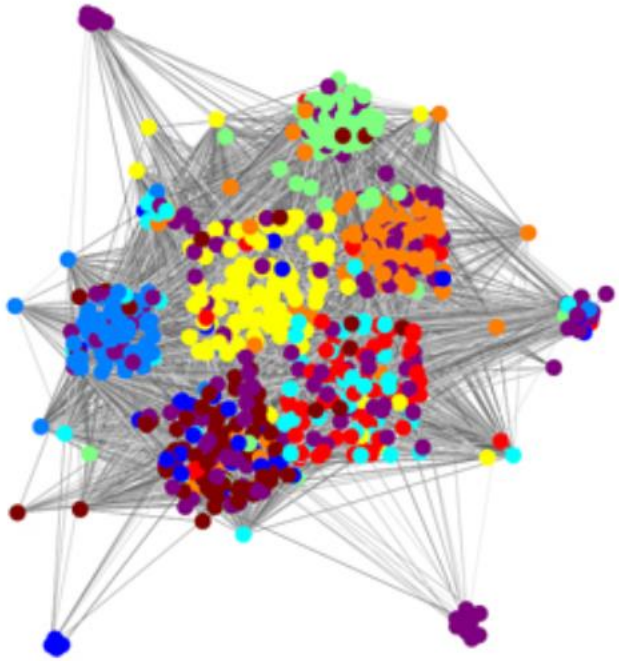
Neuronal subnetworks

Hierarchy and modularity is observed at large scale: several subnetworks responsible for arousal, attention, positive/negative valence, perception.

At the microcircuit level similar hierarchy/modularity is seen.







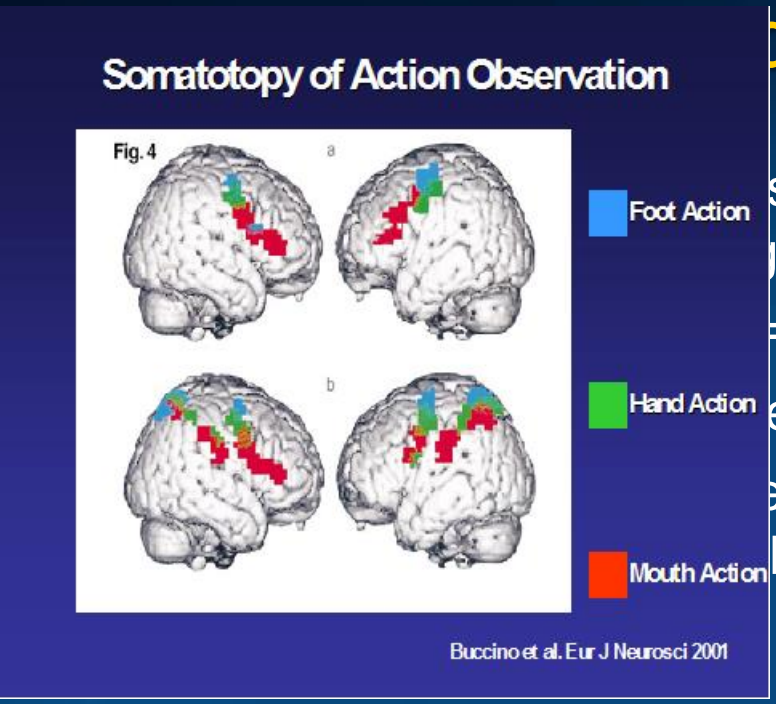
ds in the brain

show that phonological
gorical representations.

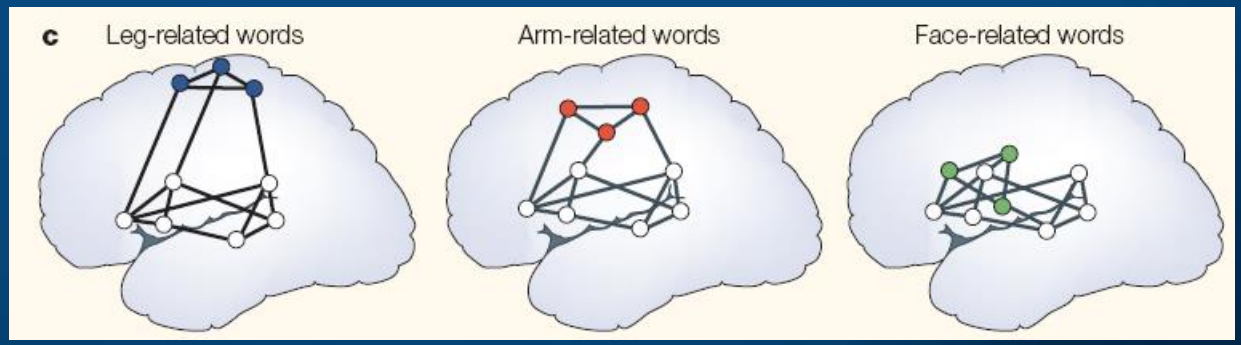
=> words => semantic concepts.

edes semantic by 90 ms (from N200 ERPs).

euroscience of Language. On Brain Circuits of
bridge University Press.

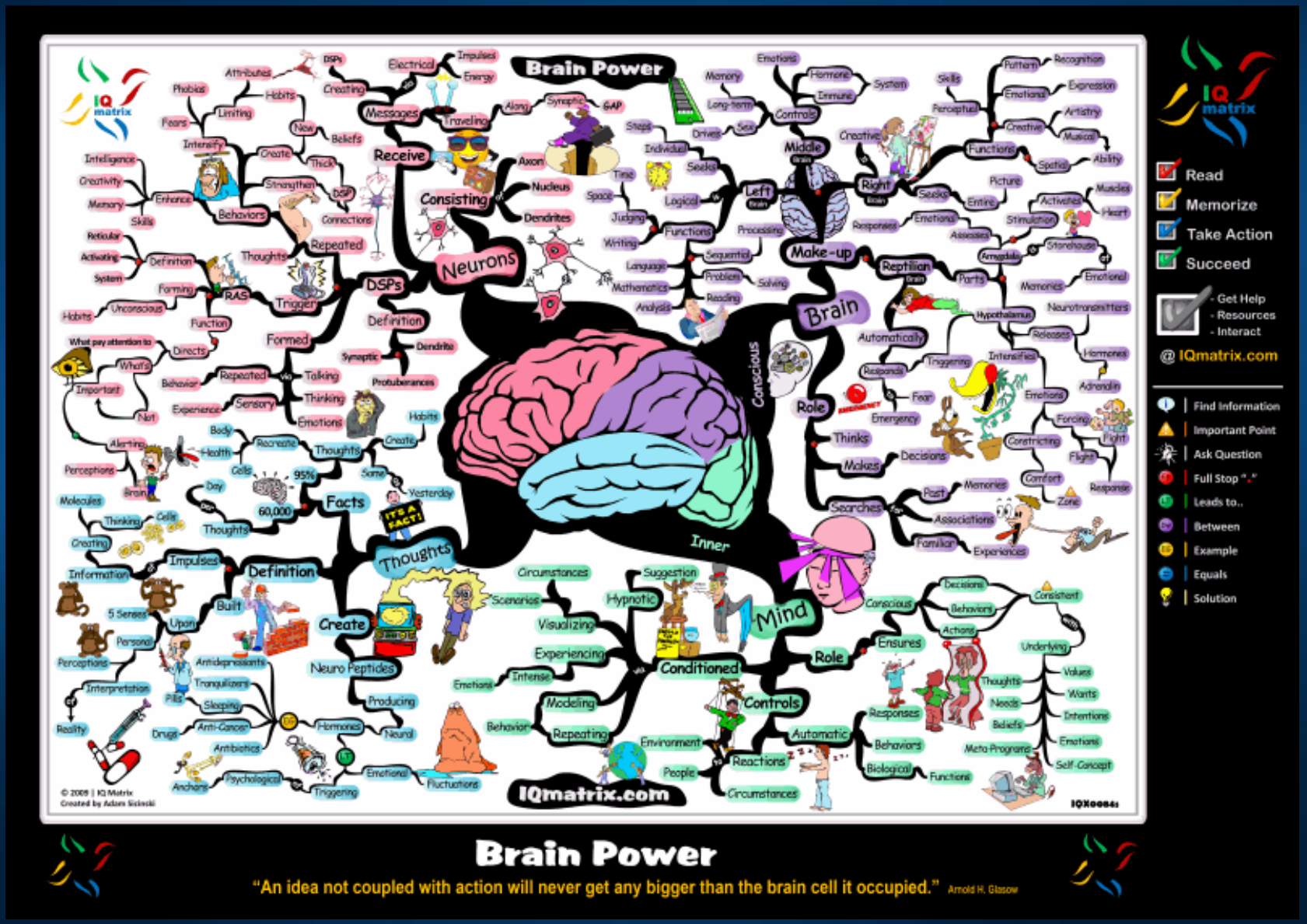


Action-perception networks inferred from ERP and fMRI



Left hemisphere: precise representations of symbols, including phonological components. Right hemisphere sees clusters of concepts, the gist.

Mindmaps: concepts in memory



Brain Power

"An idea not coupled with action will never get any bigger than the brain cell it occupied." Arnold H. Glasow

Narration

Nicole Speer et al.
Reading Stories Activates Neural Repre-sentations of Visual and Motor Experiences. Psychological Science 2009; 20(8): 989–999.

Thought: spatiotemporal pattern

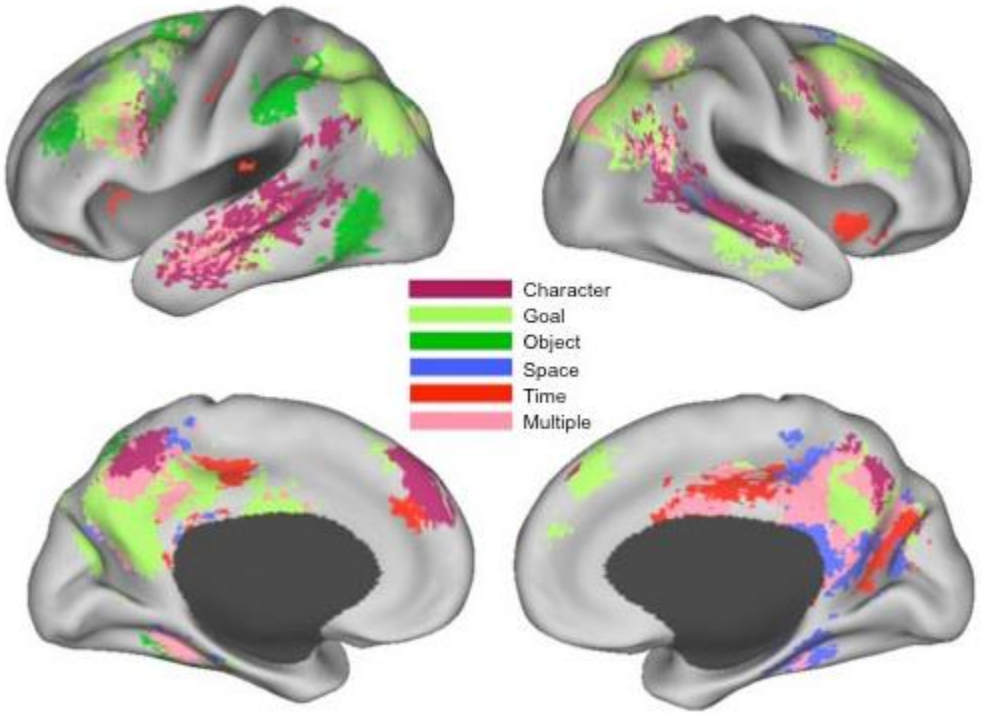
Meaning: always slightly different, depending on the context, but still may be clusterized into relatively small number of distinct meanings.

Sentences: trajectories in semantic space, building scenes, mind models with characters, objects, spatio-temporal relations.

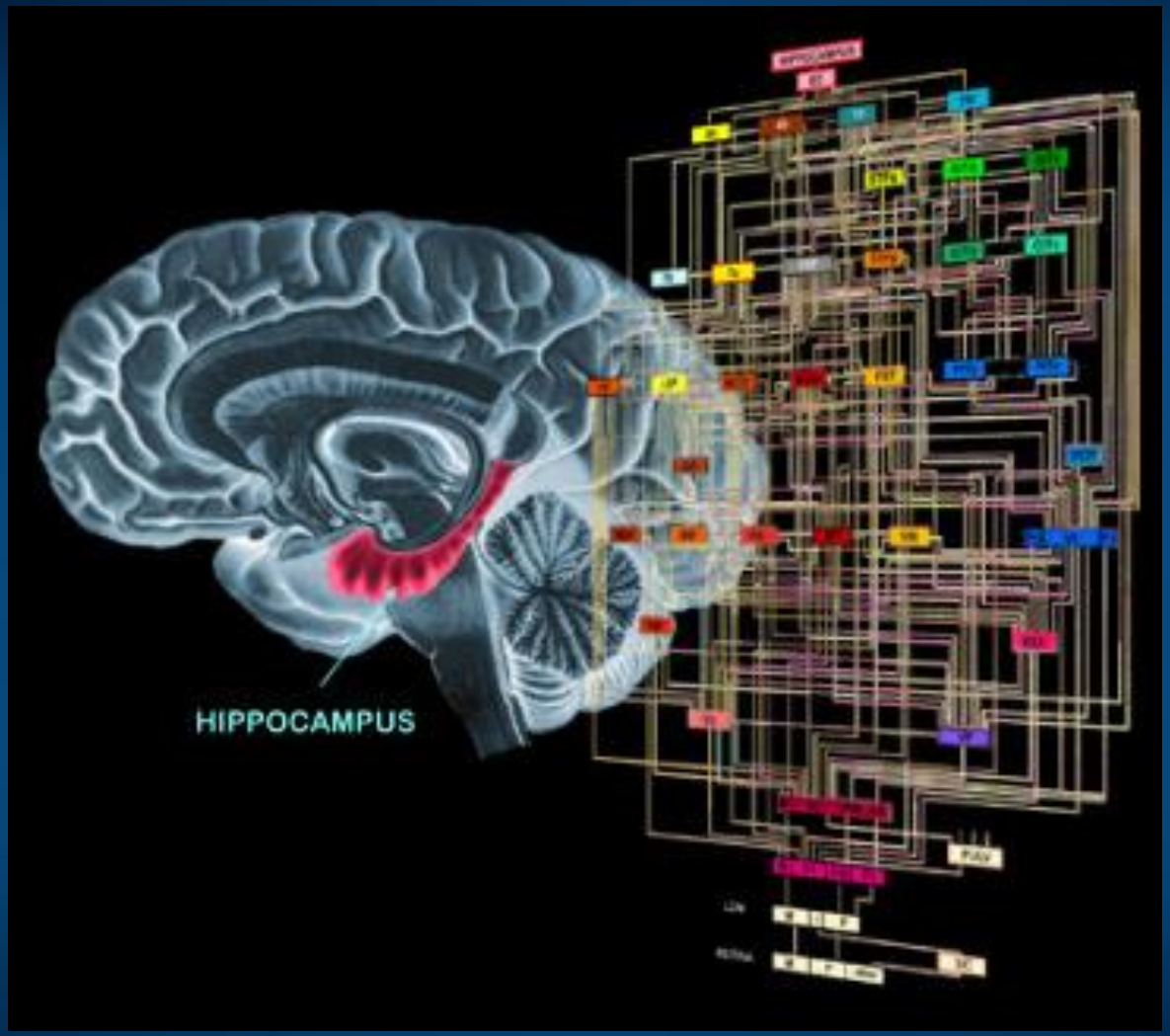
A

Clause	Cause	Character	Goal	Object	Space	Time
...[Mrs. Birch] went through the front door into the kitchen.	●				●	
Mr. Birch came in	●	●			●	
and, after a friendly greeting,	●					●
chatted with her for a minute or so.	●					●
Mrs. Birch needed to awaken Raymond.		●				
Mrs. Birch stepped into Raymond's bedroom,			●		●	
pulled a light cord hanging from the center of the room,				●		
and turned to the bed.						
Mrs. Birch said with pleasant casualness,						
"Raymond, wake up."						
With a little more urgency in her voice she spoke again:						
Son, are you going to school today?						
Raymond didn't respond immediately.		●				●
He screwed up his face			●			
And whimpered a little.						

B

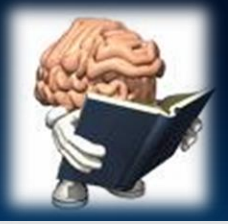


BICA, Brain-Inspired Cognitive Architecture



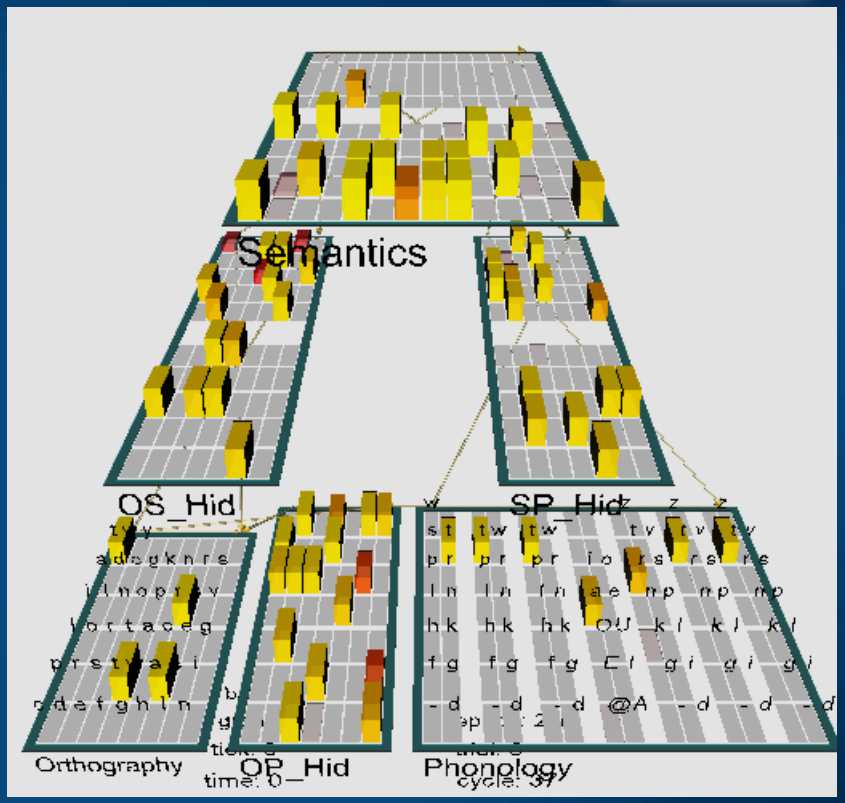
Understanding subtle mental processes requires a model that should show how internal states create narrative “stream of consciousness”.

Model of reading



Emergent neural simulator:

Aisa, B., Mingus, B., and O'Reilly, R. The emergent neural modeling system. Neural Networks, 21, 1045-1212, 2008.



3-layer model of reading:

orthography, phonology, semantics, or distribution of activity over 140 microfeatures of concepts.

Hidden layers in between.

Learning: mapping one of the 3 layers to the other two.

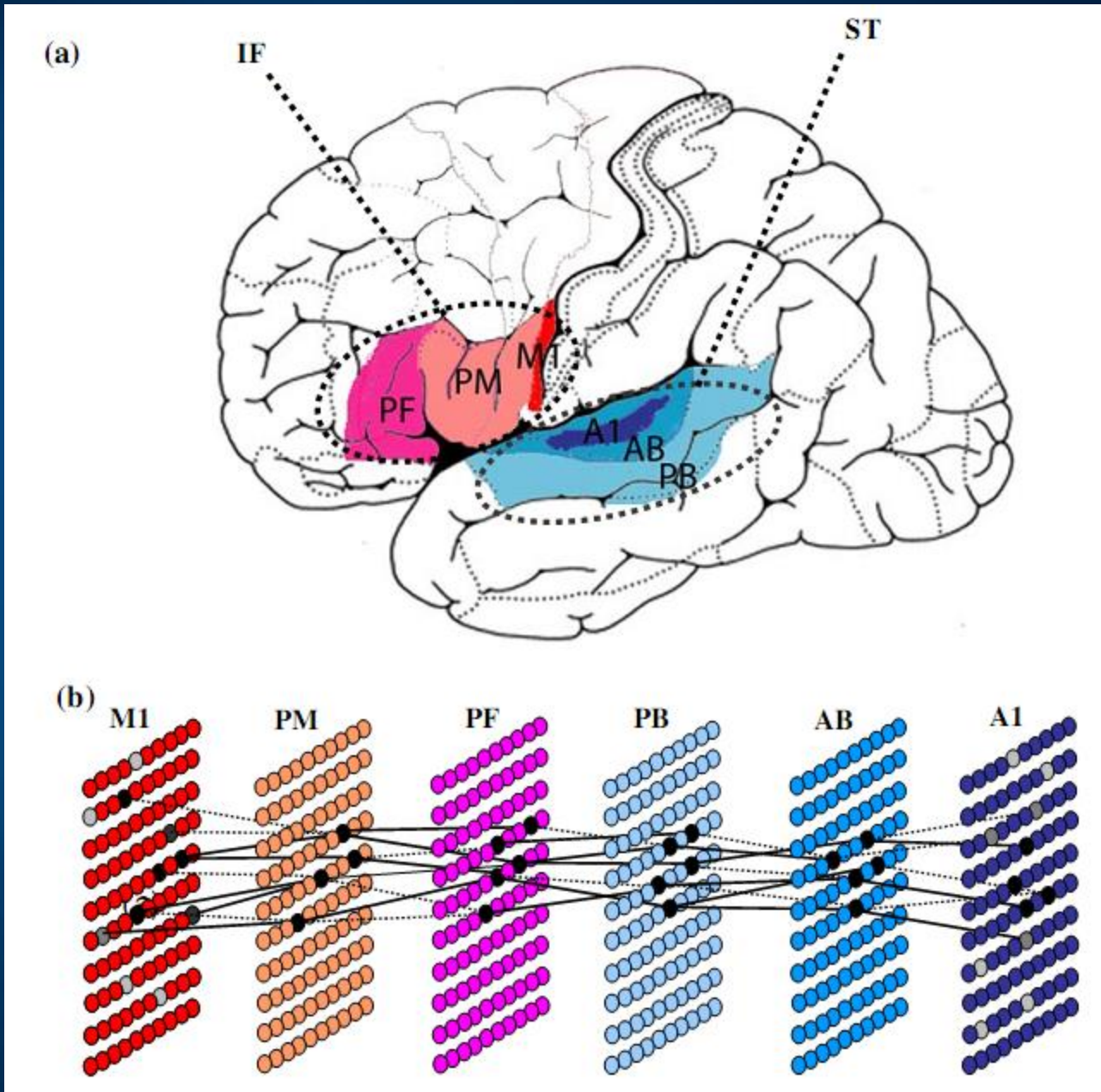
Fluctuations around final configuration = attractors representing concepts.

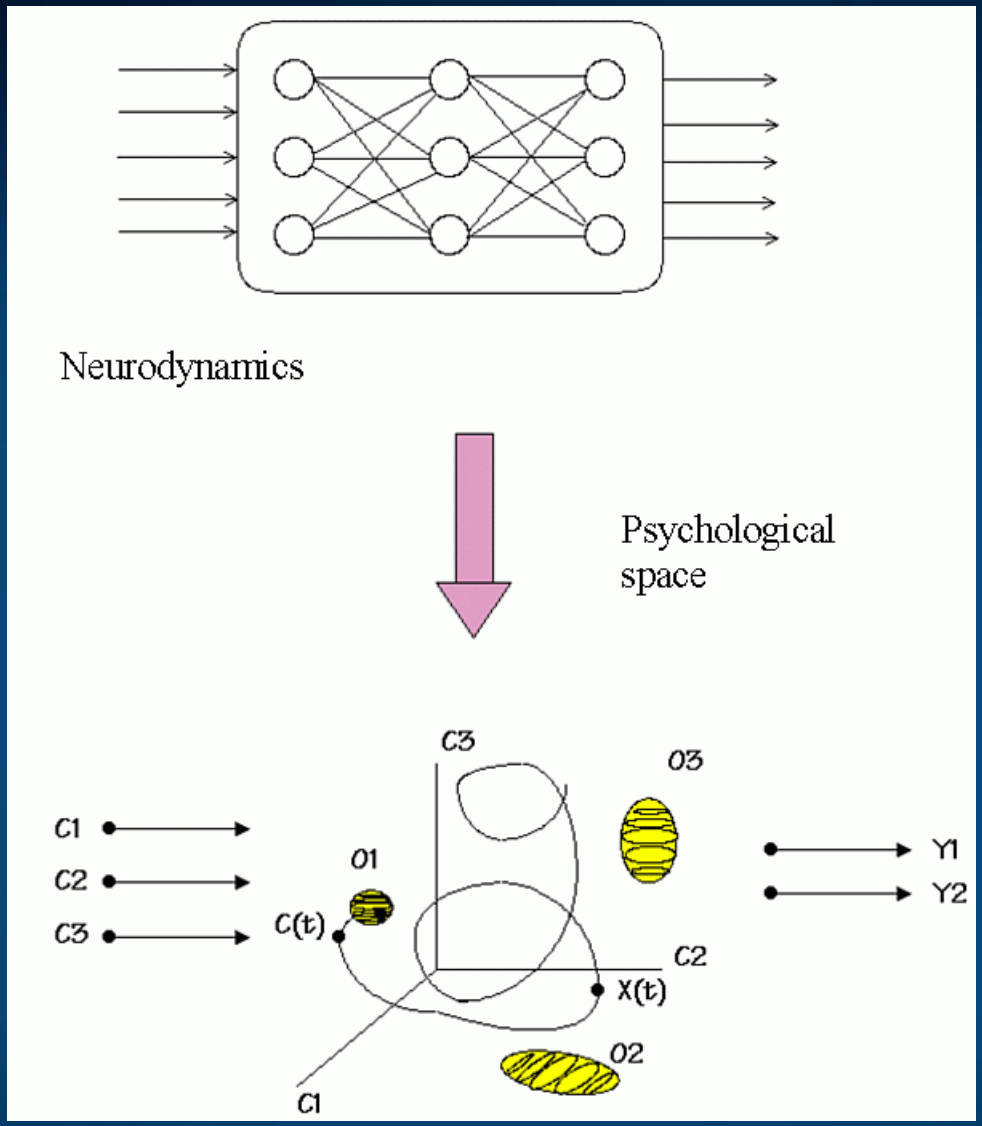
How to see properties of their basins, their relations?

A more detailed model

Garagnani et al. Recruitment and consolidation of cell assemblies for words by way of Hebbian learning and com-petition in a multi-layer neural network, Cognitive Comp. 1(2), 160-176, 2009.

Primary auditory cortex (A1), auditory belt (AB), parabelt (PB, Wernicke's area), inferior pre- frontal (PF) and premotor (PM, Broca), primary motor cortex (M1).



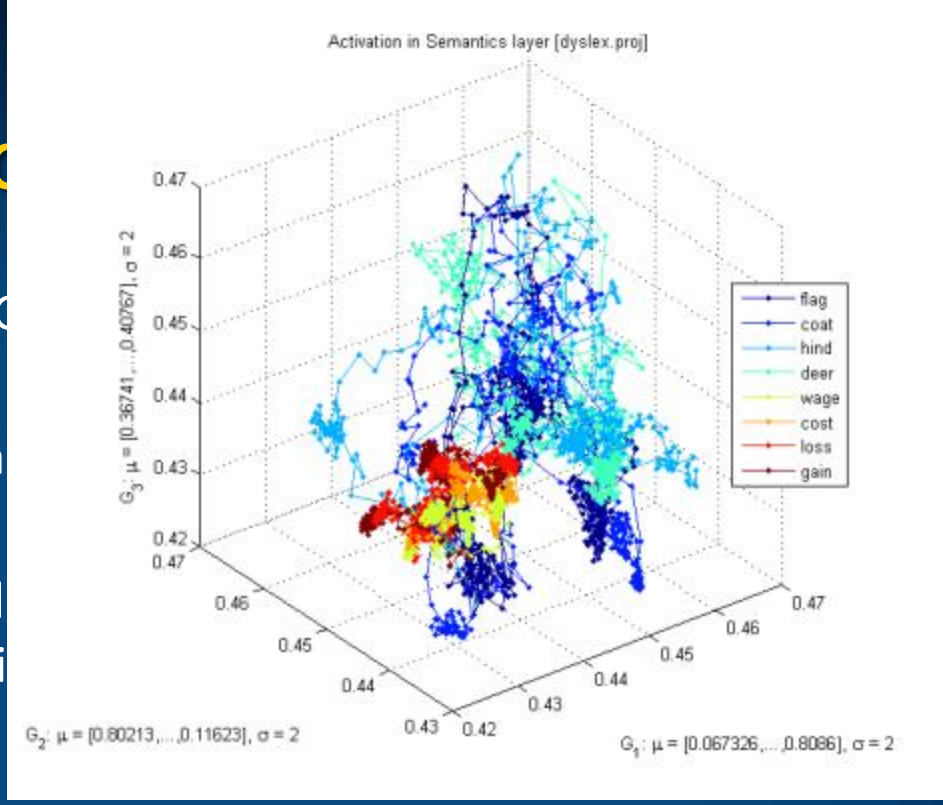


From neurodynamics we will move to dynamics in semantic spaces.
Our Viser Toolbox (Dobosz, Duch et al.) shows such trajectories.

Attrac

Basins of attractors: input activations {LC

- Normal case: relatively large, easy a
  attraction to another, exploring the
- Without accommodation (voltage-d
  basins, hard to move out of the basi

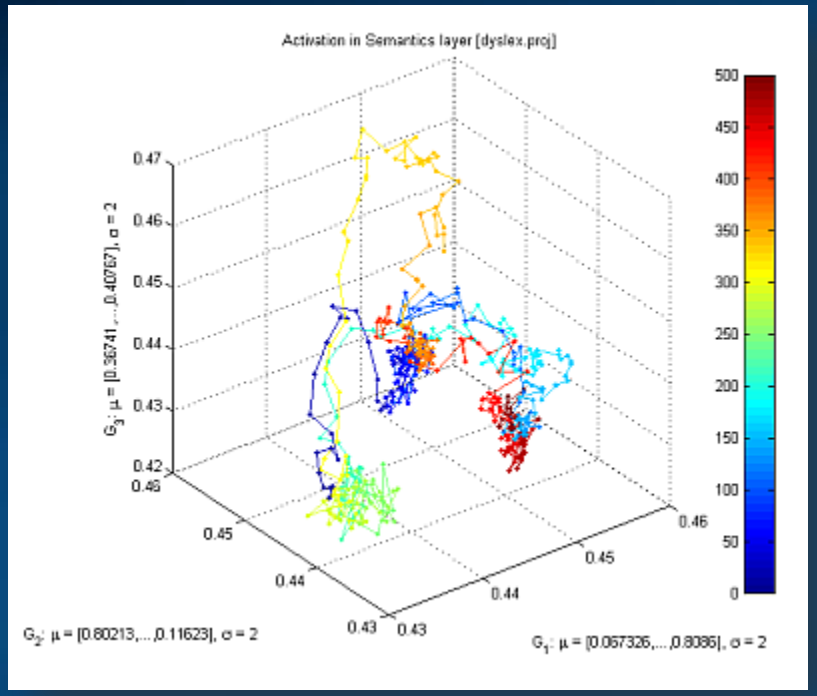


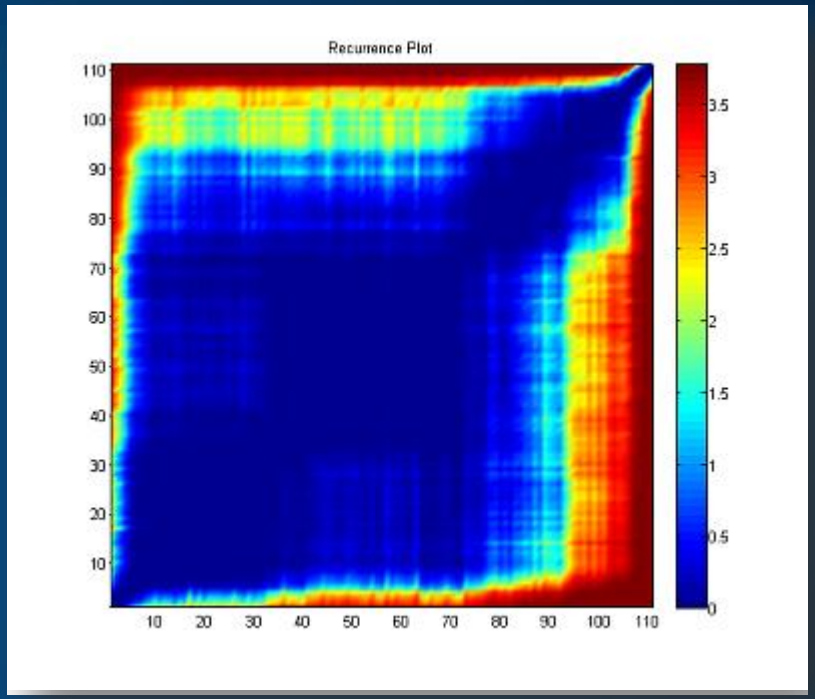
Attention results from:

- inhibitory competition,
- bidirectional interactive processing,
- multiple constraint satisfaction.

Accommodation: basins of attractors shrink and vanish because neurons desynchronize due to the fatigue; this allows other neurons to synchronize, leading to quite unrelated concepts (thoughts).

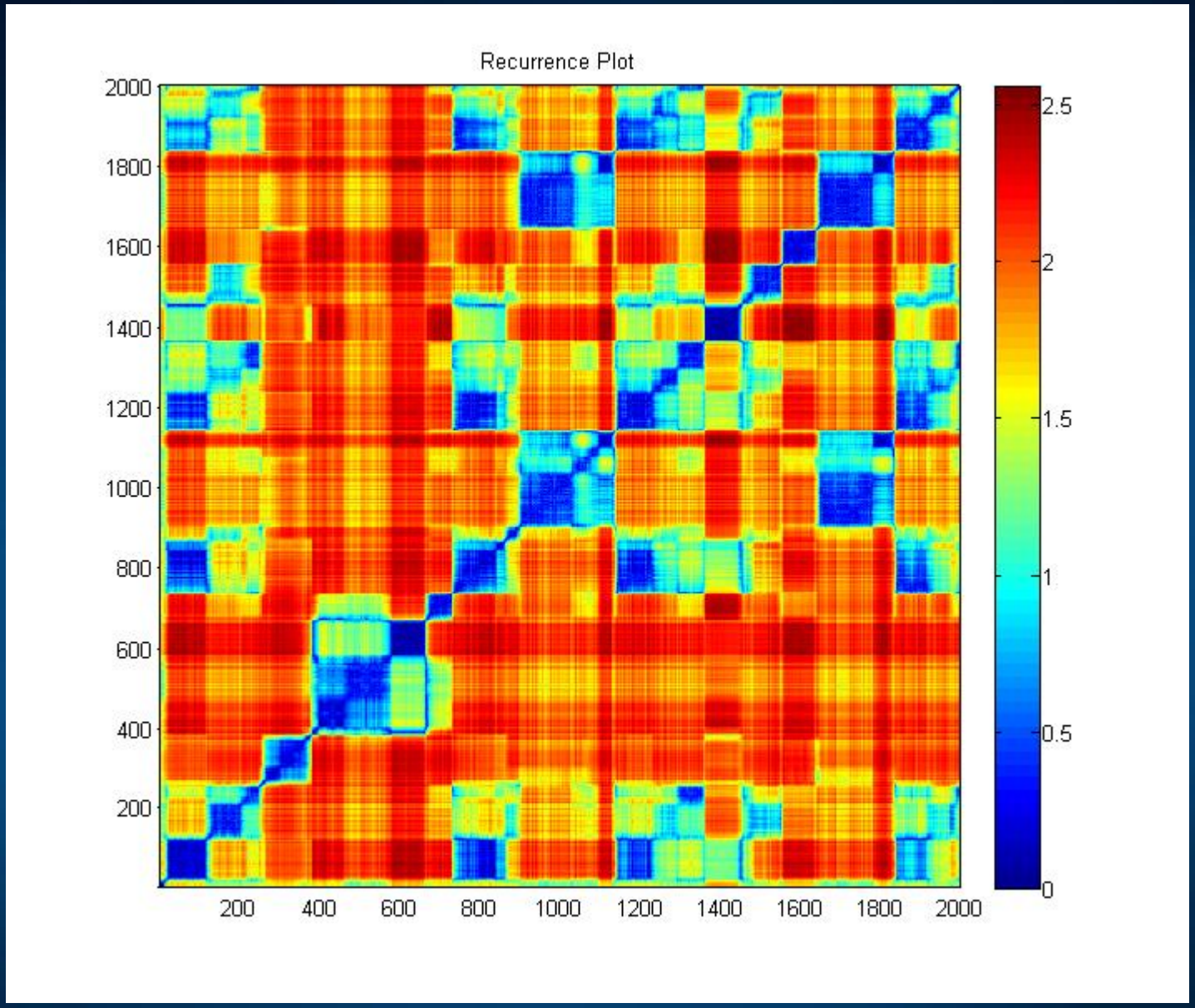
Recurrence plots





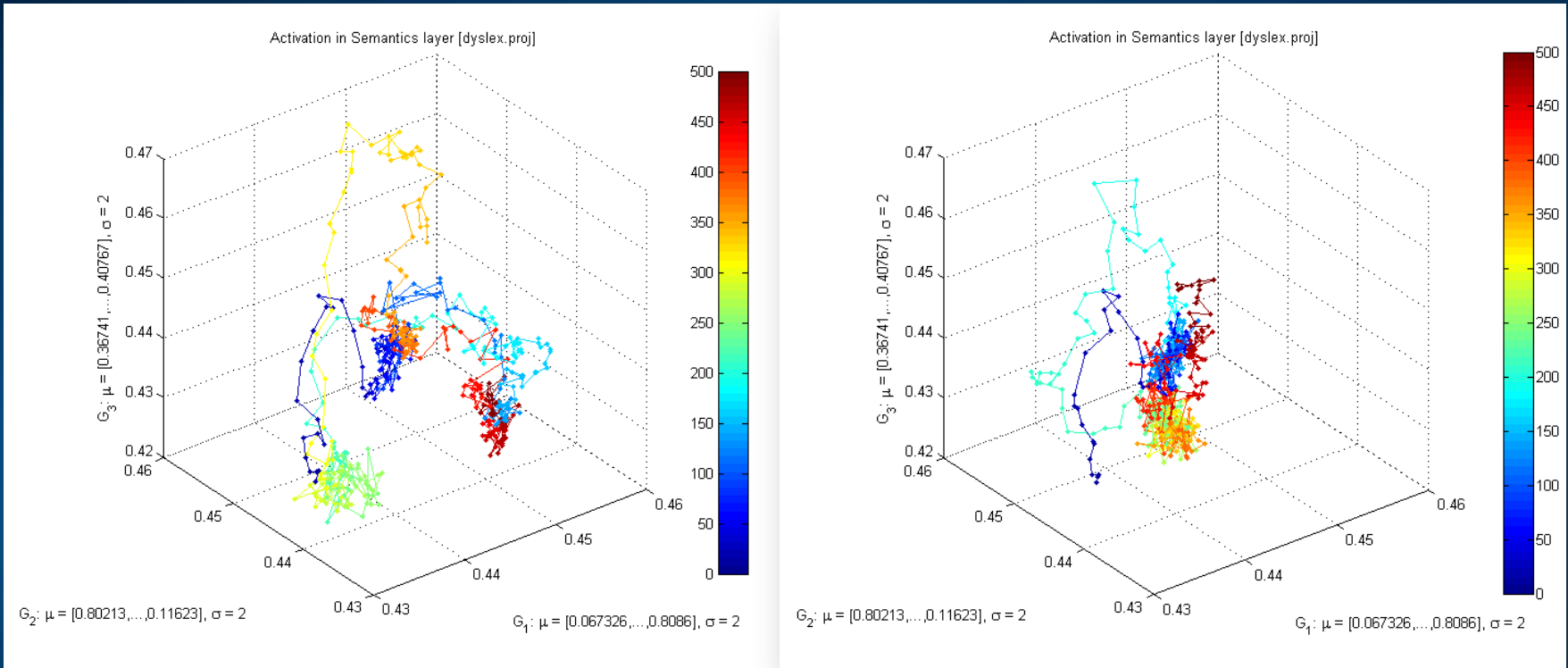
Starting from the word “flag”, with small synaptic noise (var=0.02), the network starts from reaching an attractor and moves to another one (frequently quite distant), creating a “chain of thoughts”.

Same trajectories displayed with recurrence plots, showing roughly 5 larger basins of attractors and some transient points.



Activation of 140 semantic layer units starting from the word „gain”: rapid transitions between a sequence of related concepts is seen.

Normal-Autistic

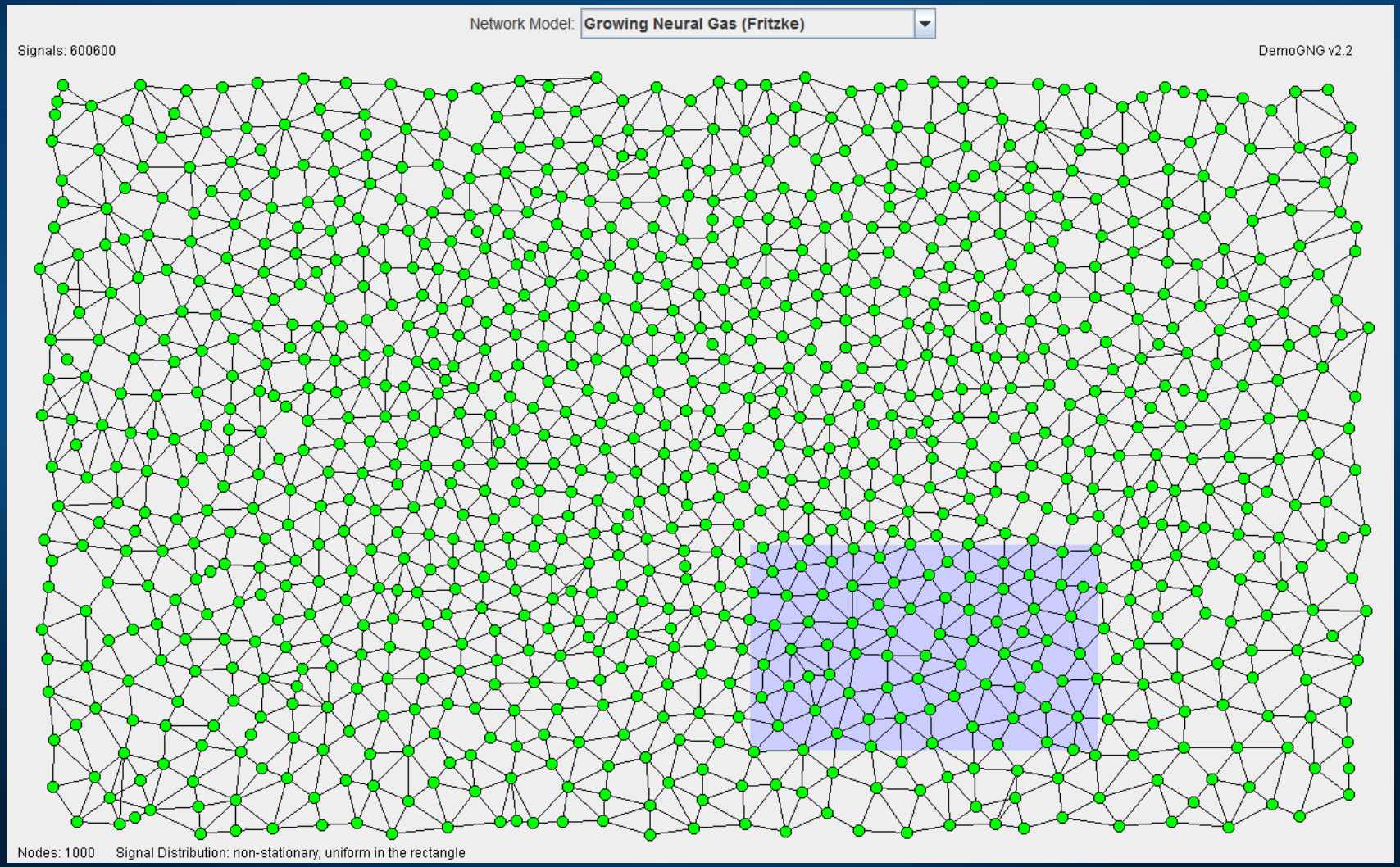


Trajectories of semantic layer (140D) for the word „flag” depends on parameters that control neural depolarization (accomodation).

If spontaneous depolarization is weak (leaky ion channels are dysfunctional) few thought and percepts are generated, leading to the powveryt of mind, concentration on simple and strong stimuli.

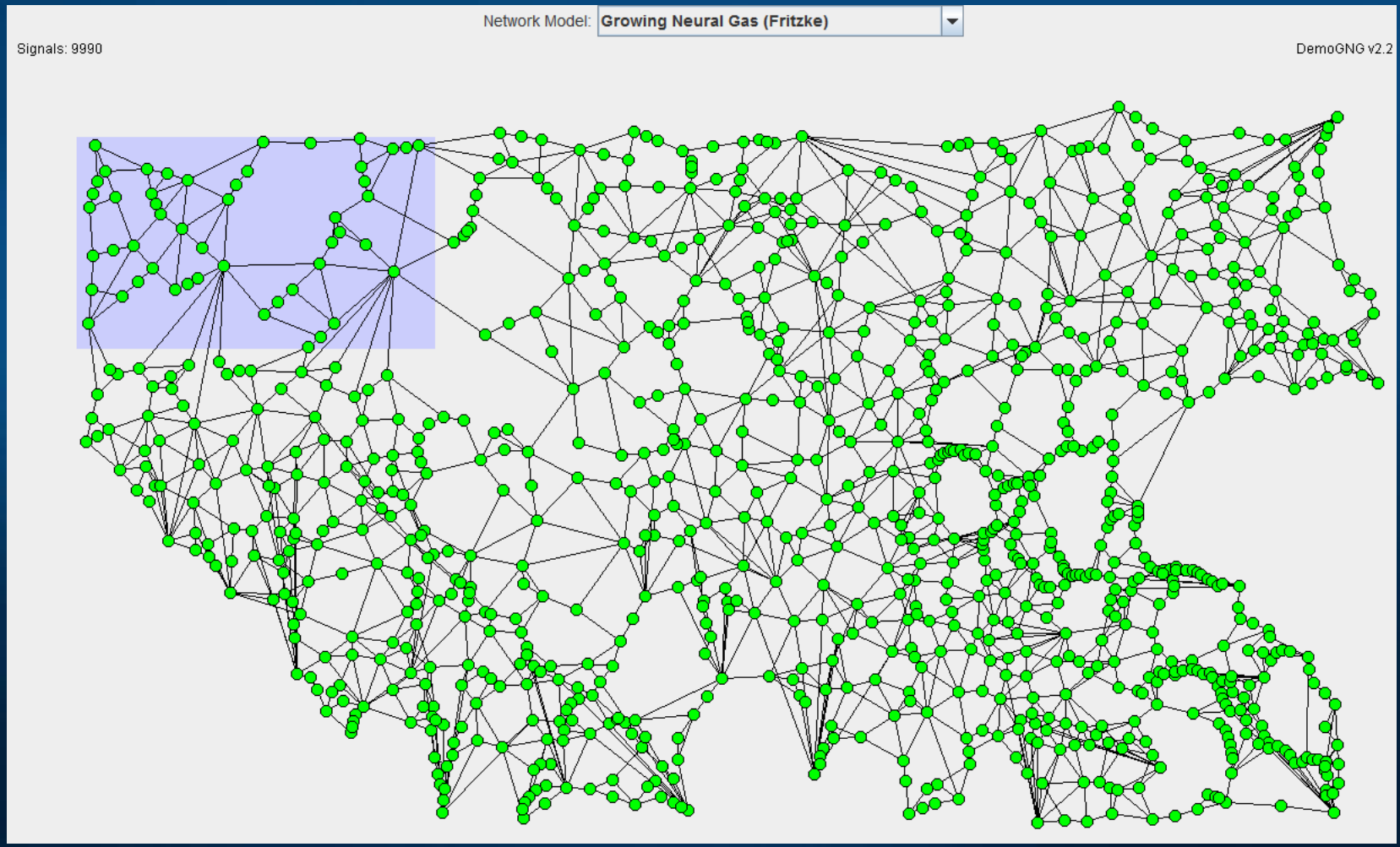
Internalization of environment

Episodes are remembered and serve as reference points, if observations are unbiased they reflect reality.



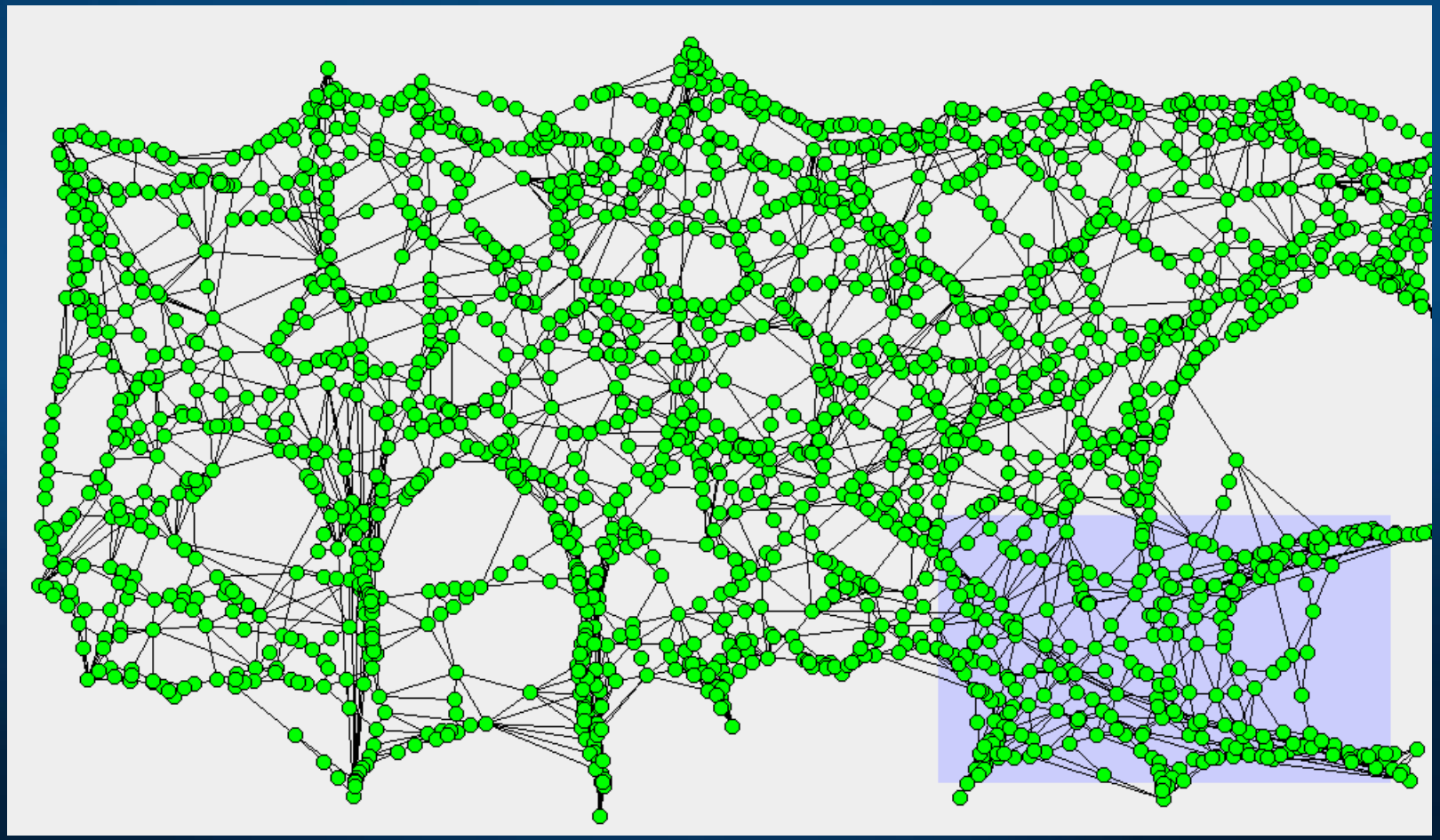
Extreme plasticity

Brain plasticity (learning) is increased if long, Slow strong emotions are involved. Followed by depressive mood it leads to severe distortions, false associations, simplistic understanding.



Conspiracy views

Illuminati, masons, Jews, UFOs, or twisted view of the world leaves big holes and admits simple explanations that save mental energy, creating „sinks” that attract many unrelated episodes.

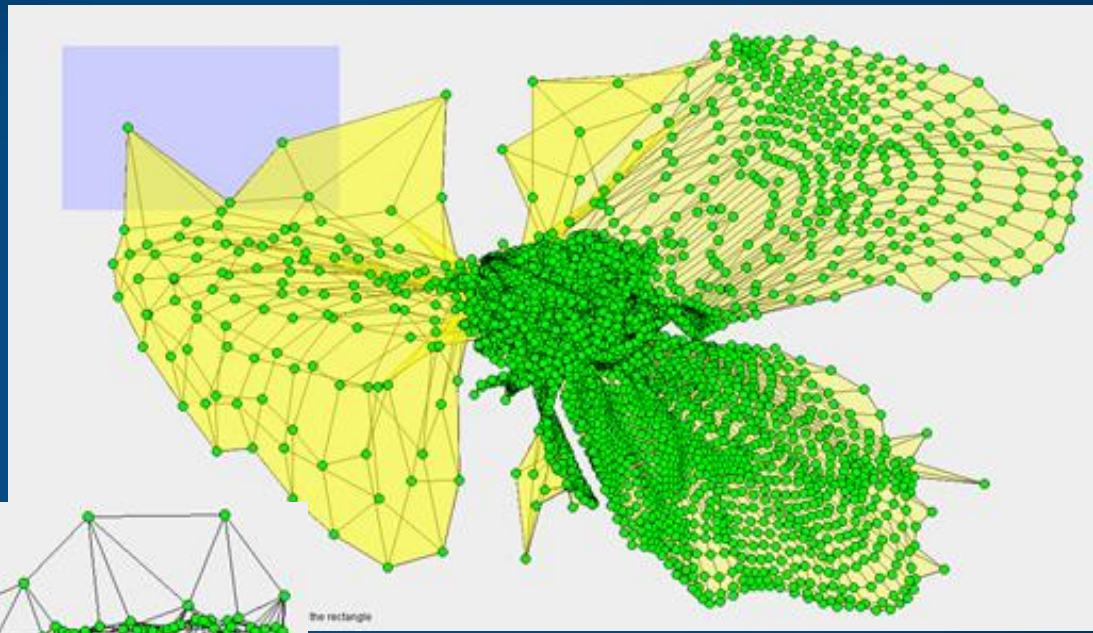


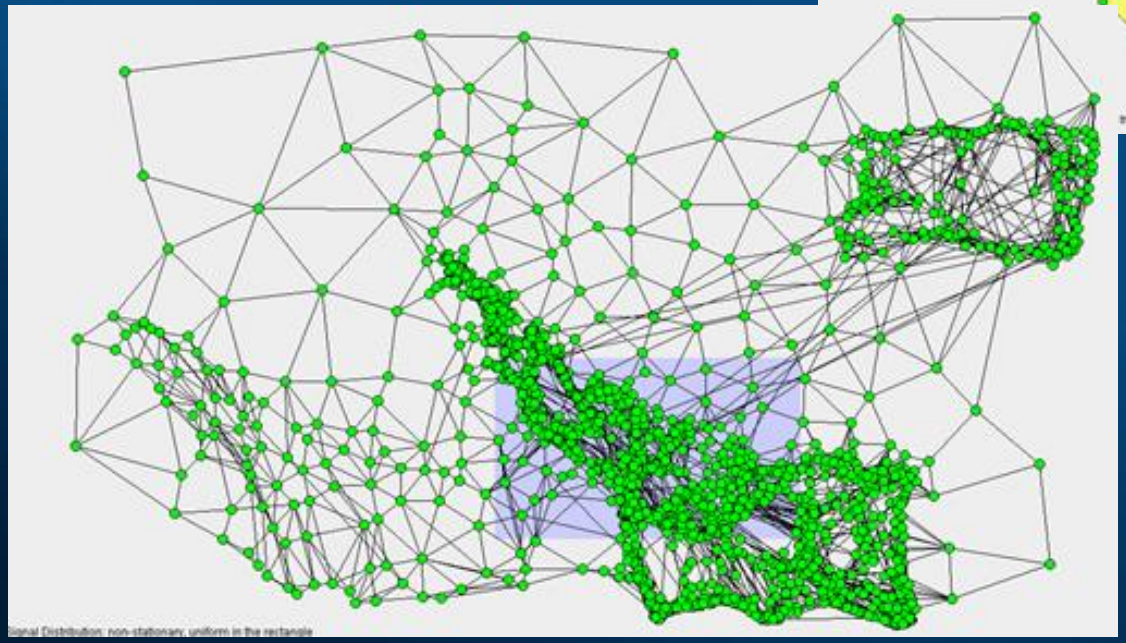
Memoids …

Totally distorted world view, mind changed into a memplex

…

Ready for sacrifice.

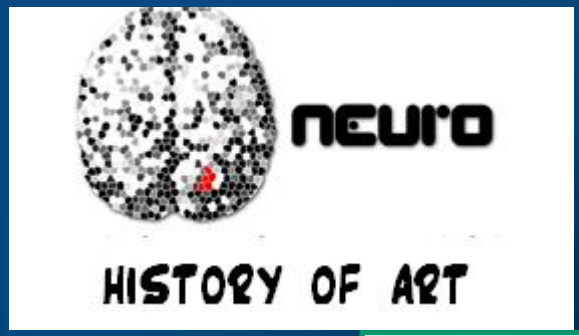




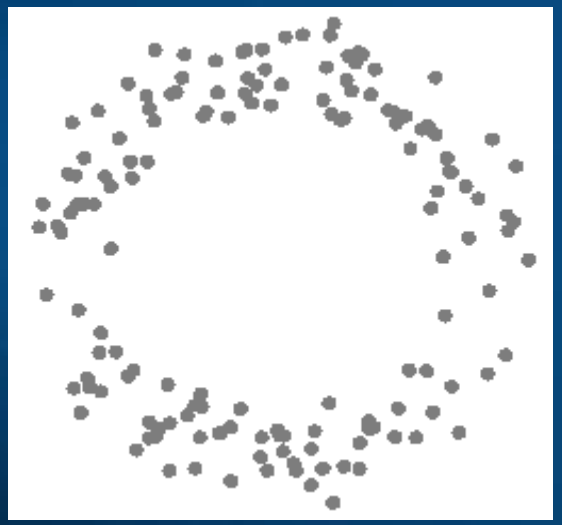
Soul or brain: what makes us human? Interdisciplinary Workshop, Toruń 19-21.10.2016

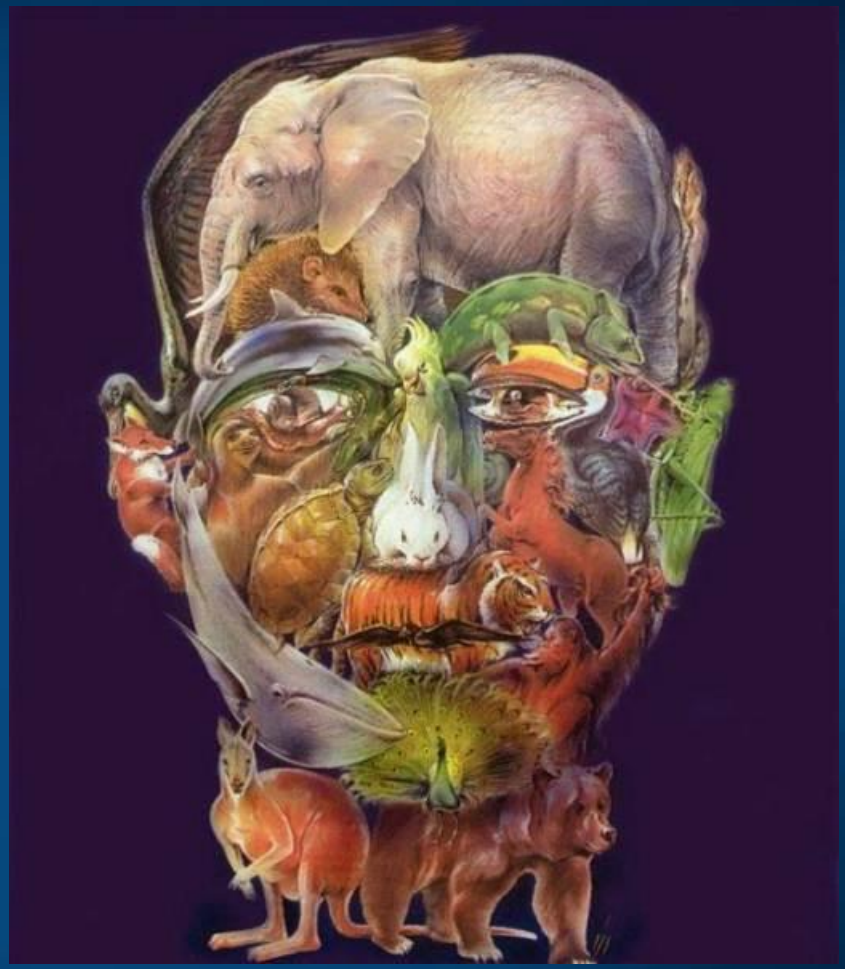
Infants, learning, and cognitive development. 4-5.11.2016

Interdoctor: Disorders of consciousness. 19-21.10.2016



Thank for synchronization of your neurons



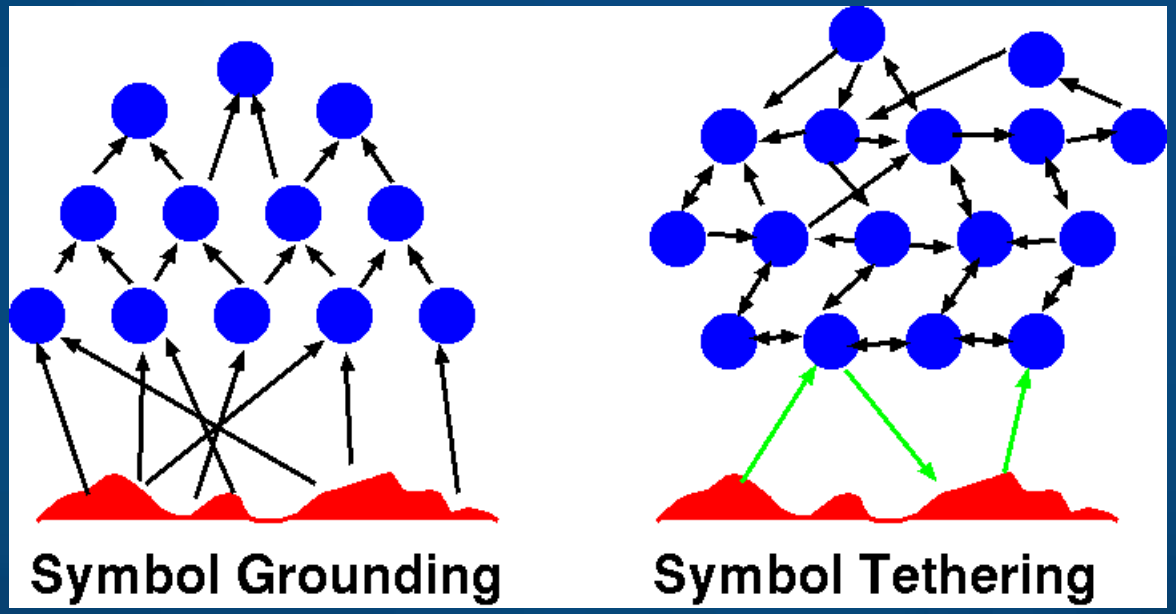


Google: W. Duch
=> talks, papers, lectures …

Where is the meaning?

How should a concept meaning be represented?

- No representations, only senso-motoric embodiment (robotics).
- Only some concepts have shared meaning through embodiment.

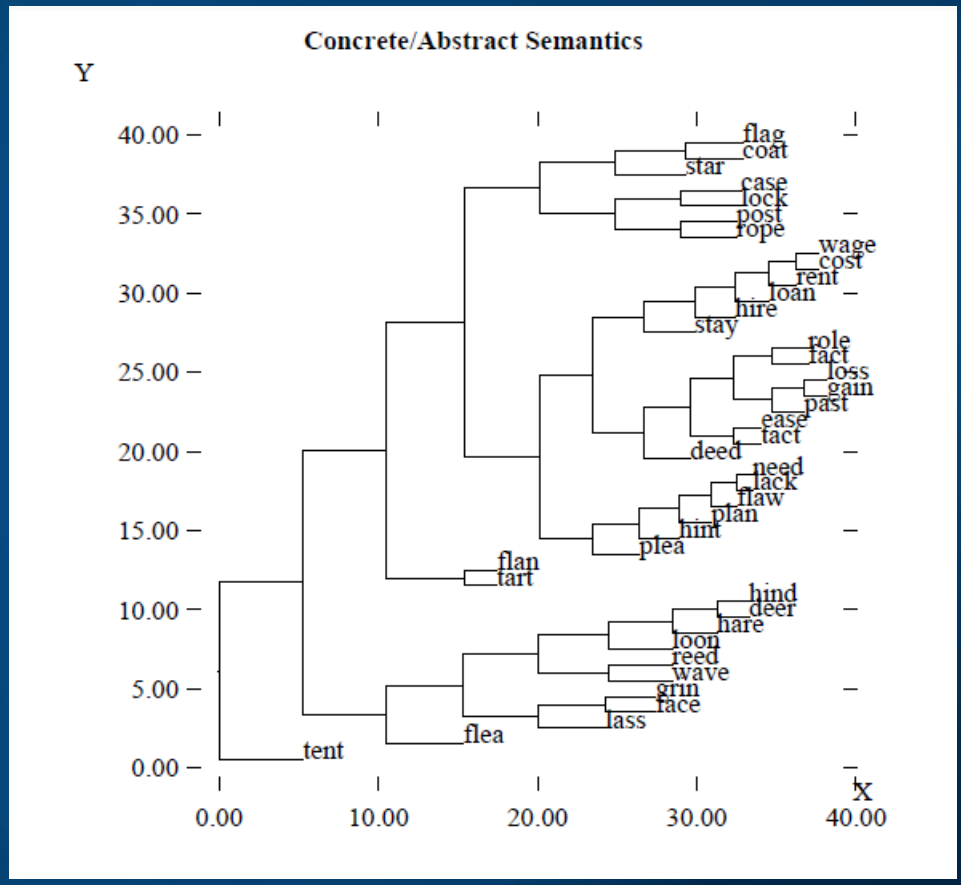


Aaron Sloman (2007): only simple concepts come from our “being in the world”experience, others are compounds, abstract.
David Hume gave good example: “golden mountain”.

Not symbol grounding but symbol tethering, meaning from mutual interactions.

Words to read

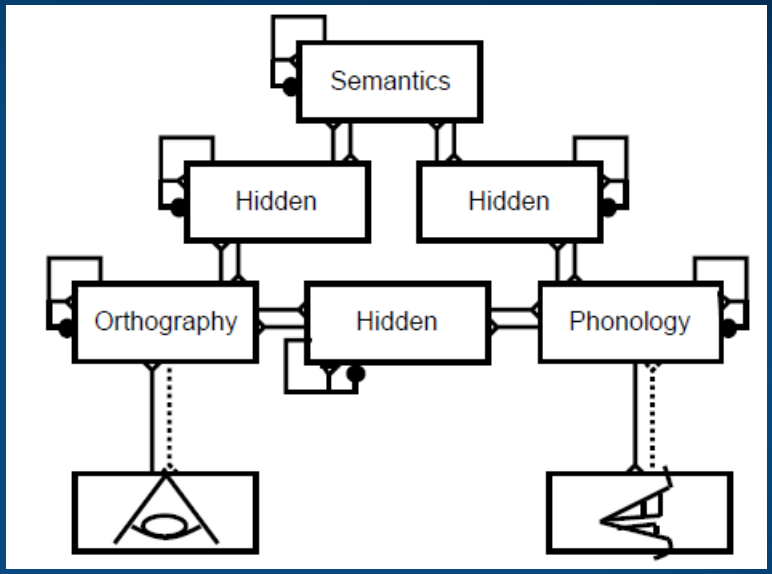
Conc	Phon	Abst	Phon
tart	tttartt	tact	ttt@ktt
tent	tttentt	rent	rrrentt
face	fffAsss	fact	fff@ktt
deer	dddErrr	deed	dddEddd
coat	kkkOttt	cost	kkkostt
grin	grrinnn	gain	gggAnnn
lock	lllakkk	lack	lll@kkk
rope	rrrOppp	role	rrrOlll
hare	hhhArrr	hire	hhhIrrr
lass	lll@sss	loss	lllosss
flan	fllonnn	plan	pll@nnn
hind	hhhIndd	hint	hhhintt
wave	wwwAvvv	wage	wwwAjjj
flea	fllE---	plea	pllE---
star	sttarrr	stay	sttA---
reed	rrrEddd	need	nnnEddd
loon	lllUnnn	loan	lllOnnn
case	kkkAsss	ease	---Ezzz
flag	fll@ggg	flaw	fllo---
post	pppOstt	past	ppp@stt



40 words, 20 abstract & 20 concrete; dendrogram shows similarity in phonological and semantic layers after training.

Reading and dyslexia

Phonological dyslexia: deficit in reading pronounceable nonwords (e.g., “nust” (Wernicke).



Deep dyslexia like phonological dyslexia + significant levels of semantic errors, reading for ex. “dog” as “cat”.

Surface dyslexia: preserved ability to read nonwords, impairments in retrieving semantic information from written words, difficulty in reading exception, low-frequency words, ex. “yacht.” Surface dyslexia - visual errors, but not semantic errors. .

Double route model of dyslexia includes orthography, phonology, and semantic layers, direct ortho=Phono route and indirect ortho => semantics => phono, allowing to pronounce rare words.