What is needed to fully understand mental processes?

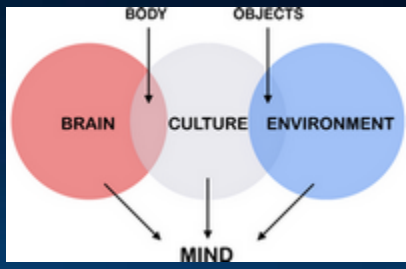
Włodzisław Duch

Neurocognitive Laboratory,
Center for Modern Interdisciplinary Technologies,
Dept. of Informatics, Faculty of Physics, Astronomy & Informatics,
Nicolaus Copernicus University

Google: Wlodek Duch

XIII Congress of the Polish Society for Cognitive Science, Toruń, 23-25.09.2021

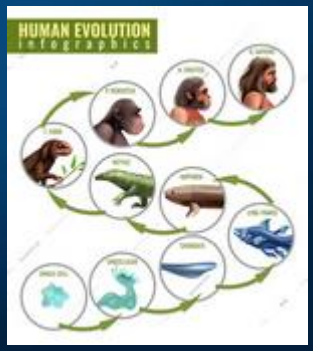
CS 4 Key Questions



"First, you can't begin to understand things like aggression, competition, cooperation, and empathy without biology" (R. Sapolsky. Behave, 2017).

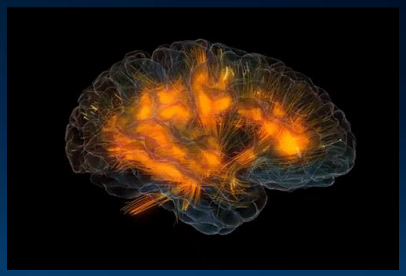
Four key questions for cognitive science and their timescales:

1. How mental states arise from specific activity of the brain networks? Millisecond to second scale – neurodynamics.
2. How the state of the brain changes due to interactions with the environment? Minutes to hours – priming, learning, hormones.
3. How brain activity arises from the state of the whole organism? Hours to years – neuroplasticity, developmental and aging processes.
4. How has it all came about? Millenia, eras and eons. Deep history of ourselves (J. Le Doux) – evolution.



Ad. 1/2. Duch W. (2012) Mind-Brain Relations, Geometric Perspective and Neurophenomenology, American Philosophical Association Newsletter 12(1).

Explanations



Seconds

Minutes

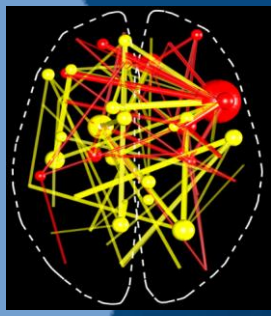
Days

Month

Years

Millenia

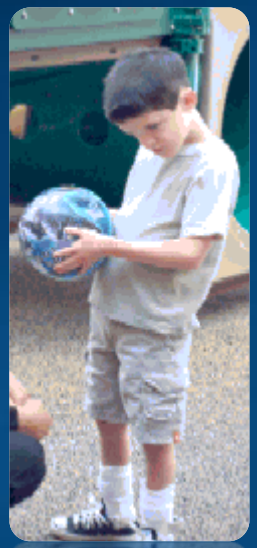
Eras/Eons

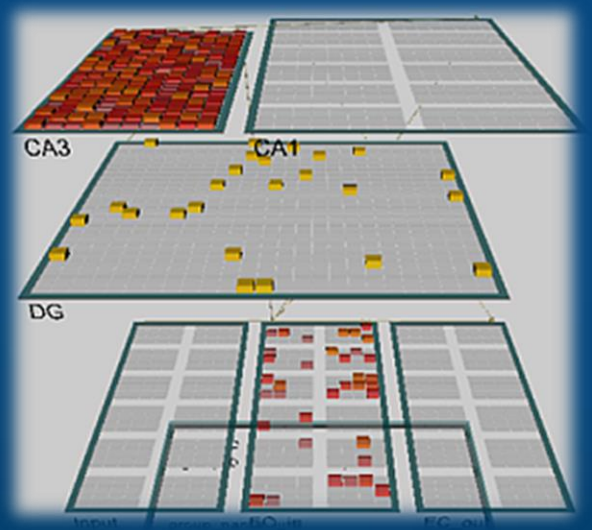


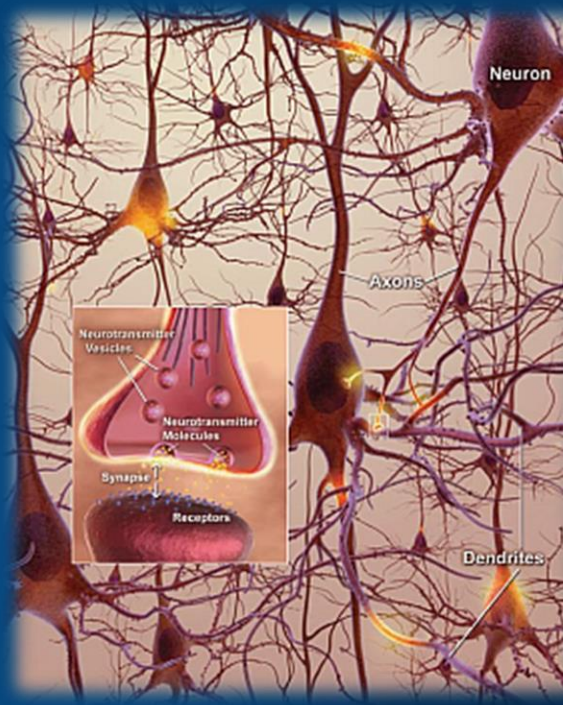
Cognitive phenomics, fast/slow: neurodynamics, hormones, education, culture, infancy, gestation and evolution.

Mind/brain phenomics

From Behavior to Neurons

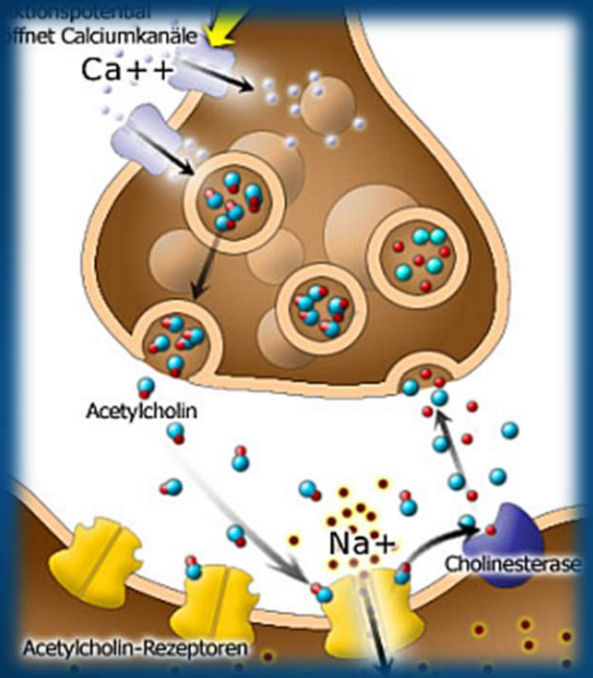


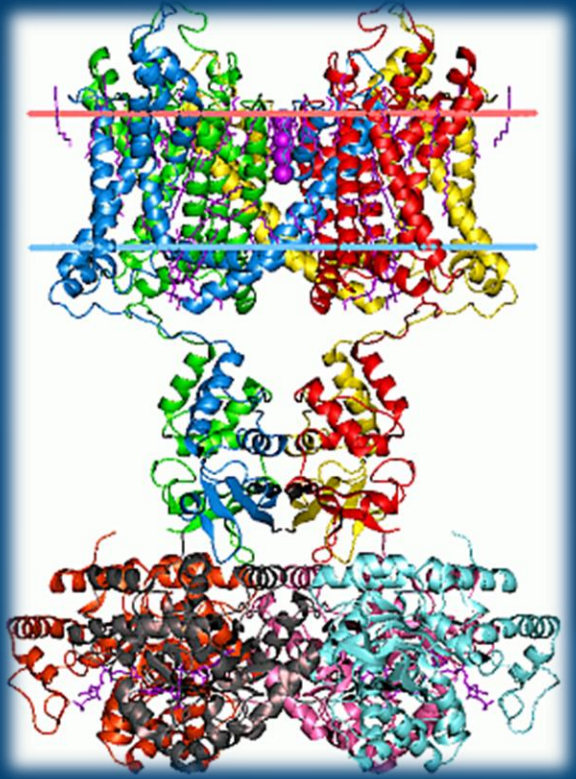


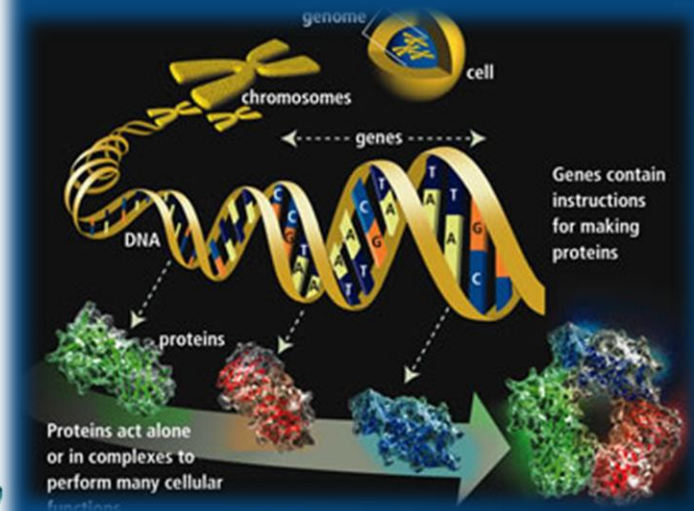


cognitive phenotypes, (abnormal) behavior
=> network structure **=> neurodynamics** => neuron properties
=> synapses, soma, receptors, ion channels => proteins => genes

From Genes to Neurons







cognitive phenotypes, behavior
=> network structure => neurodynamics => neuron properties
=> synapses, soma, receptors, ion channels => proteins => genes

Neuropsychiatric phenomics

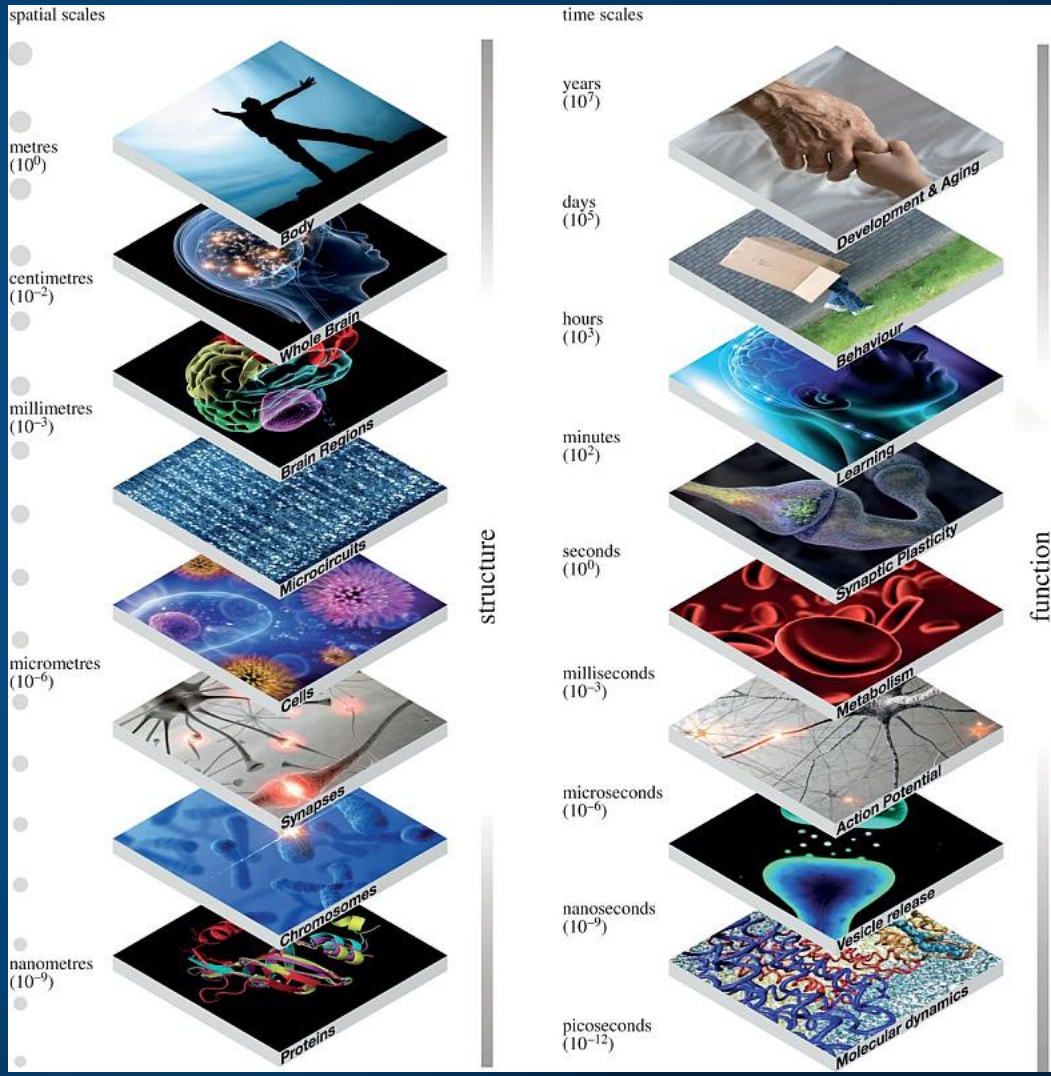
2008: The Consortium for Neuropsychiatric Phenomics

"… categories, based upon presenting signs and symptoms, may not capture fundamental underlying mechanisms of dysfunction" (Insel et al., 2010).

New approach: RDOC NIMH.

Description of organisms at different levels will help to answer different types of questions.

Network level is in the middle and can be connected to the mental level via computational models.

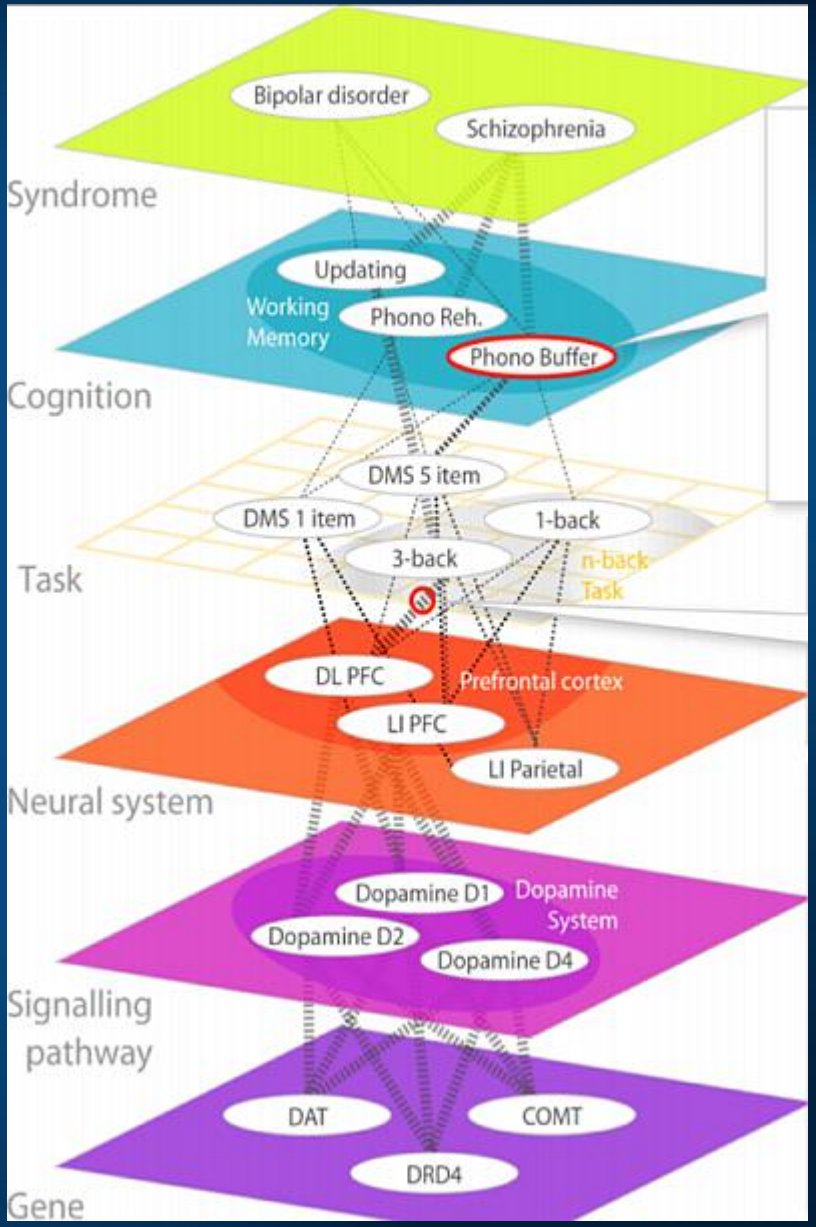


Neuropsychiatric Phenomics Levels

According to
The Consortium for Neuropsychiatric Phenomics (CNP)
http://www.phenomics.ucla.edu

From genes to molecules to neurons and their systems to tasks, cognitive subsystems and syndromes.

Neurons and networks are right in the middle of this hierarchy.



RDoC
Research Domain Criteria Initiative

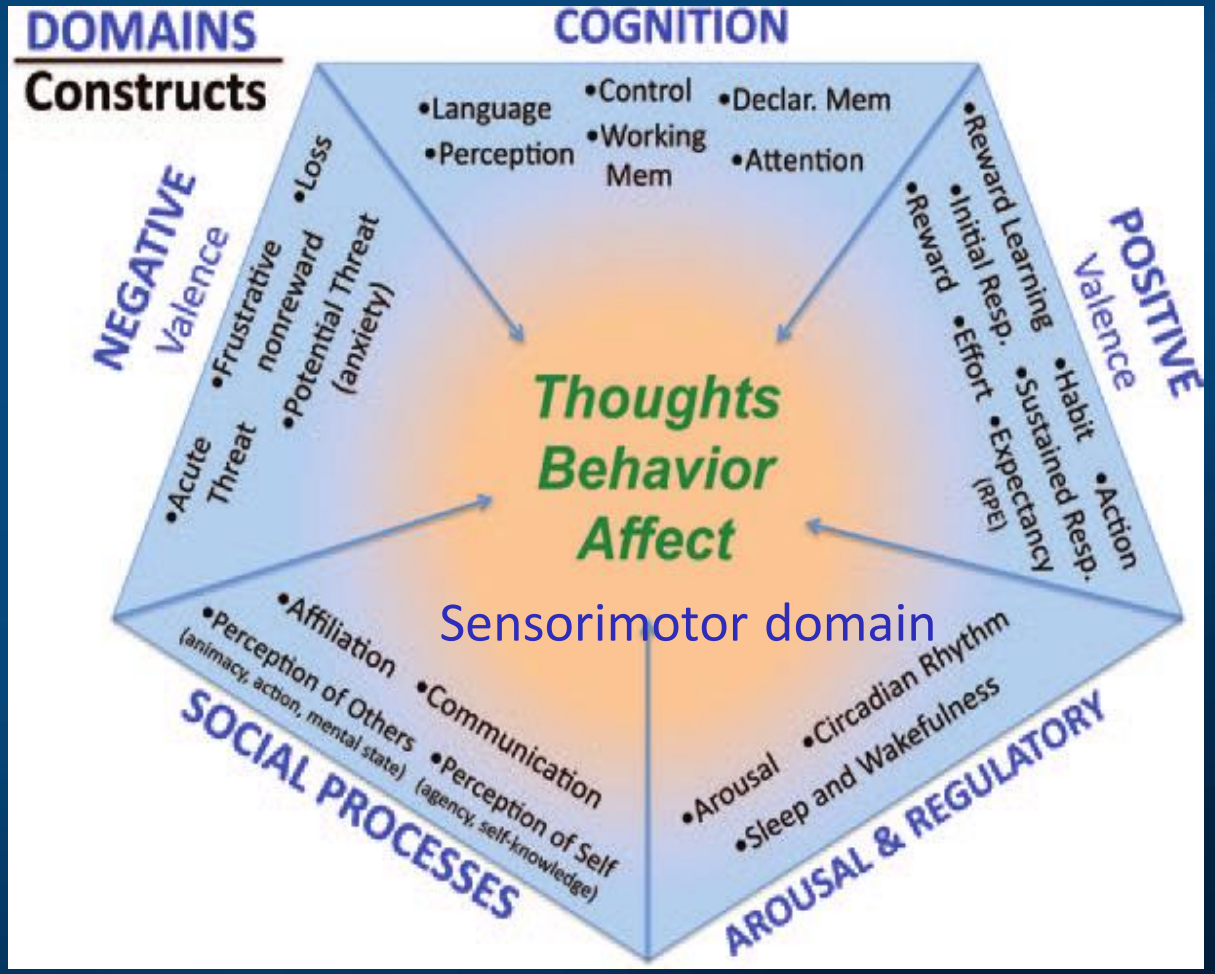
NIMH RDoC Matrix for analysis of (de)regulation of 6 large brain systems.

Psychological constructs are necessary to talk about mental states.

Regulation of these 6 large networks forms the basis of all human behavior.

Sensorimotor systems added in Jan. 2019 as the sixth brain system.

How are these functions implemented in the brain and what contributes to their activity?

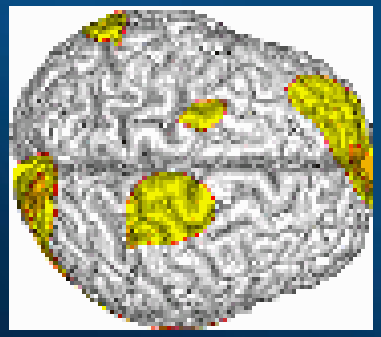


RDoC Matrix for „cognitive domain”

Construct/Subconstruct		Genes	Molecules	Cells	Circuits	Physiology	Behavior	Self-Report	Paradigms
Attention		Elements	Elements	Elements	Elements	Elements	Elements		Elements
Perception	Visual Perception	Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
	Auditory Perception	Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
	Olfactory/Somatosensory/Multimodal/Perception								Elements
Declarative Memory		Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
Language		Elements			Elements	Elements	Elements	Elements	Elements
Cognitive Control	Goal Selection; Updating, Representation, and Maintenance ⇒ Focus 1 of 2 ⇒ Goal Selection				Elements			Elements	Elements
	Goal Selection; Updating, Representation, and Maintenance ⇒ Focus 2 of 2 ⇒ Updating, Representation, and Maintenance	Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
	Response Selection; Inhibition/Suppression ⇒ Focus 1 of 2 ⇒ Response Selection	Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
	Response Selection; Inhibition/Suppression ⇒ Focus 2 of 2 ⇒ Inhibition/Suppression	Elements	Elements	Elements	Elements	Elements	Elements	Elements	Elements
	Performance Monitoring	Elements	Elements		Elements	Elements	Elements	Elements	Elements
Working Memory	Active Maintenance	Elements	Elements	Elements	Elements	Elements			Elements
	Flexible Updating	Elements	Elements	Elements	Elements	Elements			Elements
	Limited Capacity	Elements	Elements		Elements	Elements			Elements
	Interference Control	Elements	Elements	Elements	Elements	Elements			Elements

Concepts and reality

Psychological constructs,
such as memory or attention, try to group continuous brain processes into common patterns, adding more specific constructs.



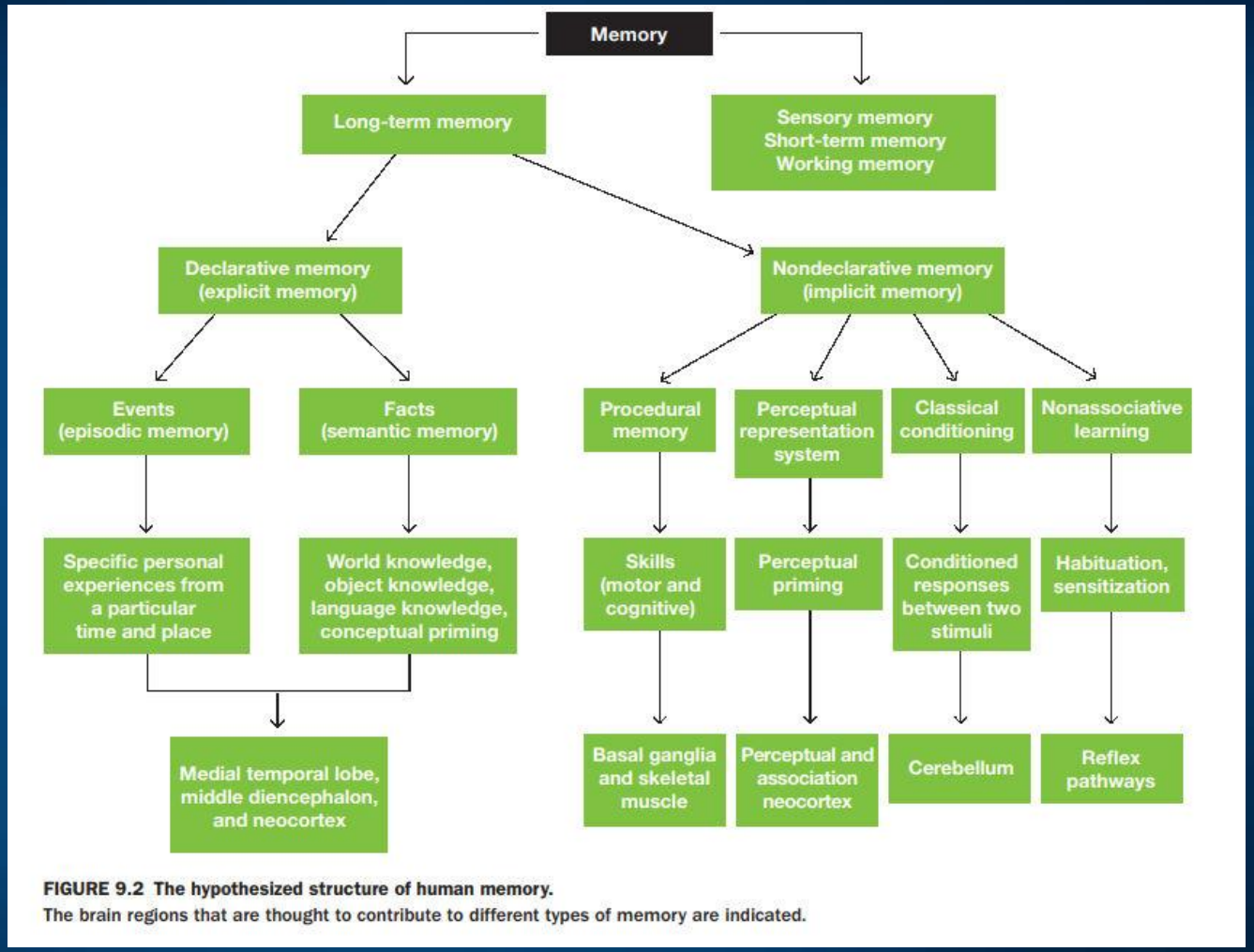


FIGURE 9.2 The hypothesized structure of human memory.
The brain regions that are thought to contribute to different types of memory are indicated.

Fig. from: Cognitive Neuroscience. The Biology of the Mind 5th ed, M Gazzaniga, 2019
Duch W. (2018), Kurt Lewin, psychological constructs and sources of brain cognitive activity.

Cognitive Atlas

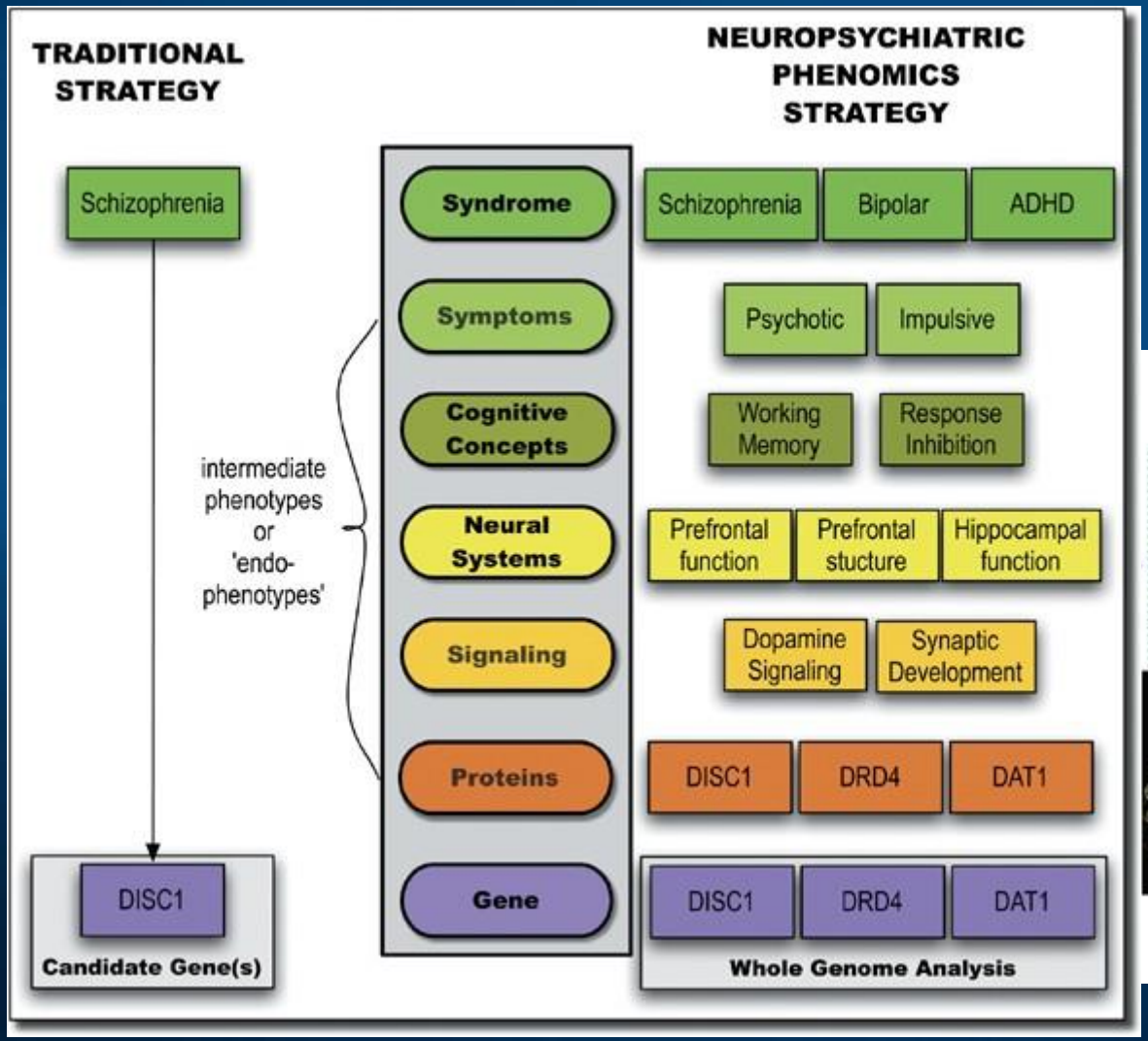
Collaborative knowledge building project to develop ontology of cognitive science (coordinated by Russel Poldrack/NIMH).

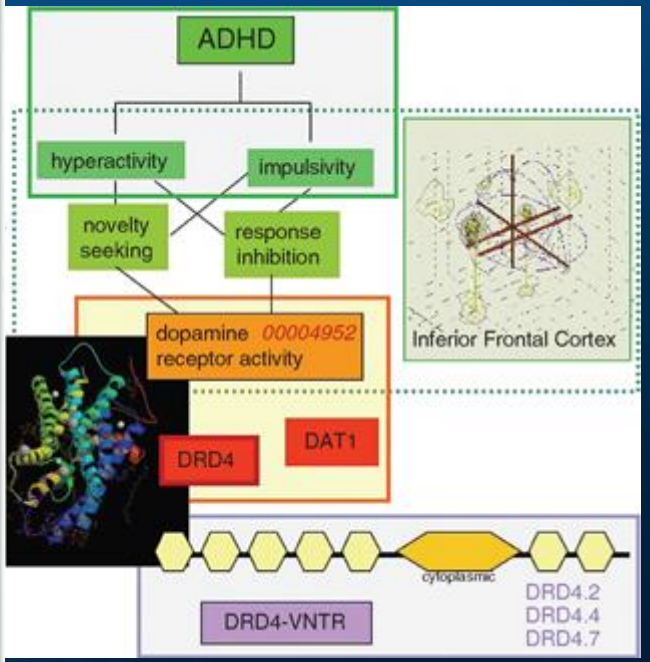
Concepts are related to both physical and mental level.

Theories are linked to NIMH RDoC and Neurosynth.

NIMH Strategy

This approach ignores environment, epigenetic influences, developmental processes that determine structure and function of brain networks.



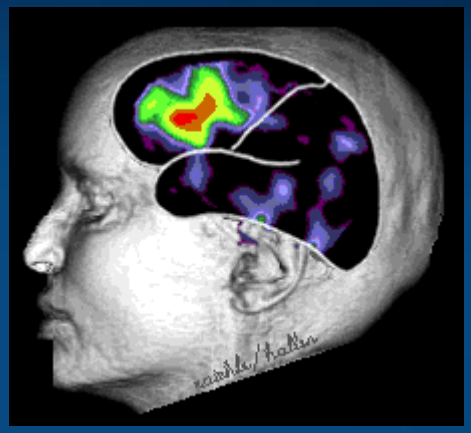


Brains ⇔ Minds

Define mapping S(M)⇔S(B). BCI: intentions => actions. How do we describe the state of mind?

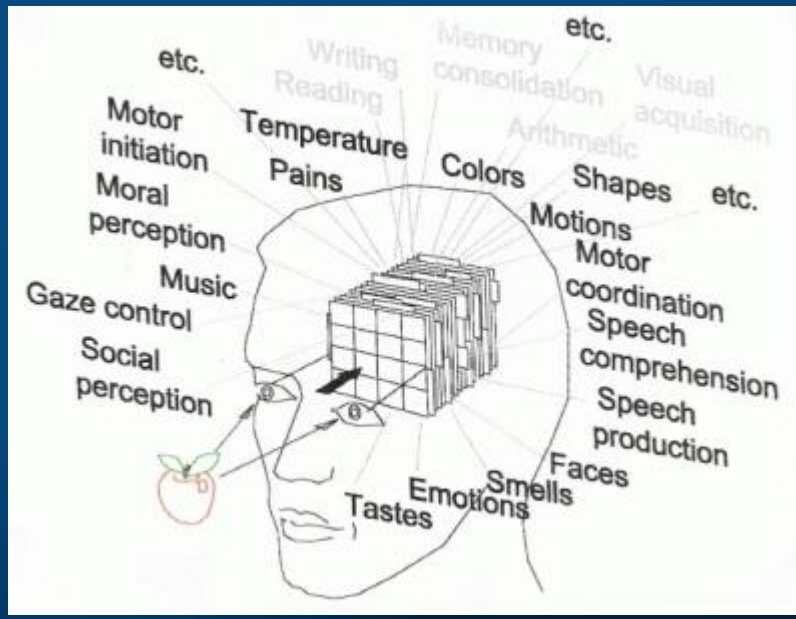
Verbal description is not sufficient unless words are represented in a space with dimensions that measure different aspects of experience.

Stream of mental states, movement of thoughts ⇔ trajectories in psychological spaces.



Two problems: discretization of continuous processes for symbolic models,
and lack of good phenomenology – we are not able to describe our mental states.

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



E. Schwitzgabel, Perplexities of Consciousness. MIT Press 2011.

Genes => proteins => cells =>networks

Genes and brains

Large-scale programs to link genes with behavior.

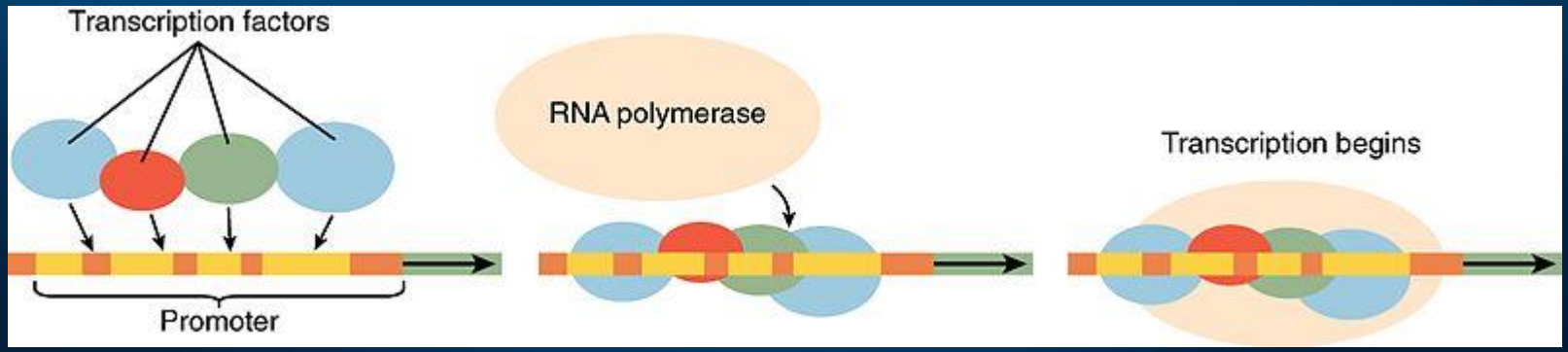
Worm (C. Elegans)

19 000 genes
302 neurons
7 800 synapses

Human

~ 19 000 genes
~ 100 B neurons (10^{11})
~ 10^{14} – 10^{15} synapses

Environment turns genes on/off via transcription factors. Genes do not control our behavior, but provide a substrate for cognition & behavior.



Genes/molecules

Nano/millisecond scale incredible complexity!

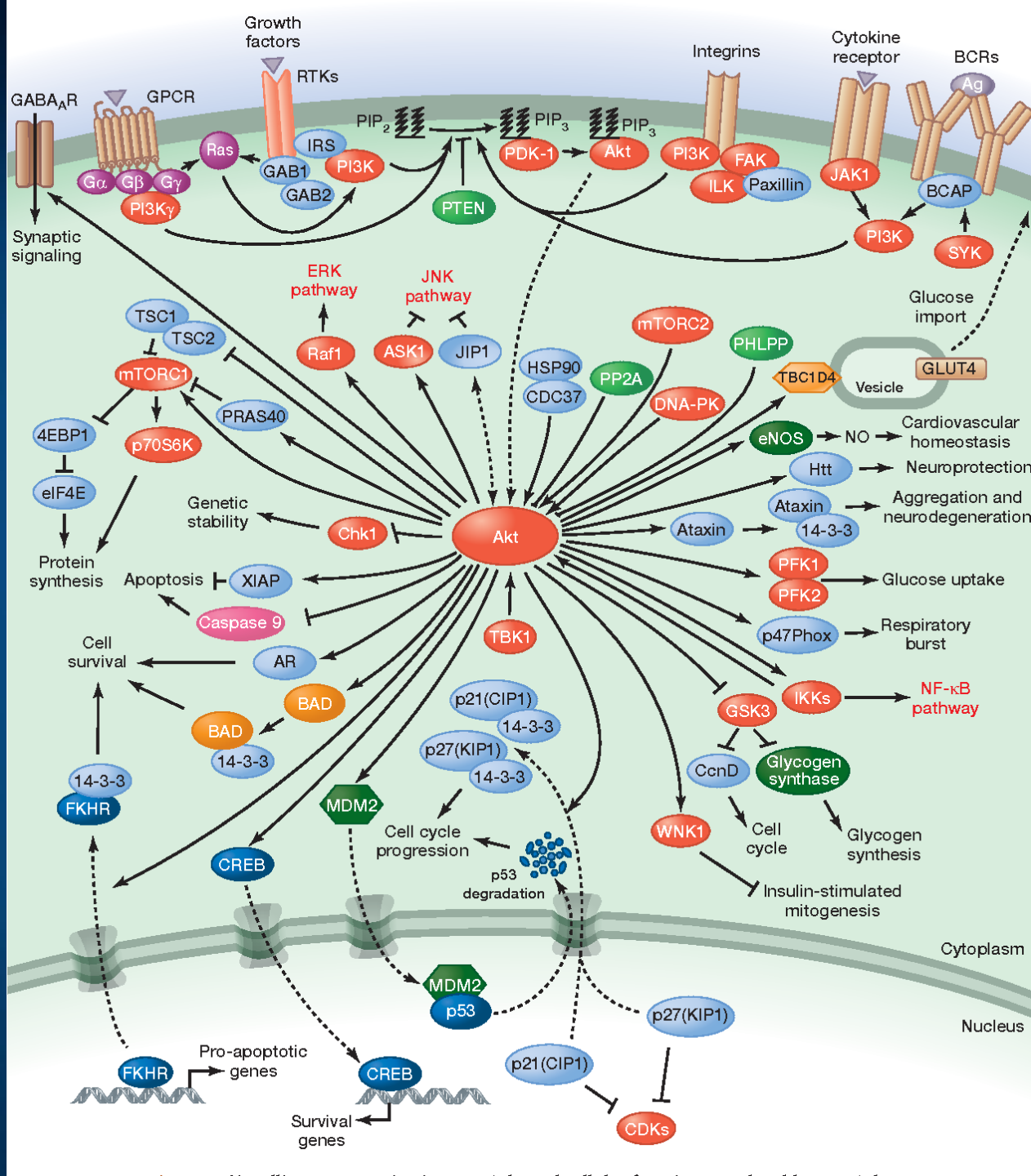
Dscam gene => 38 000 variants of proteins!

Total length of our DNA in 50 trillion body cells is 100 billion km, or about 666 times the distance to the Sun.

100 mln ions/sec in a single ion channel.

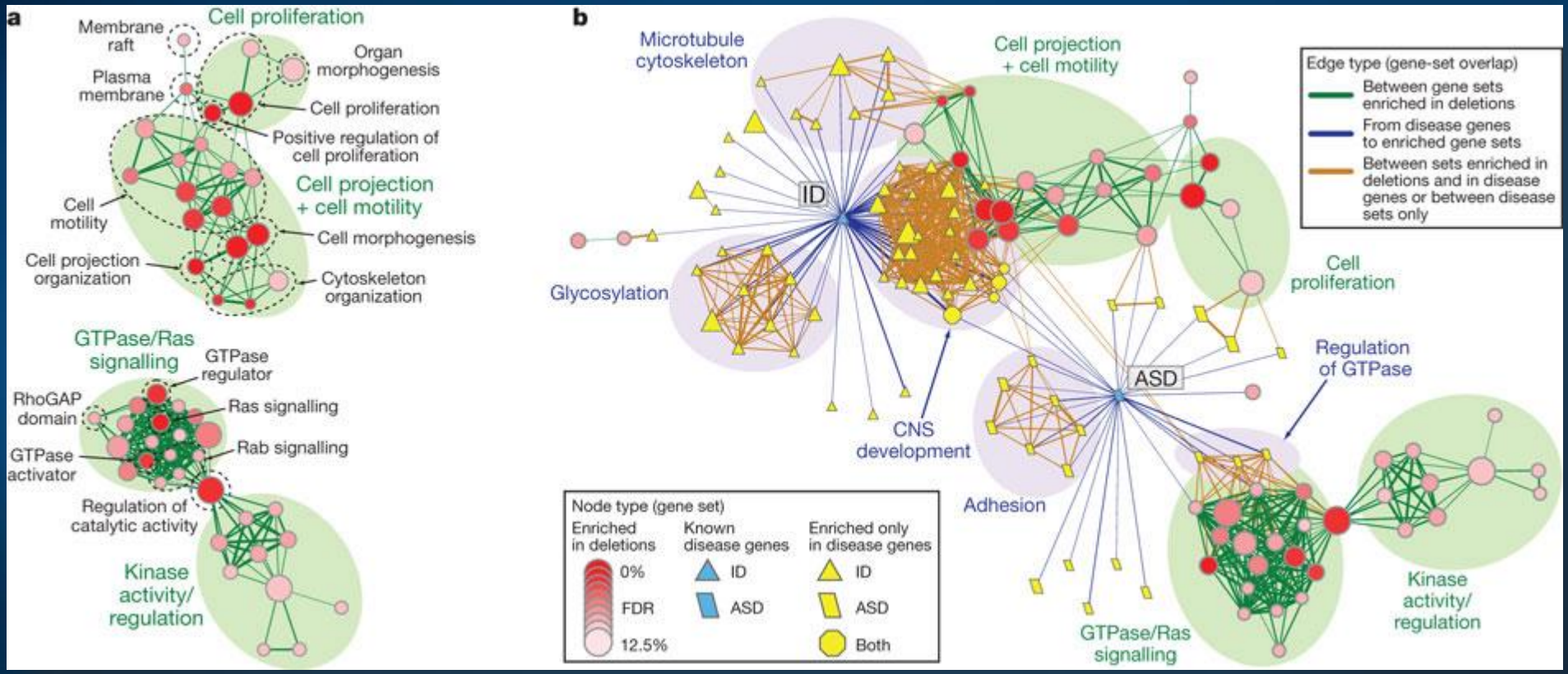
Neuron has 10 000 ion channels, billions of ions flow in each second.

Simple loops => infinite complexity (ex. fractals).



Genes & functions

Pinto, D. + 180 coauthors ... (2010). Functional impact of global rare copy number variation in autism spectrum disorders. *Nature* **466**, 368–372 (2010)



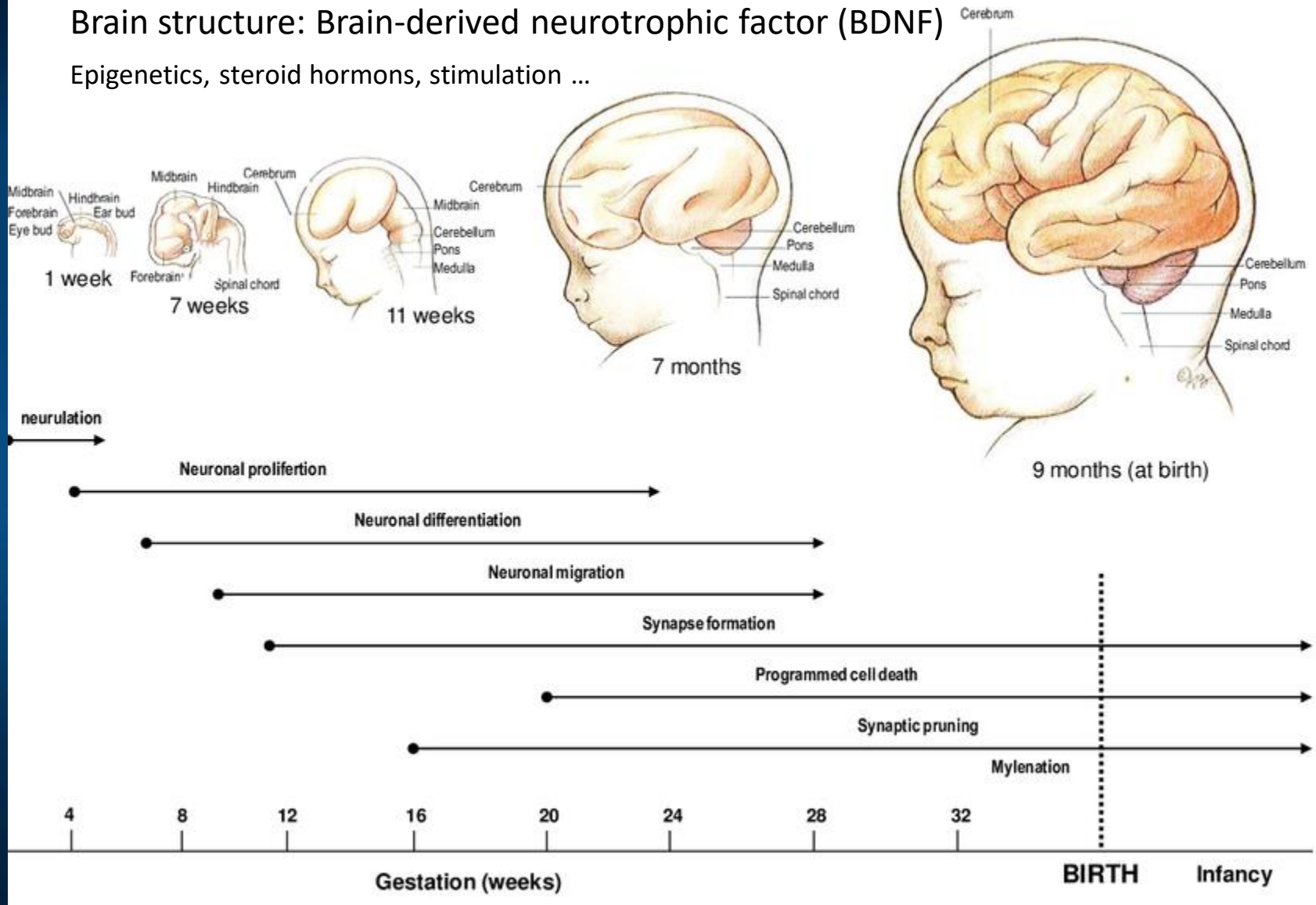
ASD heritability is ~90%, SFARI Human Gene Module database in 9/2021 listed 1028 ASD genes, implicated in 10-20% of cases, single genes in less than 1%.

Genetic variants ⇔ educational attainment: 126,559 subjects, 180 authors, most predictive genetic variant (SNP) accounted for 0.02%, all genes 2%.

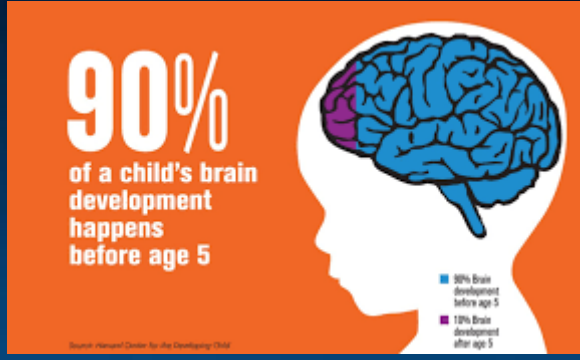
Formation of the brain

Brain structure: Brain-derived neurotrophic factor (BDNF)

Epigenetics, steroid hormons, stimulation …



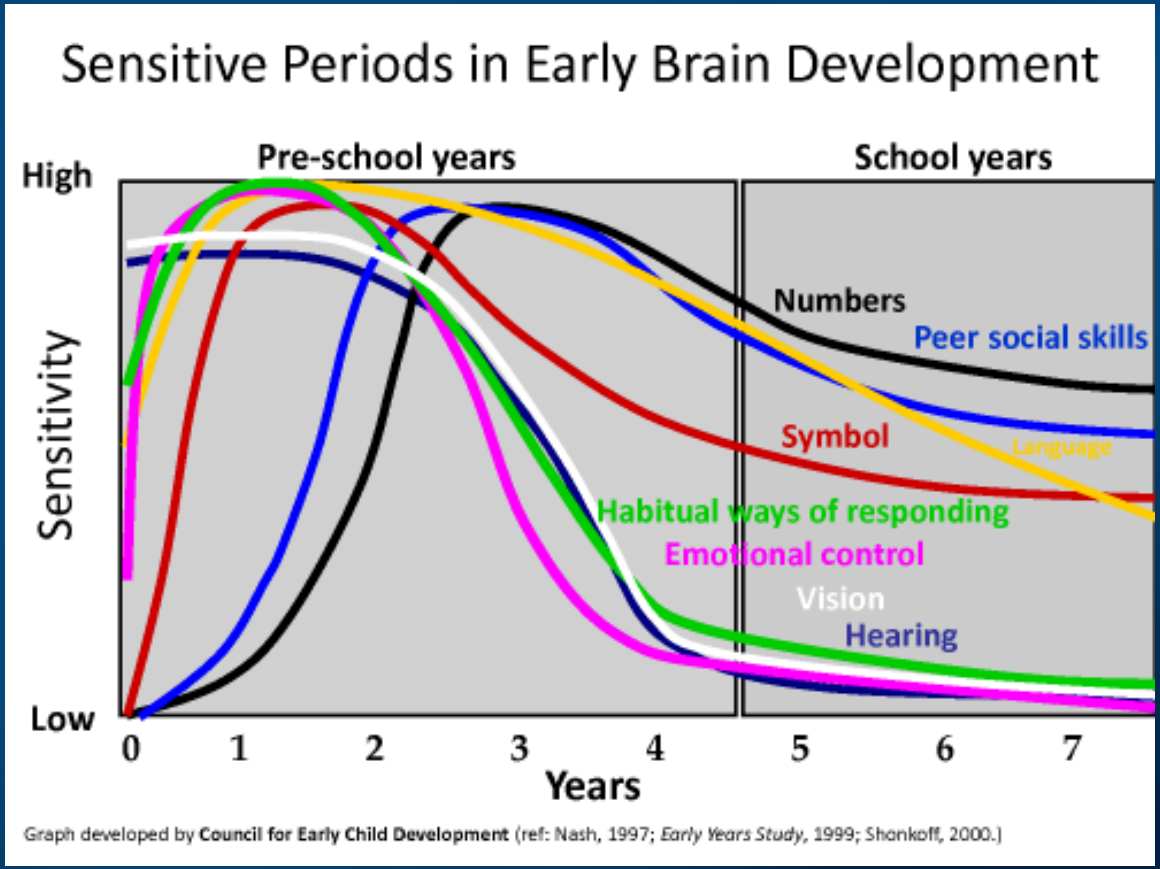
Childhood matters



To reach full potential of a child attention must be paid to early environment in relation to sensitive periods of development.

Genes specify the structure of all the proteins, therefore structure of all cells, neurotransmitters, hormones, receptors, etc.

Their effects depend on particular environment, are expressed in a particular network of other genes, creating context-dependent tendencies, predispositions, potentials, and vulnerabilities.



Hormones & neurotransmitters

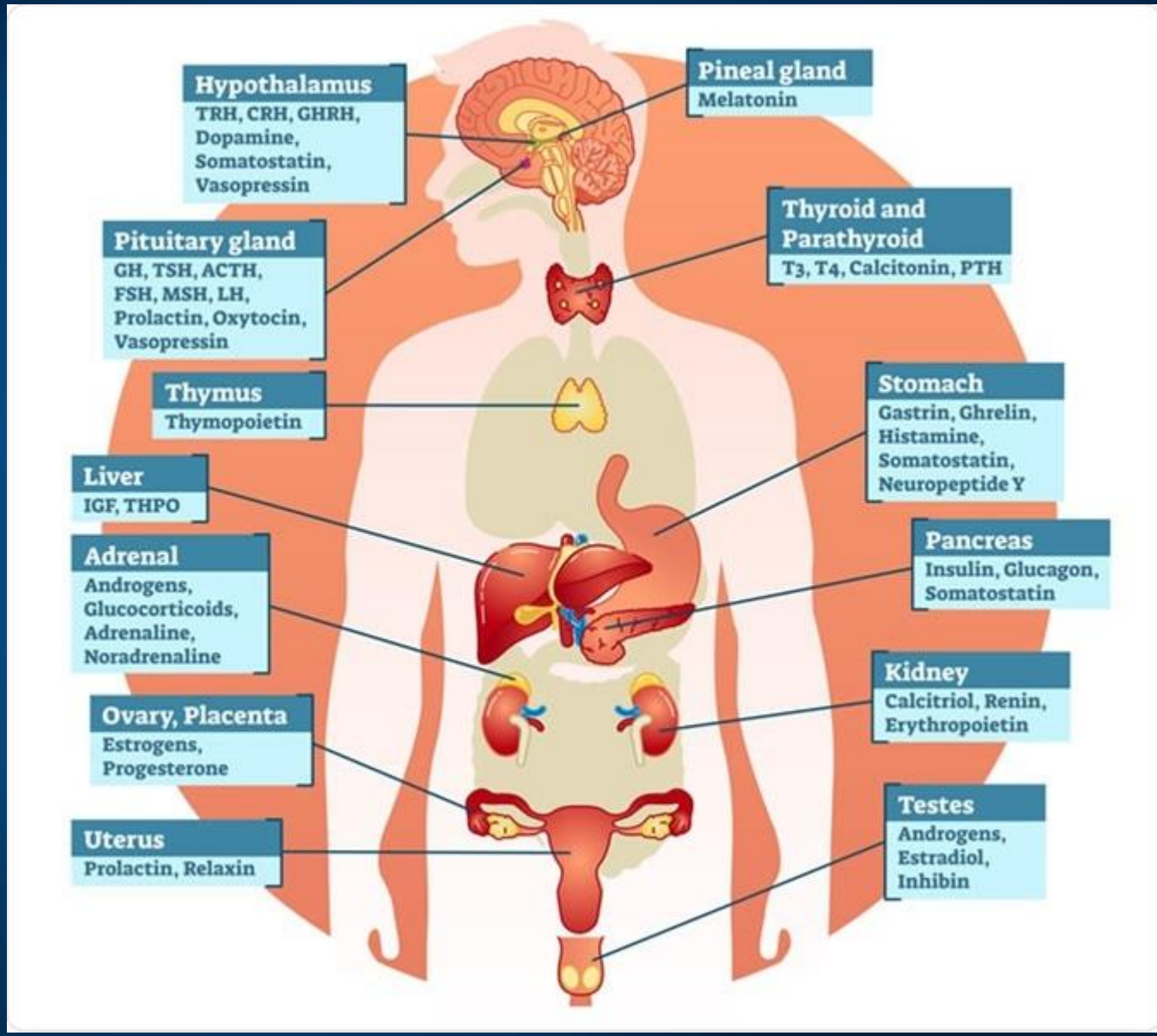
Neurotransmitters: fast, local action.

Produced in brainstem nuclei and neurons.

Hormones: relased from glands into bloodstream, act globally controlling the whole body.

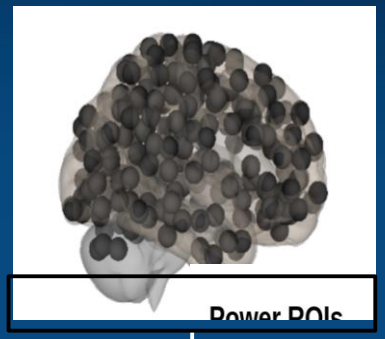
High **testosterone** levels don't lead to aggresive behavior; if good behavior enhances status testosterone helps to be prosocial.

It all about context!

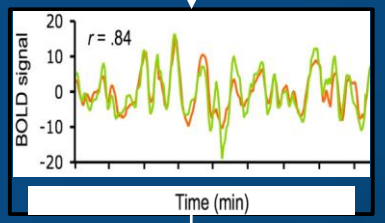


Human connectome and MRI/fMRI

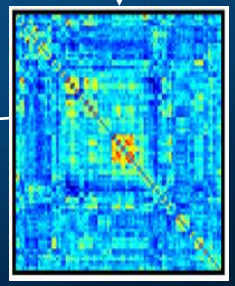
Node definition (parcelation)



Signal extraction

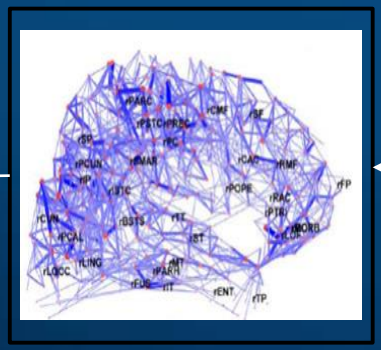


Correlation calculation

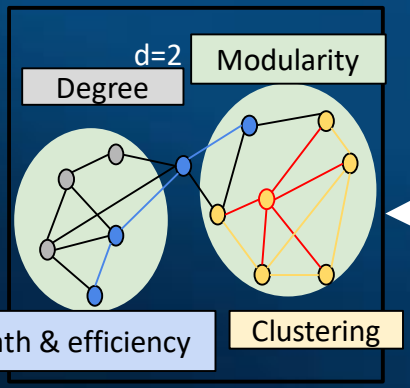


Correlation matrix

Binary matrix

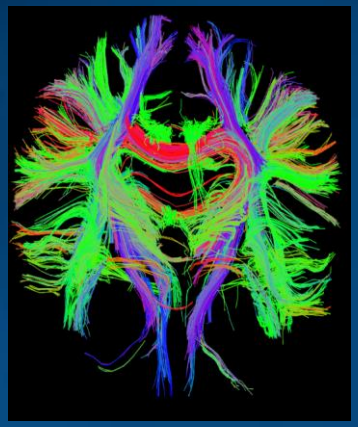


Whole-brain graph

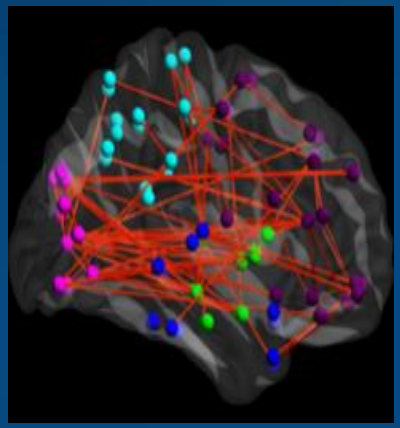


Graph theory

Structural connectivity



Functional connectivity



Many toolboxes available for such analysis.

Bullmore & Sporns (2009)

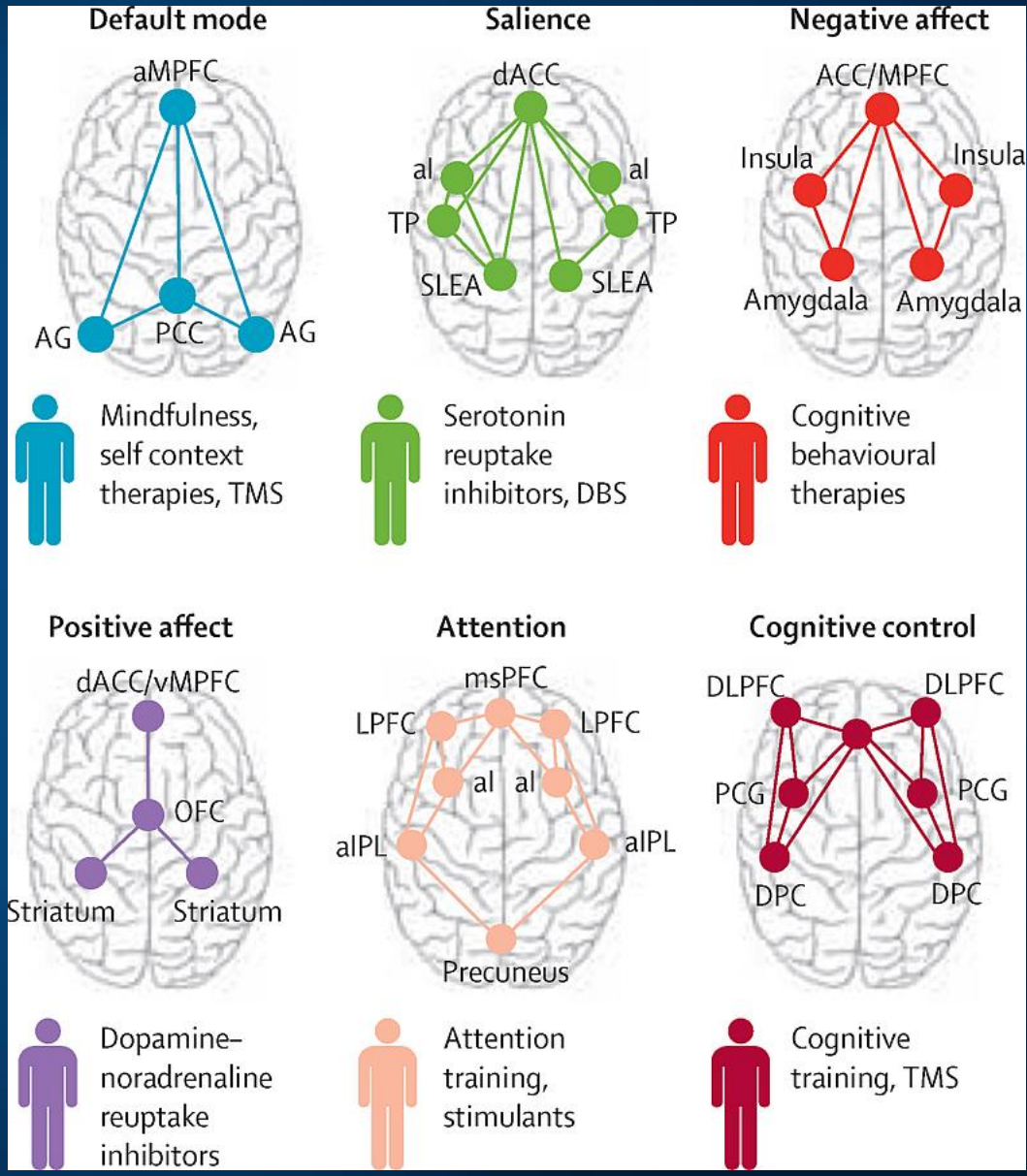
Large-scale networks and phenomics

Functions used in **Research Domain Criteria** (RDoC) matrix are connected with synchronized activation of specific brain regions (ROIs), neurotransmitters and therapeutic targets.

Include genes, molecules, cells, **circuits**, physiology, behavior, self-reports and paradigms.

Sung et al. (2018). A Set of Functional Brain Networks for the Comprehensive Evaluation of Human Characteristics. *Frontiers in Neuroscience*, *12*.

Using 163 brain regions identified functional networks related to 111 psychometric parameters.

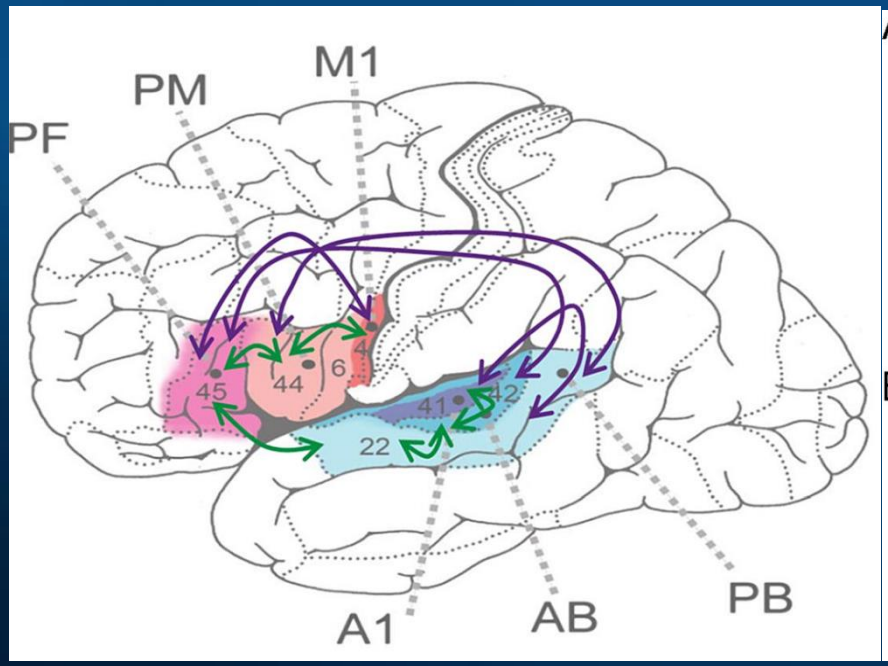


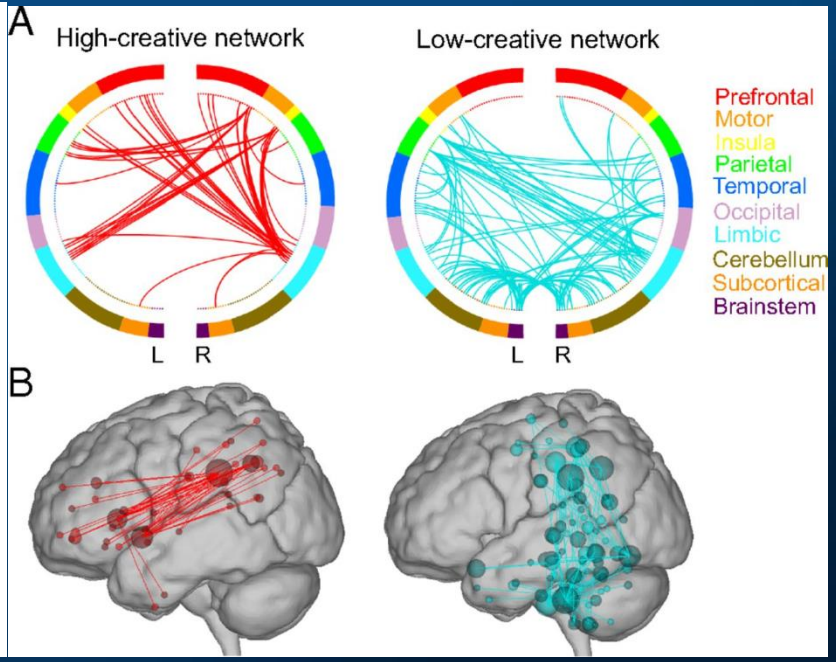
Fluid nature

Development of brain in infancy: first learning how to move, sensorimotor activity organizes brain network processes.

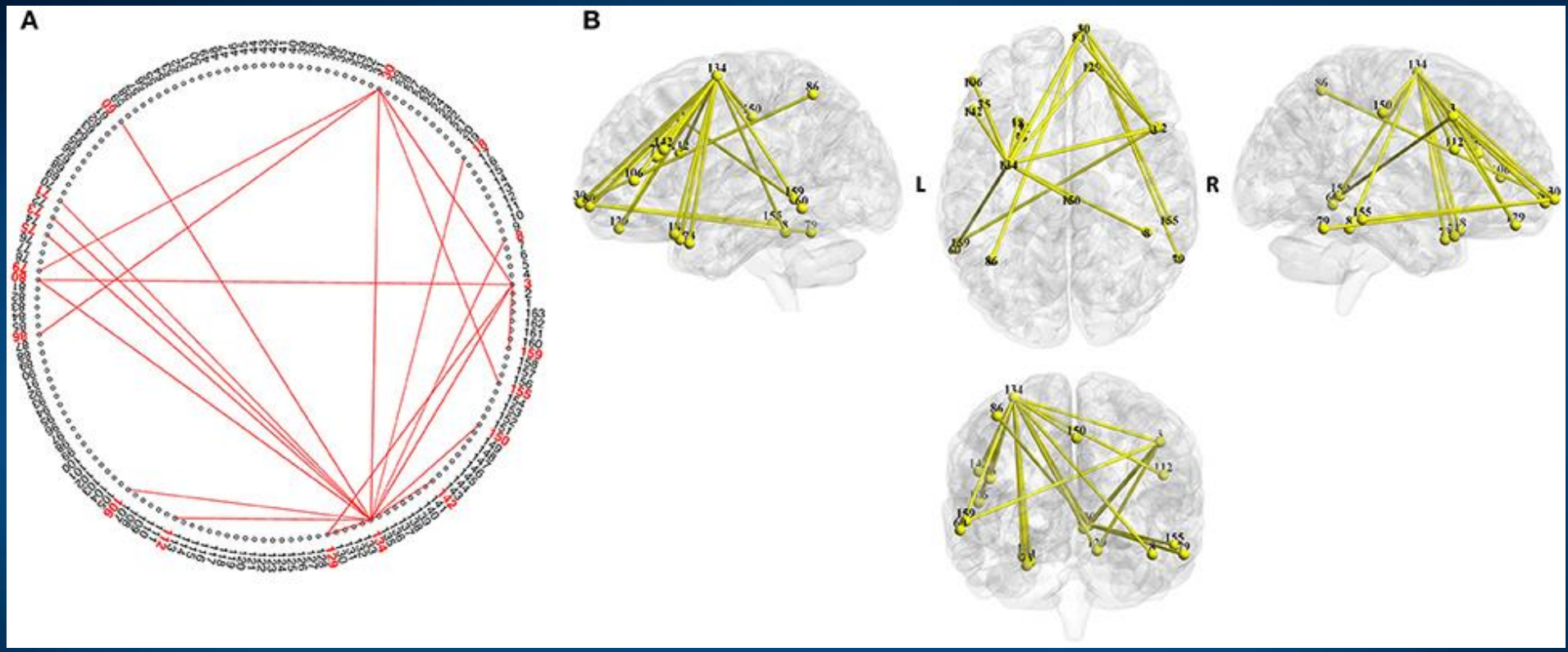
The Developing Human Connectome Project: create a dynamic map of human brain connectivity from 20 to 44 weeks post-conceptional age, which will link together imaging, clinical, behavioral, and genetic information.

Pointing, gestures, pre-linguistic (our BabyLab has a lot of EEG recordings).





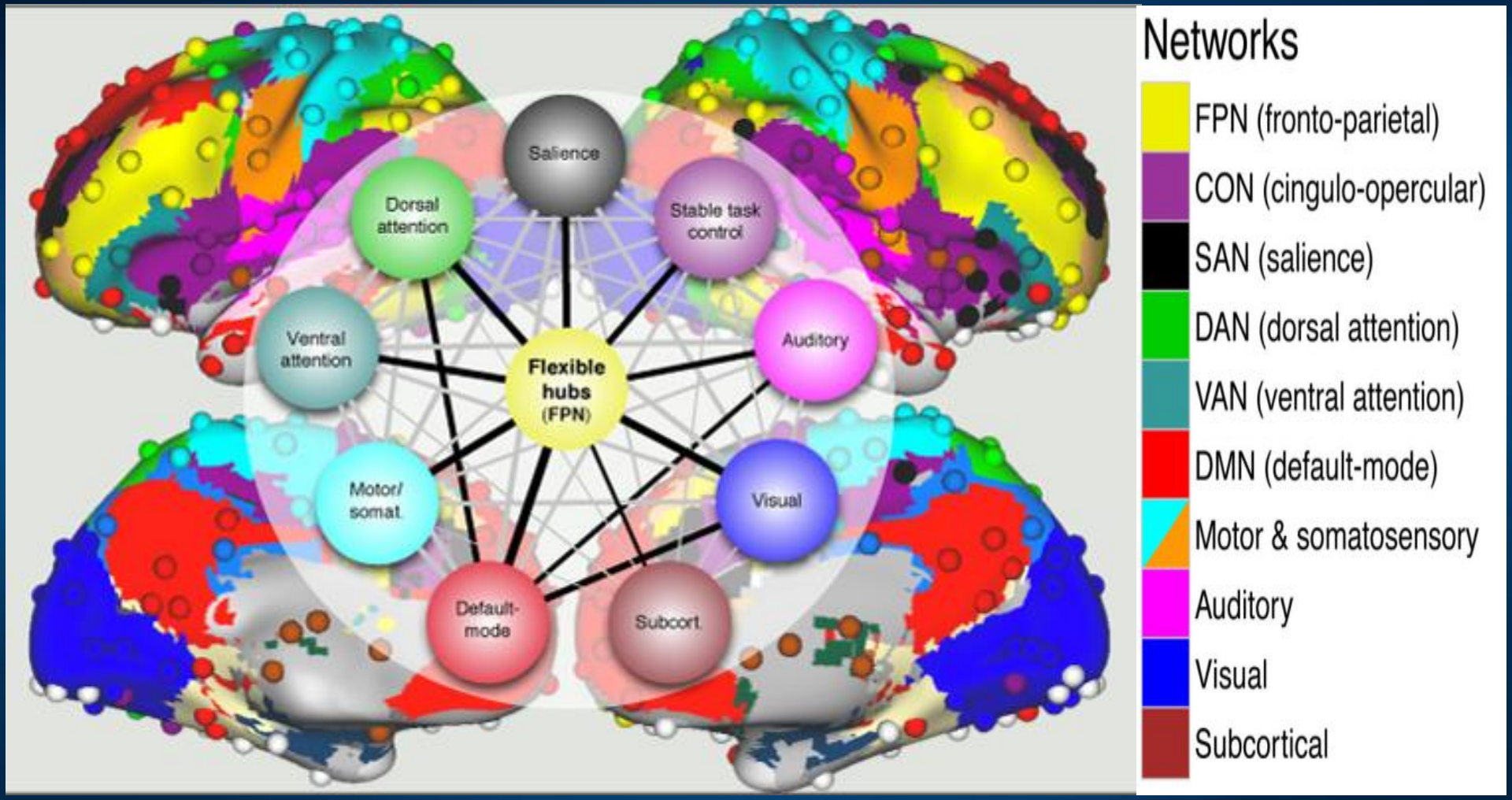
Verbal intelligence quotient



Brain map of the functional network for the psychometric parameter “verbal intelligence quotient (VIQ).” Line width ≈ the strength of the correlation. Approximates some mechanisms behind complex cognitive functions.

Sung et al. (2018). A Set of Functional Brain Networks for the Comprehensive Evaluation of Human Characteristics. *Frontiers in Neuroscience*, *12*.

Neurocognitive Basis of Cognitive Control



Central role of fronto-parietal (FPN) flexible hubs in cognitive control and adaptive implementation of task demands (black lines=correlations significantly above network average). Cole et al. (2013).

Brain networks: neuroplasticity & learning

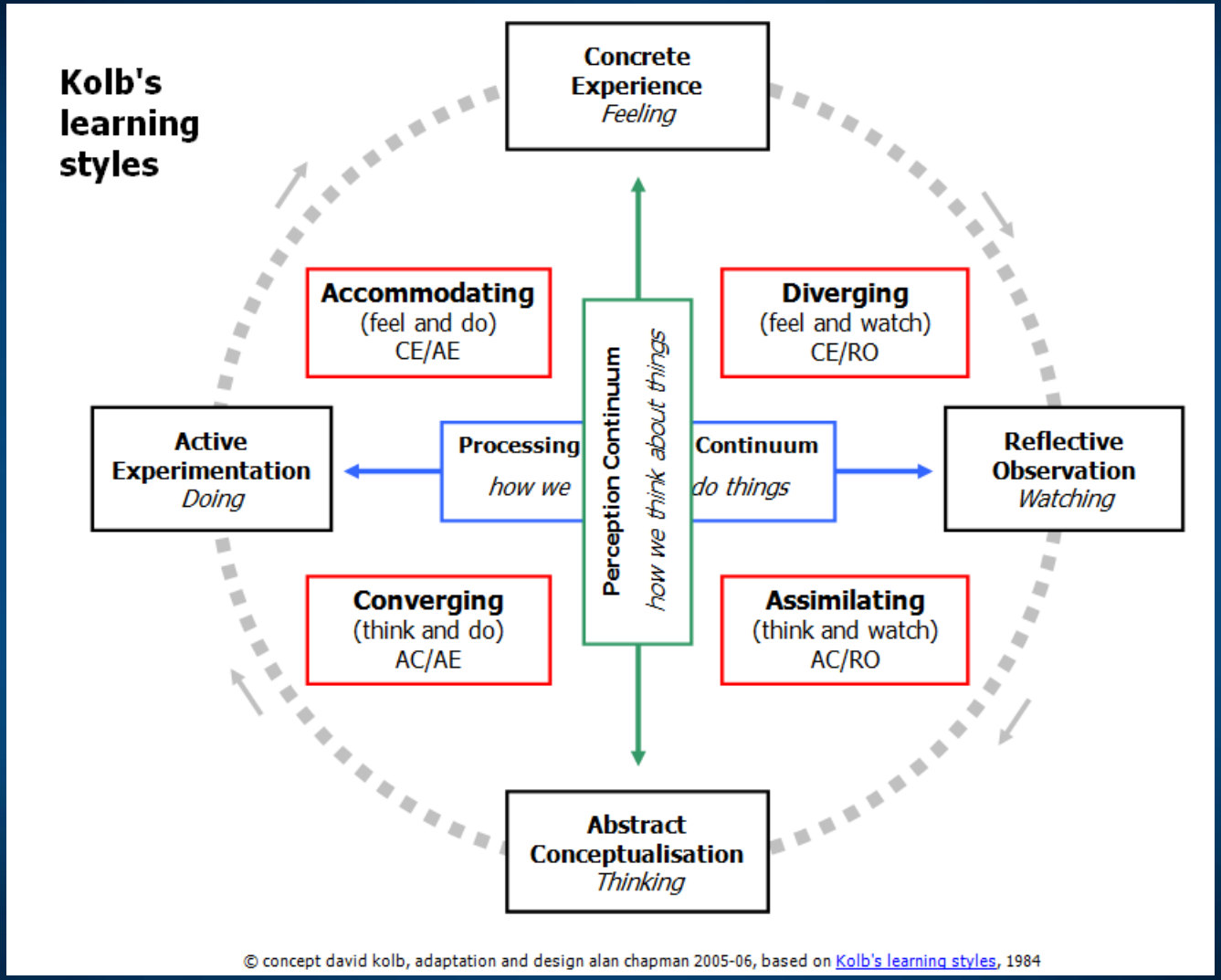
Learning abilities

Connectomes develops before birth and in the first years of life.

Achieving harmonious development is very difficult and depends on low-level (genetic, epigenetic, signaling pathways) processes, but may be influenced by experience and learning.

- Excess of low-level (sensory) processes S⇔S. Ex. ASD children.
- Poor C⇔C neural connections and synchronization, frontal⇔parietal necessary for abstract thinking, weak functional connections prefrontal lobe ⇔ other areas.
- Patterns of activation in the brain differ depending on whether the brain is doing social or nonsocial tasks.
- "Default brain network" involves several brain areas (mPFC, cingulate cortex, lateral PC), shows low activity for goal-related actions; strong activity in social and emotional processing, mindwandering, daydreaming.

Learning styles



David Kolb, *Experiential learning: Experience as the source of learning and development* (1984), and *Learning Styles Inventory*.

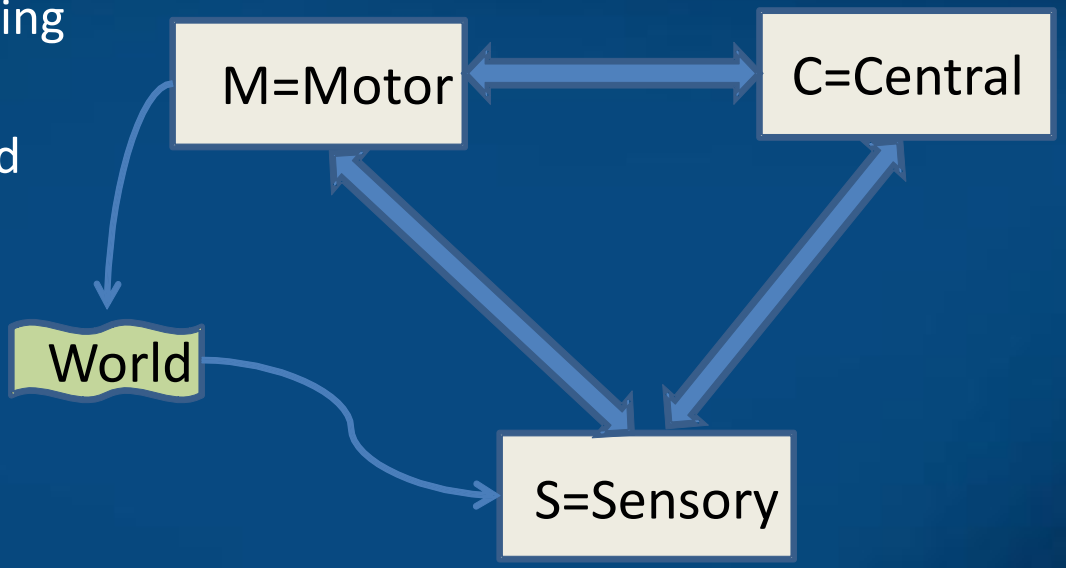
Connectome and learning styles

Simplest connectome models may help to explain and improve learning abilities.

S, Sensory level, occipital, STS, and somatosensory cortex;

C, central associative level, abstract concepts that have no sensory components,

mostly parietal, temporal and prefrontal lobes.



M, motor cortex, motor imagery & physical action.
Frontal cortex, basal ganglia.

Even without emotion and reward system predominance of activity within or between these areas explains many learning phenomena.

Duch. W. (2020) Experiential Learning Styles and Neurocognitive Phenomics.

PsyArXiv. August 30, 2020

Brain modules and cognitive processes

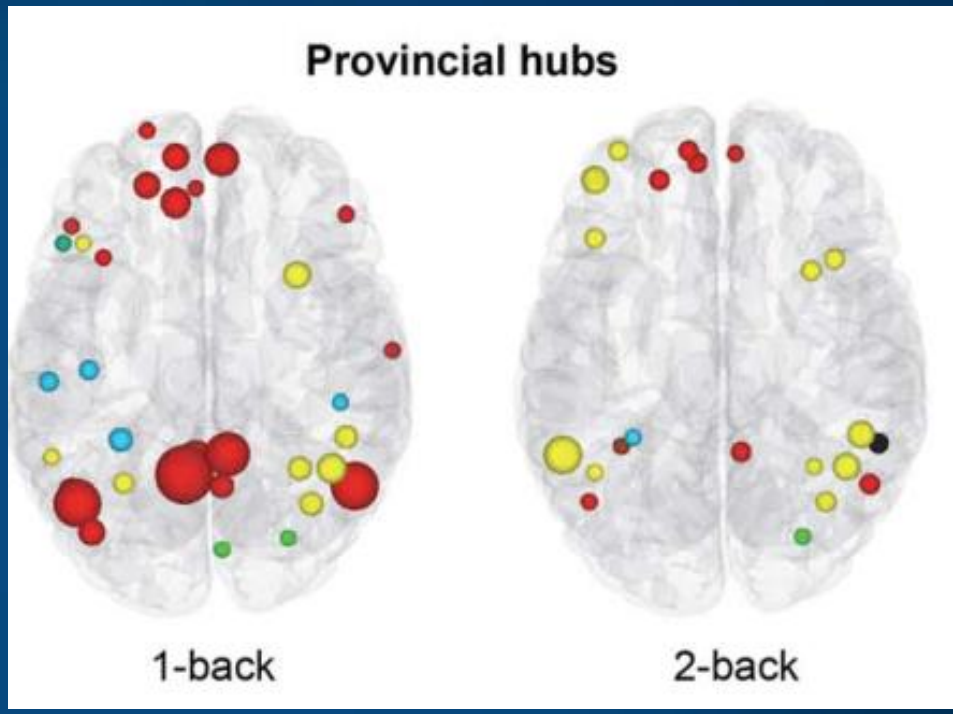
Simple and more difficult tasks, requiring the whole-brain network reorganization.

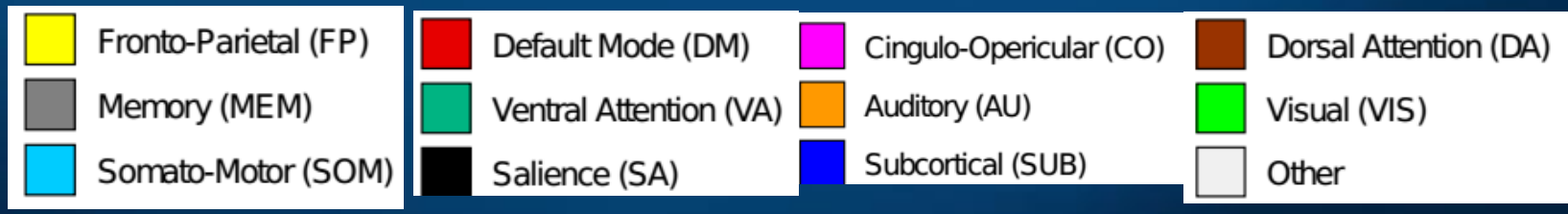
Left: 1-back local hubs

Right: 2-back local hubs

Average over 35 *participants.*

Dynamical change of the landscape of attractors, depending on the cognitive load. Less local (especially in DMN), more global binding (especially in PFC).





Finc K, Bonna K. et al. (2017) Transition of the functional brain network related to increasing cognitive demands. Human Brain Mapping 38(7), 3659–3674

Difficult cognitive processes

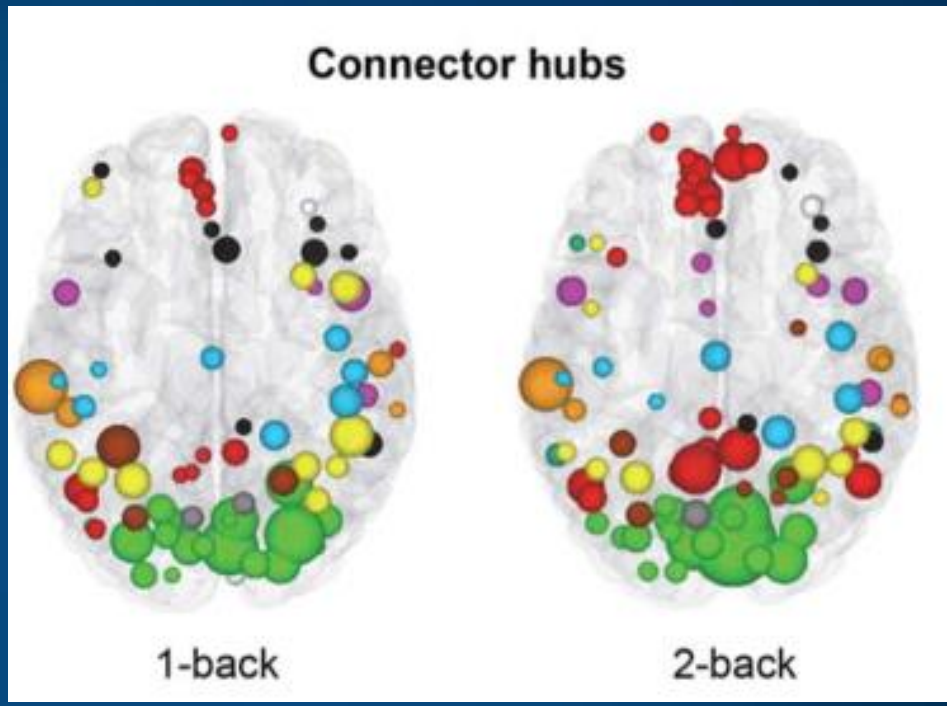
If the problem is hard recruit more brain regions to solve it! Functional synchronization unifies them.

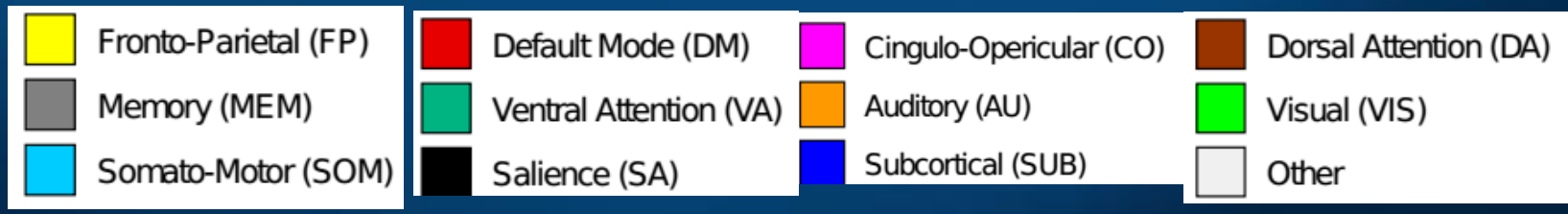
Left: 1-back connector hubs

Right: 2-back connector hubs

Average over 35 *participants.*

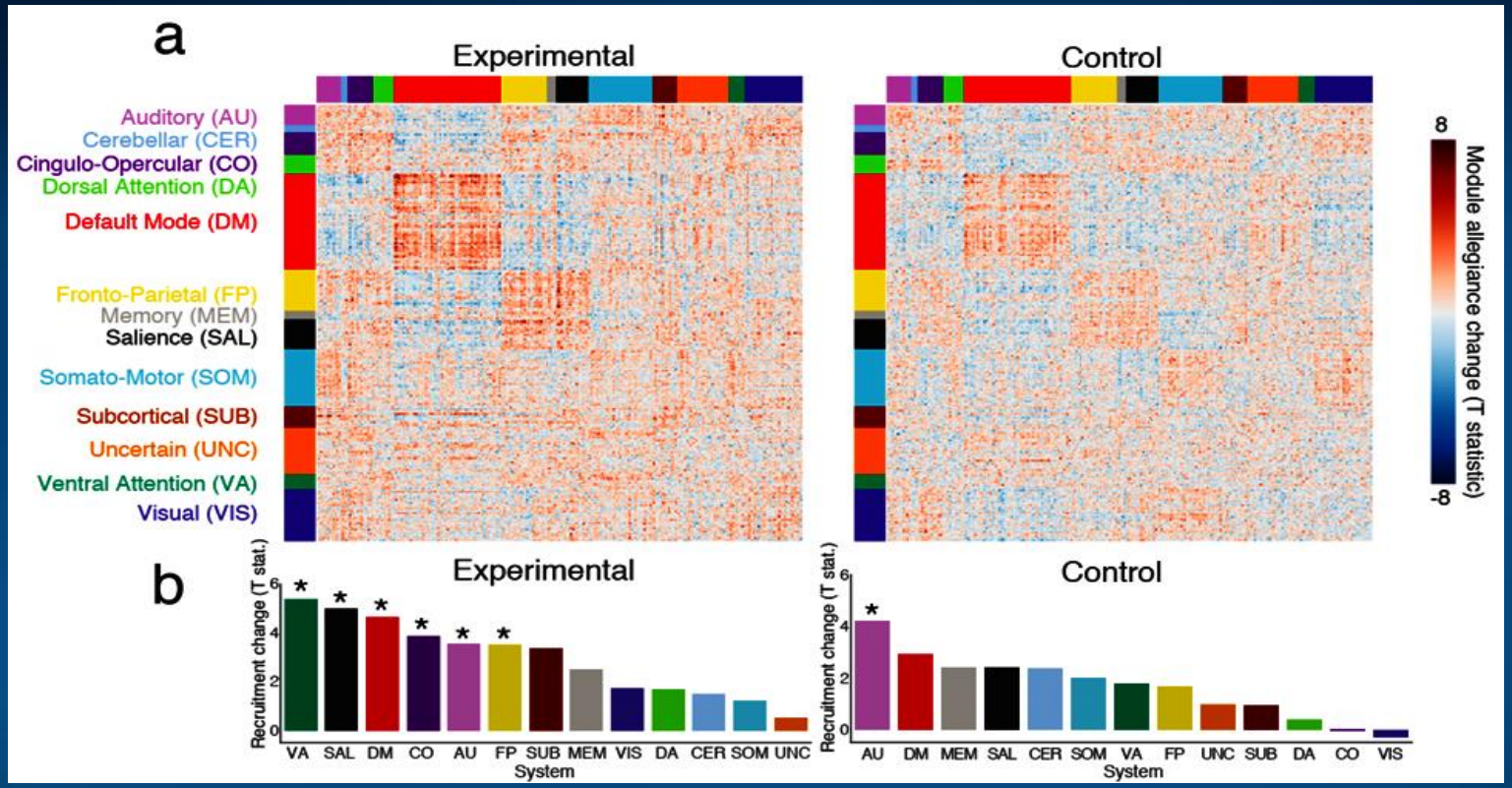
Dynamical change of the landscape of attractors, depending on the cognitive load – System 2 (Khaneman).
DMN areas engaged in global binding!





K. Finc et al, HBM (2017).

Working memory training

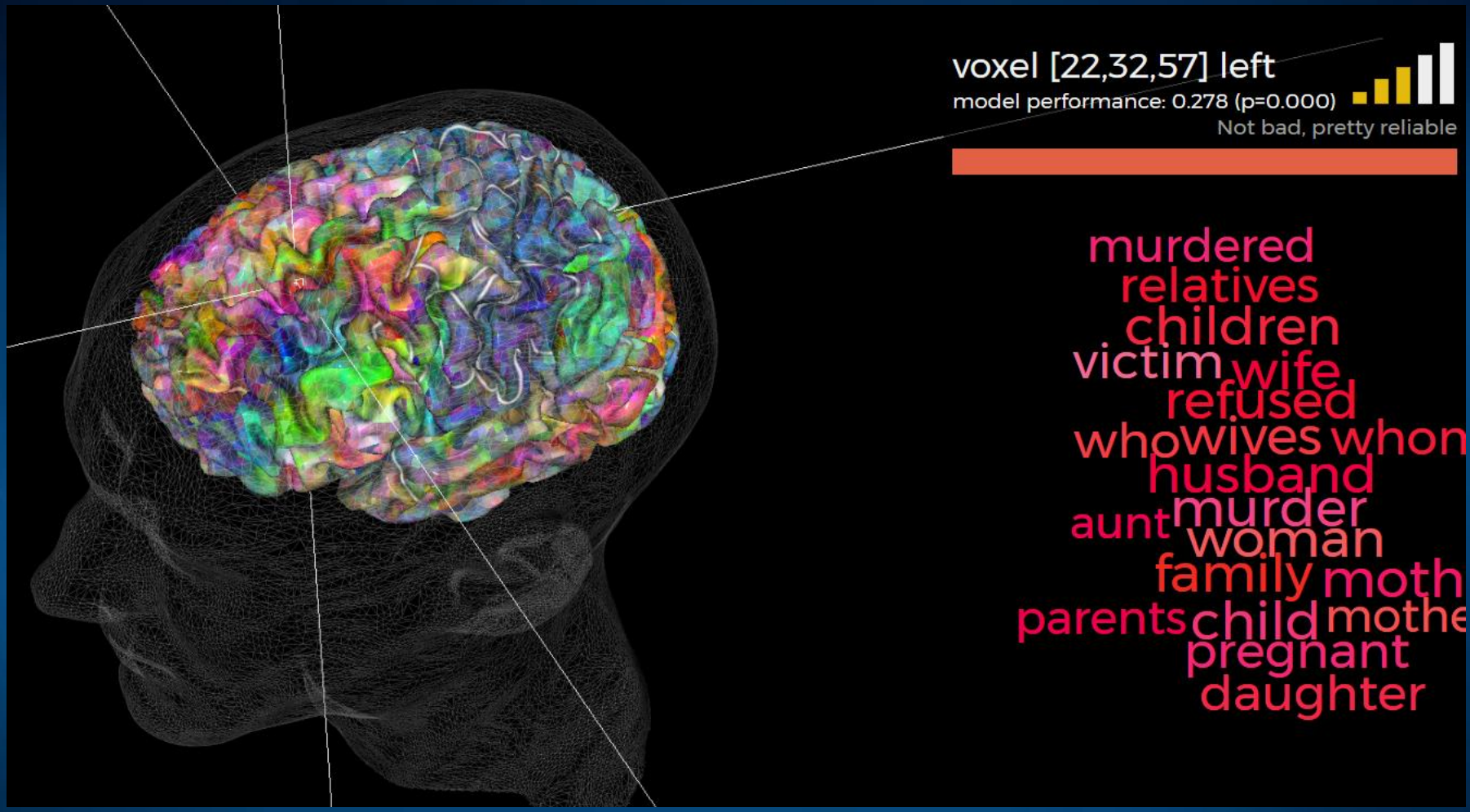


Whole-brain changes in module allegiance between the start and after 6-week of working memory training.

(a) Changes in node allegiance as reflected in the two-tailed *t*-test.

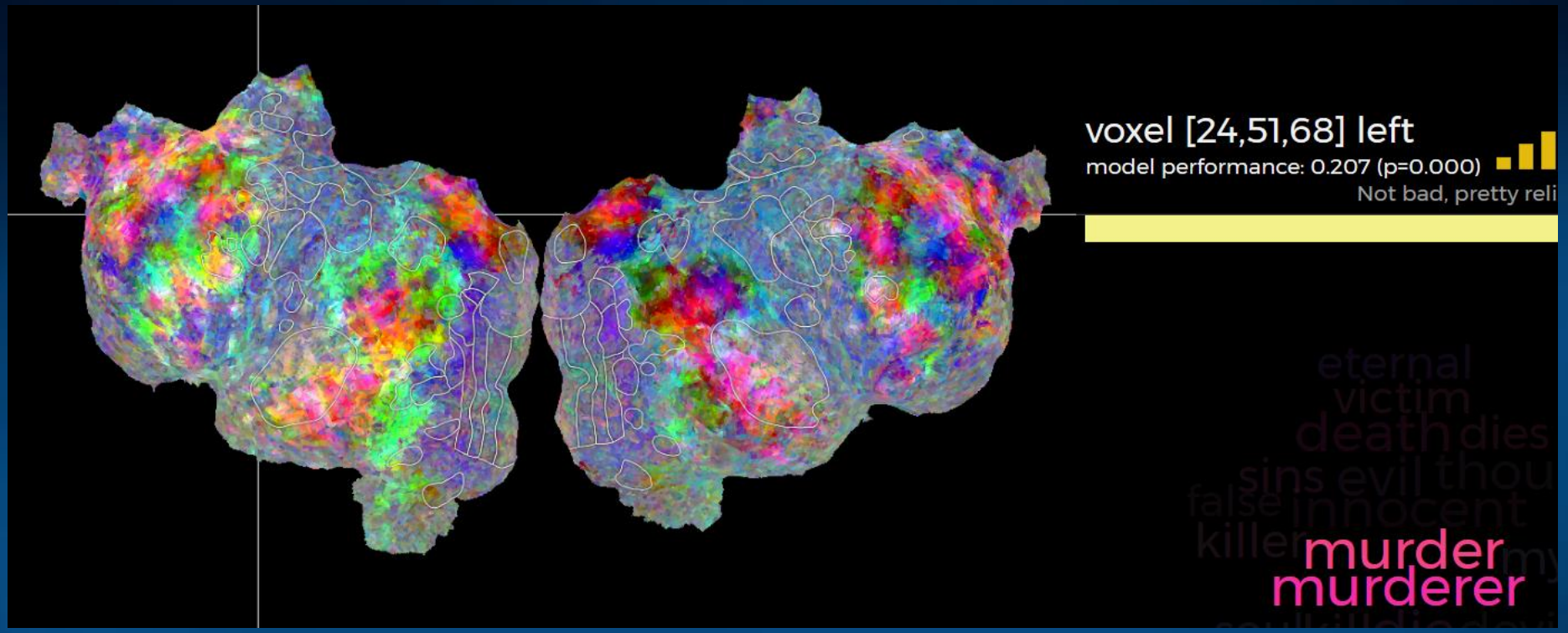
(b) Significant increase * in the ventral attention VA, salience SAL, default mode DM, cingulo-opercular CO, auditory systems AU and fronto-parietal network recruitment.

Finc, Bonna, He, Lydon-Staley, Kühn, Duch, Bassett, Nature Communic. 11 (2020).



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

Huth et al. (2016). Decoding the Semantic Content of Natural Movies from Human Brain Activity. Frontiers in Systems Neuroscience 10, pp. 81



Whole fMRI activity map for the word “murder” shown on the flattened cortex.

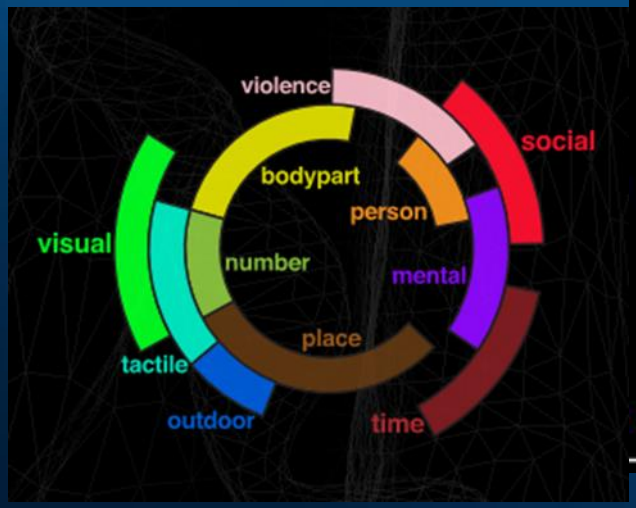
Each word activates a whole map of activity in the brain, depending on sensory features, motor actions and affective components associated with this word. Why such activity patterns arise? Brain subnetworks connect active areas.

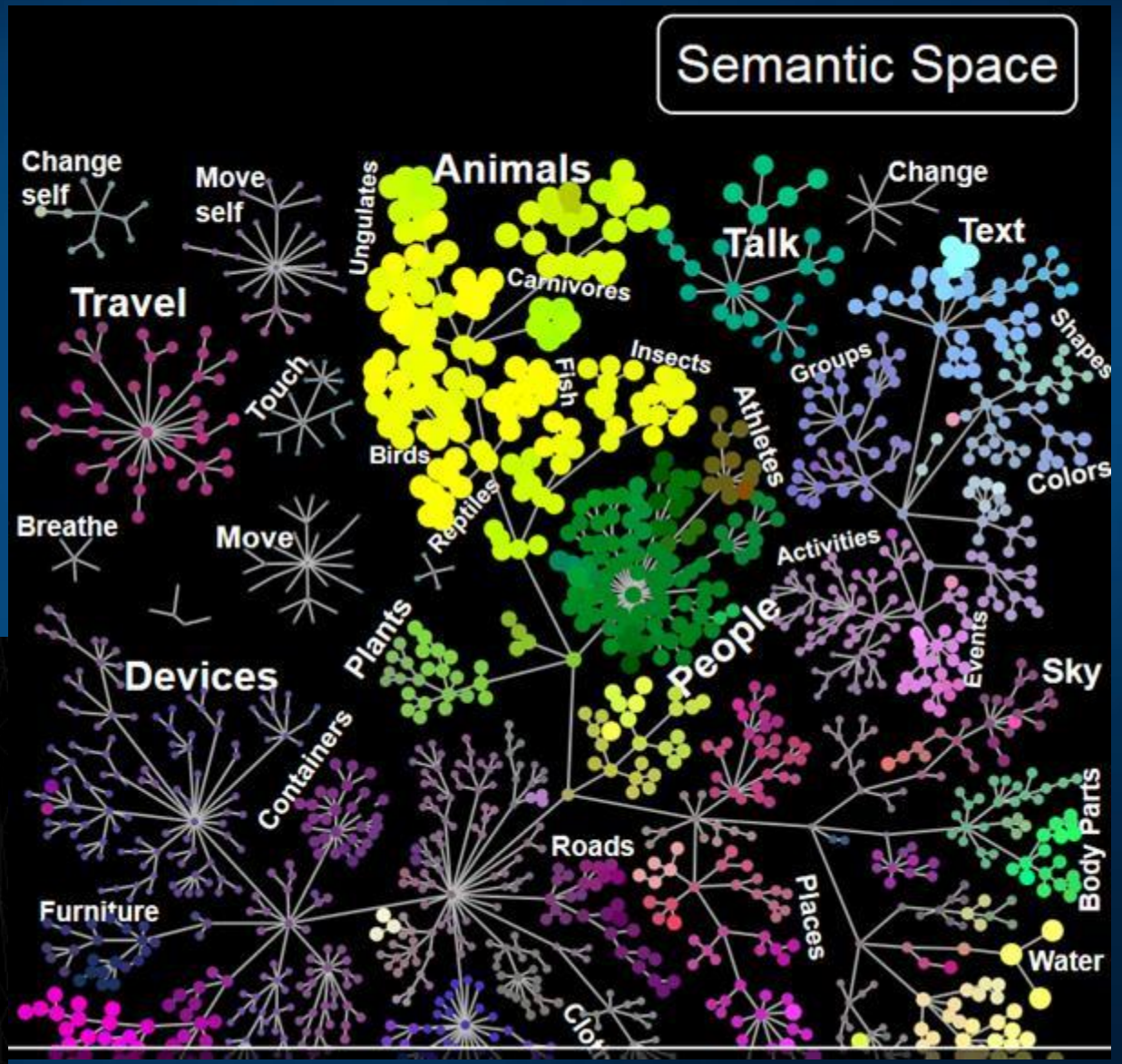
http://gallantlab.org/huth2016/ and short movie intro.

Can one do something like that with EEG or MEG? Brain dictionary - Nature video

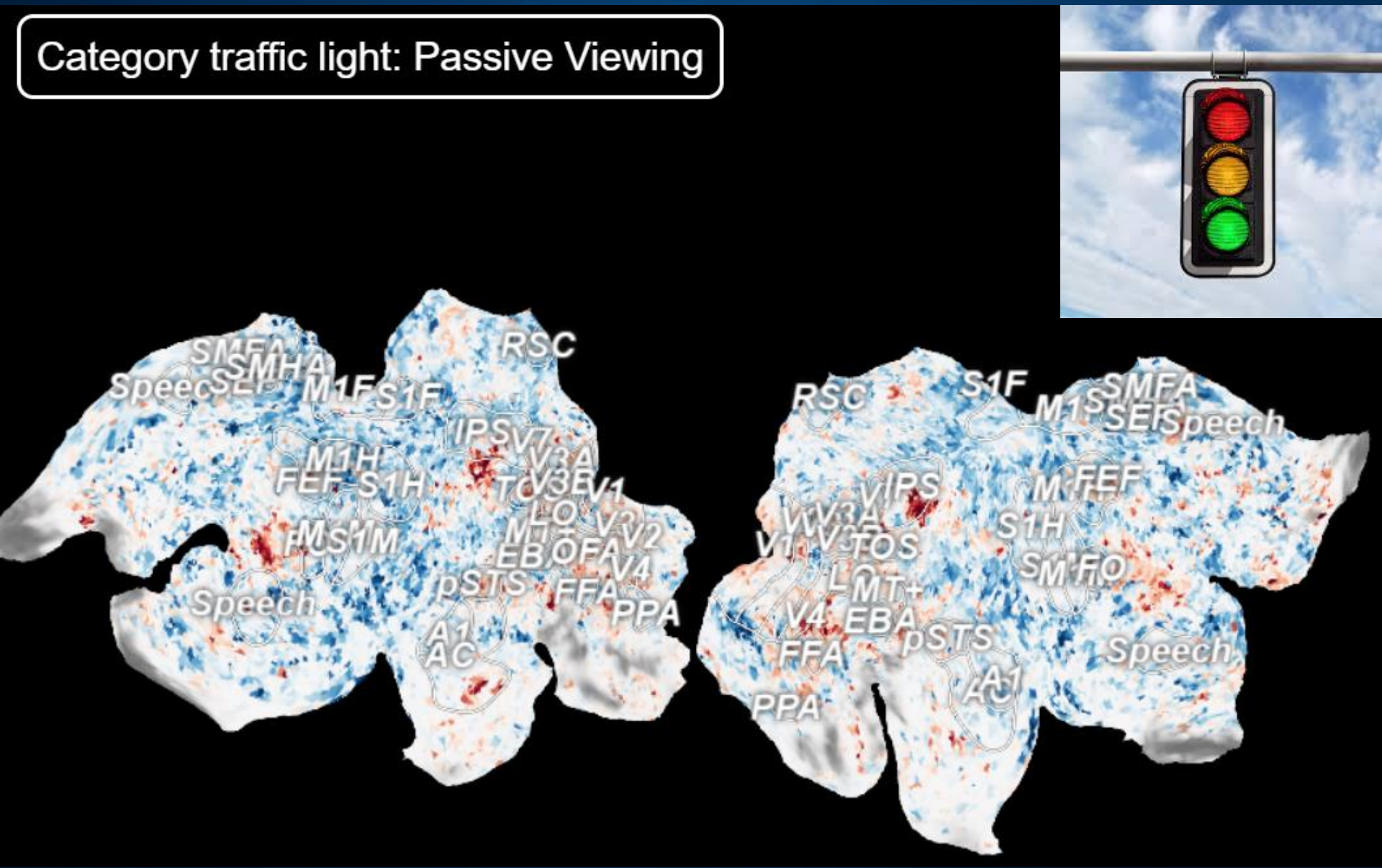
Semantic neuronal space

1700 words in the semantic space are grouped by similarity. Words activate specific ROIs, similar words create similar maps of brain activity. Video or audio stimuli, fMRI 60.000 voxel). Gallant lab, Berkeley.





Interpretation for simple objects is easy: IPS – visual attention, V4 – color, AC – object recogniton.



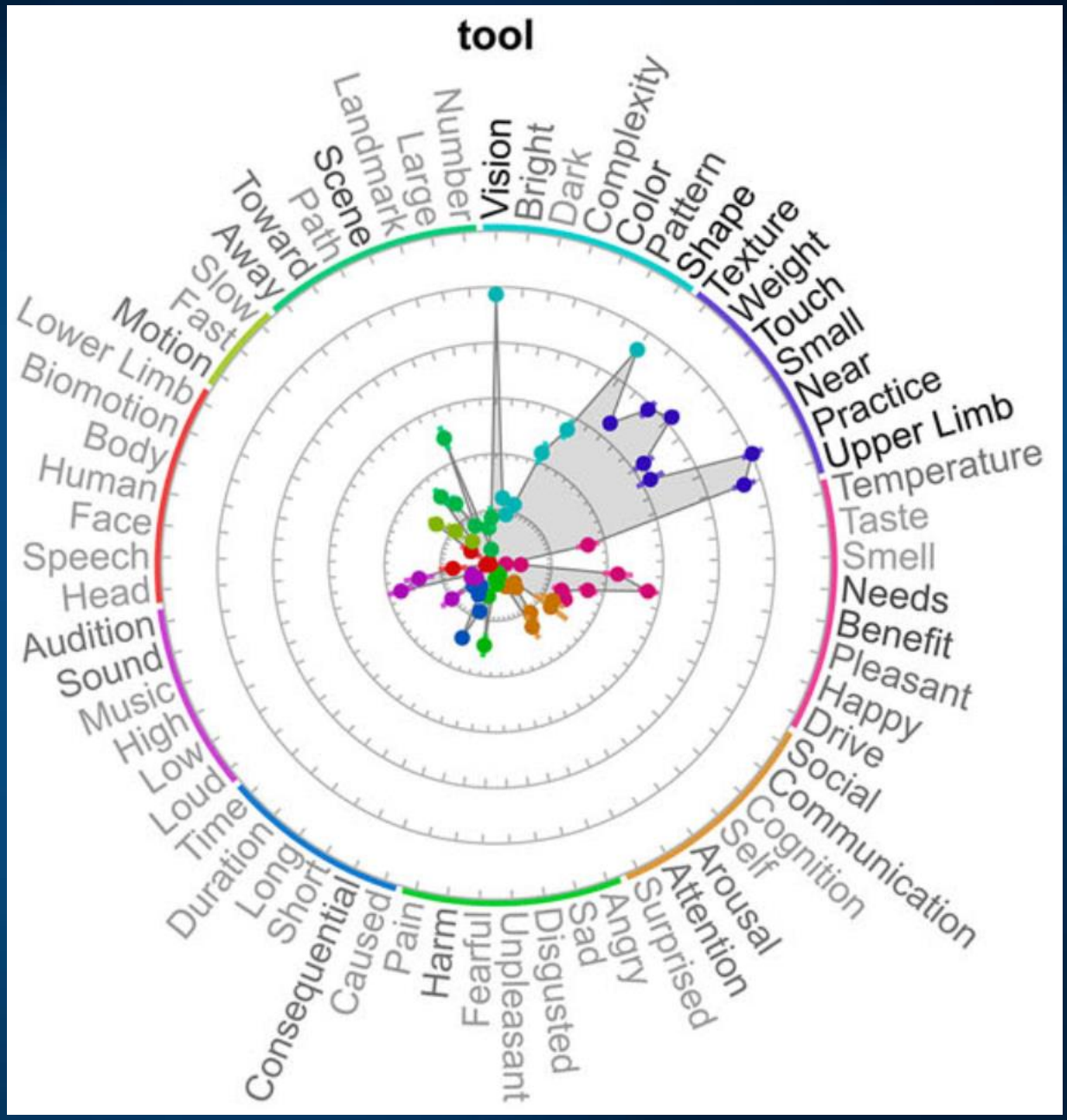
65 attributes related to neural processes.

Brain-Based Representation of tools.

J.R. Binder et al

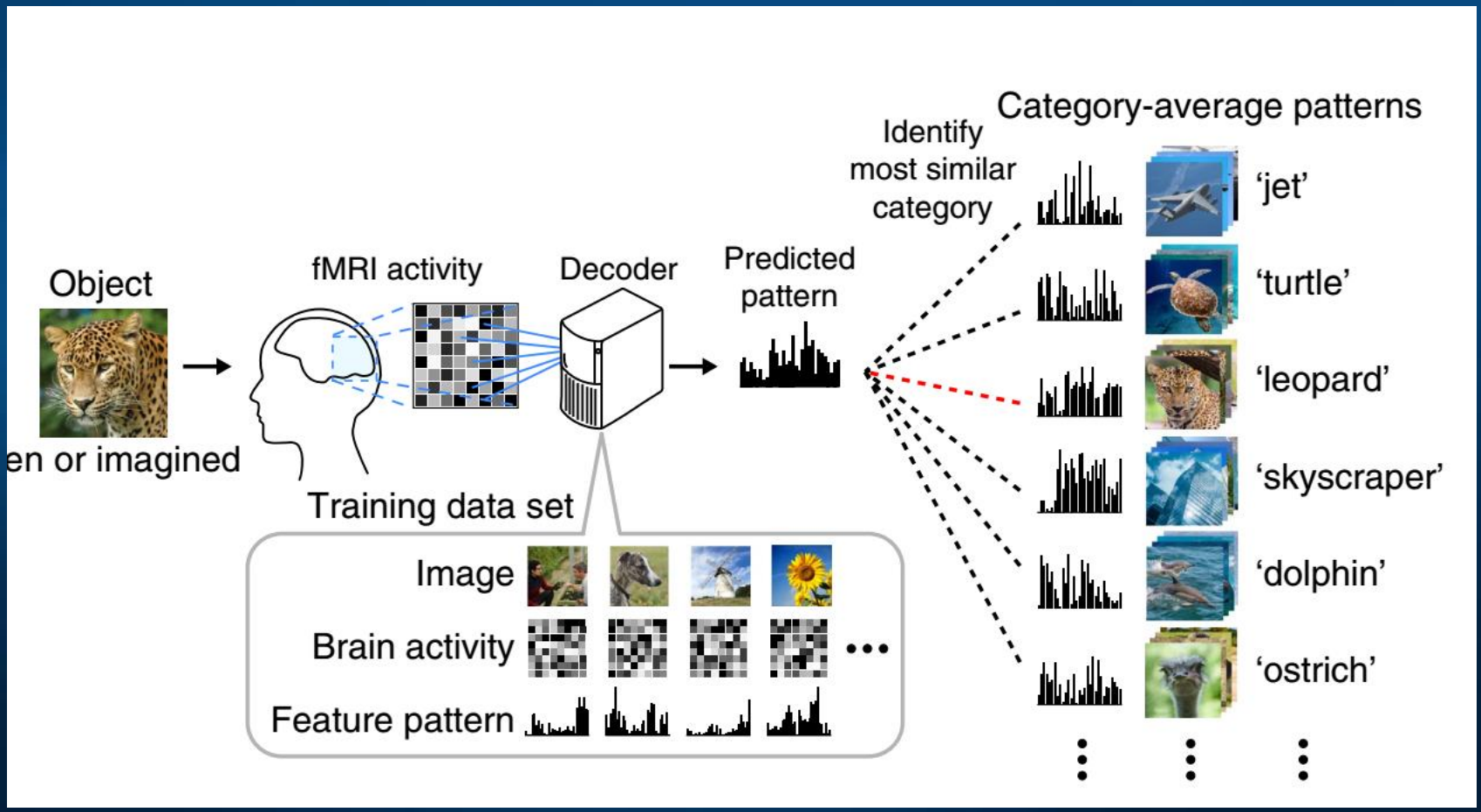
Toward a Brain-Based Componential Semantic Representation

Cognitive Neuropsychology 2016



Brain activity ⇔ Mental image

fMRI activity can be correlated with deep CNN network features;
using these features closest image from large database is selected.
Horikawa, Kamitani, Generic decoding of seen and imagined objects using hierarchical visual features. Nature Comm. 2017.



Decoding Dreams

Decoding Dreams, ATR Kyoto, Kamitani Lab. fMRI images analysed during REM phase or while falling asleep allows for dream categorization (~20 categories).

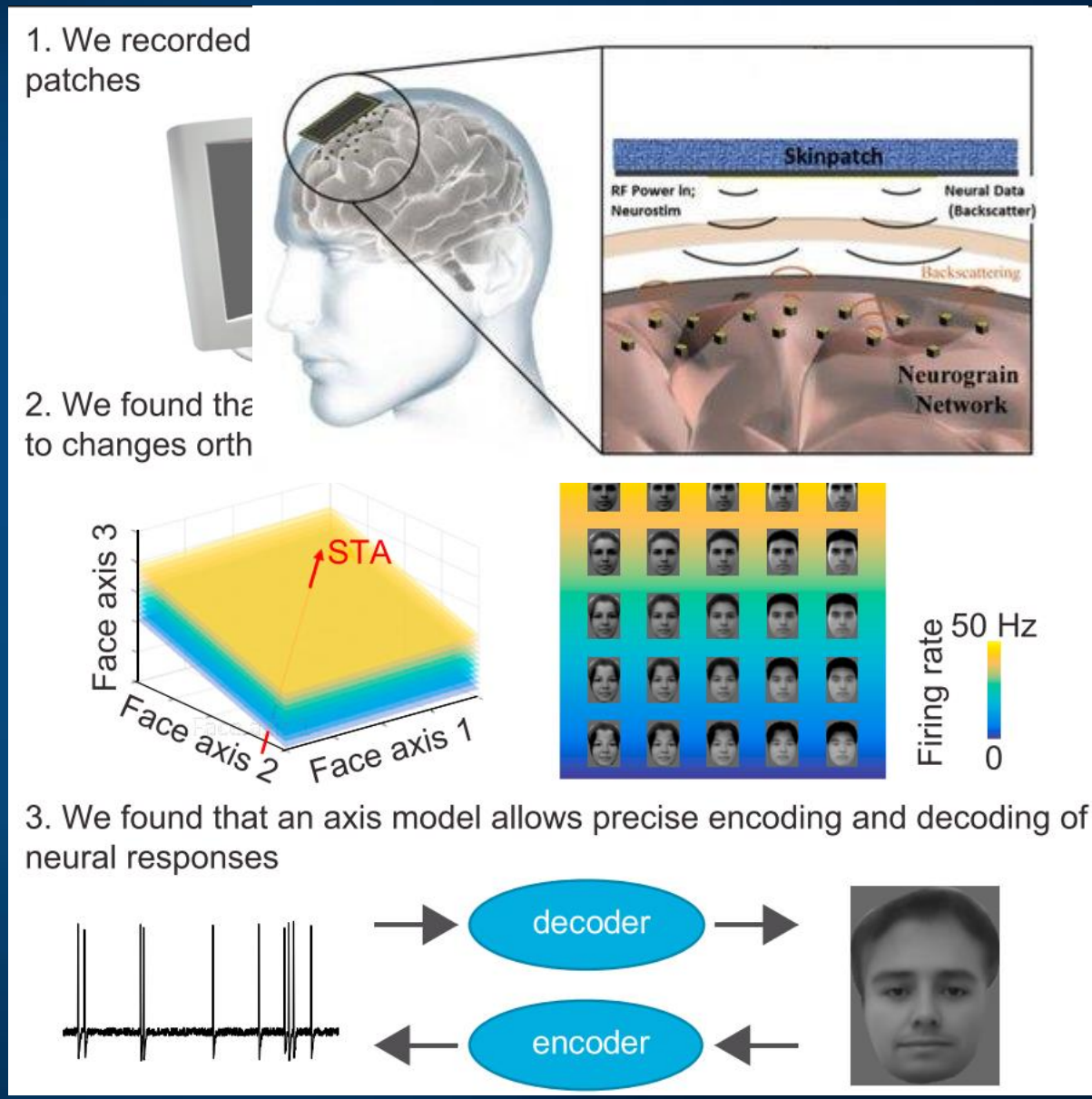
Dreams, thoughts … can one hide what has been seen and experienced?

Neural screen

Features are discovered, and their combination remembered as face, but detailed recognition needs detailed recording from neurons – 205 neurons in various visual areas used.

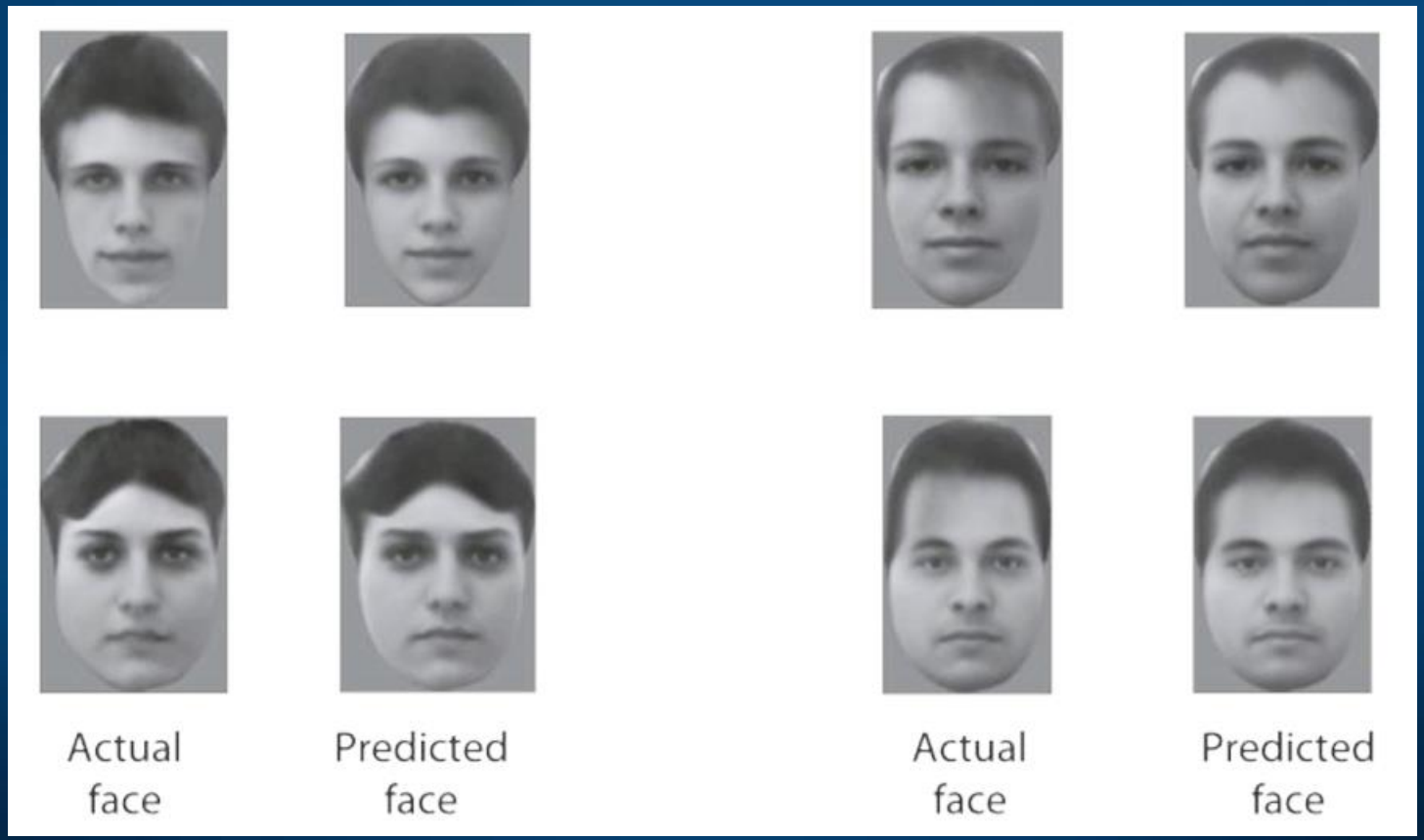
L. Chang and D.Y. Tsao, "The code for facial identity in the primate brain," *Cell* 2017

Elon Musk Neurolace, DARPA projects: put million nanowires in the brain! Use them to read neural responses, 10% will activate neurons.



Mental images

Facial identity is encoded via a simple neural code that relies on the ability of neurons to distinguish facial features along specific axes in the face space.



L. Chang and D.Y. Tsao, *Cell* 2017

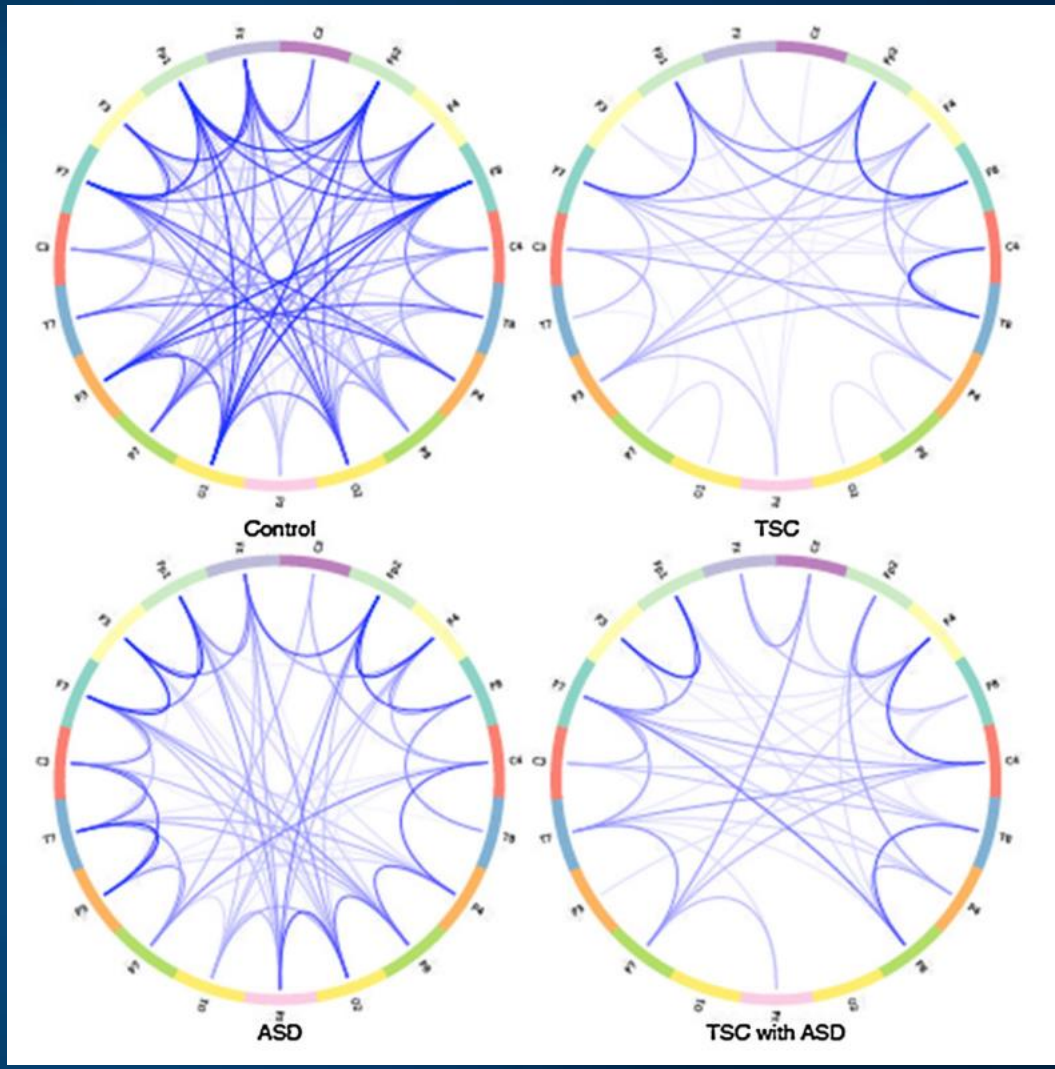
Disrupted network connectivity

ASD: pathological connections

Comparison of connections for patients with ASD (autism spectrum), TSC (Tuberous Sclerosis), and ASD+TSC.

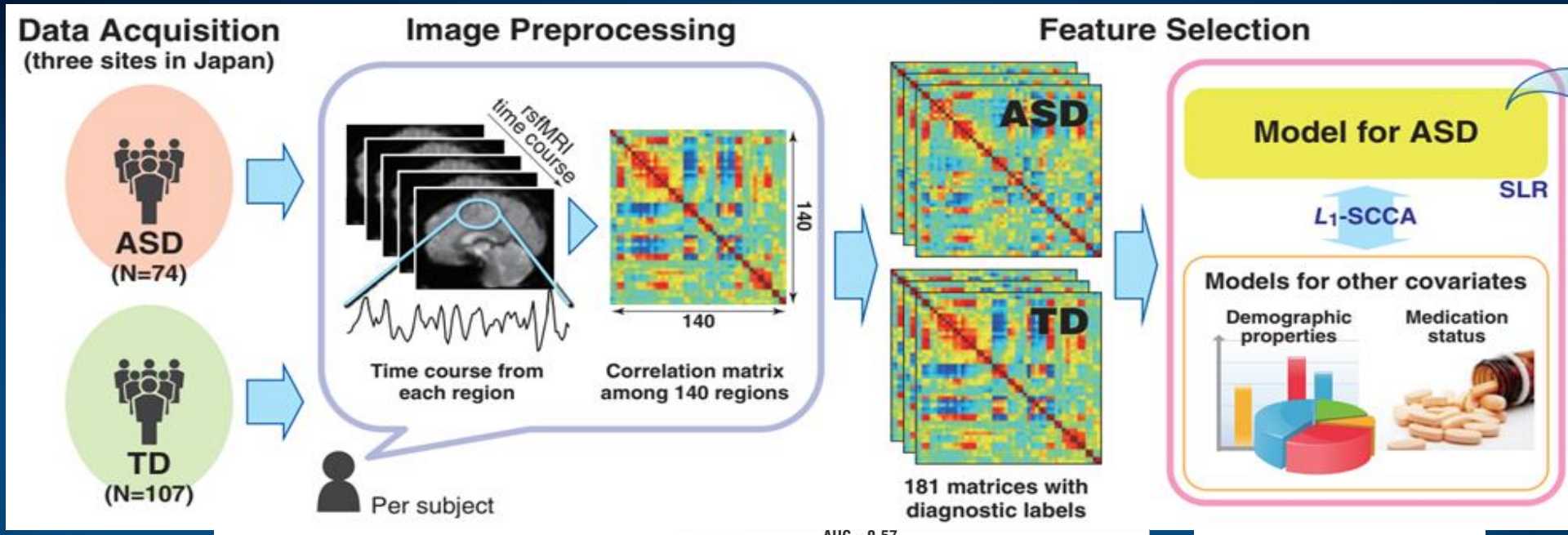
Coherence between electrodes. Weak or missing connections between distant regions prevent ASD/TSC patients from solving more demanding cognitive tasks.

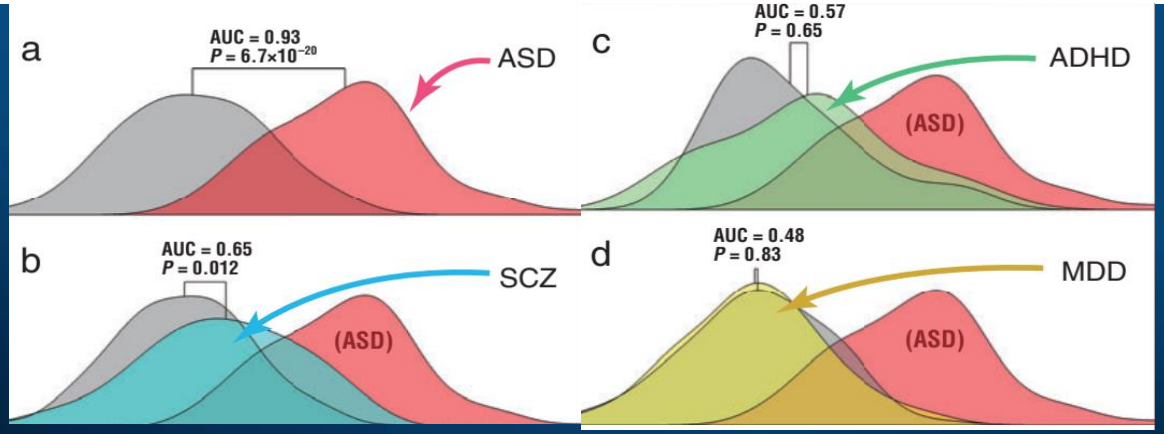
Network analysis becomes very useful for diagnosis of changes due to the disease and learning; **correct your networks**!

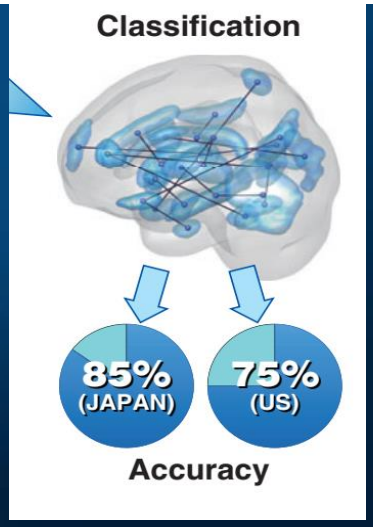


J.F. Glazebrook, R. Wallace, Pathologies in functional connectivity, feedback control and robustness. Cogn Process (2015) 16:1–16

Biomarkers from neuroimaging

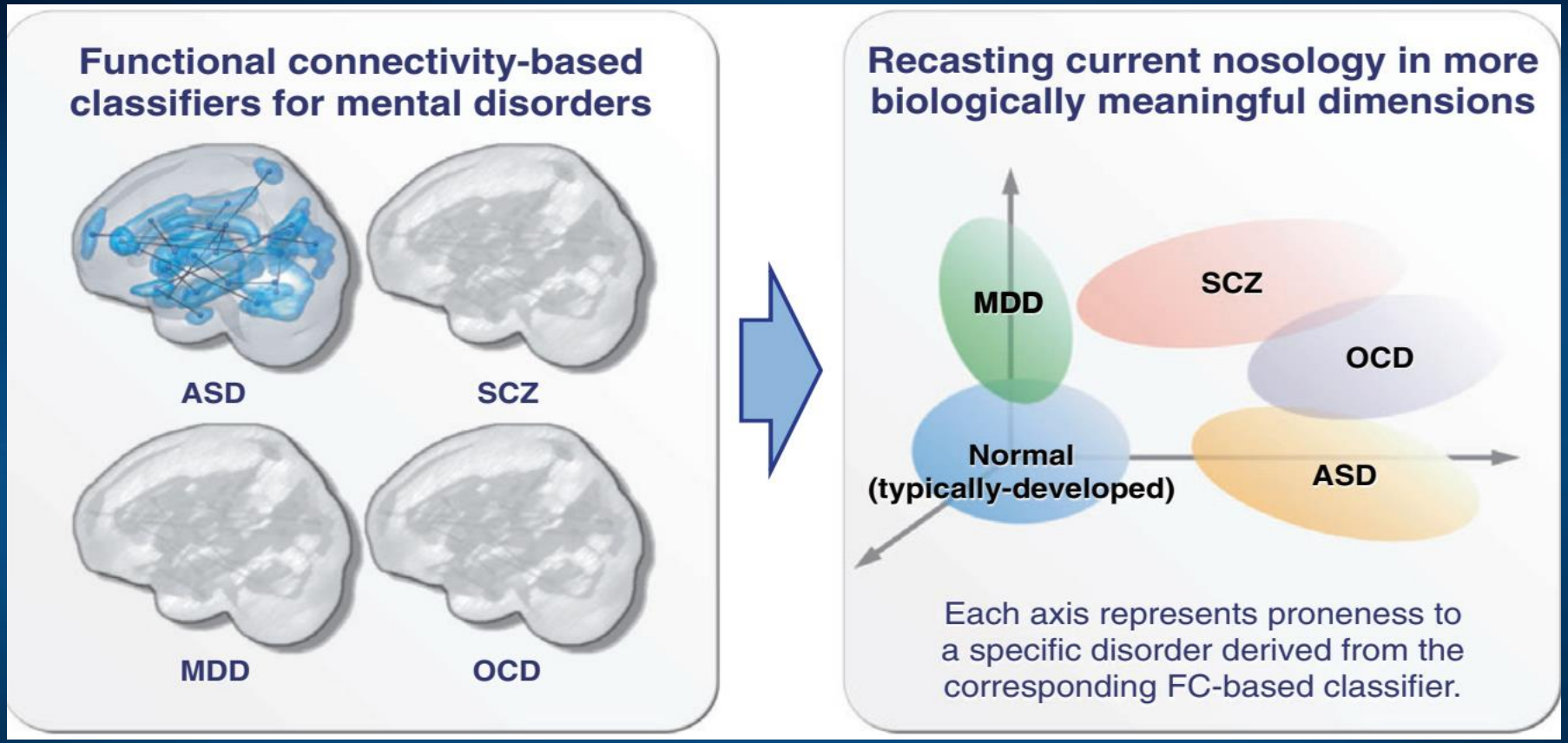






- N. Yahata et al, *Psychiatry and Clinical Neurosciences* 2017: **71**

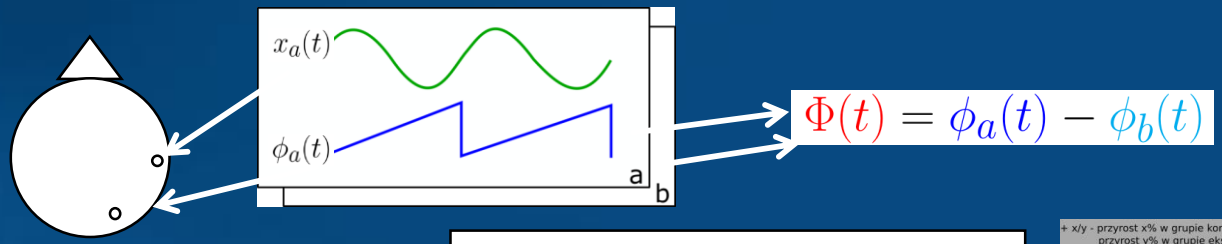
Biomarkers of mental disorders



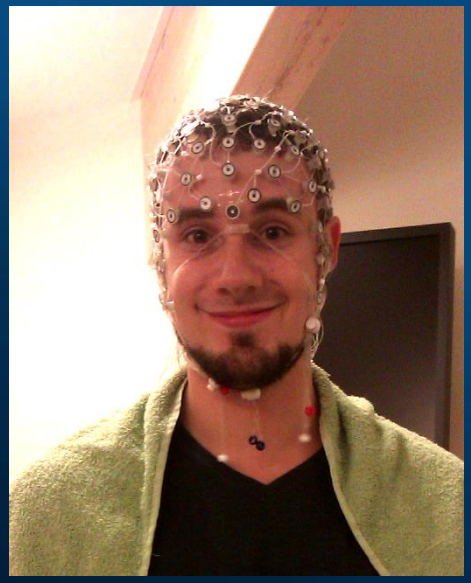
- MDD, deep depression, SCZ, schizophrenia, OCD, obsessive-compulsive disorder, ASD autism spectrum disorder. fMRI biomarkers allow for objective diagnosis. N. Yahata et al, *Psychiatry & Clinical Neurosciences* 2017; **71**: 215–237

Functional connectivity changes

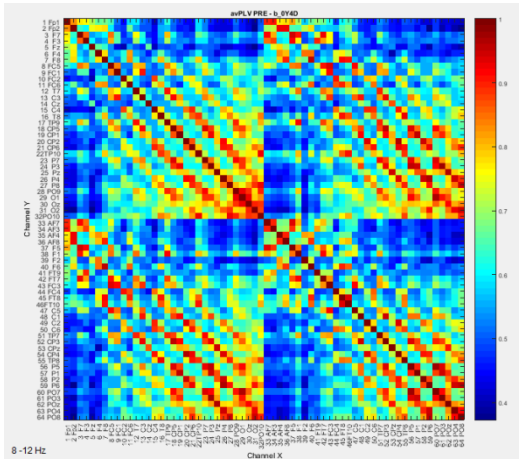
Influence of brain games on functional connectivity: **Phase Locking Value** (Burgess, 2013; Lachaux 1999), phase differences between signals measured at each electrode. PLV => synchronization maps, info flow.

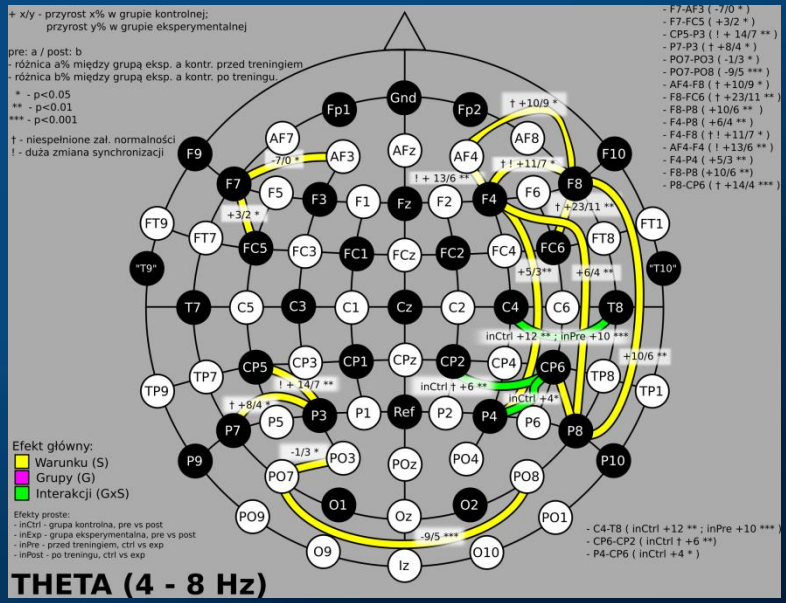


$$PLV(a,b) = \frac{1}{T}\left|\sum_{t}^{T} e^{i\Phi(t)}\right|$$

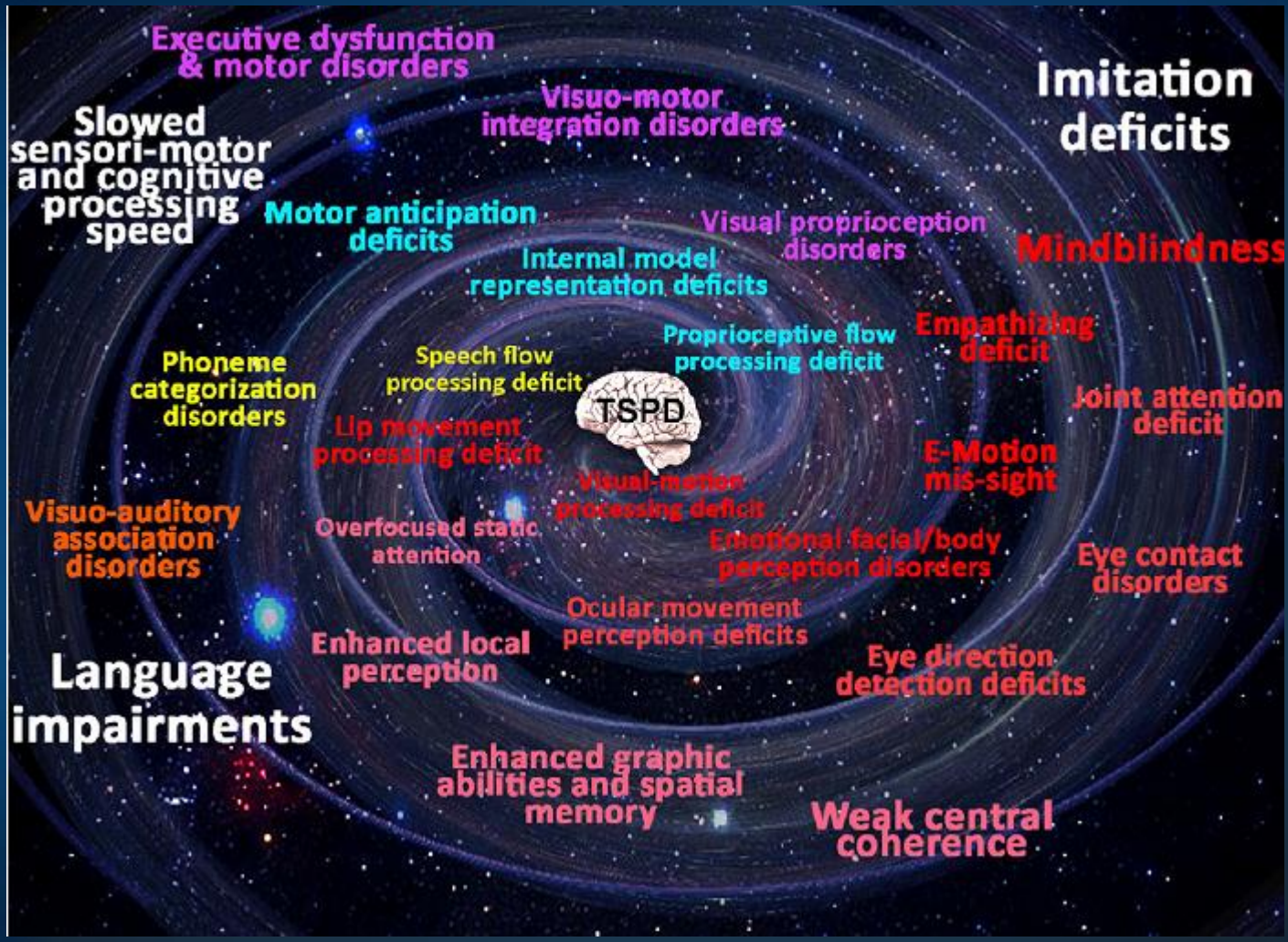


PLV channel vs channel





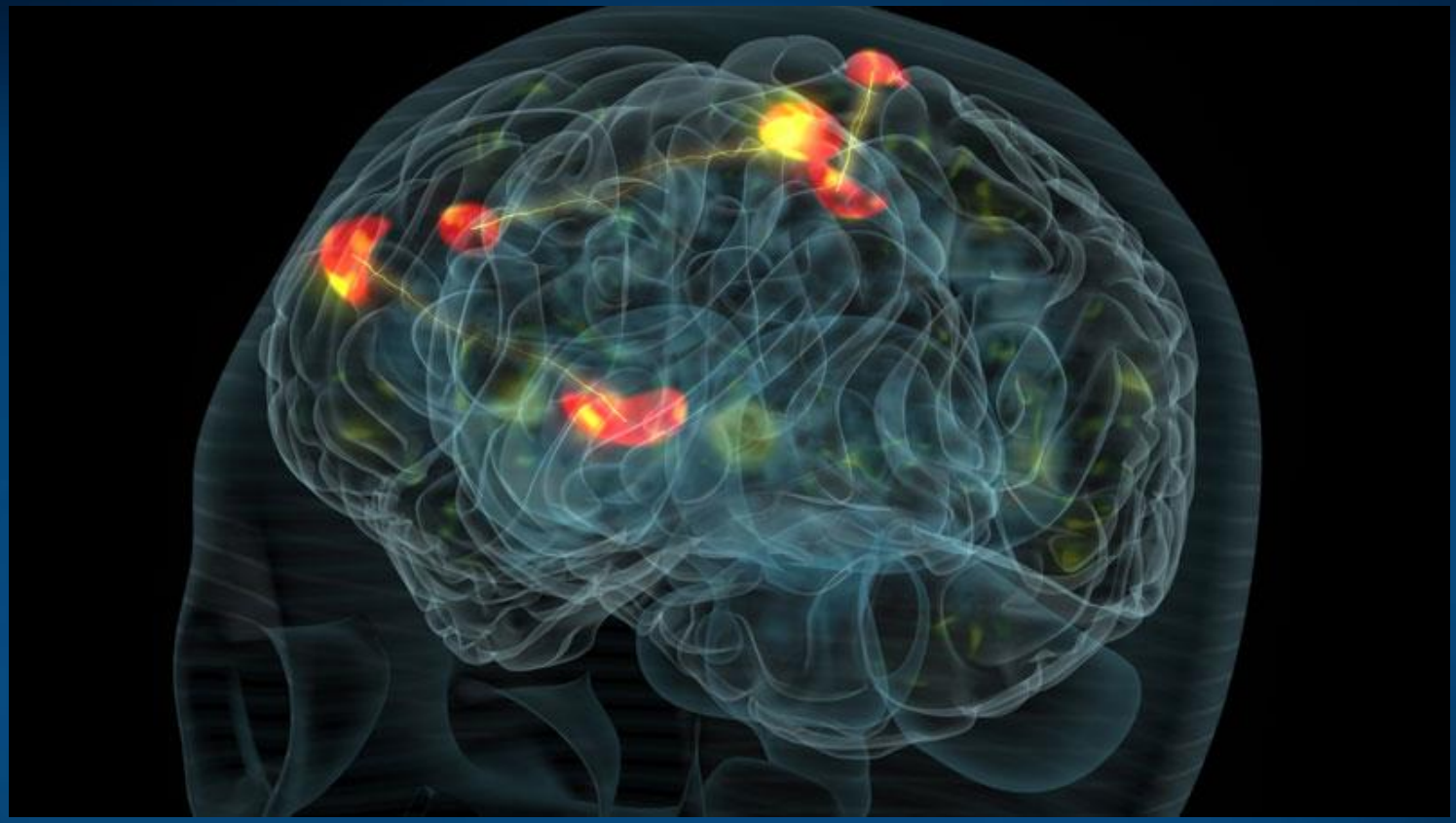
Temporo-spatial processing disorders



B. Gepner, F. Feron, Autism: A world changing too fast for a mis-wired brain? Neuroscience and Biobehavioral Reviews (2009).

Fingerprints of Mental Activity

Mental state: strong coherent activation



Many processes go on in parallel, controlling homeostasis and behavior. Most are automatic, hidden from our Self. What goes on in my head?

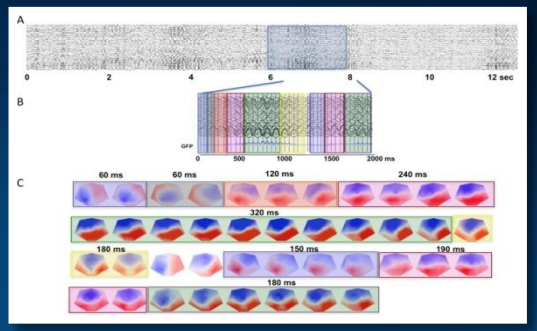
Various subnetworks compete for access to the highest level of control - consciousness, the winner-takes-most mechanism leaves only the strongest. How to extract stable intentions from such chaos?

Brain Fingerprinting

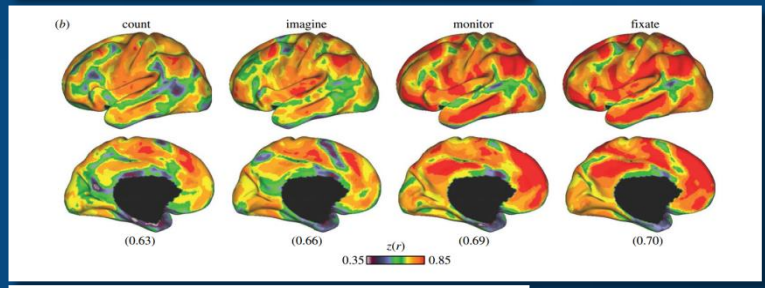
- Find unique patterns of brain activity that should help to identify:
  - brain regions of interest (ROI)
  - active neural networks
  - mental states, tasks.

- **Several approaches:**
- 1. Microstates and their transitions (Michel & Koenig 2018)
- 2. Reconfigurable task-dependent modes (Krienen et al. 2014)
- 3. Contextual Connectivity (Ciric et al. 2018)
- 4. Spectral Fingerprints (Keitel & Gross 2016)
- 5. A few more …

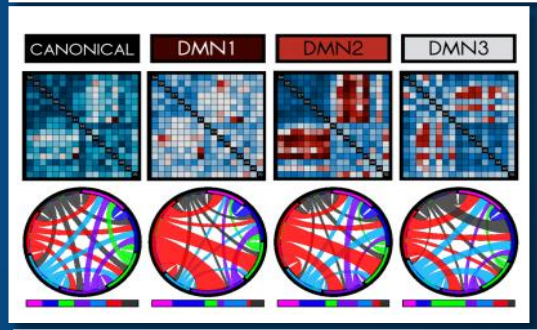
1



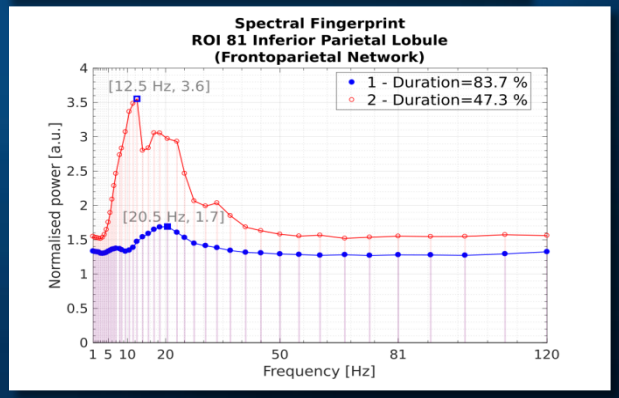
2



3



4

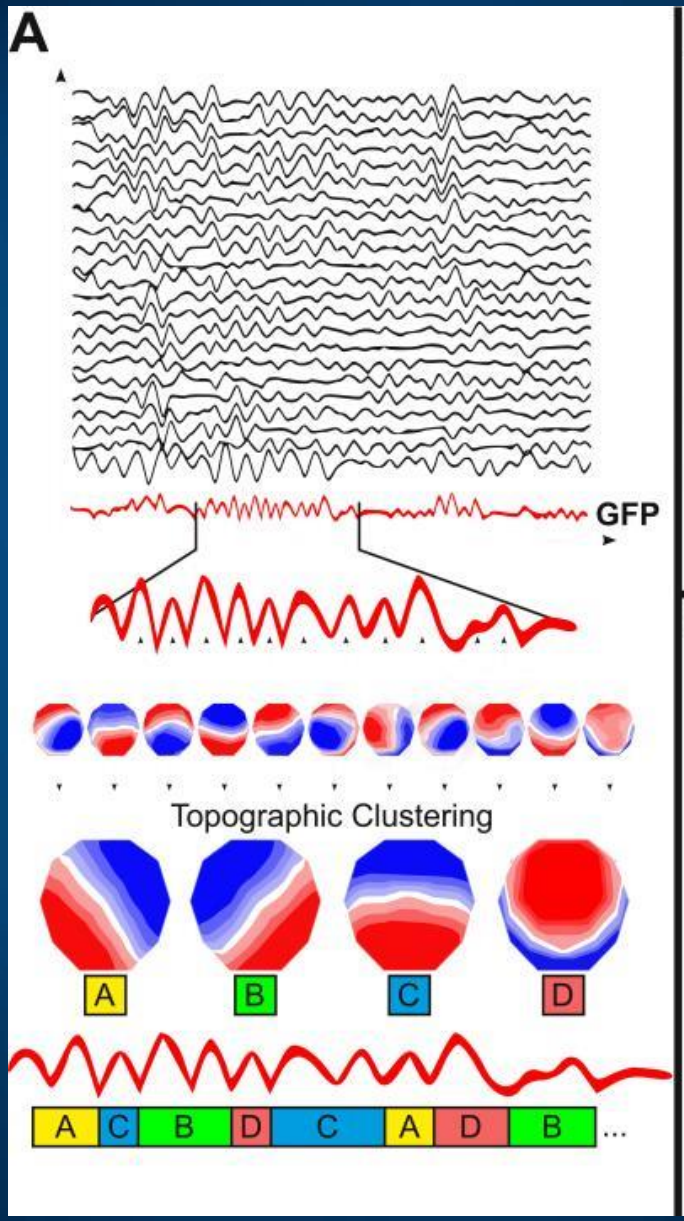


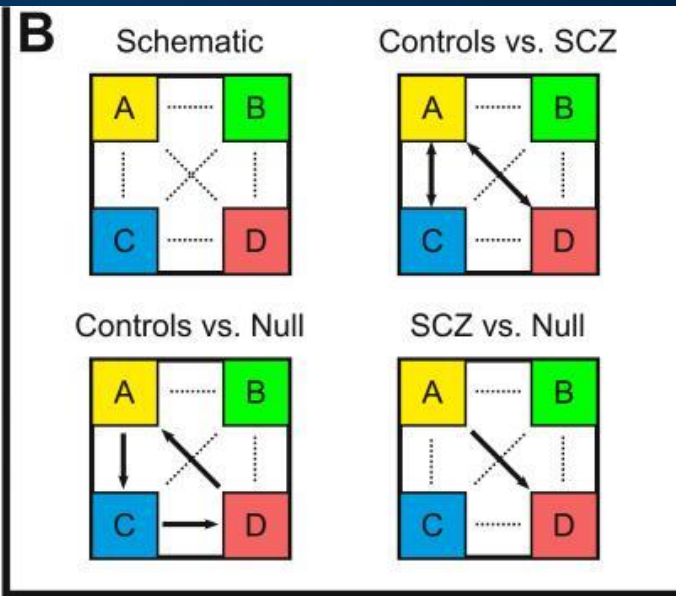
Microstates

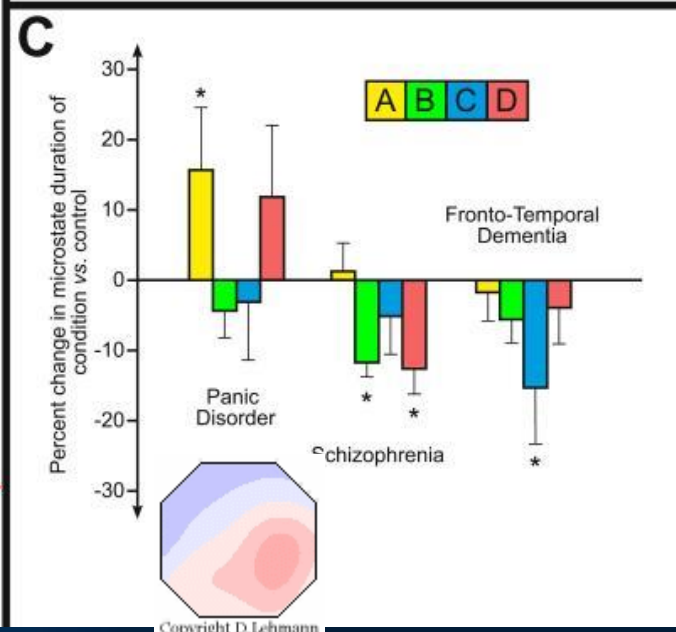
Lehmann et al. EEG microstate duration and syntax in acute, medication-naïve, first-episode schizophrenia: a multi-center study. Psychiatry Research Neuroimaging, 2005

Khanna et al. Microstates in Resting-State EEG: Current Status and Future Directions. *Neuroscience and Biobehavioral Reviews*, 2015

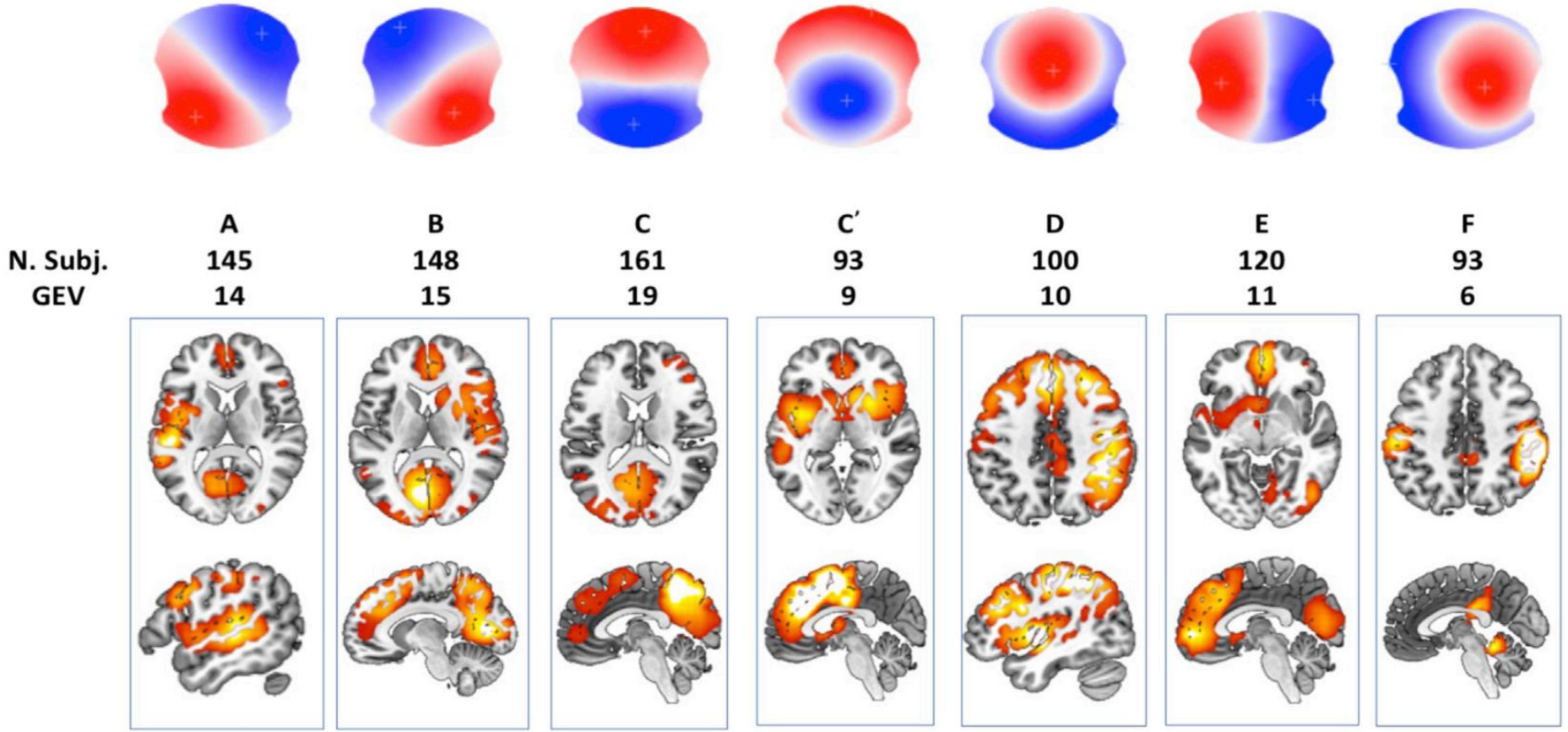
Symbolic dynamics.







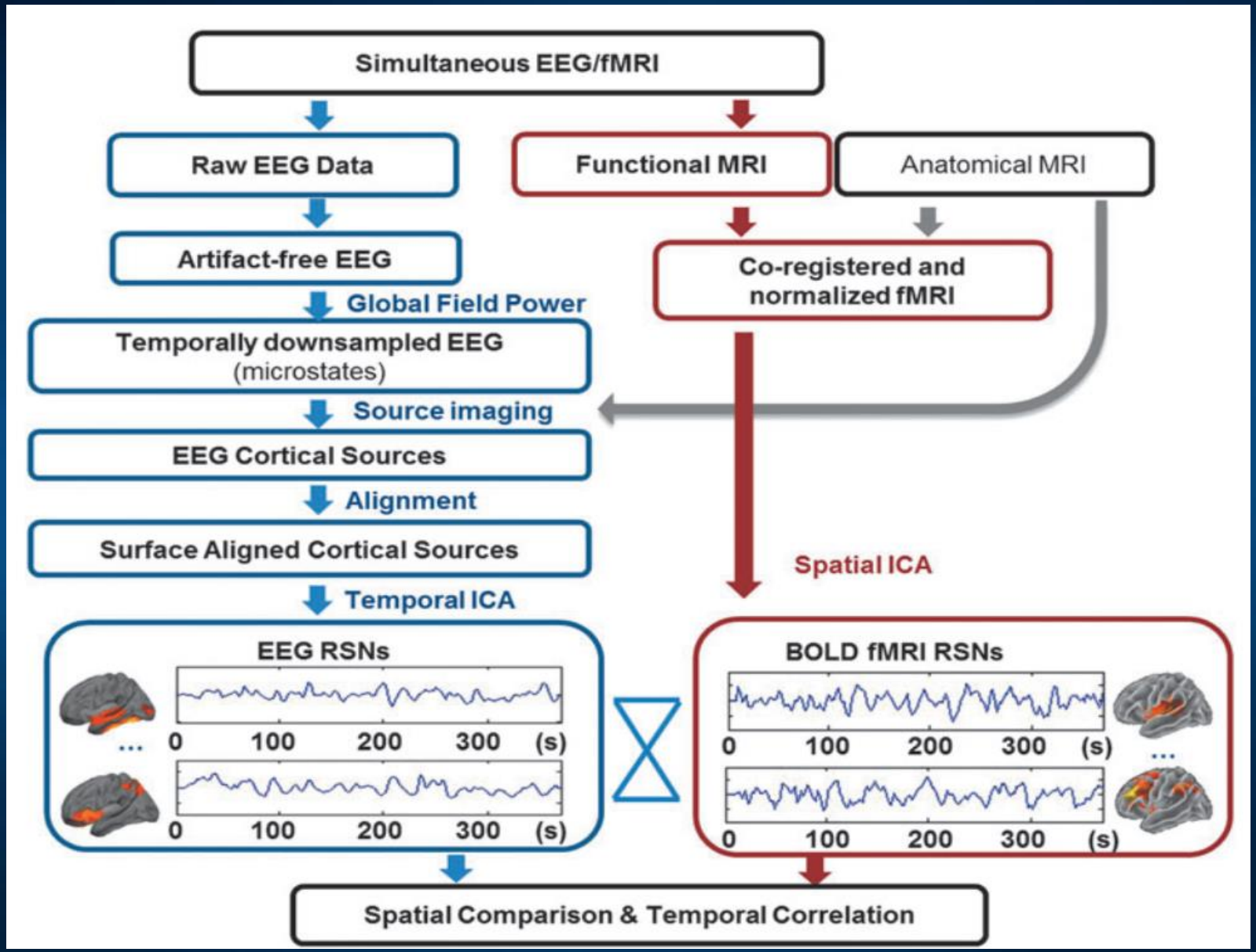
Microstates and their sources



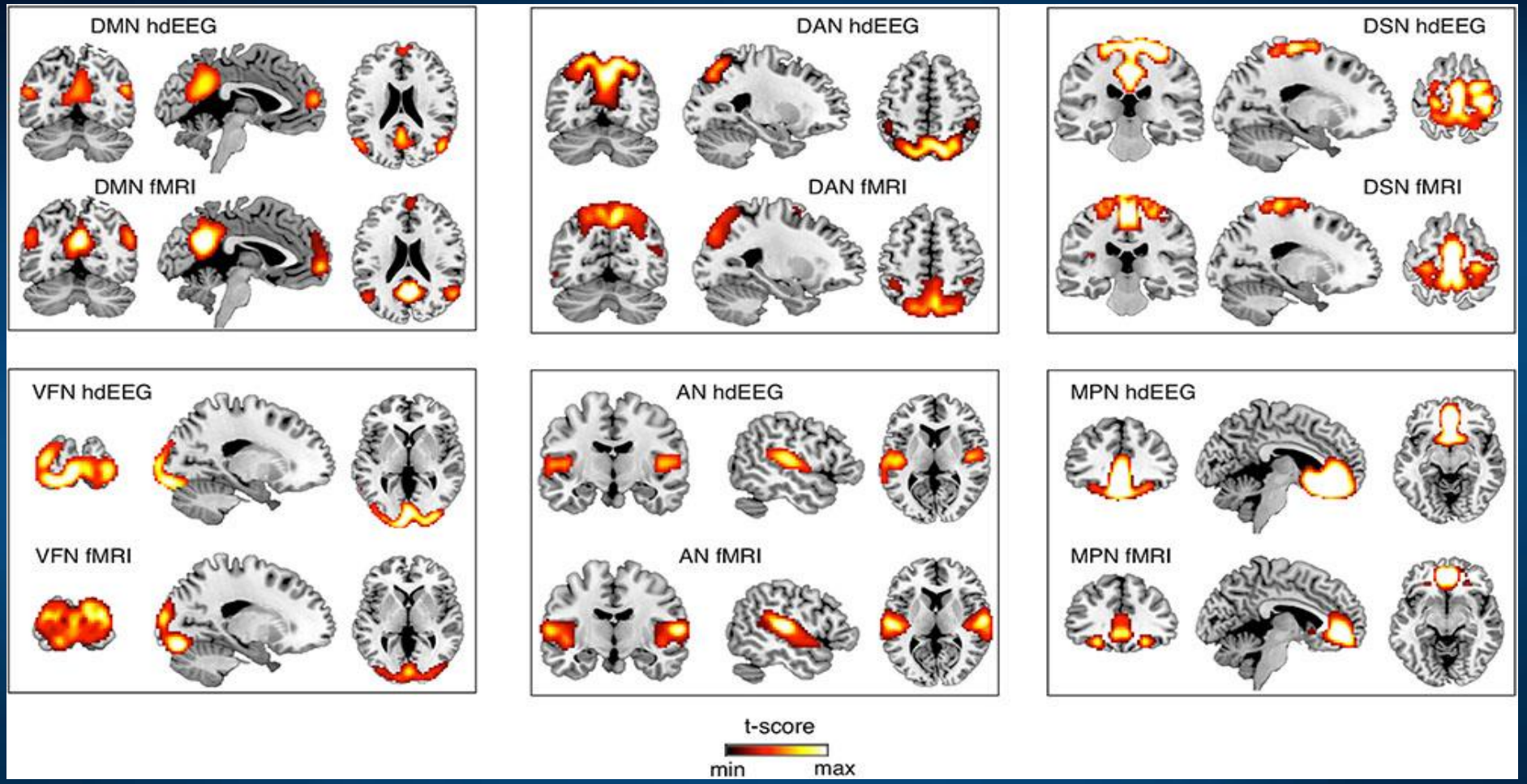
Interpretation is hard: each brain region is involved in many functions, each function engages many brain regions. Identify specific networks.

Michel, C. M., & Koenig, T. (2018). EEG microstates as a tool for studying the temporal dynamics of whole-brain neuronal networks: A review. *NeuroImage*, *180*, 577–593.

Yuan .. Bodurka, 2015-21

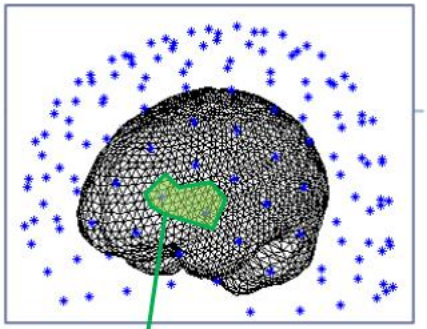


14 networks from BOLD-EEG

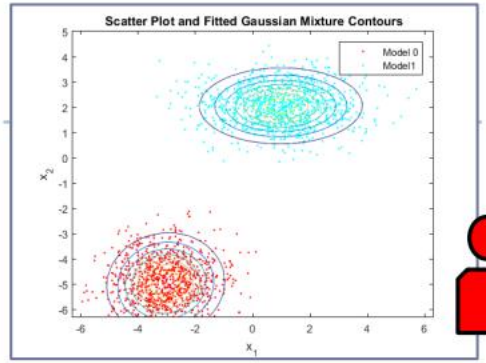


Spatial ICA, 10-min fMRI (*N* = 24). Networks: DMN, default mode; DAN, dorsal attention; DSN, dorsal somatomotor; VFN, visual foveal; AN, auditory; MPN, medial prefrontal.
Huan et al. (2015); Liu et al. Detecting large-scale networks in the human brain. HBM (2018).

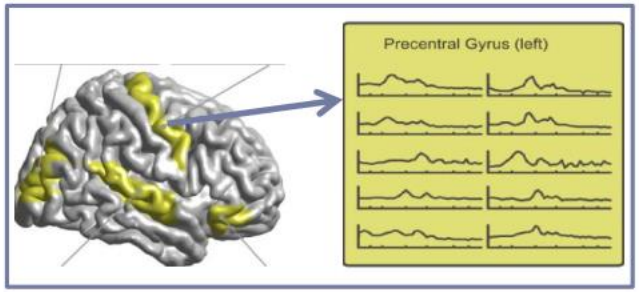
Spectral fingerprints

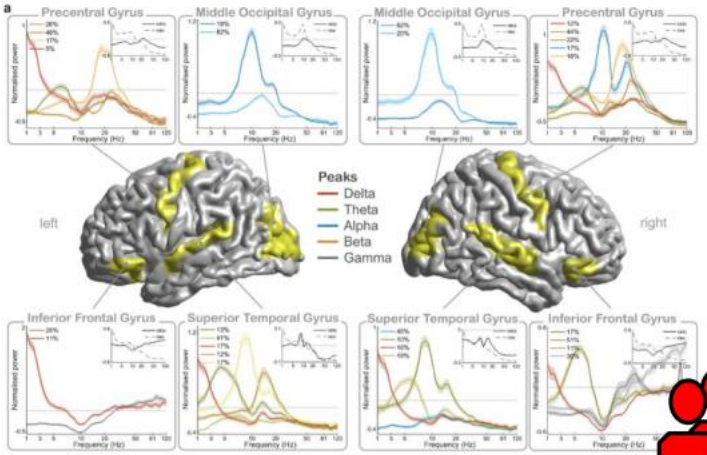


$d \in \mathrm{ROI}$



Single subject



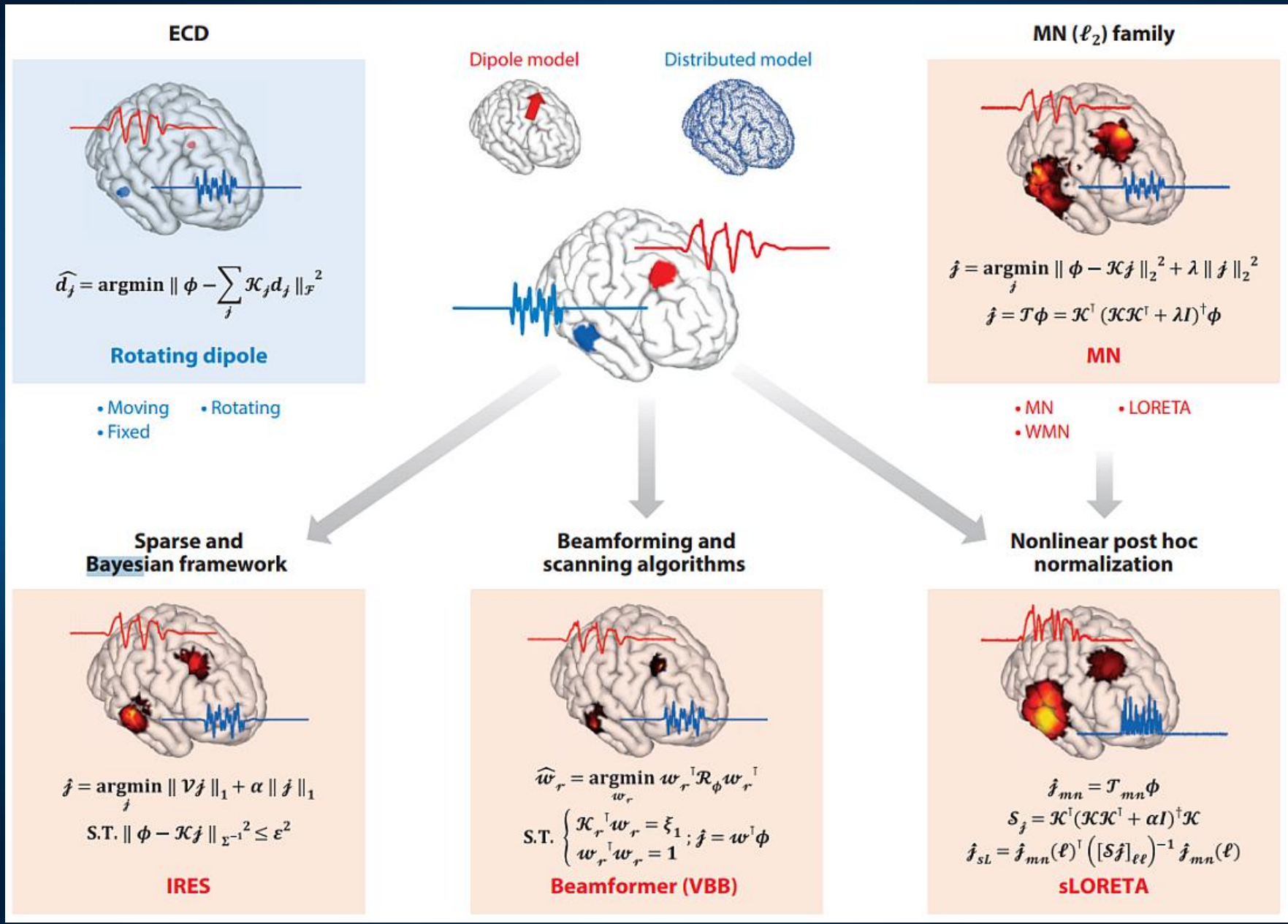


Group model

* Pictures from Keitel & Gross 2016 and Fieldtrip beamforming tutorial

A. Keitel i J. Gross, „Individual human brain areas can be identified from their characteristic spectral activation fingerprints”, *PLoS Biol* 14(6), e1002498, 2016

EEG localization and reconstruction



SupFunSim

SupFunSim: our library/Matlab /tollbox, direct models for EEG/MEG.

Provides many spatial filters for reconstruction of EEG sources: linearly constrained minimum-variance (LCMV), eigenspace LCMV, nulling (NL), minimum-variance pseudo-unbiased reduced-rank (MV-PURE) …

Source-level directed connectivity analysis: partial directed coherence (PDC), directed transfer function (DTF) measures.

Works with FieldTrip EEG/ MEG software. Modular, object-oriented, using Jupyter notes, allowing for comments and equations in LaTex.

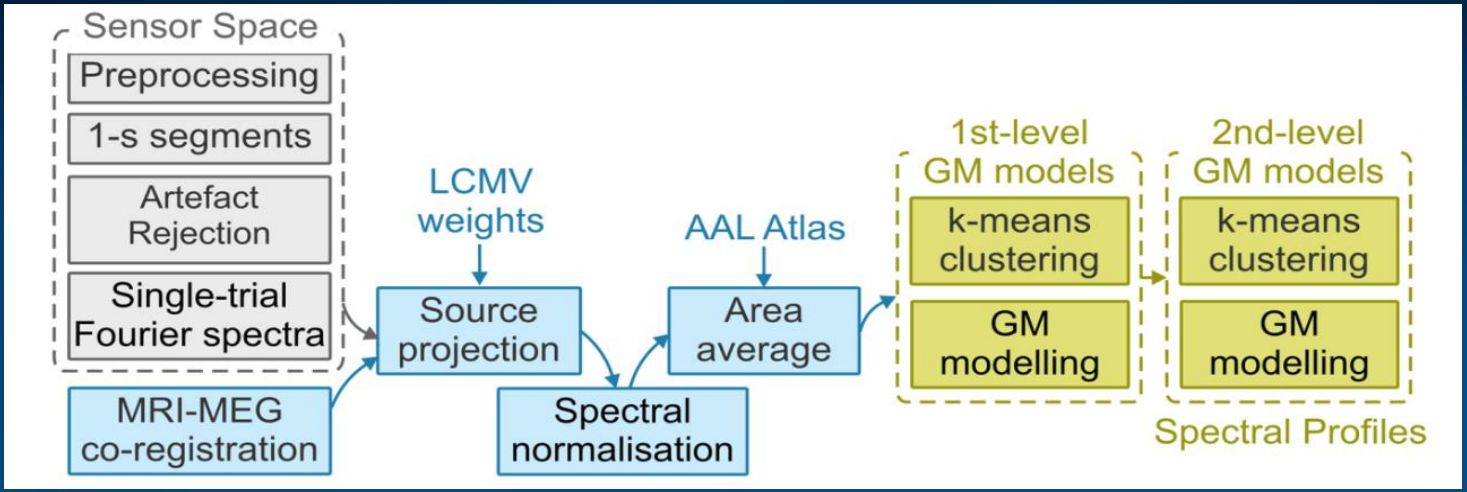
$$A := H_{Src,R} := R^{-1/2} H \tag{34}$$
$$B := H_{Src,N} := N^{-1/2} H \tag{35}$$

```
%%file calculate_H_Src.m
function model = calculate_H_Src(MODEL)
    model = MODEL;

    model.H_Src_R = pinv(sqrtm(model.R)) * model.H_Src;
    model.H_Src_N = pinv(sqrtm(model.N)) * model.H_Src;
end
```

Rykaczewski, K., Nikadon, J., Duch, W., & Piotrowski, T. (2019). *BioRxiv*, 618694

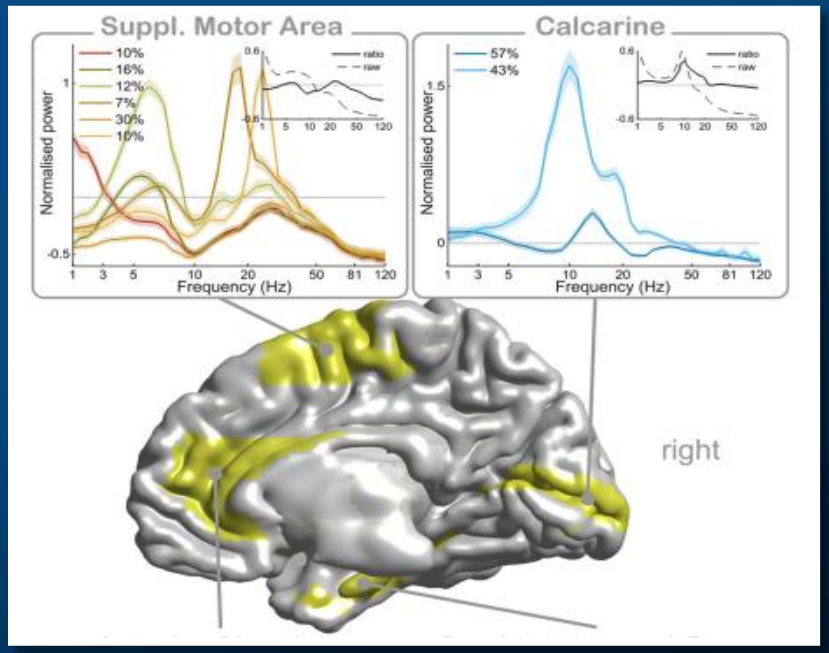
Spectral analysis



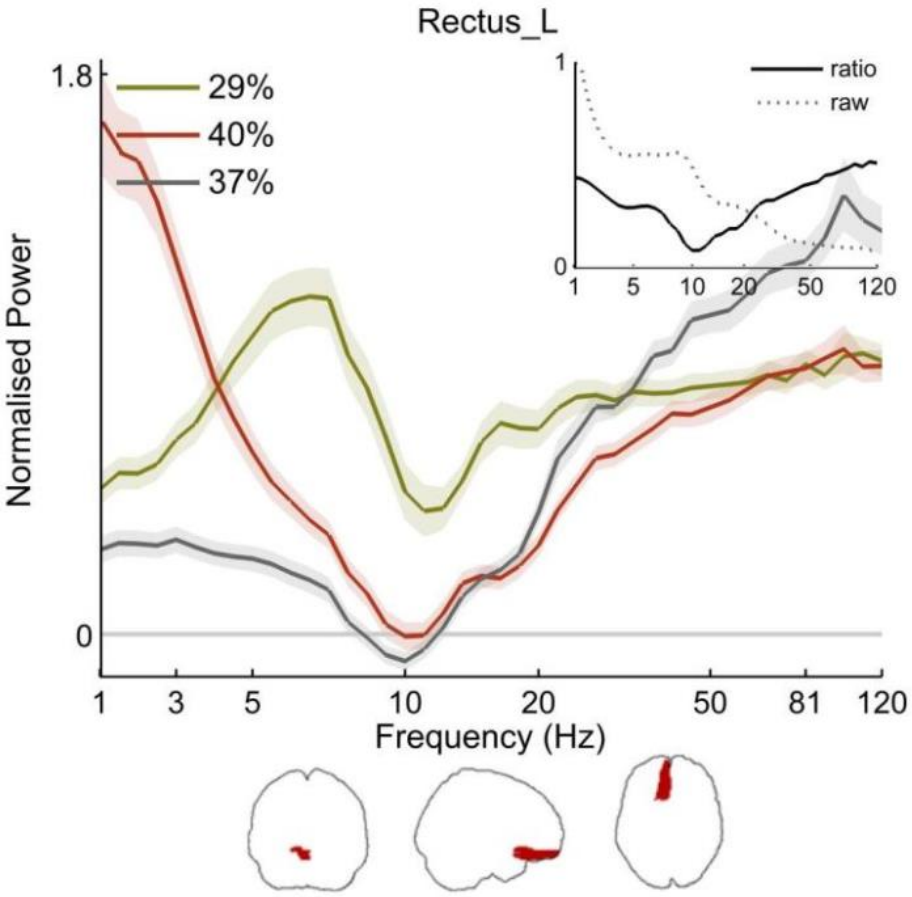
- **Spectral fingerprints**

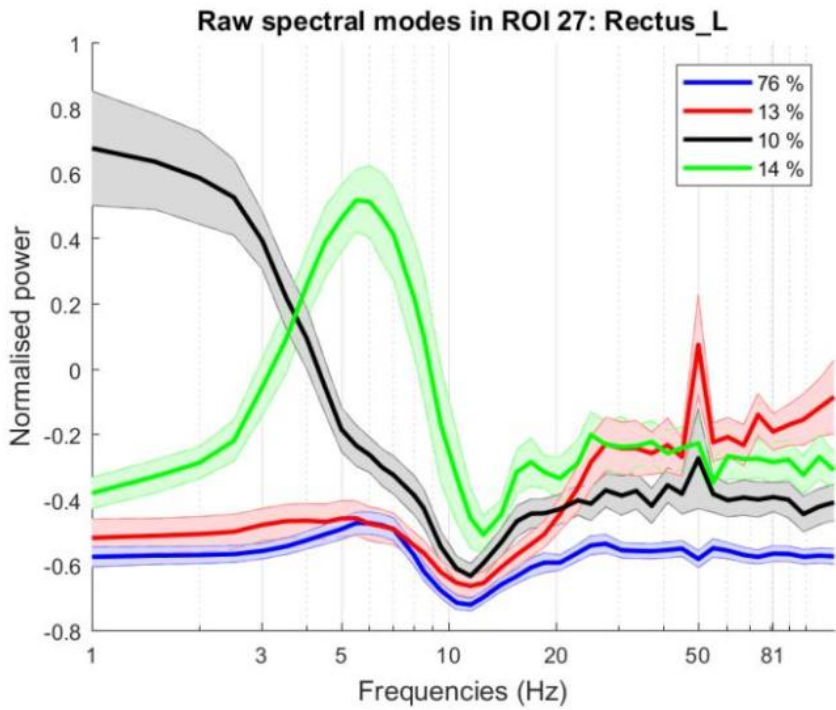
Monitor EEG/MEG power spectra in 1 sec time windows, project them to source space of ROIs based on brain atlas, and create spectra that characterize ROIs.

A. Keitel & J. Gross. Individual human brain areas can be identified from their characteristic spectral activation fingerprints. *PLoS Biol* 14, 2016



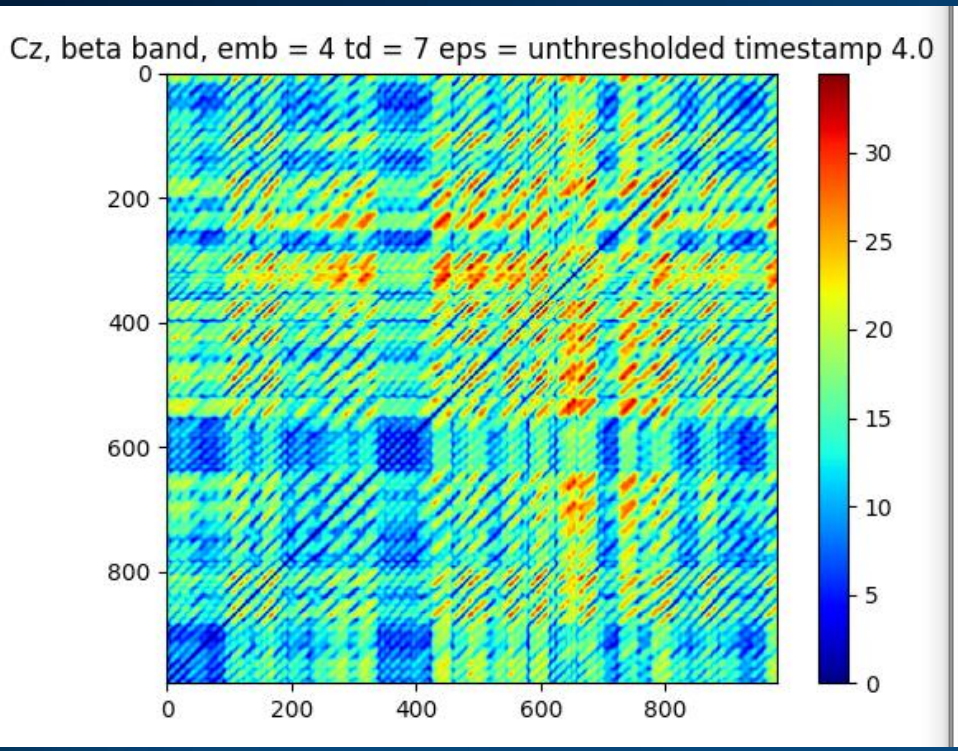
Spectral fingerprints

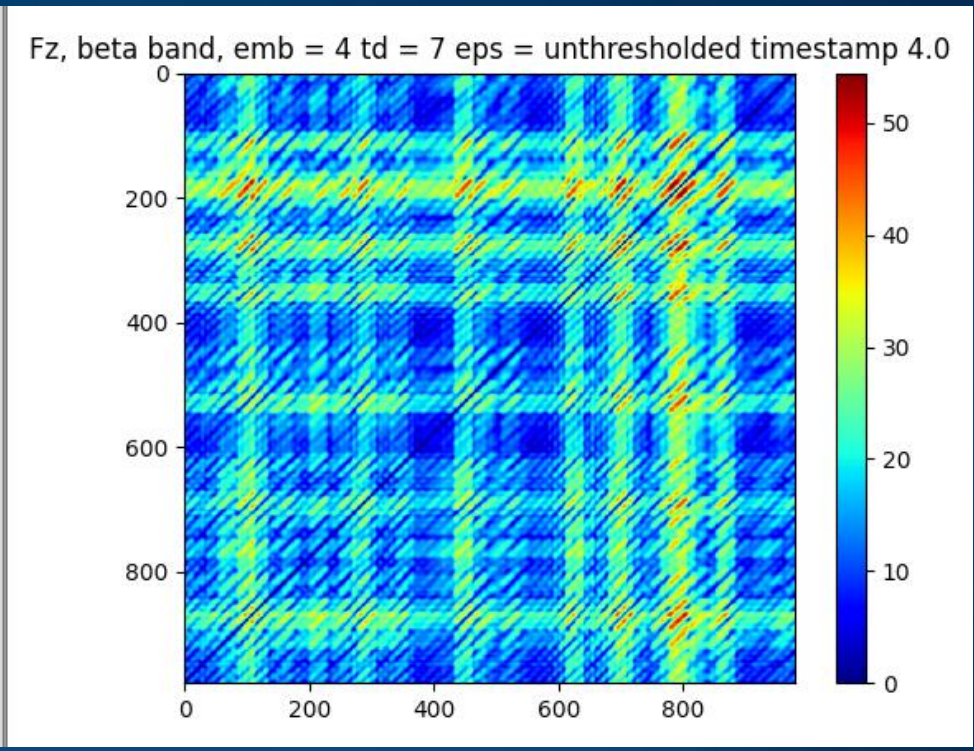




M. Komorowski et al. Toolbox for spectral analysis in prep (2021).

EEG and brain activity patterns

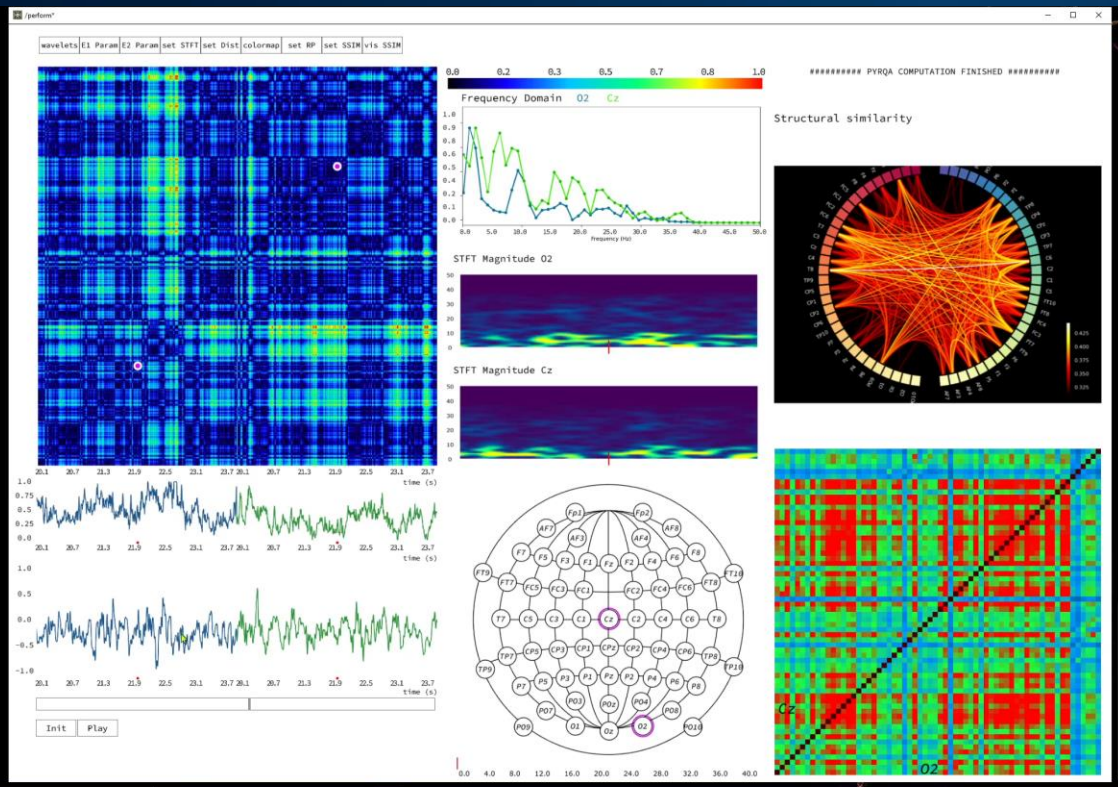


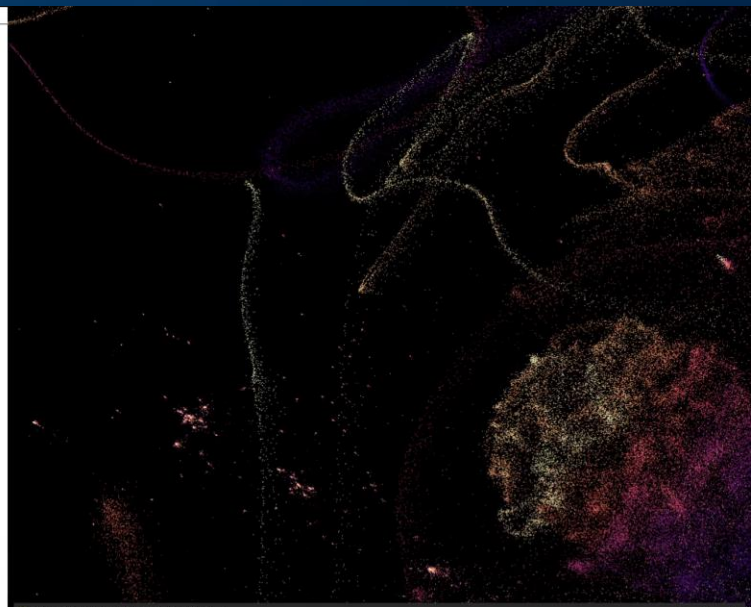


Synchronization of two channels in EEG resting state in several time windows. Cz channel between 420-700 ms is desynchronized, but Fz participates in different subnetworks. Metastable states last about 100 ms. Using fMRI 128 functional networks of cognition/behavior have been identified but their dynamics is unknown.

Sung et al. (2018). A Set of Functional Brain Networks for the Comprehensive Evaluation of Human Characteristics. Frontiers in Neuroscience, 12.

EEG fast signal changes





EEG data, 128 channels. Left upper corner - recurrence plot, power spectra from two electrodes and time/frequency plot, raw signals.
Average synchronization between electrodes, correlations between activity of brain regions (Łukasz Furman).

Computer simulations

Model of reading & dyslexia

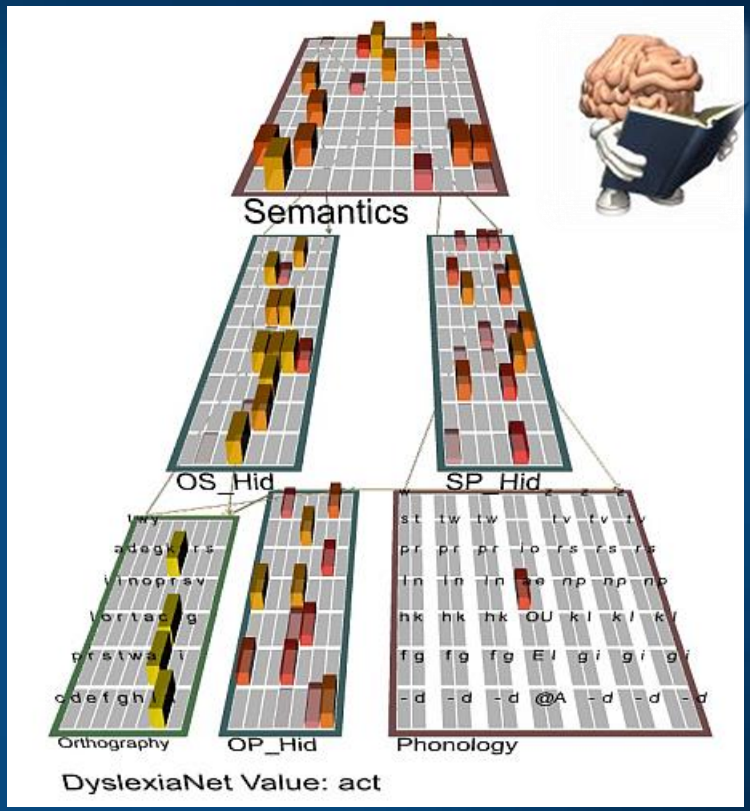
Emergent neural simulator:

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

3-layer model of reading:

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

In the brain: microfeature=subnetwork.
Hidden layers OS/OP/SP_Hid in between.

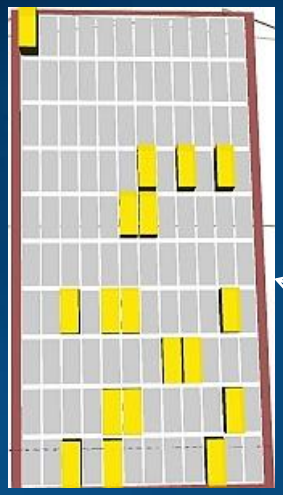


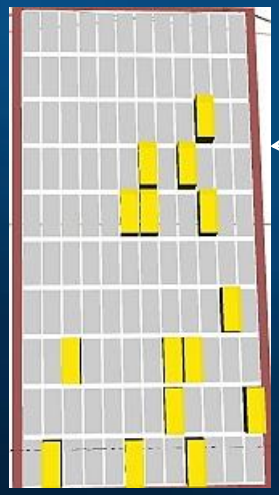
Learning: mapping one of the 3 layers to the other two.

Fluctuations around final configuration = attractors representing concepts.

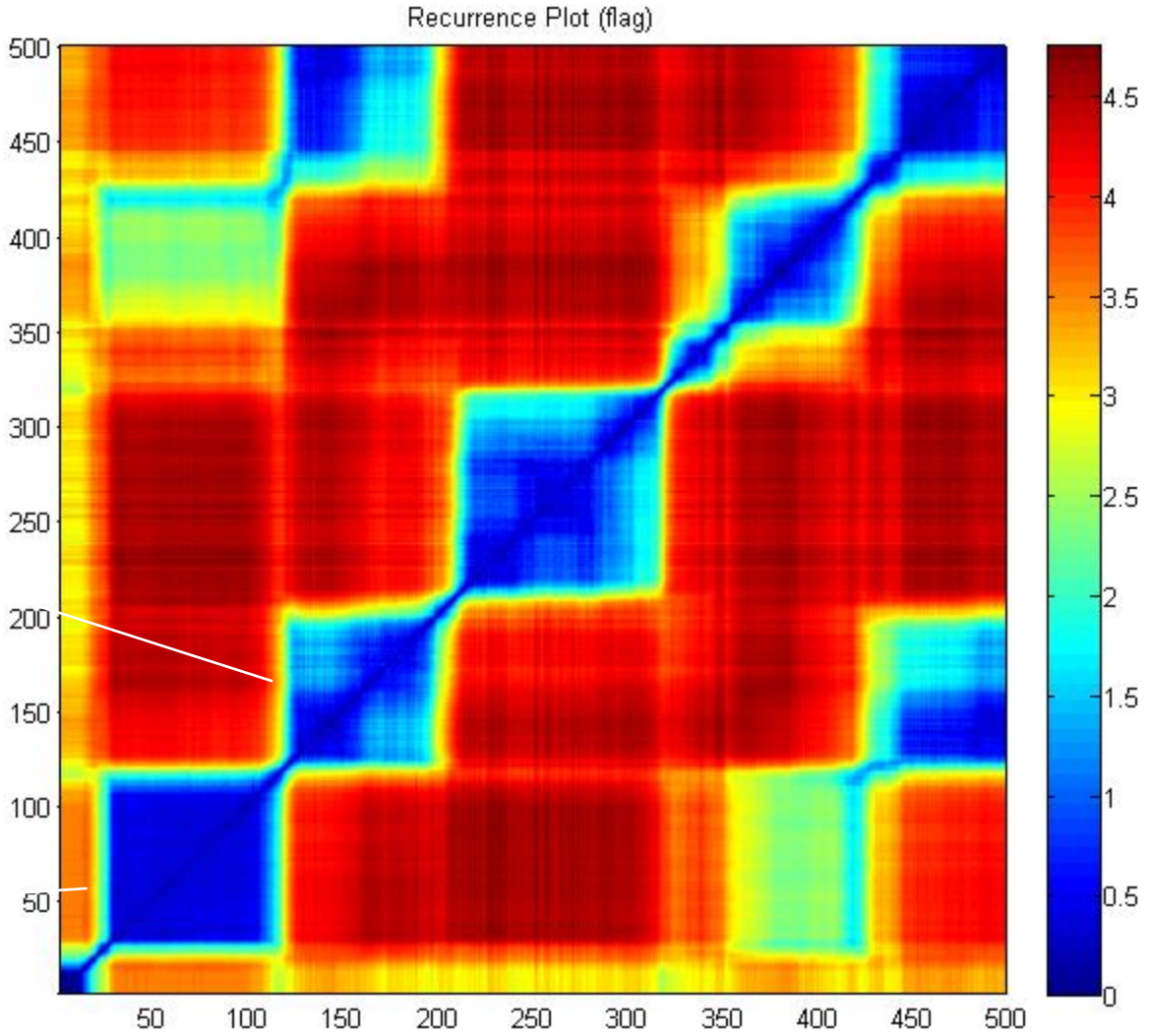
How to see properties of their basins, their relations?
Model in **Genesis**: more detailed neuron description.

rope



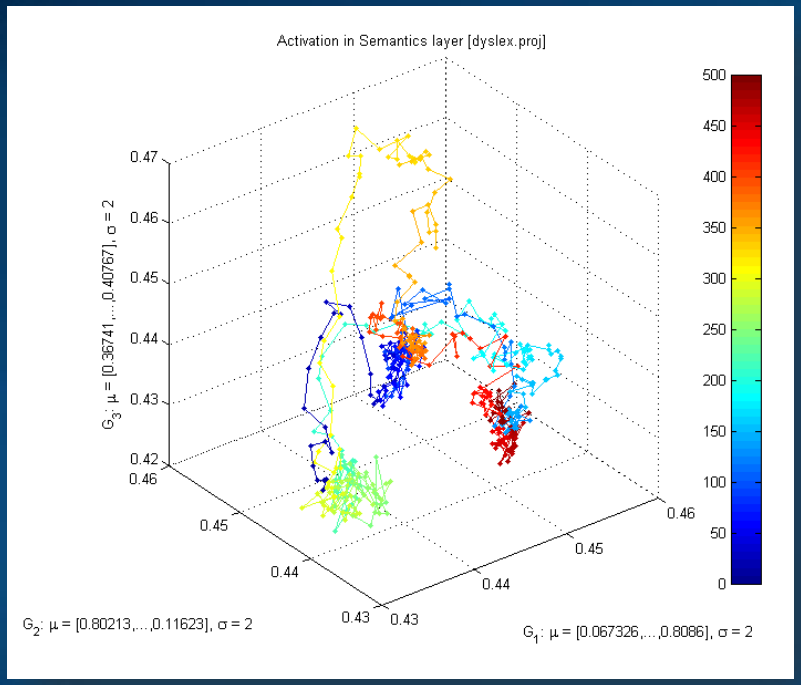


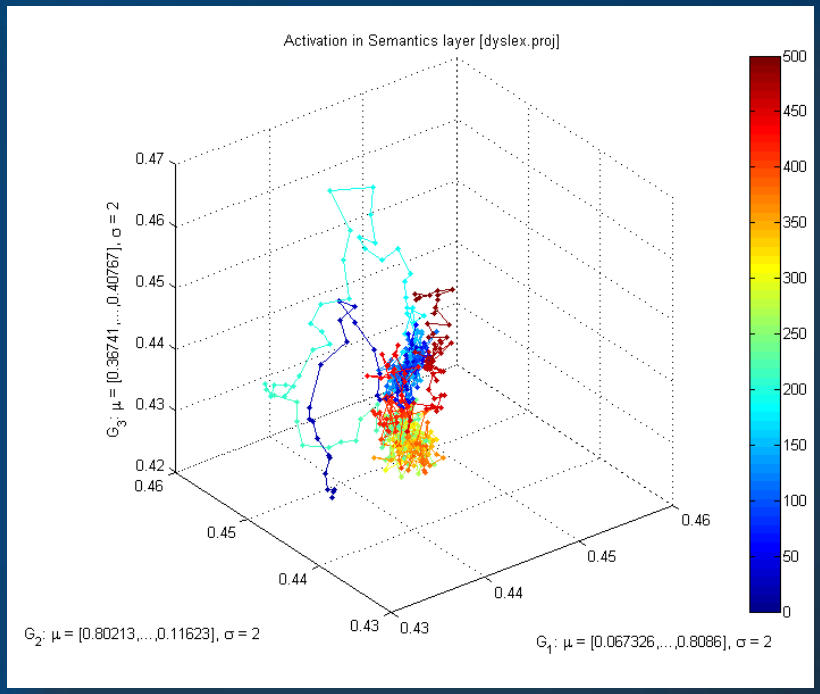
flag



Transitions to new patterns that share some active units (microfeatures) shown in recurrence plots.

Normal-Autism



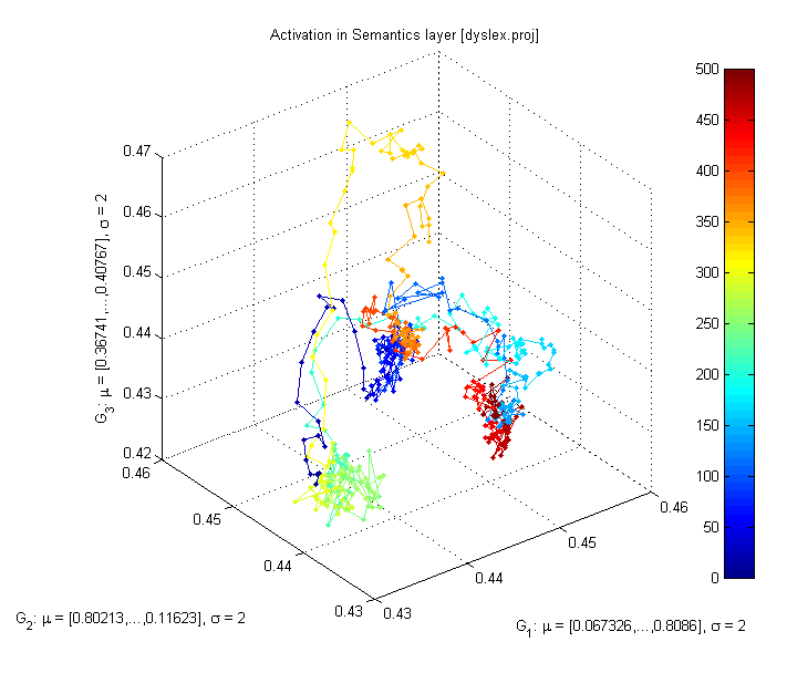


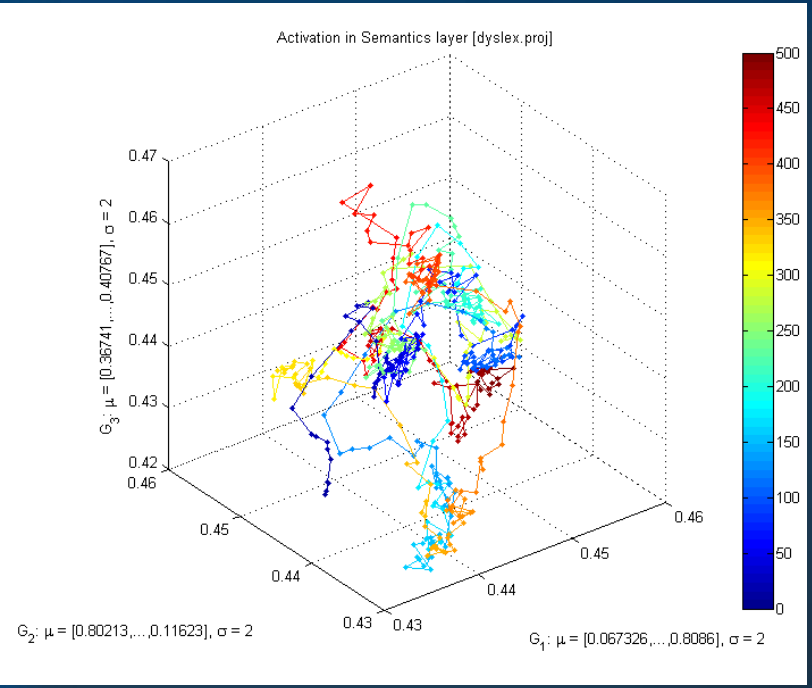
All plots for the flag word, different values of b_inc_dt parameter in the accommodation mechanism. b_inc_dt = 0.01 & b_inc_dt = 0.005

b_inc_dt = time constant for increases in intracellular calcium building up slowly as a function of activation, controls voltage-dependent leak channels.

http://kdobosz.wikidot.com/dyslexia-accommodation-parameters

Normal-ADHD



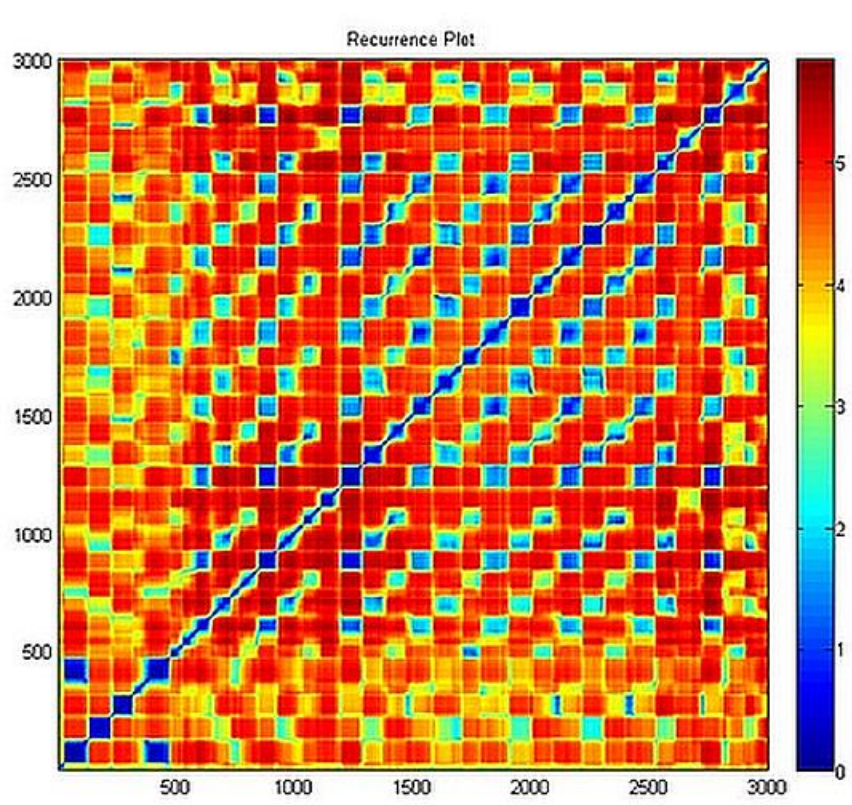


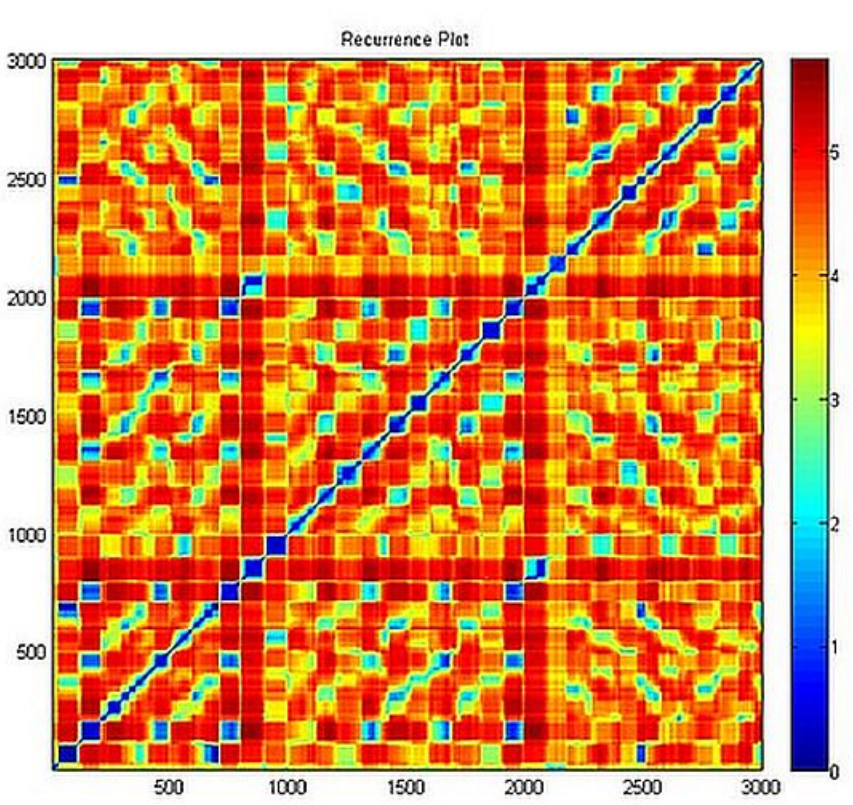
All plots for the flag word, different values of b_inc_dt parameter in the accommodation mechanism. b_inc_dt = 0.01 & b_inc_dt = 0.02

b_inc_dt = time constant for increases in intracellular calcium which builds up slowly as a function of activation.

http://kdobosz.wikidot.com/dyslexia-accommodation-parameters

RSVP: normal brain

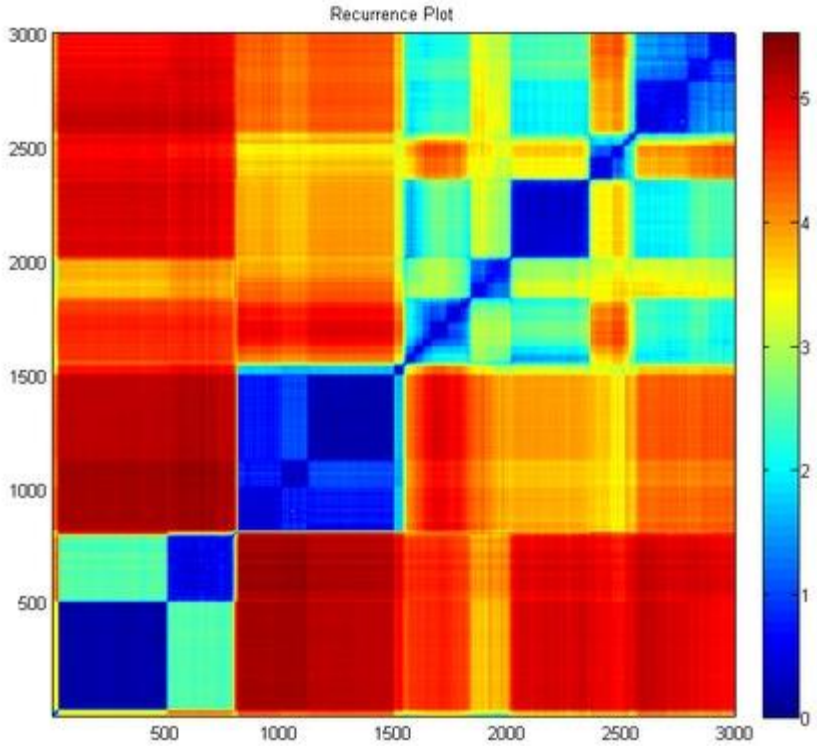


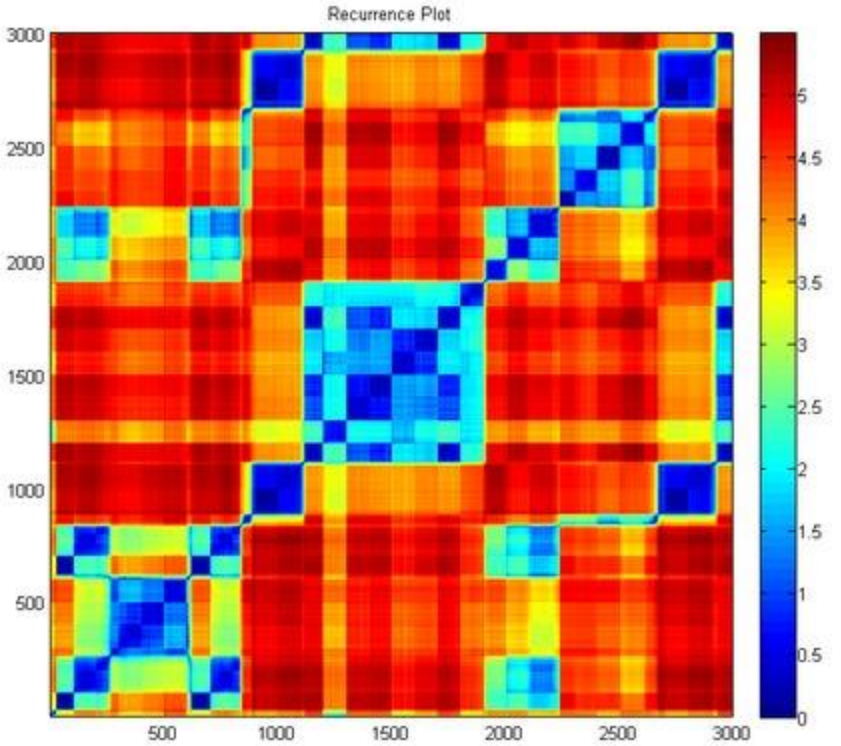


Normal speed
associations, context=>understanding

too fast, speed 5x
microstates get blurred,
few associations

RSVP simulations in deep autism





Normal speed
skipping some words,
no associations

fast presentation
more internal states
some associations arise

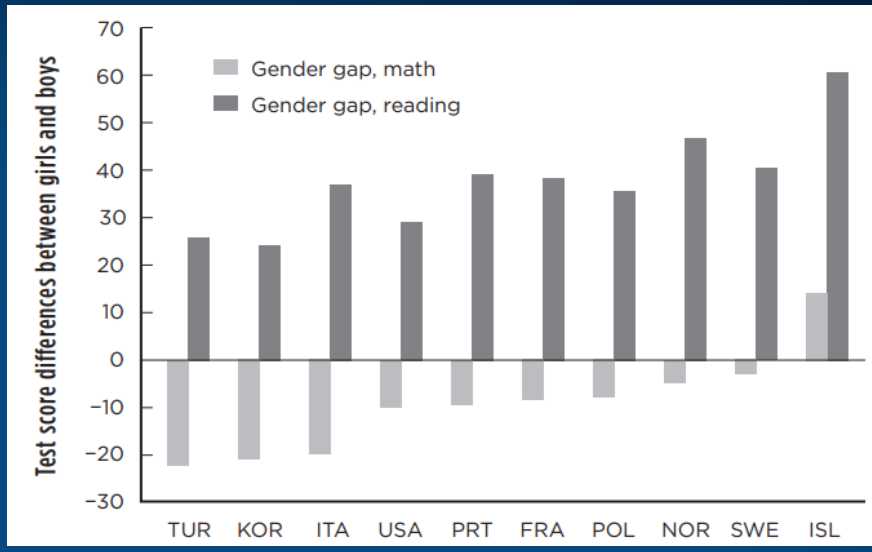
Beliefs and culture

Environment and culture

Brains ⇔ Culture ⇔ Genetics ⇔ Brains

Generalizations based on sex are **meaningless**. Scores of boys and girls in math and reading depend on culture.

Caucher Birkar, Kurdish refugee in UK, got 2018 Fields medal.



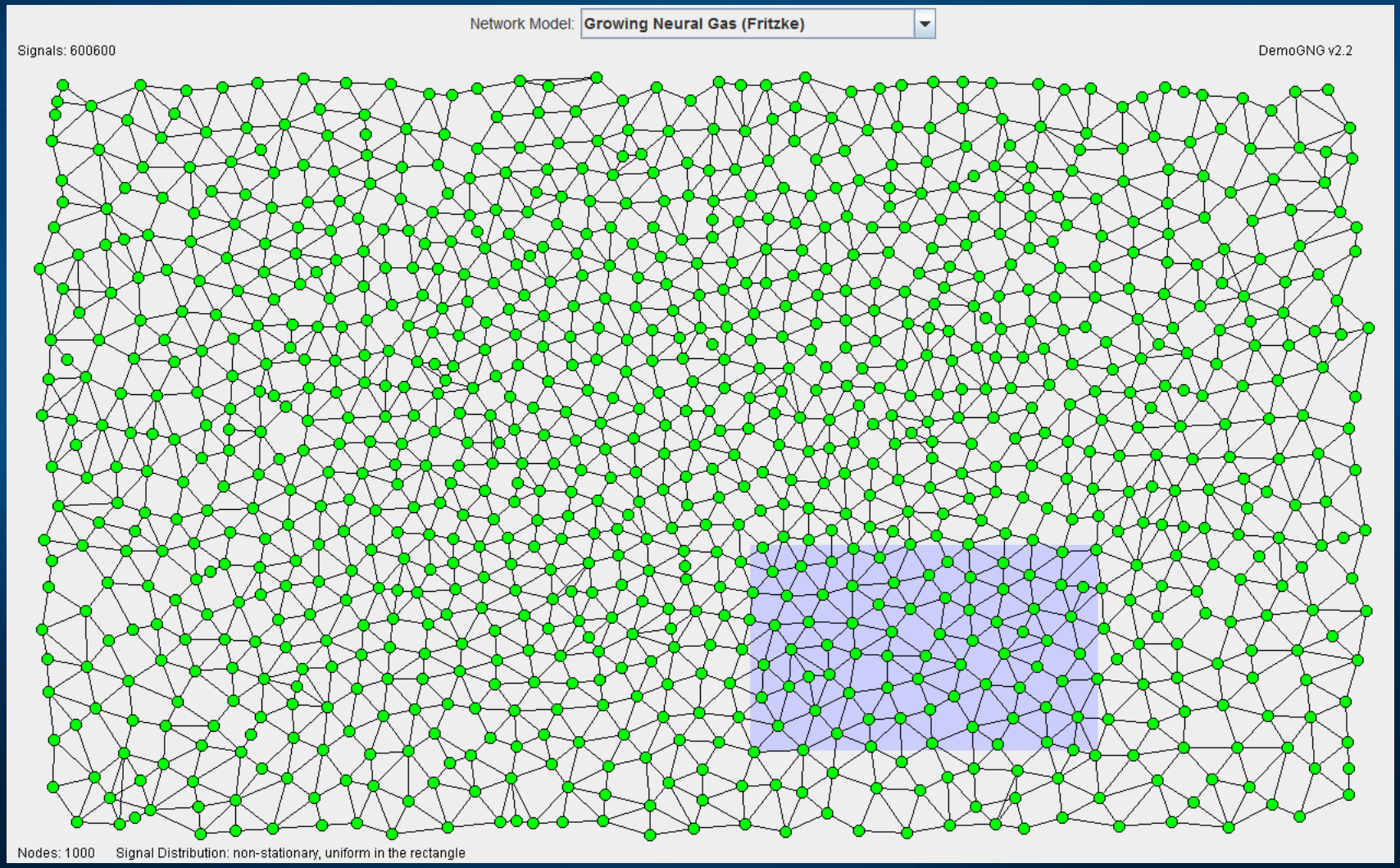
T. Talhelm et al., Large-Scale Psychological Differences Within China Explained by Rice Versus Wheat Agriculture. Science 344 (2014).

Individualist (USA) versus collectivist (China) cultures: wheat vs. rice. Divorce, inventiveness, 7R dopamine DRD4 receptor variants vs. 4R variants.

Behavior ⇔ ecosystem, climate.

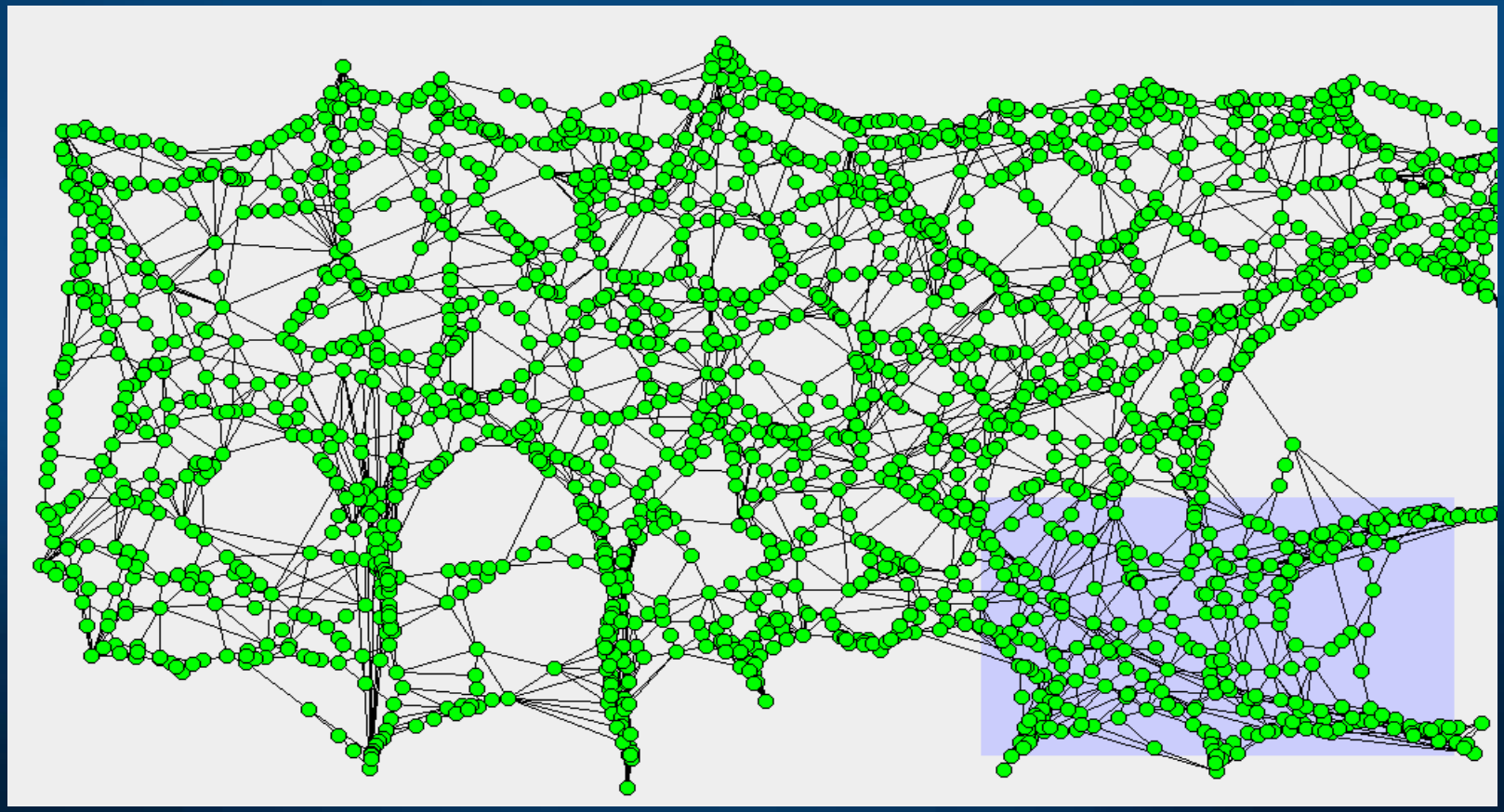
Internalization of environment

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



Conspiracy views

- Rapid learning without integration with basic world view leds to twisted views, wrong associations. Simple explanations save mental energy, creating „sinks” that attract many unrelated episodic memory states.

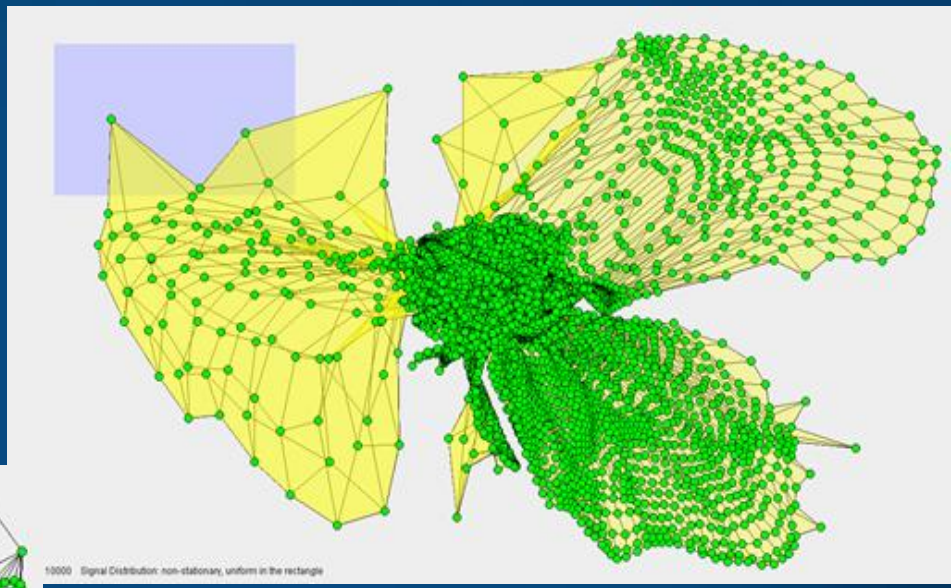


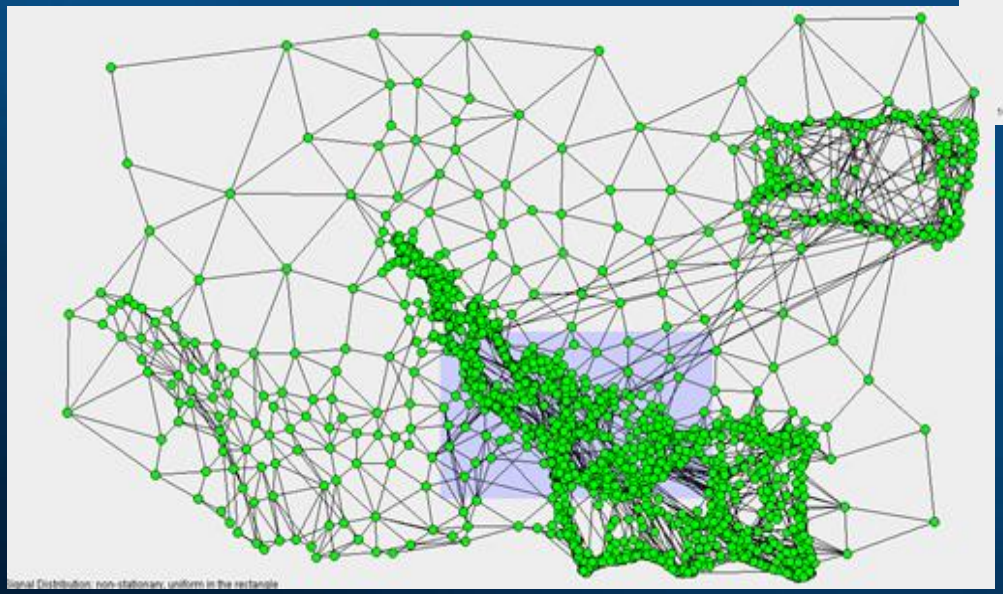
Memoids …

Everything is associated with one great idea or cause.

Totally distorted world view, mind states forming one memplex …

- Extraterrestials, politics, religion, apocalypse, vaccines and 5G …
- Simple dynamics, saves energy.



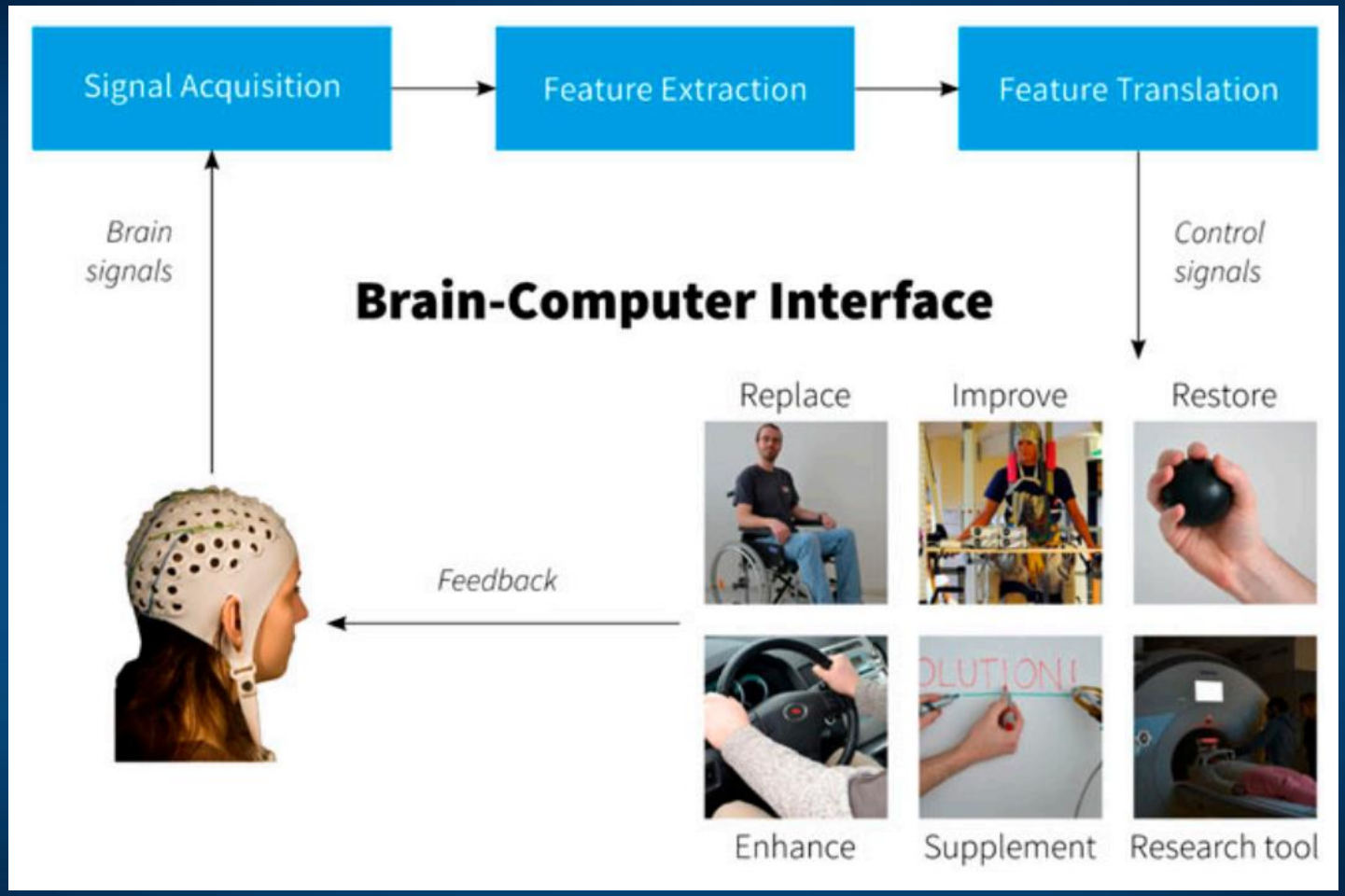


The rapid freezing of high neuroplasticity (RFHN) model.

Duch W. (2021). Memetics and Neural Models of Conspiracy Theories. Patterns. Nov. 2021.

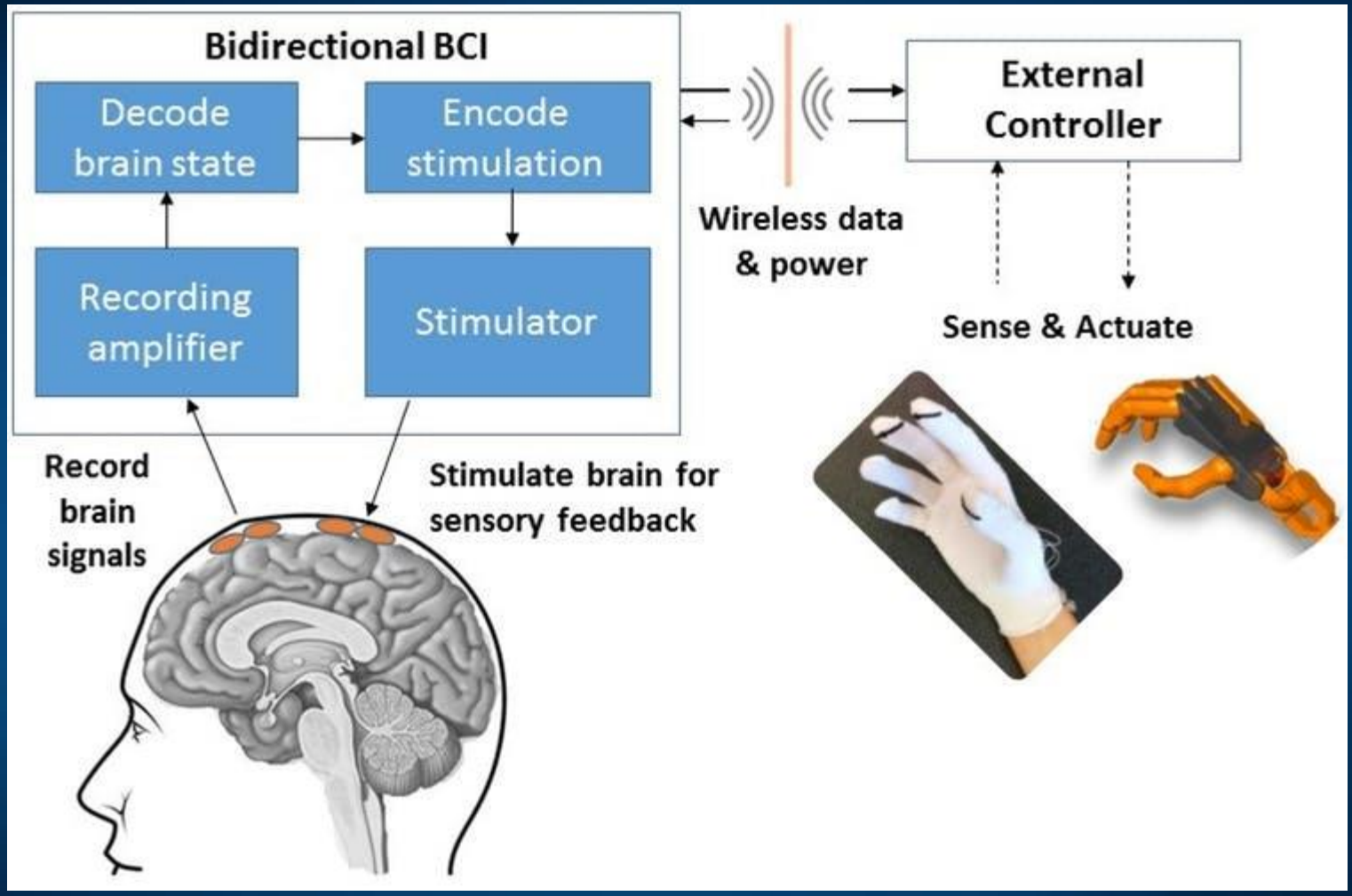
Brains Optimized

BCI Applications



Signals: invasive (brain implants), partially invasive (ECoG), and non-invasive.

Brain-Computer-Brain Interfaces



Closed loop system with brain stimulation for self-regulation.
Body may be replaced by sensory signals in Virtual Reality.

VIRTUAL BR41N.IO HACKATHON

April 17-18, 2021

during the

Spring School 2021*

IEEE brain g.tec

*BR41N.IO and Spring School 2021 are part of g.tec's Teaching Plan 2021 with more than 140 hours of online courses and lectures.

1. PLACE WINNER

"NeuroBeat"

BCI application

Team members: Alicja Wicher, Joanna Maria Zalewska, Weronika Sójka, Ivo John Krystian Derezinski, Krzystof Tołpa, Lukasz Furman, Slawomir Duda

IMPROVING HUMAN DAILY LIFE FUNCTIONING

NEUROHACKATOR 2021

21. - 23. MAY 2021 // ONLINE

FRIDAY
Organisers presentation
workshops with Judges

SATURDAY
Project development in groups
STARTS 10 a.m.

SUNDAY
Evaluation
ENDS 10 a.m.

working 24h

REQUIREMENTS:

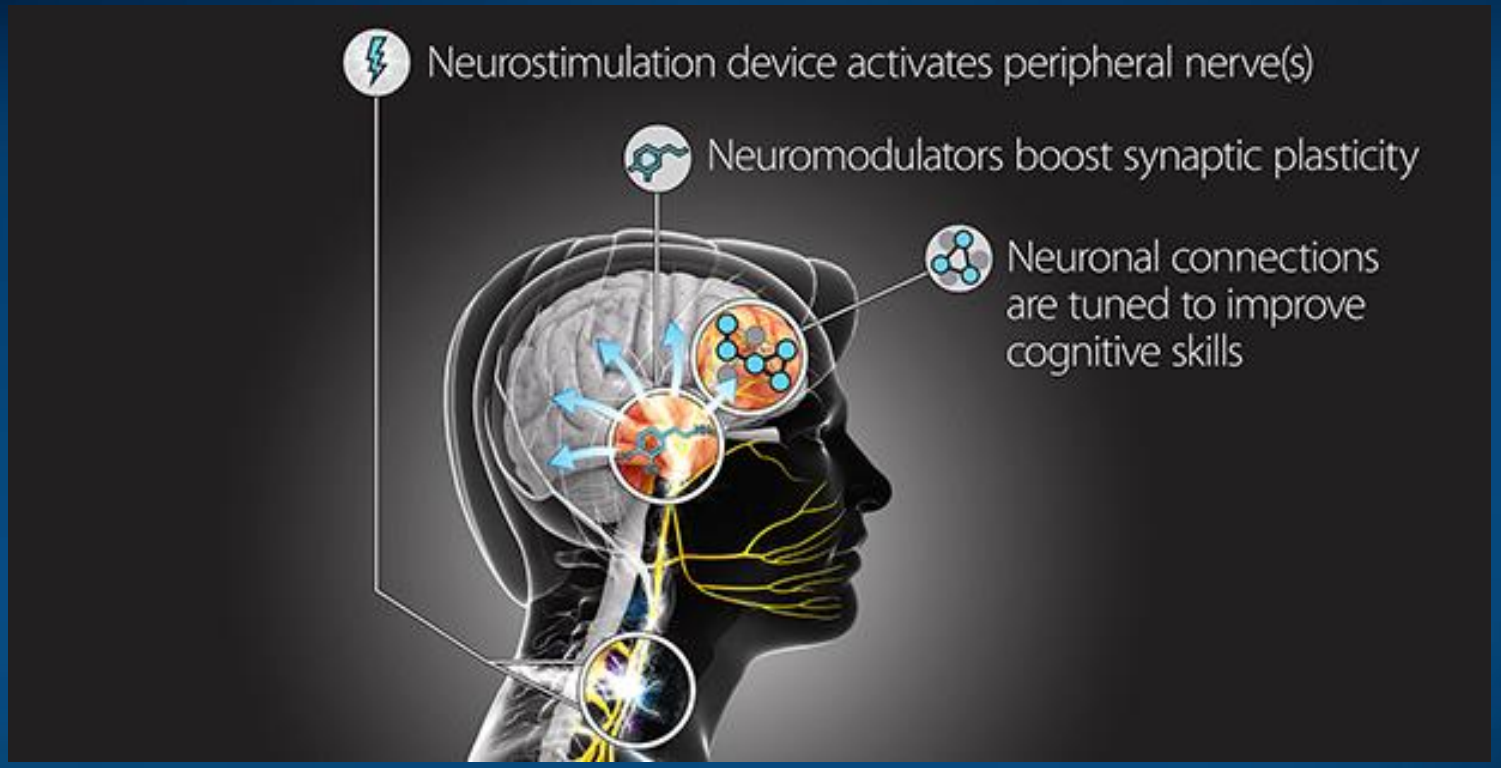
1. Create a team consisting of **3-5 people**.
2. Fill in the Registration Form (available on Facebook event).

DO YOU HAVE ANY QUESTIONS?

Write an e-mail:
NEUROTECHTOR@GMAIL.COM

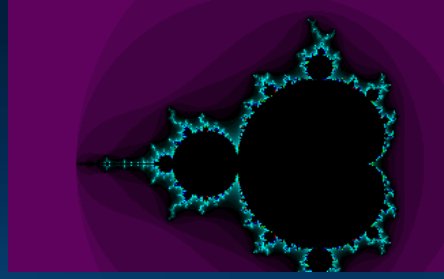
Neurotechnology Scientific Club
Center for Modern Interdisciplinary Technologies
at Nicolaus Copernicus University in Toruń
Wileńska 4 Street

Targeted Neuroplasticity Training

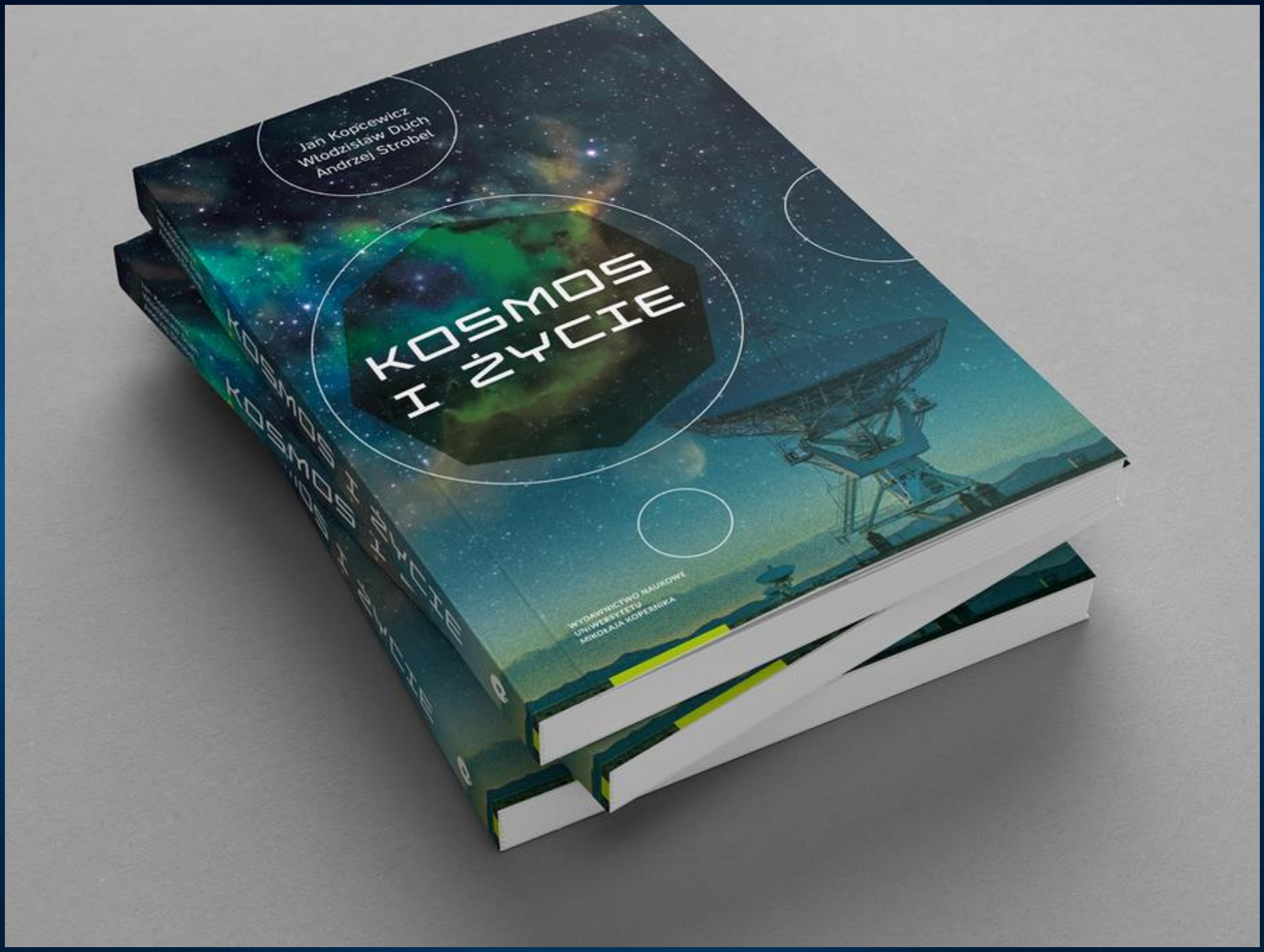


DARPA (2017): Enhance learning of a wide range of cognitive skills, with a goal of reducing the cost and duration of the Defense Department's extensive training regimen, while improving outcomes. TNT could accelerate learning and reduce the time needed to train foreign language specialists, intelligence analysts, cryptographers, and others.

Conclusions



- Coevolution: brains shape culture shape environment shape brains … loops within loops. Mandelbrot fractal shows emerging complexity.
- Many brain states are now linked to specific mental states, and can be transformed into signals that we can understand using BCI techniques: motor intentions, plans, images, inner voices …
- Neurodynamics is the key to understanding immediate causes of mental states; it creates dynamical forms. Neurodynamics itself on hormone levels, brain structure formed by genetics and developmental processes, environmental factors, ecosystems, social interactions, culture ...
- Brain activity can be analyzed using analysis of physiological signals, neural network models help to understand information processing, but connecting psychological factors with physical phenomic levels will be a big challenge.
- Many neurocognitive technologies are coming, helping to diagnose, repair and optimize brain processes.


Jan Kopcewicz
Włodzisław Duch
Andrzej Strobel
KOSMOS I ŻYCIE
WYDAWNICTWO NAUKOWE
UNIWERSYTETU
MIKOŁAJA KOPERNIKA

In search of the sources of brain's cognitive activity

Project „Symfonia”, 2016-21

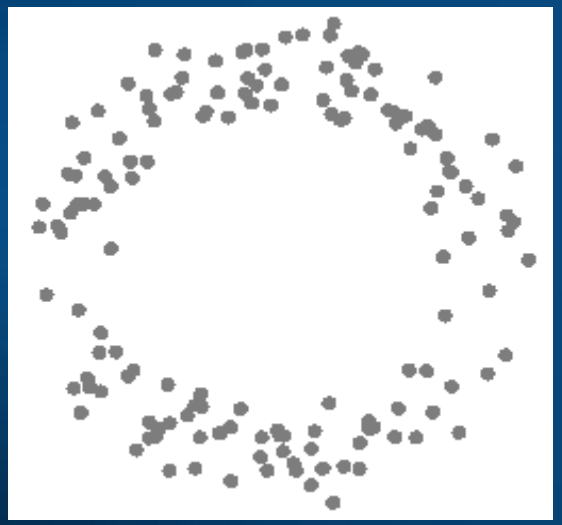
FACULTY OF PHYSICS, ASTRONOMY AND INFORMATICS

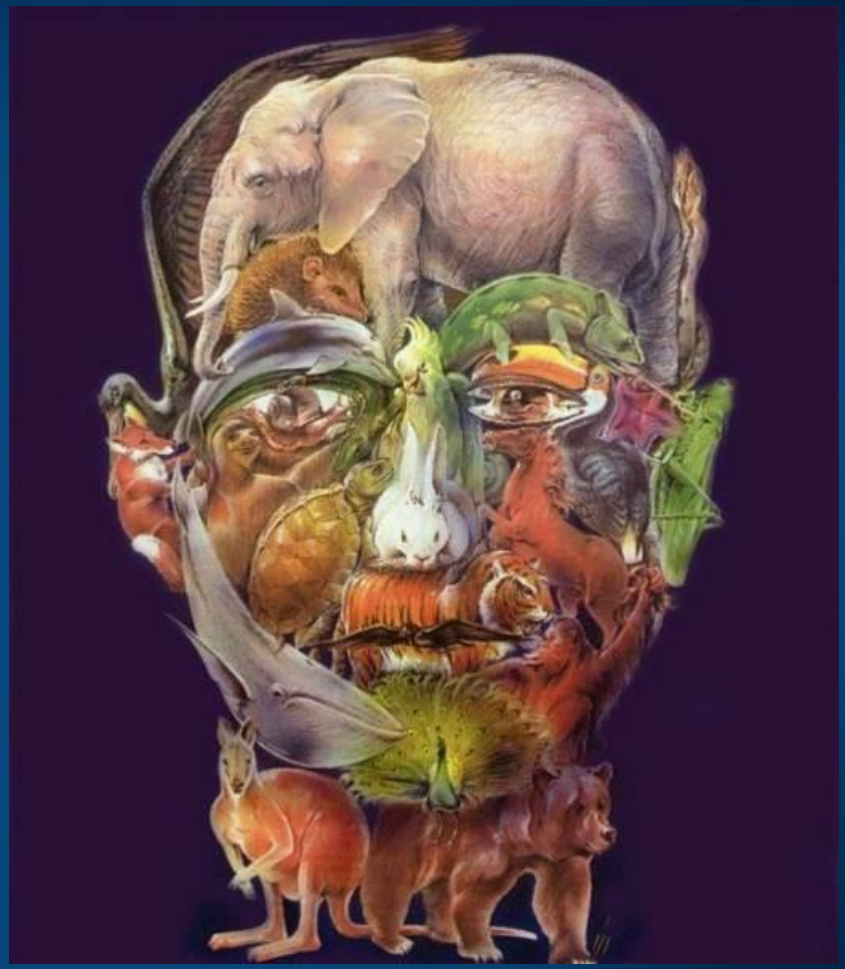
CENTRE FOR MODERN INTERDISCIPLINARY TECHNOLOGIES

INSTITUTE OF PHYSIOLOGY AND PATHOLOGY OF HEARING

nencki institute of experimental biology

Thank you for synchronization of your neurons





Google: W. Duch

=> talks, papers, lectures, Flipboard …