Imagery Agnosia

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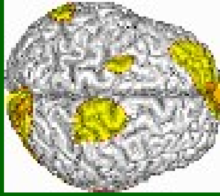
KU Leuven, 25.11.2016



Plan:

What do **I** know about **myself**?

- The need for neurophenomenology.
  - Agnosia, anhedonia and talent.
  - Visual imagery and top-down activations.
  - Imagery agnosia or aphantasia?
  - Auditory perception, amusia and other music deficits.
  - Sound of silence.
  - INMI, involuntary music imagery.
  - Graphs and visualization of brain dynamics.
  - Some questions.

Center for Modern Interdisciplinary Technologies

Why am I interested in this?

Bio + Neuro + Cog Sci + Physics =>

NeuroCognitive Lab.

Other labs: molecular biology, chemical analytics, nanotech and electronics.

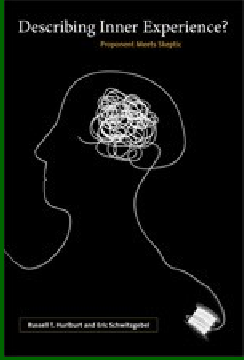
Main theme: maximizing human potential.

Goal: understanding brain-mind relations, with a lot of help from computational modeling and neuroimaging; pushing the limits of brain plasticity.

Big challenge! Funding: national/EU grants.

A group of neurofanatics

What do I know about myself?



Much less than I would like to …

Russell T. Hurlburt and Eric Schwitzgebel,
Describing Inner Experience? Proponent Meets Skeptic, MIT Press 2007.

Conclusion: “I don’t know if this book is in any way an advance.”
Does not even attempt to identify relevant dimensions for mental events.

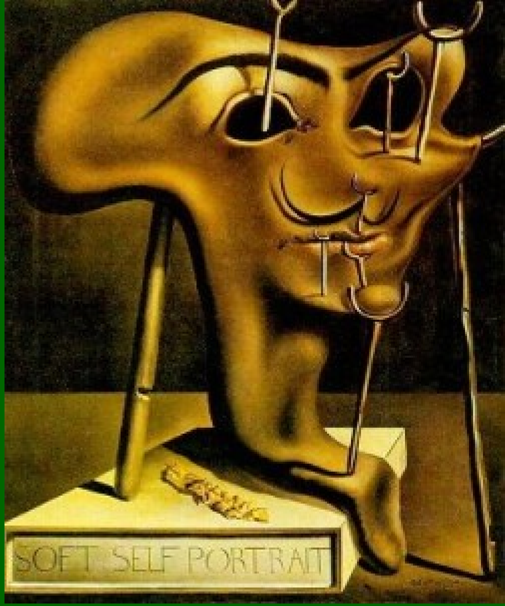
Eric Schwitzgebel, The Unreliability of Naive Introspection. Phil. Review, 2008;
Perplexities of consciousness, MIT Press (2011).

We are prone to gross error about our own ongoing conscious experience.
Self-knowledge is faulty and untrustworthy. We know only some things.
We are not simply fallible at the margins but broadly inept.

Examples include: emotional experiences, peripheral visions, visual, auditory or tactile imagery, phenomenology of thought ... What exactly do we experience?

Why? Narrative comments on unusual brain states is difficult.

Little privileges for the self



The only advantage that I have over other people to know about myself is that I can observe my behavior more often.

Without internal feedback the only way to learn about plans formed by my brain is to act and observe results.

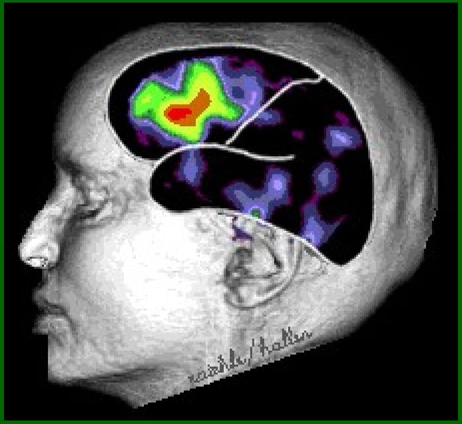
The model of what the brain considers socially acceptable may prevent execution of some actions before they are actually performed already at an early stage.

Inability to consciously interpret some brain states leads to the need to express and recognize them through various bodily actions.

For example, I scratch my head, make gestures, repeat myself, add irrelevant words to slow down, giving my brain more time to parse, associate, create.

- “We are not masters of our own house” (S. Freud).
- “We know ourselves only in so far as we have been tested” (W. Szymborska).

Geometric model of mind

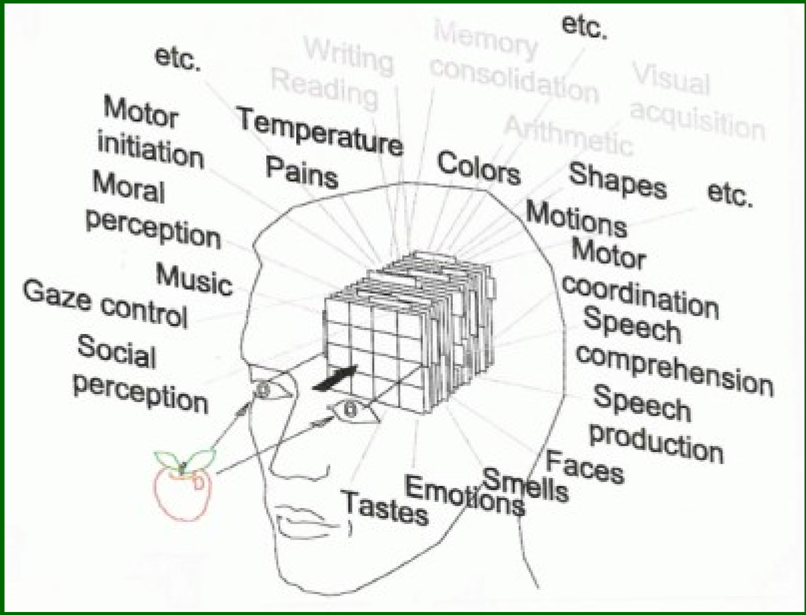


Objective ⇔ Subjective.

Brain ⇔ Mind.

Neurodynamics describes state of the brain activation measured using EEG, MEG, NIRS-OT, PET, fMRI or other techniques.

Mind states=f(Brain states)



How to represent mind state?

In the P-space based on dimensions that have subjective interpretation: intentions, emotions, basic percepts, qualia.

Mind state and brain state trajectory should then be linked together by some transformations. Intentions are uncovered by the **Brain-Computer Interfaces.**

Duch W, Mind-Brain Relations, Geometric Perspective and Neurophenomenology, Am. Phil. Assoc. 12(1), 1-7, 2012

What is needed to have qualia?

Sensory cortex, for example V4 for color, MT for movement.

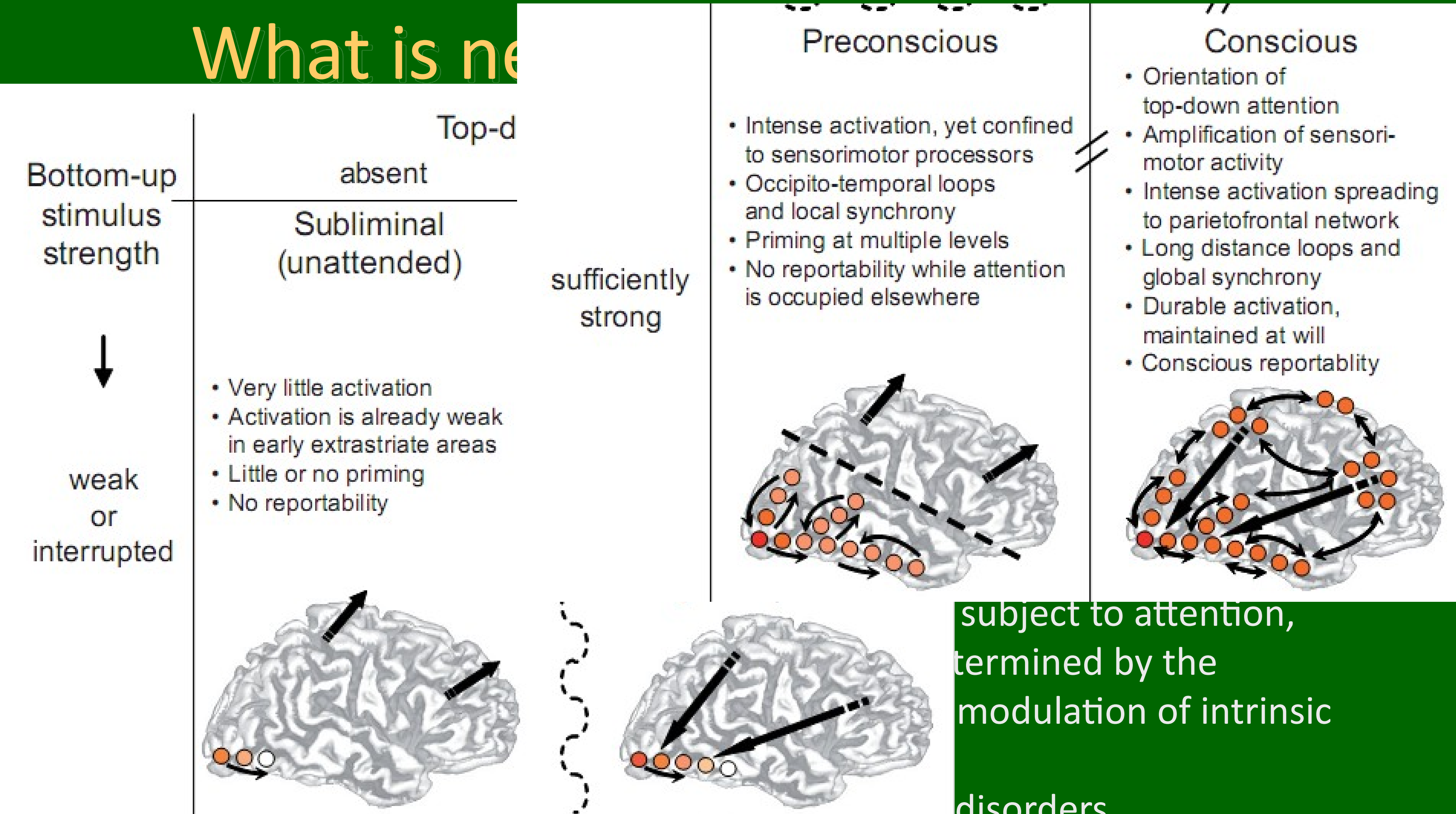
Bottom-up and top-down activations create resonant states.
What if top-down connections are weak or missing?

C. Gilbert, M. Sigman, Brain States: Top-Down Influences in Sensory Processing. Neuron, Volume 54, Issue 5, Pages 677-696, 2007

Cortical & thalamic sensory processing are subject to powerful top-down influences, the shaping of lower-level processes by more complex information. Cortical areas function as adaptive processors, being subject to attention, expectation, and perceptual task. Brain states are determined by the interactions between multiple cortical areas and the modulation of intrinsic circuits by feedback connections.
Disruption of this interaction may lead to behavioral disorders.

Dehaene et al, Conscious, preconscious, and subliminal processing. TCS 2006
Bottom-up strength & top-down attention combined lead to 4 brain states, with both stimulus and attention required for conscious reportability. no imagery?

What is ne



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Dehaene et al, Conscious, preconscious, and subliminal processing. TCS 2006
Bottom-up strength & top-down attention combined lead to 4 brain states, with both stimulus and attention required for conscious reportability. no imagery?

Agnosia

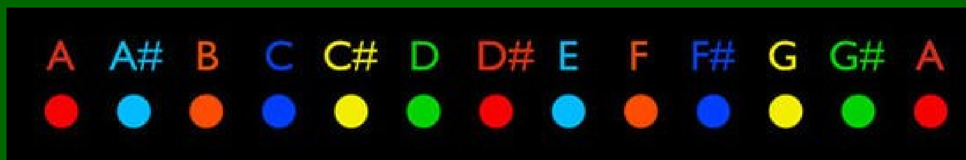
Agnosia (a-gnosis, "non-knowledge", or loss of knowledge), loss of ability to recognize, while the specific senses and memory are not defective. 100 forms of agnosia are known.

Auditory: amusia; auditory agnosia (non-verbal auditory); verbal auditory agnosia; phonagnosia (recognition of familiar voices);
Emotional: alexithymia; expressive agnosia …
Visual: color agnosia; occulomotor, visual verbal agnosia, form agnosia; integrative agnosia; mirror agnosia; prosopagnosia …
Body: autotopagnosia; anosognosia; apperceptive agnosia; finger agnosia; buccofacial (lips, mouth, tongue); ideational, pain agnosia; simultanagnosia; somatosensory agnosia; tactile agnosia;
Motor: constructional, motor (body) agnosia for physical actions (speech, limb-kinetic, ideomotor), alexia; apraxia of gait …
Cognitive: associative agnosia (symbols); semantic agnosia; time agnosia; topographical agnosia;

Imagery agnosia has never been described?
There is a whole new branch of neropsychology waiting to be discovered.

Special talents or agnosia?

Color anomia is rare: most of us can name about 12 colors.
Pitch anomia is common: few have absolute pitch. Lack of training?

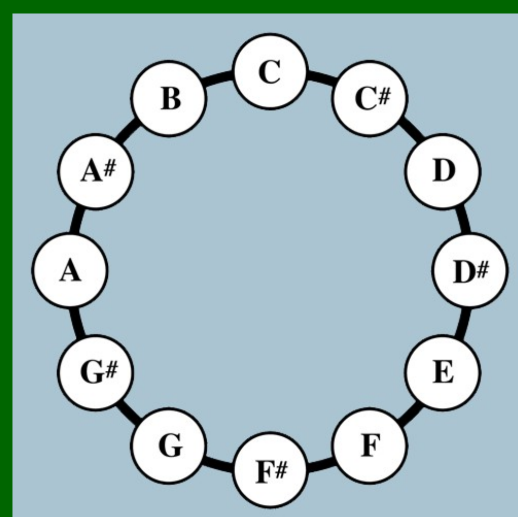


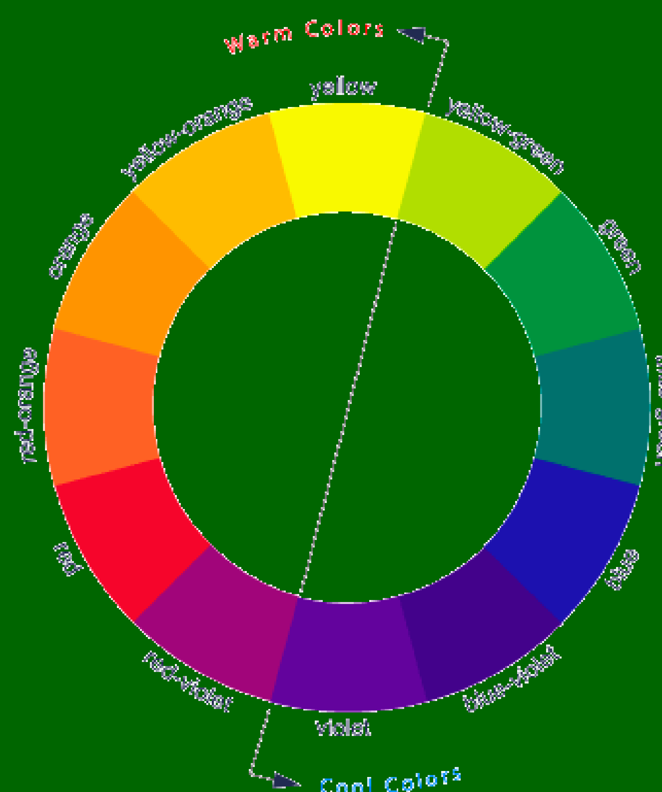
Absolute pitch in population of music students in the USA:
Caucasians 9%
Japanese 26%
Korean 37%
Chinese 65%
In general Caucasian population < 0.01%

Agnosia of synesthesia.

Grapheme-color synesthesia has been induced.

Induced color-pitch synesthesia?





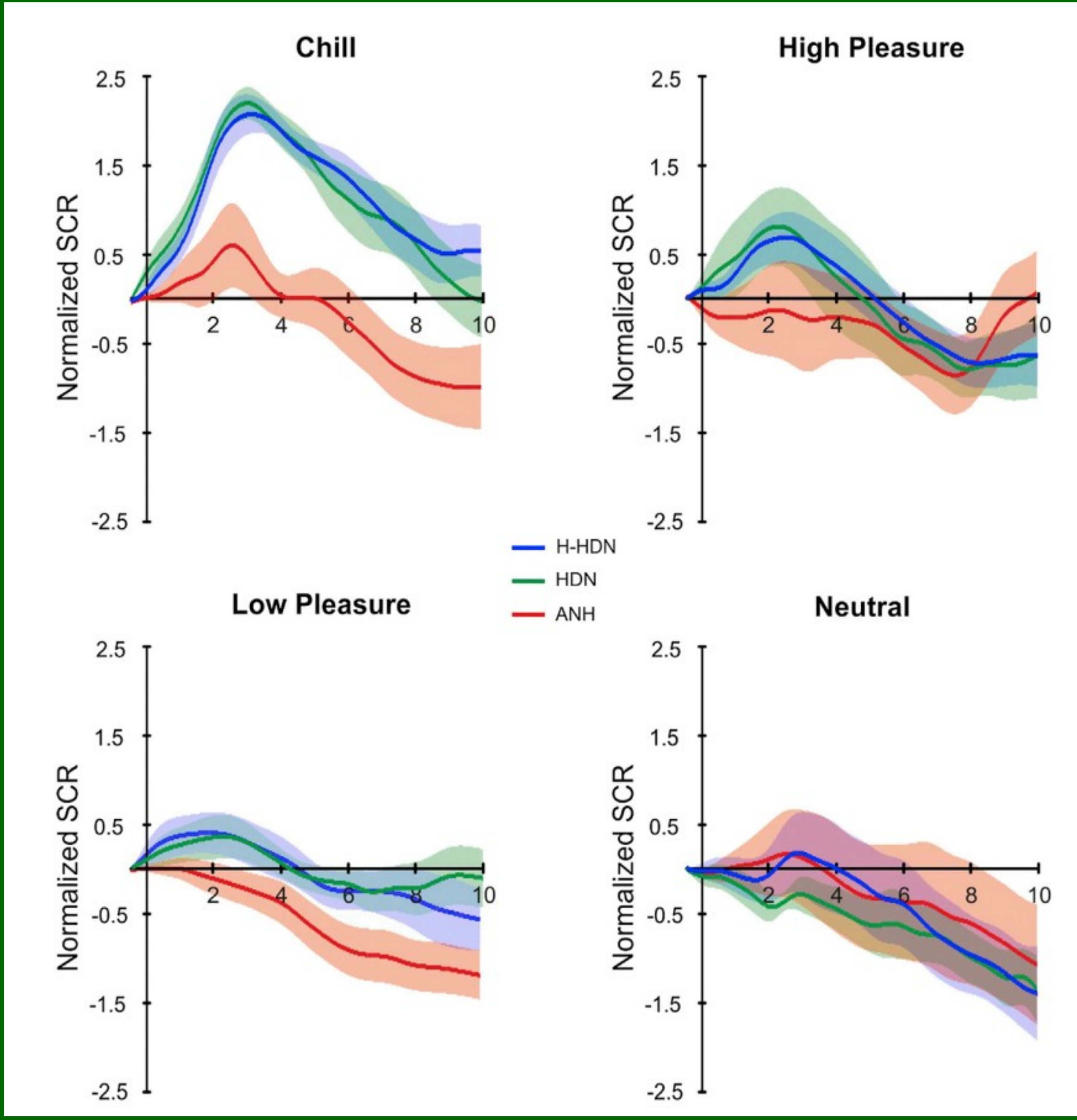
Specific Musical Anhedonia

An example of musical pleasure agnosia.

Barcelona Musical Reward Questionnaire (BMRQ) is a reliable indicator of interindividual variability in music-induced reward.

SCR = Skin Conductance Response

Mas-Herrero, Zatorre et al. (2014). Dissociation between musical and monetary reward responses in specific musical anhedonia. Current biology, 24(6), 699-704.



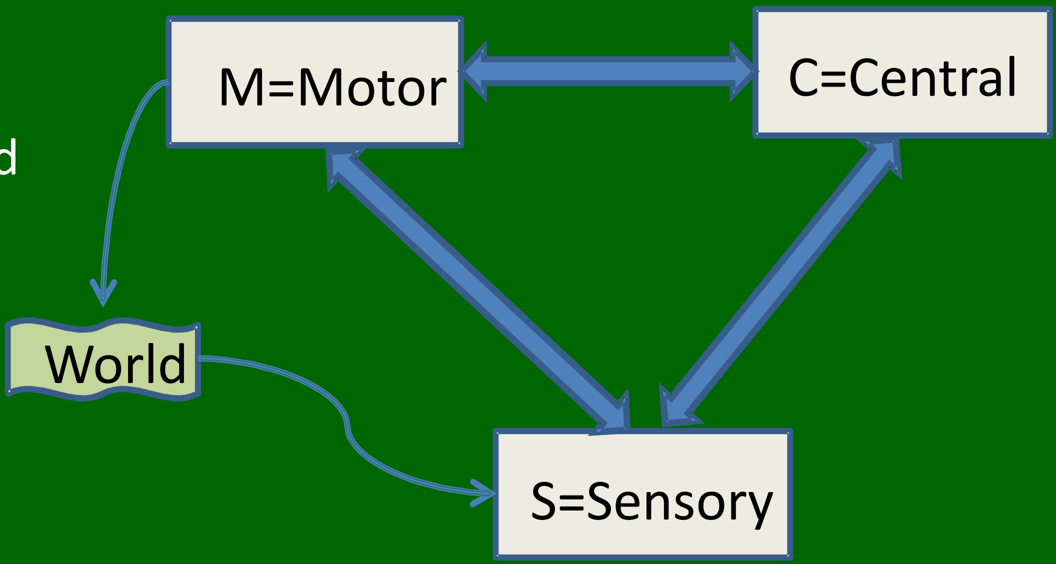
Connectome and talent

Simple connectome models may help to connect and improve classification of learning styles.

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.

$S \Rightarrow M$; $S \Rightarrow C$ strong, no agnosia, but $M \Rightarrow S$; $C \Rightarrow S$ weak.

Parietal cortex

A. Tosoni et al, Nature Neuroscience (Nov 2008 | doi:10.1038/nn.2221)
Sensory-motor mechanisms in human parietal cortex underlie arbitrary visual decisions.

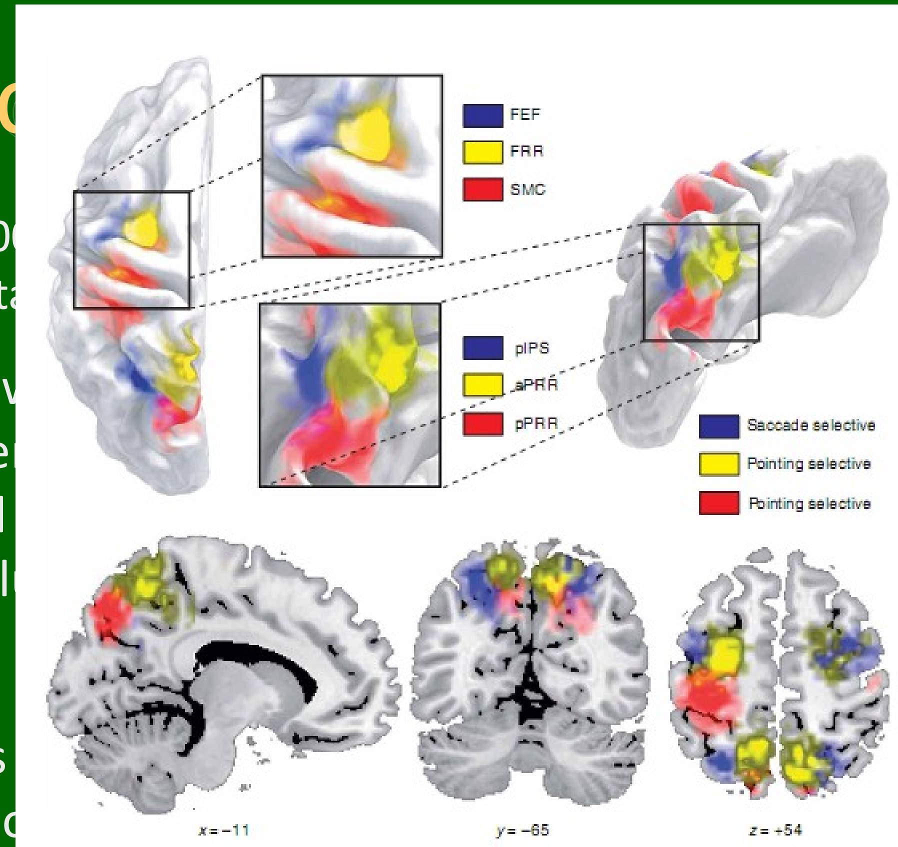
In arbitrary association of visual stimuli with different actions, activity of effector-specific regions in human posterior parietal cortex did not respond to sensory stimuli per se, but to integrated sensory evidence toward the decision outcome, triggered by contextual stimulus-response associations.

Hypothesis: normal perception requires top-down influences to form expectations. What if feedback connections to visual/auditory areas are weak?

C. Gilbert, M. Sigman, Brain States: Top-Down Influences in Sensory Processing. Neuron 54, 677-696, 2007.

“New findings on the diversity of top-down interactions show that cortical areas function as adaptive processors, being subject to attention, expectation, and perceptual task. Brain states are determined by the interactions between multiple cortical areas and the modulation of intrinsic circuits by feedback connections. ... Disruption of this interaction may lead to behavioral disorders.”

Parietal c



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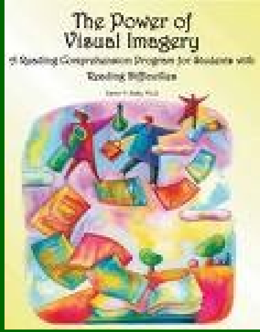
Visual imagery



Large field, with several journals, ex:

- Journal of Mental Imagery (1977), official journal of the International Imagery Association (not much neuroscience).
- Imagination, Cognition and Personality (1980), mostly psychological.
- Journal of Imagery Research in Sport and Physical Activity (2007).
- Neuroimaging of Mental Imagery: A Special Issue of the European Journal of Cognitive Psychology (2004)

S. V. Thompson, Visual Imagery: a discussion. Educ. Psych. 10, 1990 , 141-167

Individual differences in visual imagery, together with a lack of understanding that others may think in a radically different way in this respect, may have had a profound effect on theories of thought and knowledge, yet attempts to validate measures of this variable in terms of educationally significant correlates have been relatively unsuccessful.

- Verbalizers and Imagers, division important in education.
  Better tests? More subtle divisions? Statistics?

Imagery and brains

How and where are mental images formed?

- Borst, G., Kosslyn, S. M, Visual mental imagery and visual perception: structural equivalence revealed by scanning processes.
  Memory & Cognition, 36, 849-862, 2008.

The present findings support the claim that image representations depict information in the same way that visual representations do.

- Cui, X et al. (2007) Vividness of mental imagery: Individual variability can be measured objectively. Vision Research, 47, 474-478.

Reported Vividness of Visual Imagination (VVIQ) correlates well with the early visual cortex activity relative to the whole brain activity measured by fMRI (r=-0.73), and the performance on a novel psychophysical task.
Findings emphasize the importance of examining individual subject variability.

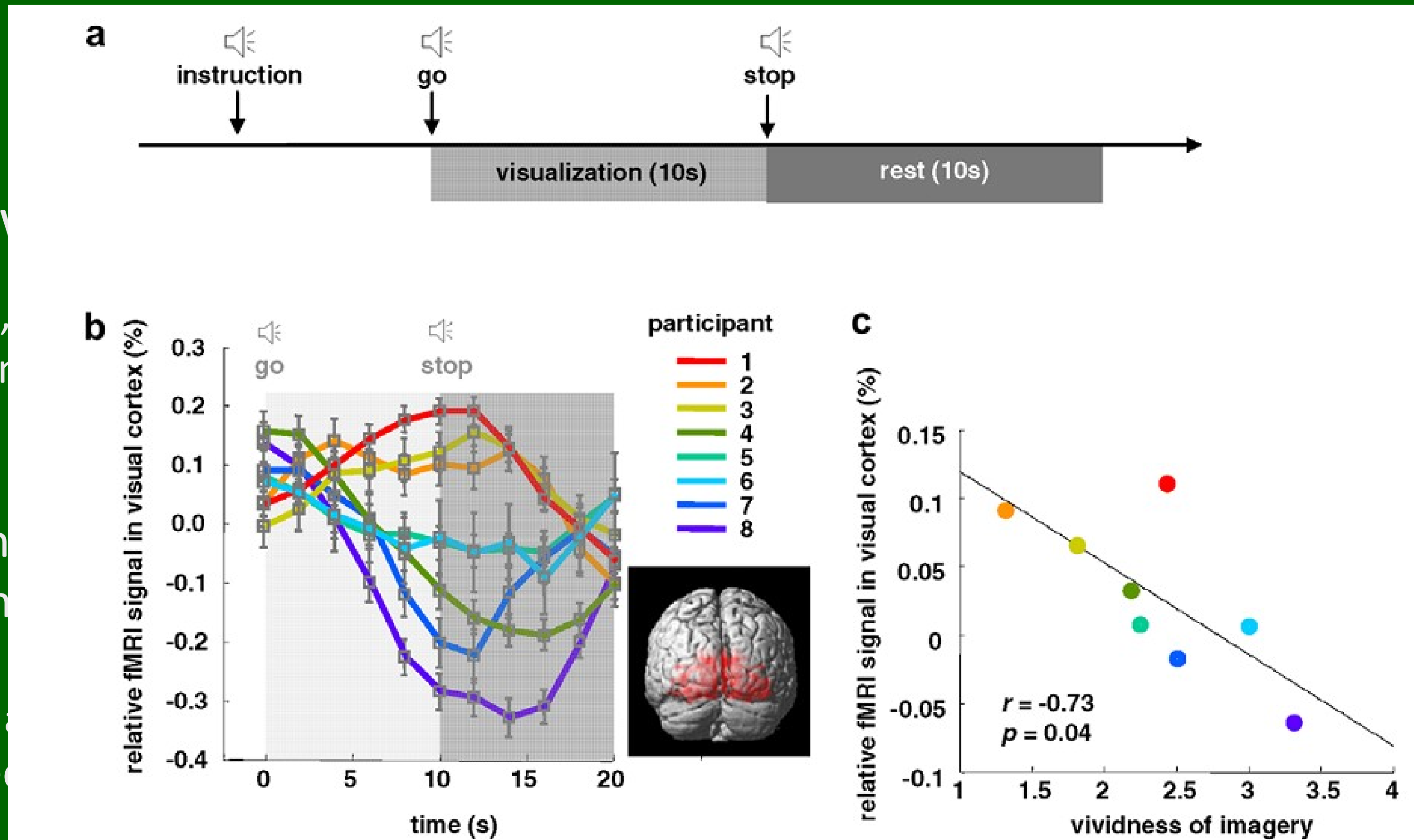
Poor perceptual imagery: why? Weak top-down influences?
Unable to draw from memory, describe details, faces, notice changes, etc.

How and \

- Borst, G., equivalen Memory

The presen information

- Cui, X et a measured



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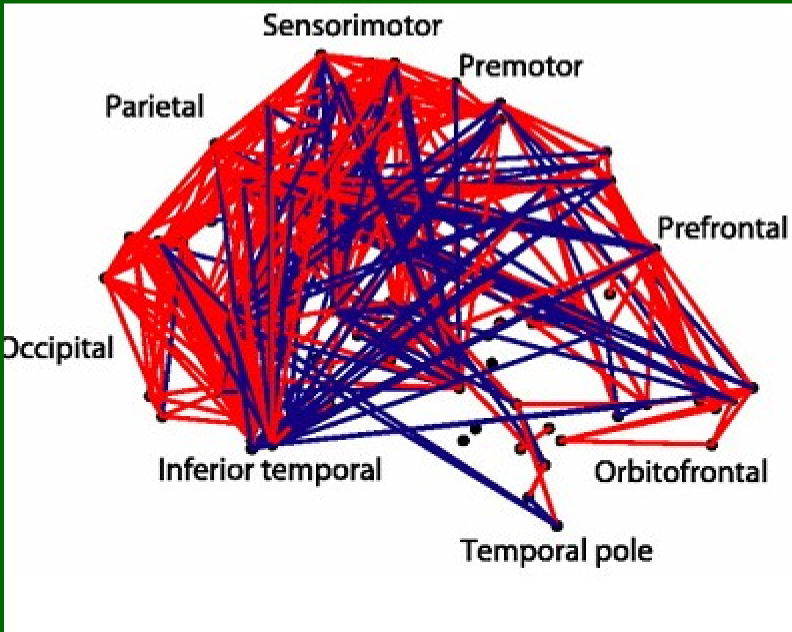
Visual top-down



- Normal perception requires top-down influences to form expectations.
- What if PC/FC feedback connections to visual/auditory areas are weak?
- This does not qualify as agnosia, but is a kind of imagery agnosia, something not yet identified!

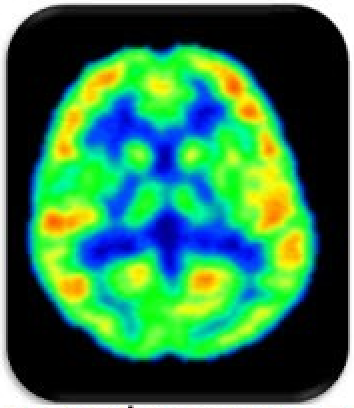
How will the weak top-down connections in visual modality manifest?

Attention problems? Only if they are very weak, then object recognition in poor lighting conditions may be impaired.
Otherwise: poor visual imagination, memory for visual features, inability to draw from memory, recall and describe faces and objects, notice changes, slow in making puzzles, difficulty to see 3D magic eye pictures, perhaps introvert?
More conceptual than perceptual thinking … recognition memory may work fine

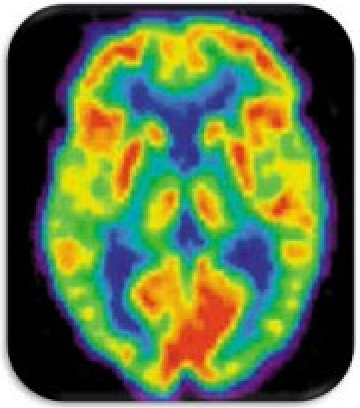
At PC/FC level less interferences from sensory areas, so imagination, creativity, reasoning are fine, perhaps even better than average.

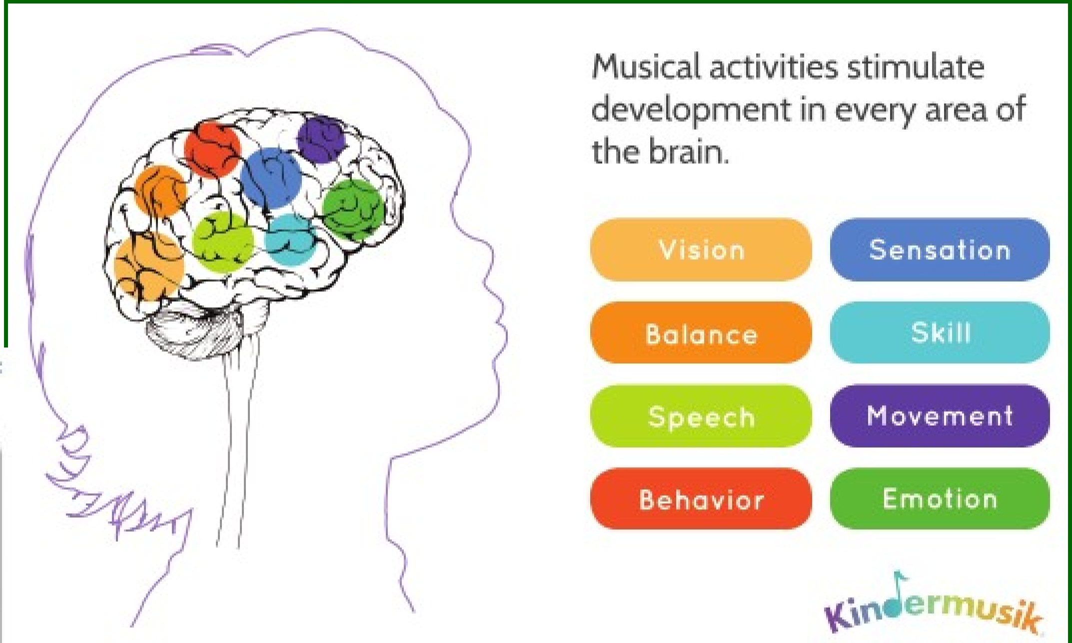
Music is good for your brain

The brain at rest

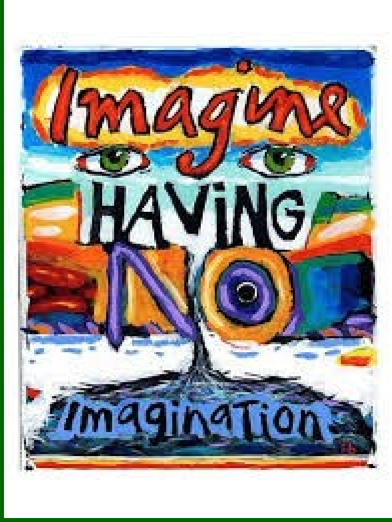


The brain' s reaction to music





Aphantasia or imagery agnosia



How vivid is visual or auditory imagination?
Many aspects of music: melody, pitch, timbre, rhythm, musical space, instruments, can all these aspects be recalled?

Faw (2009) : ~2.5% of people have no visual imagination.
Zeeman found a patient who abruptly lost the ability to generate visual Images after coronary angioplasty.
Later he identified 21 people with no imagery; 19 male,
9 substantial and 12 complete lack of voluntary visual imagery.
5 had affected relatives – significant genetic component?
10 had all modalities of imagery affected. No data on auditory imagery yet …
Majority described some involuntary imagery, 'flashes' and during dreams.

- Faw, B. Conflicting intuitions may be based on differing abilities - evidence from mental imaging research. Journal of Consciousness Studies, 2009.
- Duch W, Neurodynamics and the mind. IJCNN 2011, IEEE Press, pp. 3227-3234.
- Duch, W., What can we know about ourselves and how do we know it? In: The World Without Borders-Science Without Borders. Soc.Humb. 2012, pp. 181-208.
- Zeeman A, et al, Lives without imagery. Congenital aphantasia. Cortex 2015

Imagery Agnosia

New branch of neuropsychology: imagery agnosias.

Classical agnosias ~30 major types: alexia, akinetopsia, alexithimia, many visual types: prosopagnosia, simultanagnosia, semantic agnosia , form, color …

Little access to perceptual imagery in visual, auditory, tactile or gustatory mode.

Without internal feedback the only way to learn about plans formed by the brain is to act and observe results: trying to play an instrument in this condition is like blindsight, maneuvering blindly in the auditory space, without the ability to imagine results of next move (hitting piano key).

- Learning to play music without imagery is difficult – how far can one go? Which key do I have to press if I have no idea how it will sound like?
- Recognition memory is fine, but it is difficult to repeat or remember simple melodies (memory-motor map).
- No problem to read & improvise music, higher cognition is fine.
- Conscious mental rehearsal is not possible.
- Immediate feedback may help?

Do we all hear the same things when we hear music?

Some questions

15% of population has difficulty in singing, but < 5% have congenitial amusia.

Statistics is lacking on imagery, visual, auditory, and taste imagery.

- How clear? ERP studies should show it?
- Is there a correlation between lack of different types of imagery?
- Influence on talents or interests?
- Gender differences?

Interpretation of many experiments may be wrong, mixing brains that work in quite different styles (cf. statistics for cognitive decline).
To understand talent in its many forms it would be helpful to know it.

It may be worthwhile to distinguish between imagery and other types of amusia, and find people with imagery amusia but without spatial deficits!

High-level processes, such as imagery, planning & creativity, do not have to be conscious – when is consciousness essential?
Automatization or learning of actions.

Music deficits

Stewart et. al, Music and the brain: disorders of musical listening.
Brain, 129, 2533-2553, 2006, long review.

Pitch change directions, intervals, melodic patterns, contours, tonal structure, timbre, temporal structures (intervals, rhythm and meter), memory and emotional responses due to neurological problems are described.

Congenital amusia: true perceptual agnosia, although hearing and cognition is normal perception of music is not, usually deficit in pitch processing.

Mandell J, Schulze K, Schlaug G, Congenital amusia: An auditory-motor feedback disorder? Restorative Neurology and Neuroscience 25, 2007

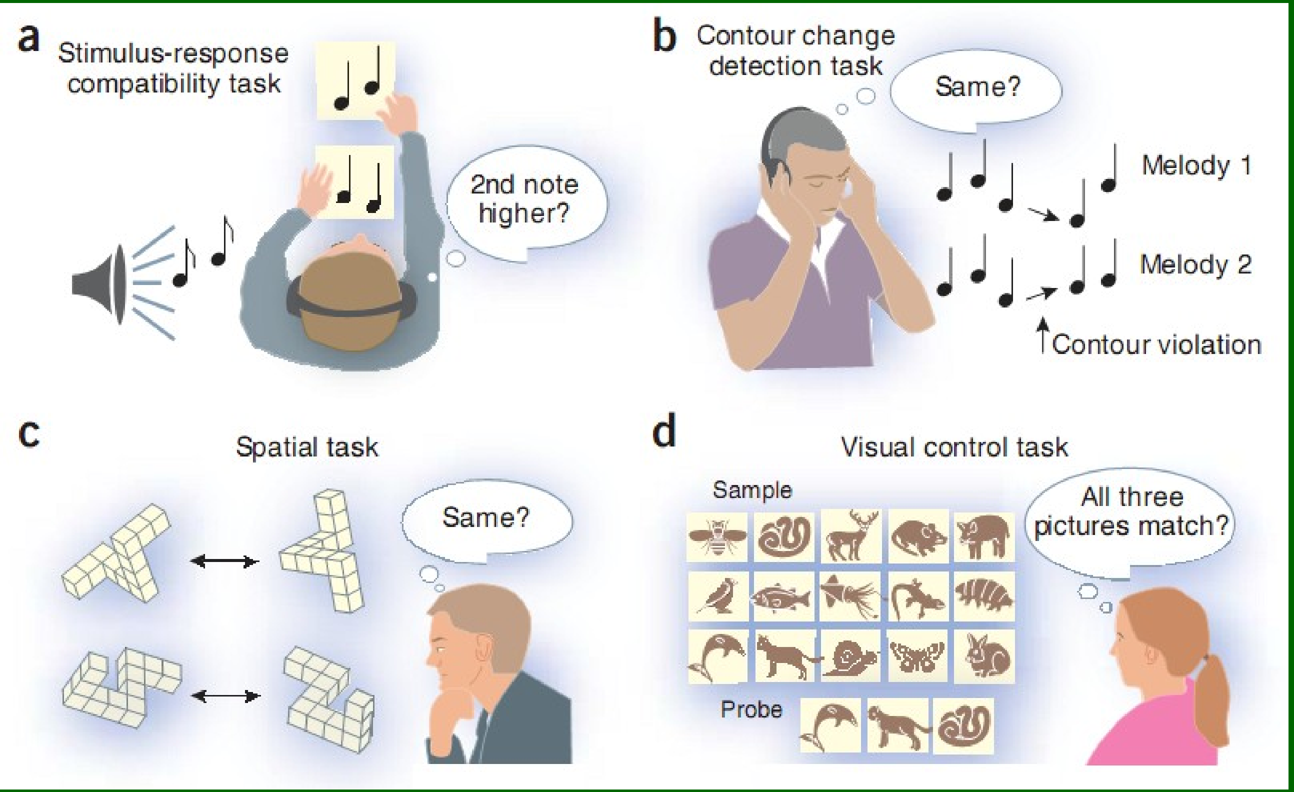
"Thus, it is conceivable that individuals with congenital amusia, or the inability to sing in tune, may actually have an impairment of the auditory-motor feedback loop and/or auditory-motor mapping system."

Conceivable, but some may have simply poor top-down feedback.
This seems to be a condition that has not been clearly identified,
a new kind of imagery amusia, the inability to imagine sounds.

Amusia and spatial processing

Anatomical locus of amusia, neuroimaging/lesion studies: auditory areas along the superior temporal gyrus in pitch discrimination and melodic contour processing.

But amusics show deficits relative to musicians and nonmusicians, in tasks that involve spatial processing.

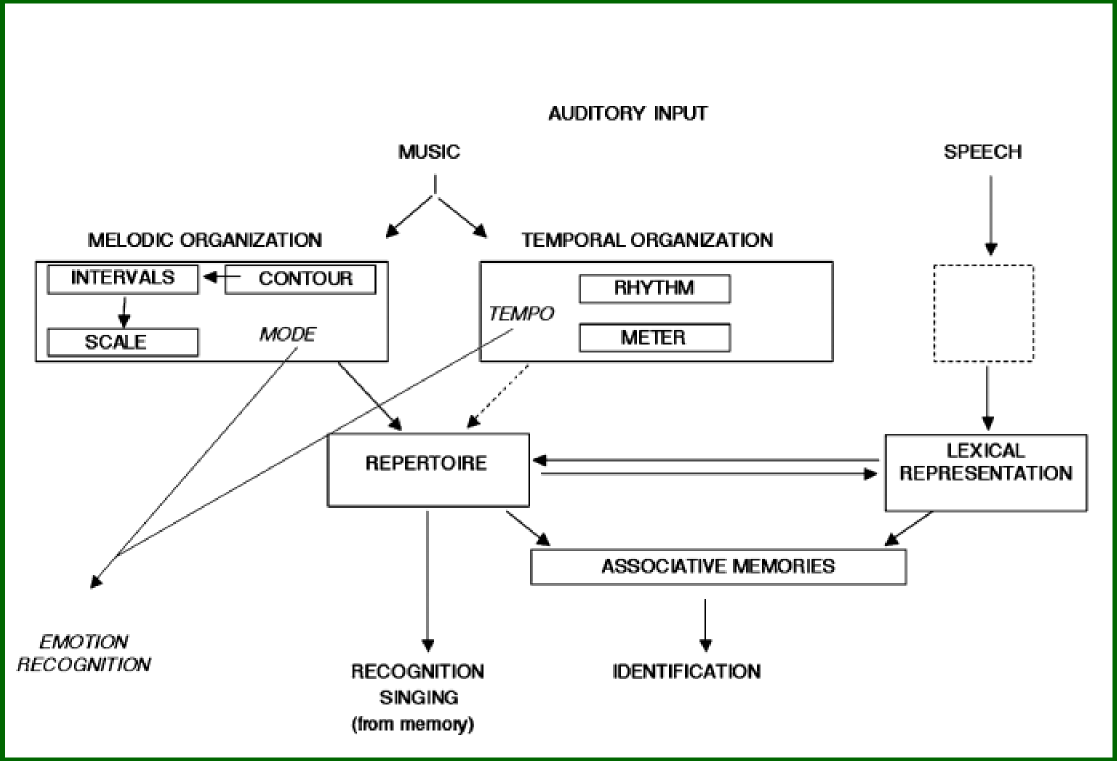


Douglas, K.M. & Bilkey, D.K. Nature Neurosci. 10, 915-921 (2007)

No evidence for morphological correlates of amusia in parietal regions. “The deficit may derive from changes in neural functioning that are invisible to the tools that have been applied to date.”

Auditory Perception

Much less research has been done with auditory perception.



Peretz, I., Champod, S. & Hyde, K, Varieties of Musical Disorders: The Montreal Battery of Evaluation of Amusia. Annals of the New York Academy of Sciences, 999, 58-75, 2003.

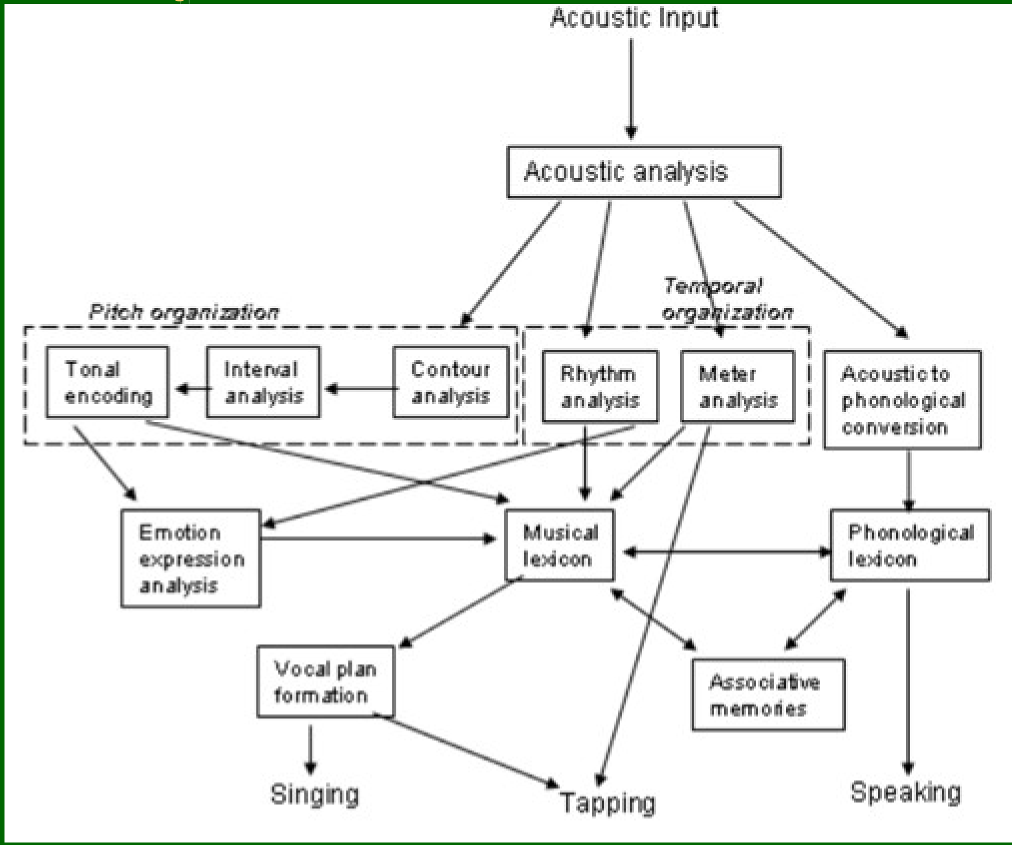
Model of music perception behind the MBAE test – no imagery.

Music Perception

Cognitive model of music processing is focused on pitch and rhythm processing: pitch in lateral Heschl's gyrus, timbre in posterior superior-temporal lobes, rhythm in motor/mesiolimbic areas.

Conscious hearing requires activation of the auditory cortex .

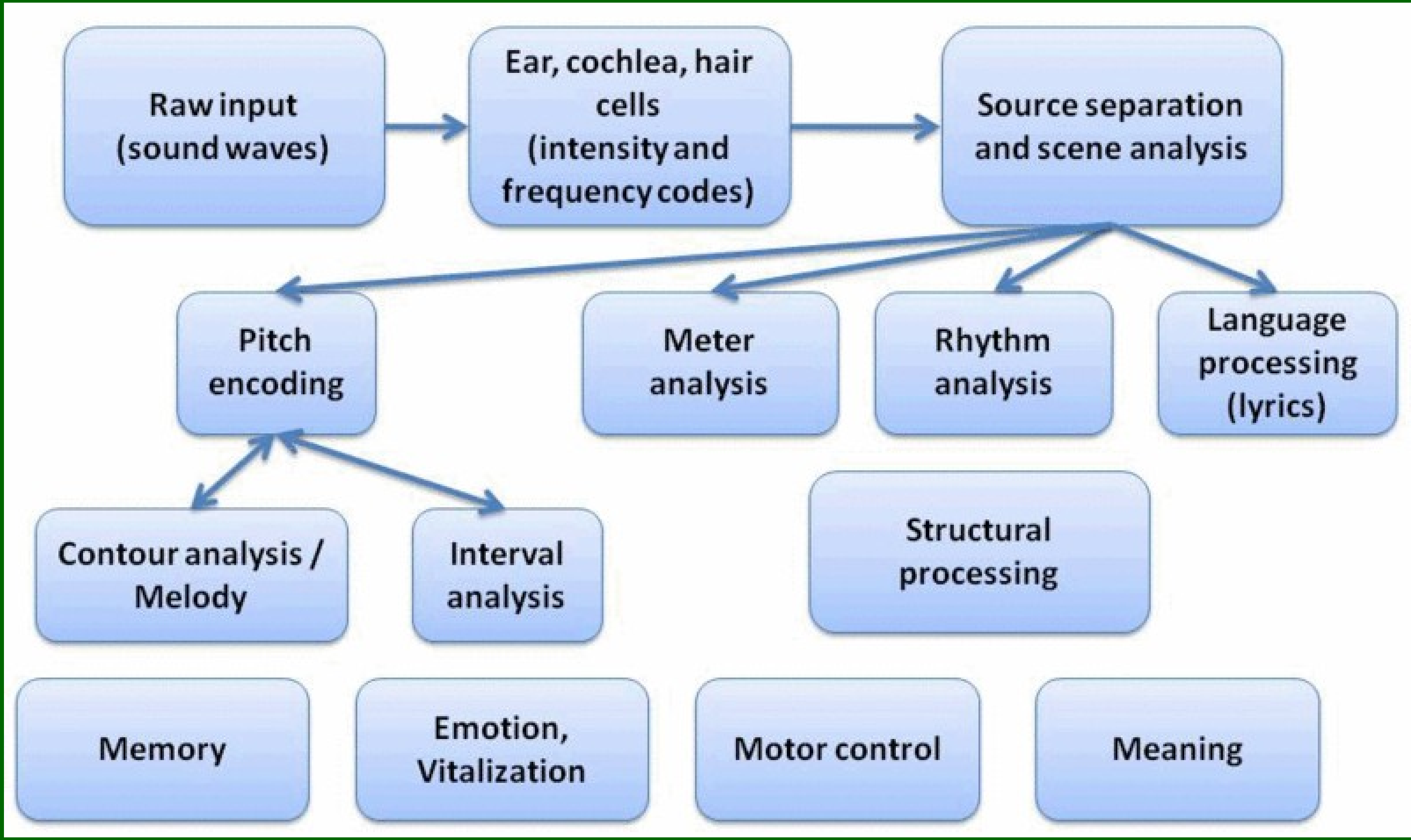
Books that teach improvisation encourage imaging and hearing the effect of playing internally.



Cognitive model of music processing: no imagery, no top-down processes.

Peretz I, Coltheart M, Modularity of music processing. Nature Neuroscience, vol. 6(7), 688-691, 2003; this model has also been used in:
Stewart L. et al. Music and the brain: disorders of musical listening. Brain, 129, 2006.

Decomposition of sound

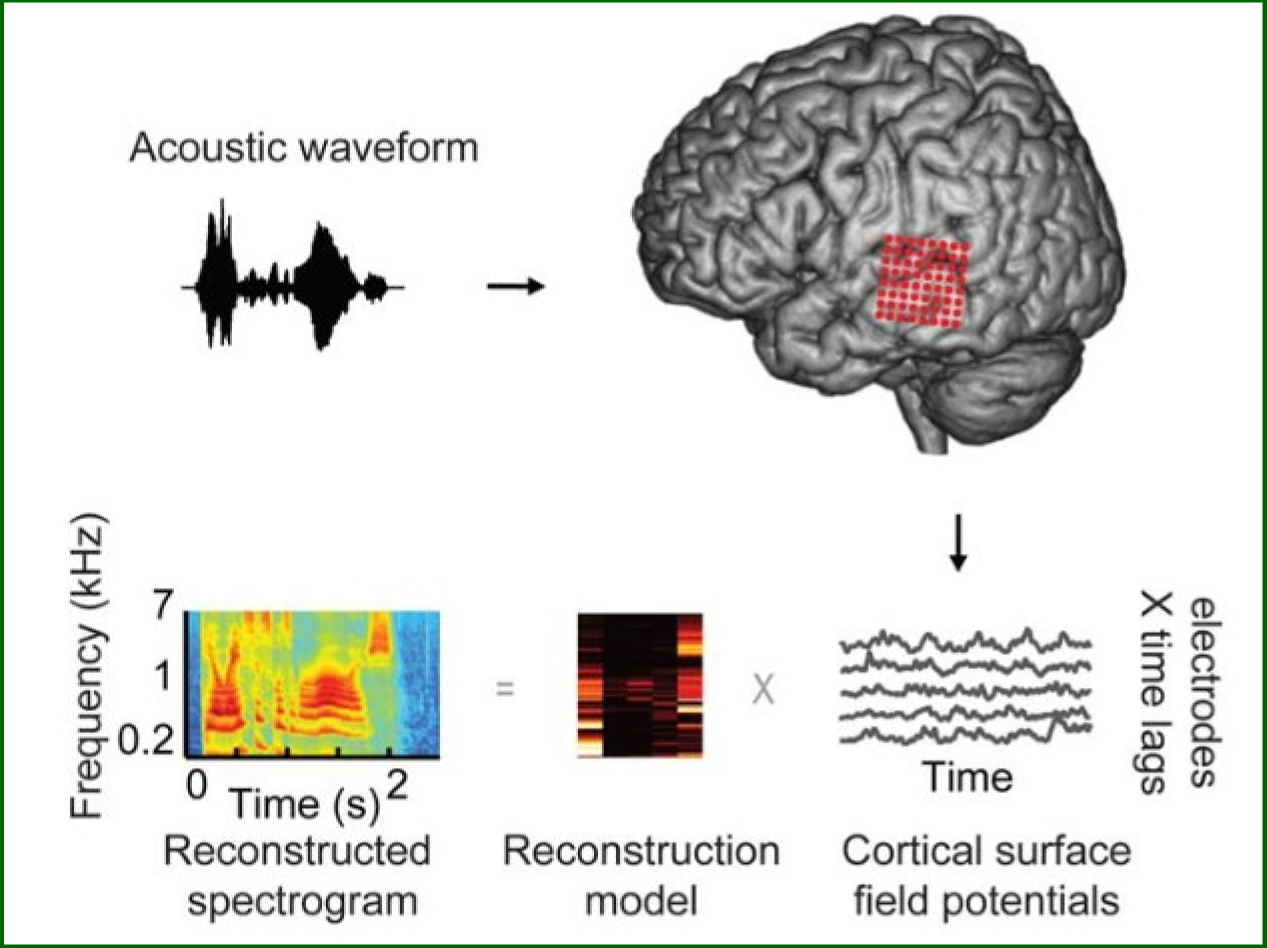


S. Koelsch, Toward a neural basis of music perception – a review and updated model. Front. in Psychology 2 (110), 1-20, 2011

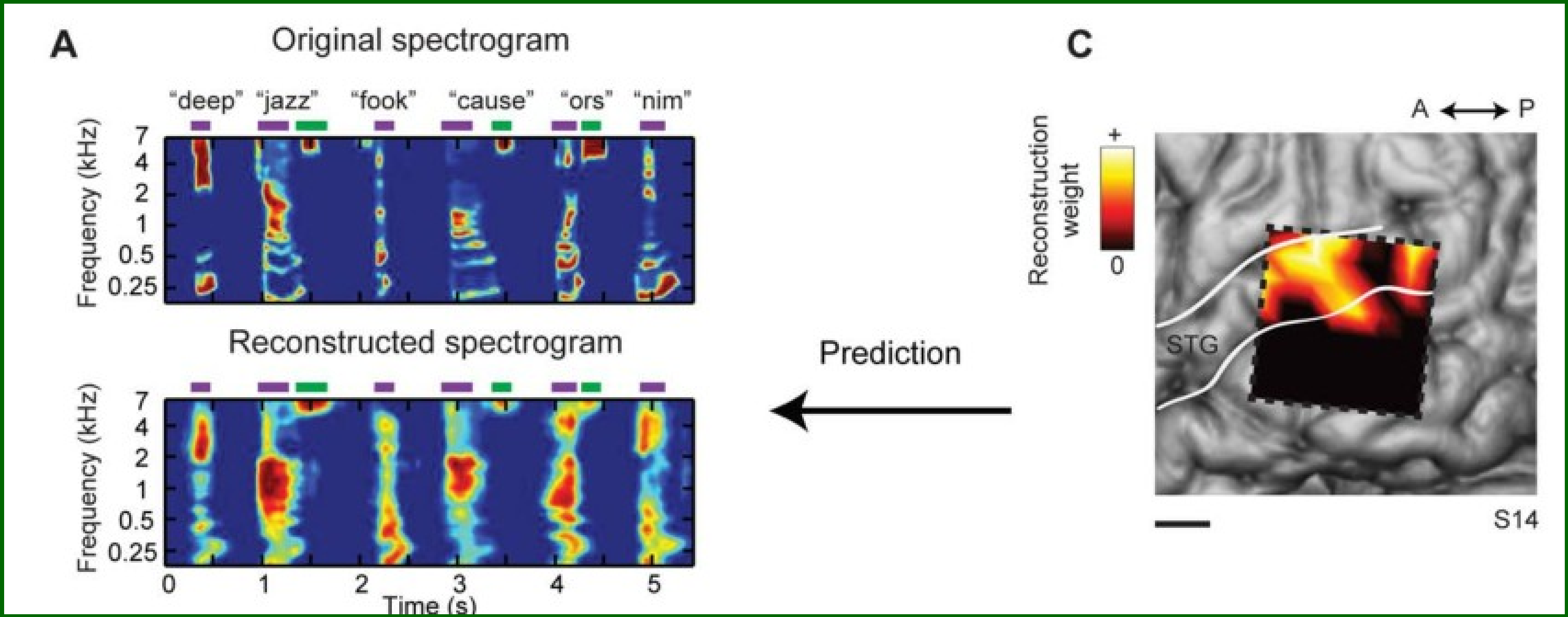
Memory $\Rightarrow$ imaginary music experience?

Sound in the brain

A mesh of electrodes measuring cortical electric field potentials allows for reconstruction of speech from measured brain activity.



Time, place, energy, frequency



All brain activity is just trains of neural impulses and microcircuit activations. Neural representation of sound can be analyzed by a 4-dimensional spectrograms of the auditory cortex activity.

Pasley et al. Reconstructing Speech from Human Auditory Cortex. PLOS Biology 2012.

Neurocognitive Model

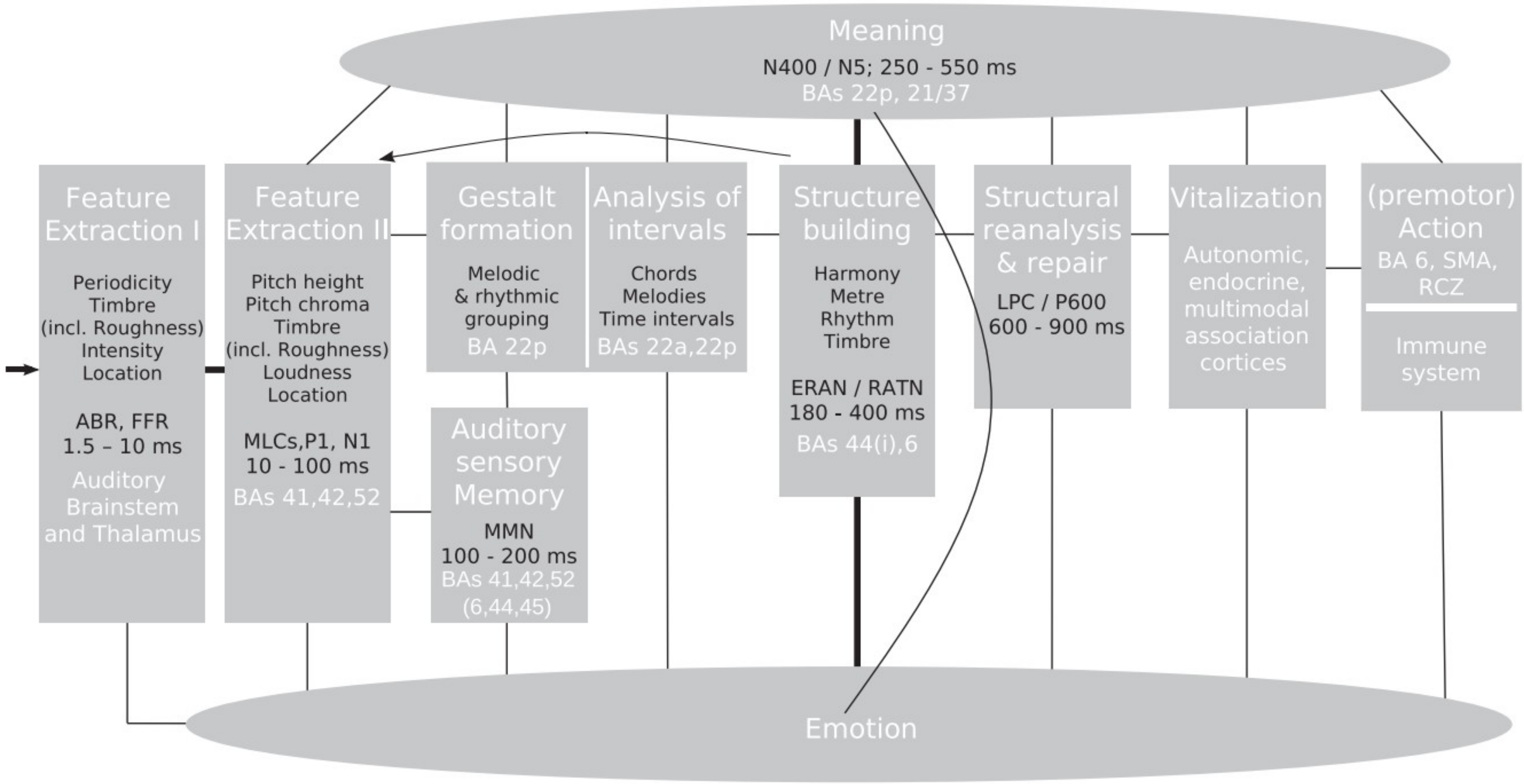
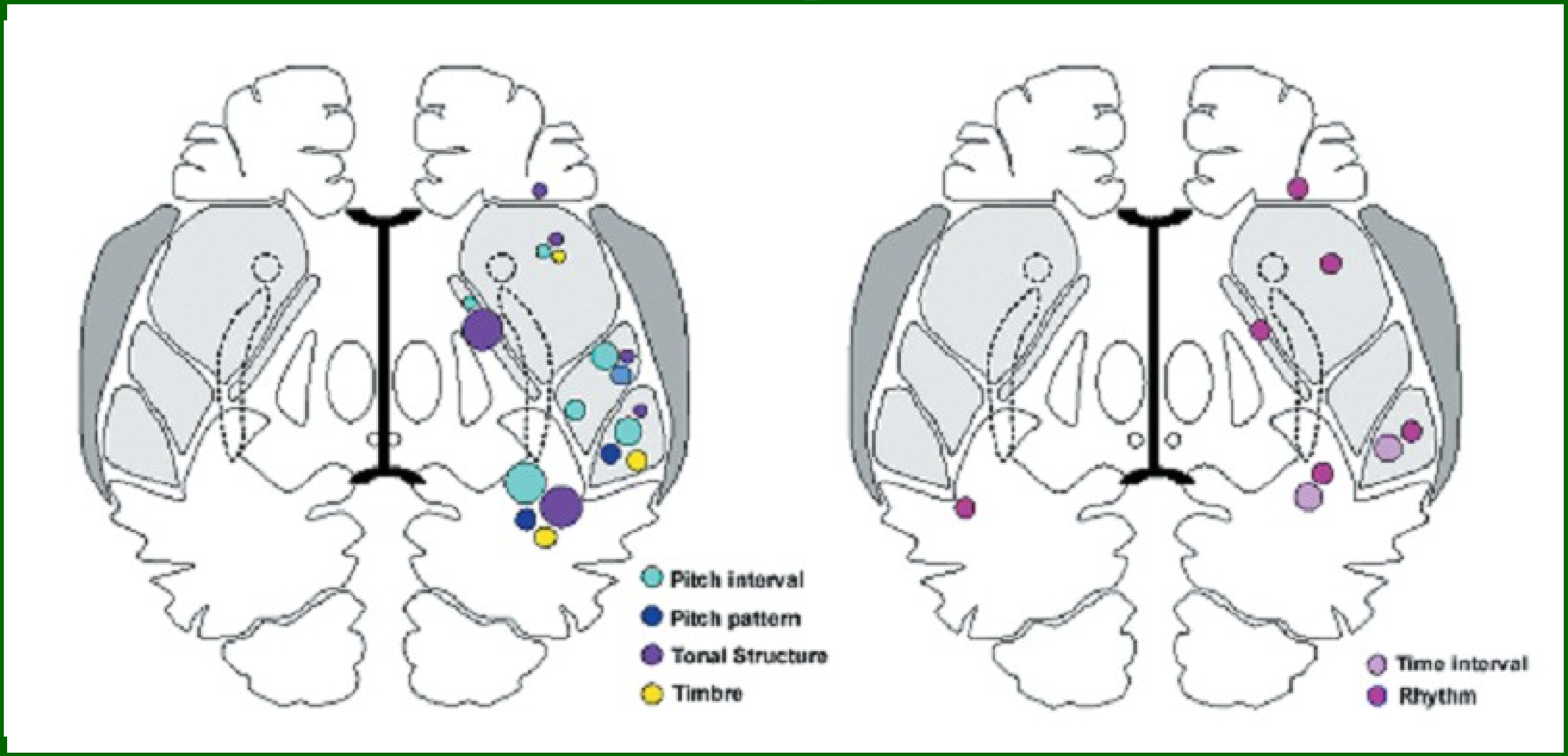


FIGURE 1 | Neurocognitive model of music perception. ABR, auditory brainstem response; BA, Brodmann area; ERAN, early right anterior negativity; FFR, frequency-following response; LPC, late positive component; MLC, mid-latency component; MMN, mismatch negativity; RATN, right anterior-temporal negativity; RCZ, rostral cingulate zone; SMA, supplementary motor area. Italic font indicates peak latencies of scalp-recorded evoked potentials.

S. Koelsch, Toward a neural basis of music perception – a review and updated model. Front. in Psychology 2 (110), 1-20, 2011

Processing Music



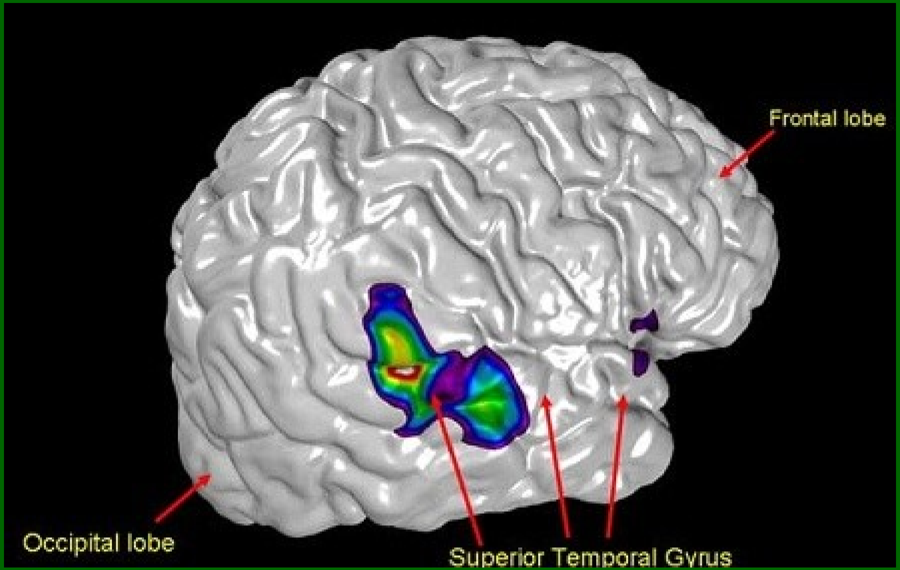
Cognitive model of music processing point to a widely distributed network, focused on pitch and rhythm processing: pitch in lateral Heschl's gyrus, timbre in posterior superior-temporal lobes, rhythm in motor/mesiolimbic areas.

Conscious hearing requires activation of the auditory cortex (temporal gyrus). **We do not have names** for internal aspects of music processing in the brain.

Music Imagery

fMRI hemodynamic increase during an Auditory Imagery Task performed in silence, in the auditory cortex posterior superior temporal gyrus.

Zatorre & Halpern, Mental Concerts: Musical Imagery and Auditory Cortex, Neuron 47, 9-12, 2004.

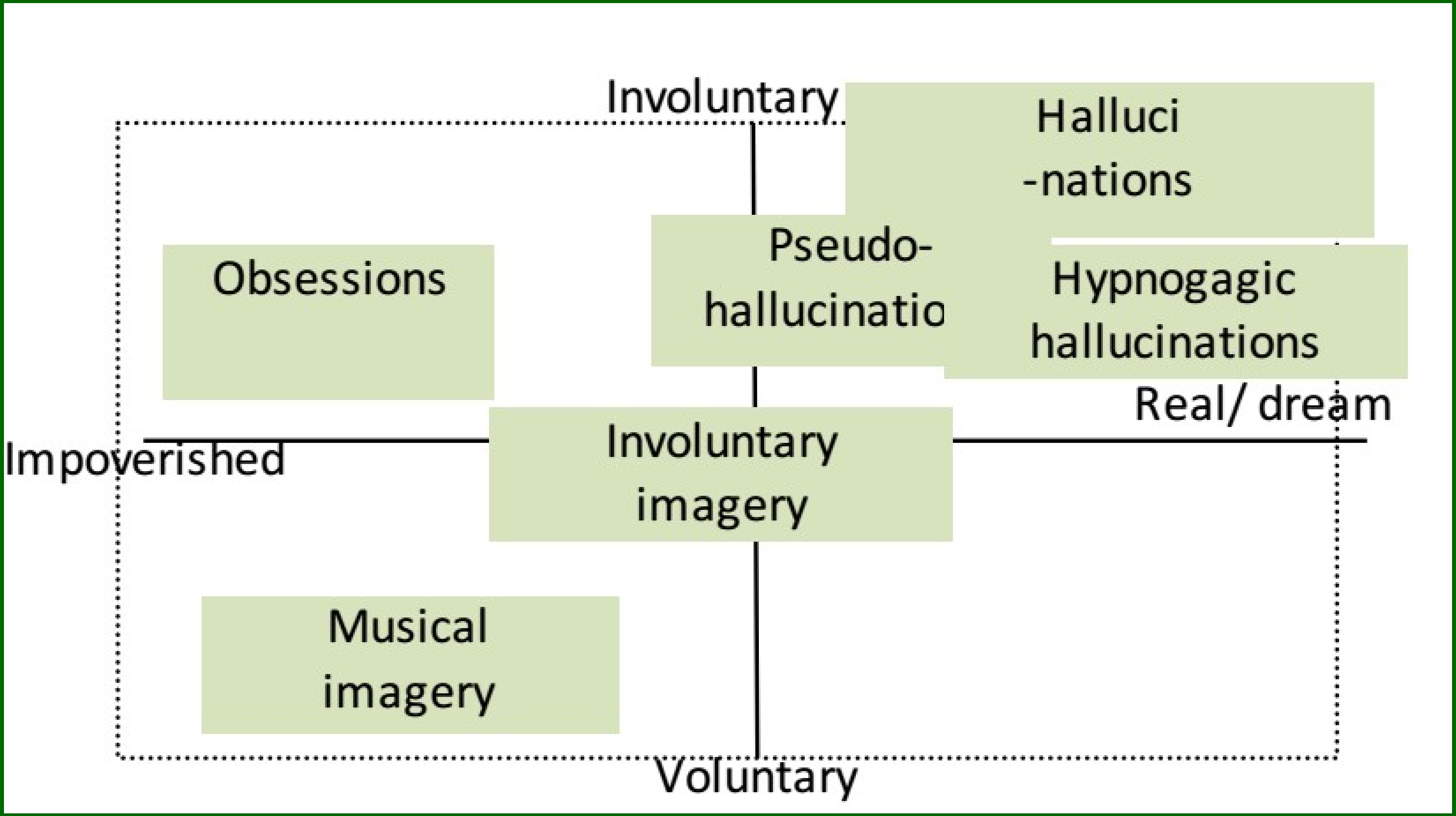


Aural imagery or **inner hearing** is … an important aspect of musical development. … connect the sound .. with a "feel" they know will produce that sound. The goal of music performance is the reproduction of the internal auditory image. (D.R. Allen musicology thesis, 2007)

“An anticipatory image of feedback from an action participates in the selection and initiation or that action. [...] In the closed-loop formulation, the image may serve as a template for comparison with current feedback and need not be activated prior to performance.” A.G. Greenwald, Psych. Rev, 77, 73-99, 1970.

Varieties of musical imagery

Involuntary (or intrusive) musical imagery (INMI), internal perception of spontaneous melodies, repetitive musical sounds.



Liikkanen 2012

If I have a good musical ear can I imagine music?

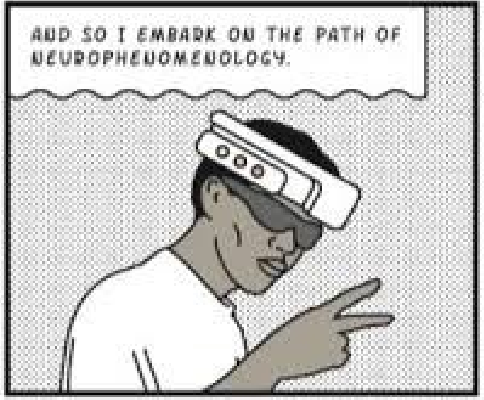
The Listener
James C. Christensen

How strong are your top-down connections?

On being a listener

- I have little access to perceptual imagery, in all modalities: visual, auditory, tactile and gustatory – is this common? Related to depersonalization of self?
- I am not more privileged to have conscious insight into my own brain then external observer, although I observe myself more frequently.
- Playing musical instrument (EWI) I have no idea what will come out. I feel like a listener, like everyone else, listening to what my brain tries to say. Yet the music is there, phrases come out and the brain plans all the actions.
- Recall is not possible, in my mind I cannot repeat a simple melody, but can read music and improvise.
- Learning to play music without imagery is difficult – how far can one go?
- Recognition memory is fine, but without inner ear how will I know what to play? Conscious mental rehearsal is not possible.
- Will a lot of training help to grow new synaptic connections?
- **Conclusion: Vivid imagery is a part of artistic and musical talent.**

Neurophenomenology



General: how precisely can episodic memory be recreated?

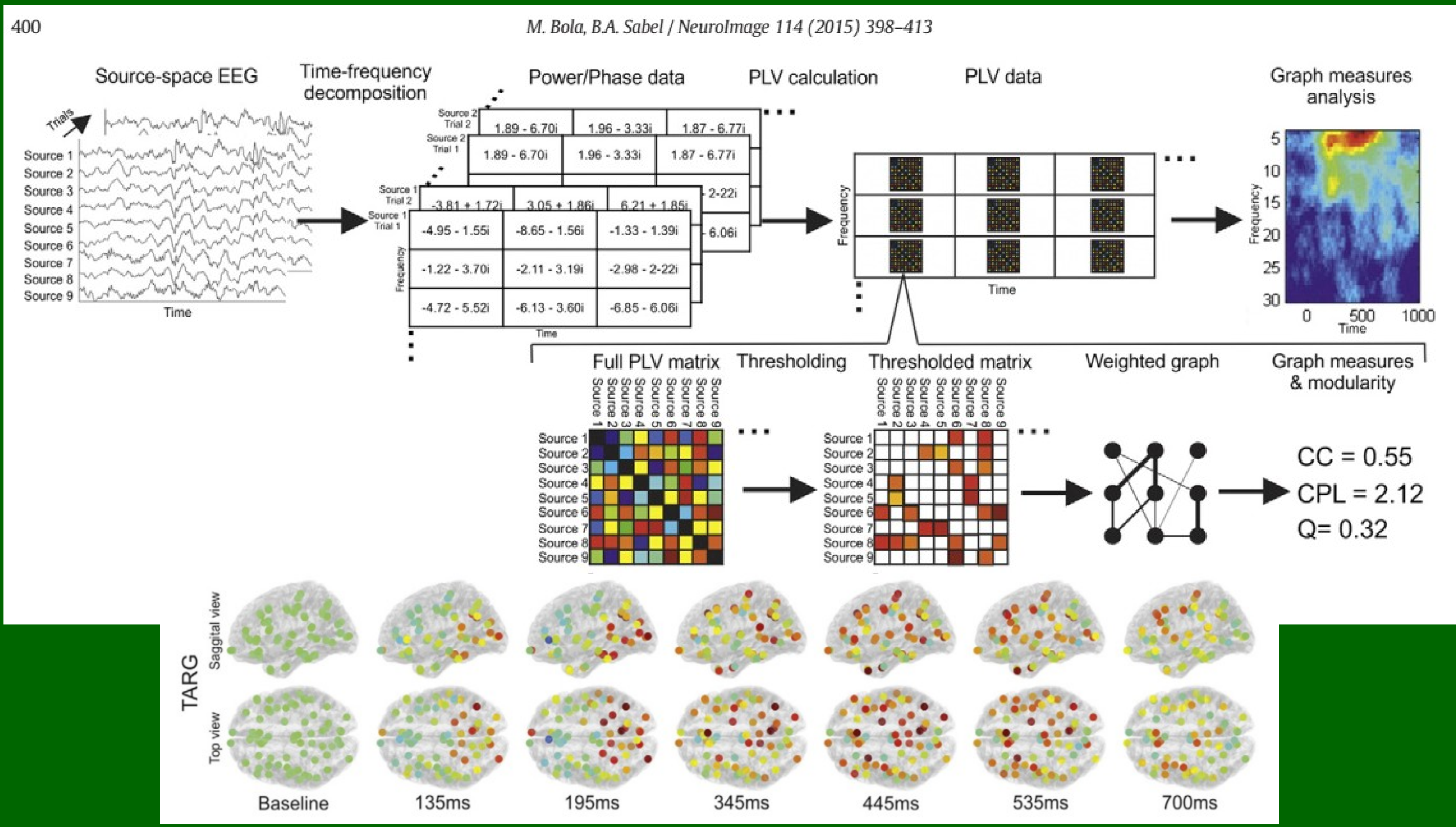
Top-down impairments may lead to *imagery agnosia*, that have not yet been investigated by neuropsychology.

People who do not have vivid imagery may experience untypical brain states that are hard to express in words. Such unusual inner experience rarely creates noticeable problems in communication, despite limited recall. Phenomenology of imagery agnosia is hard to describe using language: words do not map well categories of brain states in this case.

Can **crossmodal stochastic resonance** help? Crossmodal SR is a ubiquitous phenomenon in humans (in sensory but also in associative cortex), but experiments with noise failed to activate my visual imagery.

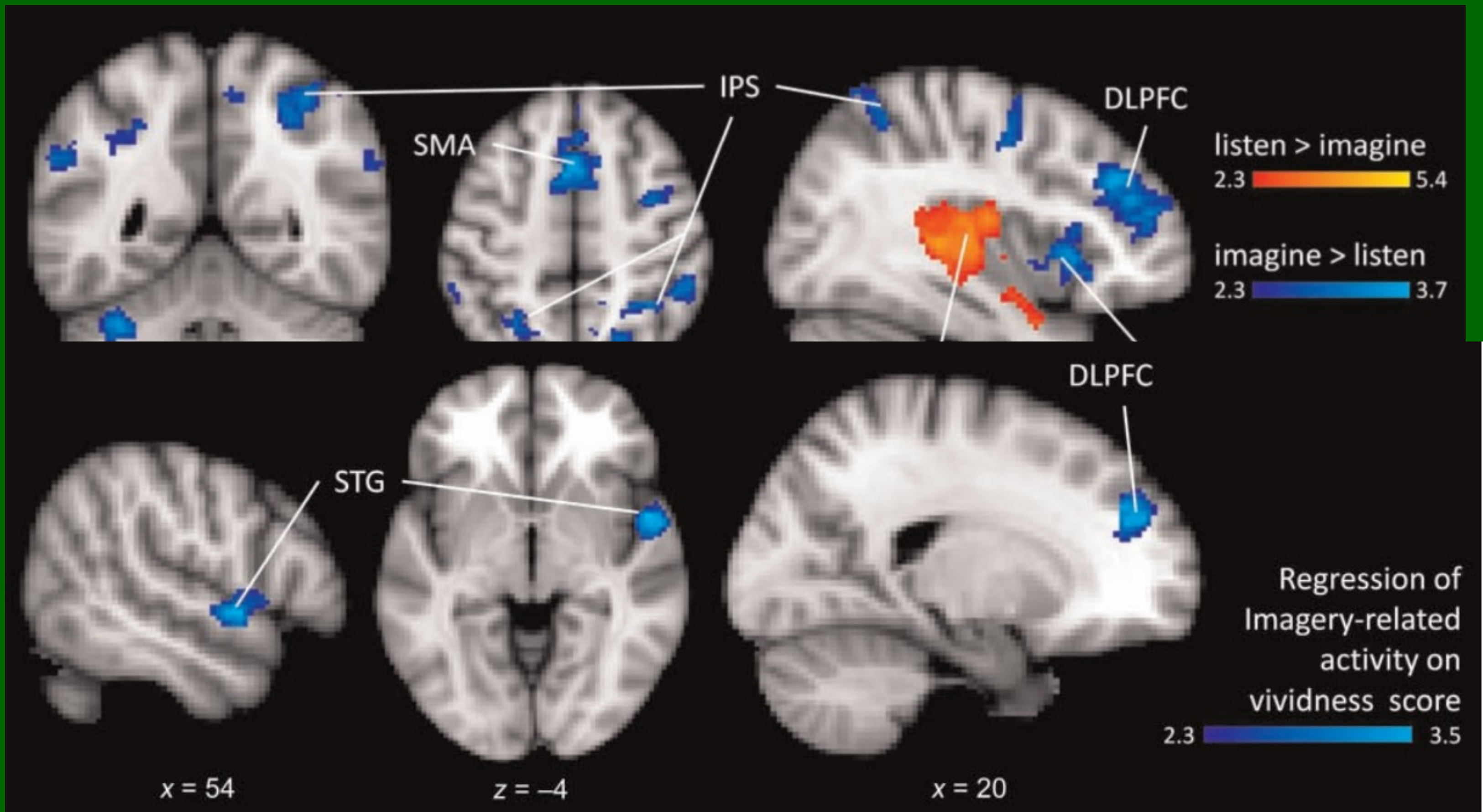
Lugo E, Doti R, Faubert J (2008) Ubiquitous Crossmodal Stochastic Resonance in Humans: Auditory Noise Facilitates Tactile, Visual and Proprioceptive Sensations. PLoS ONE 3(8): e2860
Duch W. (2012) What can we know about ourselves and how do we know it? Book chapter in: The World Without Borders - Science Without Borders. Societas Humboldtiana Polonorum, 2012, pp. 181-208.

Dynamic reorganization of brain functional networks during cognition



Listen vs imagine

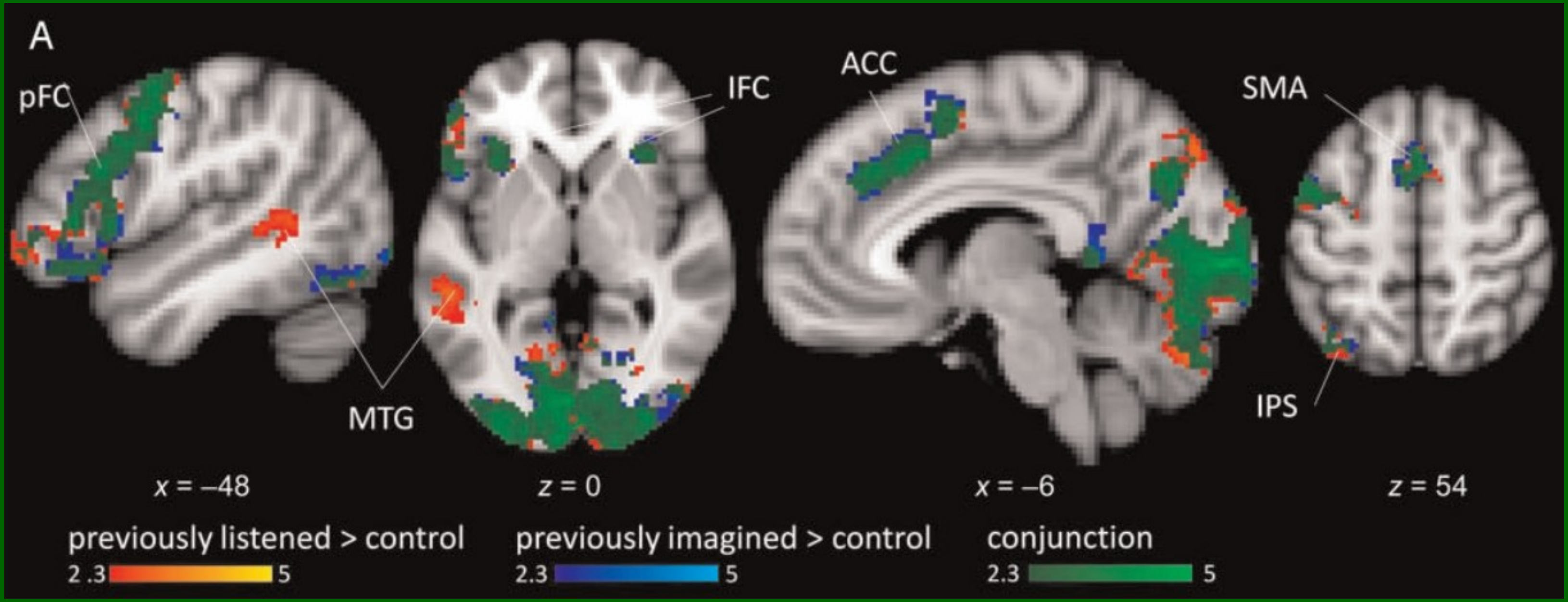
General: how precisely can episodic memory be recreated?



gure 4. Regression of activity during imagery compared with baseline during the encoding phase of the experiment on the vividness of imagery

Herholz, S.C, Halpern, A.R, Zatorre, R.J. (2012) Neuronal correlates of perception, imagery, and memory for familiar tunes. JCN 24

Listening/imaging familiar melodies



The correlation of a person's general ability to vividly imagine auditory information (BAIS score) with brain activity during imagery compared with baseline revealed a cluster in the anterior part of the right STG (not PAC). More vivid imagers showed significantly more activity in this area while performing auditory imagery task than people who reported only weak imagery capabilities.

Herholz, S.C, Halpern, A.R, Zatorre, R.J. (2012) Neuronal correlates of perception, imagery, and memory for familiar tunes. JCN 24

Silent gaps in familiar melodies

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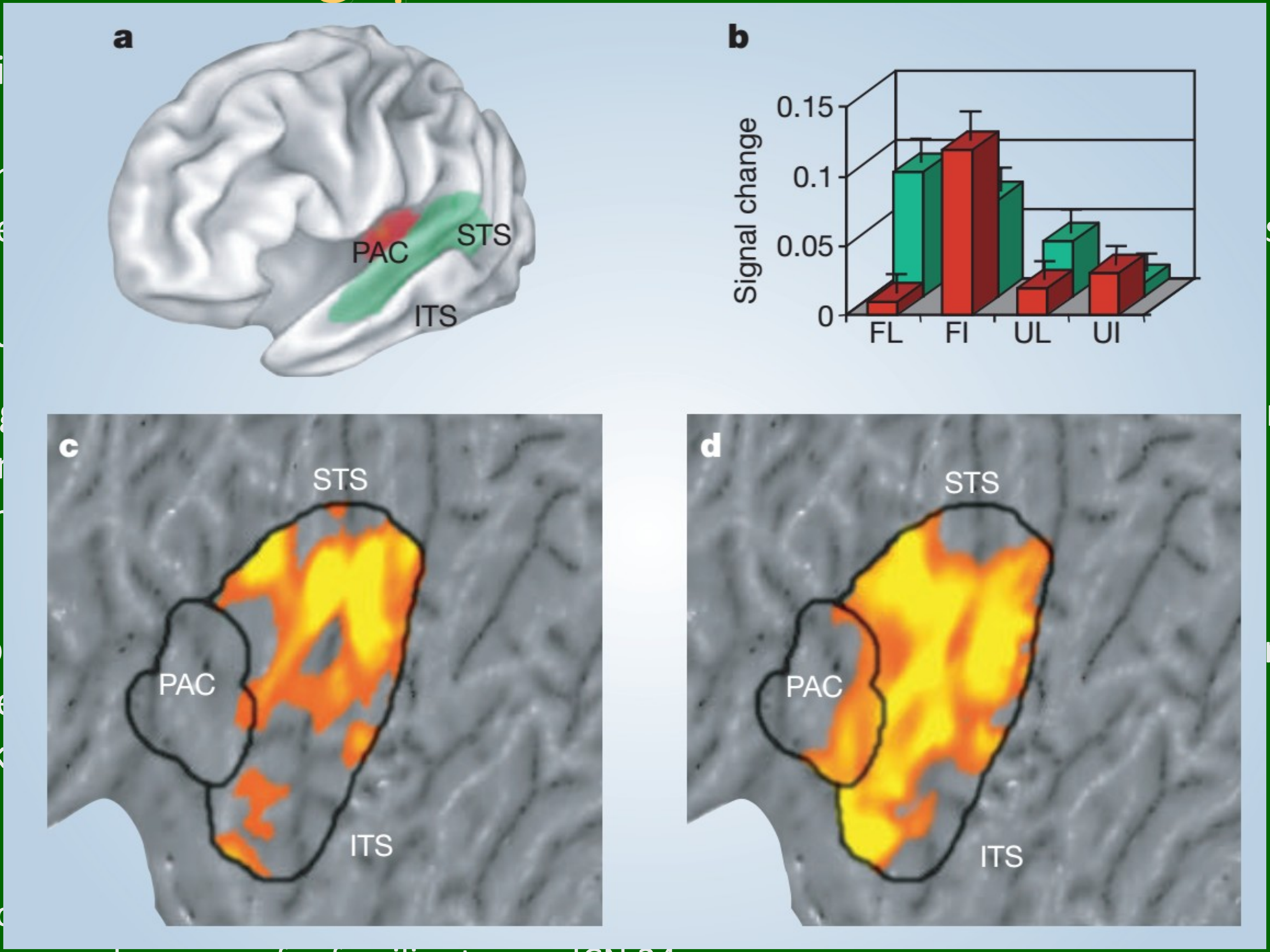
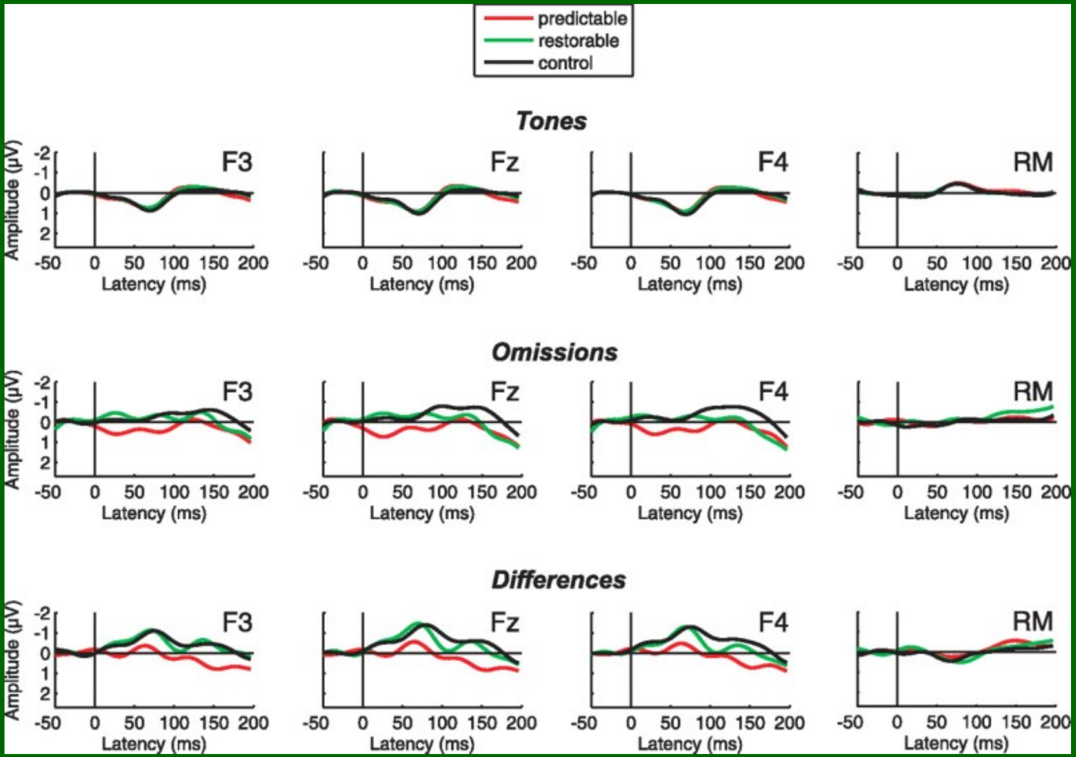


Herho

imagery, and memory for familiar tunes. JCN 24

Listing/imaging familiar melodies

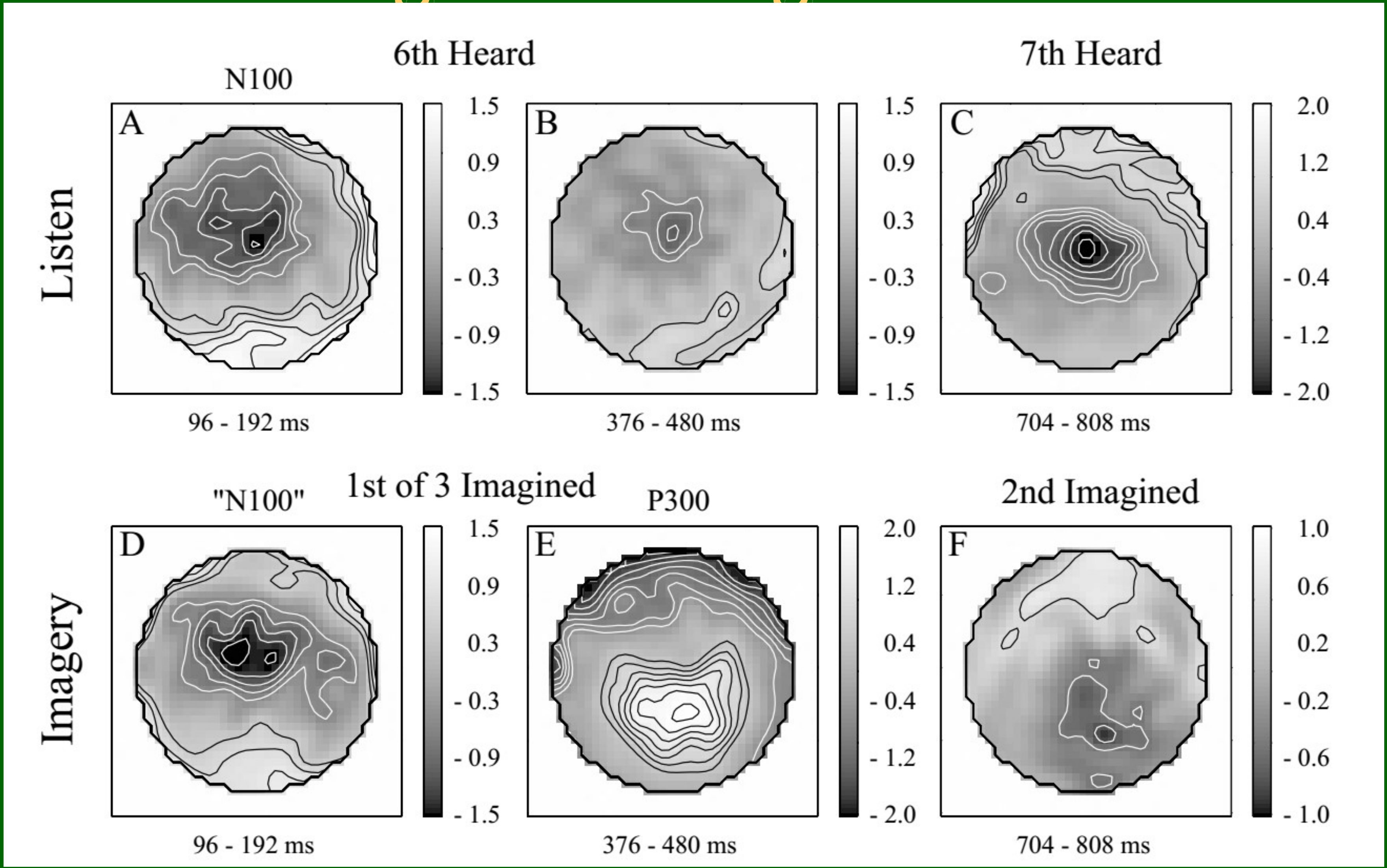
ERP responses,
group-average (N = 14).
ERPs elicited by tones
(top row) and omissions
(middle row), and difference
waveforms (bottom row) in
the predictable (red line),
restorable (green line), and
control (black line) conditions
Difference waveforms are
corrected for the position
within the sequence.



The 0 time point = onset of the tones ("expected" onset in case of omissions).

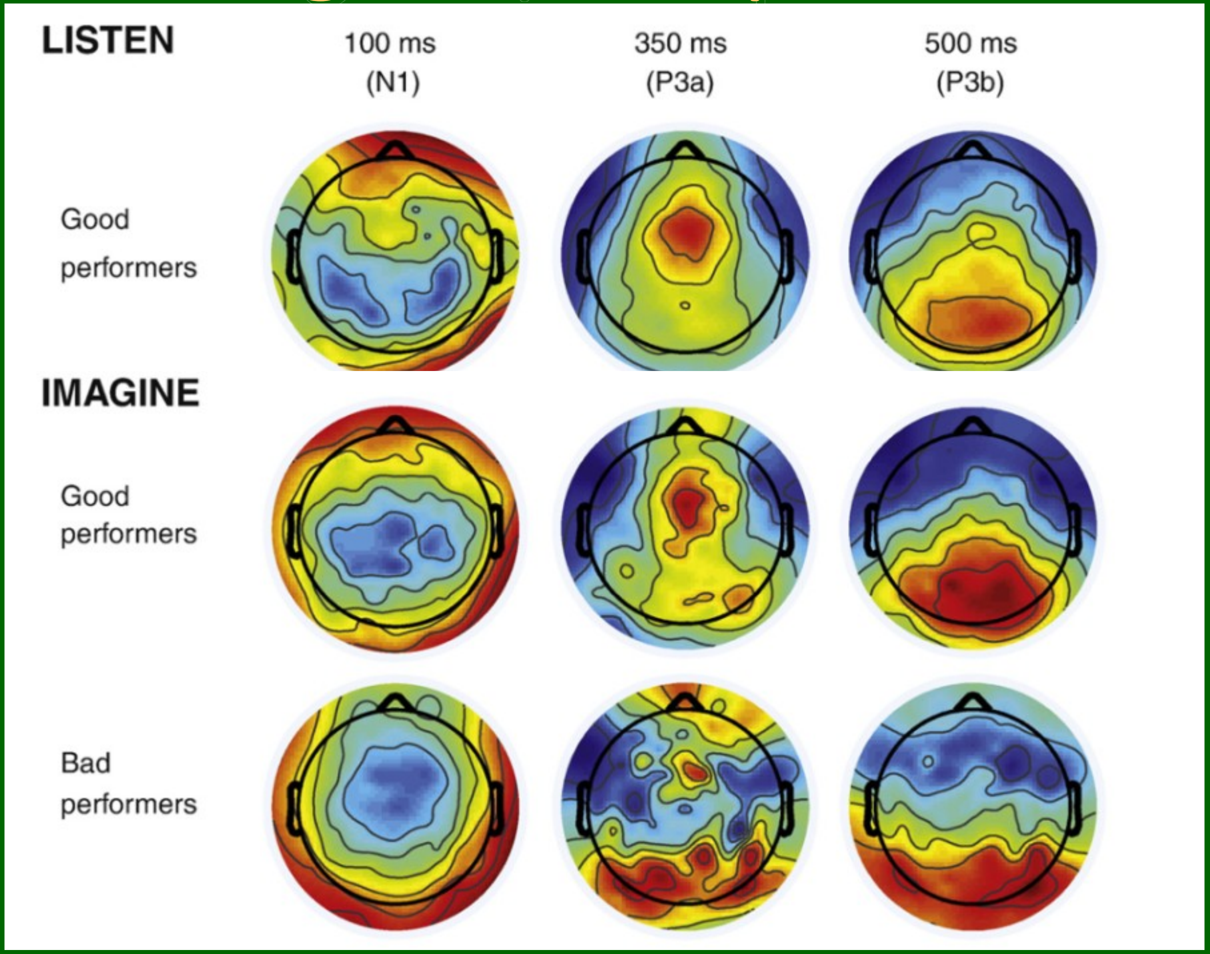
A. Bendixen, E. Schröger, I. Winkler, I Heard That Coming: Event-Related Potential Evidence for Stimulus-Driven Prediction in the Auditory System. J. of Neurosci. 2009, 29

Imagine missing notes



Petr Janata, Neurophysiological Mechanisms Underlying Auditory Image Formation in Music. Brain Topography 13, 169–193, 2001

ERPs of good/bad performers



Listen: 8 notes of a scale. Imagine: first 4 notes and the last note of the scale, imagine the (two or three) notes that were not played.

A.N. Cebriana, P. Janata, Electrophysiological correlates of accurate mental image formation in auditory perception and imagery tasks. Brain Research 1342, 2010

Sound imagery

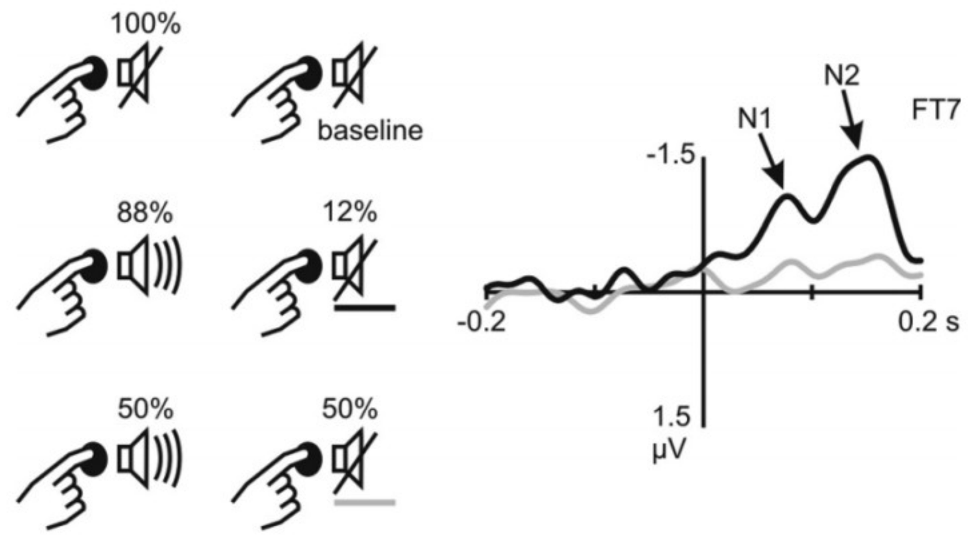
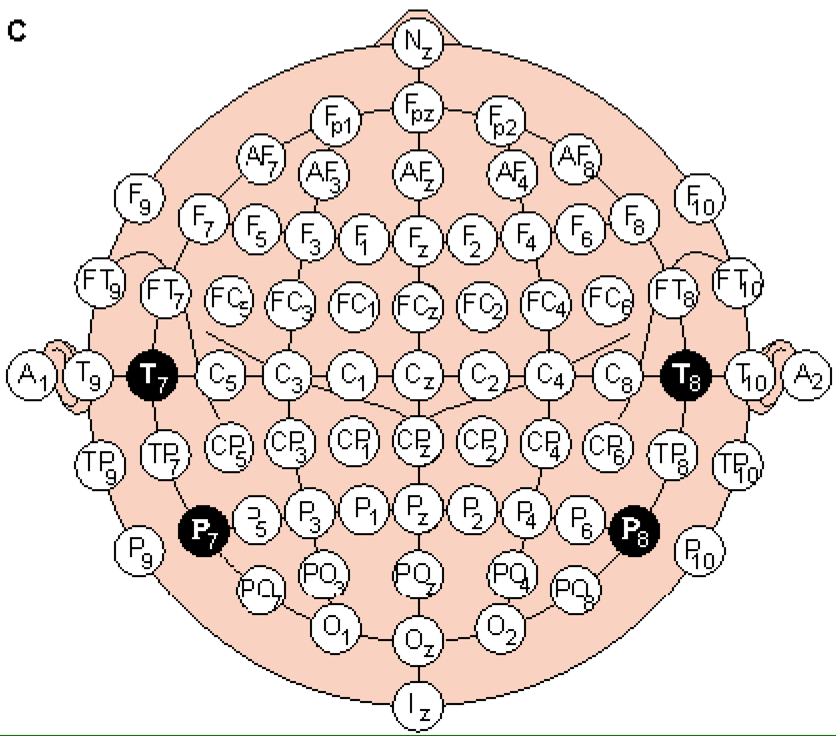
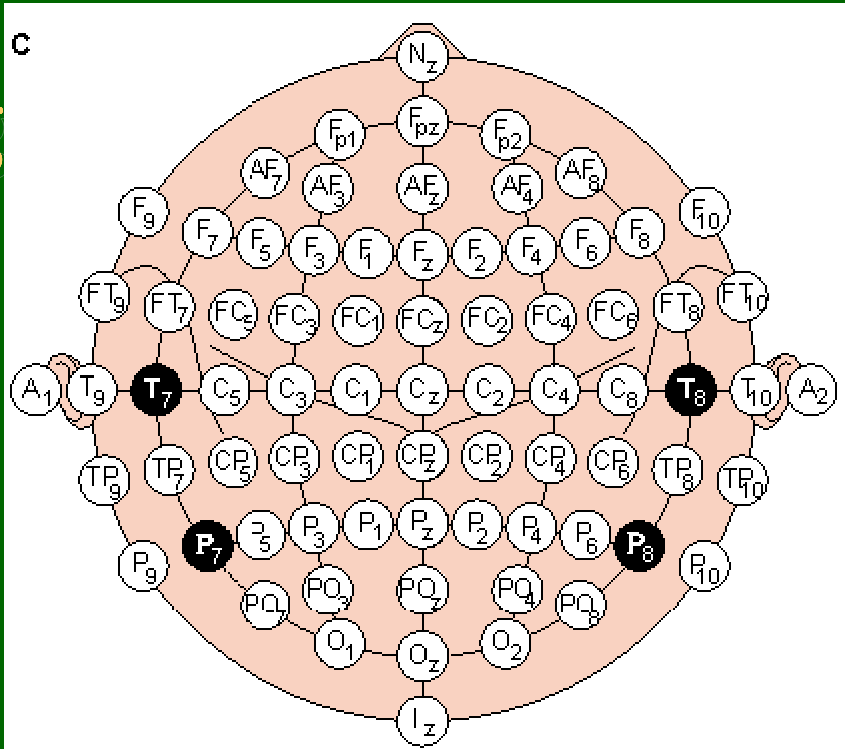


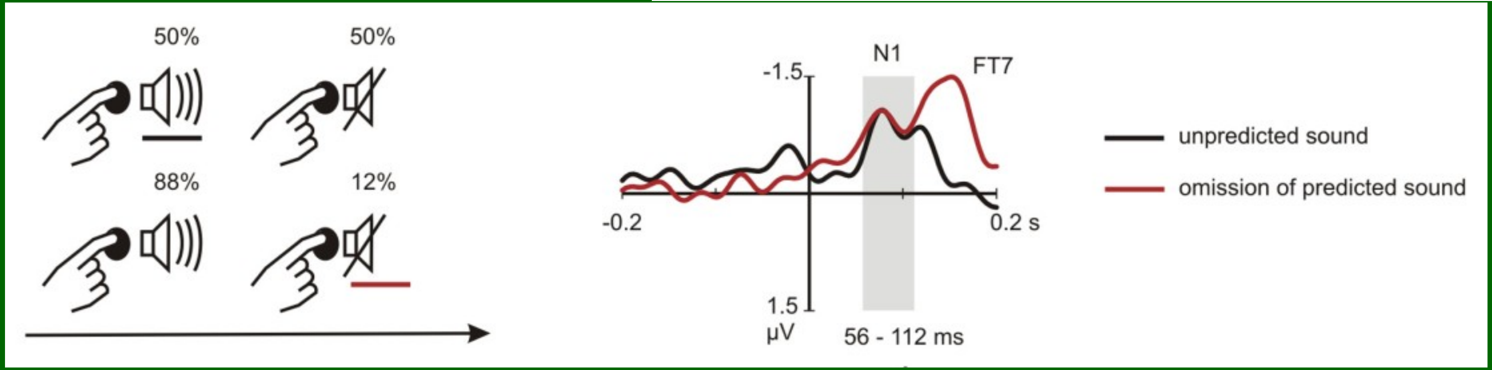
Figure 2. Extraction of neural activity reflecting sound prediction. The experimental conditions are depicted on the left. In the motor baseline (top row), button presses never produced a sound. In the other two conditions, button presses produced a sound that was unpredictably omitted in either 12% (middle row) or 50% (bottom row) of the trials. The right plot depicts brain responses in button press trials not followed by a sound, after subtraction of the motor baseline. Prediction-related activity was only observed when sound omissions were rare.



I SanMiguel, A Widmann, A Bendixen, Hearing silences: human auditory processing relies on preactivation of sound-specific brain activity patterns
The Journal of Neurosci. 2013

Sound imag





I SanMiguel, A Widmann, A Bendixen, Hearing silences: human auditory processing relies on preactivation of sound-specific brain activity patterns
The Journal of Neurosci. 2013

Rich Club Coefficient

Phase locking value between ROI k and l averaged over N trials for frequency-point f and time-point t.

$$PLV_{kl}(f,t) = \frac{1}{N}\left|\sum_{n=1}^{N} \exp\left(i\left[\varphi_k^n(f,t) - \varphi_l^n(f,t)\right]\right)\right|$$

Converted full PLV adjacency matrices into sparse, undirected, weighted graphs $A(f,t)$,

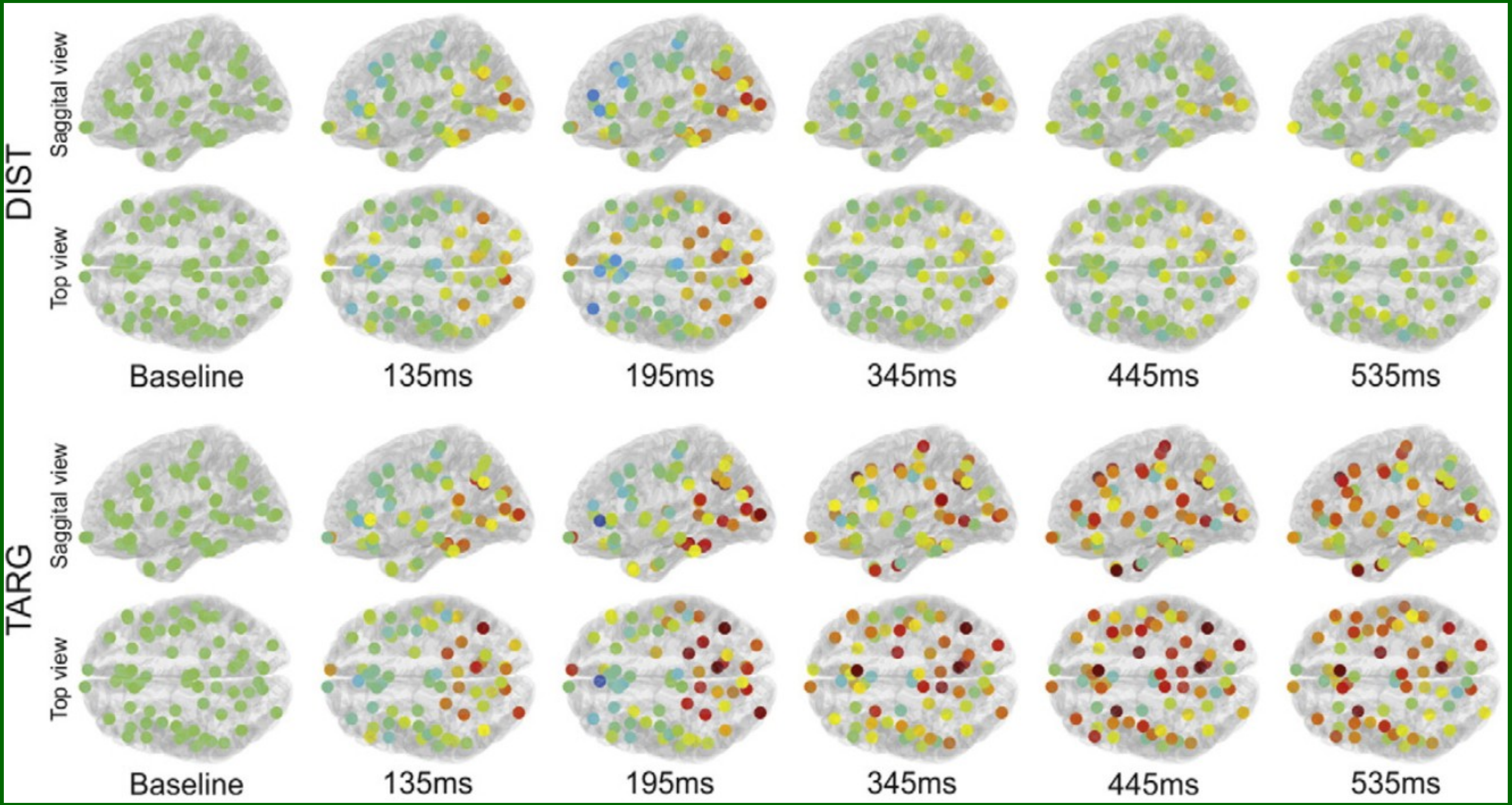
Rich-club organization: network hubs are more strongly interconnected among themselves than nodes of a low degree.

Weighted Rich Club Coefficient (RCC) measures the strength of interactions among networks' hubs:

$$RCC(rck) = W_{rc} \Big/ \sum_{k=1}^{E_{rc}} W_k^{rank}$$

Rank edges W^{rank}, select strongest E_{rc} edges (>rck) of the whole graph.

Priming activates subnetworks



M Bola, B.A. Sabel, Dynamic reorganization of brain functional networks during cognition. NeuroImage 114 (2015) 398–413 (RCC values from EEG PLV)

Brain modules and cognitive processes

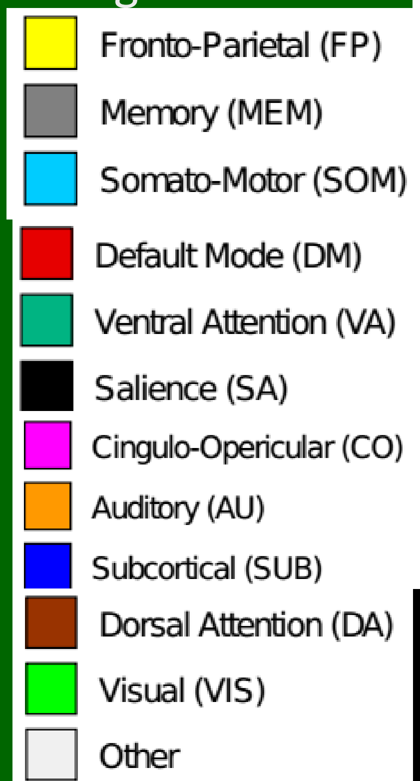
Simple and more difficult tasks, requiring the whole-brain network reorganization.

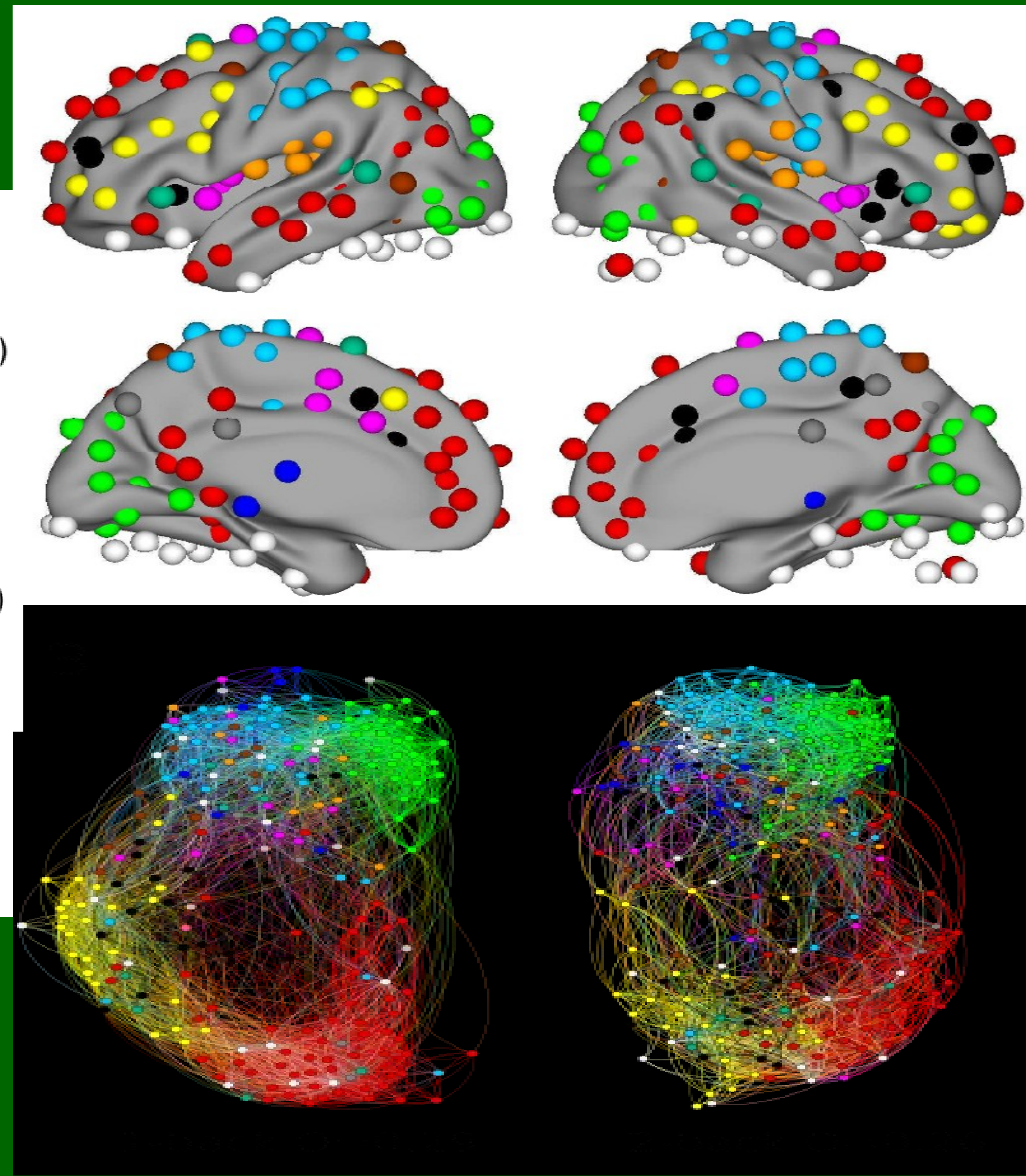
Left: 1-back

Right: 2-back

Average over 35 participants.

Left and midline sections.





K. Finc et al (HBM, in rev, with World Hearing Center, MPI for Human Development).

Can musical imagery be controlled?

Involuntary musical imagery (INMI)

Involuntary (or intrusive) musical imagery (INMI), internal perception of spontaneous melodies, repetitive musical sounds.

How common is INMI? How people react to INMI?

Can they control it? Is it always pleasant?

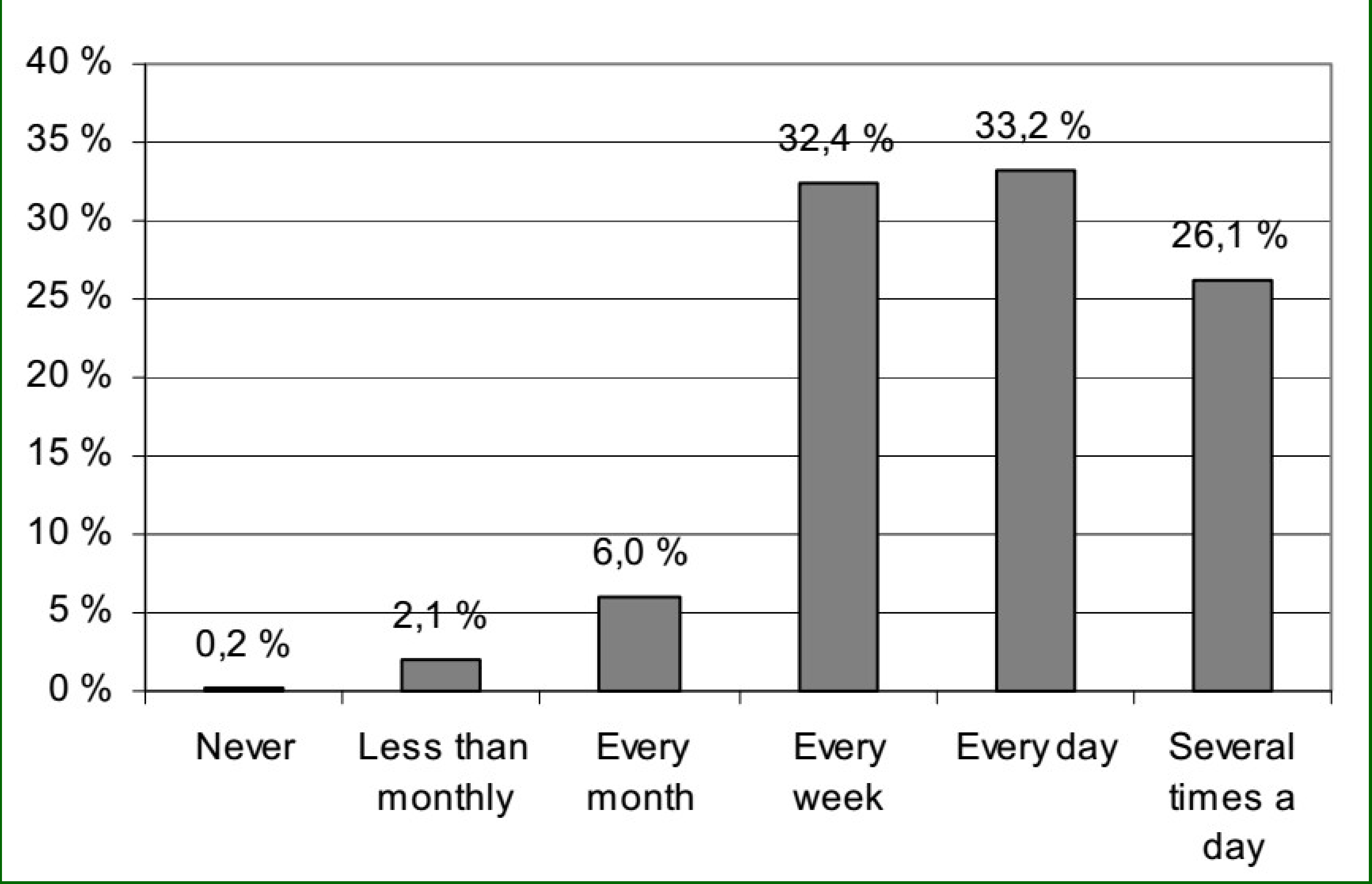
Passive acceptance and enjoyment is frequent, but a significant number of people want to stop the unwanted **earworms**.

It happens at different time of the day, subjective evaluation of the INMI experience depends on the context situation.

Activity and context situation => the experience of mind wandering => enables INMI.

INMI is a common internal experience recruiting brain networks involved in perception, emotions, memory and spontaneous thoughts.
Frequency of INMI and its affective aspects has been related to cortical thickness in several cortical and limbic areas.

INMI Frequency



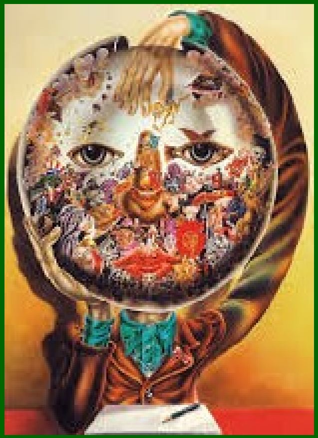
Internet questionnaires 12.500 people (Liikkanen 2010)

Reactions to INMI

Responses from the Finnish study using Internet questionnaires, 12.500 people (Liikkanen 2010).

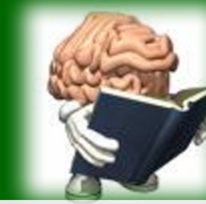
Have you ever done any of the following because of the music that is playing in your head?

1. 74.6% Hum, sing or talk aloud
2. 60.2% Try to figure out the identity of the song
3. 57.3% Listen to the particular song
4. 50.5% Listen to music, radio or television to prevent songs playing
5. 40.7% Sing or play the particular song
6. 29.5% Try to focus on doing something else
7. 0% Avoid listening



INMI happens even if you have imagery agnosia, but to know about it one must act: hum, sing, play.

Model of reading & dyslexia

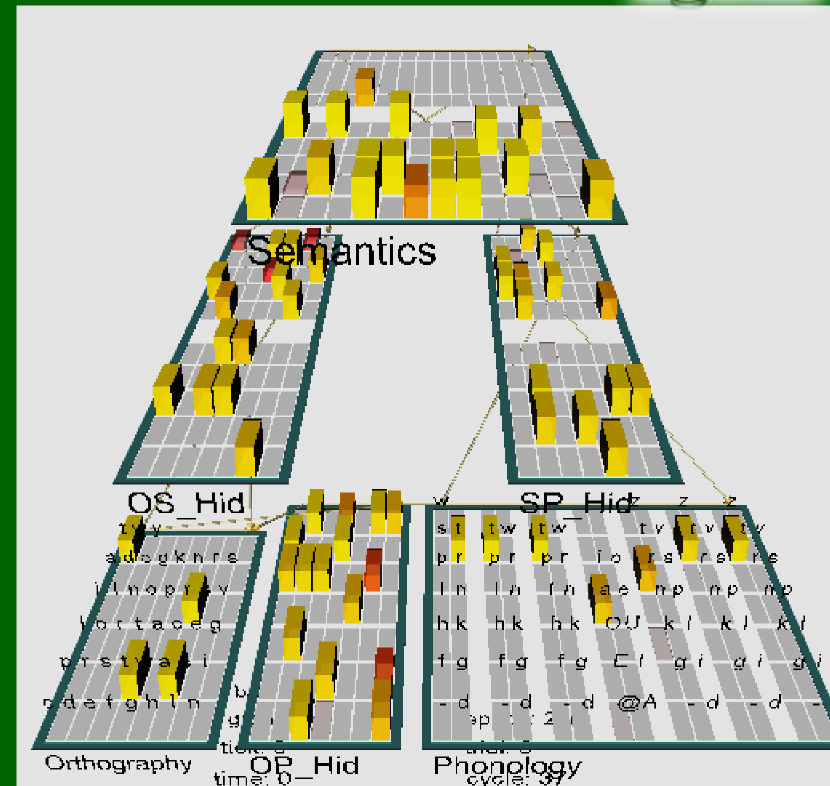


Emergent neural simulator:

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

3-layer model of reading:

Recurrent neural network (RNN) with orthography, phonology, and semantic layer = activity of 140 microfeatures that define concepts by distribution of their activations.



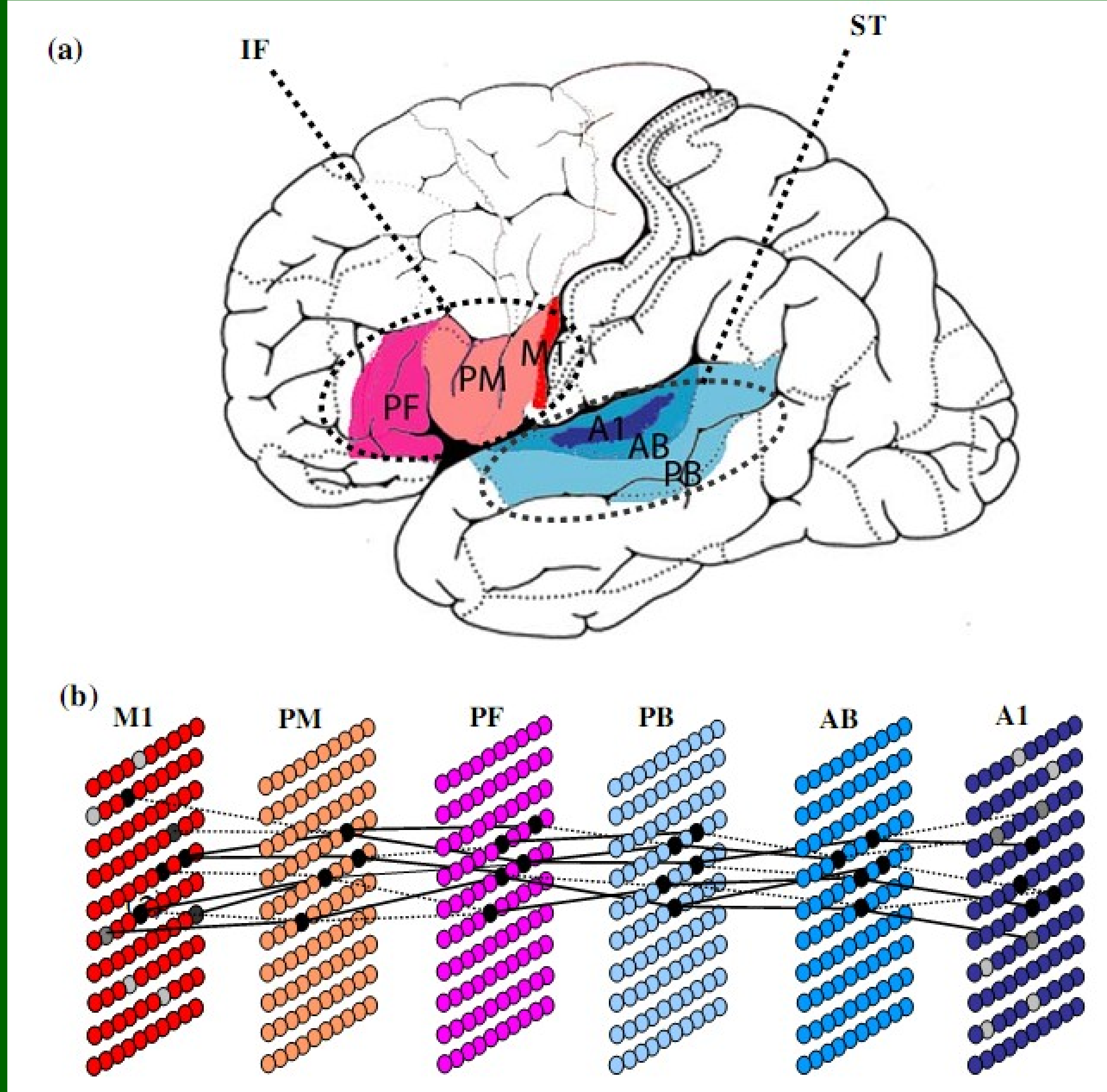
Word (written or spoken) presentation => activate semantics, quickly reaching specific configuration of fluctuating active units ⇔ attractor representing concept. Transition to related attractor soon follows.
Sequence of attractor states can be labeled by the activity of phonological or orthographical layers, stream of verbal comments on internal state.

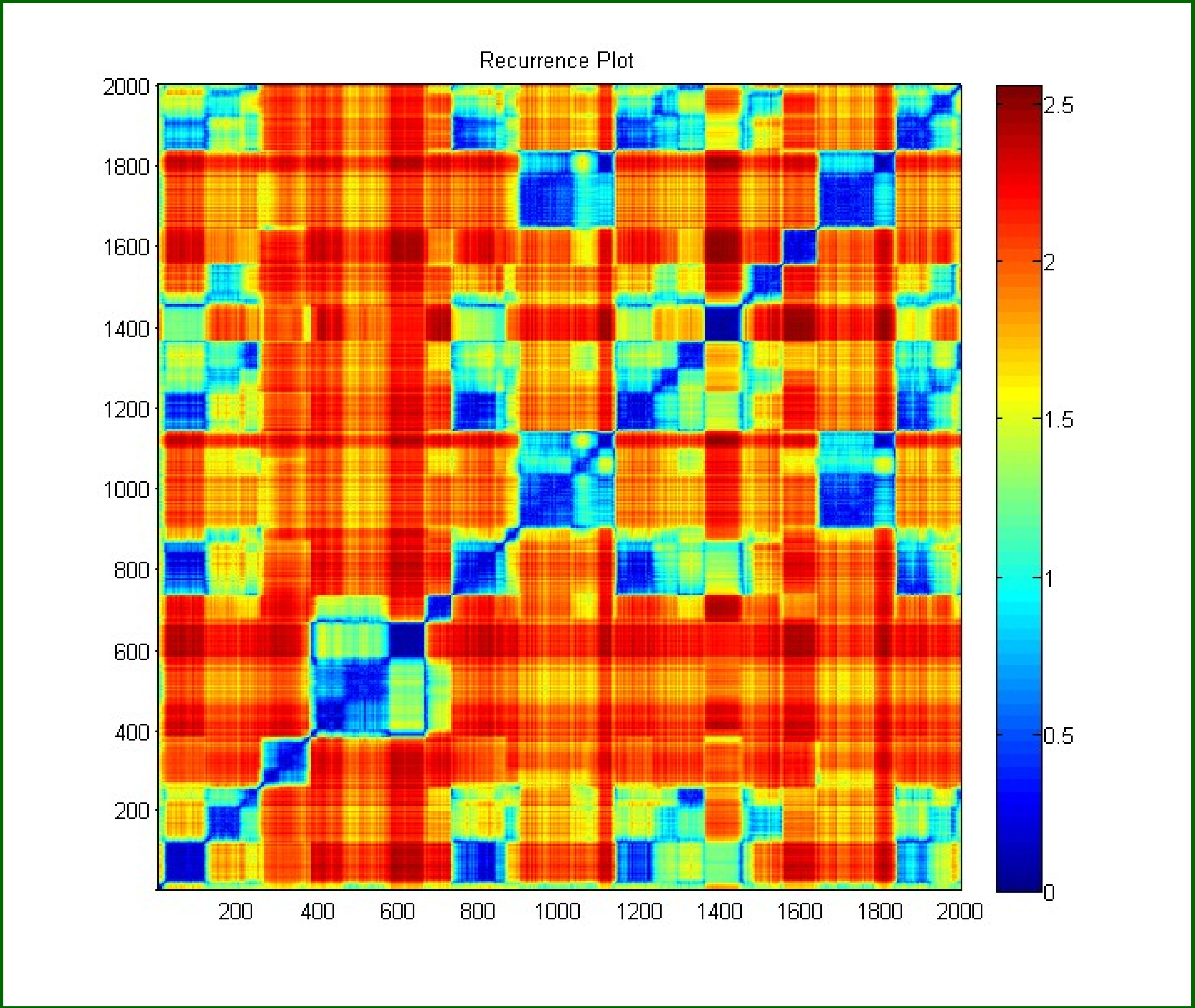
Detailed model

Recruitment and consolidation of cell assemblies for words by way of Hebbian learning and competition in a multi-layer neural network.

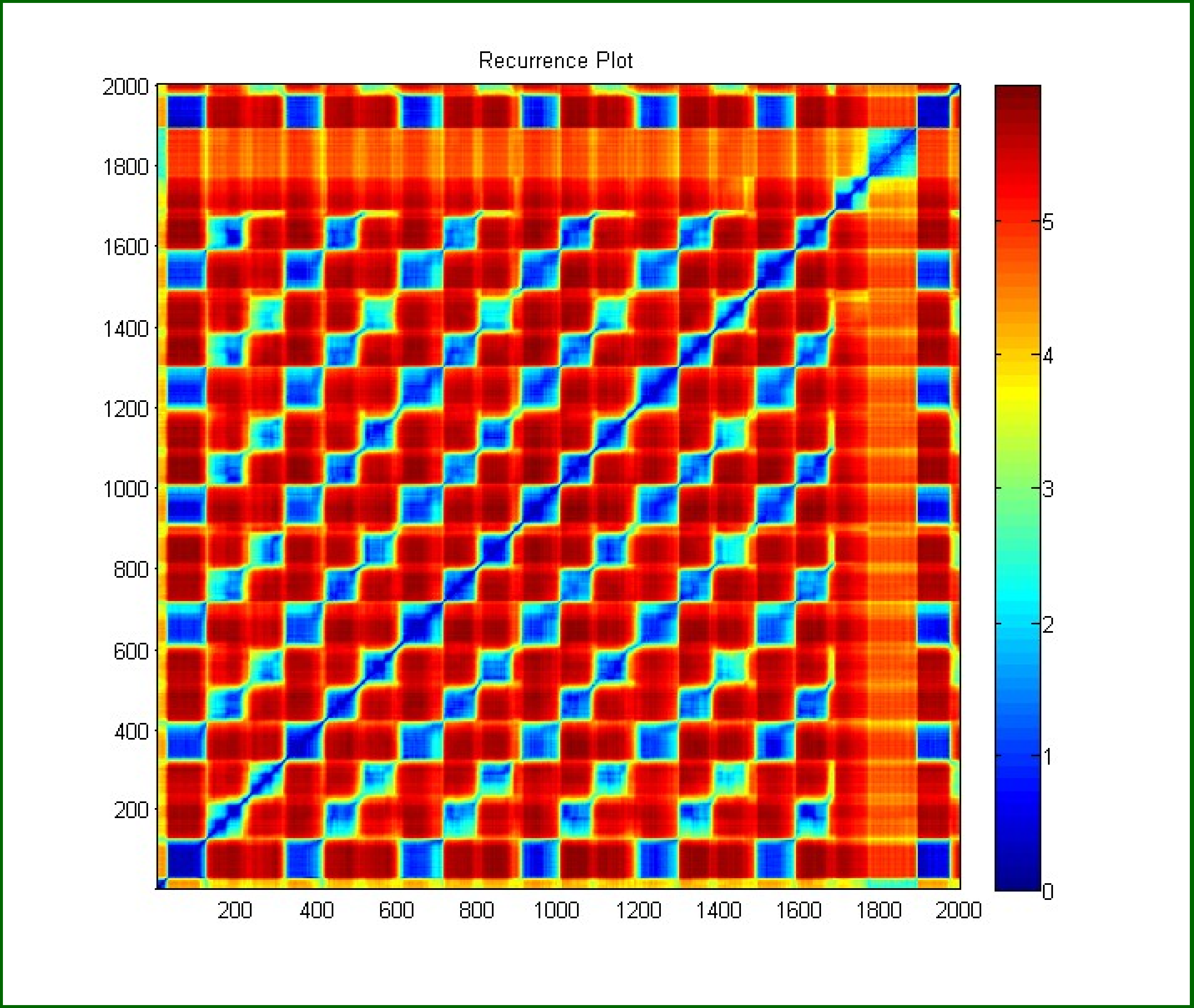
Primary auditory cortex (A1), auditory belt (AB), extended belt (PB, Wernickie area), lateral ventral prefrontal cortex (PF), premotor cortex (PM, Broca), and motor cortex (M1).

Garagnani et al. Cognitive Comp. 1(2), 160-176, 2009.

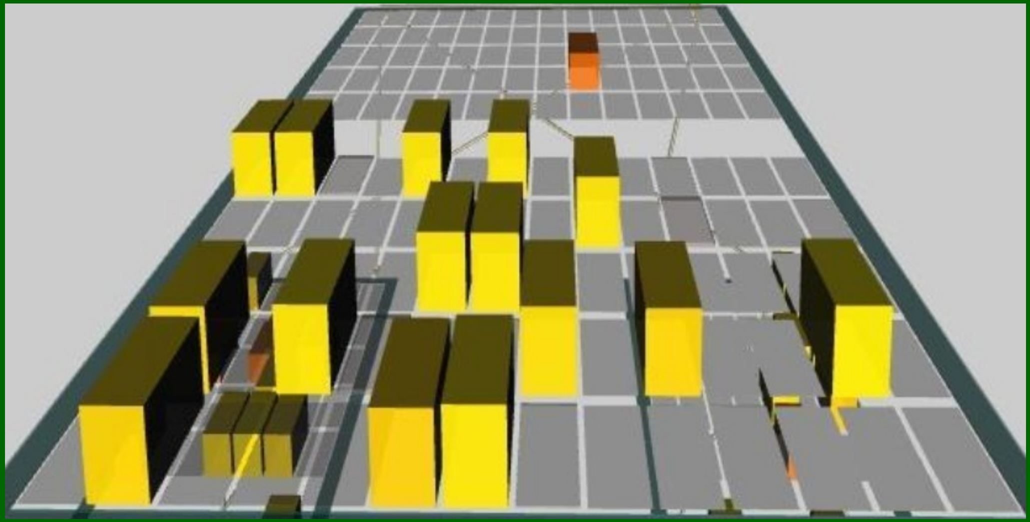


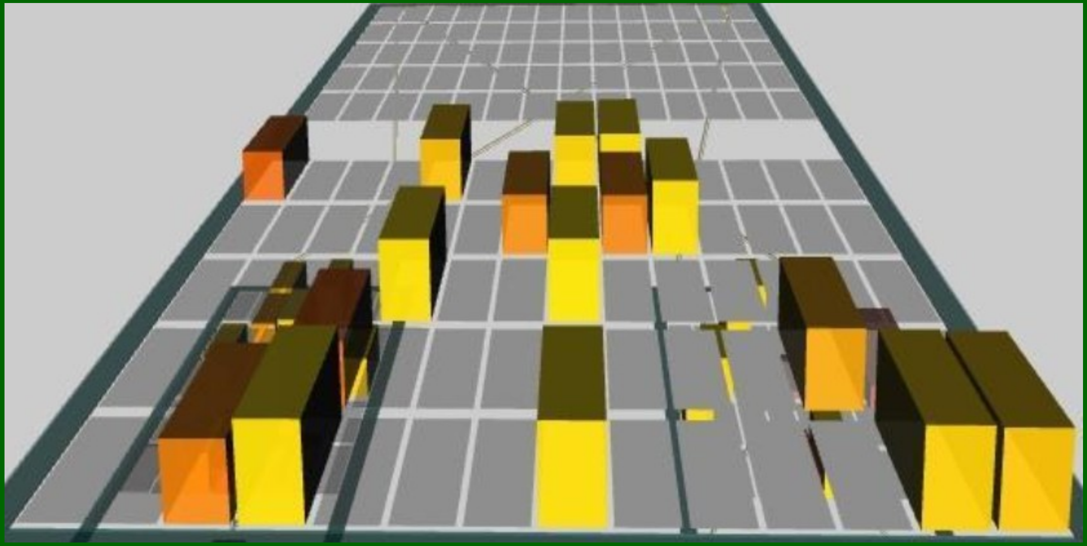


„Gain" – for abstract words semantic layer trajectory rarely comes back to similar states, there are fewer attractors than for the concrete words.



„Deer" – trajectory of the semantic layer goes through some transient states and tends to come back to original attractor, near the end moving far from it.





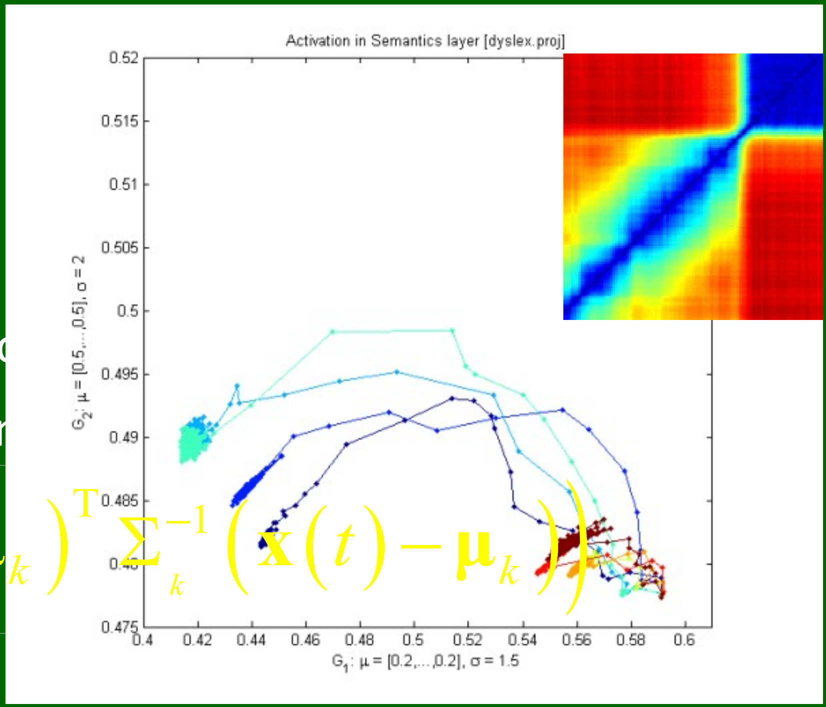
Transition from “case” to “rope”.

Fuzzy Symbolic Dynamics (FSD)

Complementing information in RPs:

RP plots $S(t,t_0)$ values as a matrix; FSD

1. Standardize data.
2. Find cluster centers (e.g. by k-means alg
3. Use non-linear mapping to reduce dimen



$$y_k(t;\boldsymbol{\mu}_k,\Sigma_k) = \exp\left(-\left(\mathbf{x}(t)-\boldsymbol{\mu}_k\right)^{\mathrm{T}}\Sigma_k^{-1}\left(\mathbf{x}(t)-\boldsymbol{\mu}_k\right)\right)$$

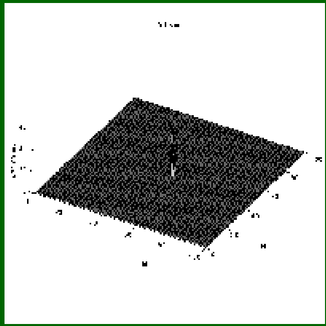
Localized membership functions $y_k(t;W)$:

sharp indicator functions => symbolic dynamics; $x(t)$ => strings of symbols;

soft membership functions => fuzzy symbolic dynamics, dimensionality reduction $Y(t)=(y_1(t;W), y_2(t;W))$ => visualization of high-dim data.

We may then see visualization of trajectory in some basin of attraction. Such basins are simply referred to as "attractors".
FSD shows dynamics on graphs from brain imaging.

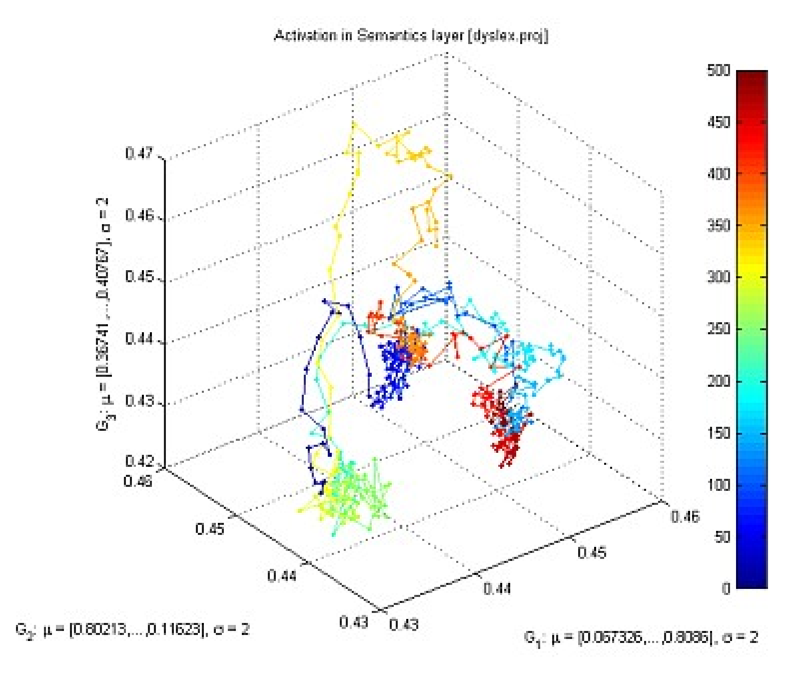
Basins of attractors



Groups of neurons synchronize, become highly active, these activations fluctuate around some specific distributions, inhibiting competing groups of neurons.

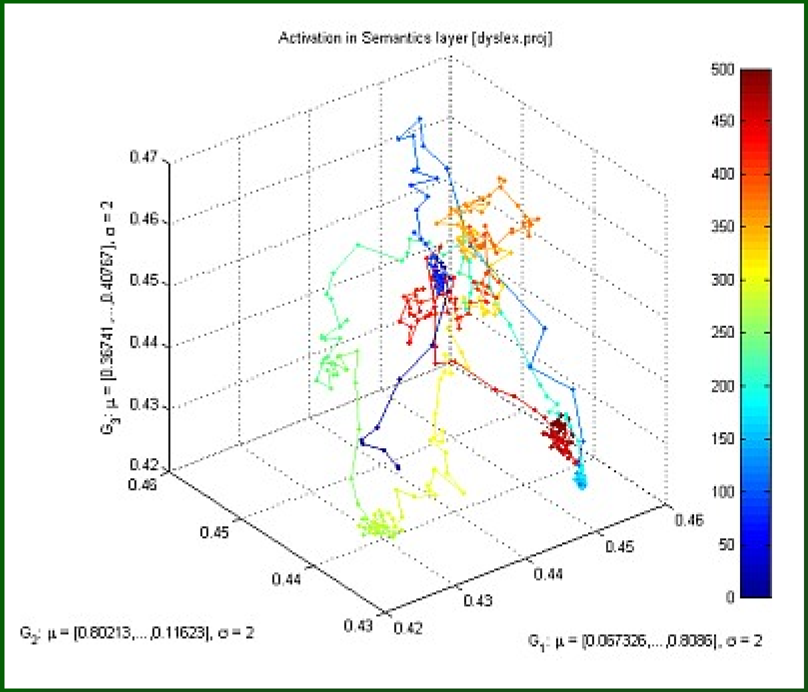
Normal case: relatively large, easy associations, fast transitions from one basin of attraction to another, creating "stream of consciousness".

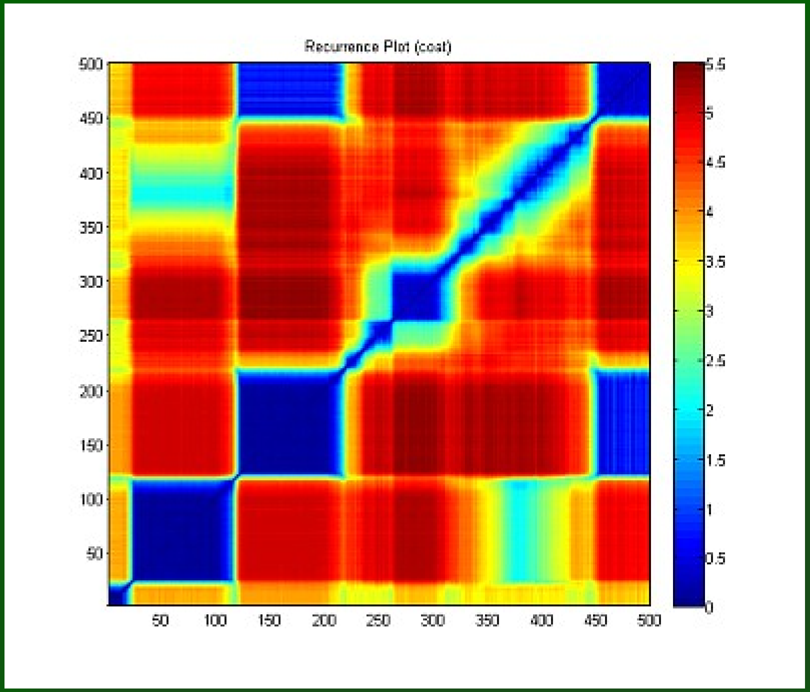
Brain has about 3 mln minicolumns in the cortex alone, corresponding to units in computational model, so this is a huge space. Here each point ⇔ 140 dim. vector.



Accessible basins of attractors = available mental states that can be categorized and identified. They shrink and vanish as neurons desynchronize due to the fatigue; this allows other neurons to synchronize, leading to new mental states (thoughts).

Fast transitions

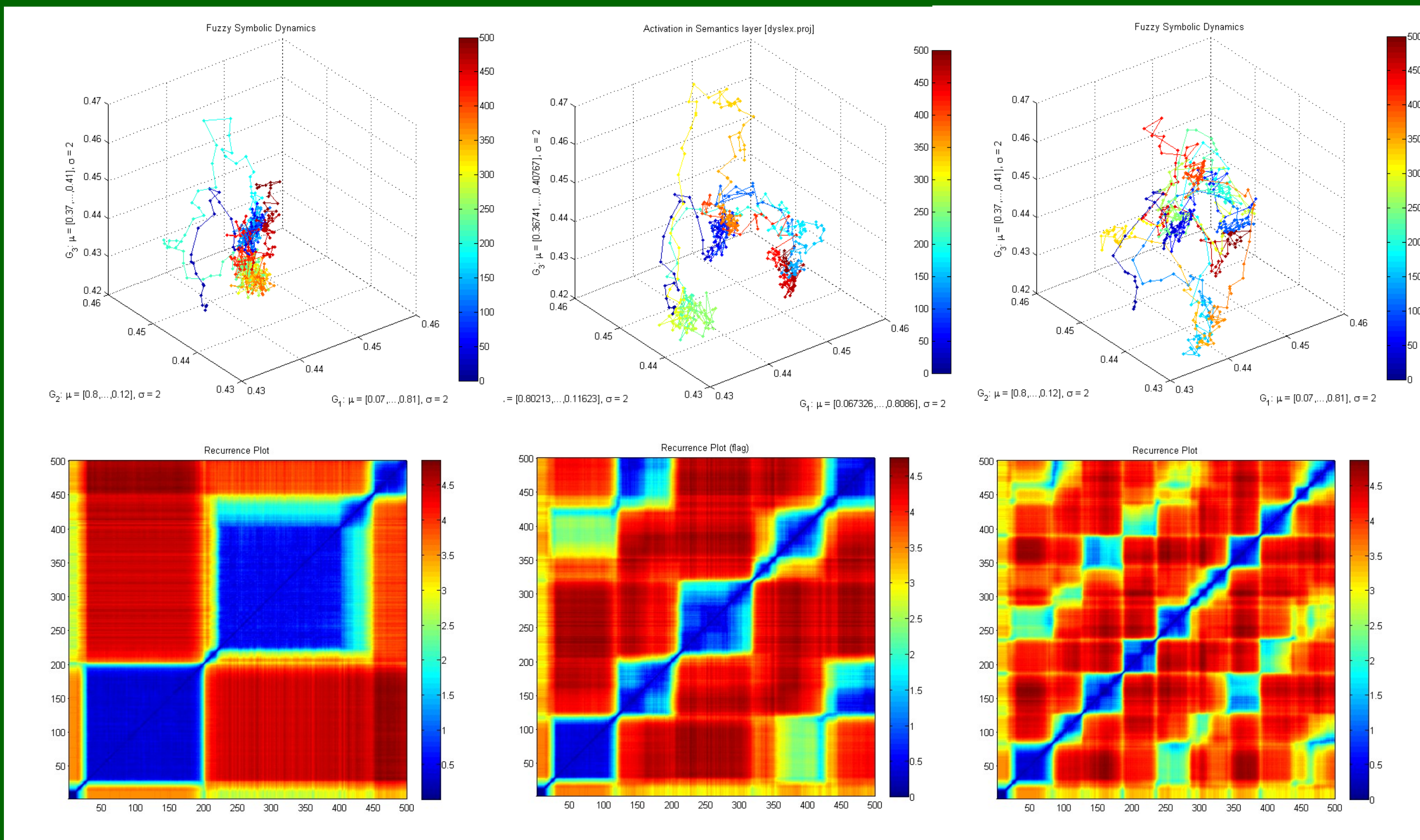




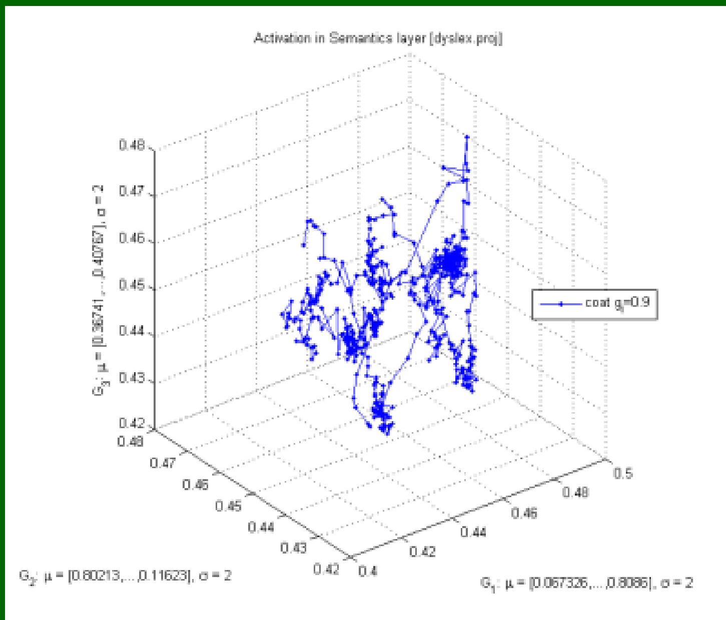
Attention is focused only for a brief time and than moved to the next attractor basin, some basins are visited for such a short time that no action may follow, no chance for other neuronal groups to synchronize. This corresponds to the feeling of confusion, not being conscious of fleeting thoughts.

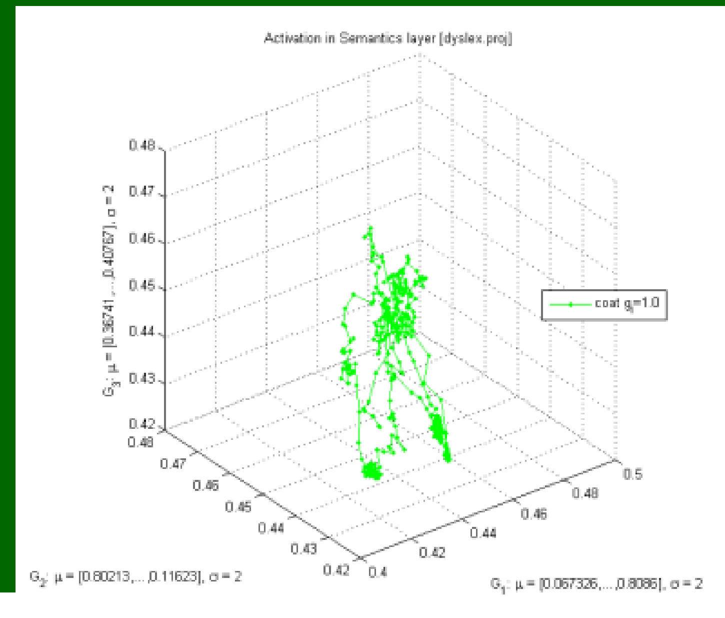
Autism-Normal-ADHD

b_inc_dt = 0.005 *b_inc_dt* = 0.01 *b_inc_dt* = 0.02

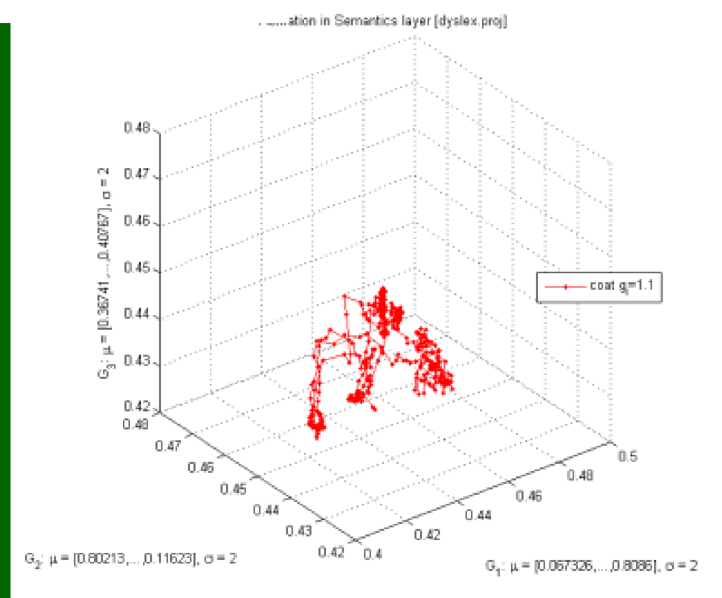


Inhibition



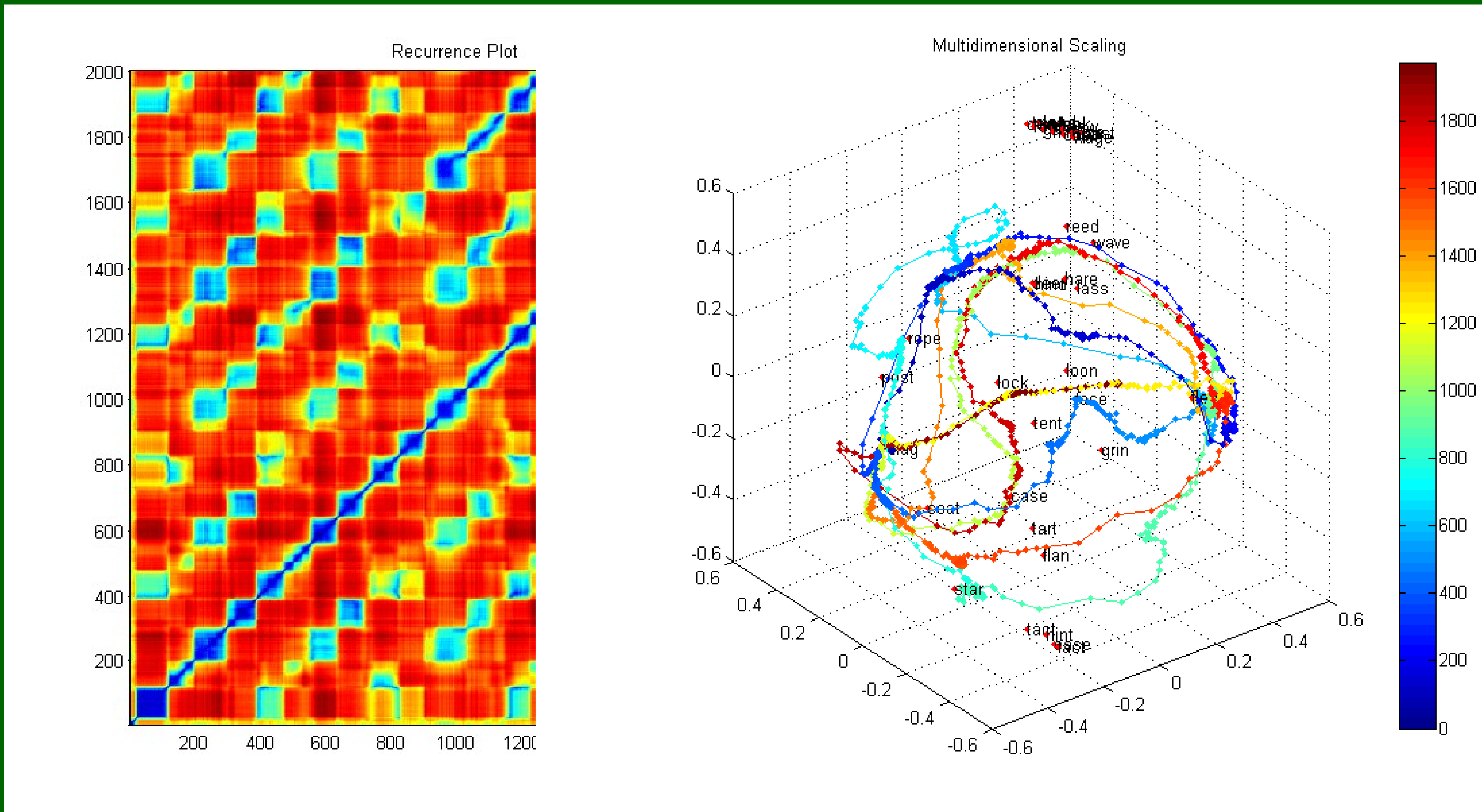


Increasing g_i from 0.9 to 1.1 reduces the attractor basin sizes and simplifies trajectories.

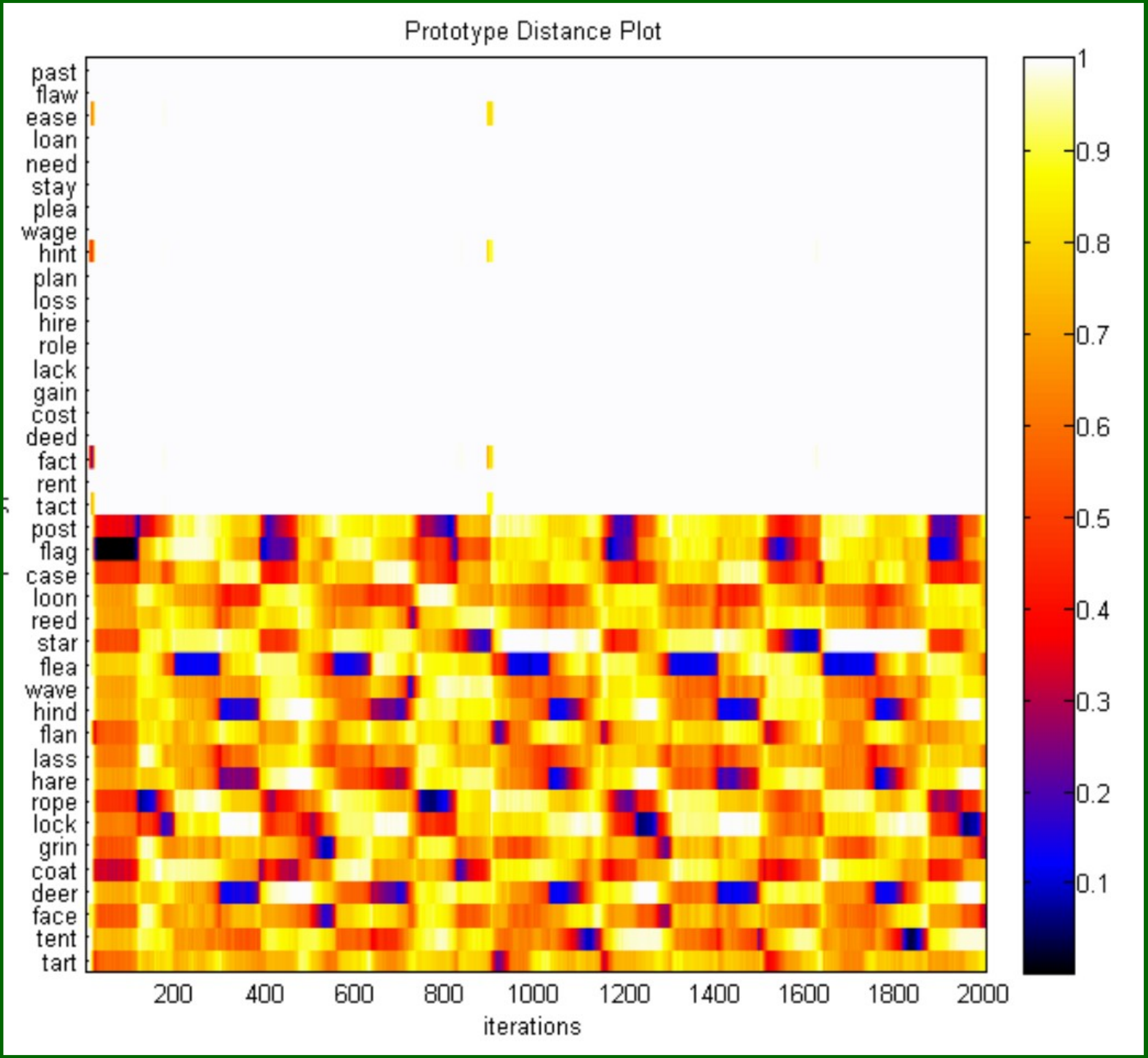


Strong inhibition, empty head …

Long trajectories



Recurrence plots and MDS visualization in 40-words microdomain, starting with the word “flag”.



PDP for transitions starting from „flag”

MDS word mapping

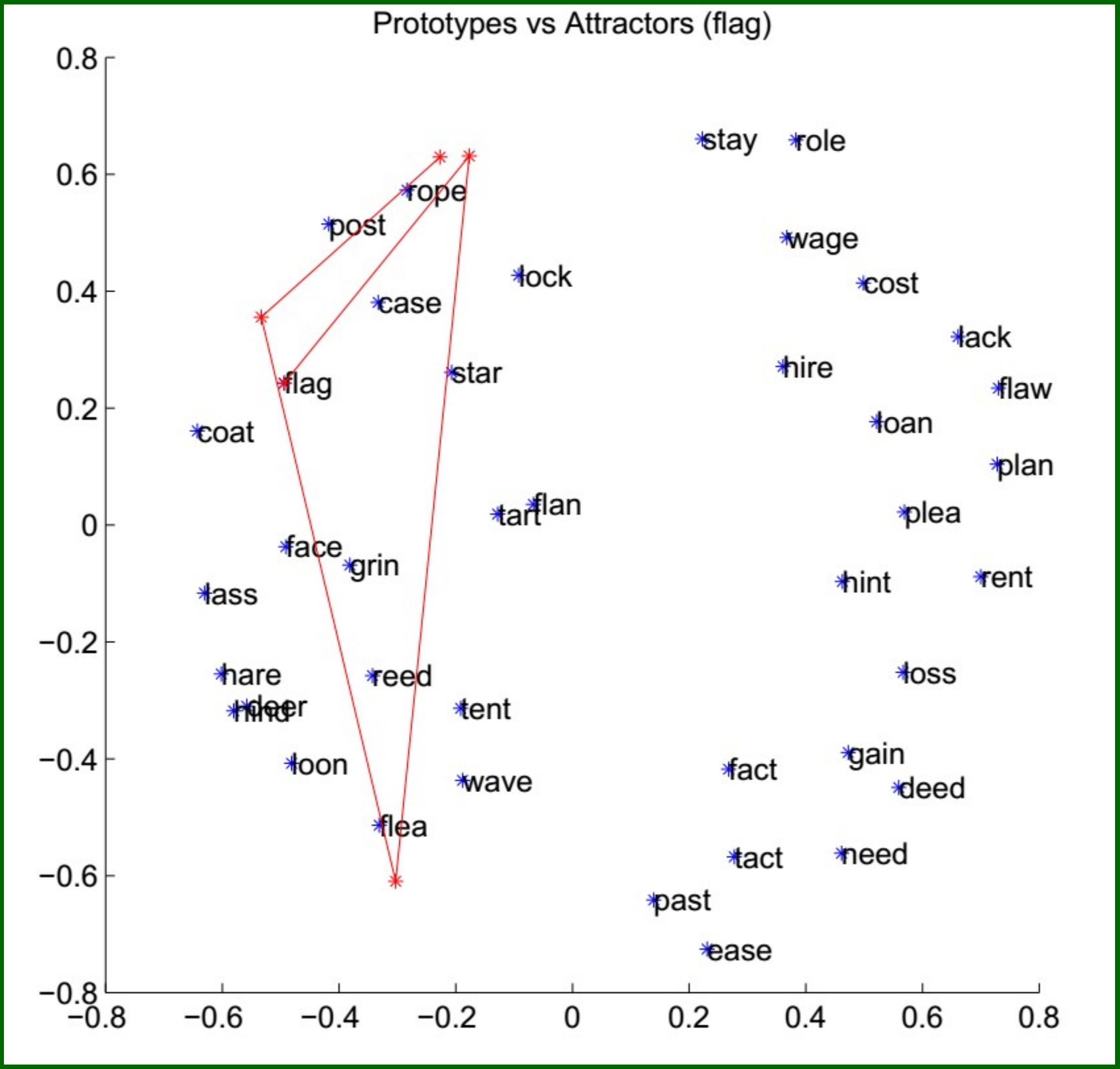
MDS representation of all 40 words, showing similarities of their 140 dimensional vectors.

Attractors are in some cases far from words.

Transition

Flag => rope => flea ...

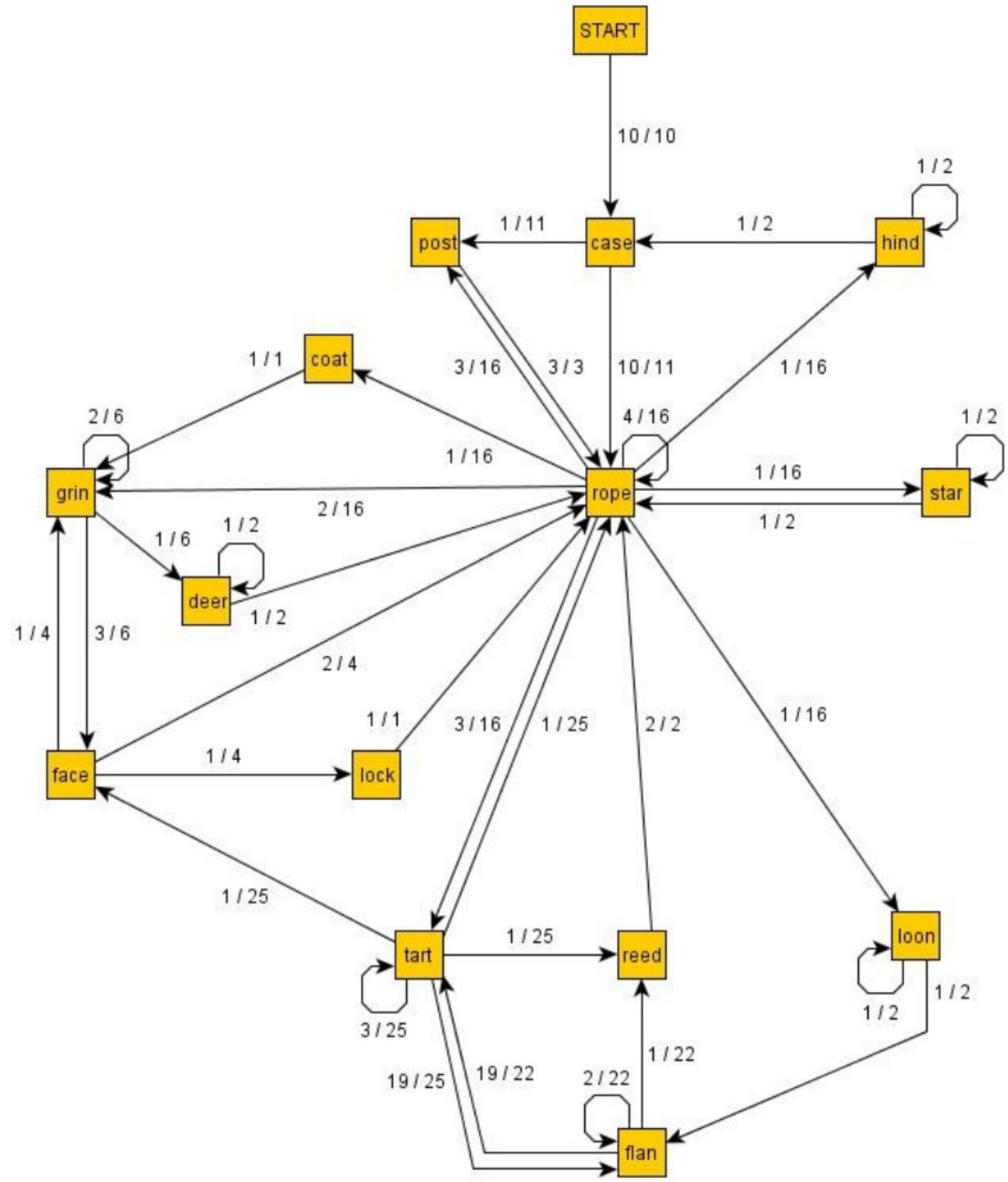
Can we make semantic map of concepts in real brains? See trajectories of thought?



Graph of transitions between attractors after 10 runs.

Why these particular transitions?

Escape from attractors makes some micro-features (neural units) stronger and some weaker. Visualization using RP or FSD does not show such details. The whole landscape of available attractors is very dynamic! Transition probabilities change, dimensions (features) are rescaled.



Practical implications

Better understanding of these issues will have far reaching implications for education, assessment of talent, understanding role of conscious experiences.

- Work on VVIQ-like questionnaire-based evaluation of auditory imagery.
- Repeat ERP experiments using NIR-OT (Janata, Zatorre) – imagery of missing sounds, priming cadences, look at auditory cortex response.
- Development of simple tests for imagery agnosia, correlations of such tests with NIR-OT, ERP studies.

Ex: Correlation of sounds with buttons: memory for mapping sounds to buttons should correlated with the ability to imagine sounds; as memory for images should correlate with ability to draw from memory.

- Collecting statistical data, ex. children in music classes at school, correlation of IA with grades in different subjects?
- Gender differences?
- Can one recover from imagery agnosia? Neurofeedback? Is it a good goal? Influence of intensive musical training on auditory cortex activation.

Few answers, many questions …

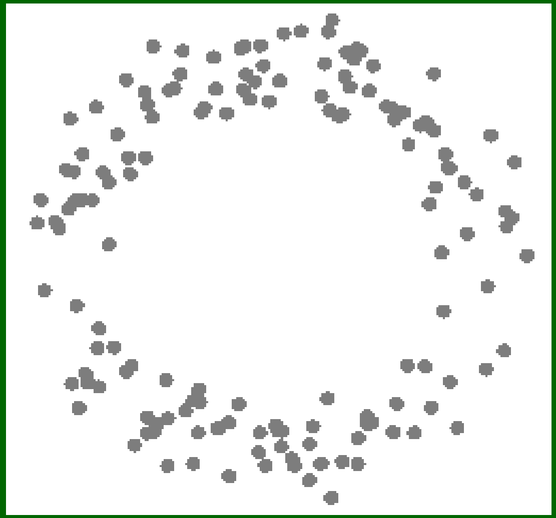
- Individual differences in musical imagery are an interesting subject for further study. Develop an analog of vividness of visual imagery test.
- Various forms of imagery agnosia have not yet been studied but should be important in understanding musical talent.
- Sudden loss of visual imagery is a big surprise.
- Can deaf people imagine music? Beethoven certainly could. How prevalent is INMI in deaf people?
- Can we use neurofeedback techniques combined with filtering of EEG artifacts to significantly improve adaptation to implants? Will training on elementary phonetic contrast discrimination help?
- How can child prodigies play complex music with their connectomes?

Neurohistory: Why particular music forms have appeared around the world?
Why some musical forms have become popular at certain times?
Why some stayed and other vanished?
How is this related to perception mechanism? Technical developments in construction of instruments? Social millieu?

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

COGNITIVIST AUTUMN IN TORUŃ

Thank you for synchronization of your neurons!



Google: Wlodzislaw Duch
=> papers, talks, lectures …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notes

- PLV, RCC examples of bias or priming in differnt brains
- Zatorre, ERP
- Review of Fay, statistical aphantasia, episodic memory recreation,
- FMRi our data? Network science.
- Visualization of trajectories, autism cases
- Neurophenomenology. My experiences. Schwitzgabel
- Talent, screening, learning styles 3-part connectome
- Stochastic resonance

- http://www.is.umk.pl/projects/img.html

Source localization maps brain activity to attractor dynamics.

Problem: these sources pop up and vanish in different places.

Fig. from:
Makeig, Onton, 2009
ERP Features and
EEG Dynamics:
An ICA Perspective.

Brain fingerprinting: discover in EEG specific patterns identifying attractor dynamics = subnetwork activation.