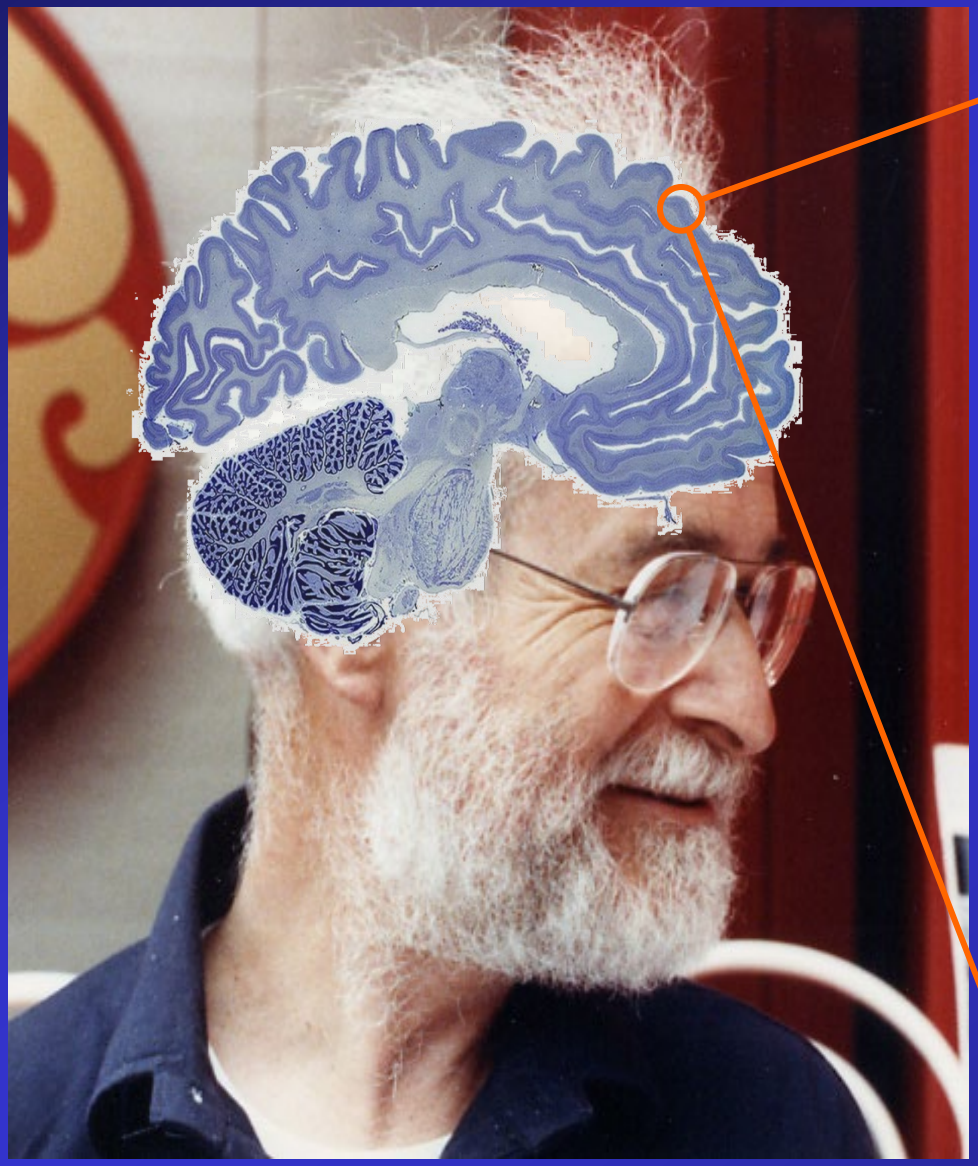
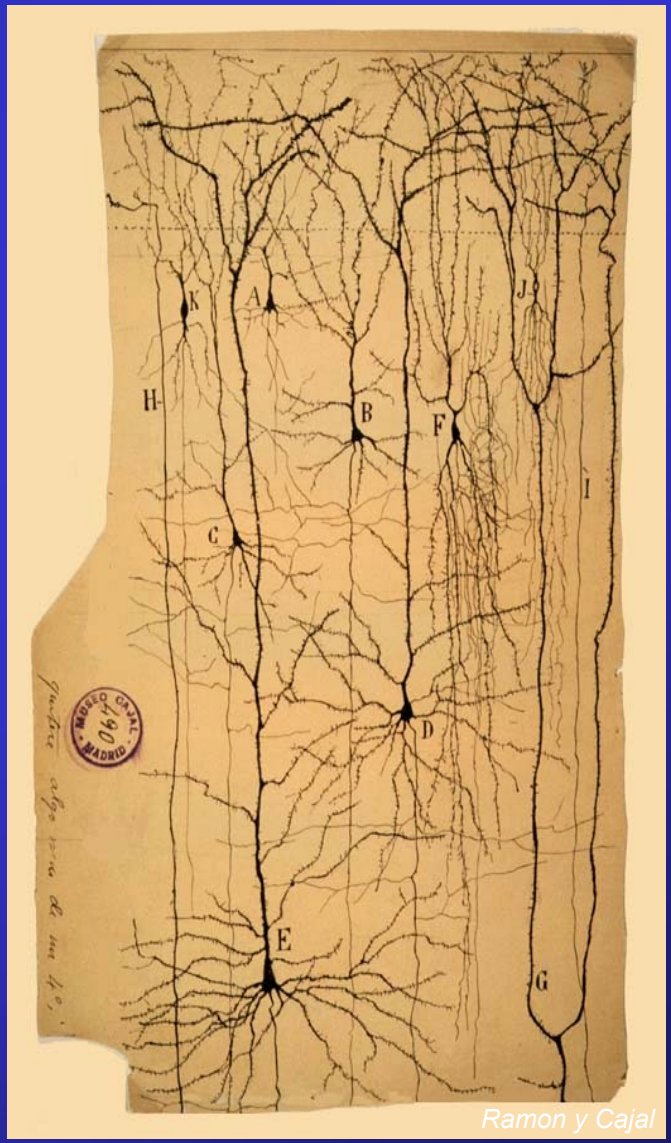
Art and the Brain

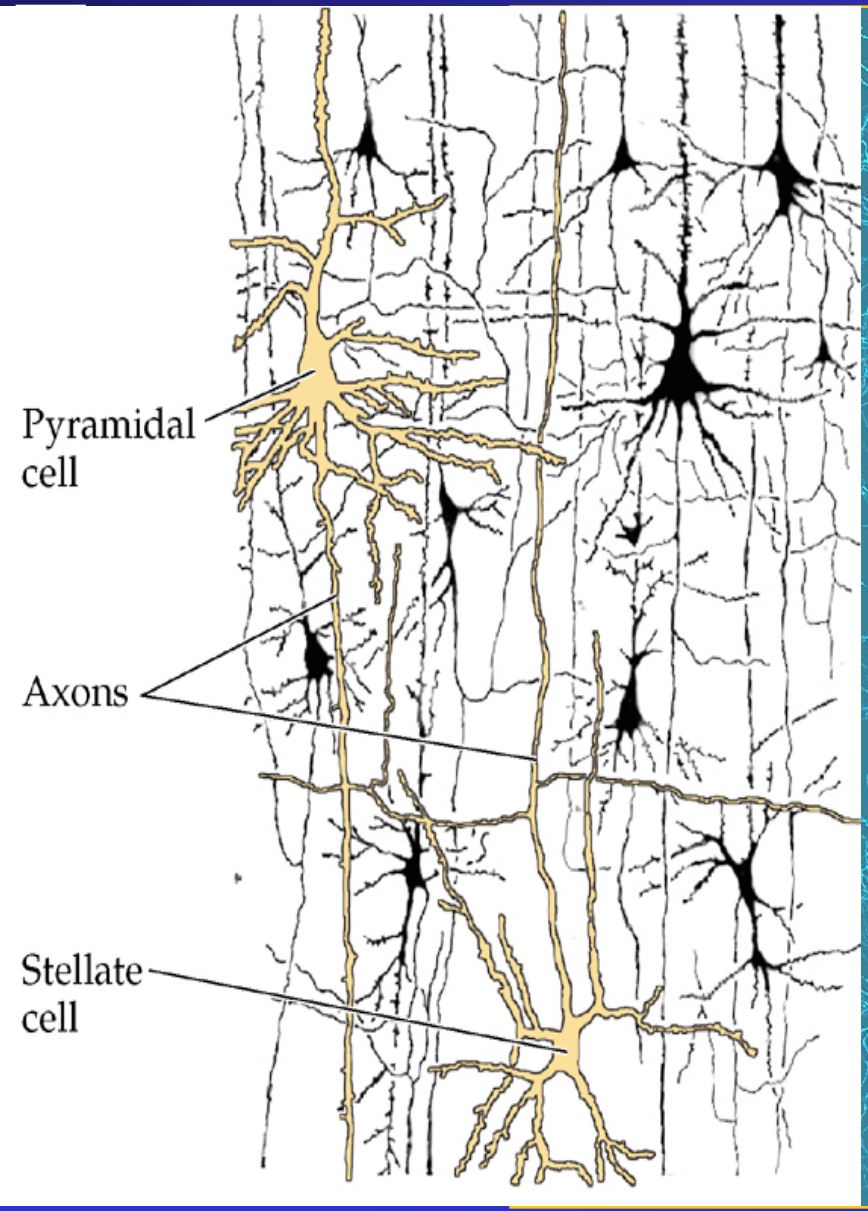
Neural Networks in the Neo-Cortex

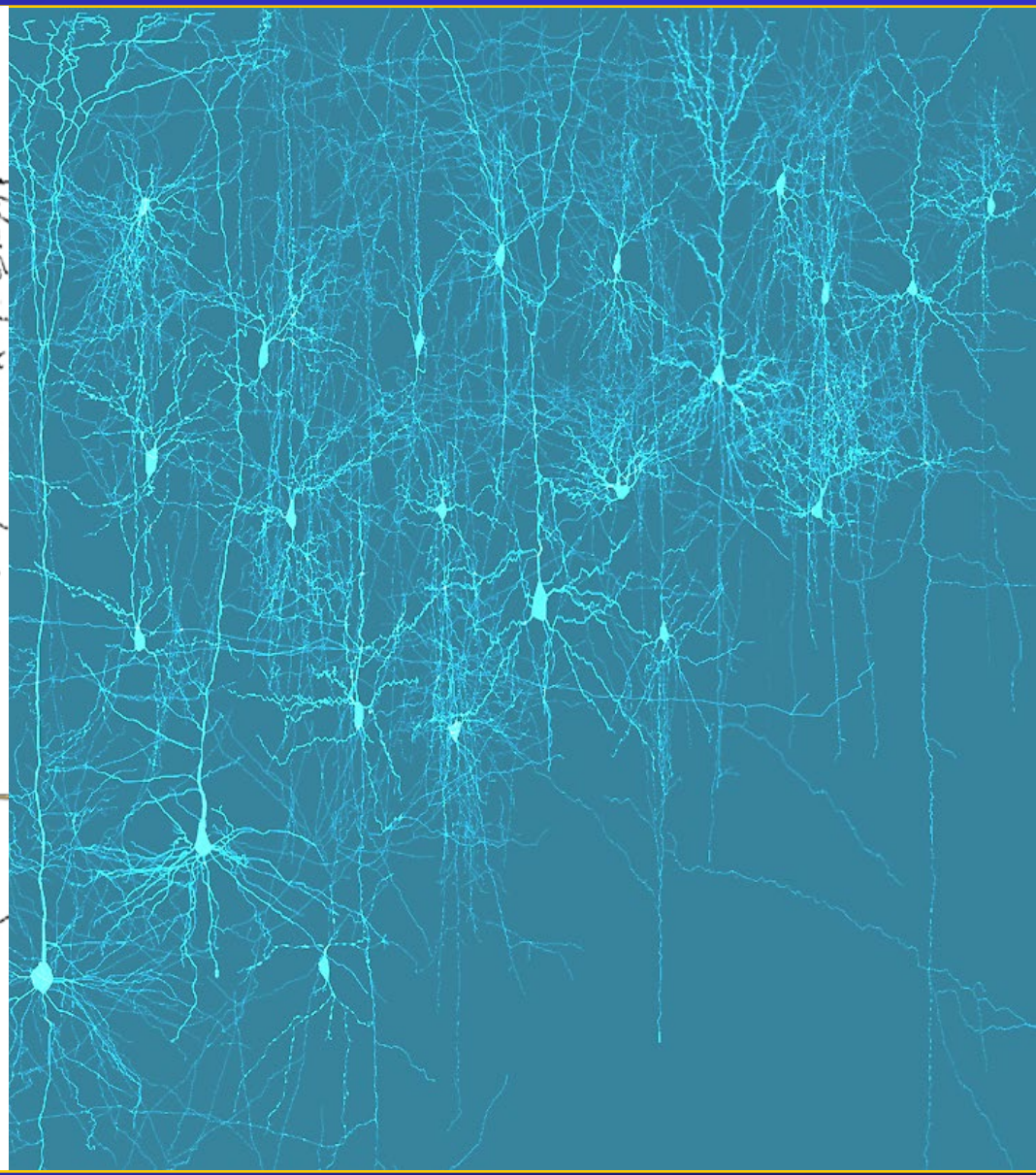




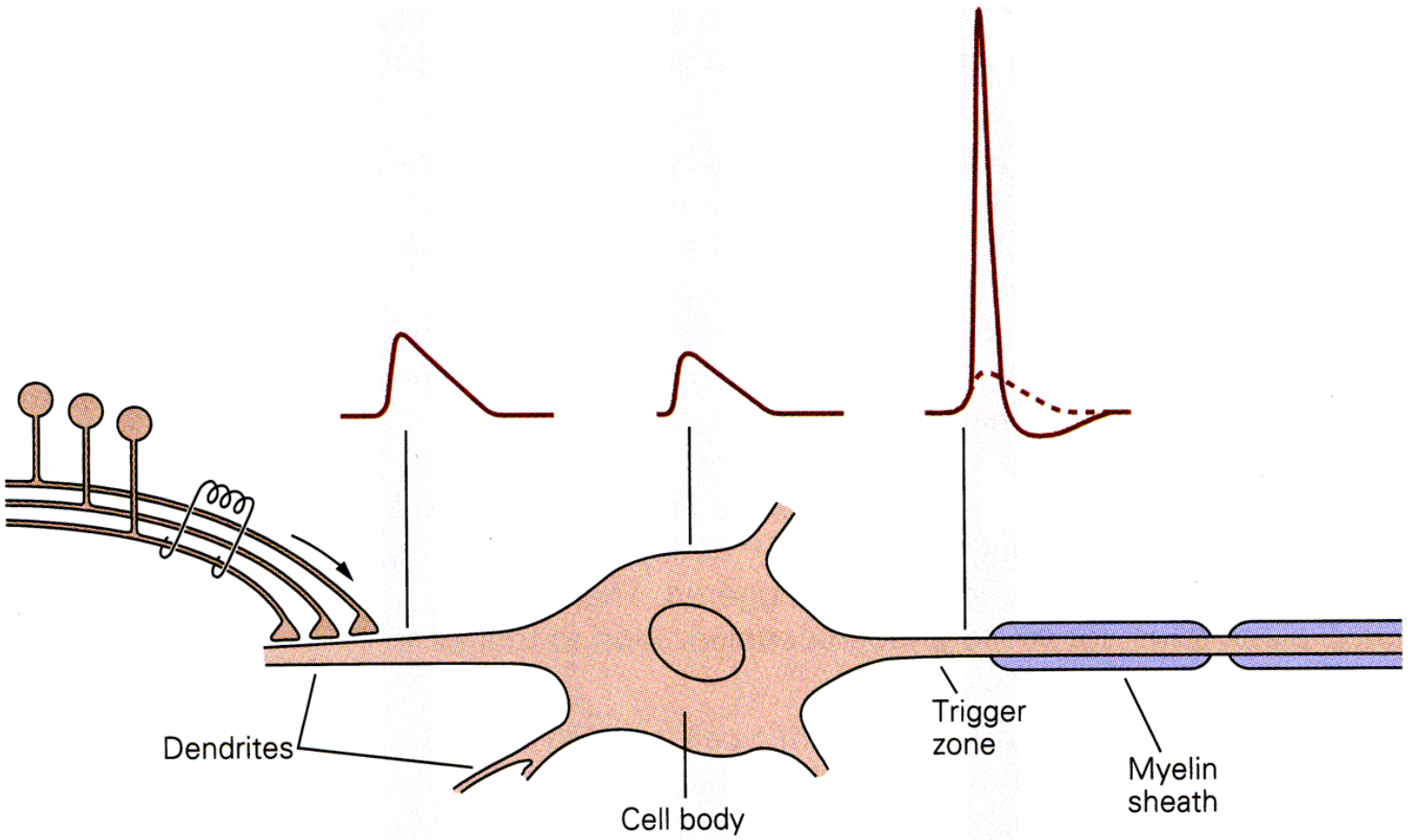
Computation is performed by cortical neurons

90,000/mm^3; 8,000 synapses/neuron



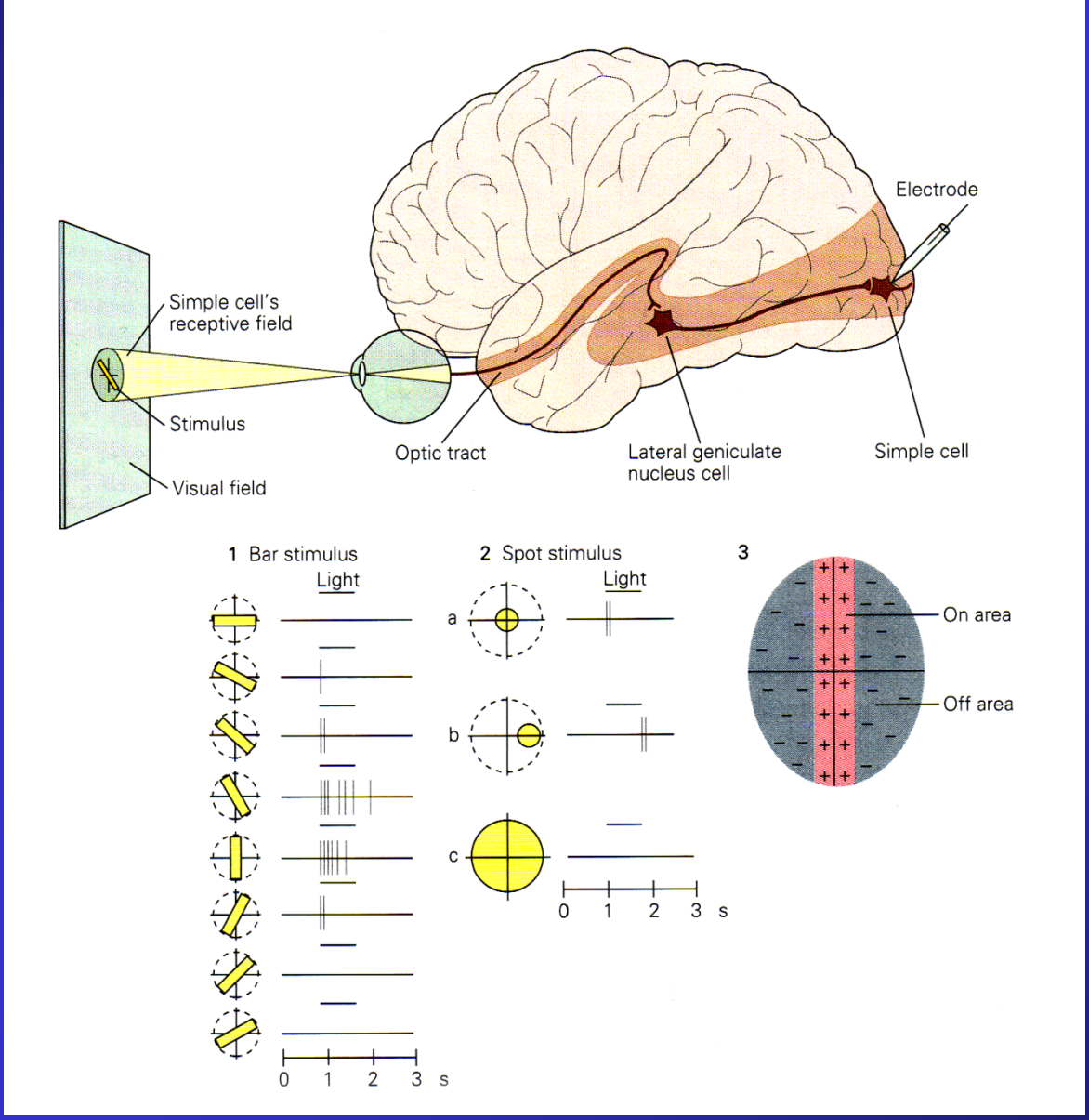


Neurons integrate synaptic input & transmit action potentials

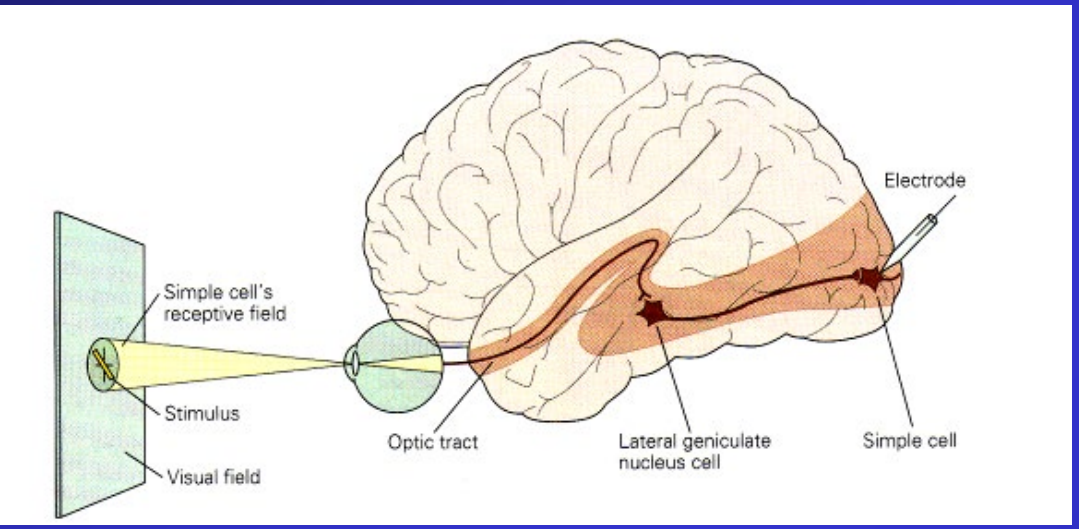


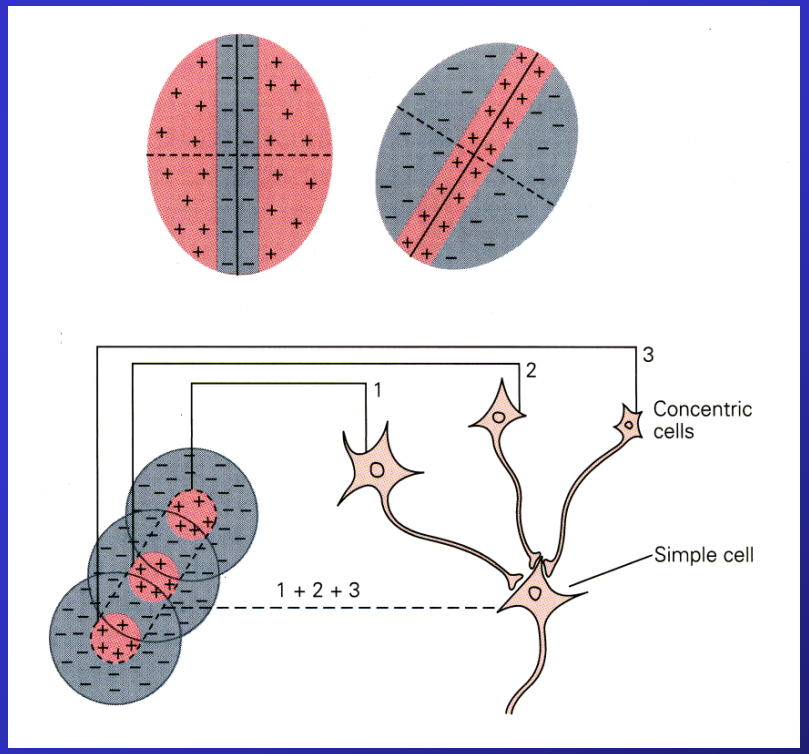
Kandel, et al, Principles of Neural Science, 5th ed.

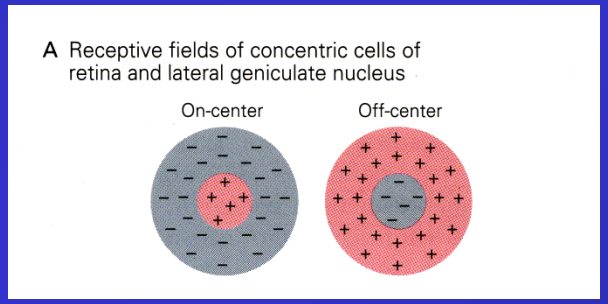
Receptive field of V1 neuron



Receptive field of V1 neuron is formed by convergent input from geniculate cells

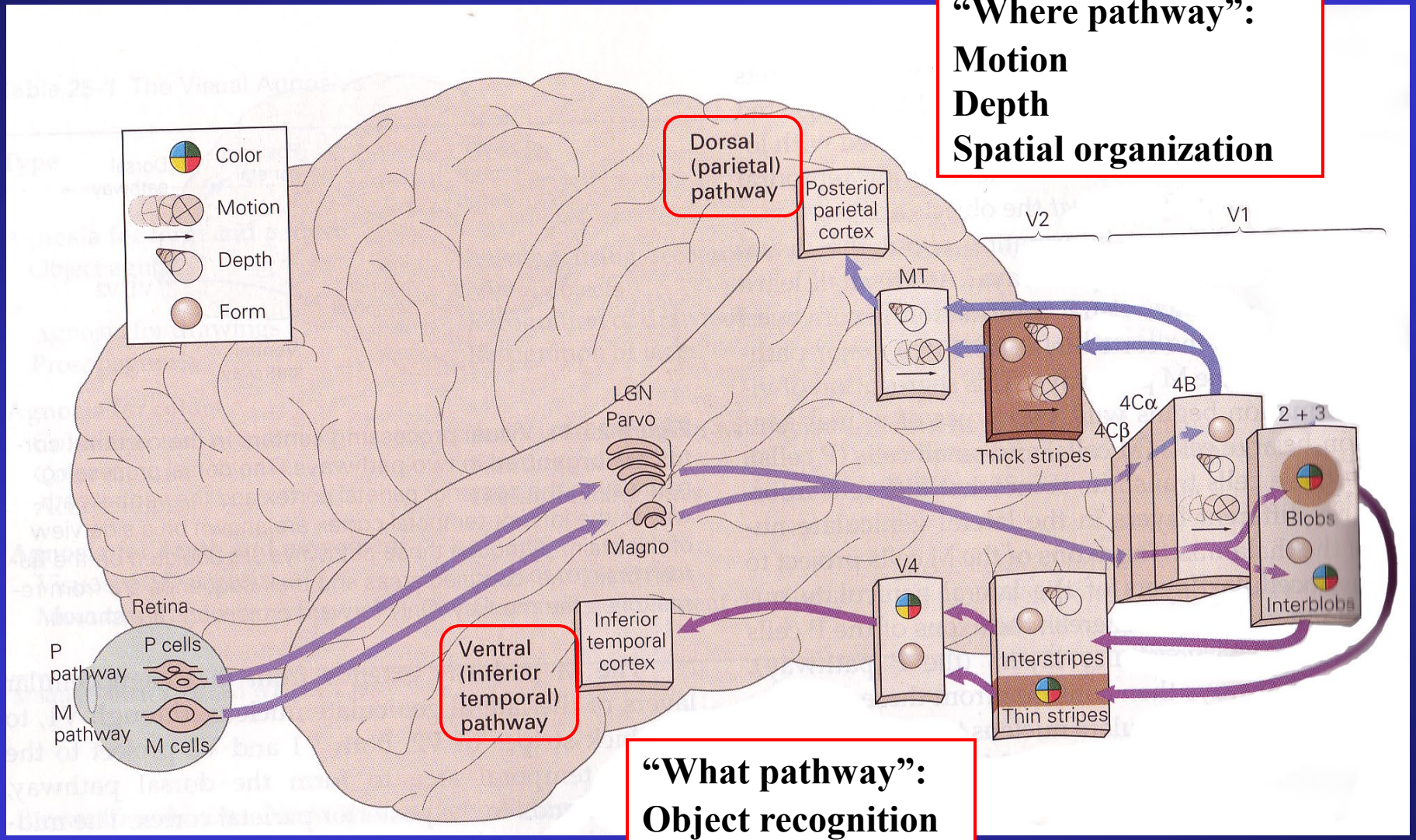






Hubel & Wiesel, *J. Physiol.* 160:106 1962

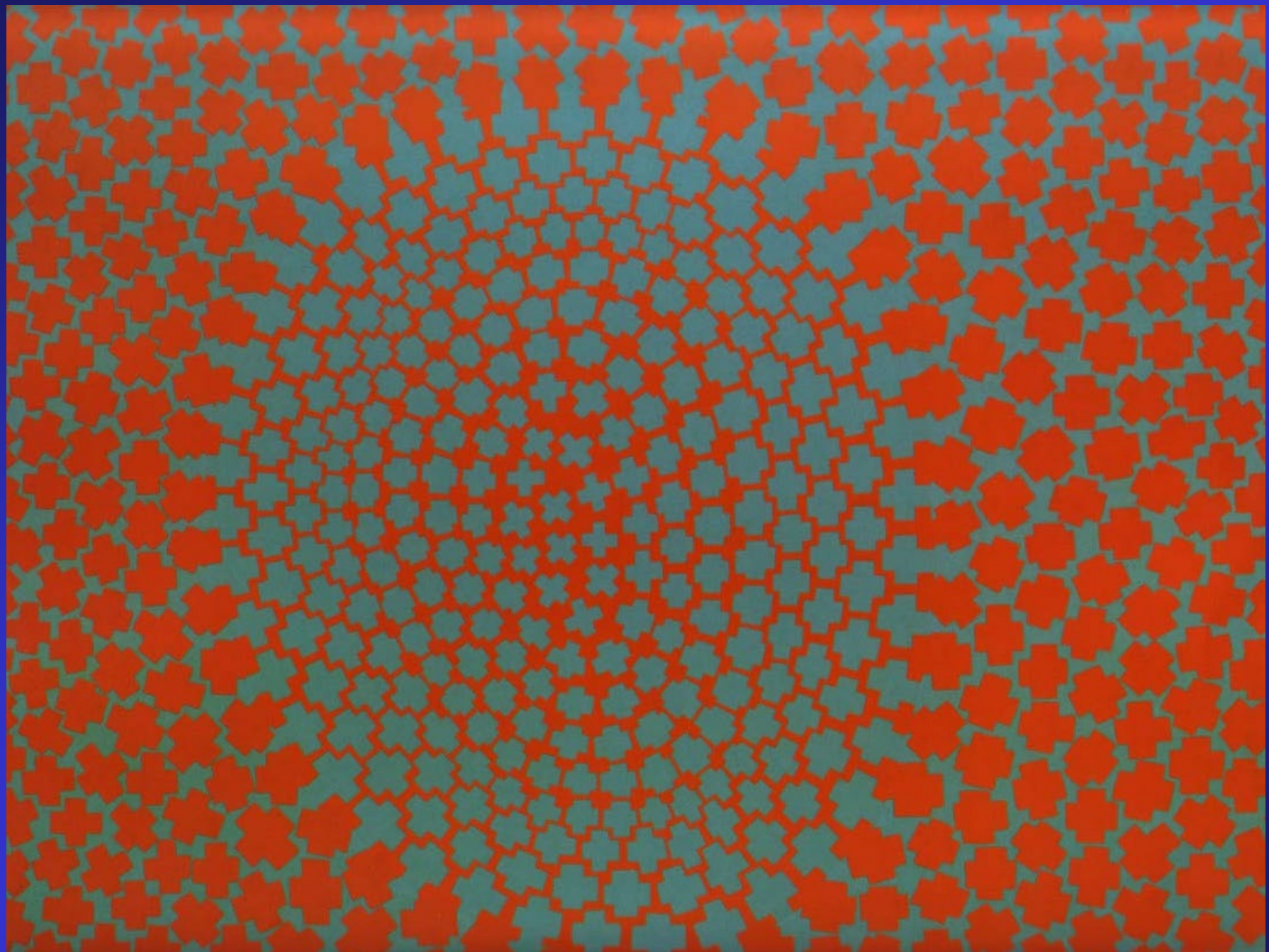
Two major visual pathways



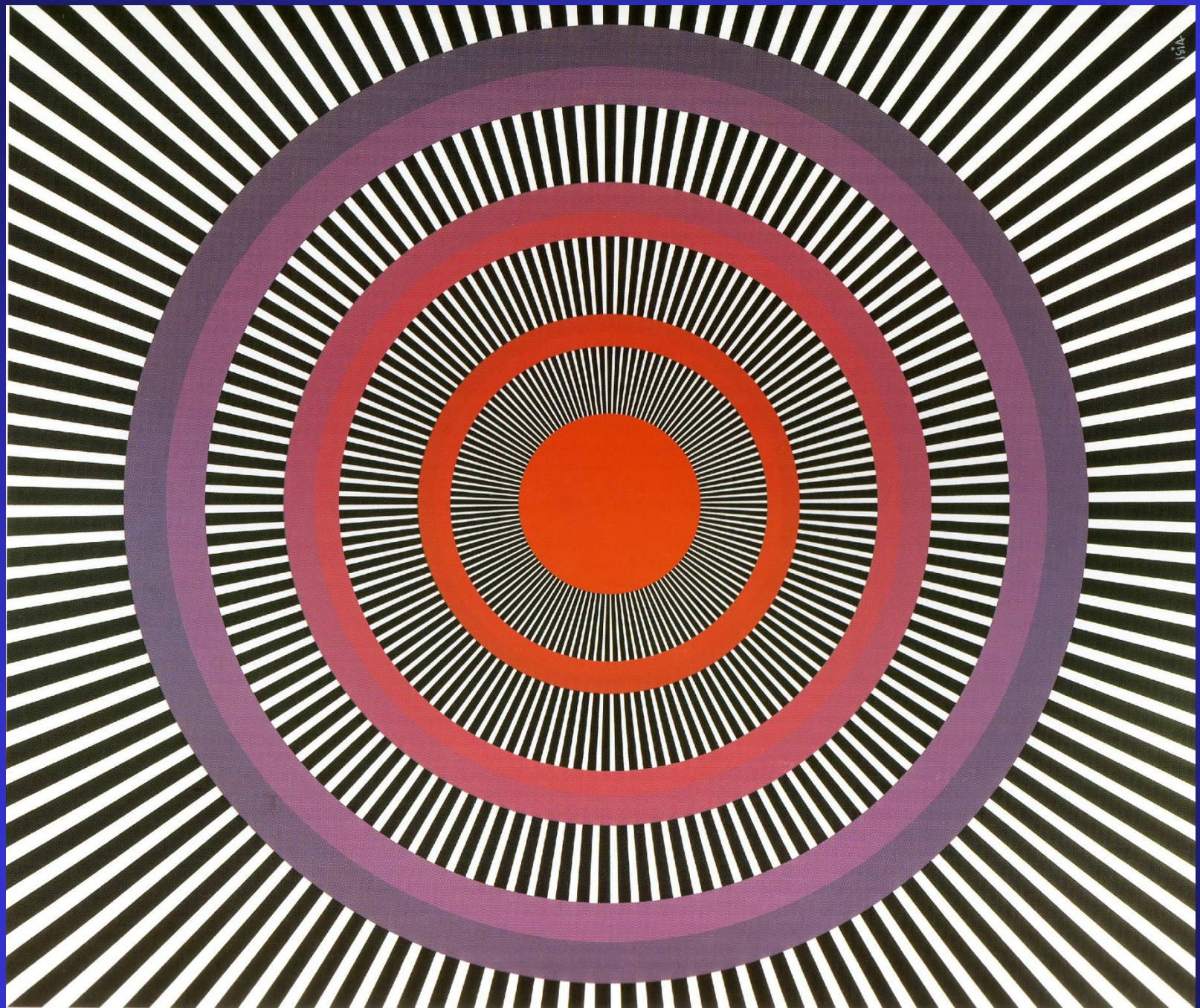
"Where pathway":
Motion
Depth
Spatial organization

"What pathway":
Object recognition
Face recognition
Color perception

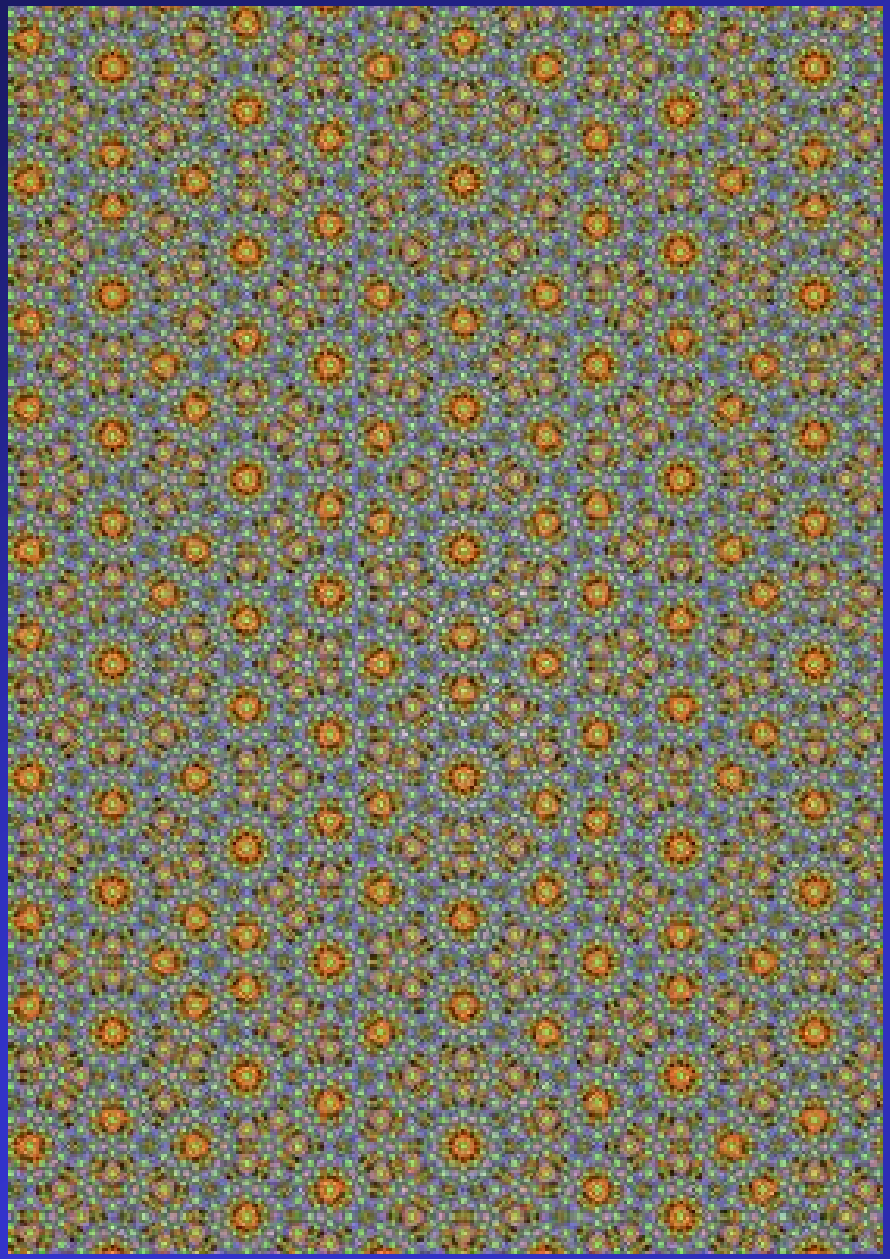
Equiluminant shapes can be seen, but not reliably placed [Anuszkiewicz: *Plus Reversed*]



Illusion of motion induced by high-contrast lines [Leviant: *Enigma*]



Replicated patterns stimulate visual circuits



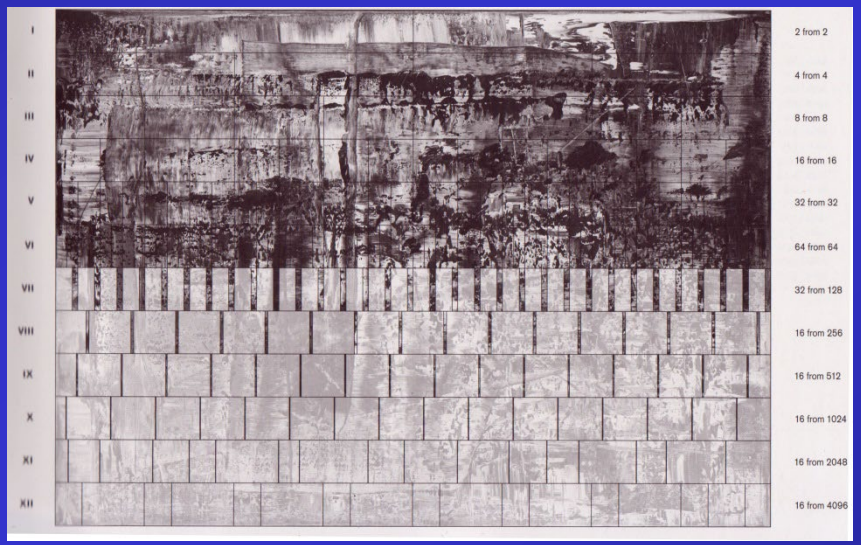
Heller: Quasicrystal II

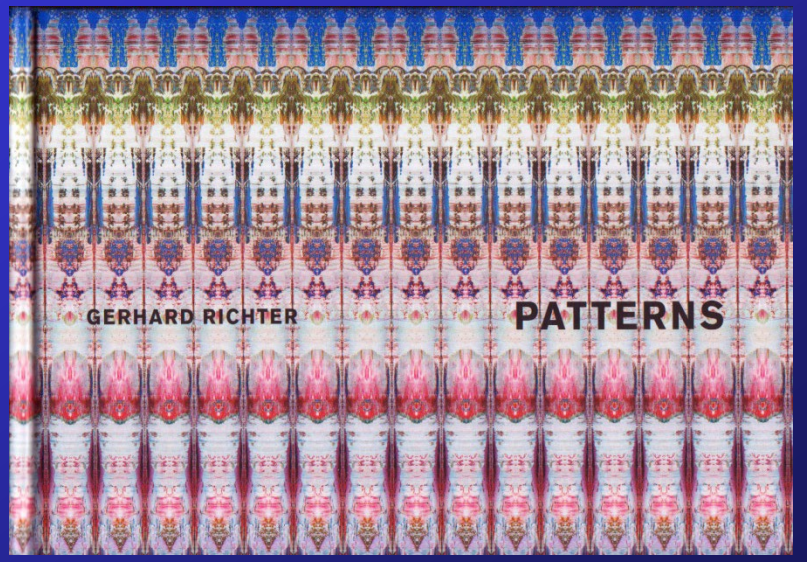
Heller: Bessel 21

Complex and Repeated patterns

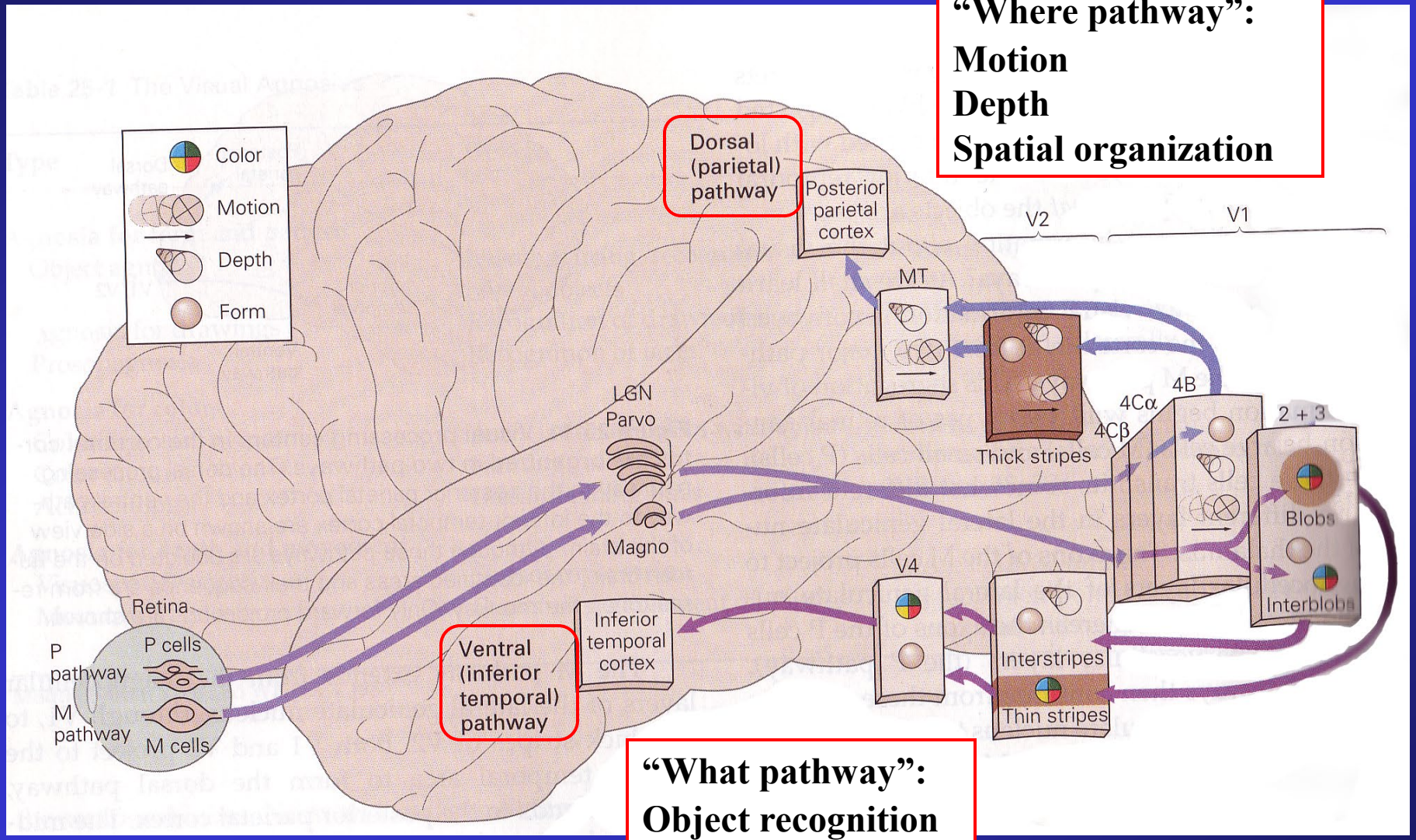
Richter, G., Abstract Painting (724-4) 1990

Richter, G, PATTERNS, Walter König Verlag, 2012



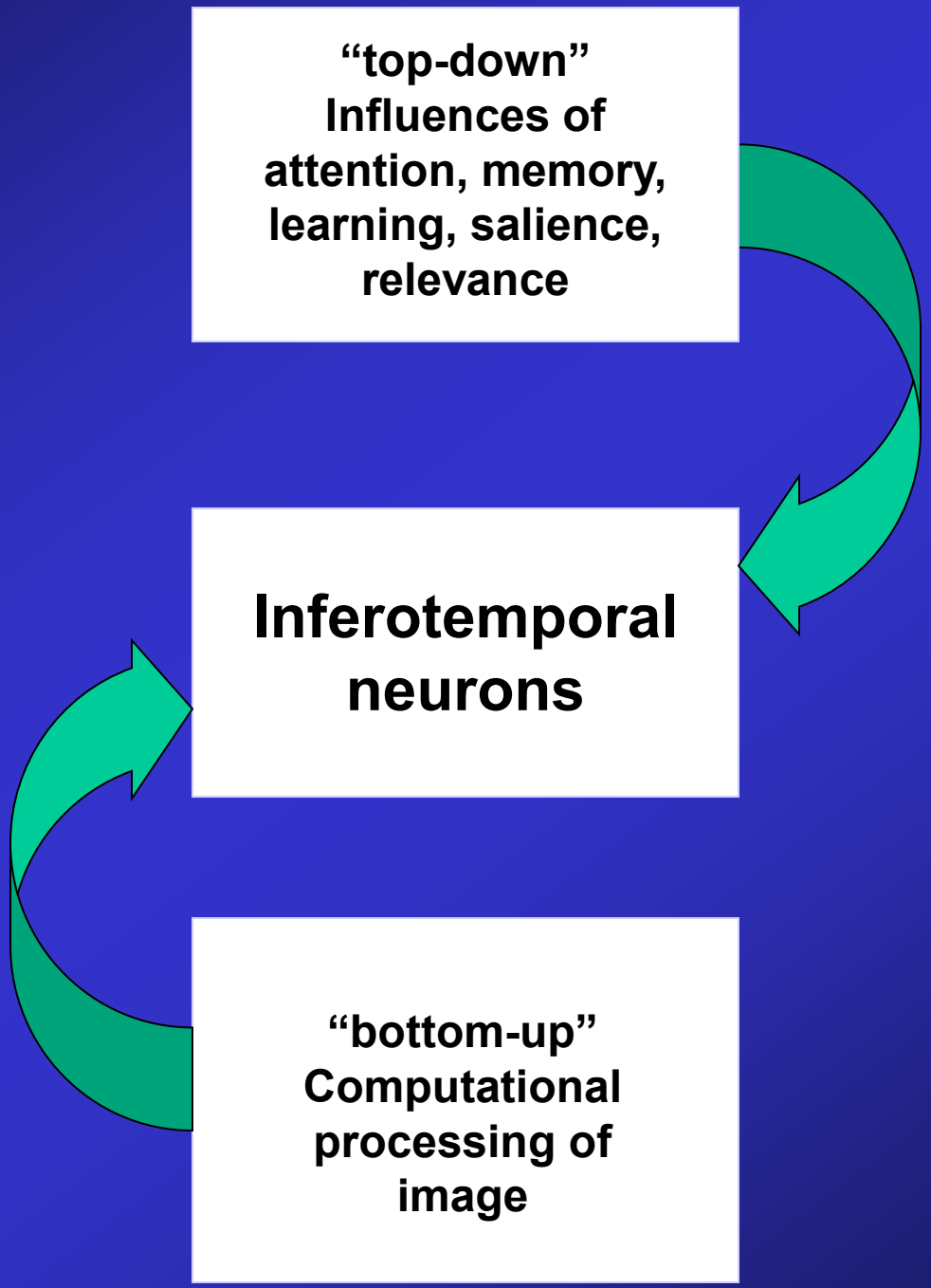


Two major visual pathways

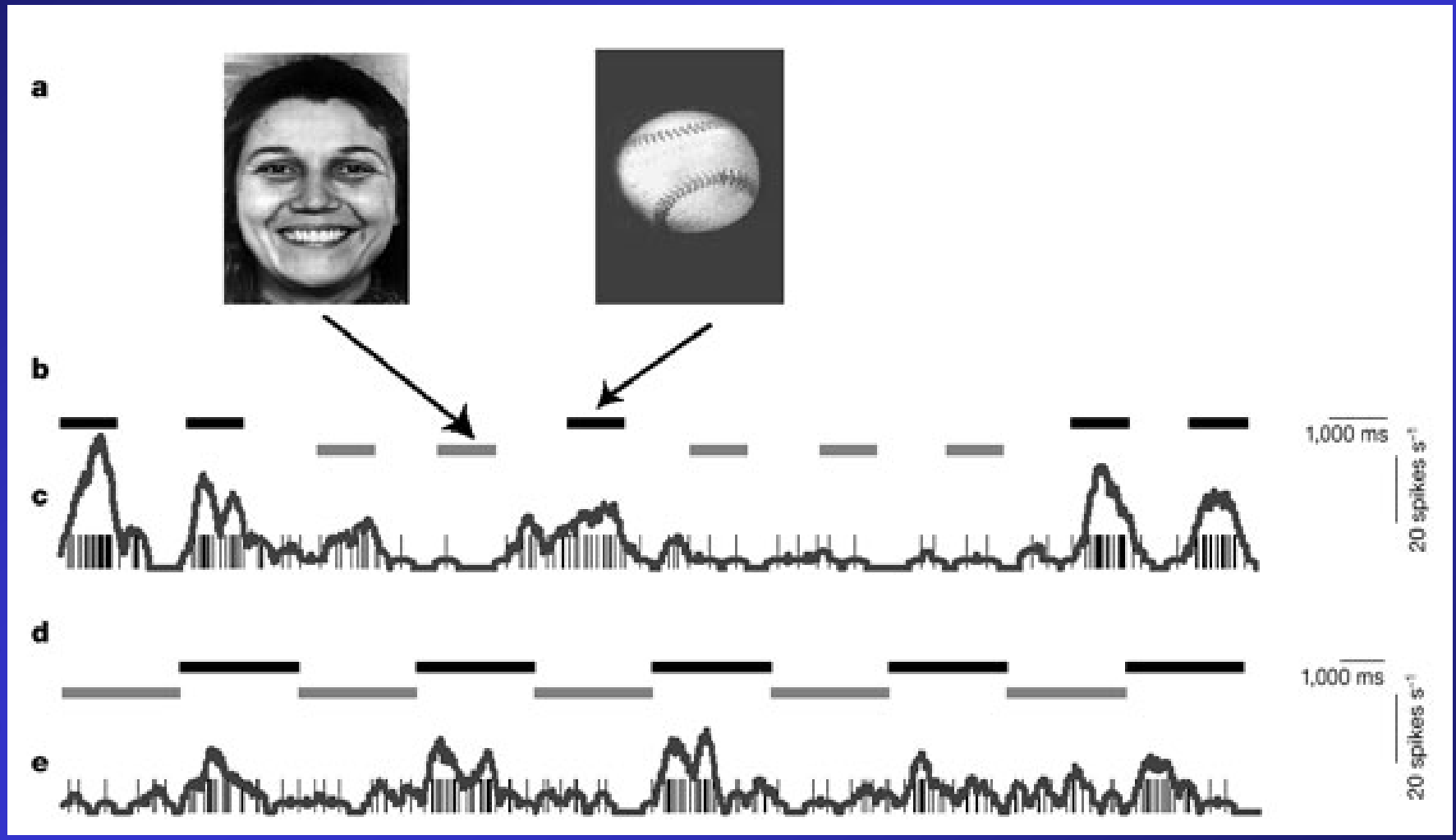


"Where pathway":
Motion
Depth
Spatial organization

"What pathway":
Object recognition
Face recognition
Color perception


"top-down"
Influences of attention, memory, learning, salience, relevance
Inferotemporal neurons
"bottom-up"
Computational processing of image

Cells are activated by visual imagery
in amygdala, entorhinal cortex, hippocampus

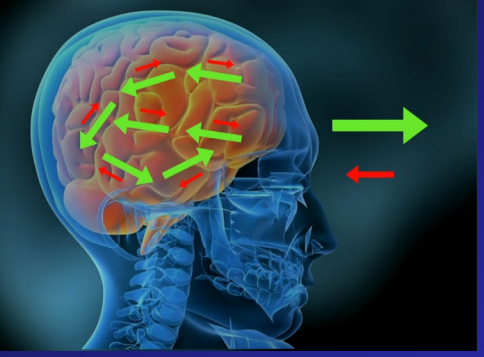


vision

imagery

Kreiman, Koch & Fried, *Nature* 408: 357, 2000

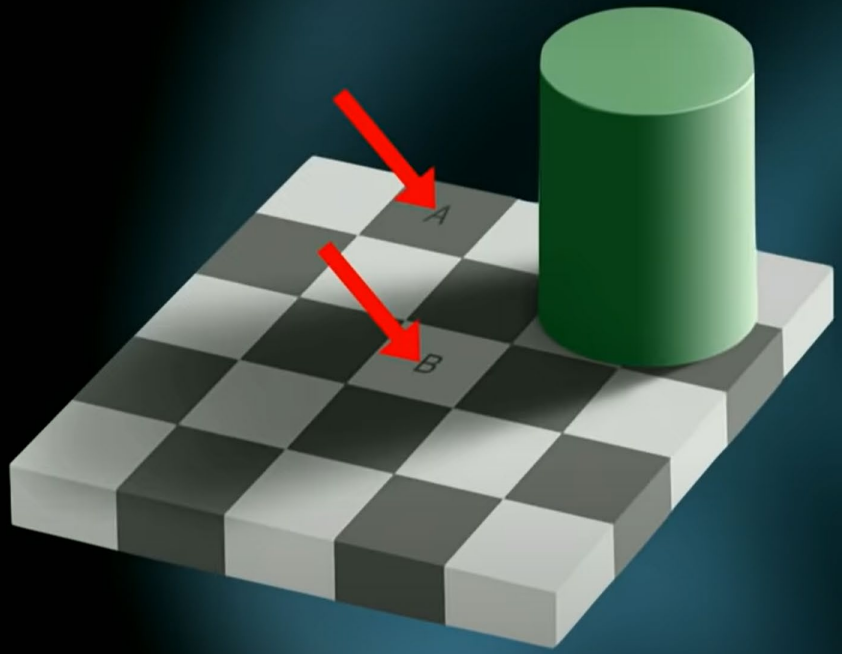
The perceived size of an object depends on top-down influences of internal model

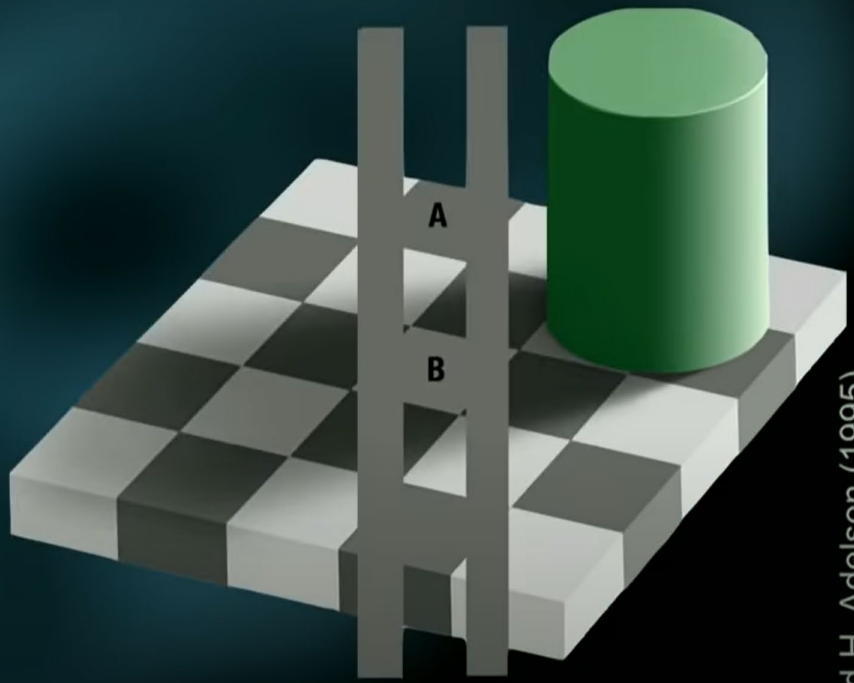


Prior expectations influence perceptions

Top-down brain-generated activity [green arrows] can dominate bottom-up peripherally generated activity [red arrows].

Your brain hallucinates your conscious reality | Anil Seth



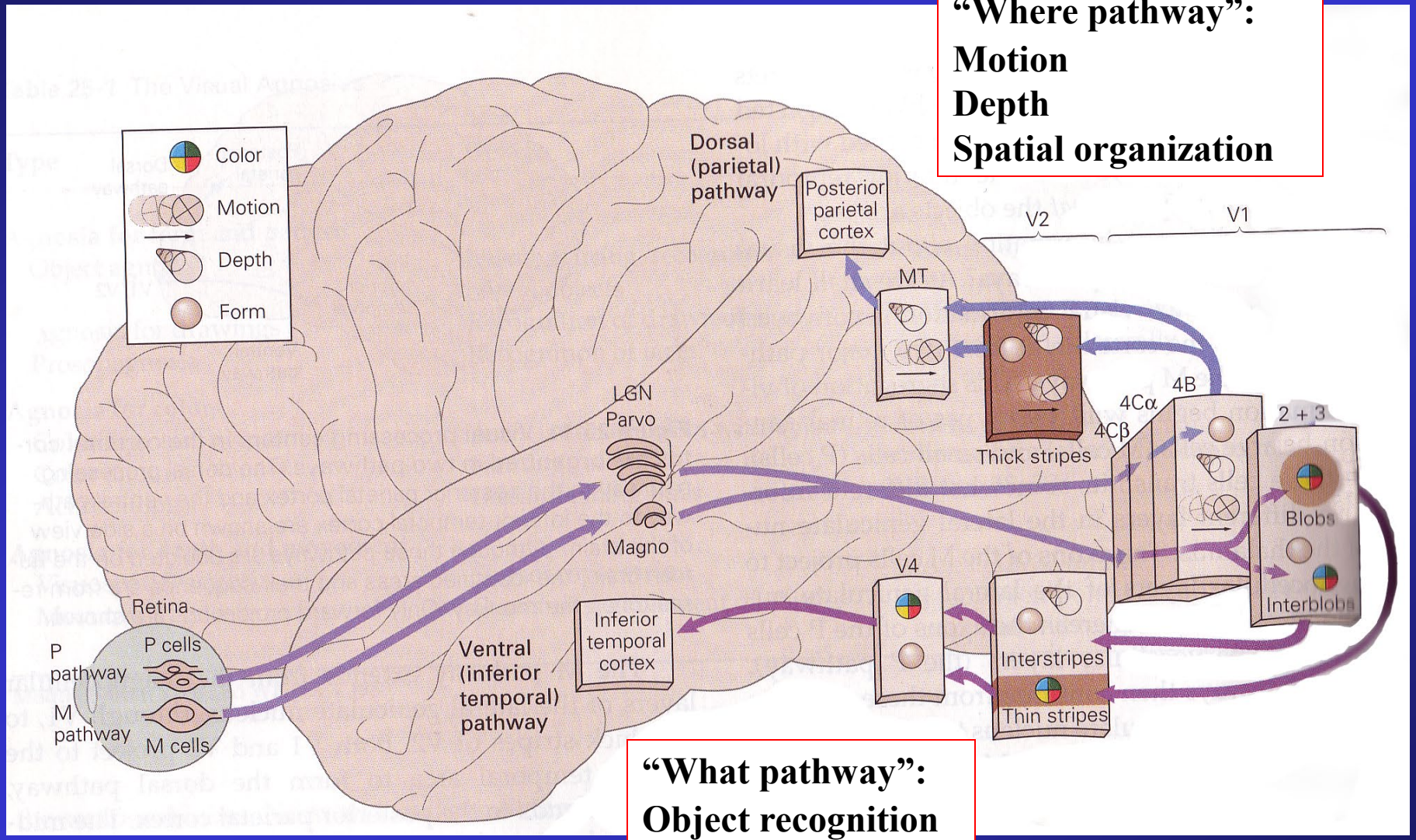


Edward H. Adelson (1995)

TED

5:30 / 17:00

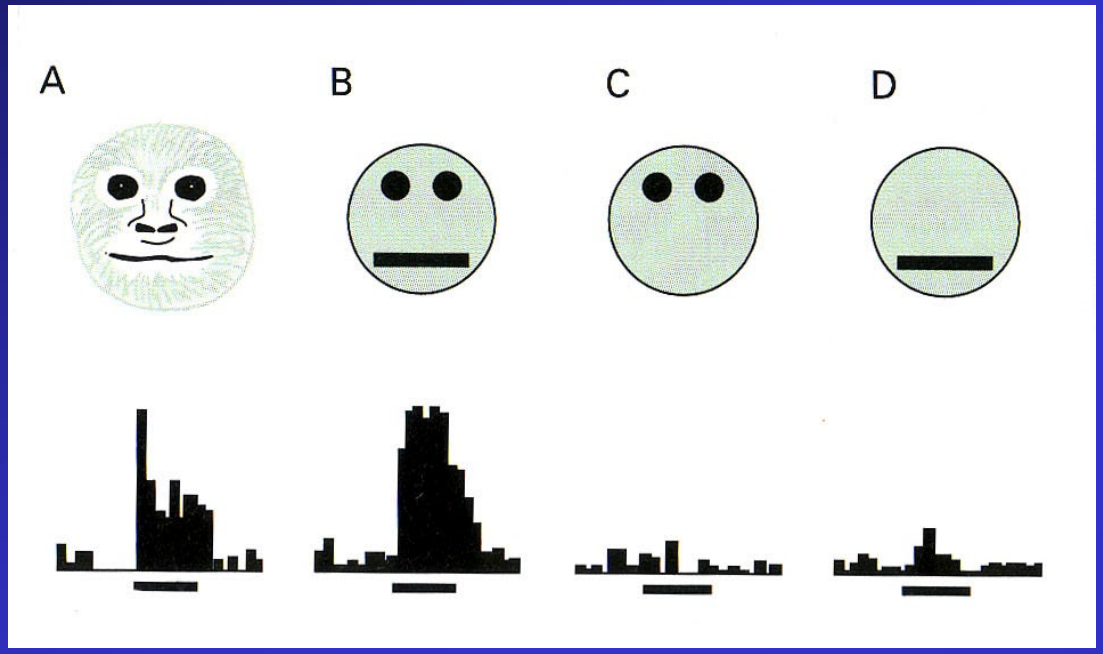
Two major visual pathways

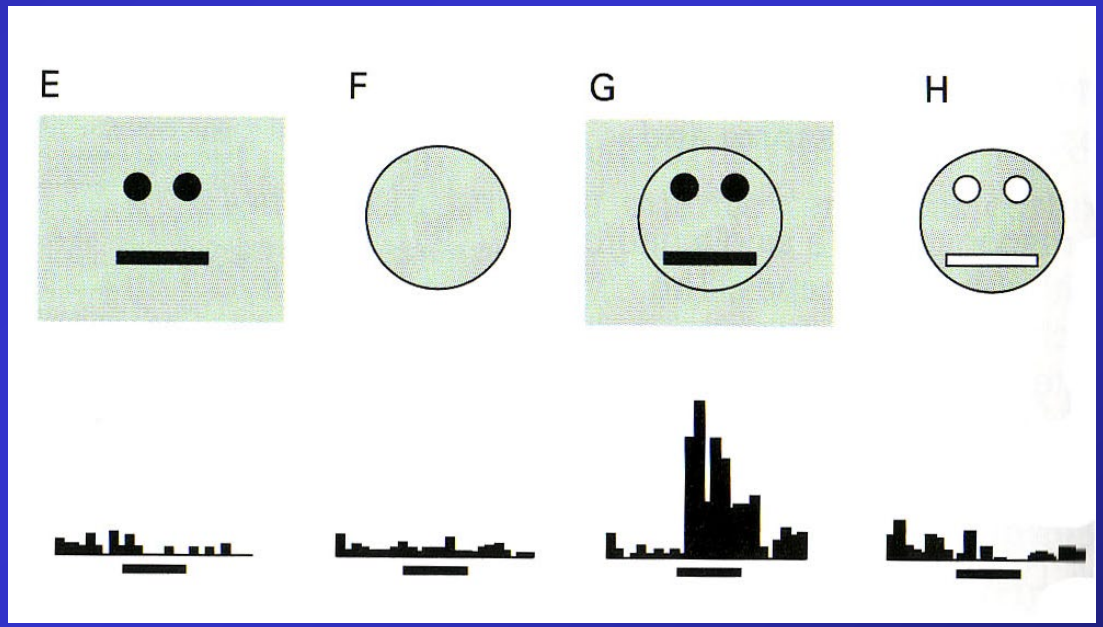


"Where pathway":
Motion
Depth
Spatial organization

"What pathway":
Object recognition
Face recognition
Color perception

Responses of an infero-temporal cortex neuron to visual stimuli

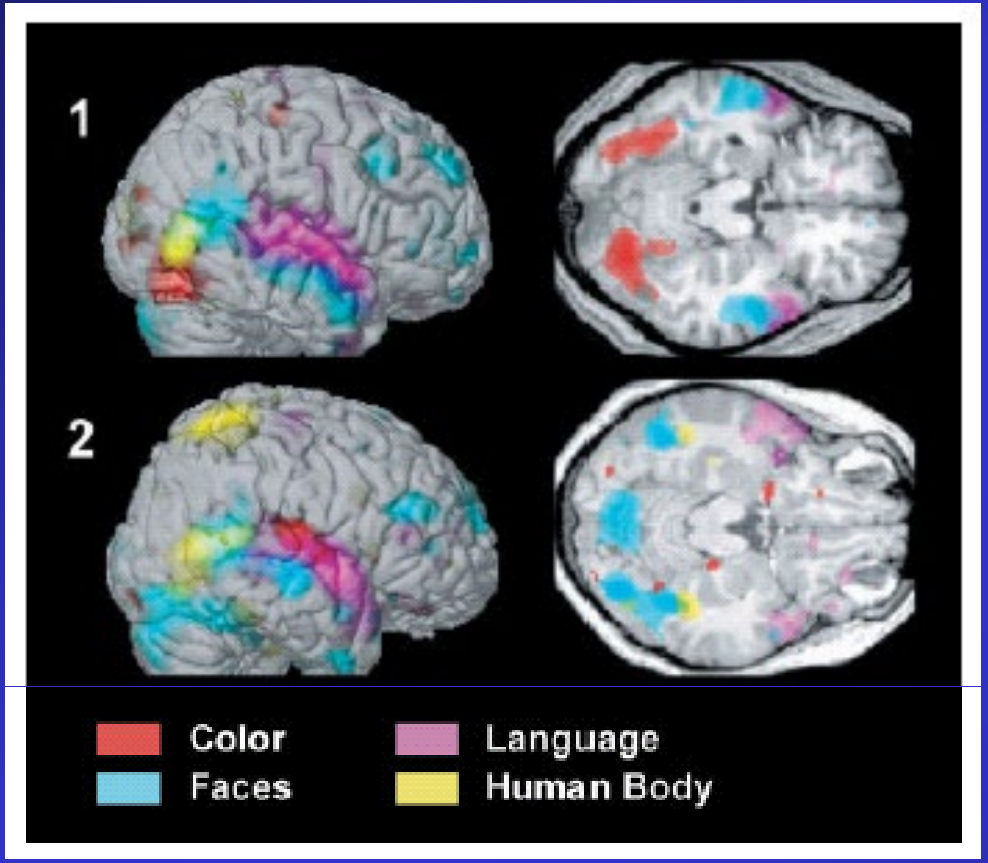




Kobatake & Tanaka,
J. Neuro. 71:856, 1994

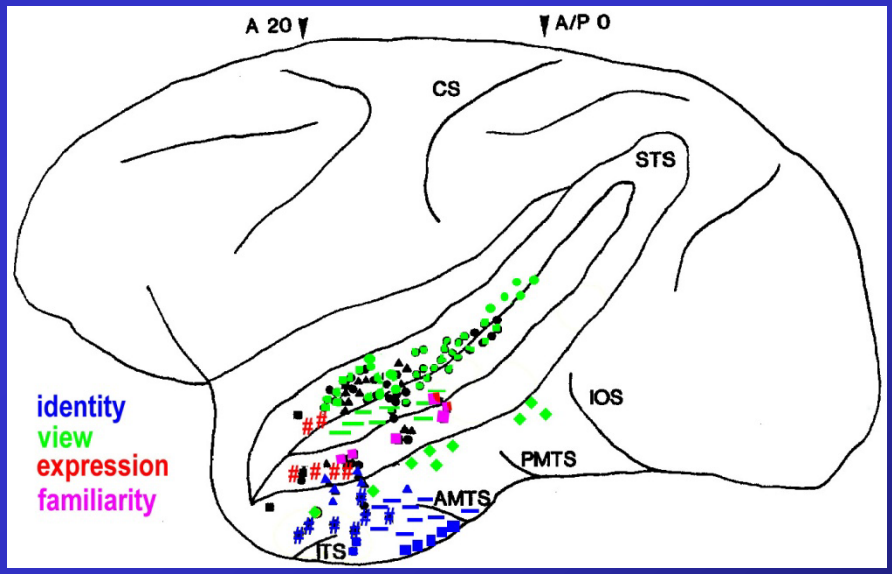
Large areas of the primate brain are devoted to face recognition

Human (fMRI)



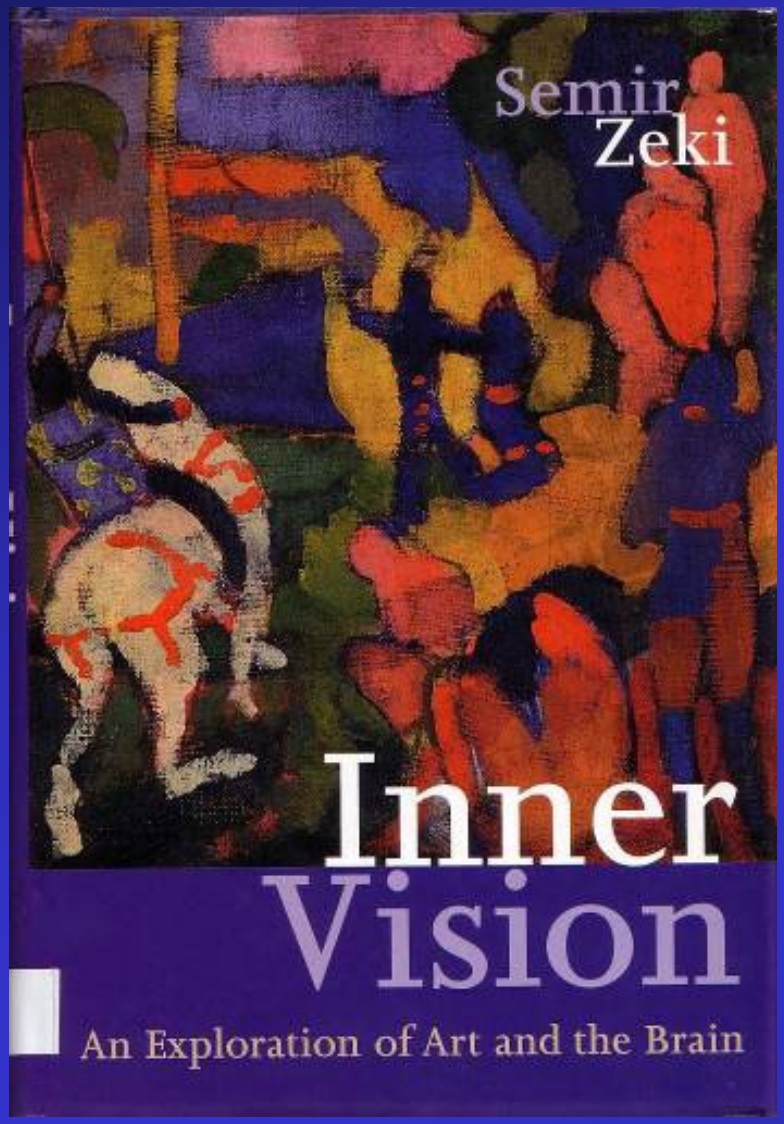
Bartels & Zeki, *Human Brain Mapping* 21:75-83, 2004

Macaque (neurons)



Tsao & Livingstone, *Annu Rev Neurosci*. 31:411-37, 2008

Art and the visual system



Fantin-Latour Self -portrait

Portraiture is a major artistic theme

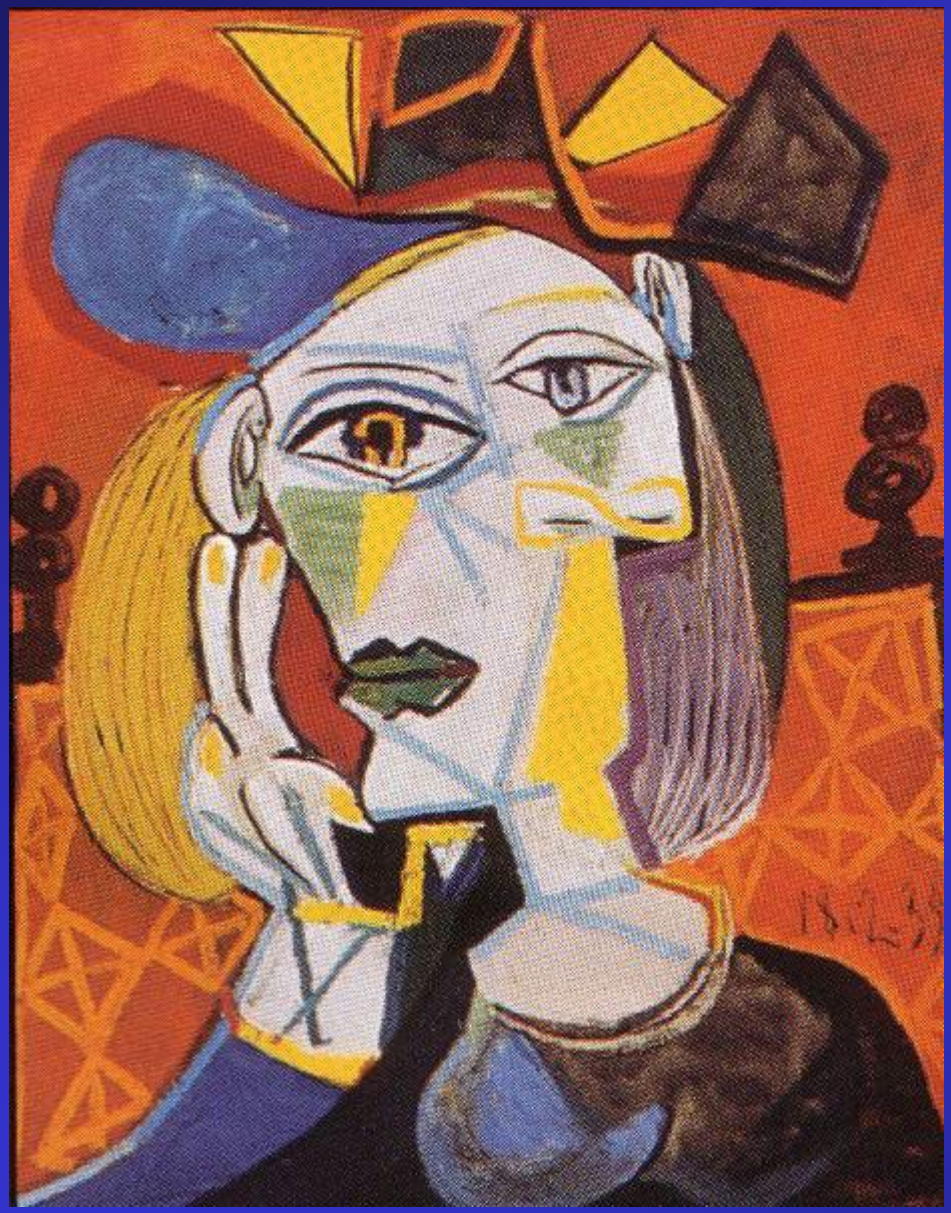
Titian: Portrait of a man

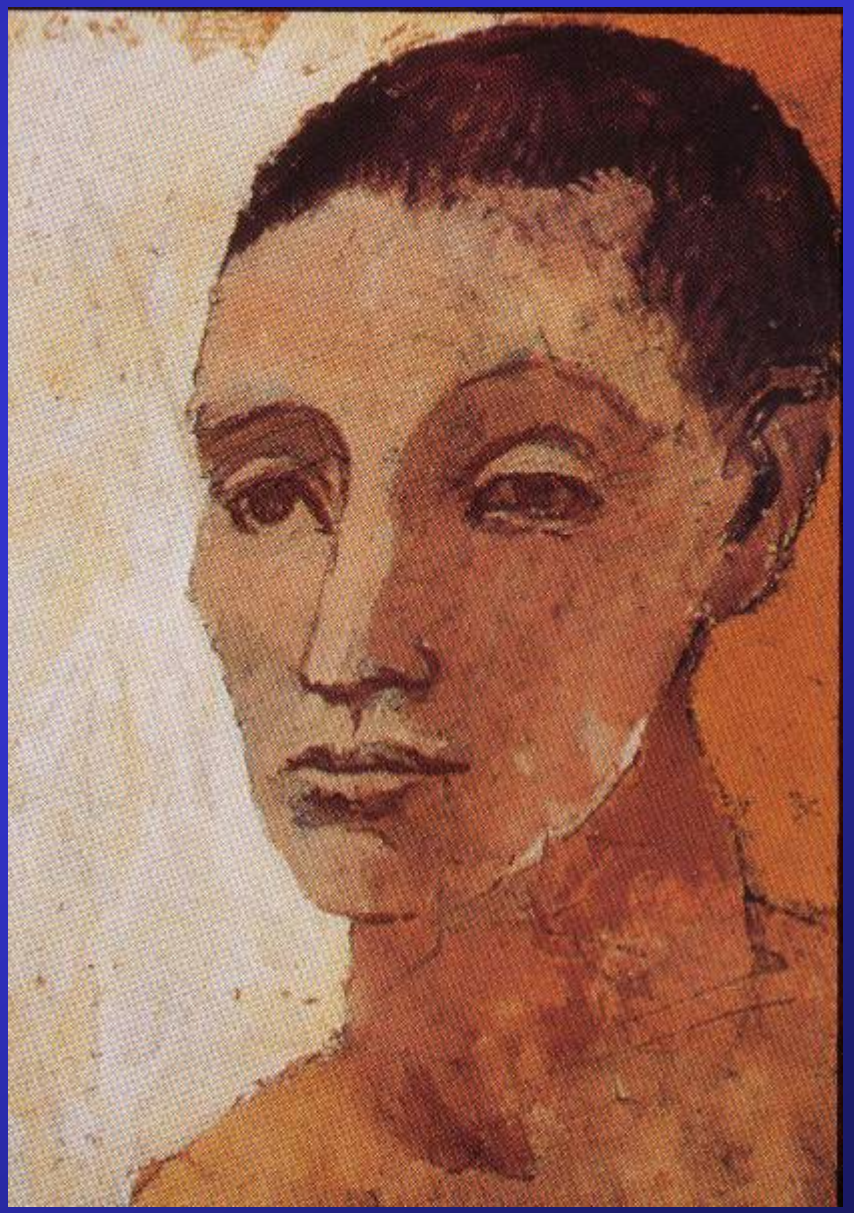
Picasso: Dora Maar

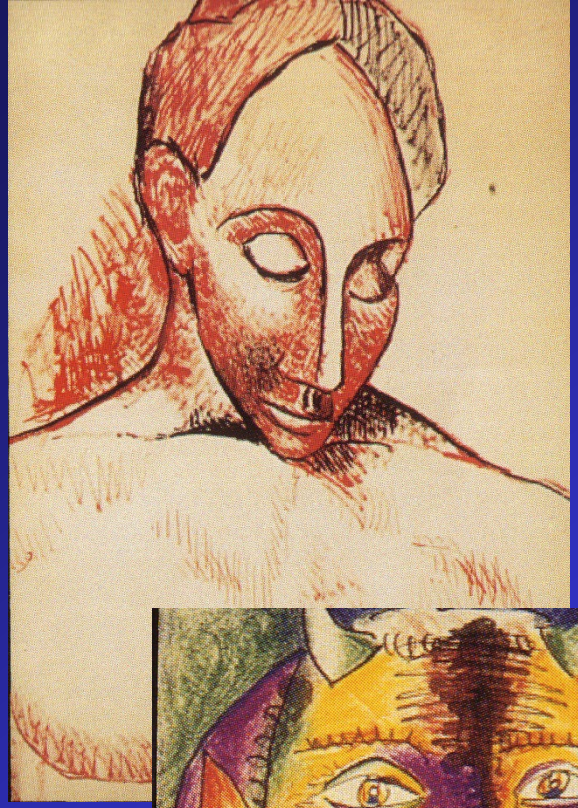
Portaits by Picasso in Sammlung Berggruen, Berlin

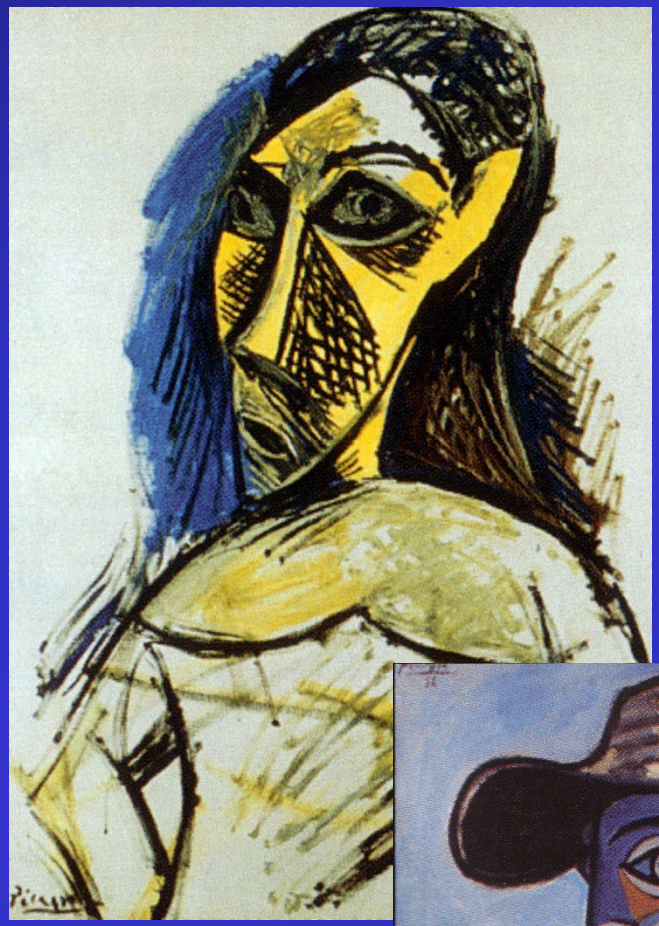
Portraits by Picasso in Berggruen Museum, Berlin

Portraits by Picasso in Berggruen Museum, Berlin







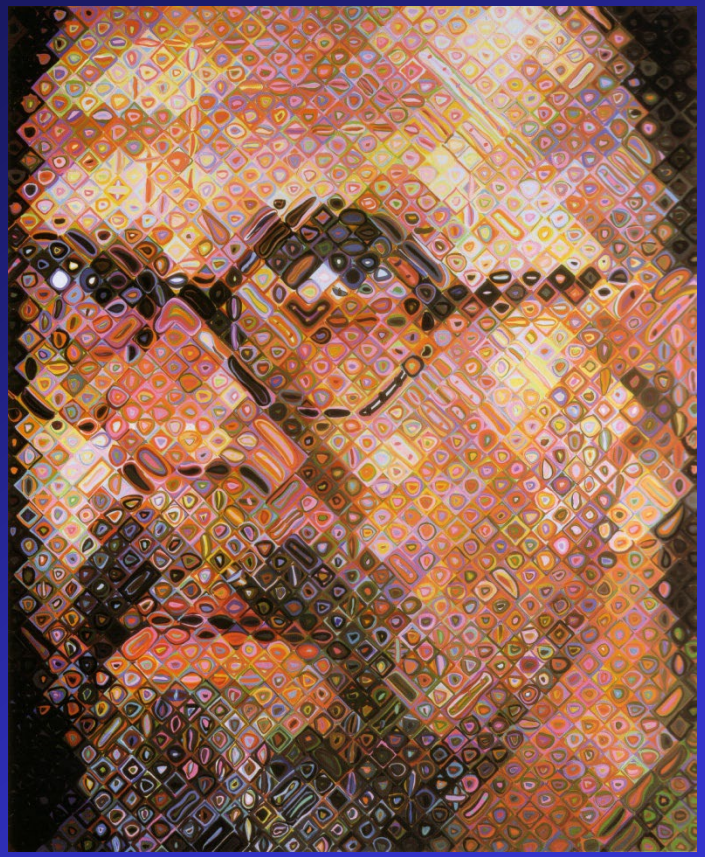


Berggruen Museum, Berlin

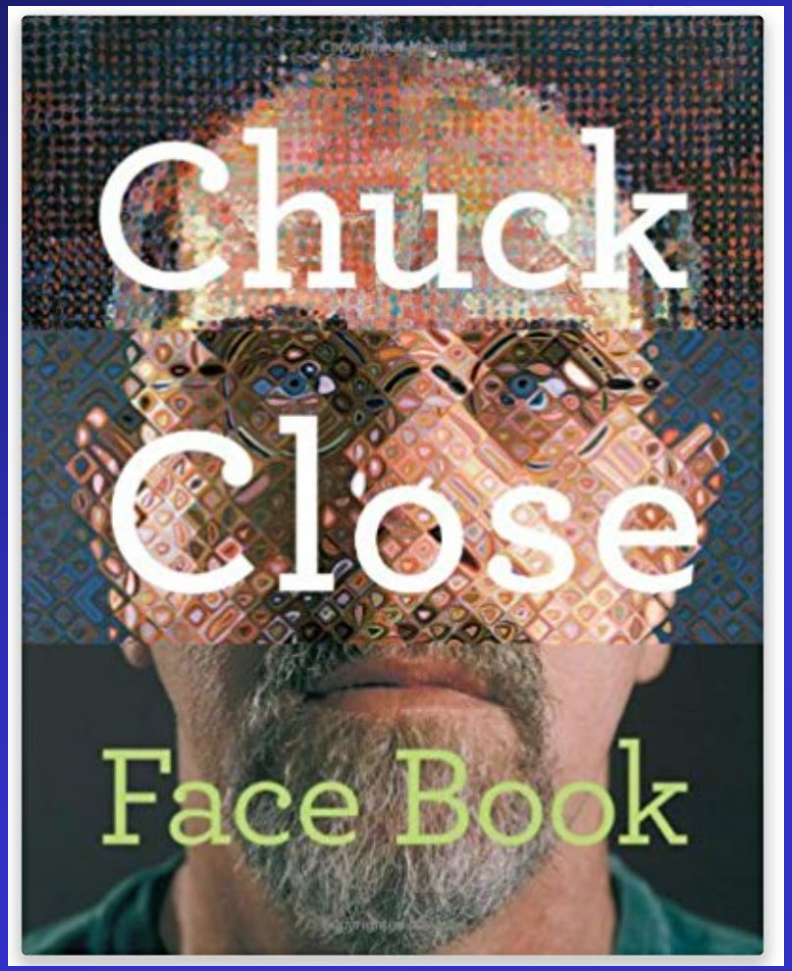
Picasso represented essential features of subject

[thanks to Marge Livingstone]

Rich range of portraiture reflects brain specialization for face recognition

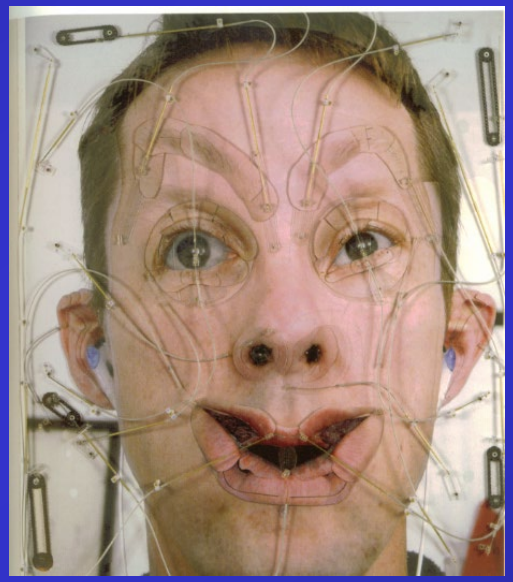


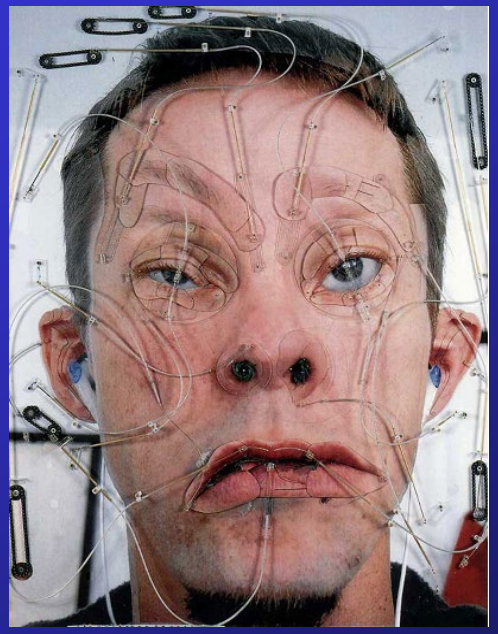
12 self portraits that can be scrambled



chuck close art - Google Search

Dynamic portrait: Tim Hawkinson: *Emoter*



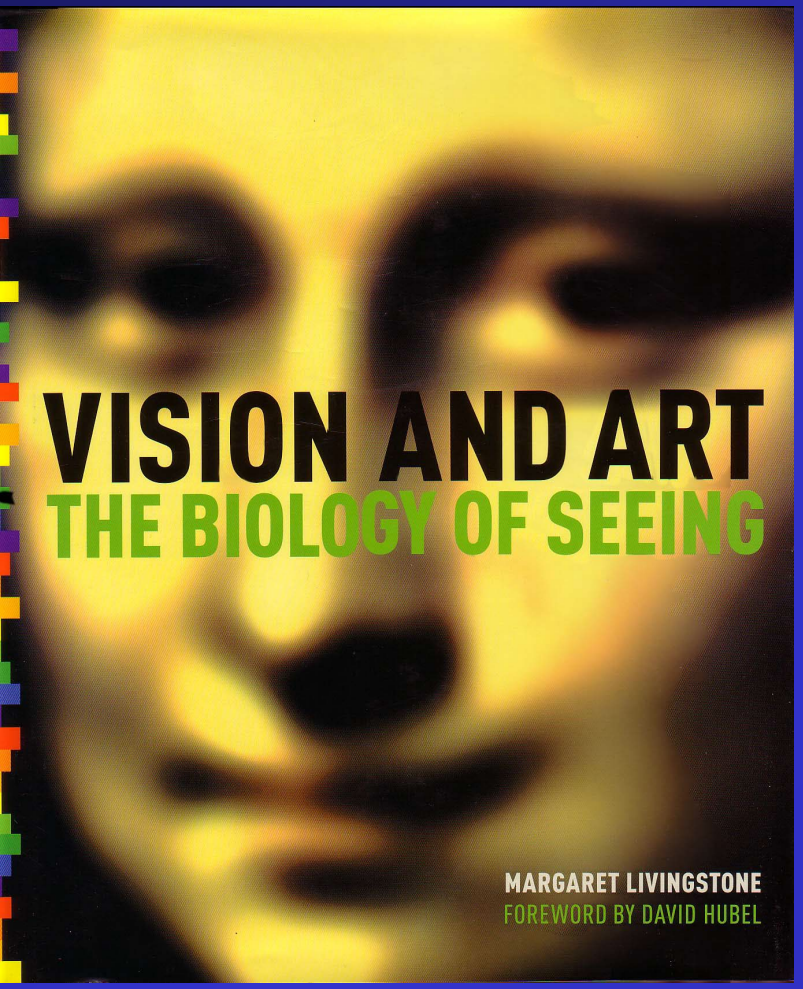


http://www.youtube.com/watch?v=ZVNI6OZwyJc

AI generated faces: Mario Klingemann: *Memories of Passerby I*

Artificial neural networks continuously generate changing faces of non-existing people
Memories of Passersby I by Mario Klingemann on Vimeo

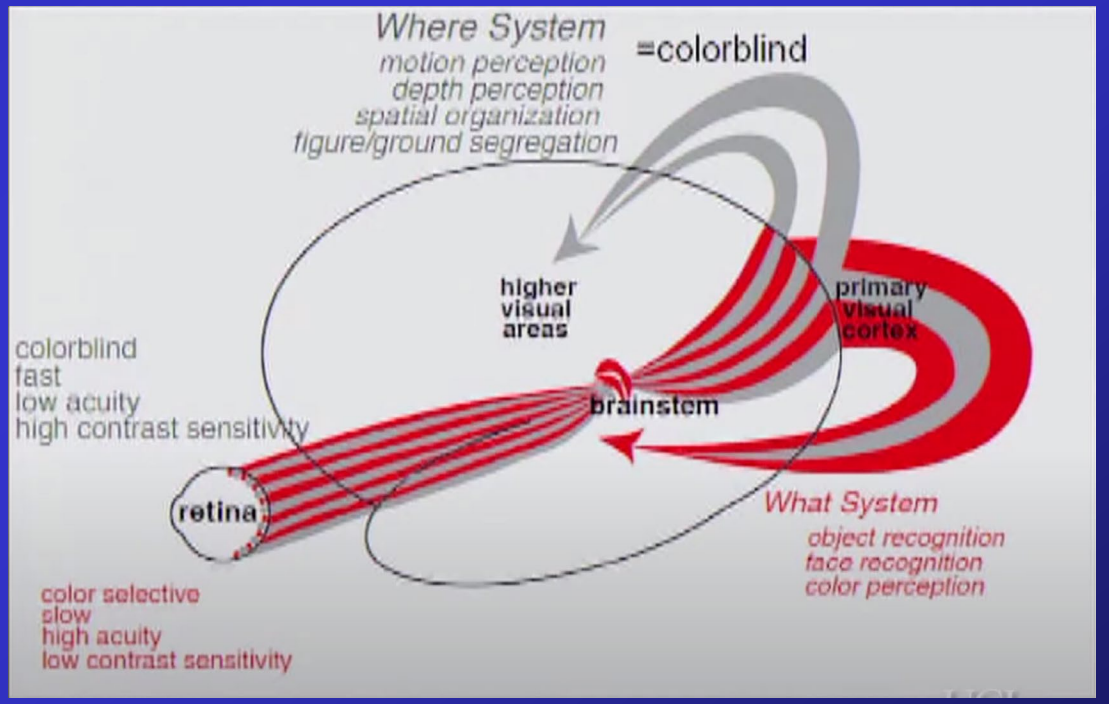
Neural mechanisms underlying appreciation of art

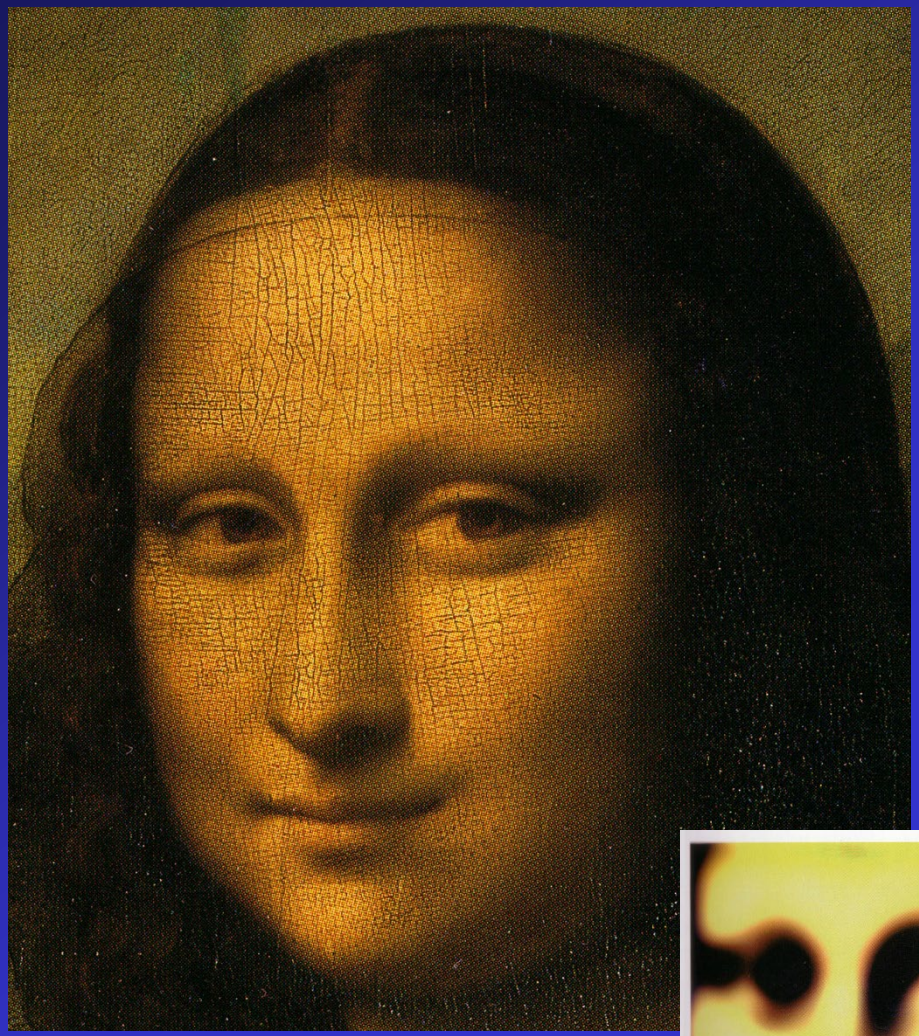


The Journal of Neuroscience, November 1987, 7(11): 3416–3468

Psychophysical Evidence for Separate Channels for the Perception of Form, Color, Movement, and Depth

Margaret S. Livingstone and David H. Hubel
Department of Neurobiology, Harvard Medical School, Boston, Massachusetts 02115

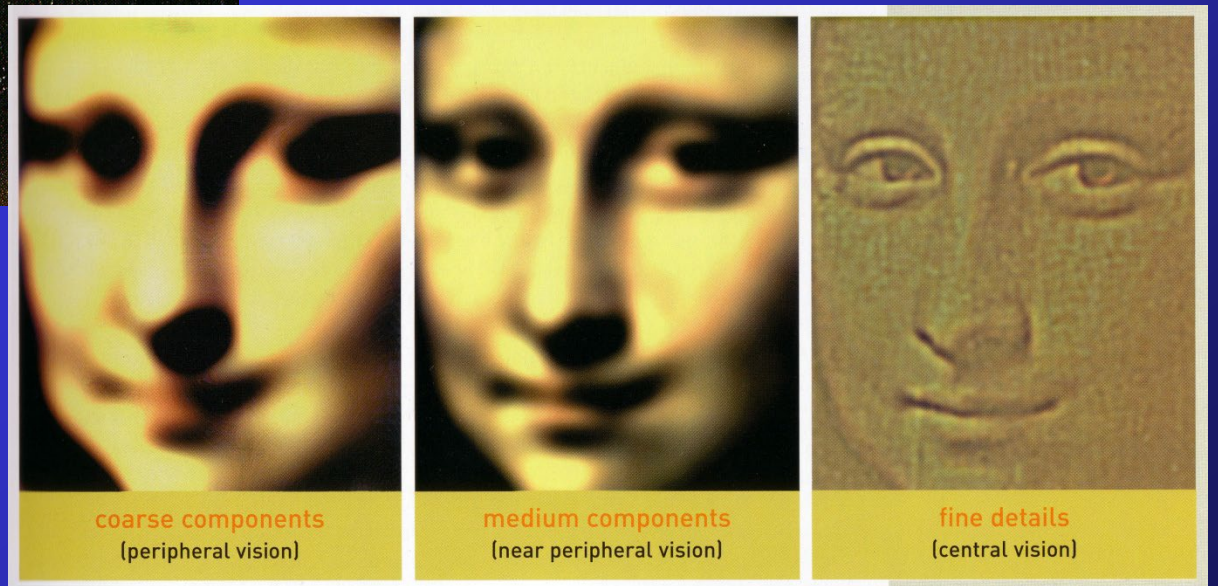




Neural explanation of mysterious Mona Lisa smile :

Smile appears greater when seen by peripheral vision, which has lower spatial acuity

Smile appears more restrained when seen by central vision, which is better tuned to fine details



Livingstone MS: Is it warm? Is it real? Or just low spatial frequency? Science. 290:1299, 2000

[Title is a riff on Nat King Cole hit song Mona Lisa: "Are you warm, are you real, Mona Lisa Or just a cold and lonely, lovely work of art?"]

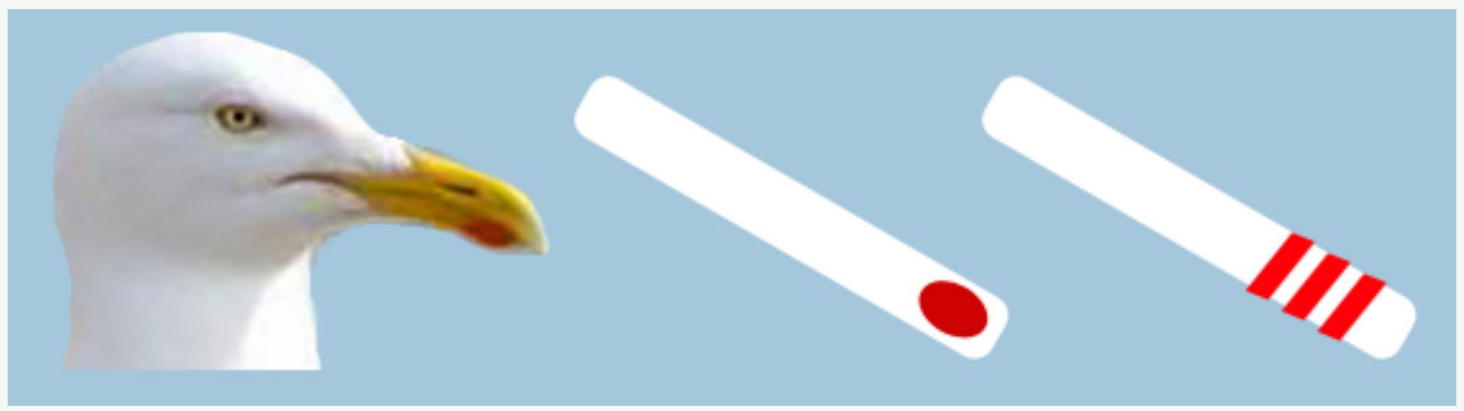
Principles of art and their neurophysiological bases

1. Contrast
2. Isolation
3. Perceptual problem solving
4. Grouping
5. Orderliness
6. Symmetry
7. Metaphor

YouTube link: “Ramachandran Neurology of Art”

Ramachandran and Hirstein, The Science of Art; a neurological theory of aesthetic experience, *Journal of Consciousness Studies*, 6, 1999.

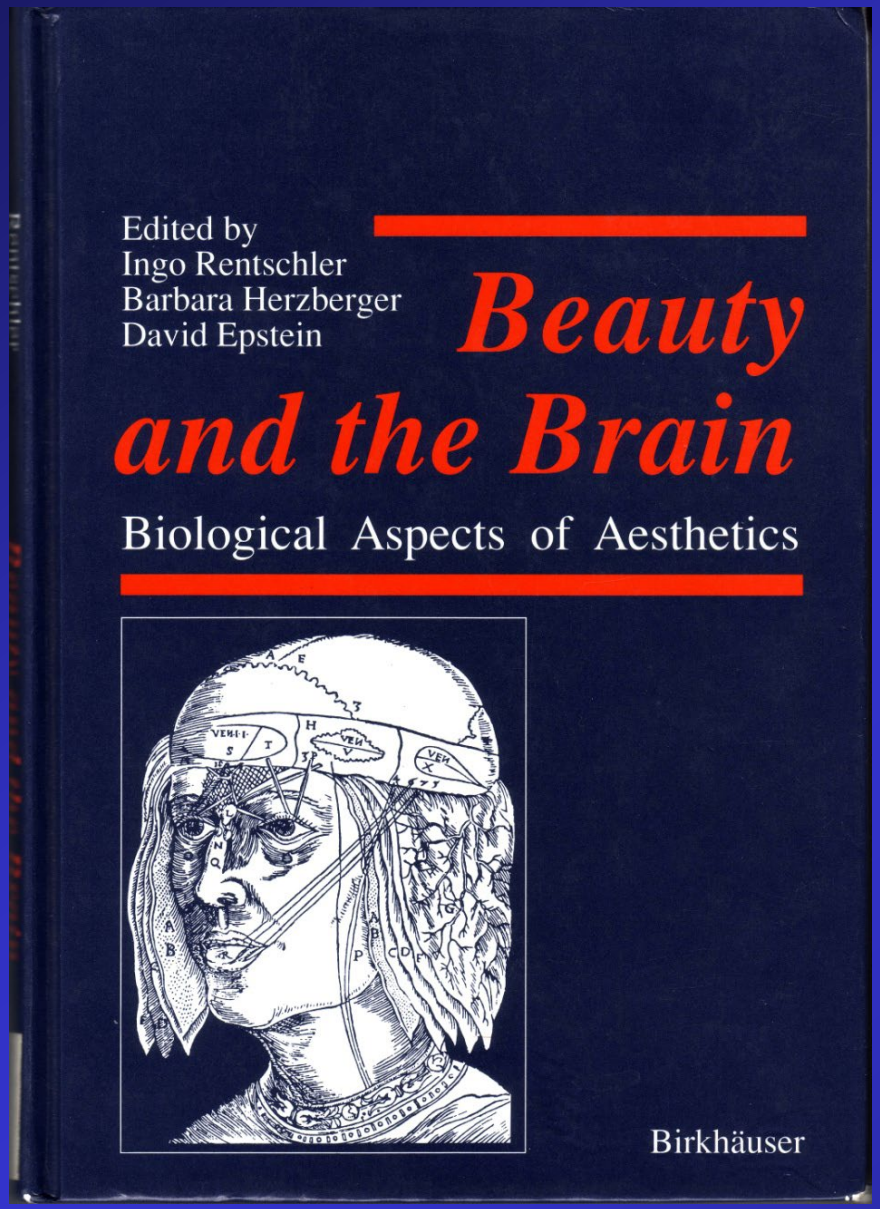
Seagull chicks respond to red spot on beak; even more to red spots on a stick

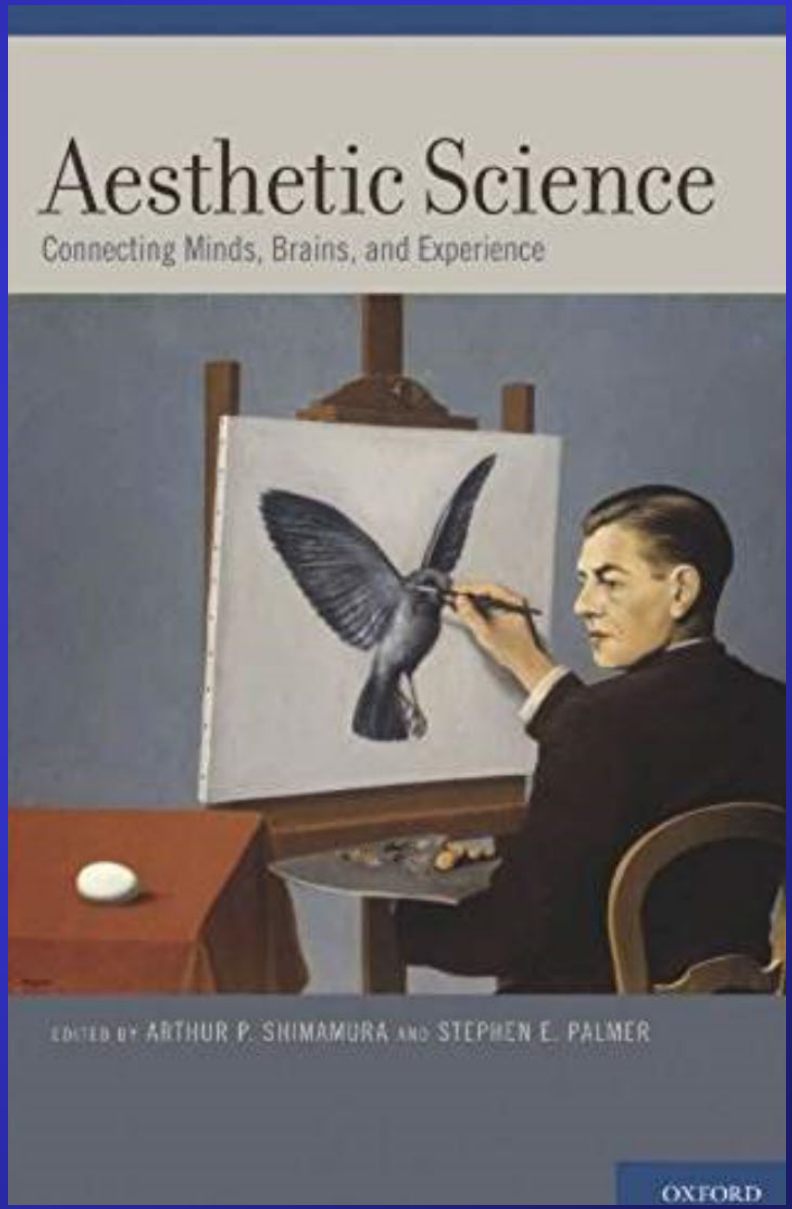


"Imagine that seagulls had an art gallery. They would hang this long thin stick with three stripes on the wall. They would call it a Picasso, worship it, fetishize it, and pay millions of dollars for it, while all the time wondering why they are turned on by it so much, even though (and this is the key point) it doesn't resemble anything in their world. I suggest this is exactly what human art connoisseurs are doing when they look at or purchase abstract works of art; they are behaving exactly like gull chicks. By trial and error, intuition or genius, human artists like Picasso or Henry Moore have discovered the equivalent of the seagull brain's stick with three stripes."

Ramachandran VS. The Tell-Tale Brain

Neurobiology of aesthetic experience





Medial orbito-frontal cortex is activated by experience of musical and visual beauty

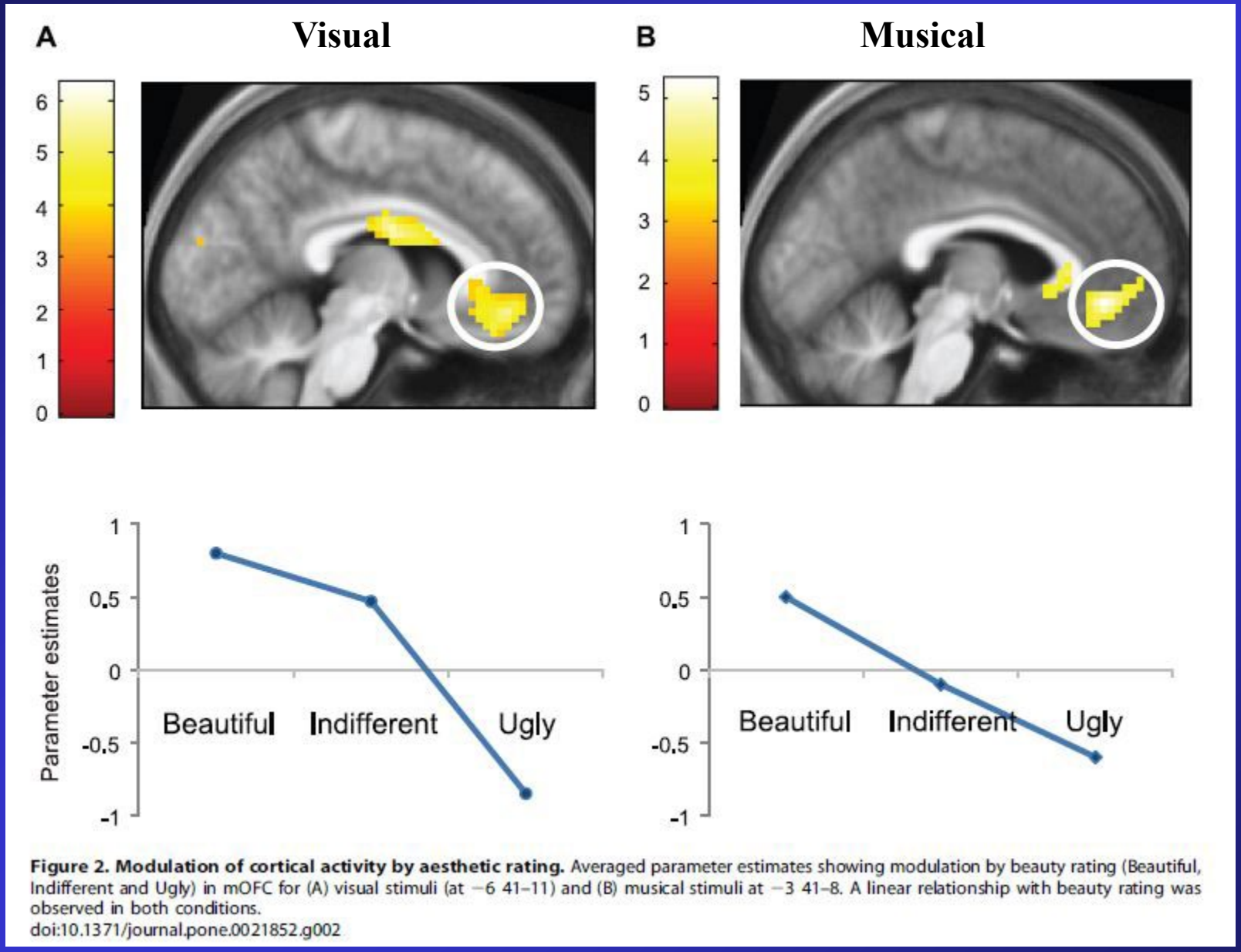


Figure 2. Modulation of cortical activity by aesthetic rating. Averaged parameter estimates showing modulation by beauty rating (Beautiful, Indifferent and Ugly) in mOFC for (A) visual stimuli (at −6 41–11) and (B) musical stimuli at −3 41–8. A linear relationship with beauty rating was observed in both conditions.
doi:10.1371/journal.pone.0021852.g002

Ishizu & Zeki, Toward a brain-based theory of beauty *PLoS One*, *6*, e21852, 2011

1. How the brain processes art

All art activates specific brain circuits

Op art stimulates particular visual system mechanisms

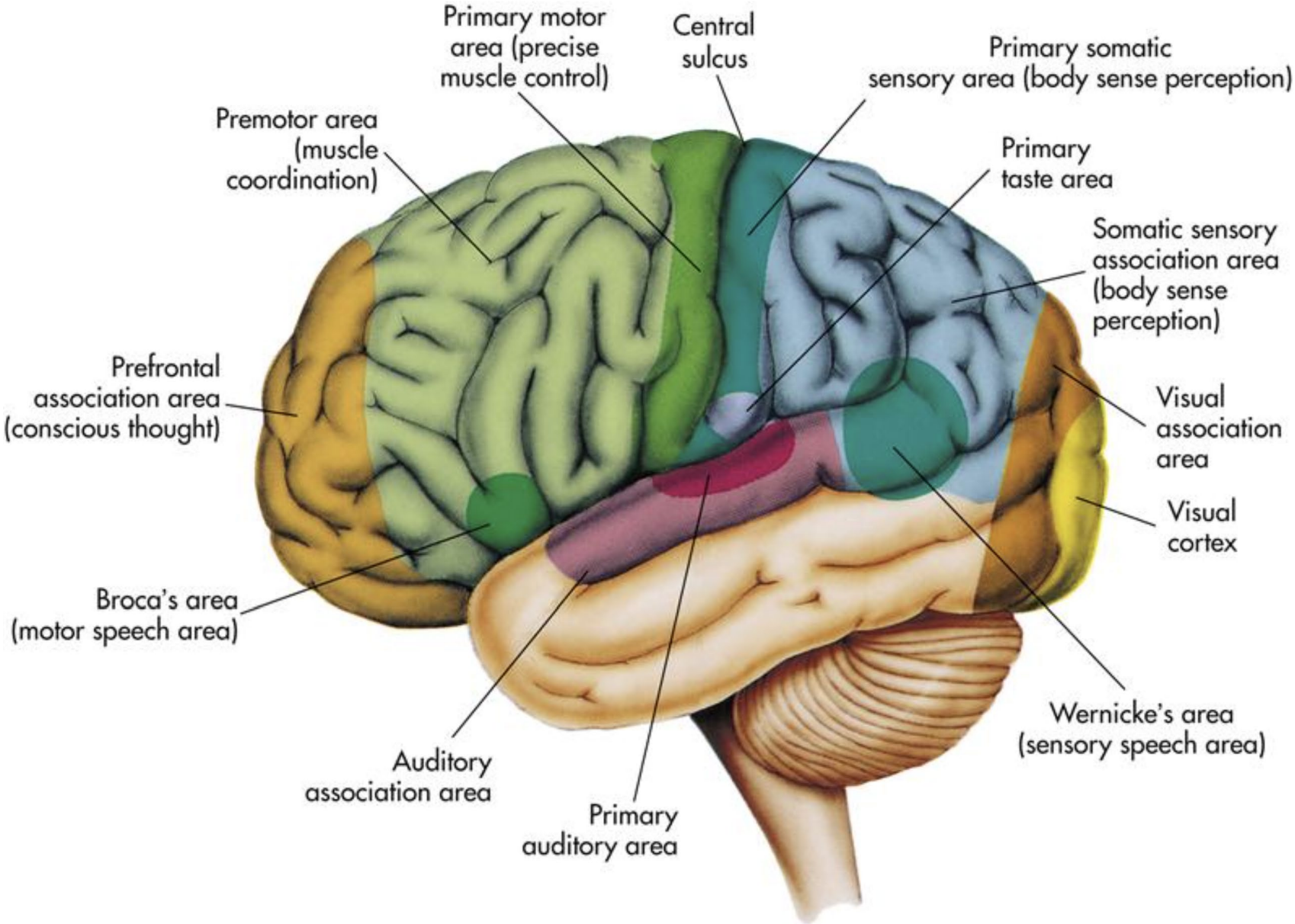
Portraiture exploits extensive representation of faces

Similarly, neural mechanisms mediate experience of music, literature, performing arts

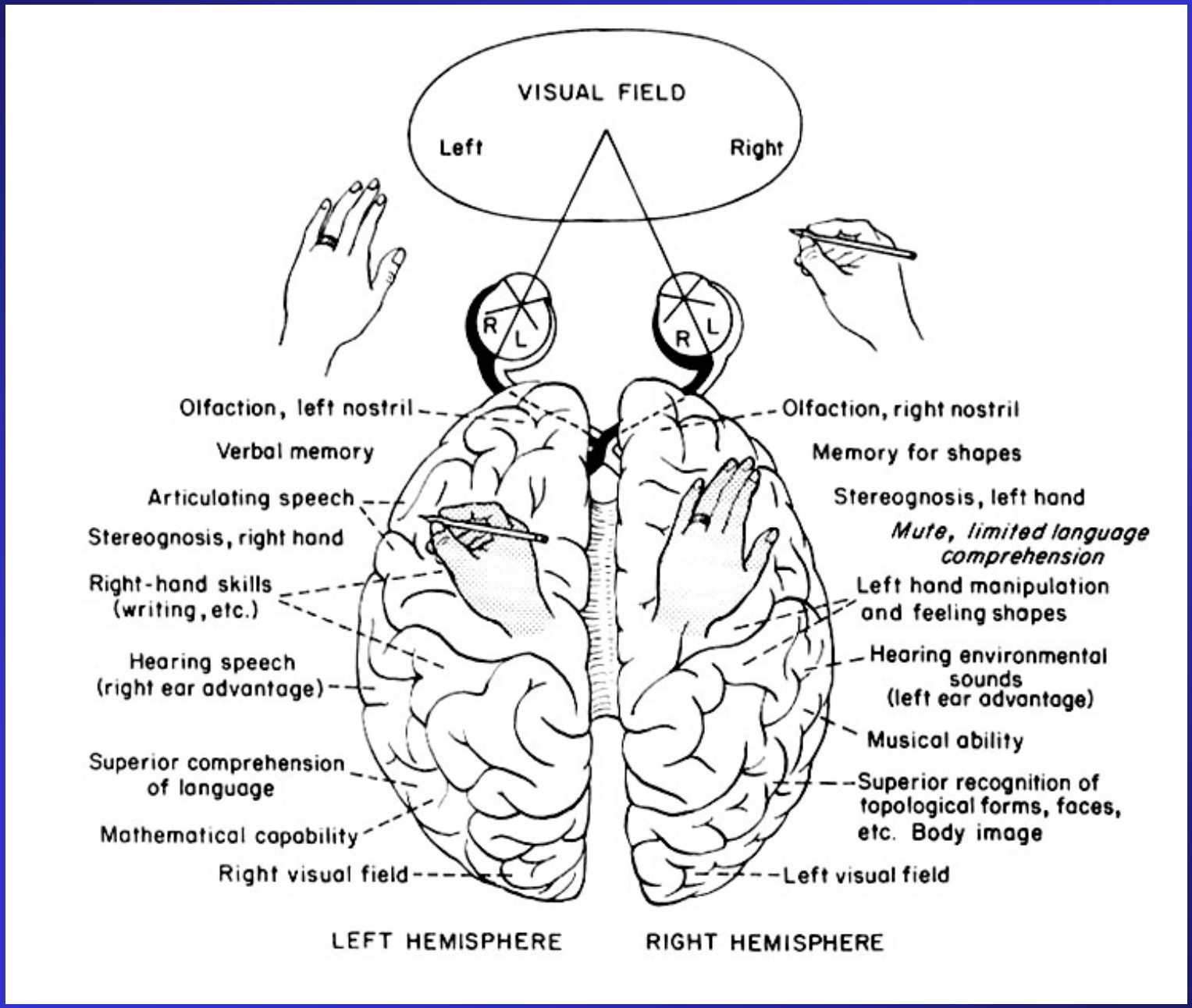
Certain brain areas are activated by aesthetic experience

2. Cognitive operations of the brain

Functional areas of human cerebral cortex



Hemispheric specialization



Presentation of information to left & right hemisphere in "split-brain" subject shows that only left side can verbalize

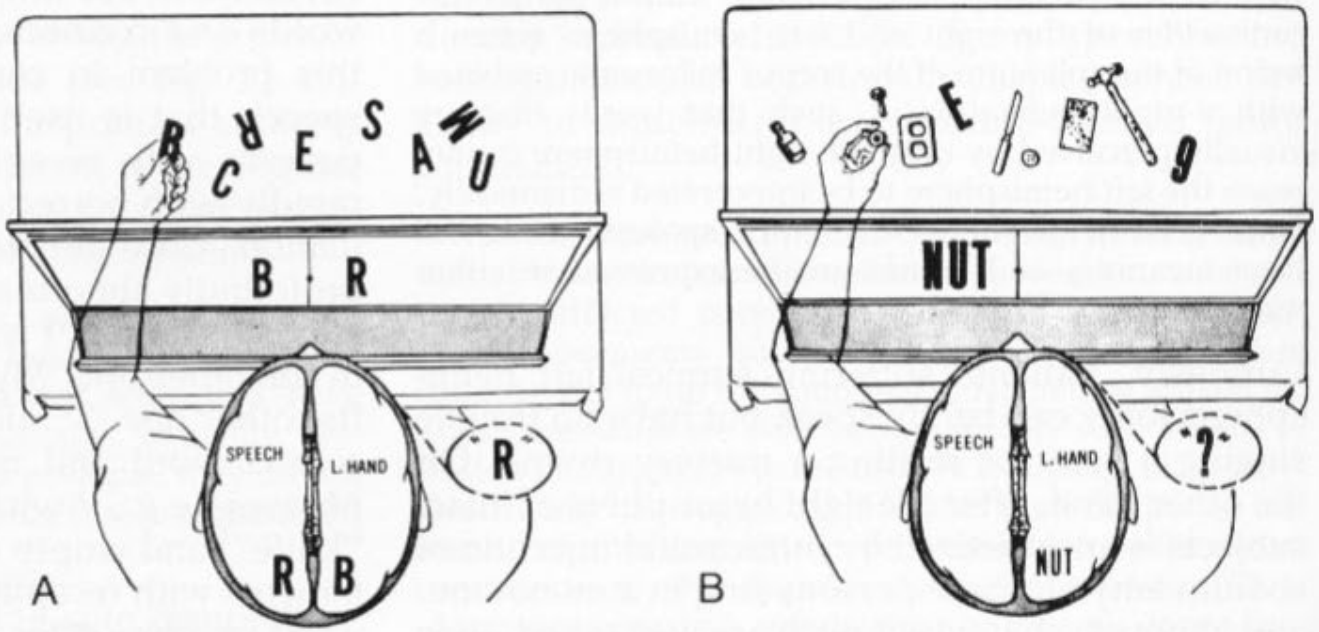


Figure 31–18 Responses of a commissurotomized patient to the tachistoscopic presentation of stimuli to the left and right visual fields, which reach the right and left hemispheres, respectively. *A*, When stimuli are presented simultaneously to the right and left hemifields, the subject can name the right-field stimulus but retrieves the left-field stimulus. *B*, The subject can read and understand the names of objects presented in the left hemifield and can retrieve the appropriate items with his left hand but cannot name them. (After Sperry R.W.; Gazzaniga, M.S.; Bogen, J.E. In Vinken, P.J.; Bruya, G.W., eds. *Handbook of Clinical Neurology*, vol. 4, 273–290. Elsevier Science Publishers (Biomedical Division), 1969.)

Interhemispheric access

Left hemisphere is anesthetized via carotid injection of sodium amytal, and a specific memory trace is laid down in the right hemisphere via tactile and visual input

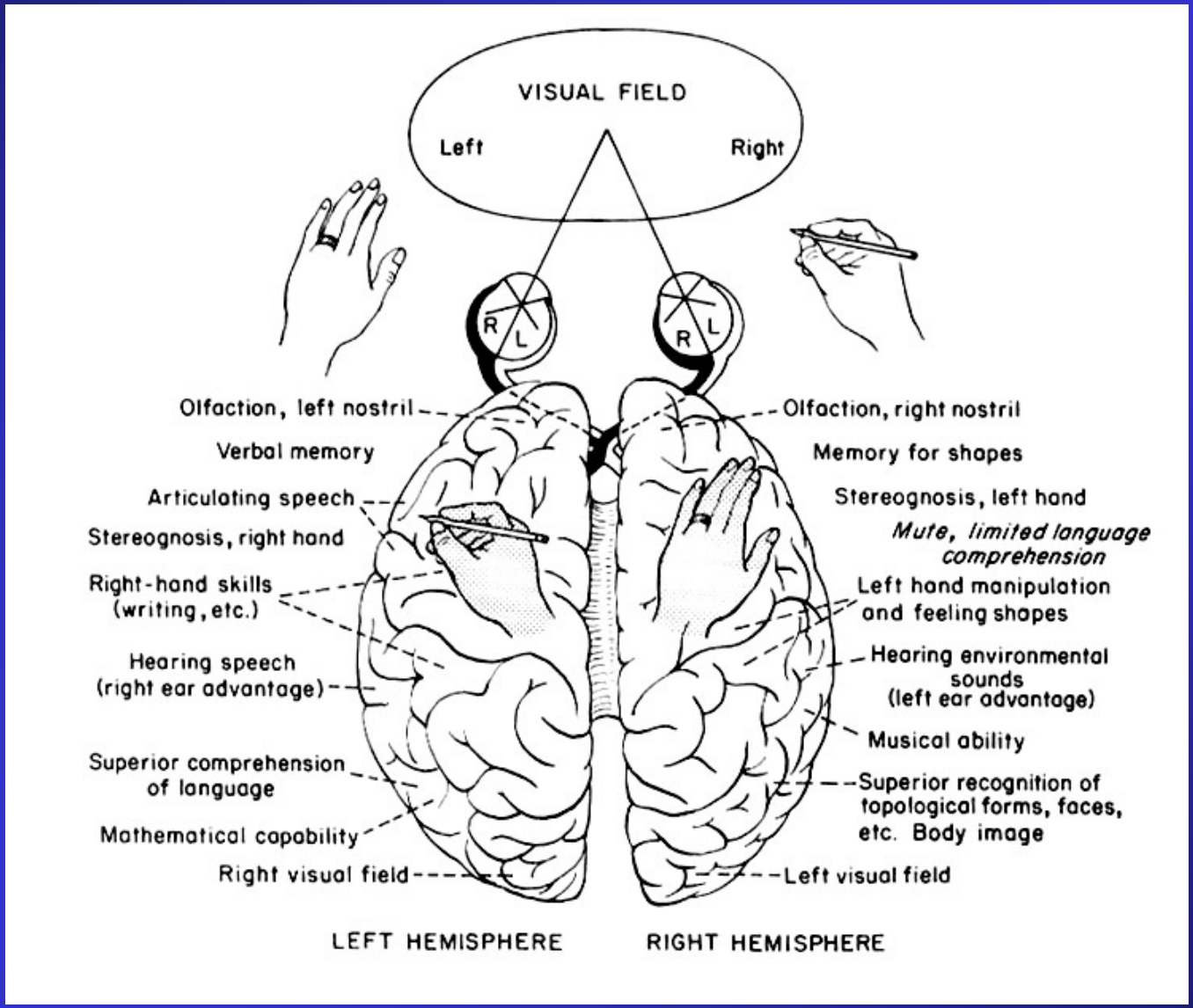
With both hemispheres awake and connected, the subject is unable to name the object

The existence of the memory trace in the right hemisphere can be demonstrated by non-verbal means

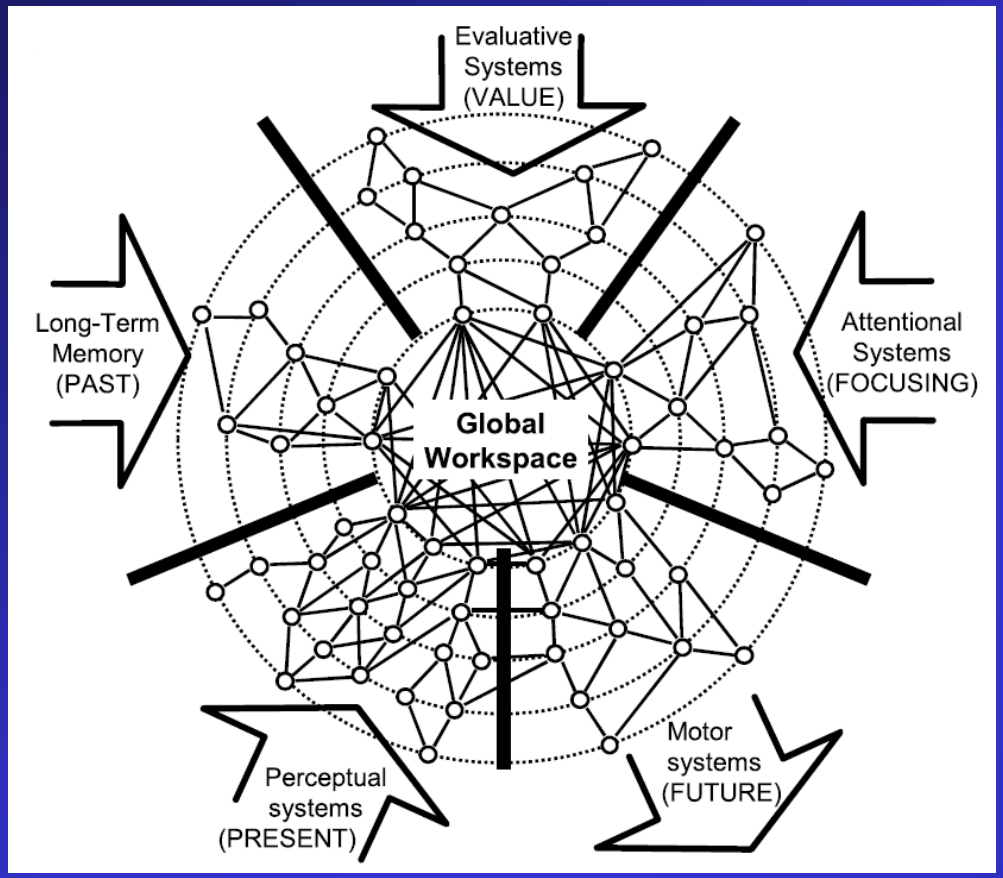
Interpretation: memory trace laid down in one hemisphere cannot be accessed by the other side.

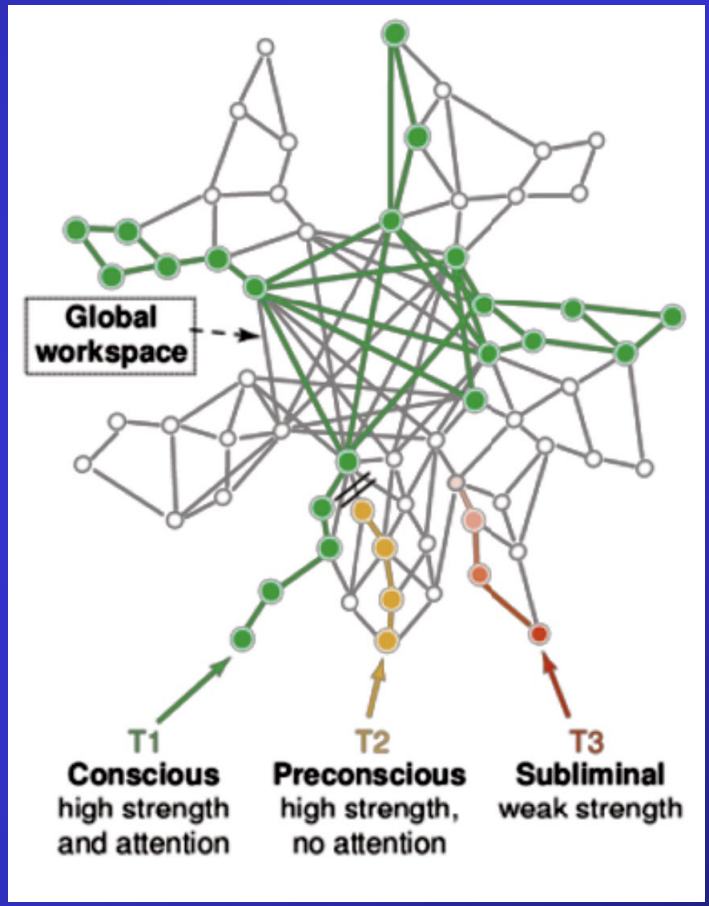
Gazzaniga & LeDoux, The Integrated Mind, 1978

All of these functional areas are active.
What determines the contents of consciousness?



Global Workspace Theory of Conscious Processing





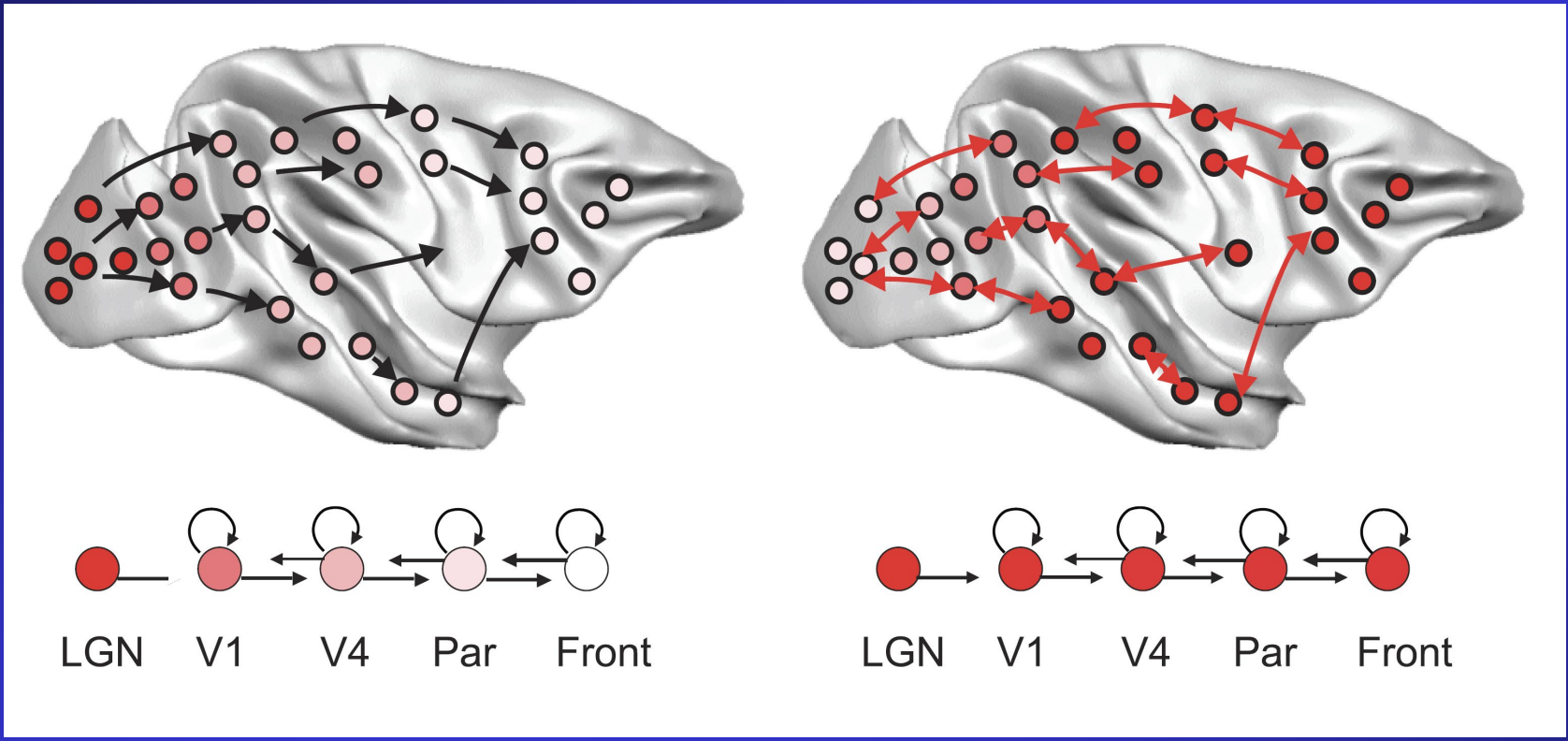
"The Global Neuronal Workspace hypothesis proposes that, in the conscious state, a non-linear network ignition associated with recurrent processing amplifies and sustains a neural representation, allowing the corresponding information to be globally accessed by local processors."

Mashour et al, *Neuron* 105, 776. 2020

Global Workspace Theory of Conscious Processing

subconscious

conscious



Two dynamic states for an identical stimulus: either the incoming activity cascades upward in a self-amplified manner, ultimately igniting the entire network, thus corresponding to conscious access (right) or the propagating activity remains below the threshold for ignition and induces only a progressively decaying wave of activity in higher regions, corresponding to subliminal processing (left).

Mashour et al, *Neuron* 105, 776. 2020

https://youtu.be/CgpQzRE2ORE?t=81

Art can stimulate brain states

https://youtu.be/Q_6HAMtqW3Y?t=190

https://njpvideo.ggcf.kr/asset/video/1004

1. **How the brain processes art**
2. **Cognitive operations of the brain**

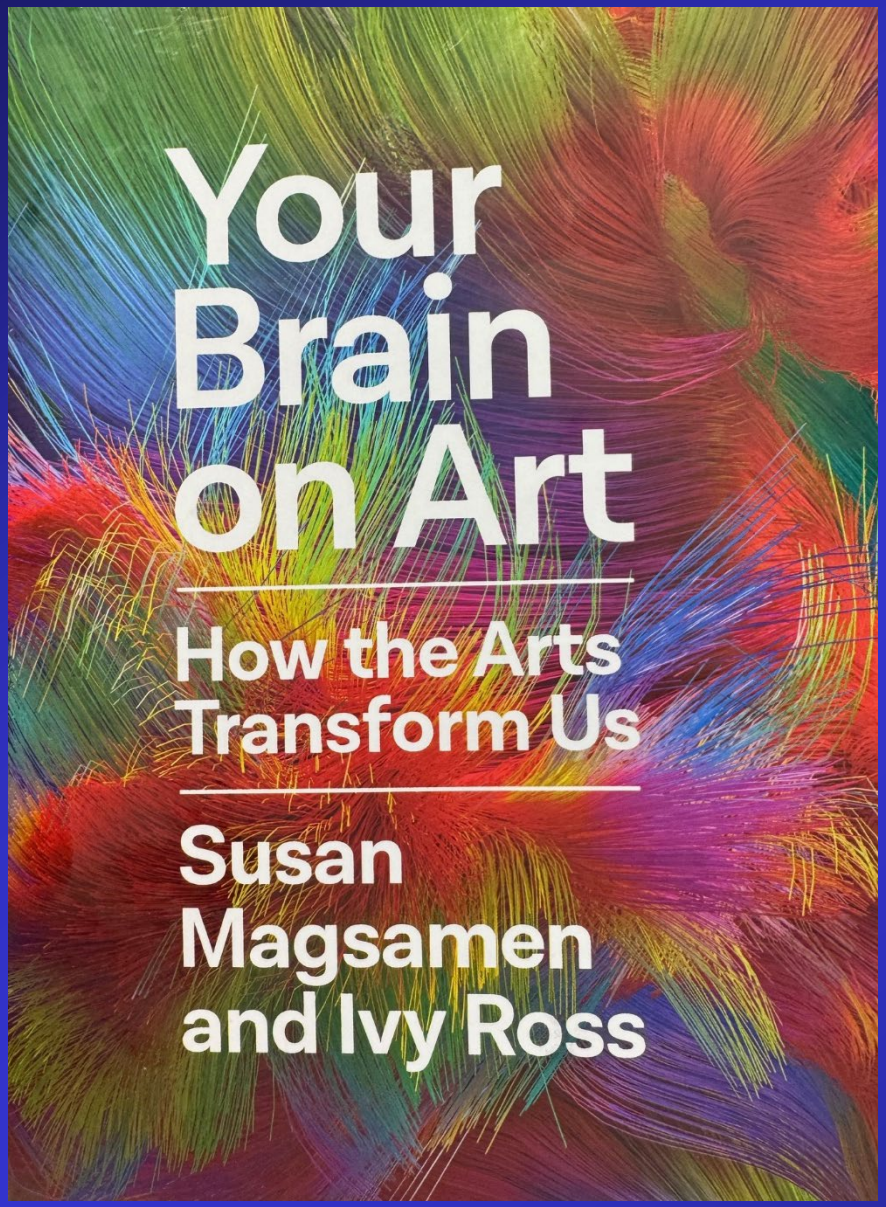
Different areas of the brain are specialized for particular functions

Localized modules are continuously active

We are consciously aware of a subset of synchronized modules

3. **How art effects the brain**

Effects of Art on the Brain



Exposure to arts increases longevity and slows the rate of cognitive decline.

"The arts trigger release of neurochemicals, hormones and endorphins that provide an emotional release."
Art engages many areas of the brain.
Creating art is more stimulating and beneficial than passive viewing.

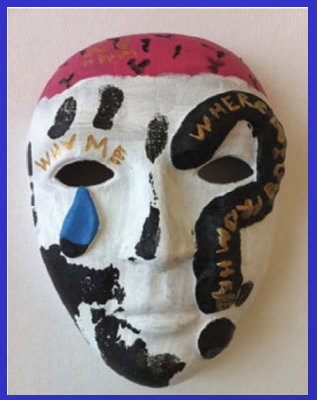
Targeted Healing Effects of Art on the Brain

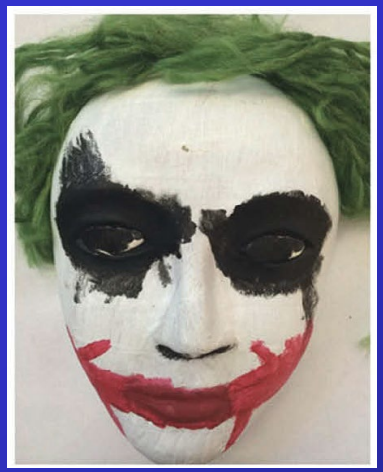
1. Music reduces stress and pain
2. Singing reduces post-partum depression
3. Virtual Reality helps reduce acute pain during medical procedures

    VR of snow world alleviates pain of replacing bandages for burn patients

4. Tools for successfully living with chronic issues
5. Paralyzed patients can create art through brain-computer interfaces and regain agency and purpose
6. Creating masks helps represent trauma and reduce PTSD

Representations of PTSD and TBI in masks





Walker et al, Active-duty military service members' visual representations of PTSD and TBI in masks
https://www.tandfonline.com/doi/full/10.1080/17482631.2016.1267317

Nature as an Artistic Theme

Turner sunset

Anacortes Nature Photographer and Writer

Nature Inspires Artists

Cathy Schoenberg

Greg or Melanie Dugan

Nature Inspires Artists

Alfred Currier

Dee Doyle

1. **How the brain processes art**
2. **Cognitive operations of the brain**

3. How art effects the brain

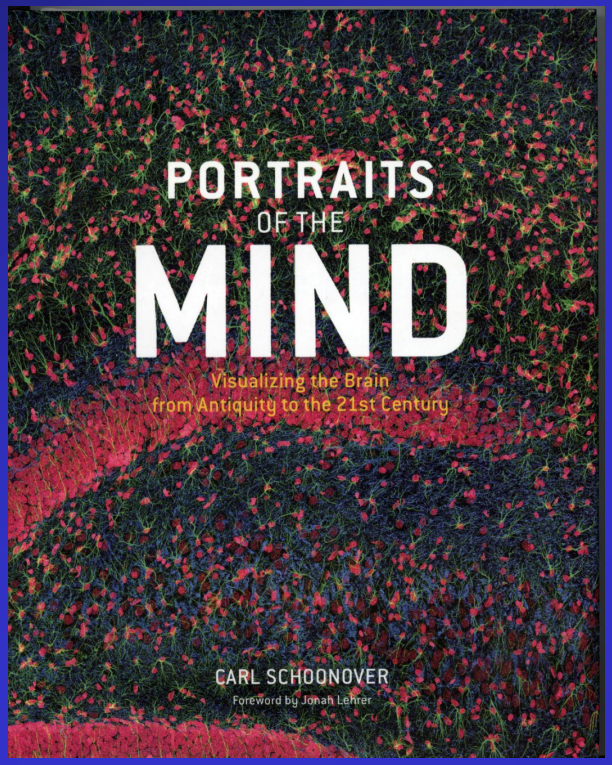
Art can have therapeutic effects on the brain

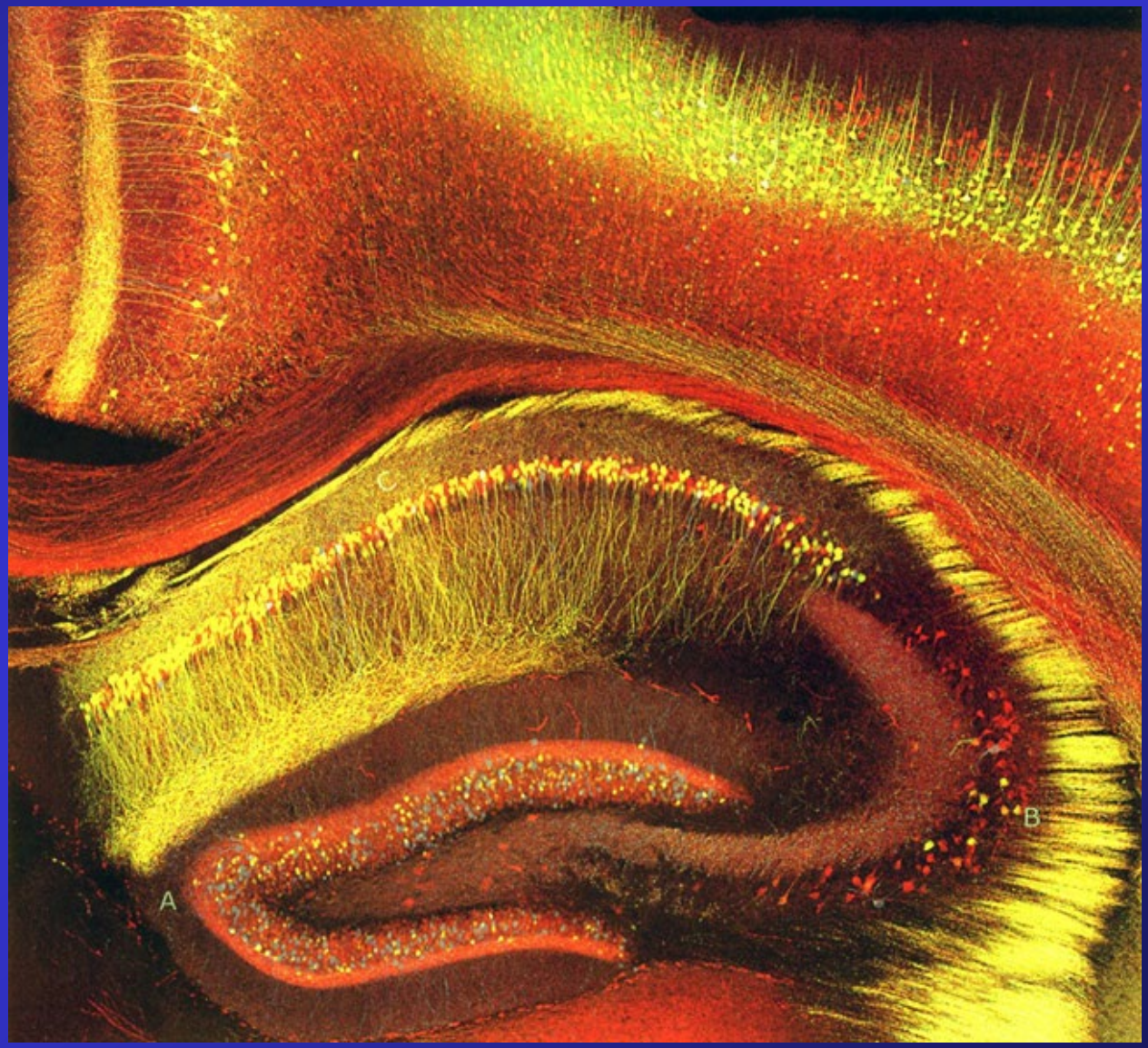
Nature creates forms with aesthetic resonance

Nature provides artistic inspiration

4. How artists are representing the brain and/or mind directly

Neural forms have aesthetic appeal





Neural forms have aesthetic appeal

Synaptogenesis by Greg Dunn *(in gold, mica and enamel)*
GREG DUNN NEURO ART- Brain and Neuroscience Fine Art Paintings (gregadunn.com)

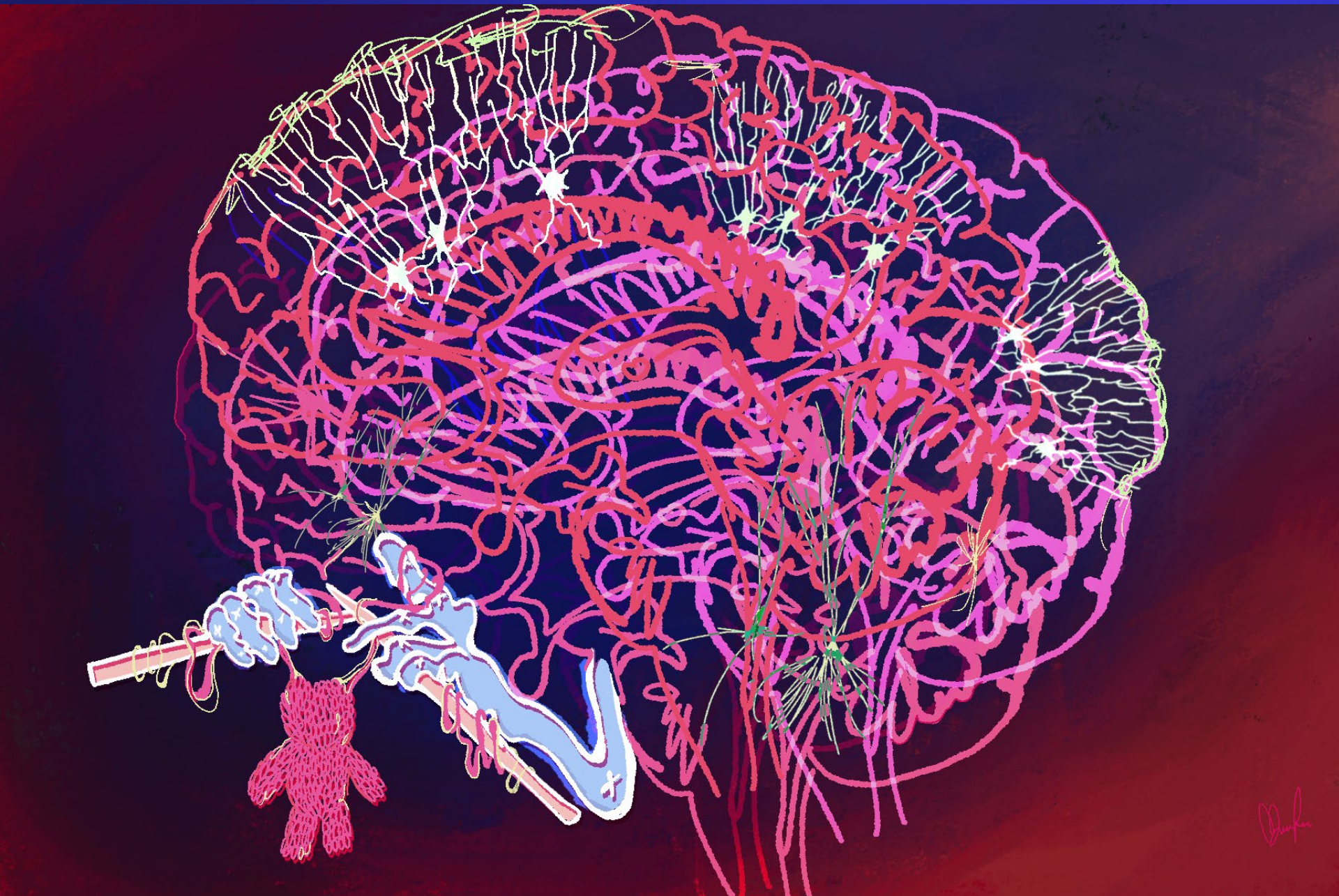
Neural forms have aesthetic appeal

Glomerulus *(enamel on composition gold, copper & latex)*

Greg Dunn: Gold Cortex
(enamel on composition gold)

https://www.gregadunn.com/

ConsciousKnit by Makenna Fojas



The Neuro Bureau

Brain Art Competition 2015

Galleries of 2015 submissions to be posted shortly…

A. Best Representation of the Human Connectome
B. Best Abstract/Freestyle Brain Illustration
C. Best Image Resulting from an Error or Bug
D. Best Video Illustration of the Brain
E. Special Topic: Best Multimodal Brain Illustration
F. Best "Under 14" Brain Illustration

Congratulations to the winners:

Best Representation of the Human Connectome

'Round the Connectome in Eighty Seconds
Katja Heuer, Roberto Toro
MPI, Institut Pasteur

Best Abstract/Freestyle Brain Illustration

Moitryoshka-Mytryoshka
Josefina Maranzano
McGill University

https://www.neurobureau.org/

News

The 2015 Brain-Art Competitionwinners are posted!

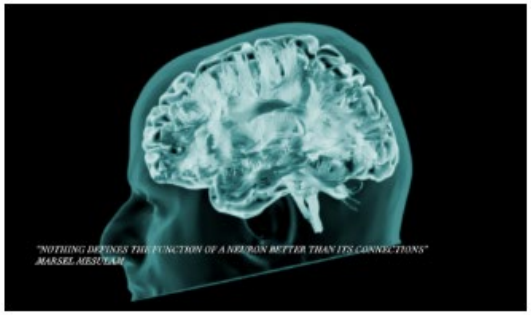
Blog Categories

art@HBM (13)
brainhack (6)
data sharing (2)
neuroart (13)
neuroimaging (1)
newsletter (2)
open neuroscience (6)
Uncategorized (4)

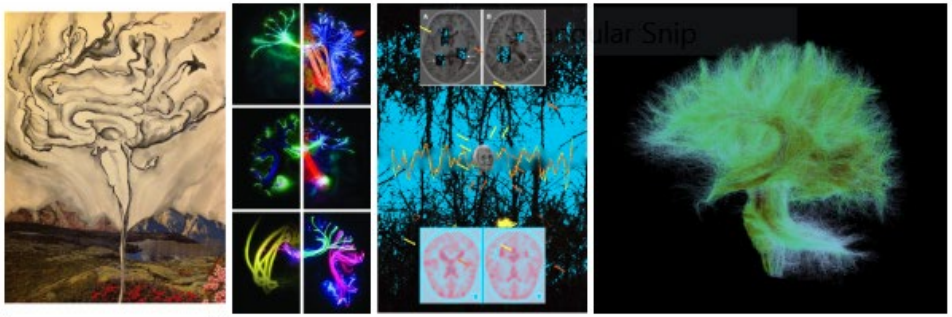
Select Pages

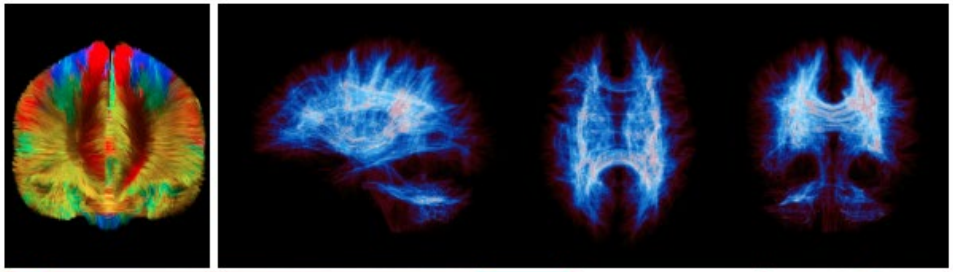
Blog
Brainhack
- Brainhack 2014
- Brainhack Unconference (2013)
- Brainhack Unconference (2012)
- Data Sharing

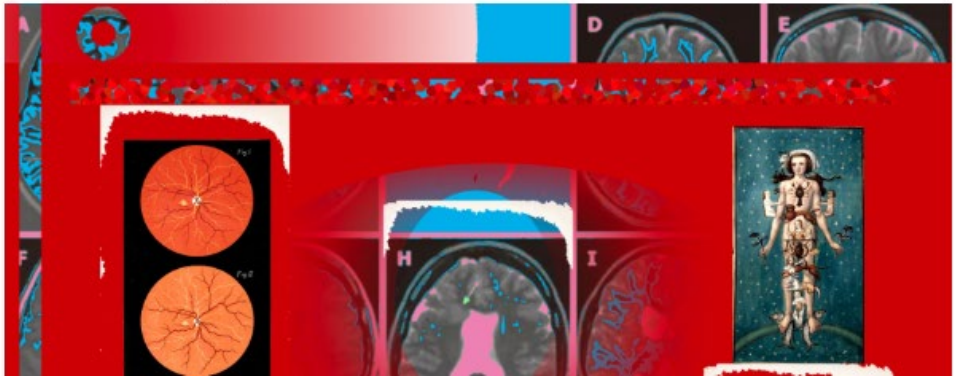
Brain Art Galleries
- Brain Art Competition 2014
- Brain Art Competition 2013
- Brain Art Competition 2012



Best Abstract Brain Illustration



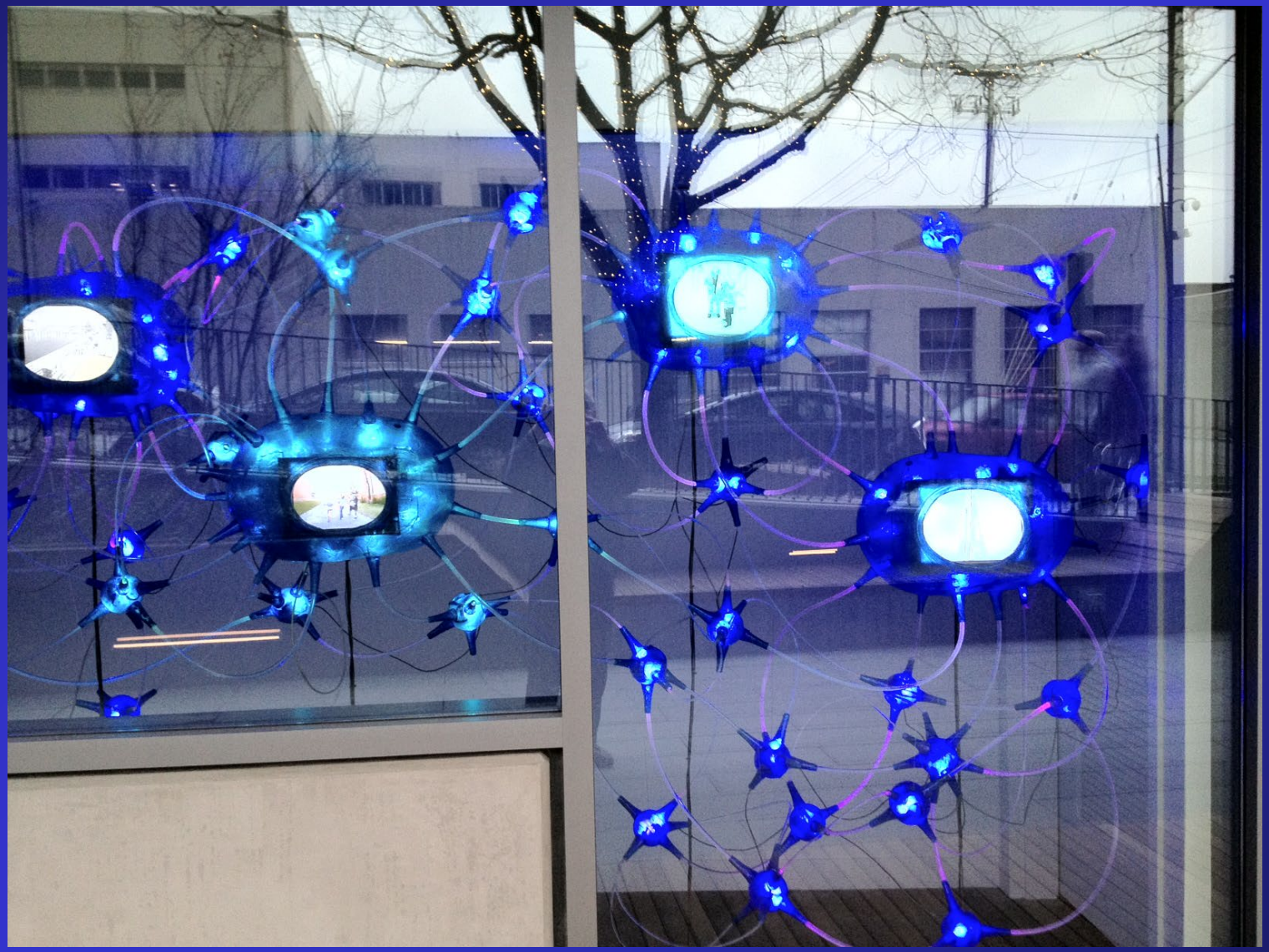




Deborah Ashheim: Neural Architecture

Deborah Ashheim: Amazon Building

207 Boren Ave. N., Seattle



http://www.deborahaschheim.com/projects/index/neural-architecture

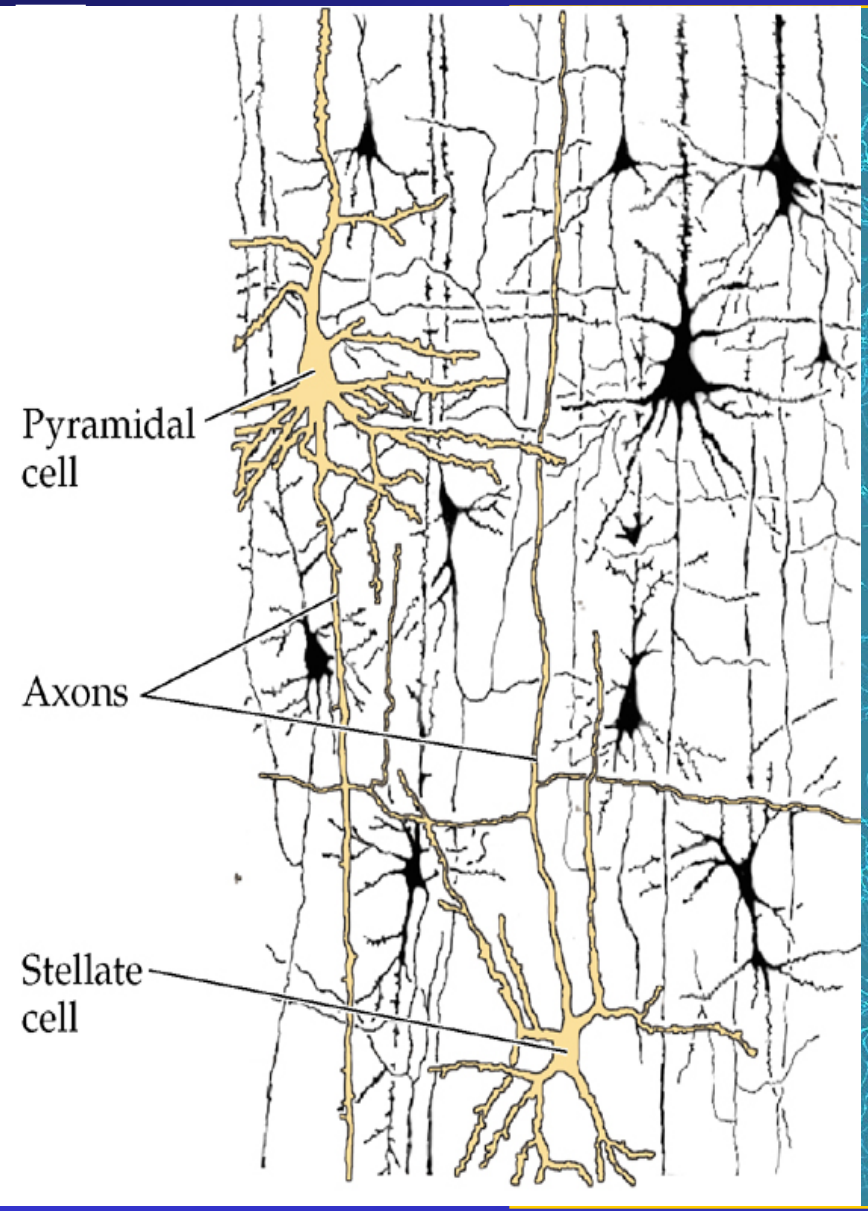
Todd Siler: prolific artist inspired by the brain

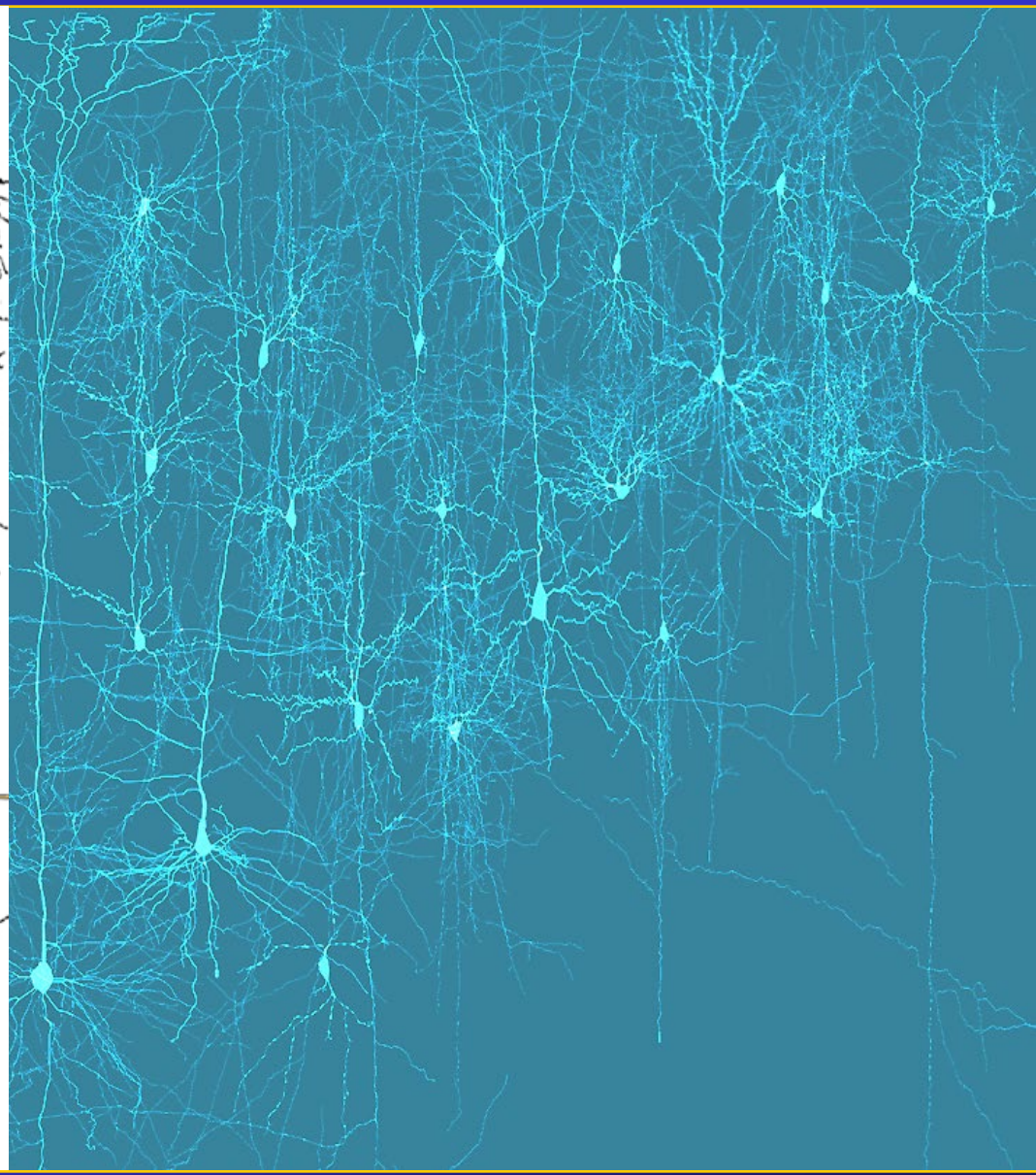
https://www.toddsilerart.com/videos

Todd Siler, "Mind Icons," 1991-93. Mixed media, multi-part art installation, *Radical Futures*, at Ronald Feldman Fine Arts, New York City, 1993. http://www.toddsilerart.com

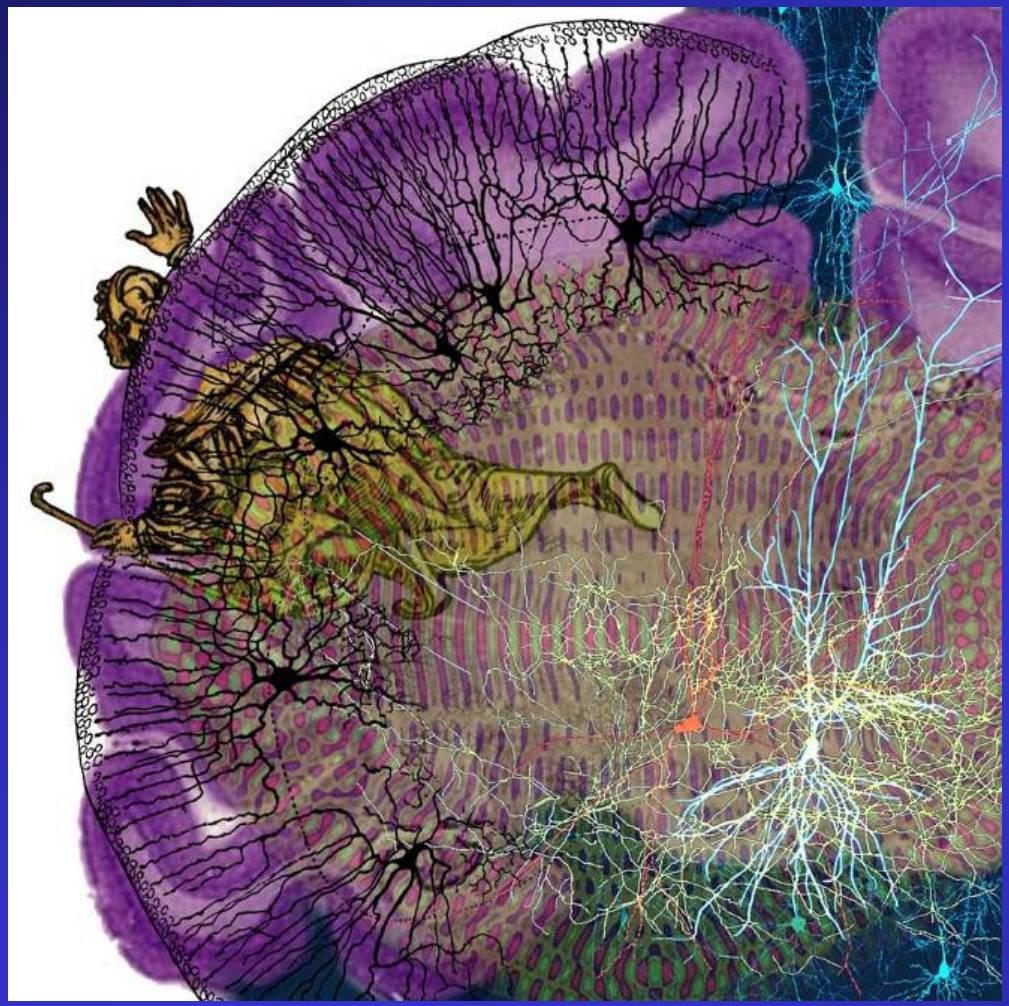

Metaphorming Lounge

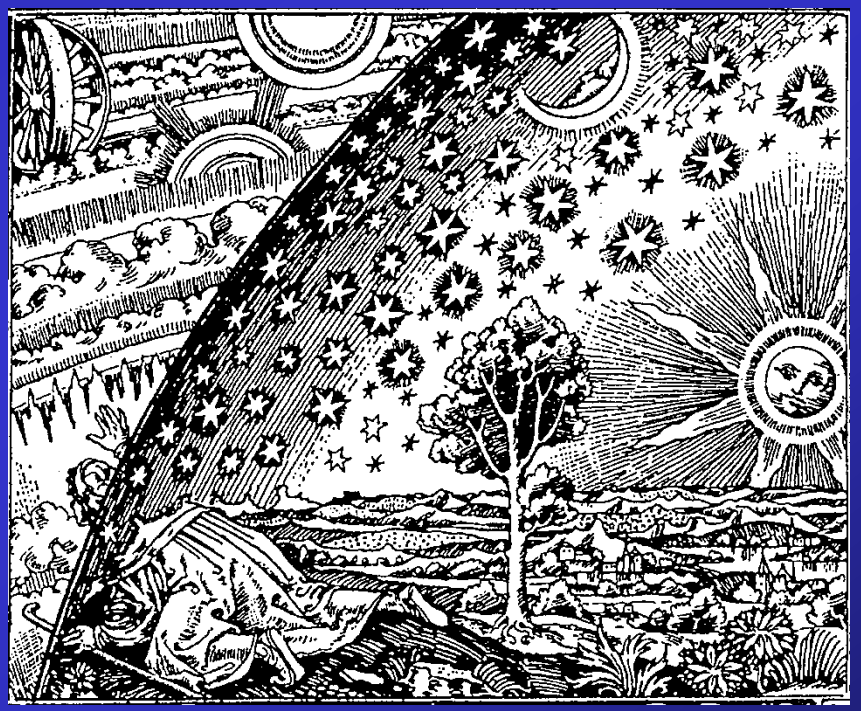
How does conscious experience emerge from chaotic neural networks?





Conscious self emerging from the brain

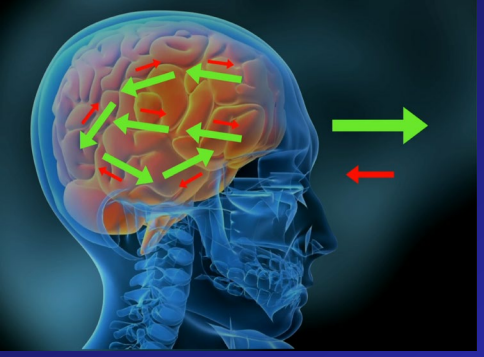




Flammarion woodcut

https://depts.washington.edu/fetzweb/brain-art.html

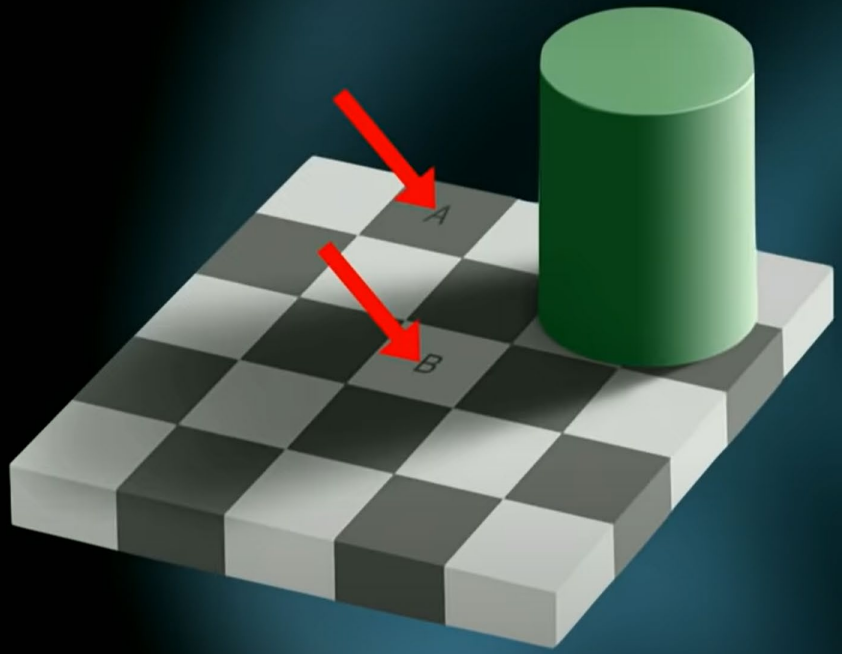

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x)\Psi(x,t) \equiv \hat{H}\Psi(x,t)$$
5*256/NFT; % x-space grid spacing
;ang2=.2;ang3=.3;ang4=.4;
*3.2;y0=.07*3.2; spr=.095107;kk=50;
= meshgrid(-3.2:del:3.199);
the initial wavefunction
exp(-(xt-x0).^2/spr-(yt-y0).^2/spr).*
lj(0,kk*sqrt((xt-x0).^2+(yt-y0).^2));
4*3.2;y0=-.2*3.2; spr=.095107;kk=50;
nature

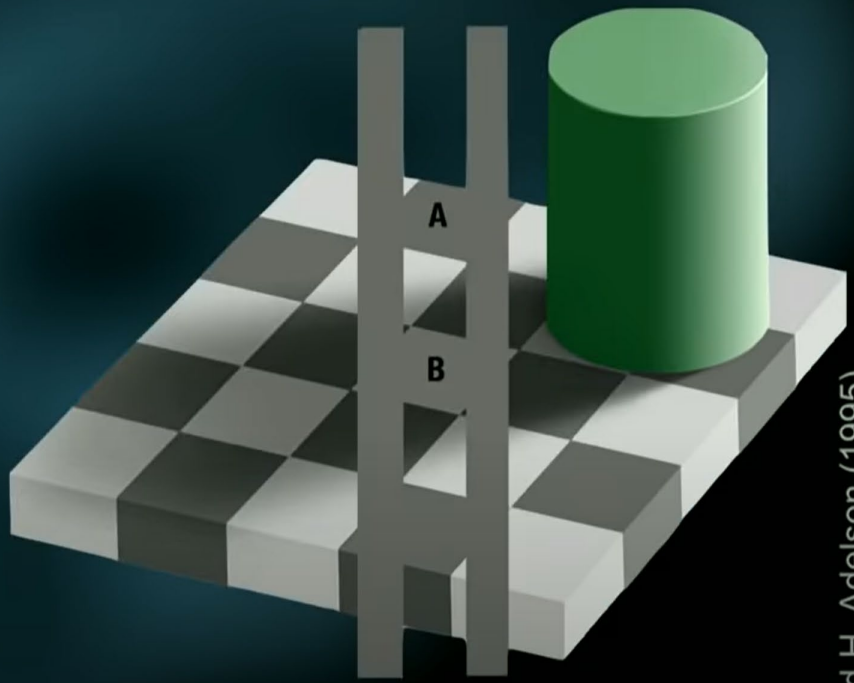


Prior expectations influence perceptions

Top-down brain-generated activity [green arrows] can dominate bottom-up peripherally generated activity [red arrows].

Your brain hallucinates your conscious reality | Anil Seth





Edward H. Adelson (1995)

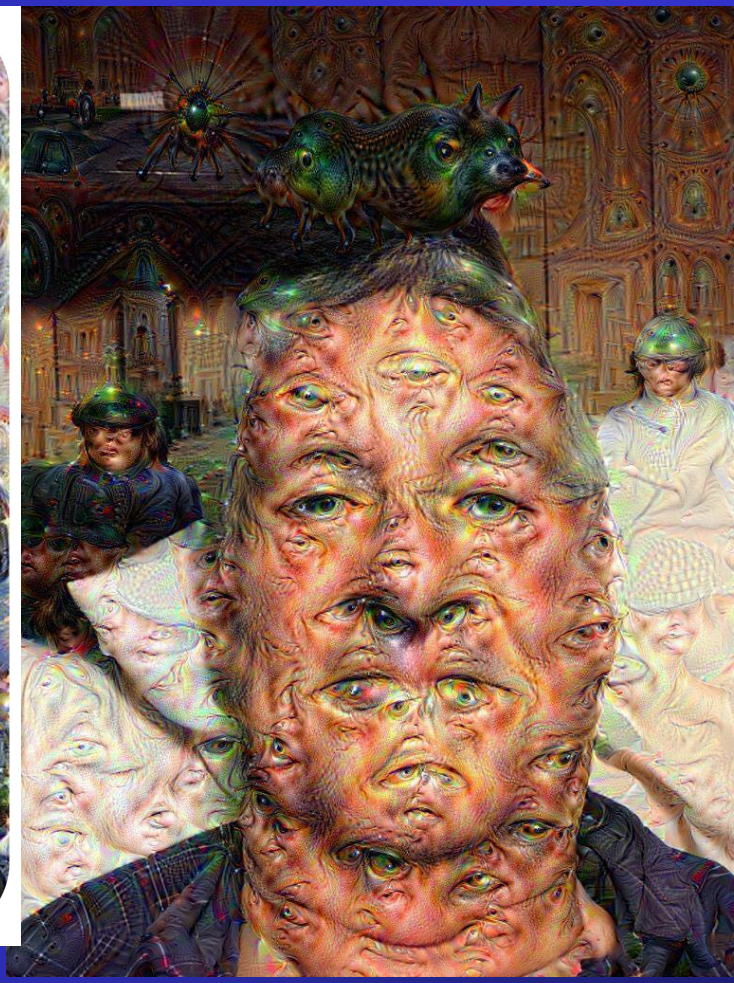
TED

5:30 / 17:00

Hallucinations produced by excessive appearance of internal representations

Hallucinations are uncontrolled perceptions.
"Normal" perceptions are controlled hallucinations.

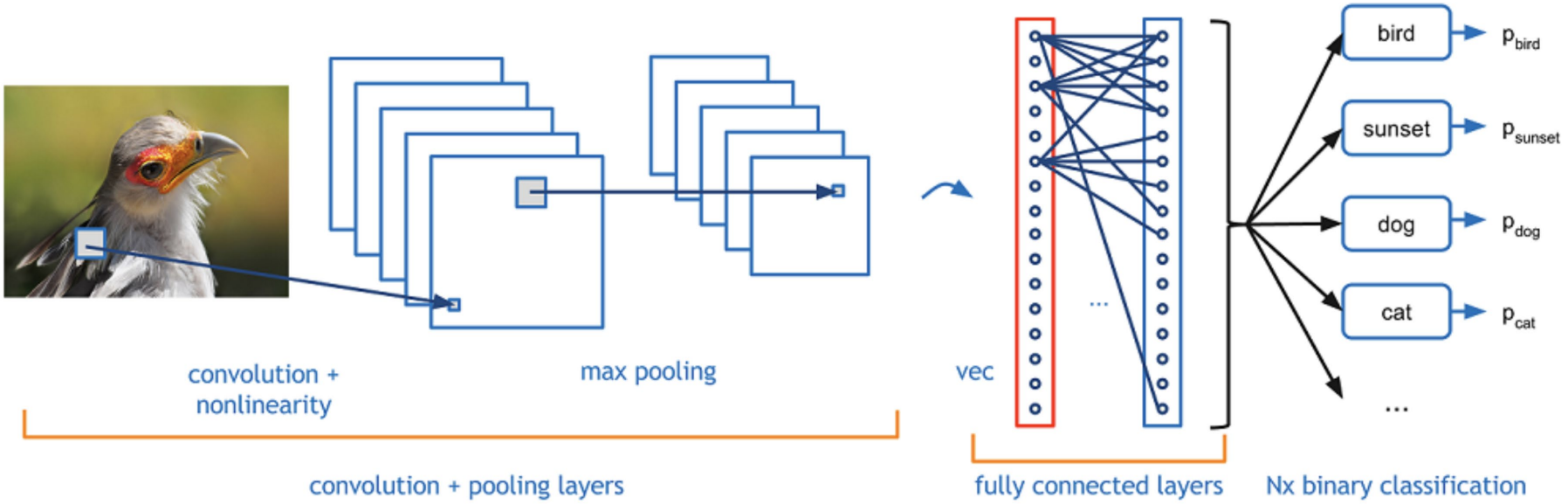
Inceptionism: art from convolutional neural networks



Inceptionism creates images by iteratively modifying an initial image to optimize the response of a hidden unit in a convolutional neural network that was trained to recognize other images.

https://research.google/blog/inceptionism-going-deeper-into-neural-networks/

Convolutional neural network



Multilayer feed-forward network. Successive convolution operations in early layers.

Neural network layers at end produce probability of different categories.

Weights are optimized for classification by training on massive amounts of examples.

Inceptionism iteratively modifies the initial image to optimize the response of a hidden unit. The response of the hidden unit is increased by melding trained images with the presented image.

https://research.google/blog/inceptionism-going-deeper-into-neural-networks/

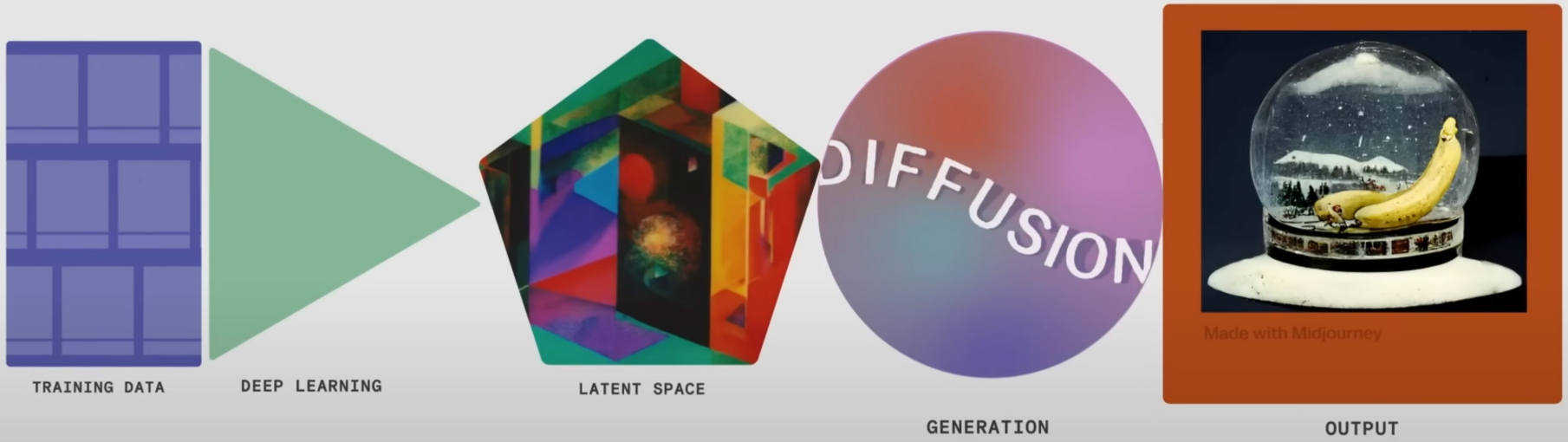
Foundational AI programs can generate art from verbal prompts

Artificial neural networks trained on massive amounts of images and text

DALL-E2 Explained: https://youtu.be/qTgPSKKjfVg

https://labs.openai.com/

Foundational AI programs can generate art from verbal prompts



1. Massive amounts of images and text are processed via deep learning convolutional neural networks and stored in a "latent space".

2. Multidimensional latent space stores data in terms of similarity of features. Somewhat analogous to a brain, with parameters analogous to synapses.

3. A verbal prompt activates corresponding image parameters which are converted to output via a "diffusion" generation stage.

For a simplified description of the underlying technology see the video "AI art, explained":

https://youtu.be/SVcsDDABEkM