NST II Psychology
NST II Neuroscience (Module 5)

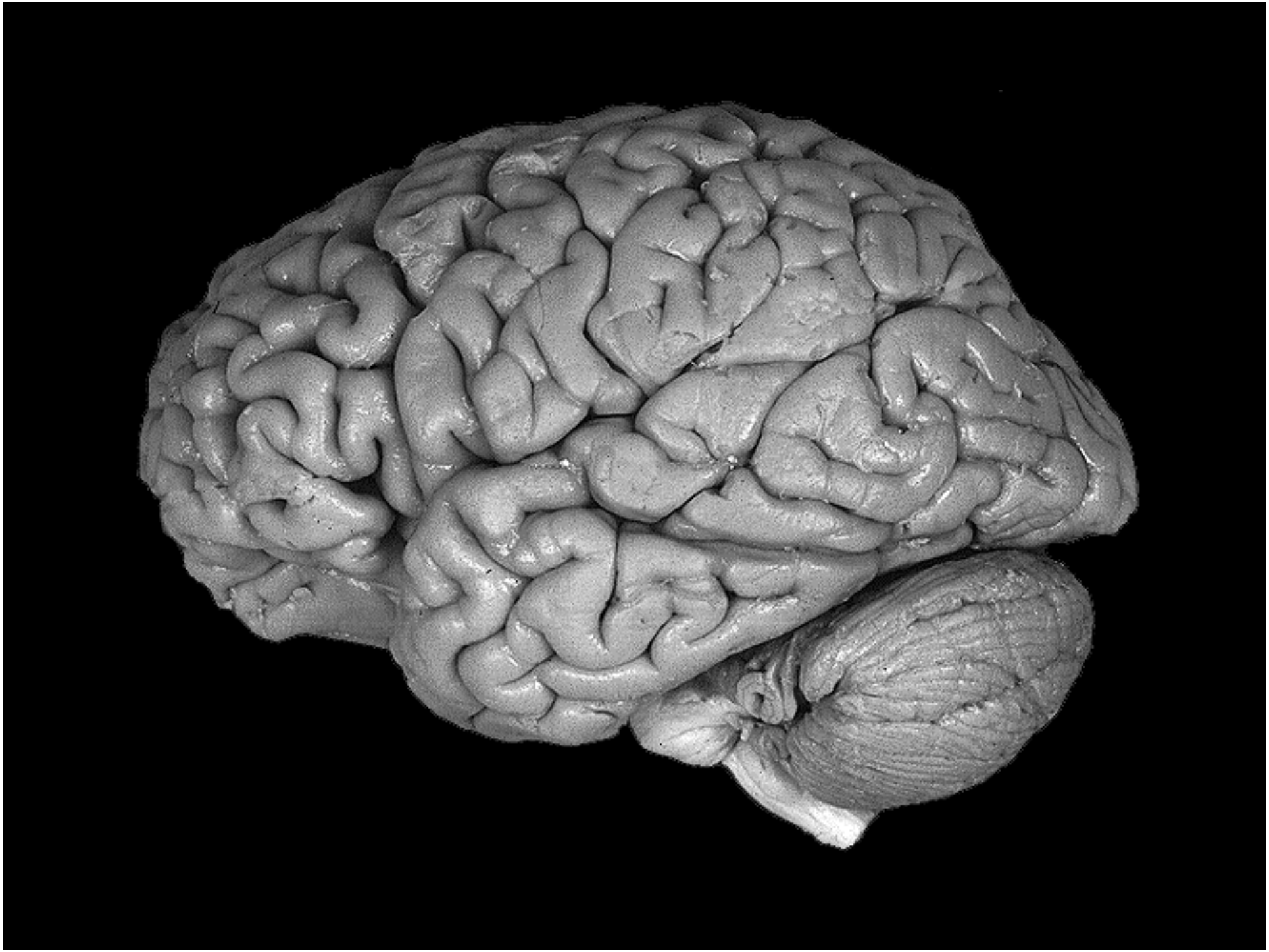
Brain Mechanisms of Memory and Cognition – 1

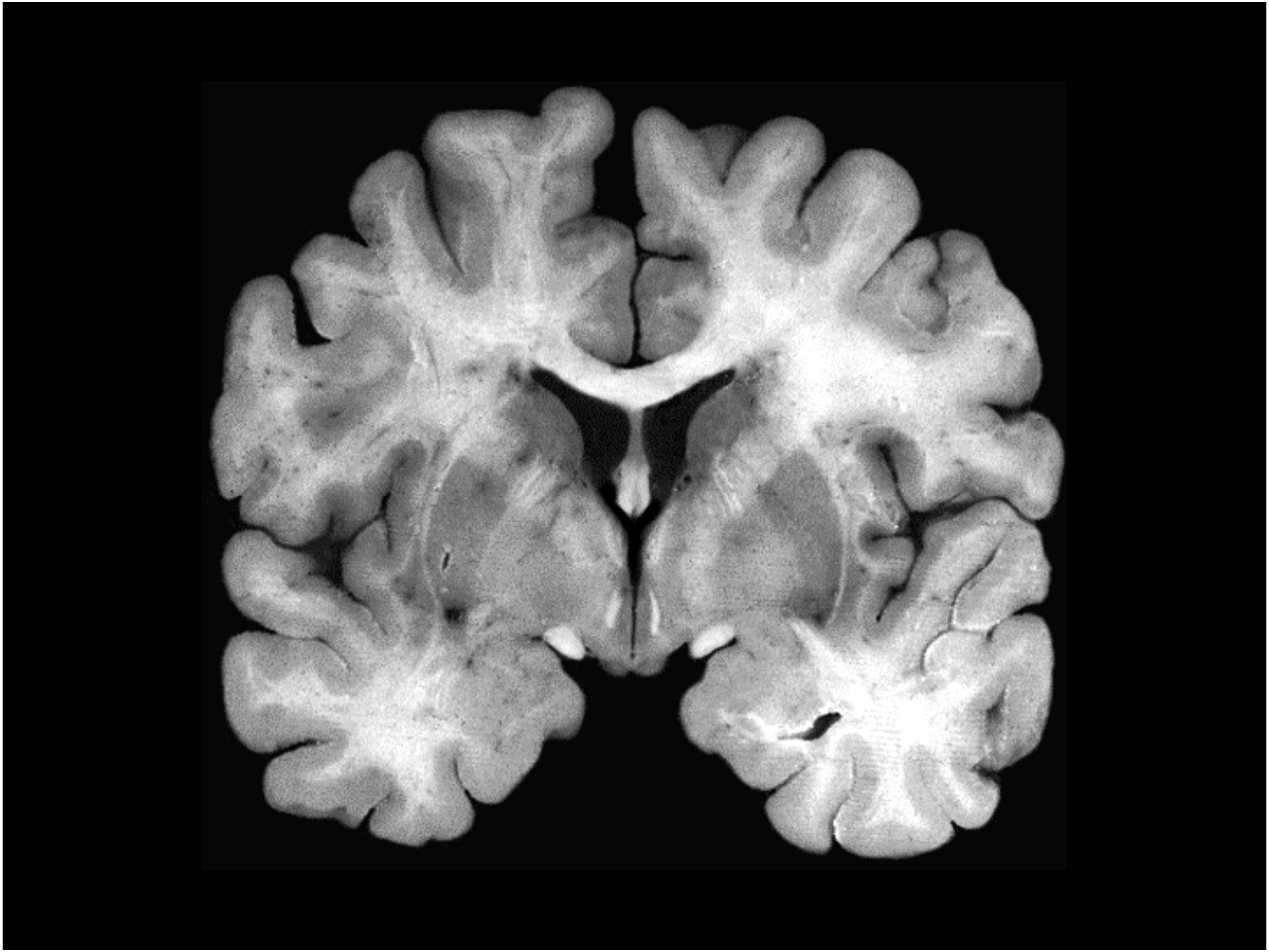
Cerebral cortex; the two visual streams

Rudolf Cardinal
Department of Experimental Psychology

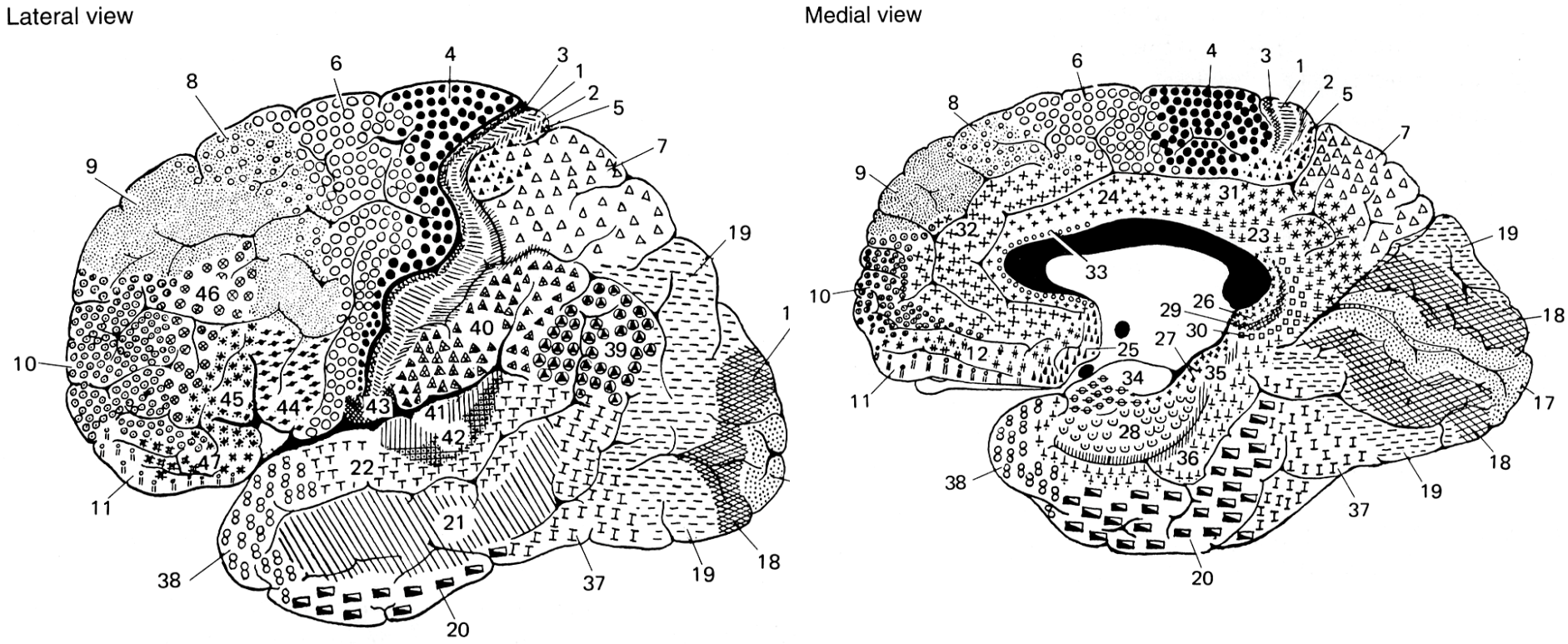
Monday 12, 19, 26 Jan; 2, 9, 23 Feb 2004; 10 am
Physiology Main Lecture Theatre
Slides will be at pobox.com/~rudolf/psychology

Part 1
Cerebral cortex





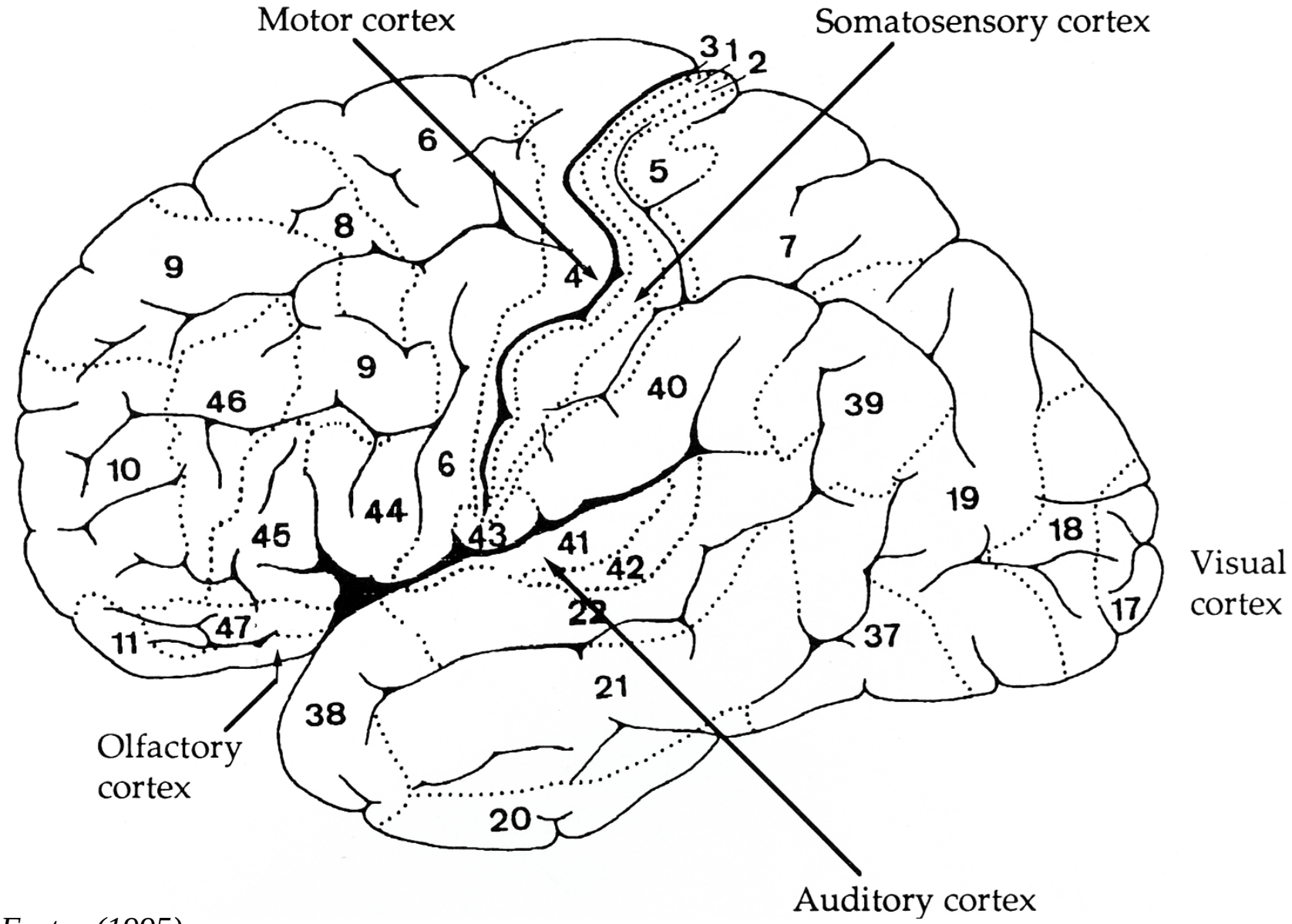
Heterogeneity of cerebral cortex



Brodmann's areas in the human

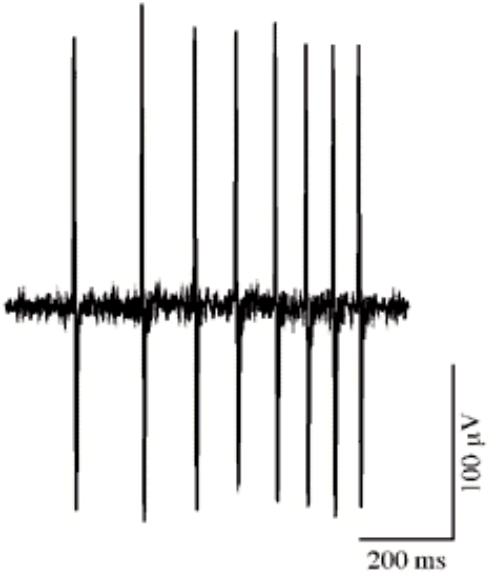
Brodmann (1909)

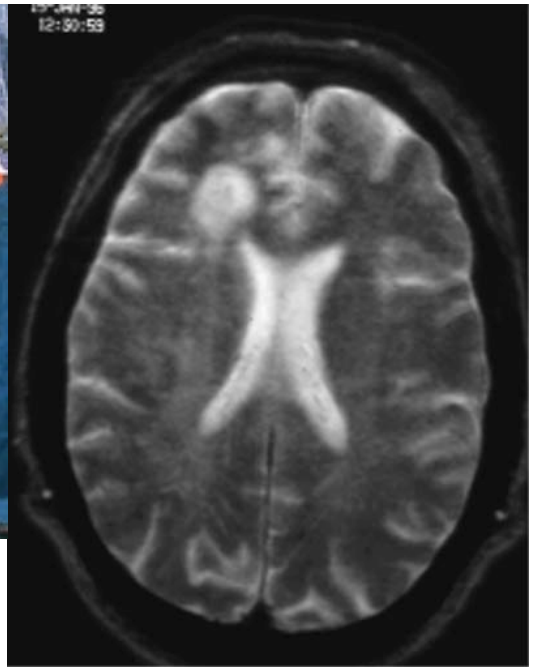
Heterogeneity of cerebral cortex

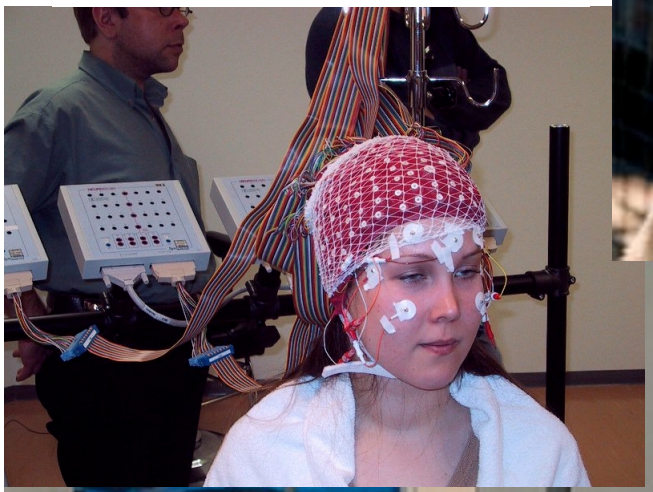


from Fuster (1995)

Heterogeneity of cerebral cortex: study techniques

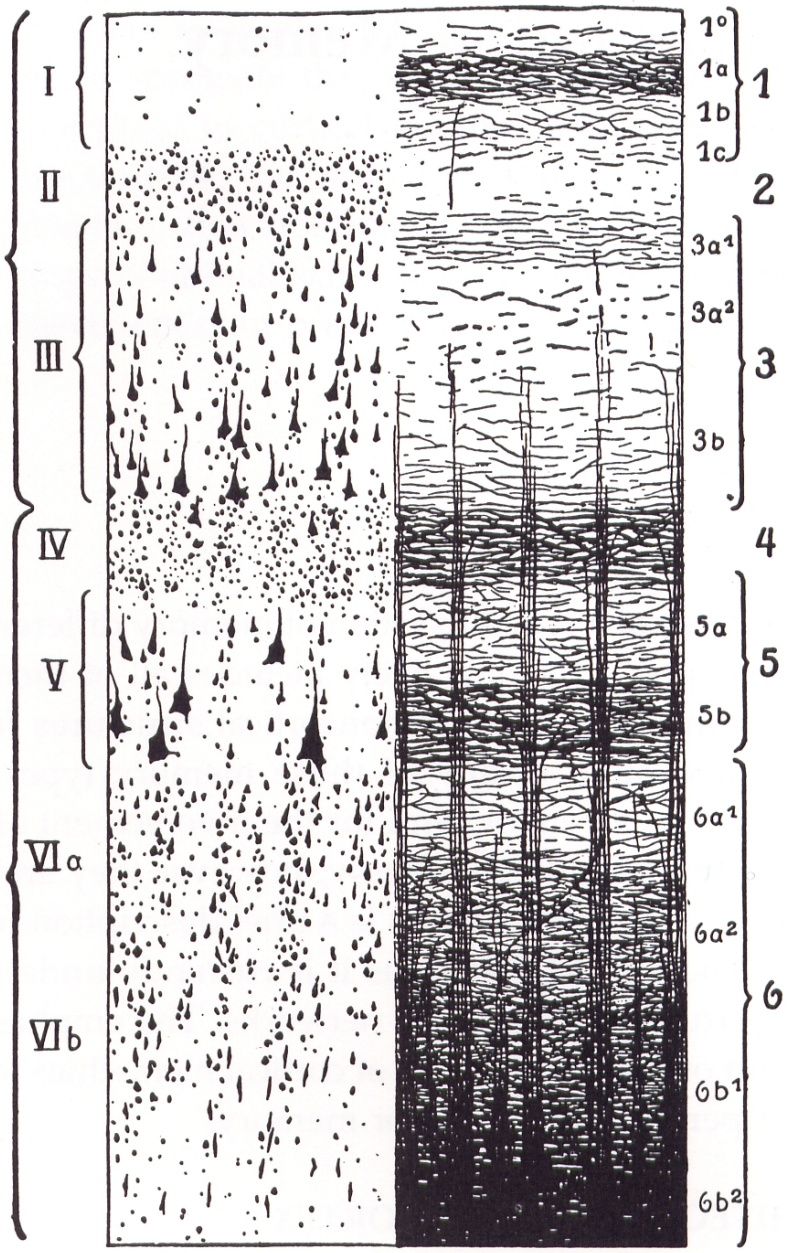






Layers of the cerebral cortex: appearance

cellular



myelin

from Fuster (1995)

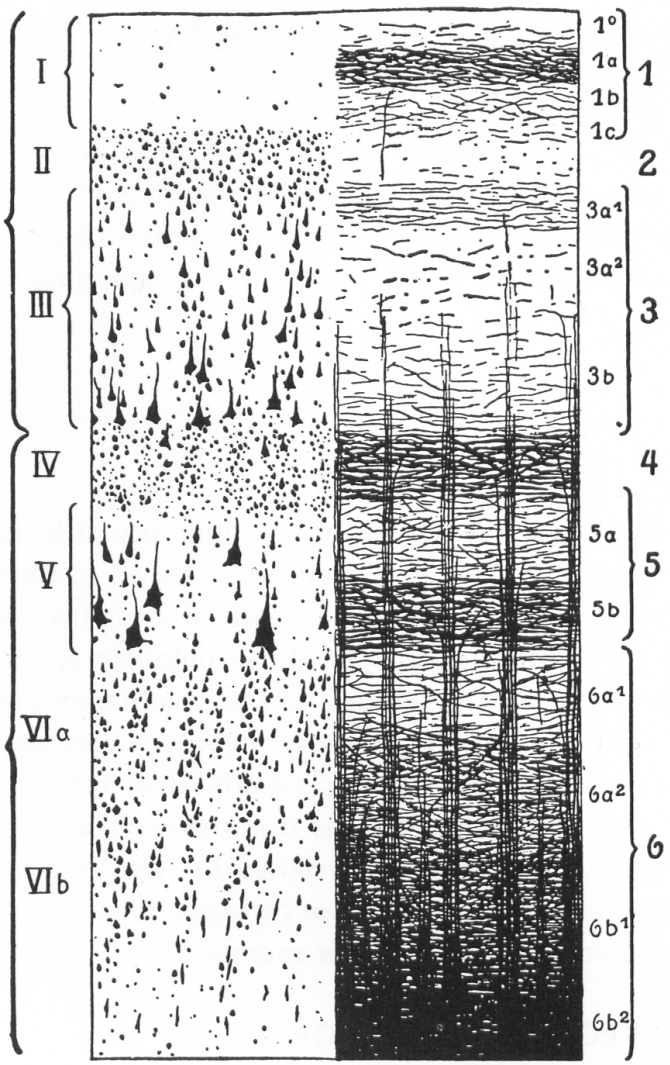
Layers of the cerebral cortex: connections

corticocortical connections
via many layers, esp. from 3 and to 1-3

specific thalamic
afferents to layer 4

outputs to subcortical
structures from layer 5

outputs to thalamus
from layer 6



Neuromodulatory inputs
to all layers

modified from Fuster (1995)

The column: a basic unit of cortical function?

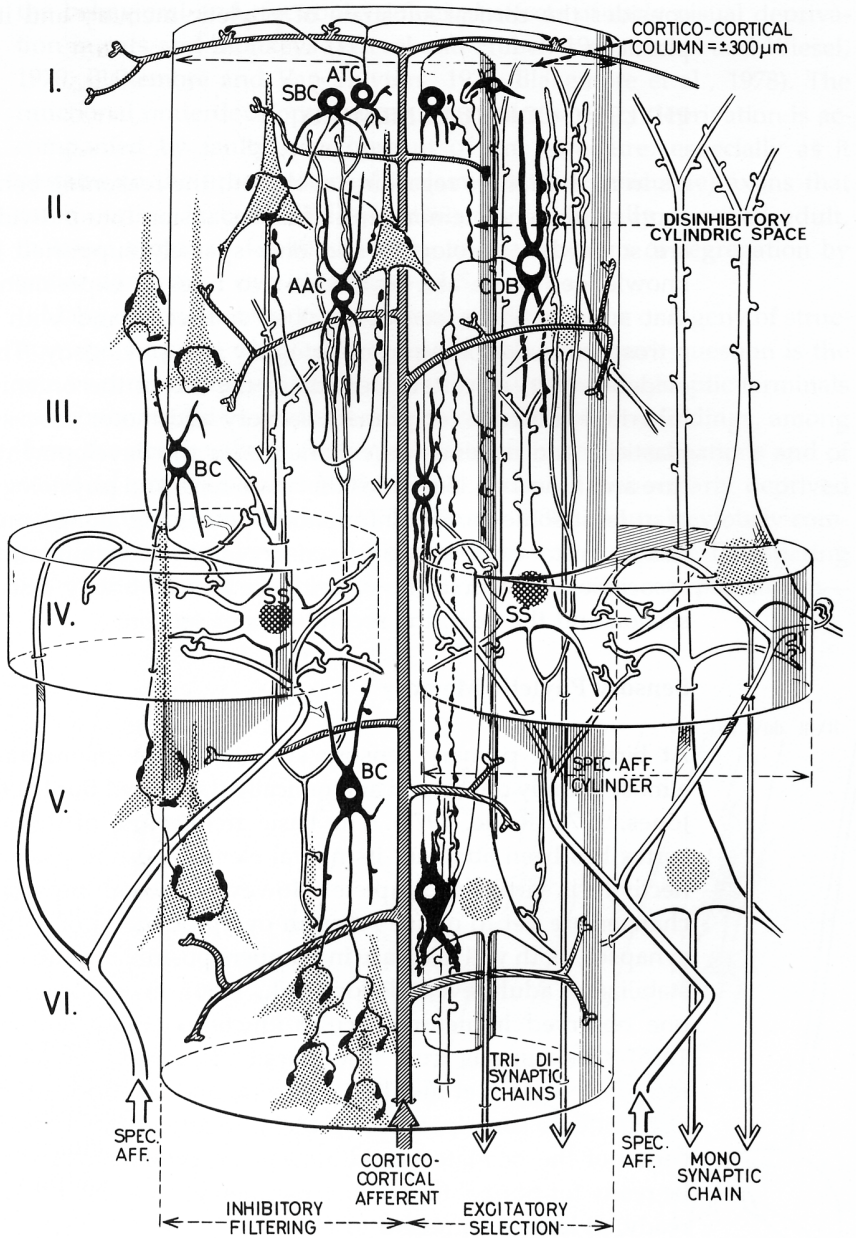
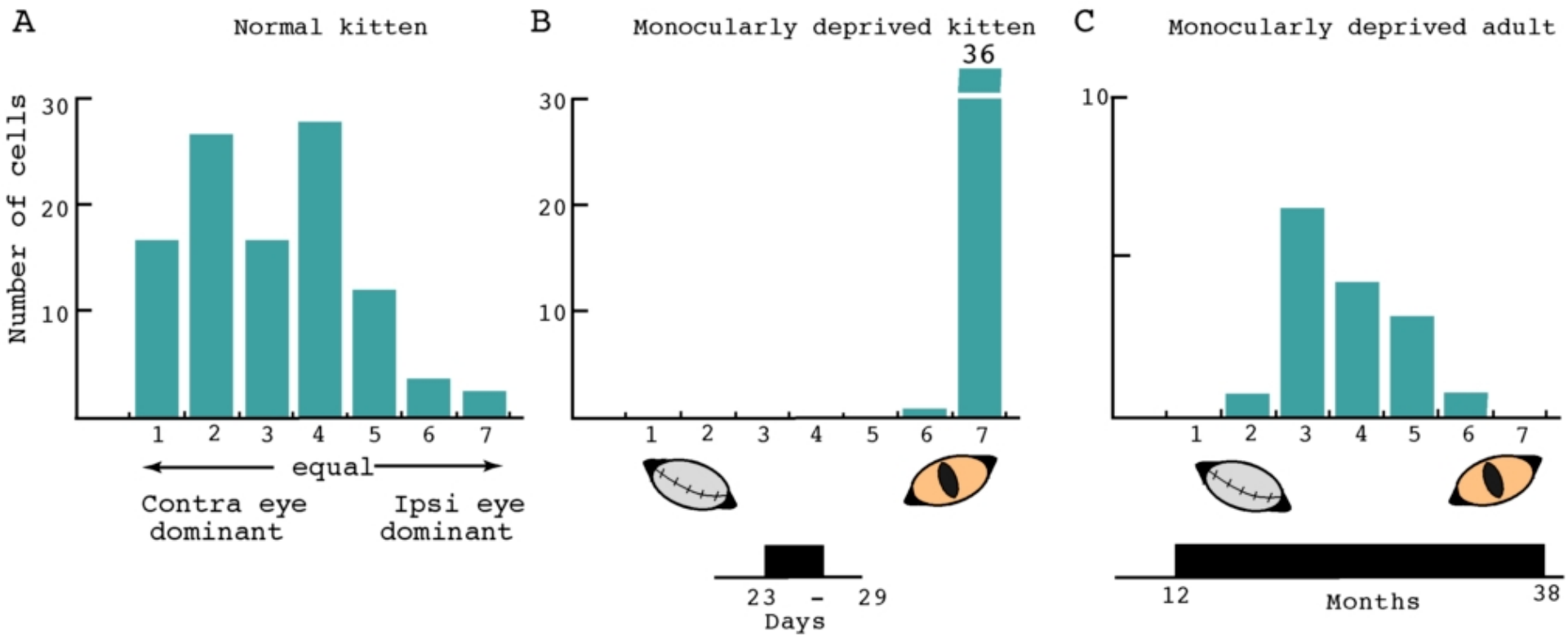


Figure 4.4 An idealized column of cortex comprising and defined by the terminal branches of a corticocortical afferent axon (three functional assumptions are noted in the diagram). The column is flanked by sections of two specific (thalamic) afferent cylinders. AAC, axoaxonic cell; ATC, axonal tuft cell; BC, basket cell; CDB, cell *à double bouquet;* SBC, small basket cell; SS, spiny stellate cell. (From Szentágothai, 1983, with permission.)

from Fuster (1995)

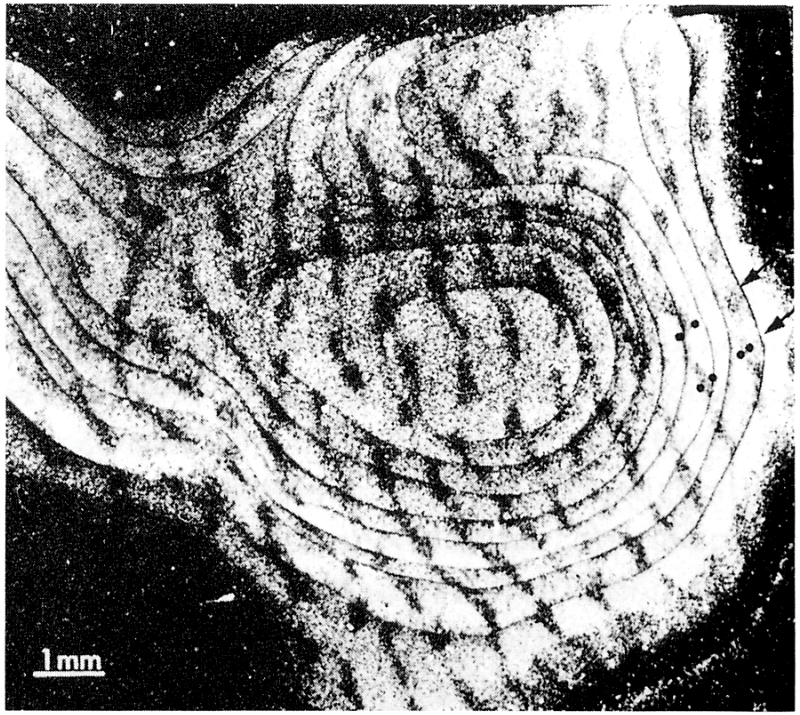
Developmental plasticity in kitten visual cortex: critical periods



Hubel & Wiesel (1970)

Plasticity in kitten visual cortex: ocular dominance columns

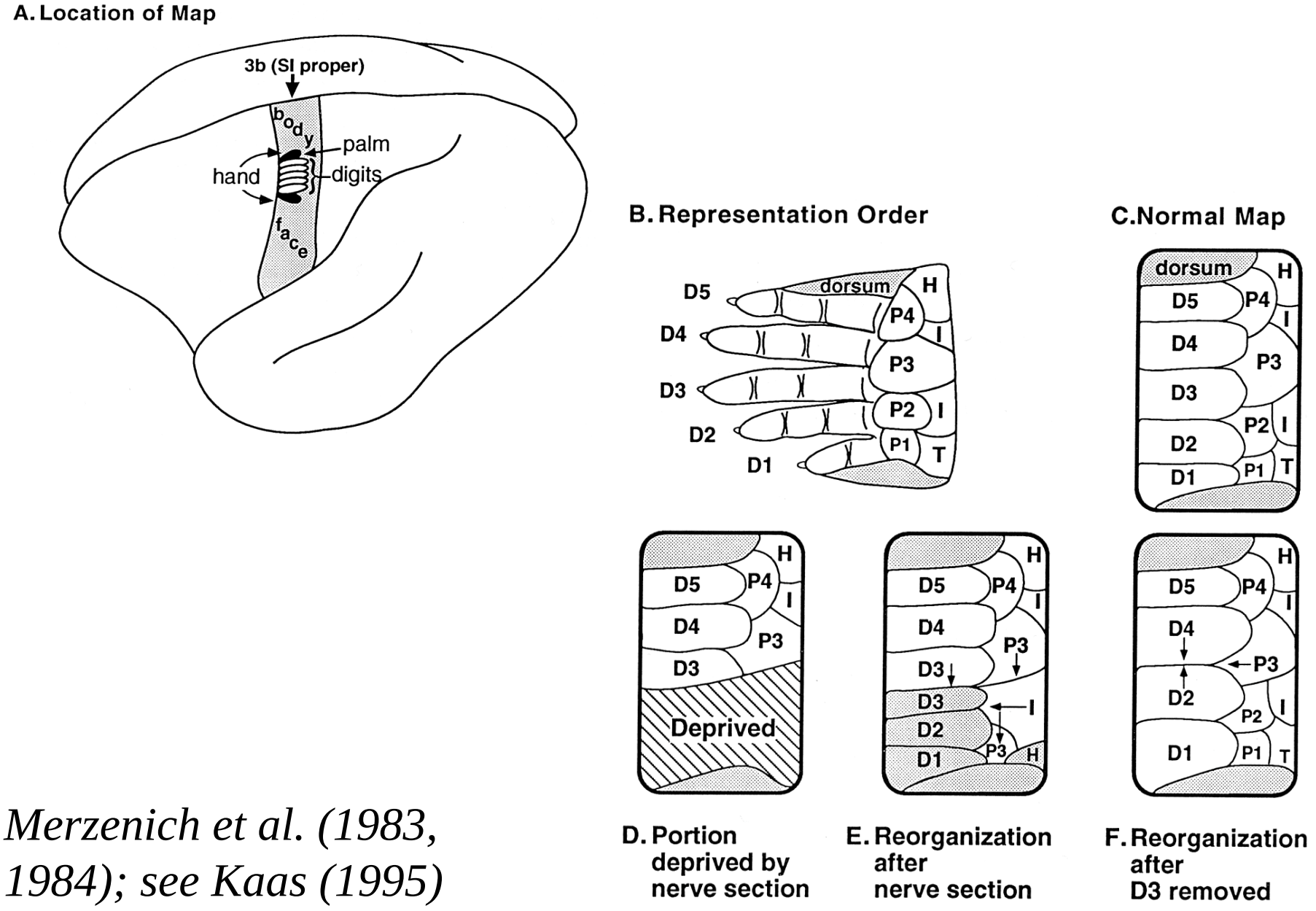
normal



deprived (white label is from open eye)

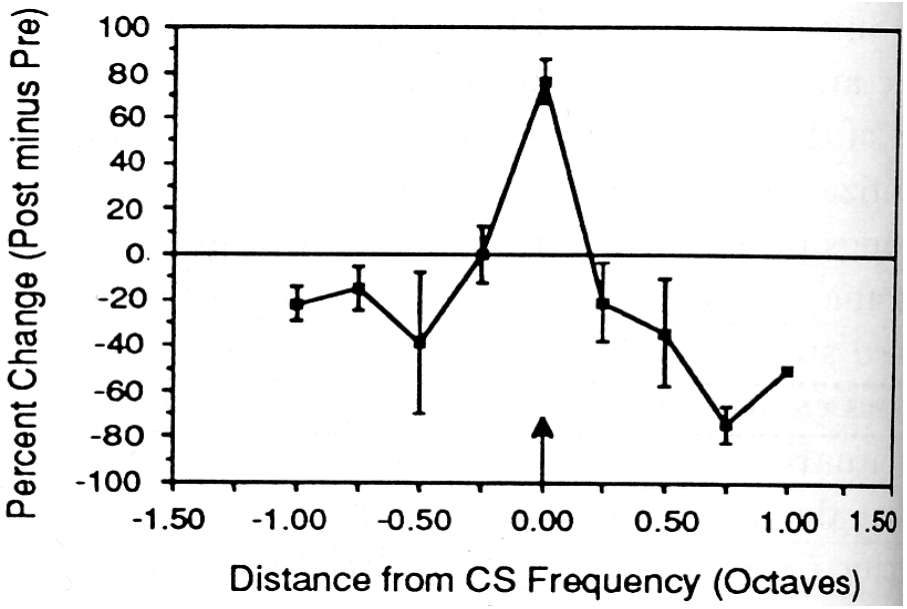
Hubel & Wiesel (1977)

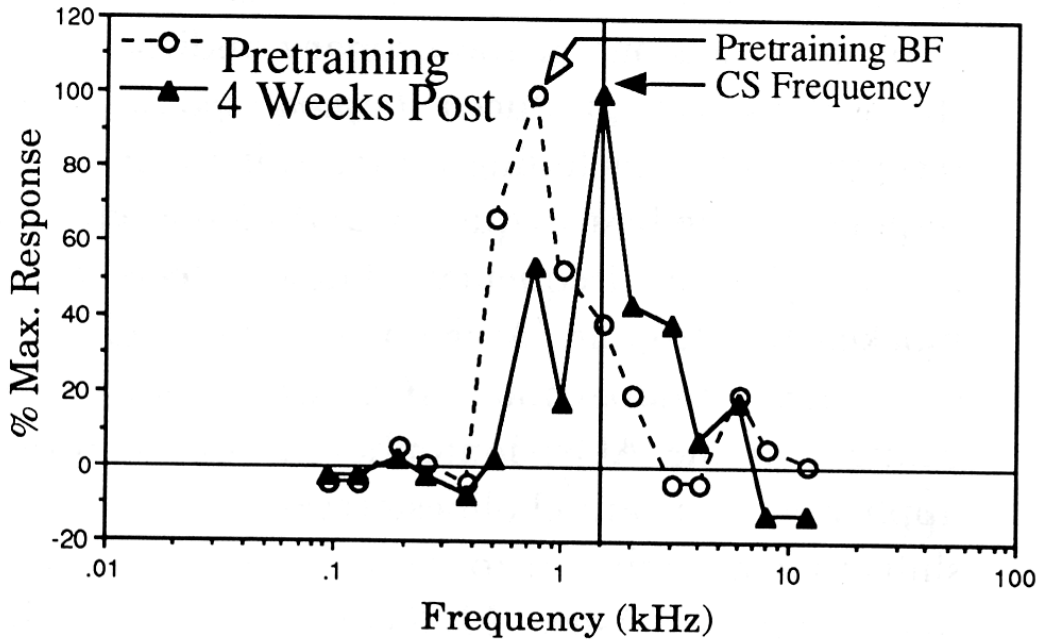
Adult cortical plasticity in a somatosensory map



Merzenich et al. (1983, 1984); see Kaas (1995)

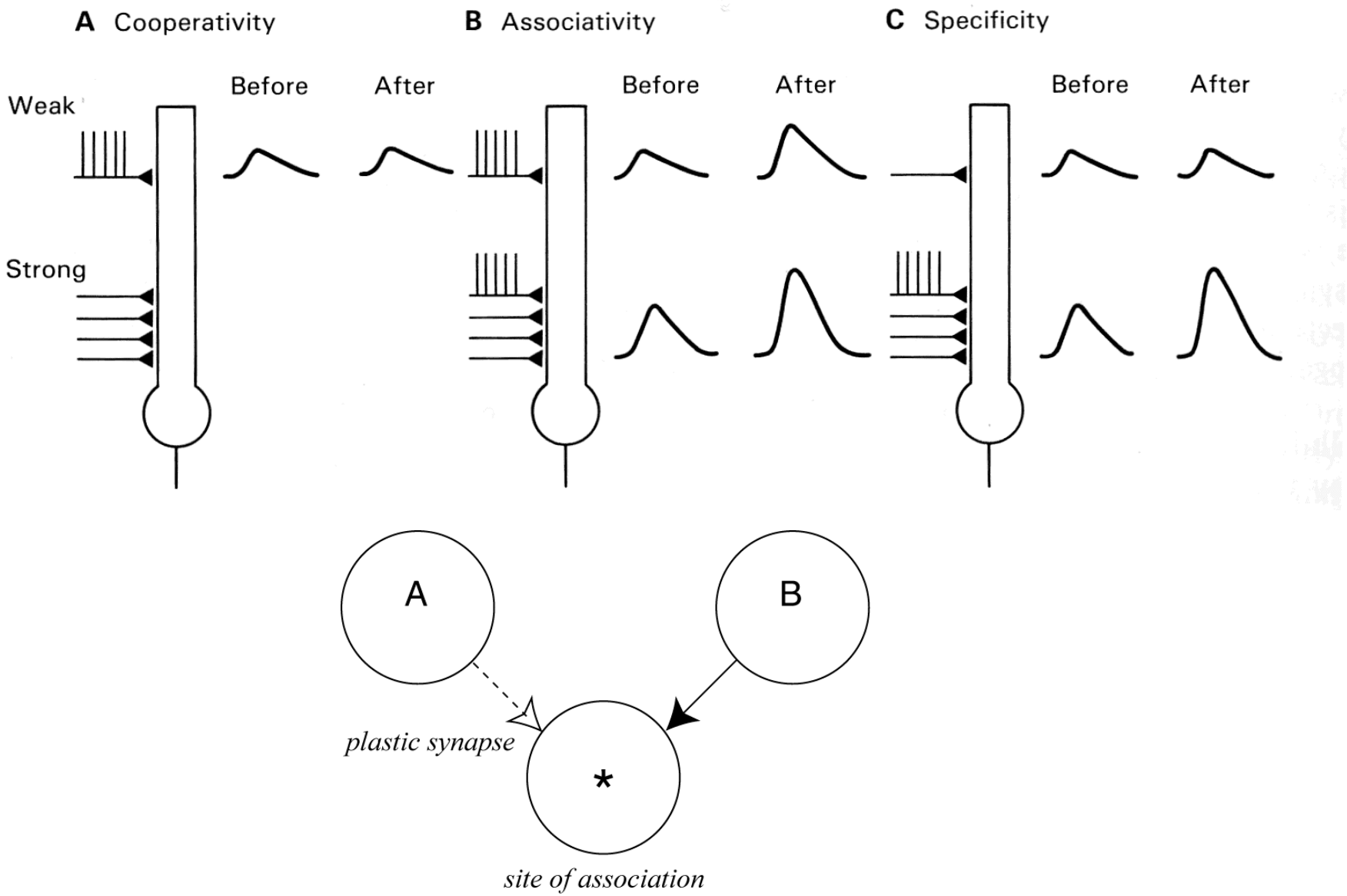
Rapid, long-lasting, task-related auditory cortex plasticity



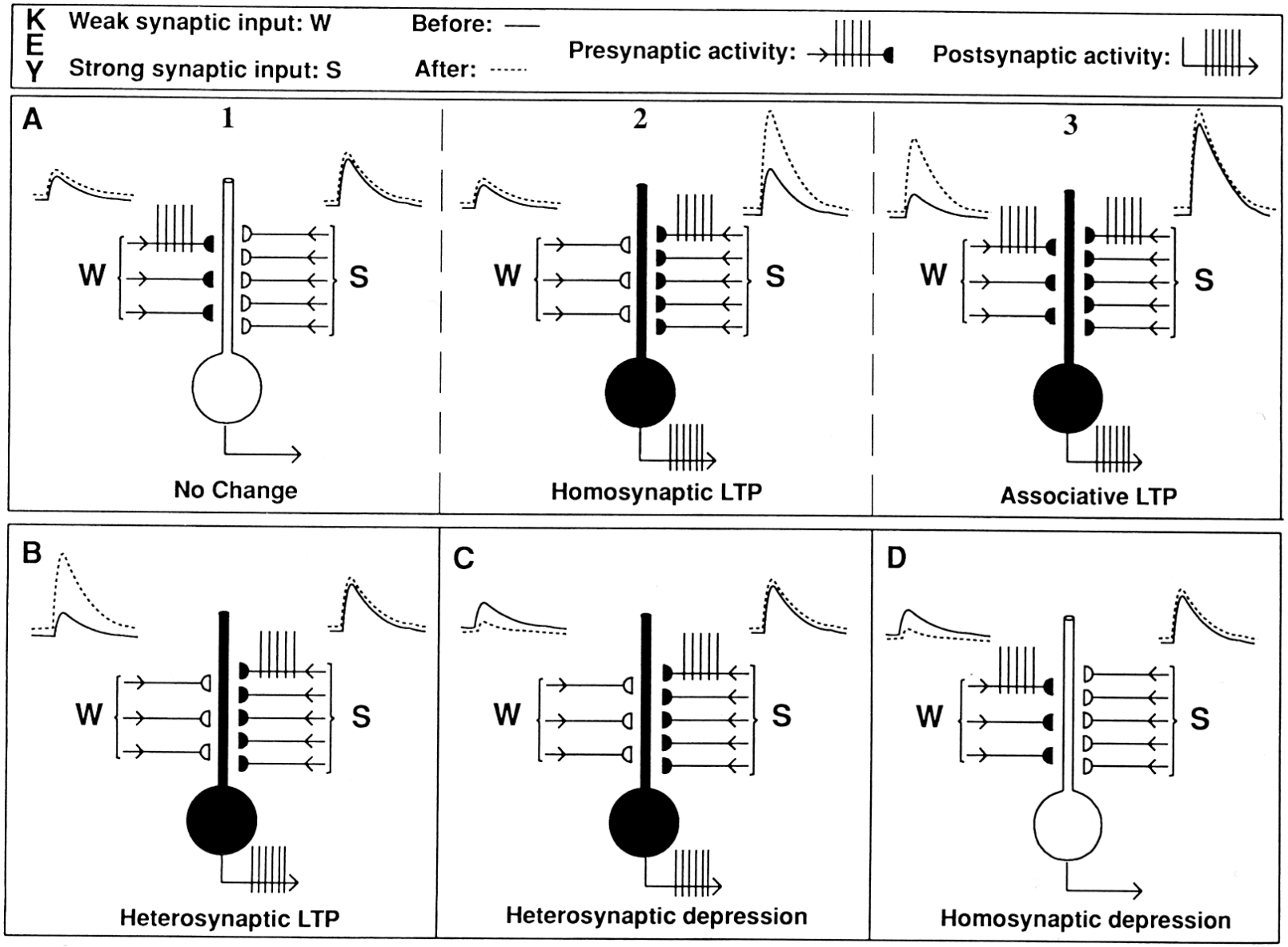


Weinberger (1995)

Long-term potentiation (LTP): a form of synaptic plasticity...

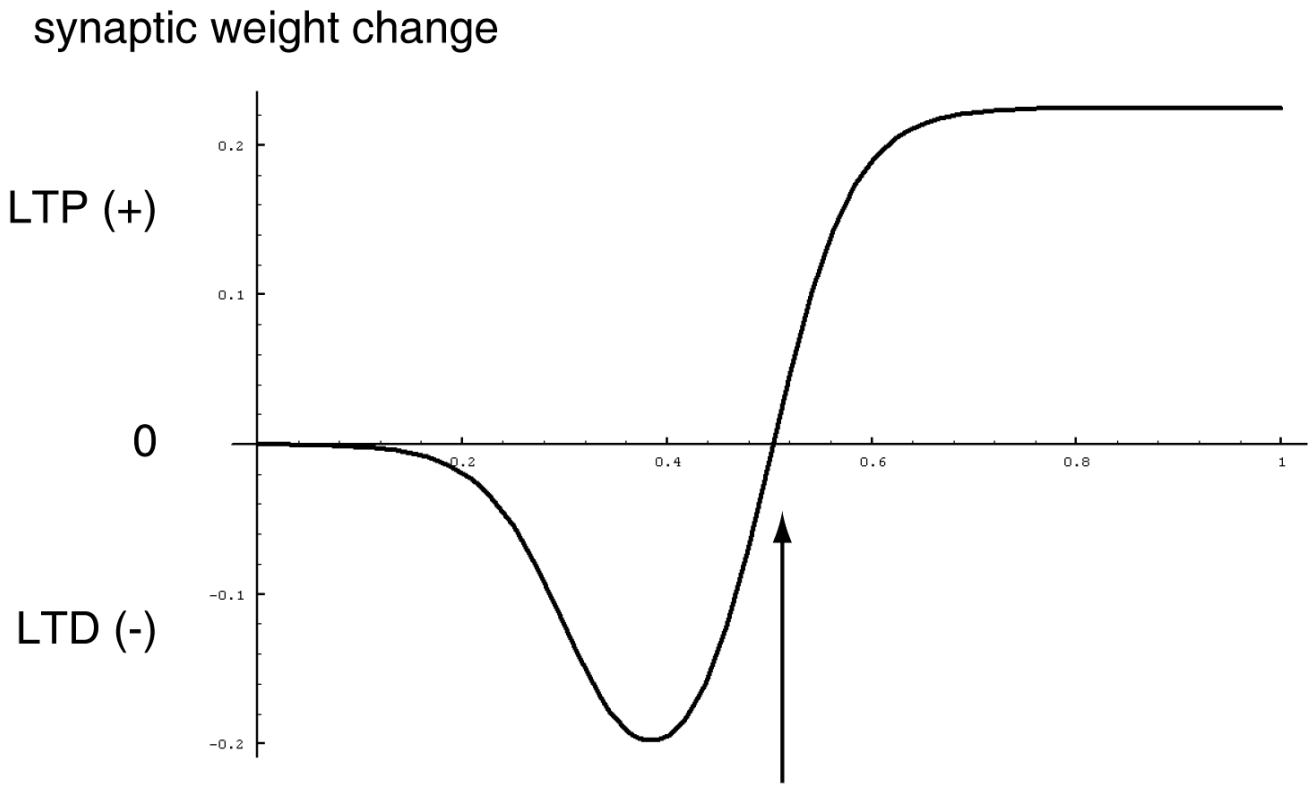


… of which there are several



from Fuster (1995)

Synaptic metaplasticity: Bienenstock-Cooper-Munro model



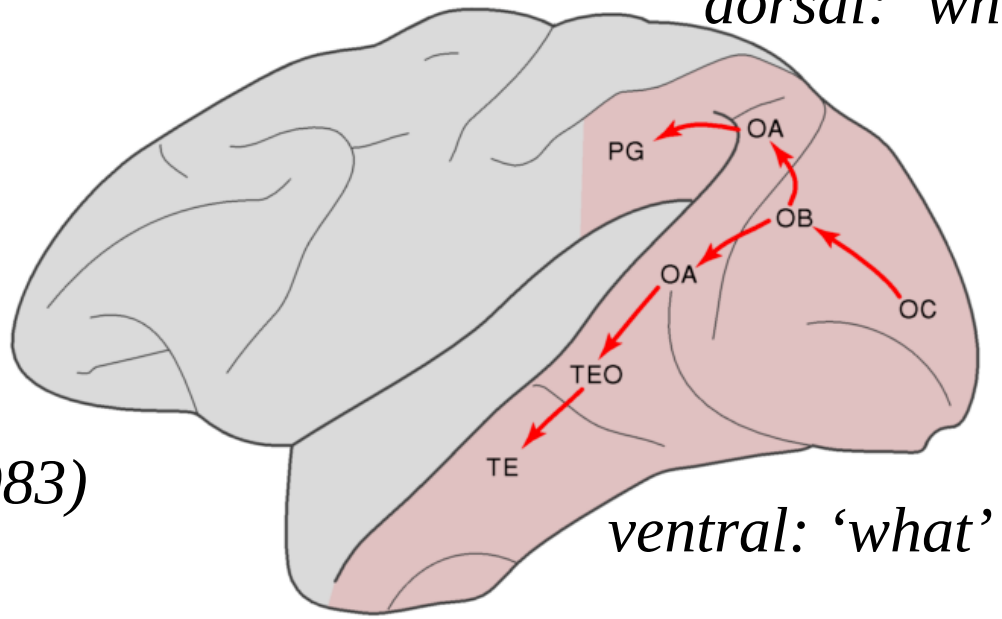
According to the Bienenstock-Cooper-Munro theory, this threshold increases when the postsynaptic cell has been active recently (and decreases when it hasn't).

Bienenstock, Cooper, Munro (1982)

Part 2
Visual streams

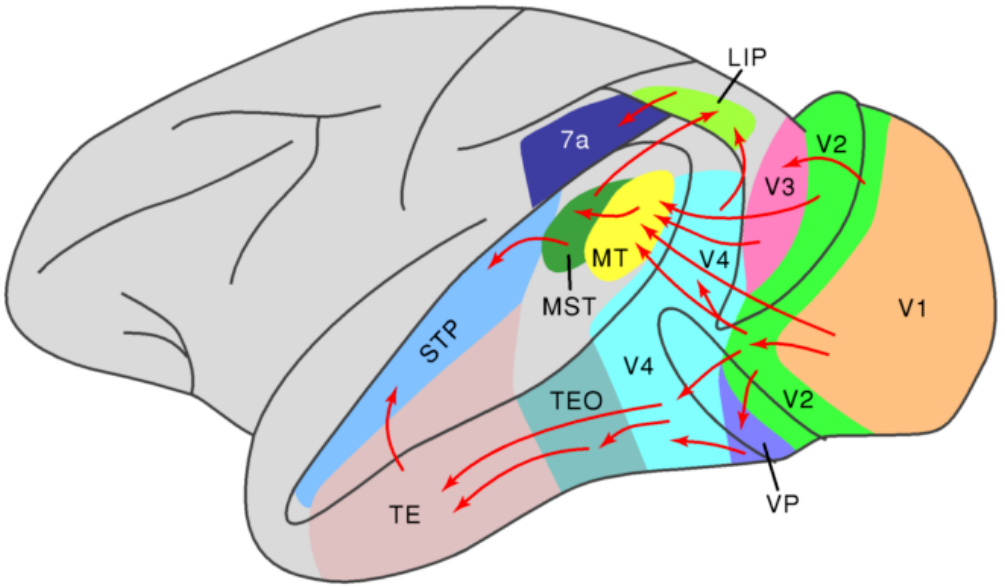
Two visual streams

dorsal: 'where' (or 'how')

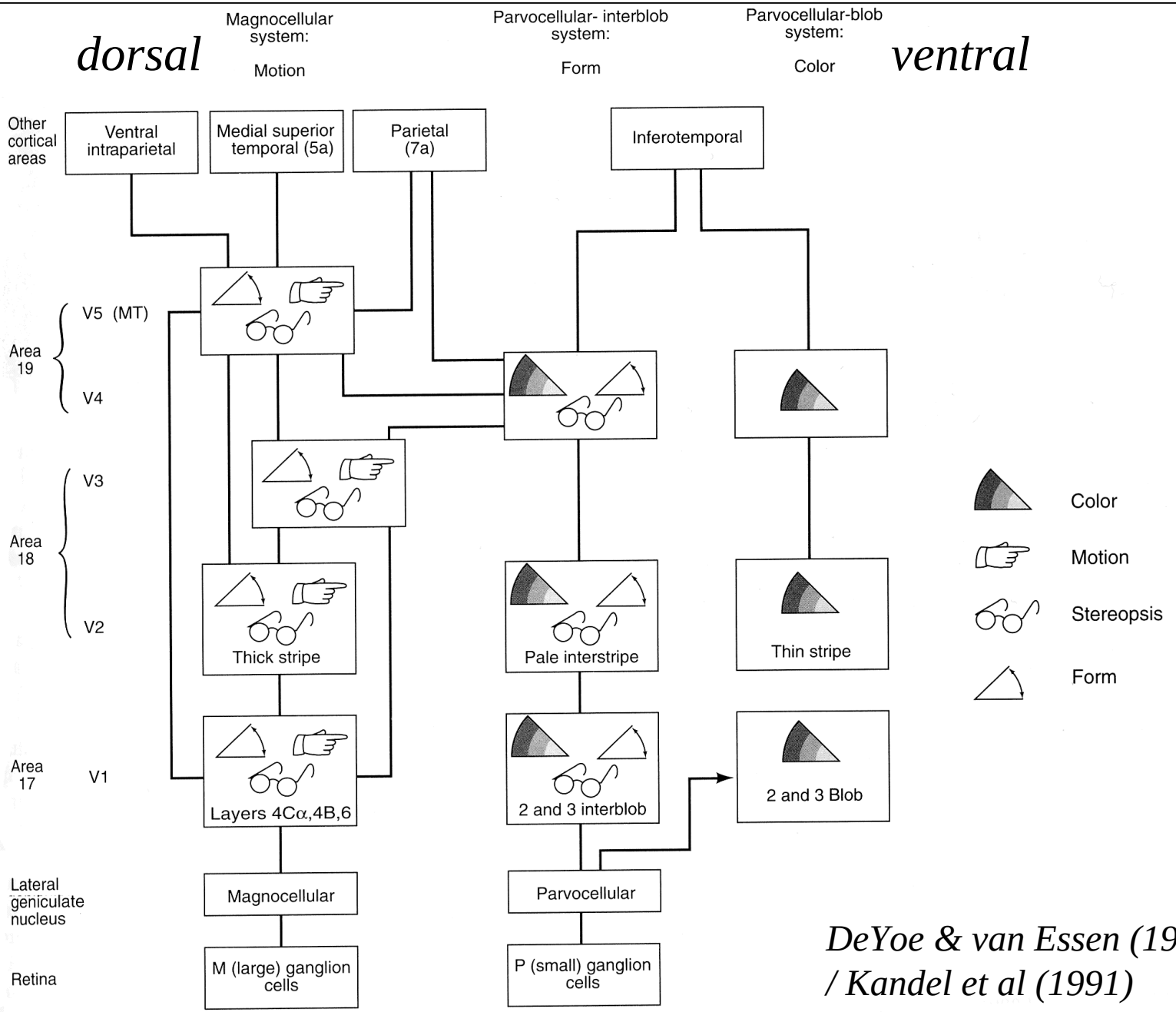


Mishkin et al. (1983)

ventral: 'what'

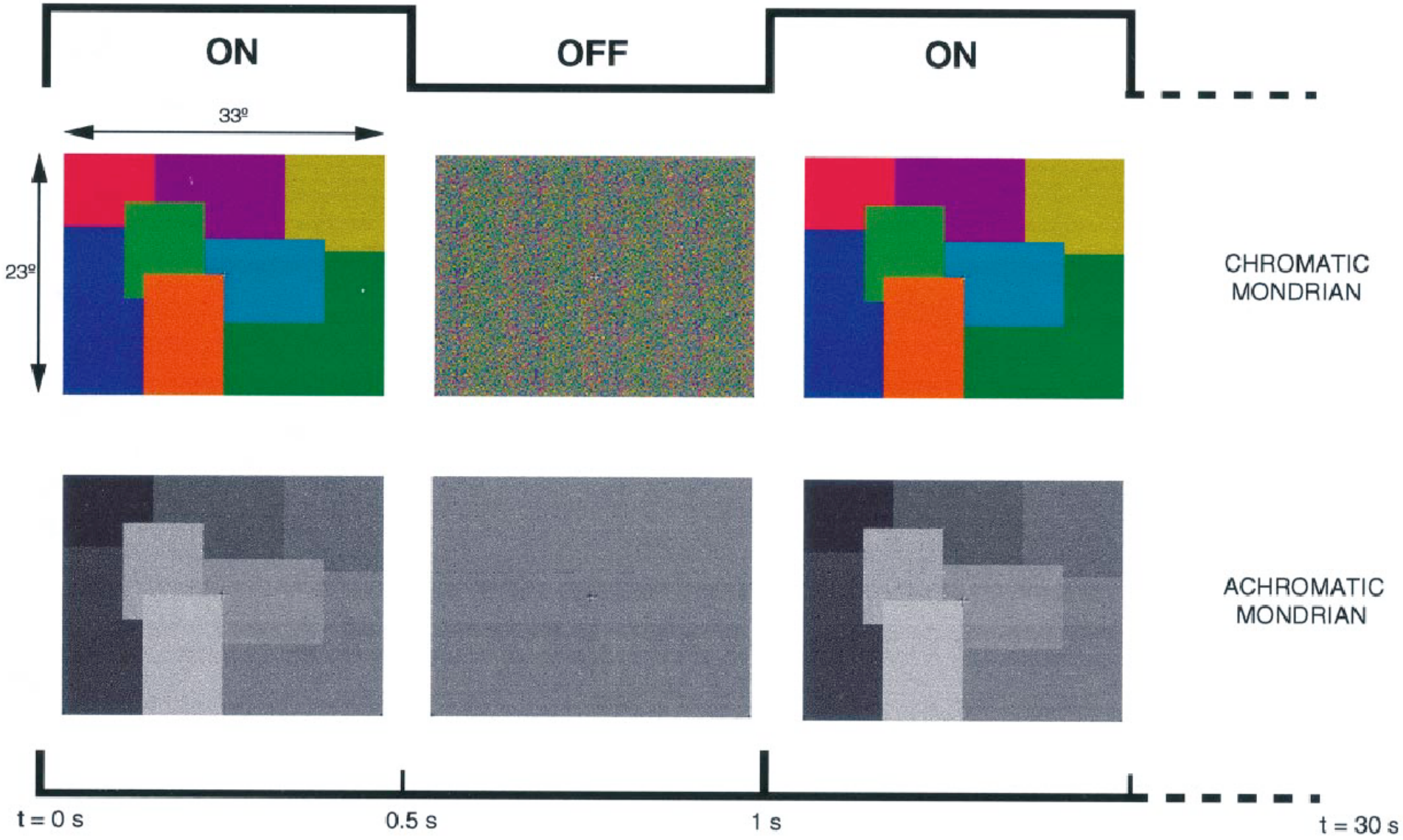


Concurrent (parallel) processing begins at the retina



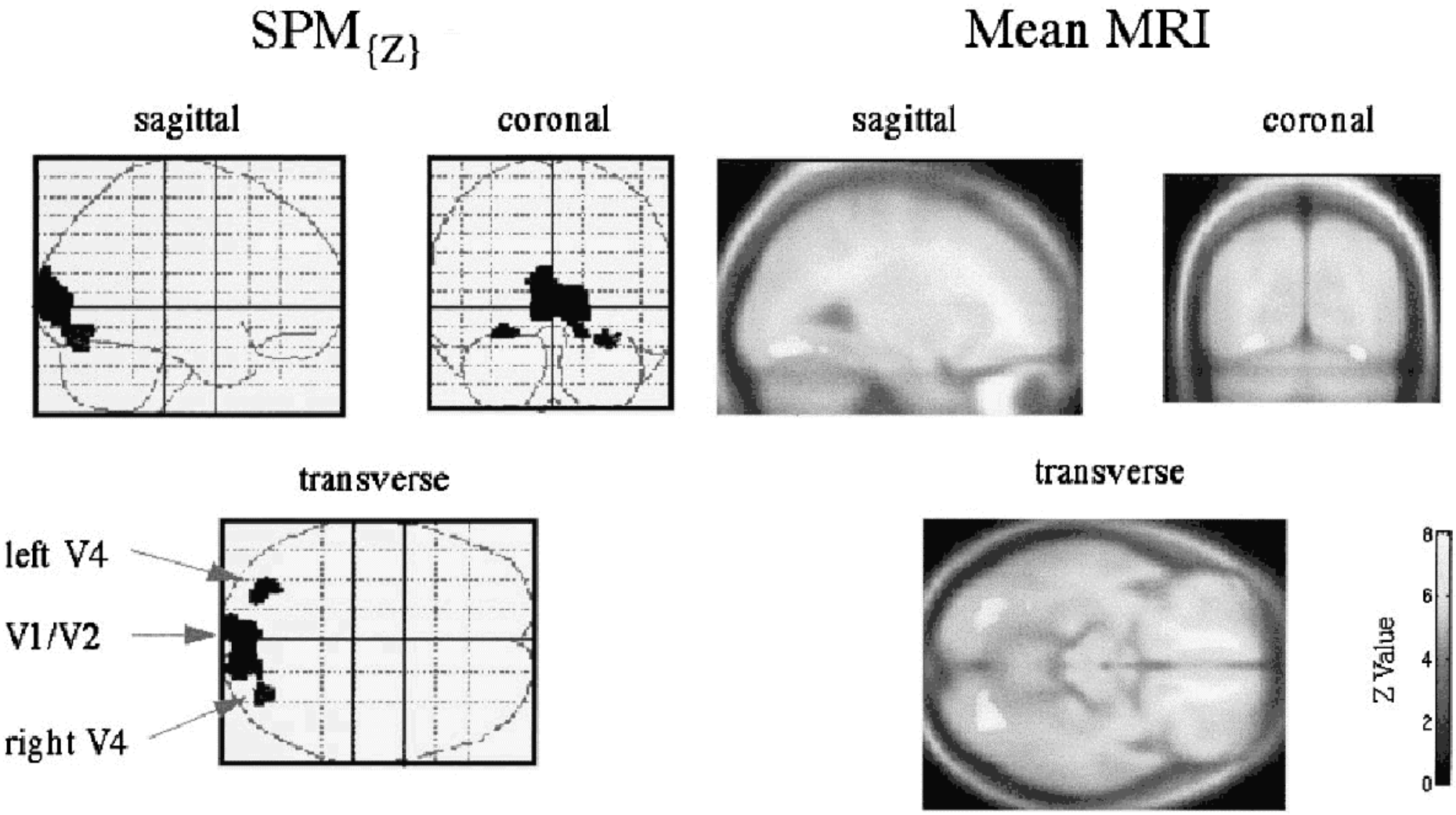
DeYoe & van Essen (1988) / Kandel et al (1991)

fMRI of V4 during colour perception



McKeefry & Zeki (1997) Brain 120: 2229

fMRI of V4 during colour perception



McKeefry & Zeki (1997) Brain 120: 2229

Achromatopsia following V4 lesions in humans

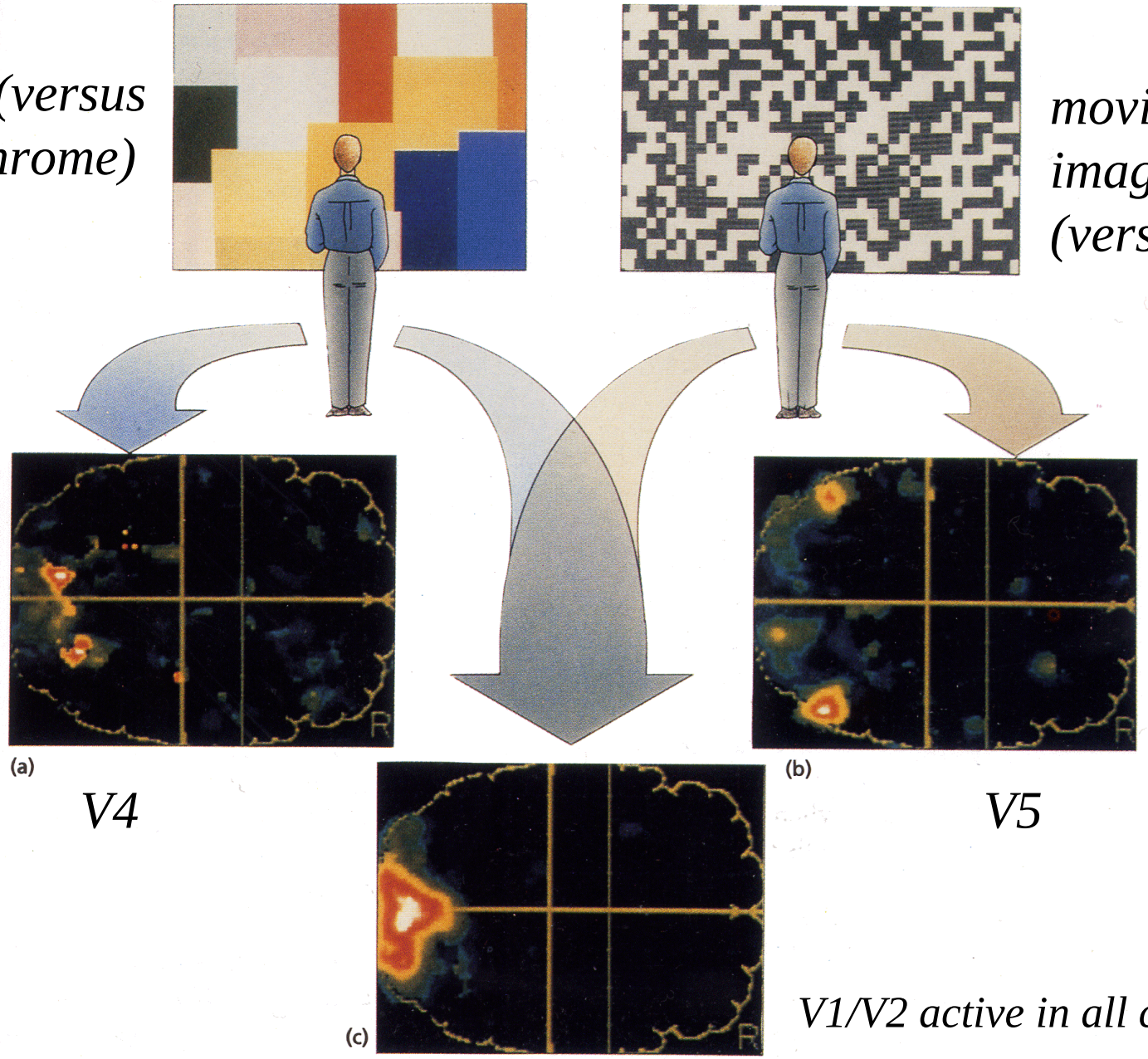
Achromatopsia in an artist (Sacks & Wasserman, 1987). Clockwise: banana, tomato, canteloupe, leaves.

Hemiachromatopsia following a unilateral V4 lesion (Zeki 1990)

Colour (V4) and motion (V5)

colour (versus monochrome)

moving dot image (versus still)



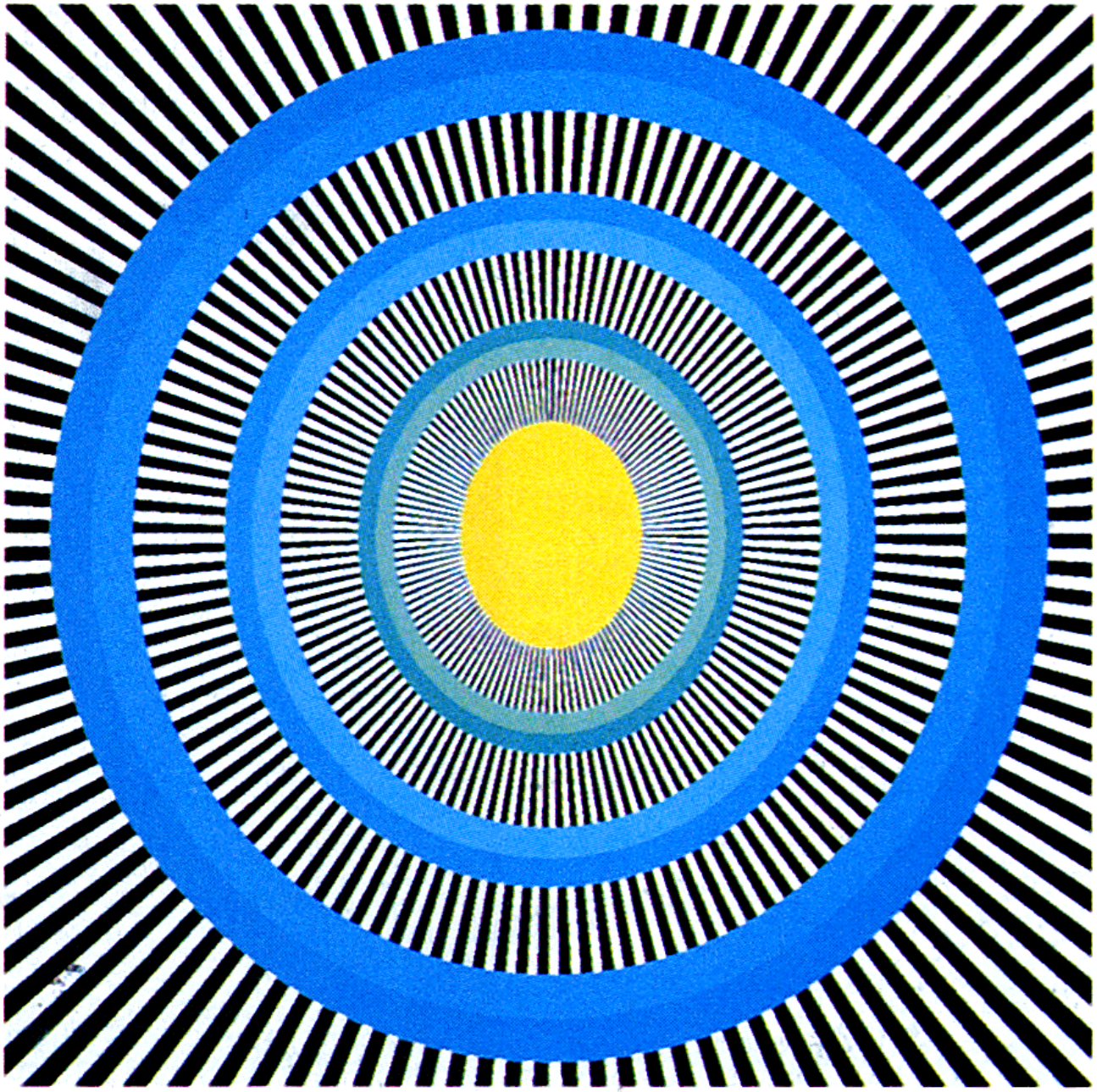
V4

V5

V1/V2 active in all conditions

Zeki (1993)

Apparent motion and V5



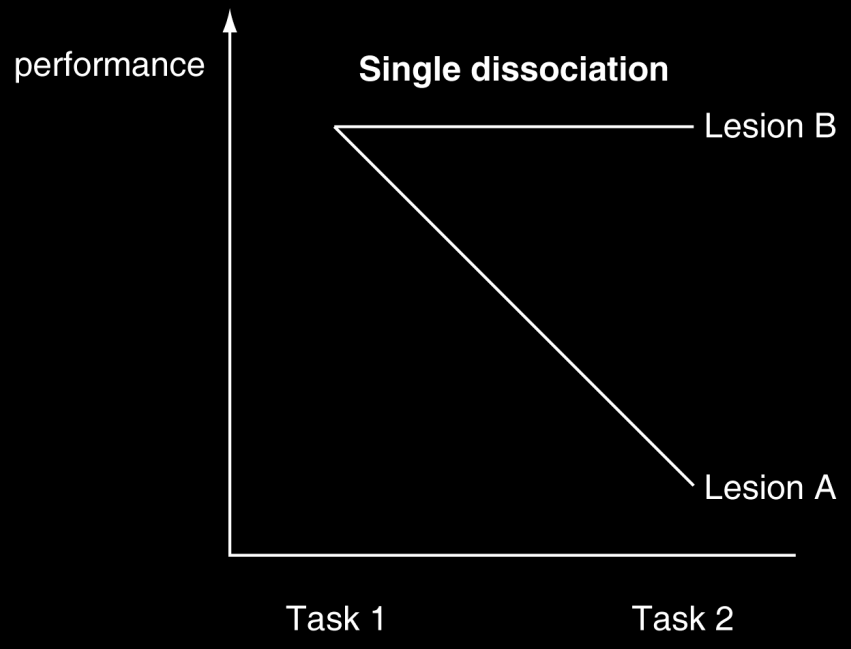
‘Enigma’, by Isia Levant.

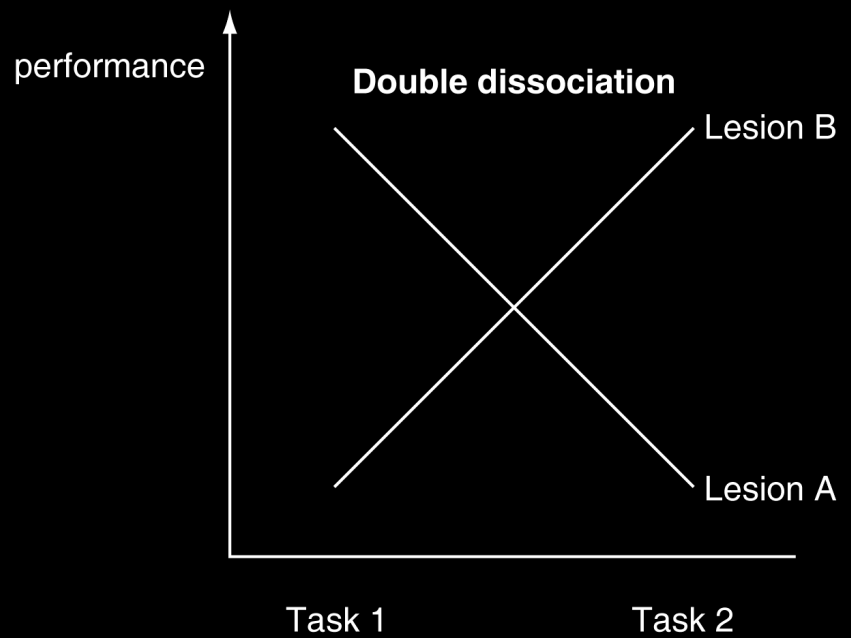
Apparent motion is correlated with V5 activation.

Zeki (1993)

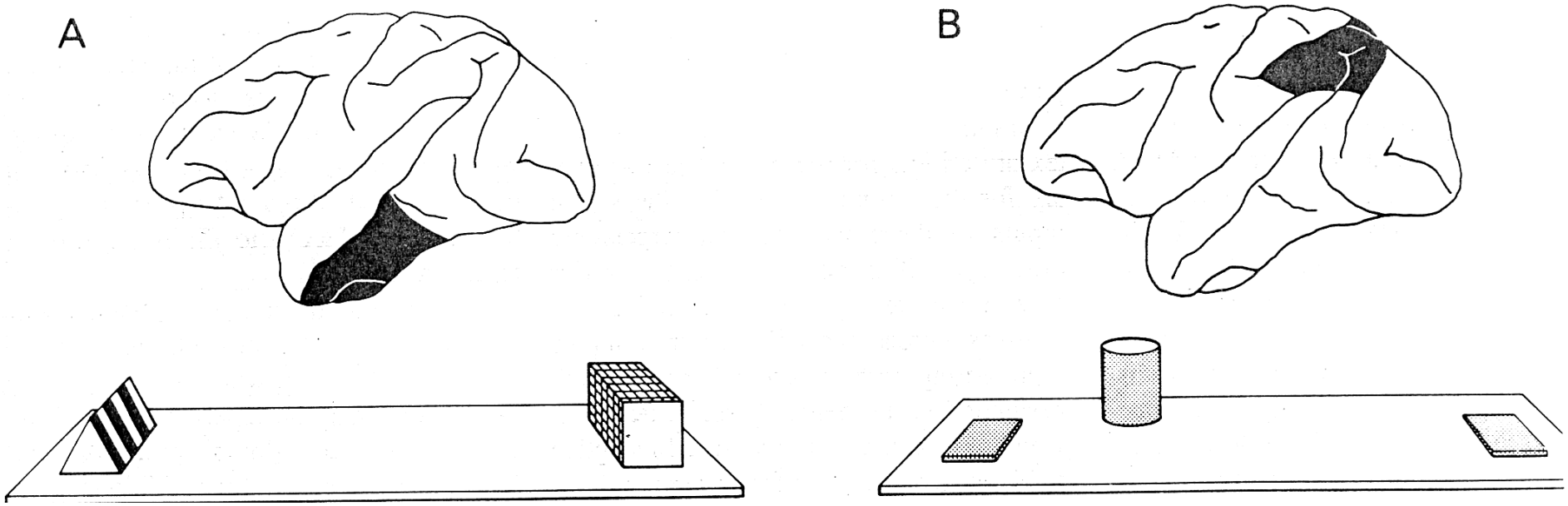
The logic of double dissociations applied to lesion studies

- Dissociation of function: when a manipulation (e.g. a lesion) impairs one aspect of function, but not another.
- Single dissociations may occur be because A and B are distinct information-processing systems, *or* may simply reflect (for example) task difficulty.
- Double dissociations rule out the latter interpretation and imply independence of A and B for specific functions in at least some situations.



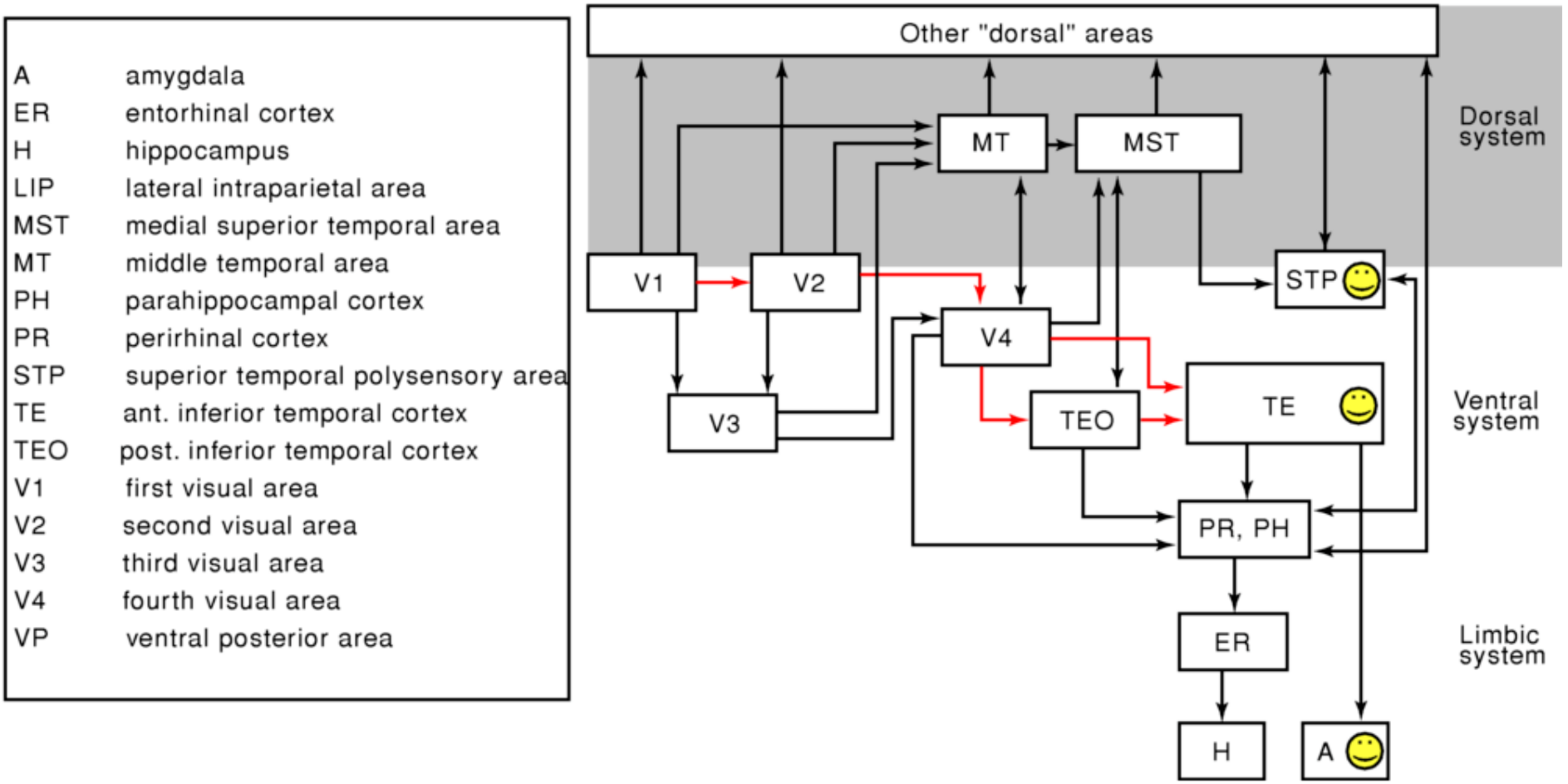


Beyond occipital cortex: ‘what’ versus ‘where’



Mishkin et al. (1983)

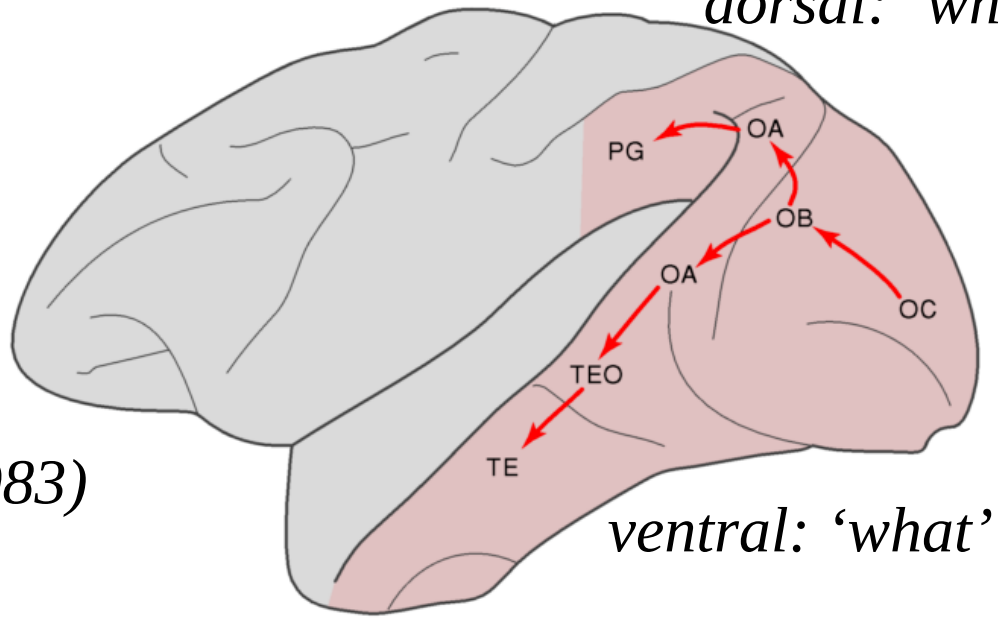
Two visual streams: close-up on the ventral stream



from Zigmond et al. (1999)

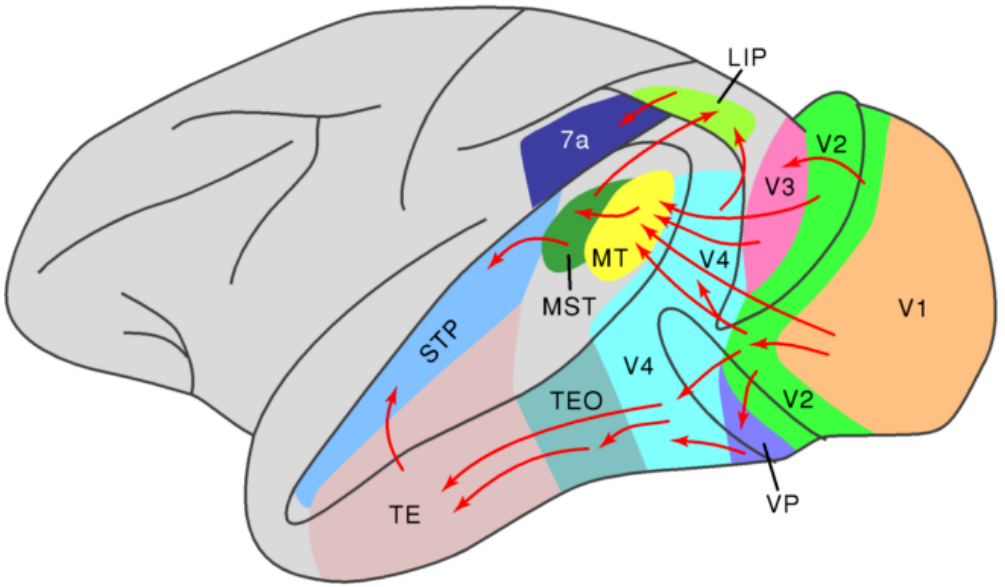
Two visual streams

dorsal: 'where' (or 'how')



Mishkin et al. (1983)

ventral: 'what'



Progressing anteriorly along the ventral stream:

- **Roughly, V1 → V2 → V4 → TEO → TE → temporal pole/perirhinal cortex.**

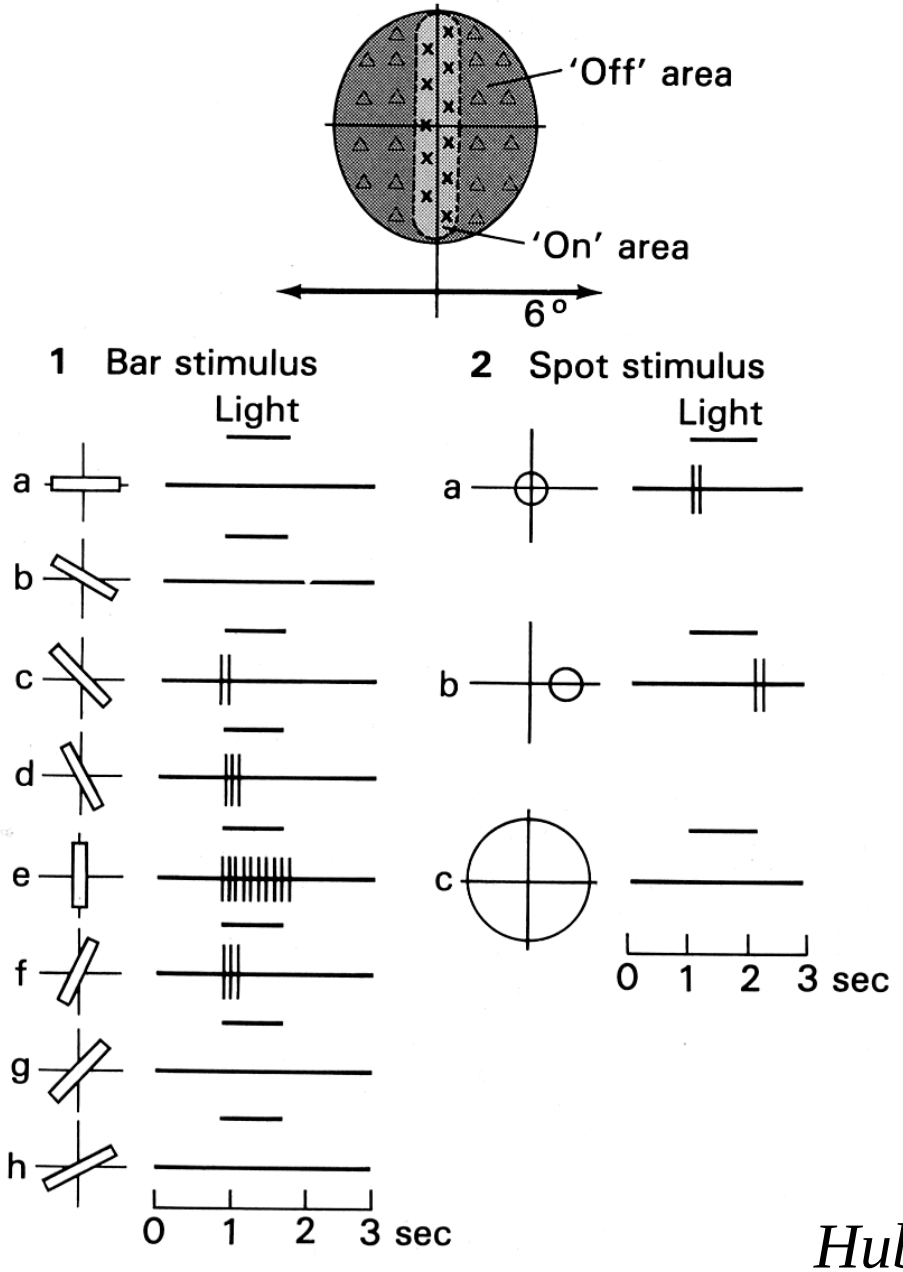
Note feedback projections, projections to frontal lobes, side projections inc. to STP, subcortical projections (basal ganglia, amygdala, pulvinar), interhemispheric connections.

- **Receptive fields get larger; retinotopicity lost.**
- **'Trigger features' become more complex and specific.**

i.e. **object detection.**

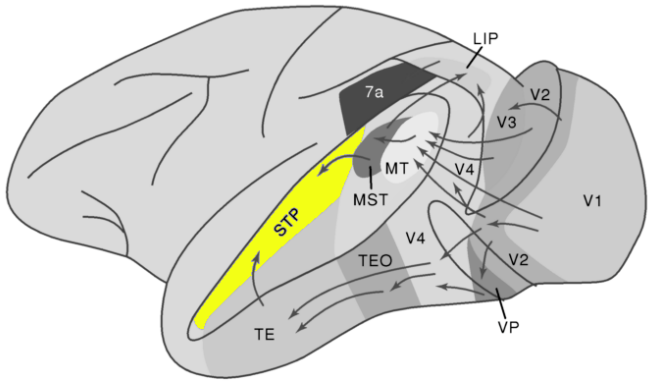
- **Mnemonic effects** (e.g. habituation, firing when an object isn't present) **more prominent.**

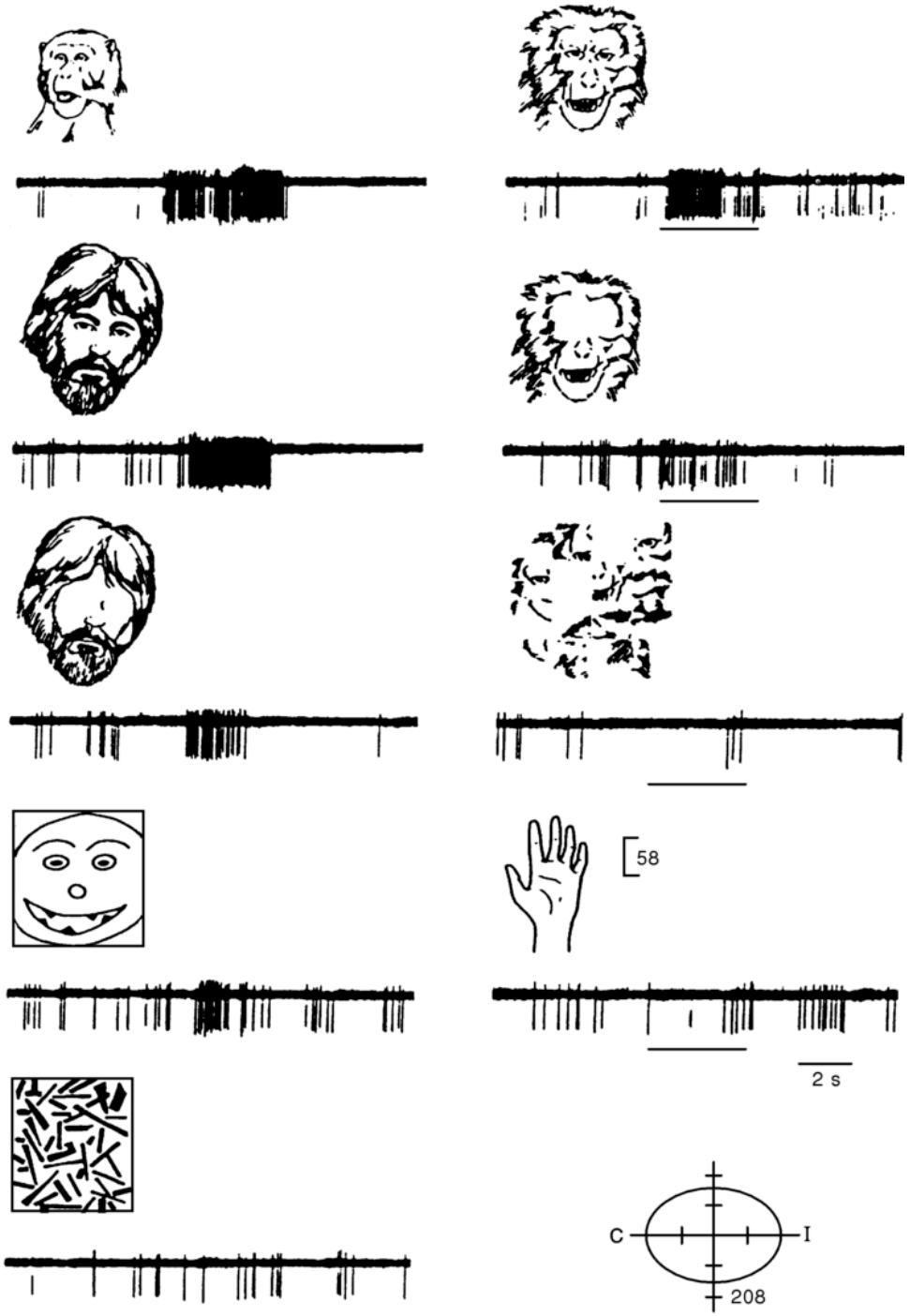
A simple orientation-selective cell in V1...



Hubel & Wiesel, 1959

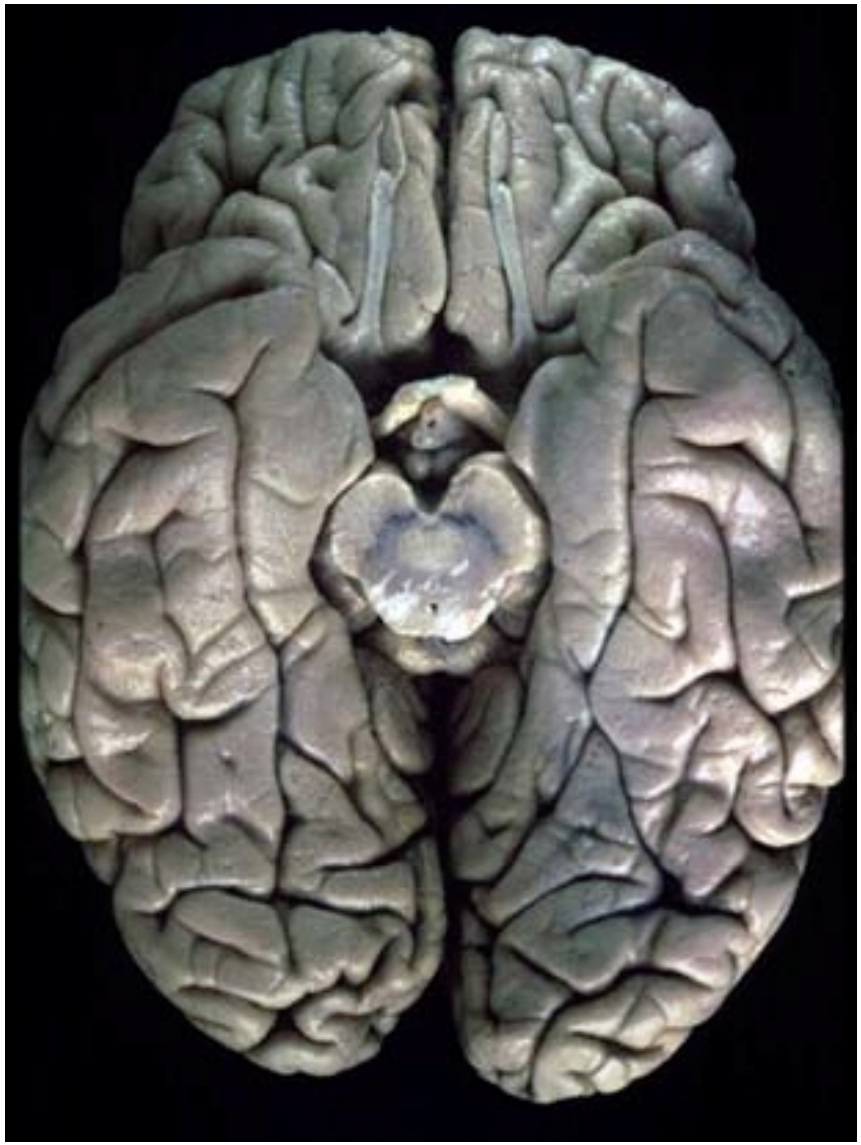
… and a face-responsive neuron in STP

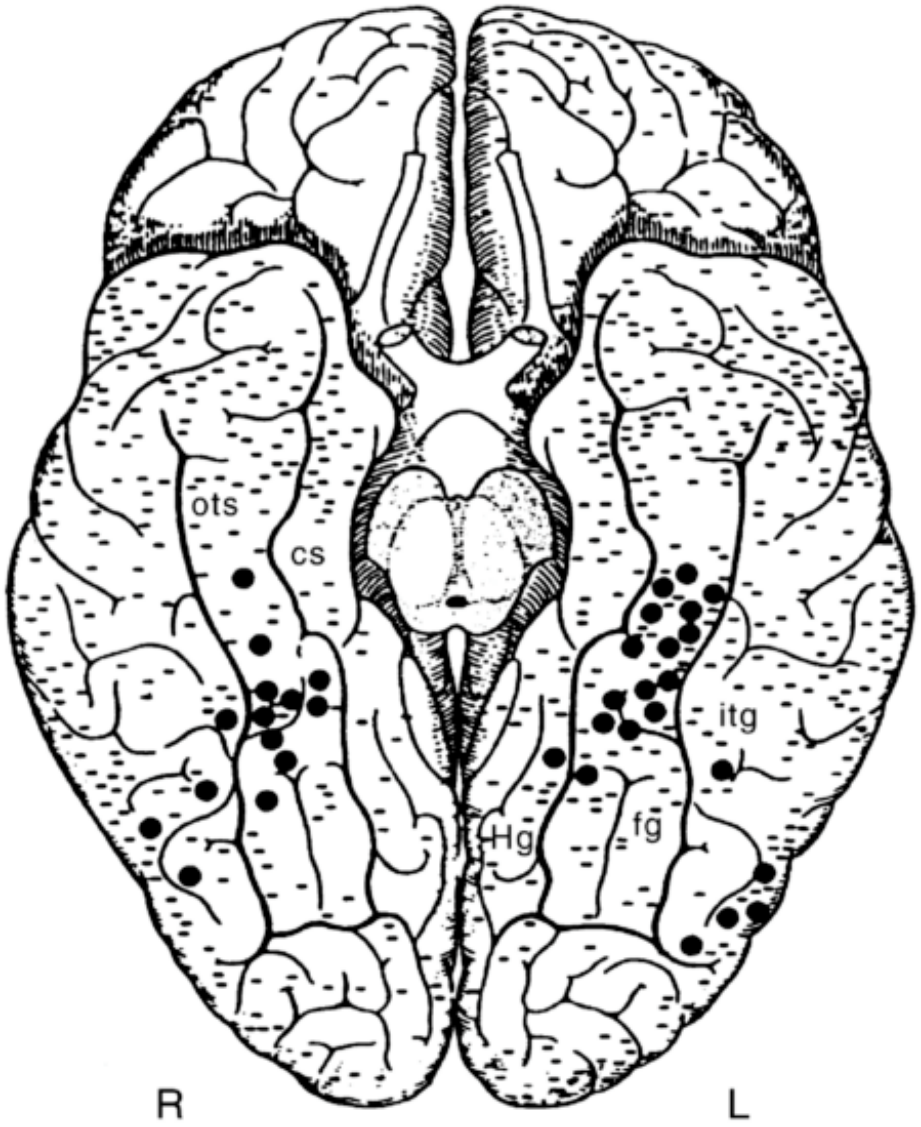




Bruce et al. (1981)

Electrophysiology of face-response areas in humans





Allison et al. (1994) J Neurophysiol 71: 821