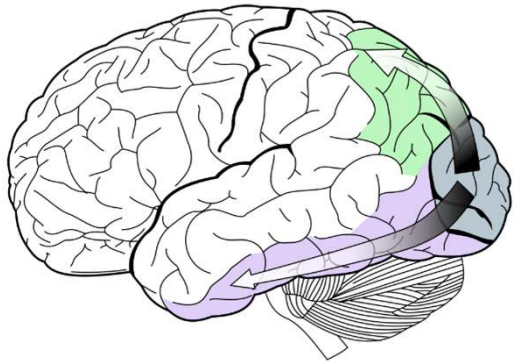
FAV, Talk no. 9, Visual Cortex,



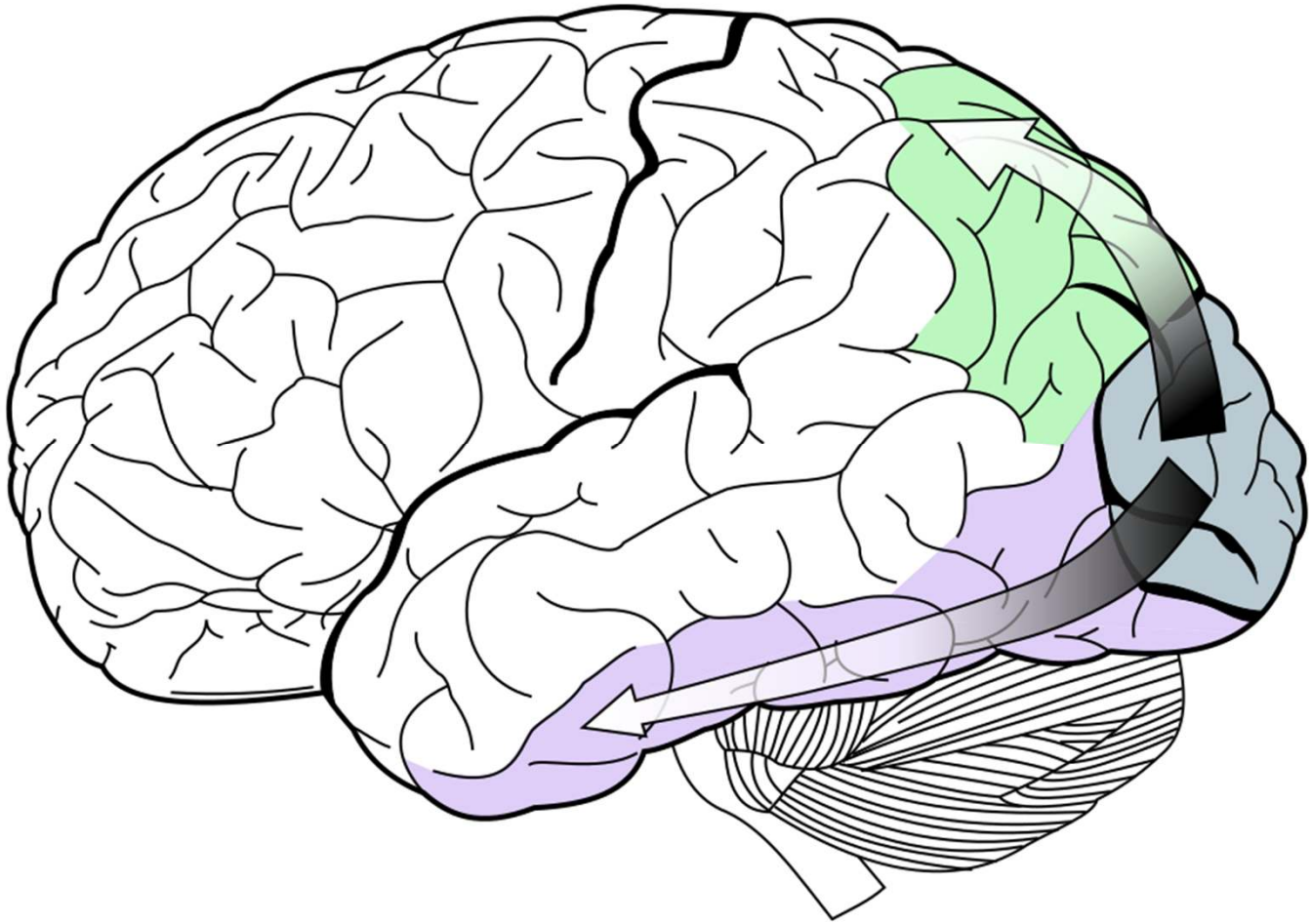
Petr Maršálek

Academic Year 2020/ 2021

Outline 9 – Visual Cortex

- Primary and Secondary Visual Areas
- Synthetic Overview: Image Processing, Receptive Fields, Physiological ‘Laws’
- Not All Visual Areas Contain Consciously Accessible Representation – Eye Rivalry
- Magnocellular and Parvocellular Pathways
- V1, V2, V3, V4, MT (=V5) and Other Areas
- Modalities of Vision Based on Cortical Processing
- Features not Residing in Unique Areas: Stereo Disparity, Color
- Features Located To Areas: Dorsal (Location and Motion) versus Ventral (Object) Streams
- Controversies
- Processing Hierarchy of the Visual Cortex

Ventral and Dorsal Stream



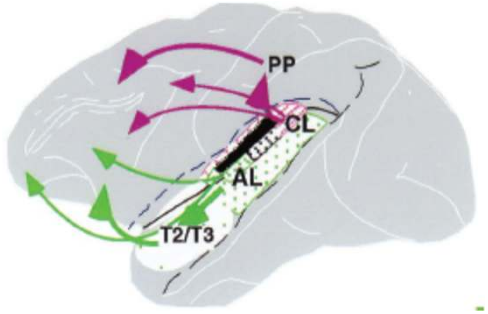
THIS PANEL IS A SPECULATIVE ATTEMPT TO CLASSIFY BRODMANN AREAS DIFFERENTLY

“Binary Trees of Brodmann Areas” and Beyond Brodmann Areas

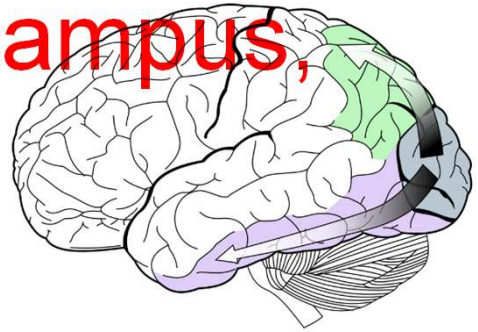
- Bit 1: (Left) vs. (Right) Hemisphere
- Bit 2 and 3: (Motor/ Frontal Lobe) (Somatosensory/ Parietal L.)
- Bit 2 and 3: (Auditory/ Temporal L.) (Visual/ Occipital L.)
- Bit 4: (Primary) vs. (Secondary) Sensory projection areas
- Bits 5, 6, 7: subdivisions of visual/ sensory areas
- Sensory Domains: Bits 1 and 7: (Left/ Right) vs. (Bottom/ Top) Extensions, Retinotopy, Spatial Maps
- Bit 8: Temporal encodings: subcortical
- Bit 9: Other modality encodings – Hippocampus (Archi-cortex)/ space navigation, and so on.

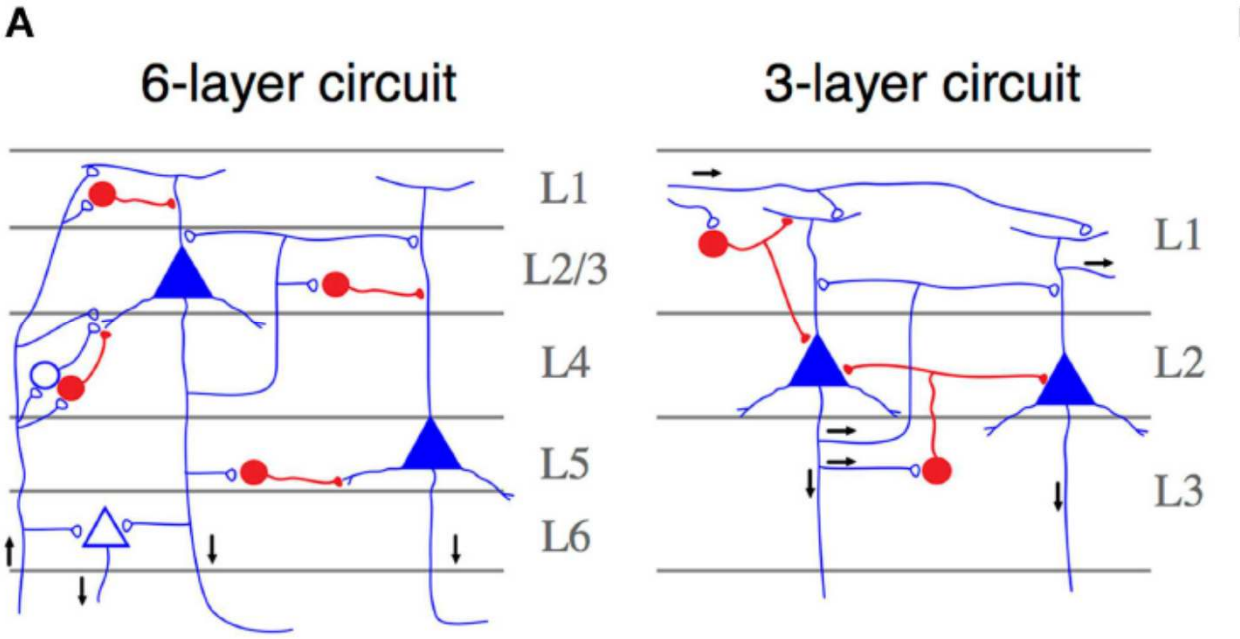
Olfactory cortex and Hippocampus (Archi-cortex), Olfacory Bulb (Paleo-cortex), Vestibular Cortex (Part of Temporal lobe), Cortical Projections, Remaining senses: Olfaction, Taste and Touch

CORTICAL MICROCIRCUIT

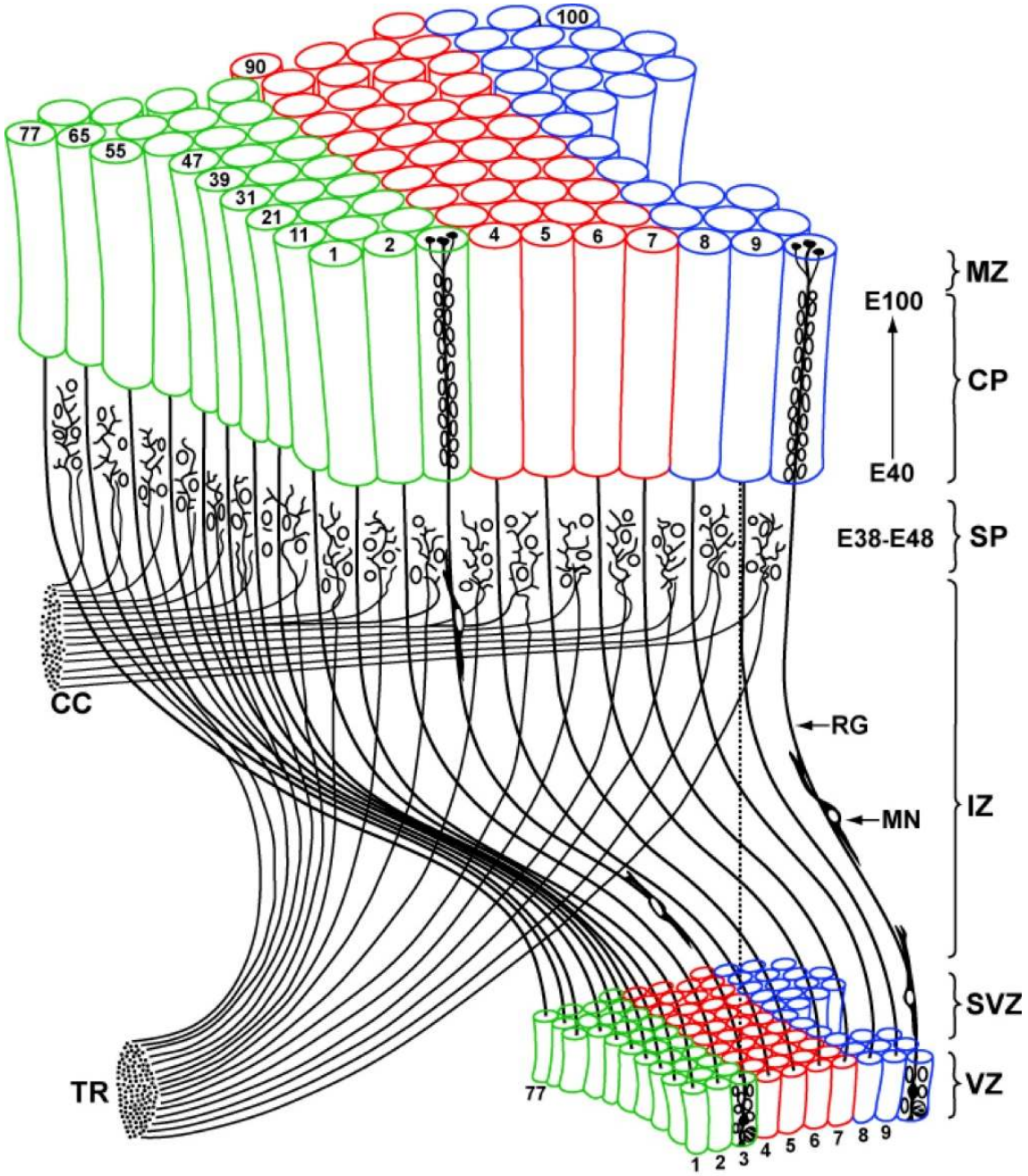


Neocortex and Other Cortices
(Paleocortex, Olfact. Only: 3 Layers, Archicortex, Olfact. and Hippocampus; 3 or 4 Layers)





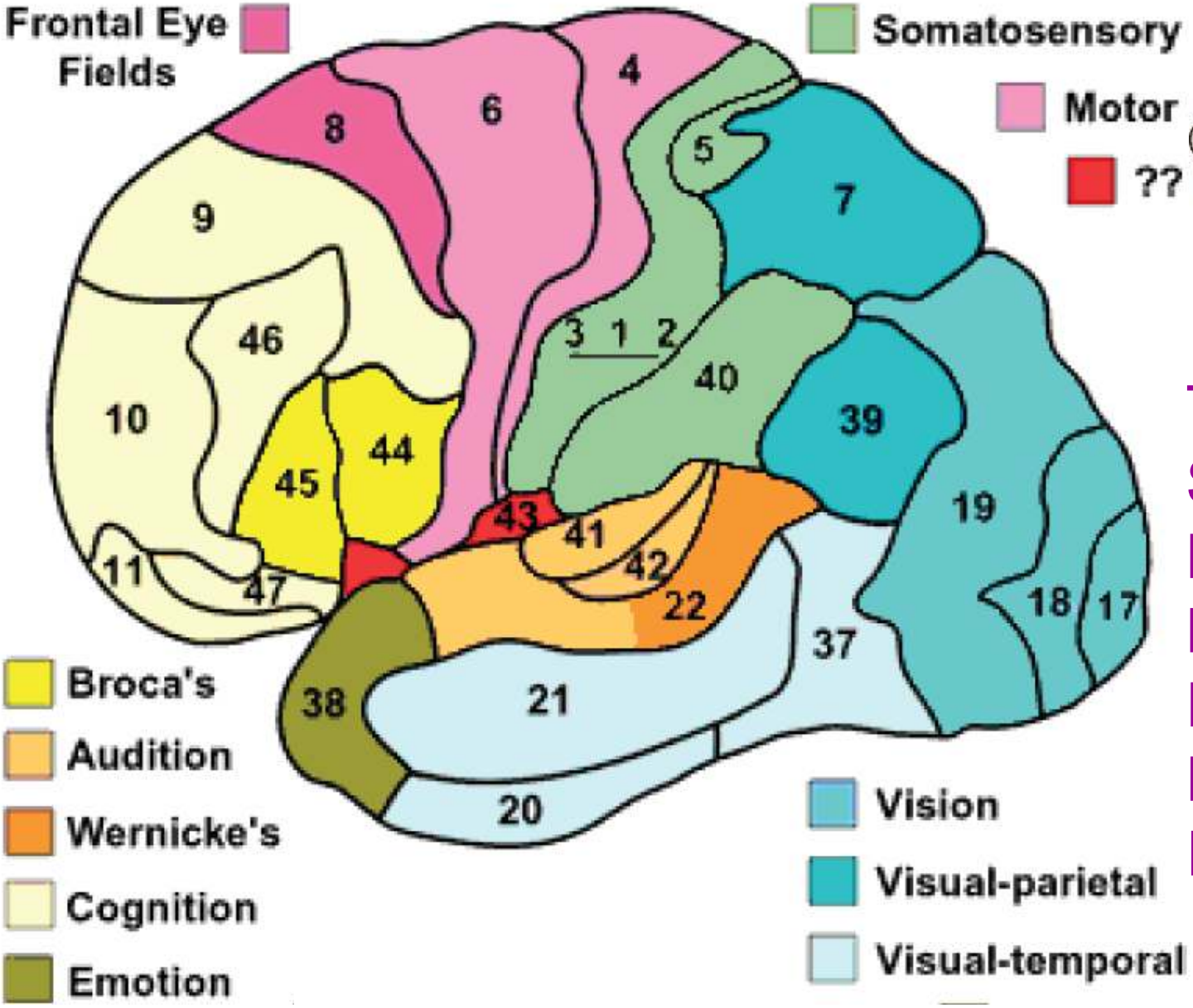
Cortex Consists of Columns as Functional Units



Area of Cerebral Cortex Correlates with the Size and Surface Area of the Mammal

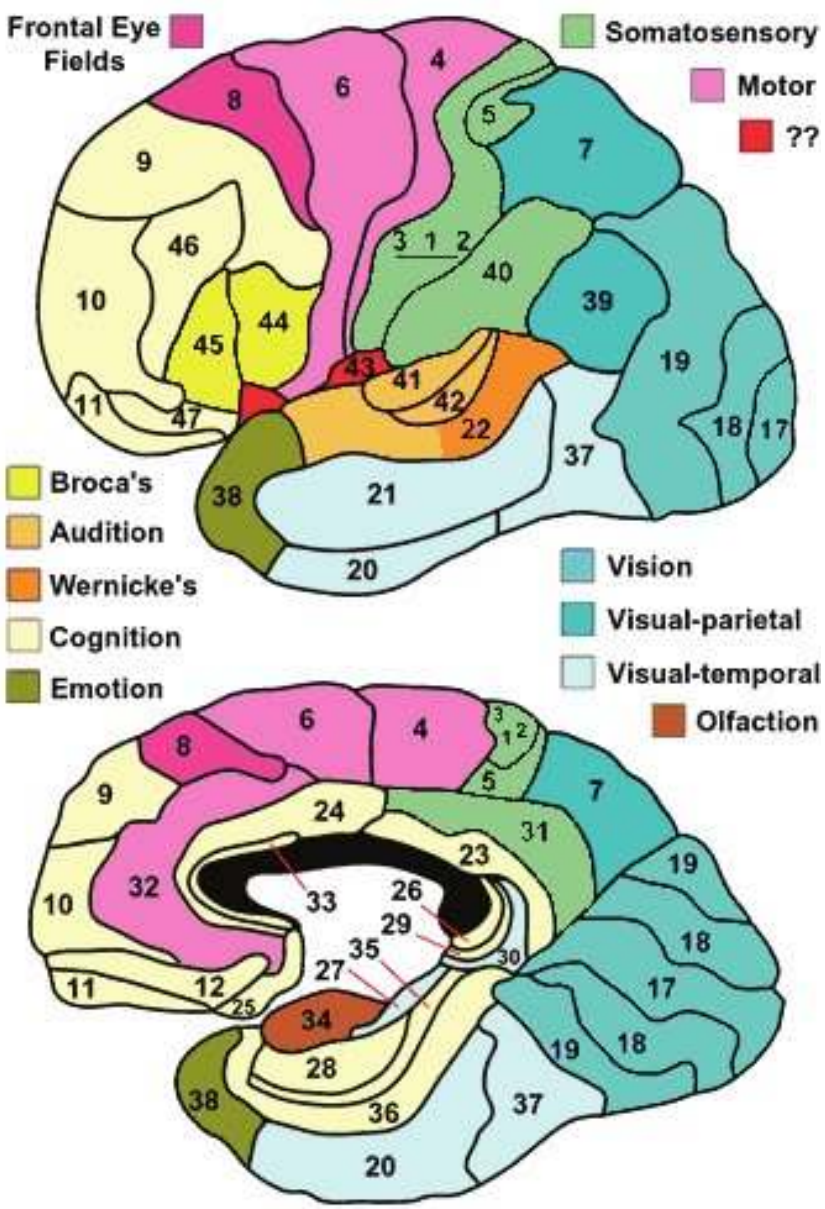
CC = Cortico-Cortical Connections, TR = Thalamic Radiation

Brodmann Areas (Outer Hemisphere Part)

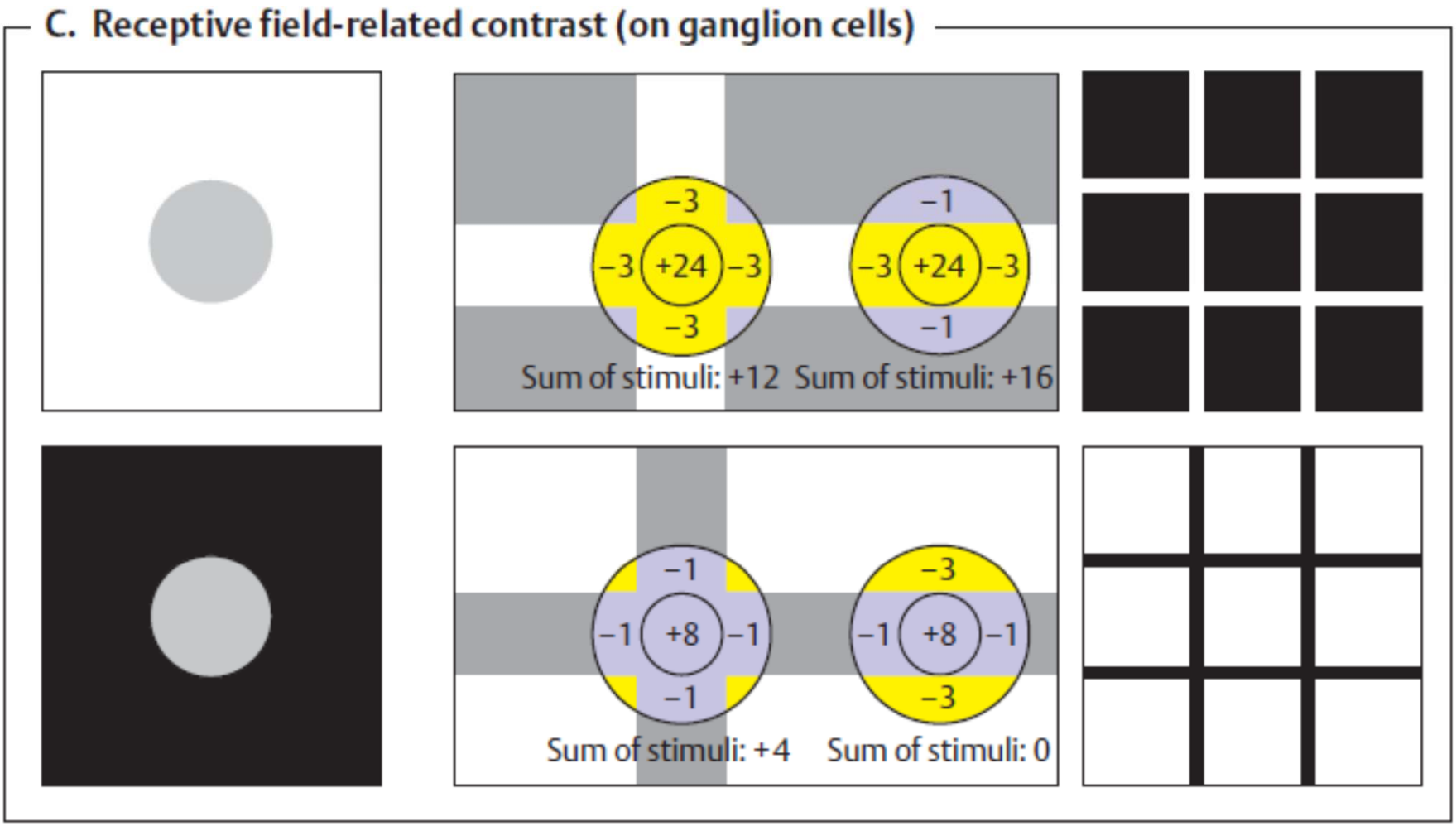


The Least Structured Mammalian Brain is Found in Rodents and Insectivora

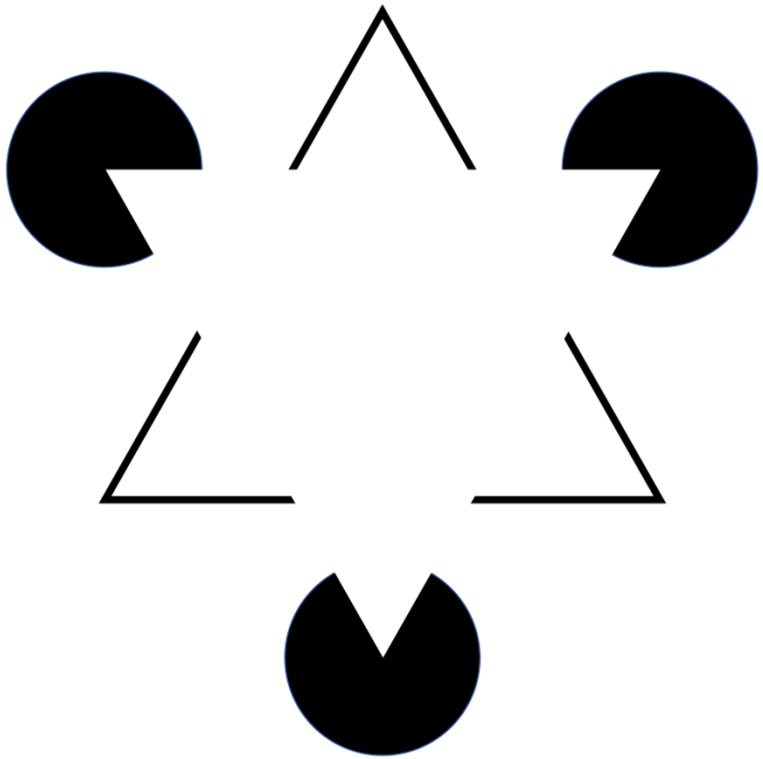
Brodmann Areas (Outer and Inner Hemisphere Parts)



Visual Pathway Inner Workings

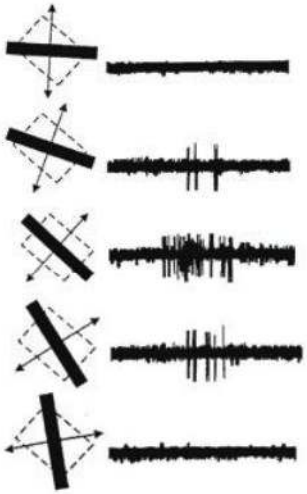


Experimental Construction of Receptive Fields:
Simple and Complex Cells in Primary Visual Cortex, Area V1,
Illusory Contours by von der Heydt, Area V2, and Higher Areas

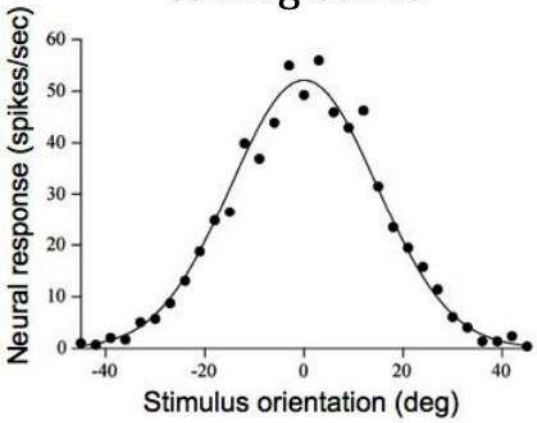


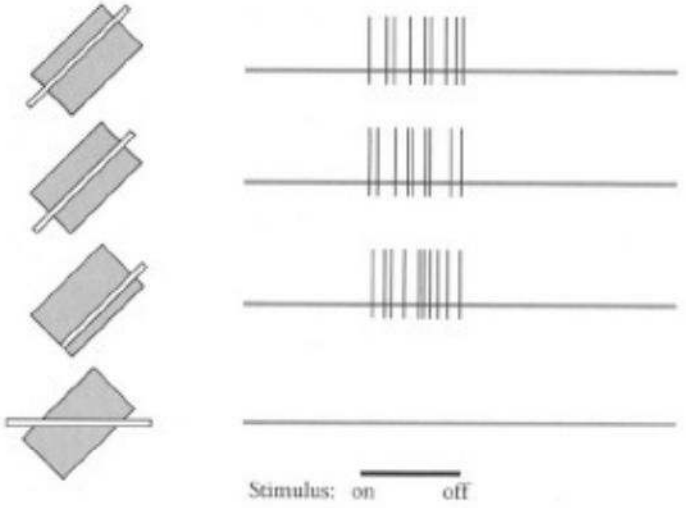
V1 simple & complex cells

simple cells respond best to edges or bars of a particular position, orientation, and sign of contrast



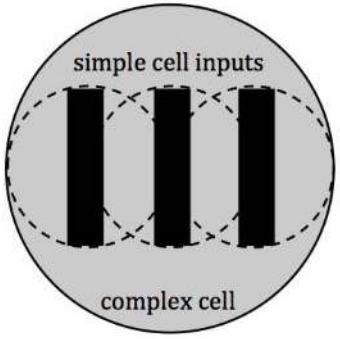
tuning curve





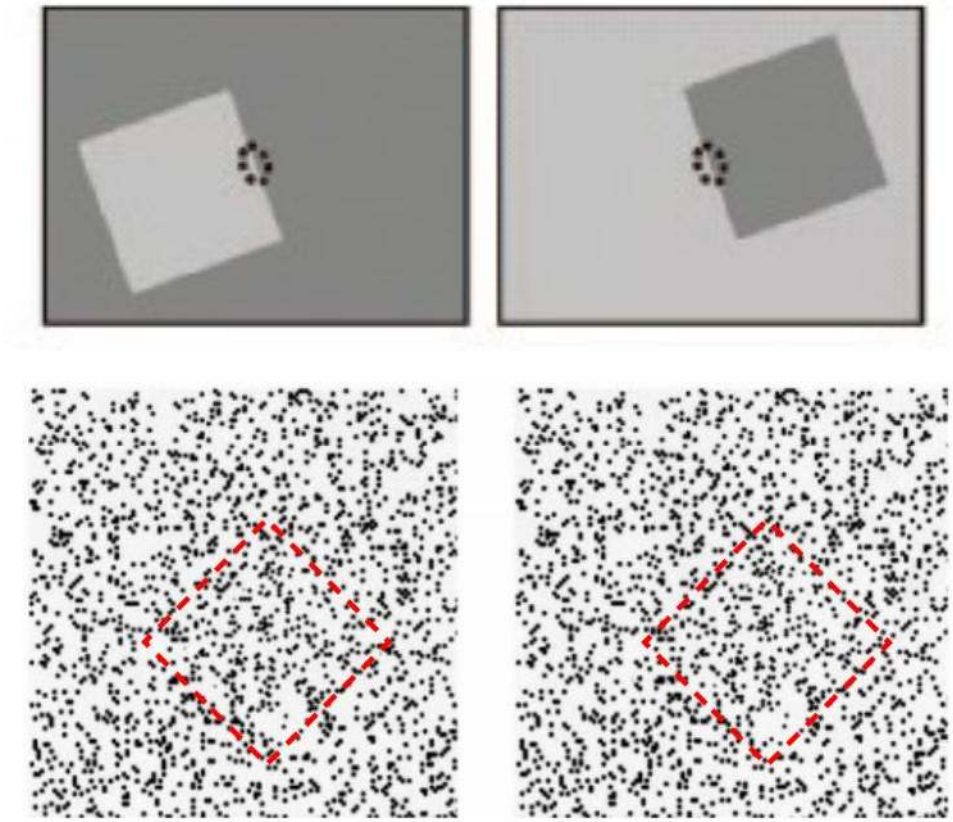
complex cells have larger receptive fields and are more tolerant to position

Kreiman, 2013



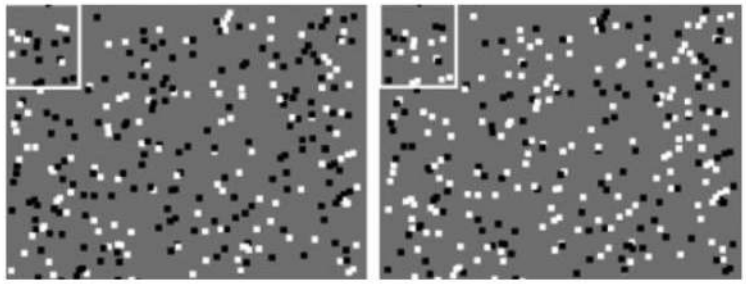
complex cell may "pool" inputs from many simple cells within receptive field

Selectivity for *stereo boundaries* in V2



Von der Heydt & colleagues:

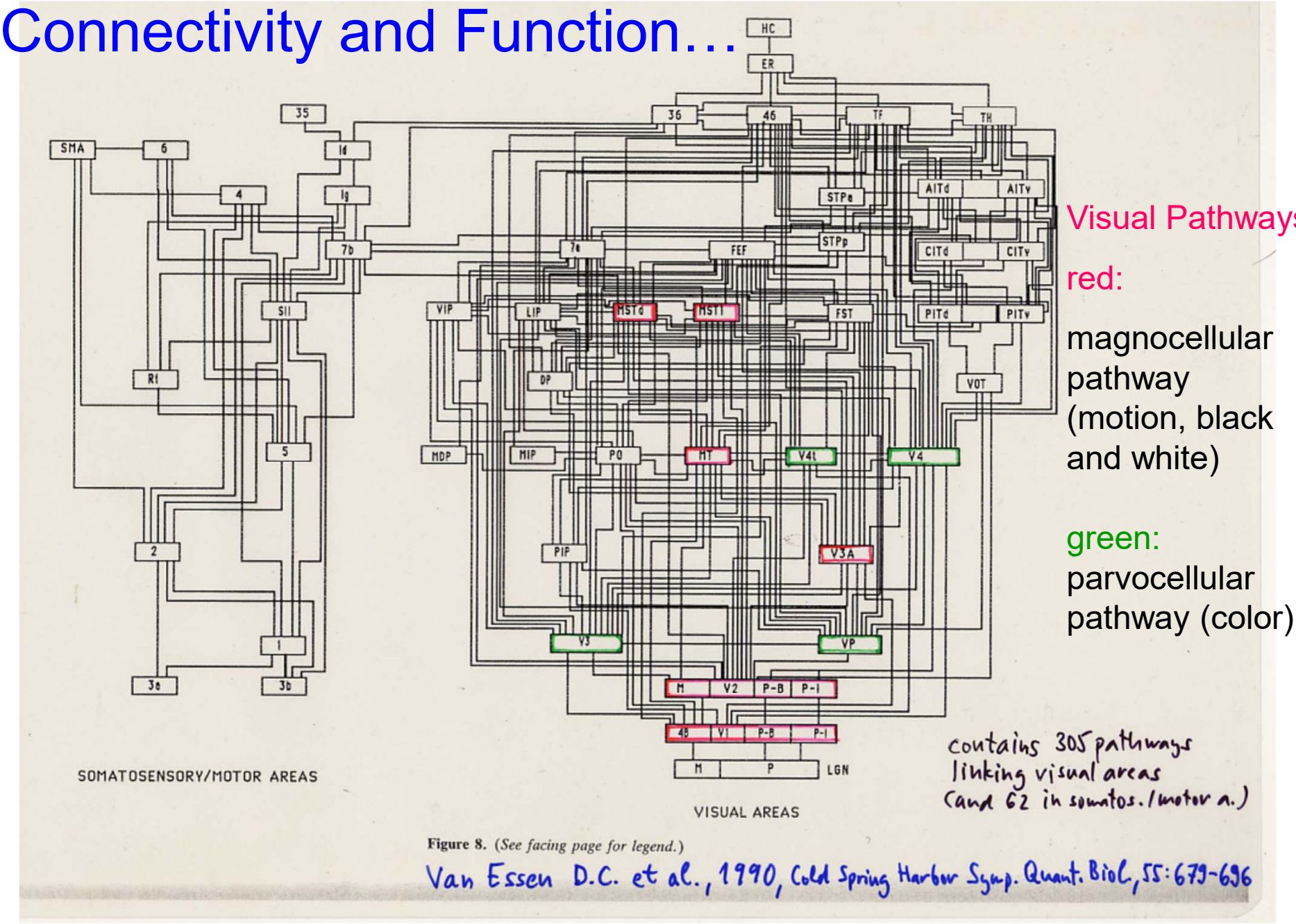
Some V2 cells are selective for the orientation, contrast, and *side of border ownership* of an edge ... for edges defined by luminance *or stereo disparity*



"anti-correlated" stereogram

Later, in area V4, neural responses to stereo disparity appear to correspond more closely to perceived depth

Too Complicated Way to Explain Visual Cortex Connectivity and Function…



Visual Pathways

red:

magnocellular pathway (motion, black and white)

green:

parvocellular pathway (color)

contains 305 pathways linking visual areas (and 62 in somatos./motor a.)

Figure 8. (*See facing page for legend.*)

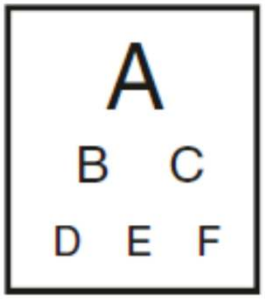
Van Essen D.C. et al., 1990, Cold Spring Harbor Symp. Quant. Biol, 55:679-696

Alternative Way to Explain Vision…

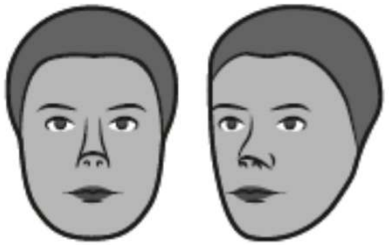
Overview of higher functions of visual cortex

Early vs. Late vision

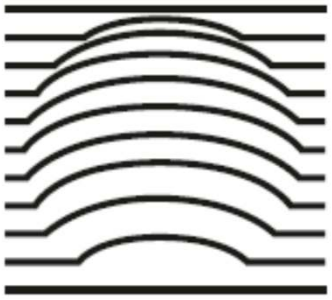
Navigation



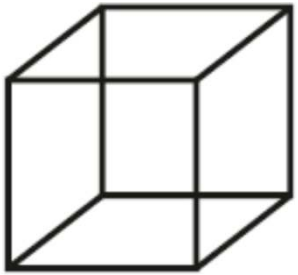
Reading



Face recognition

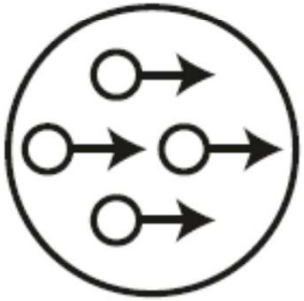


Shades



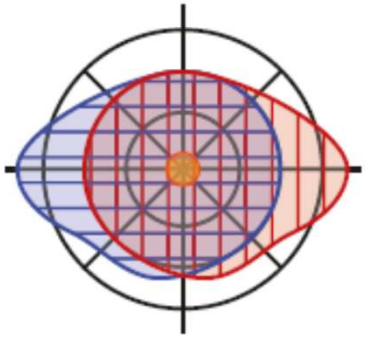
Contours

Stereo disparity



Motion

Color



Form

Face recognition – to recognize these blurred faces, some degree of visual acuity is needed

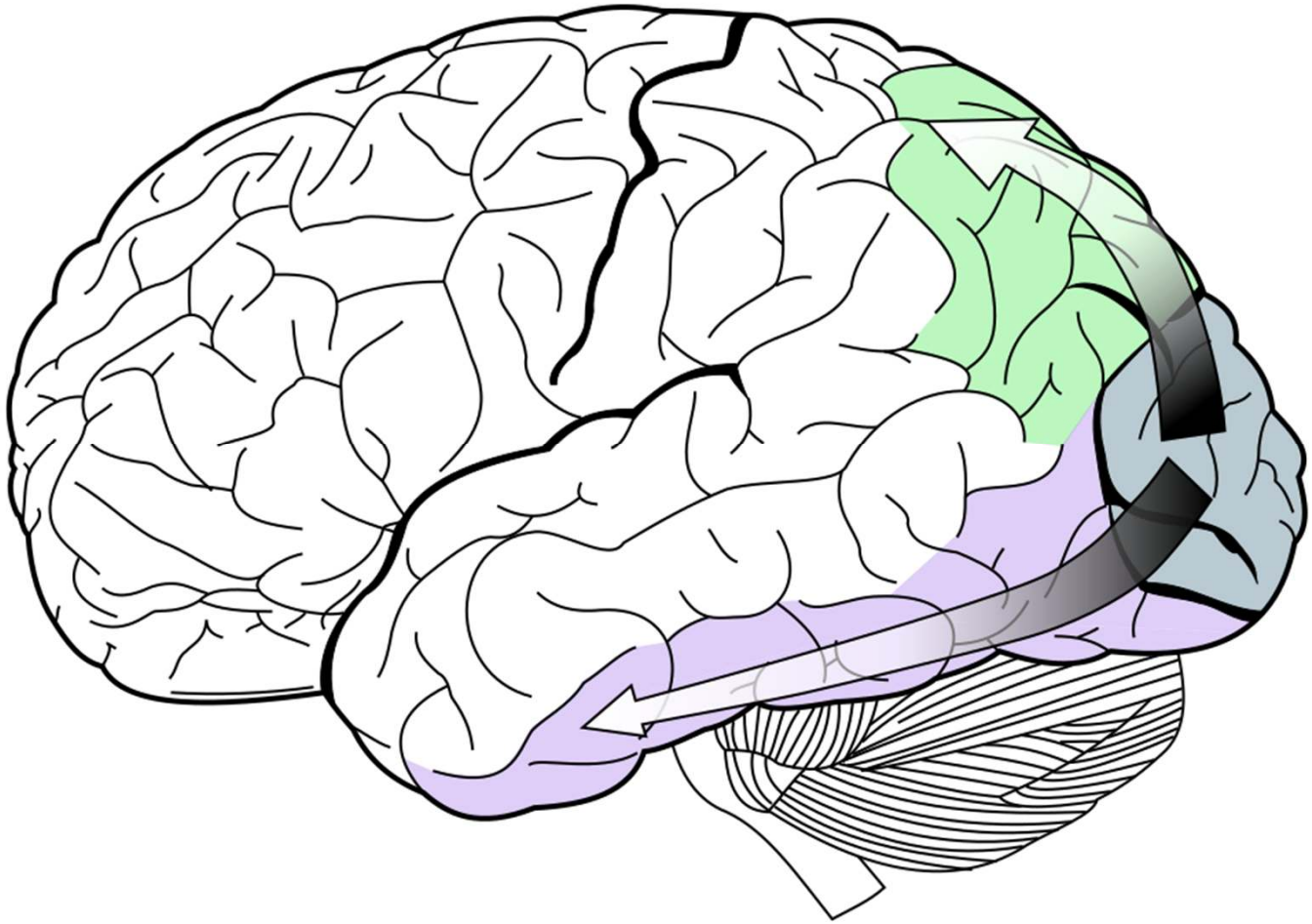
Blurred faces, however these famous people are recogizable from the context

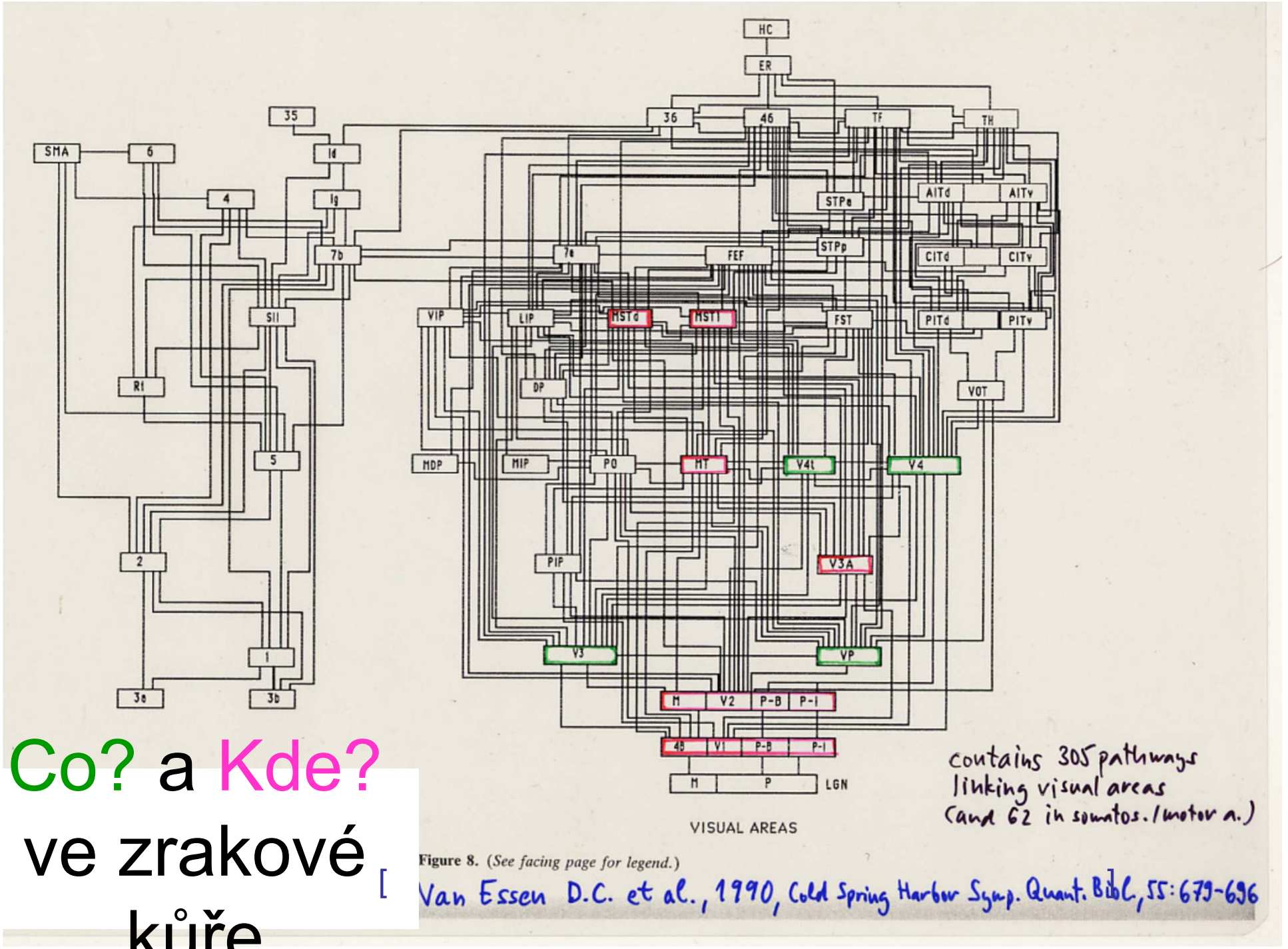
2G. Bush Sr.[+] - 5B. Obama - 4G.W. Bush - 3B. Clinton - 1J. Carter

-...

2G. Bush Sr.[+] - 5B. Obama - 4G.W. Bush - 3B. Clinton - 1J. Carter

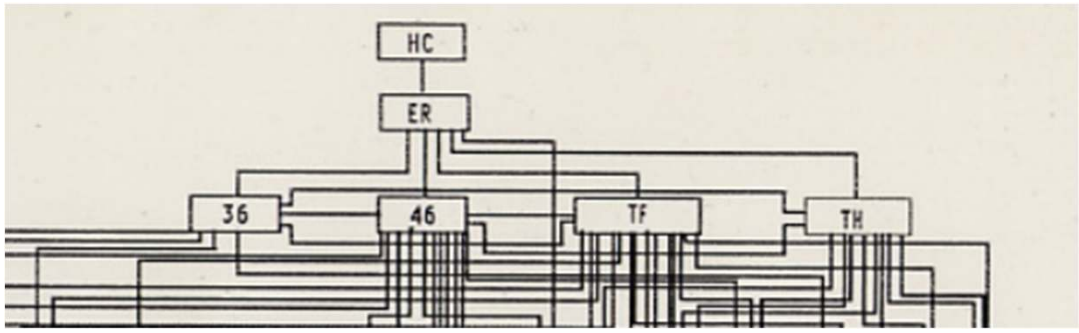
Ventral What and Dorsal Where Stream





Co? a Kde? ve zrakové kůře

Co je HC? Higher Center, Hippocampus, Hommunculus,..., je vůbec něco na vrcholu hierarchie projekčních oblastí mozkové kůry?



Je primární a sekundární zraková kůra

What je ve (ventrálních=) v předních korových projekčních oblastech

Where je v (dorzálních=) v zadních korových projekčních oblastech

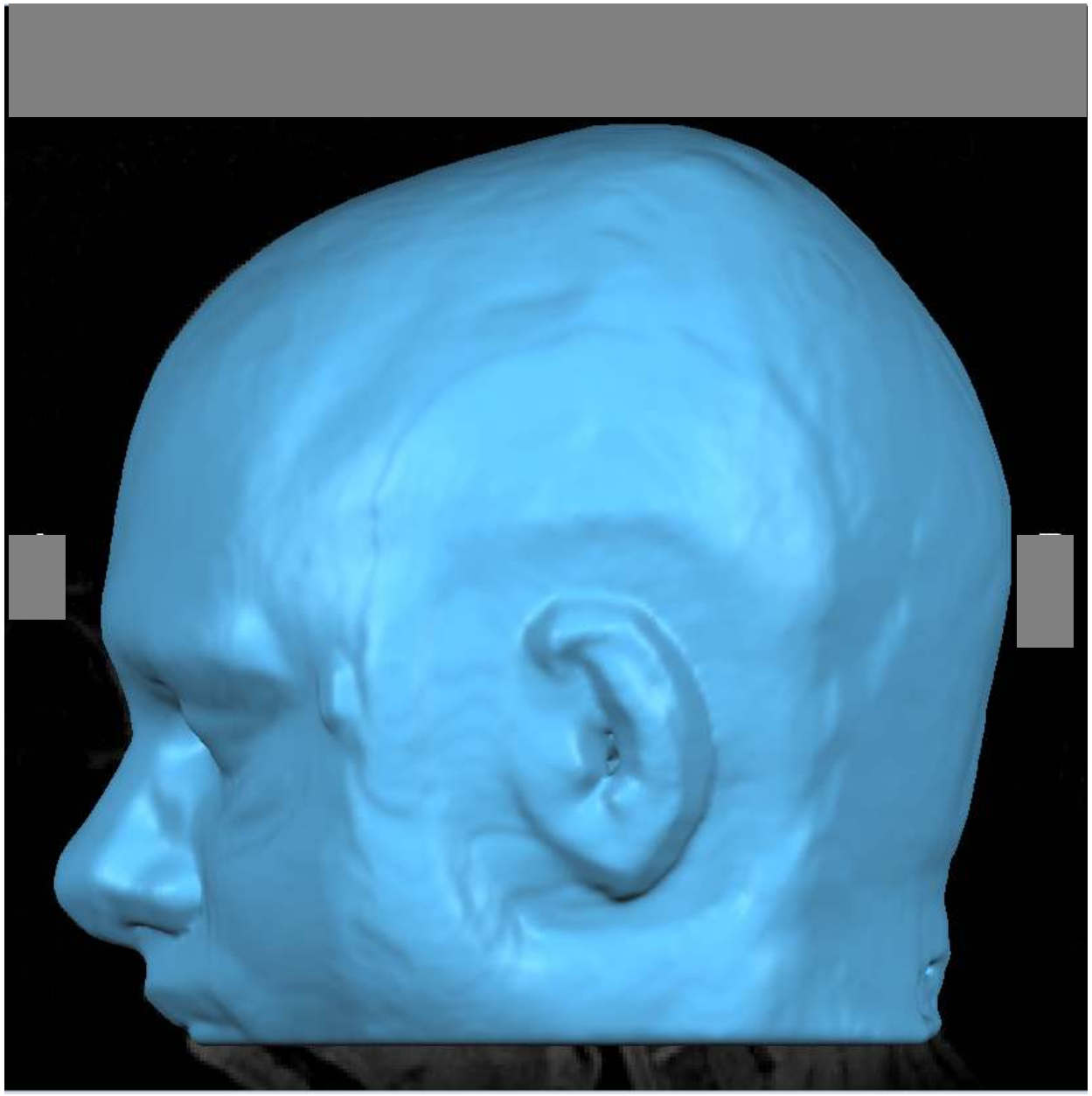
Retreating to Sensory Diagnostic Methods

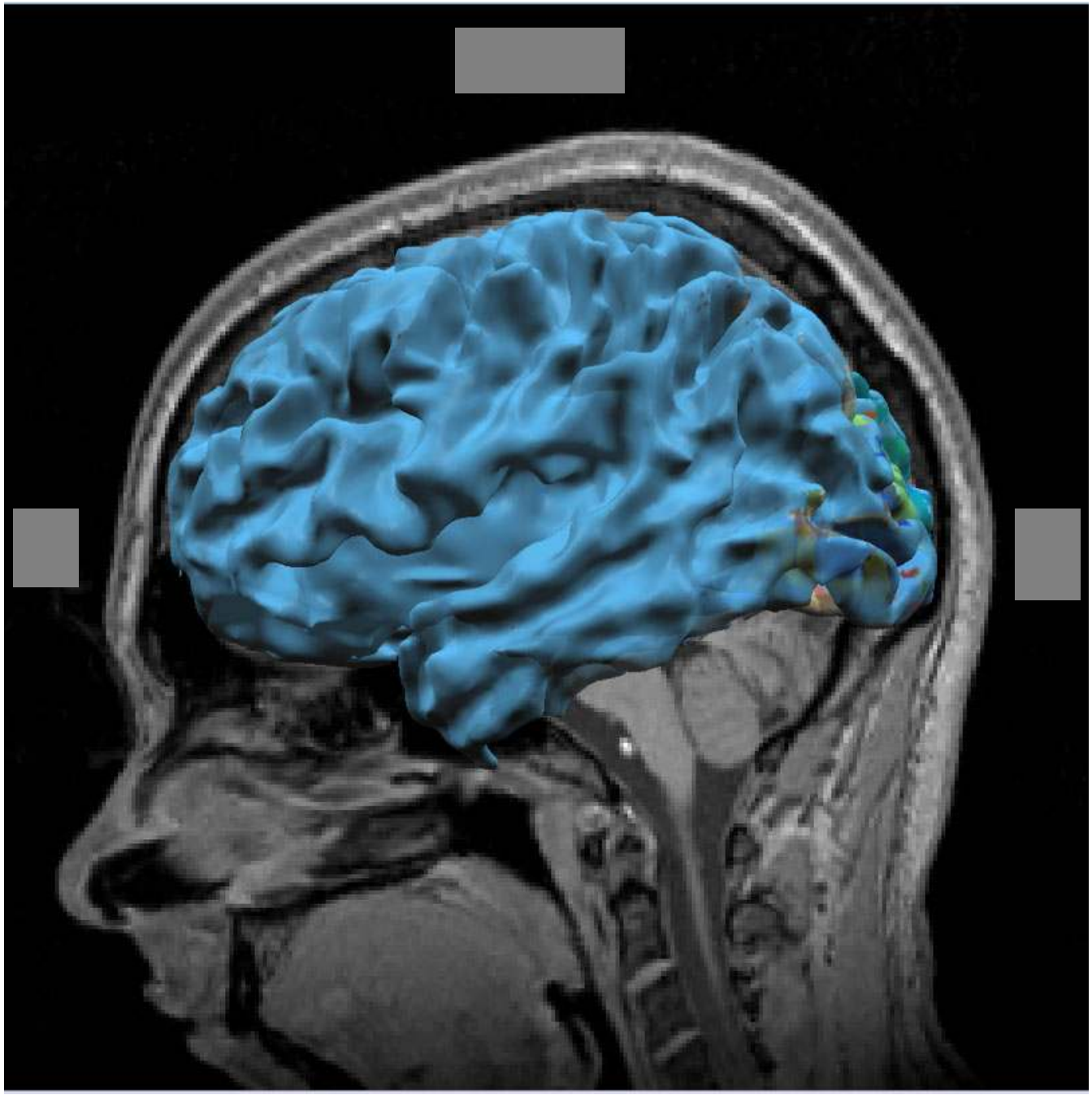
Magnetic Resonance Imaging (MRI)
(Spatial Domain)

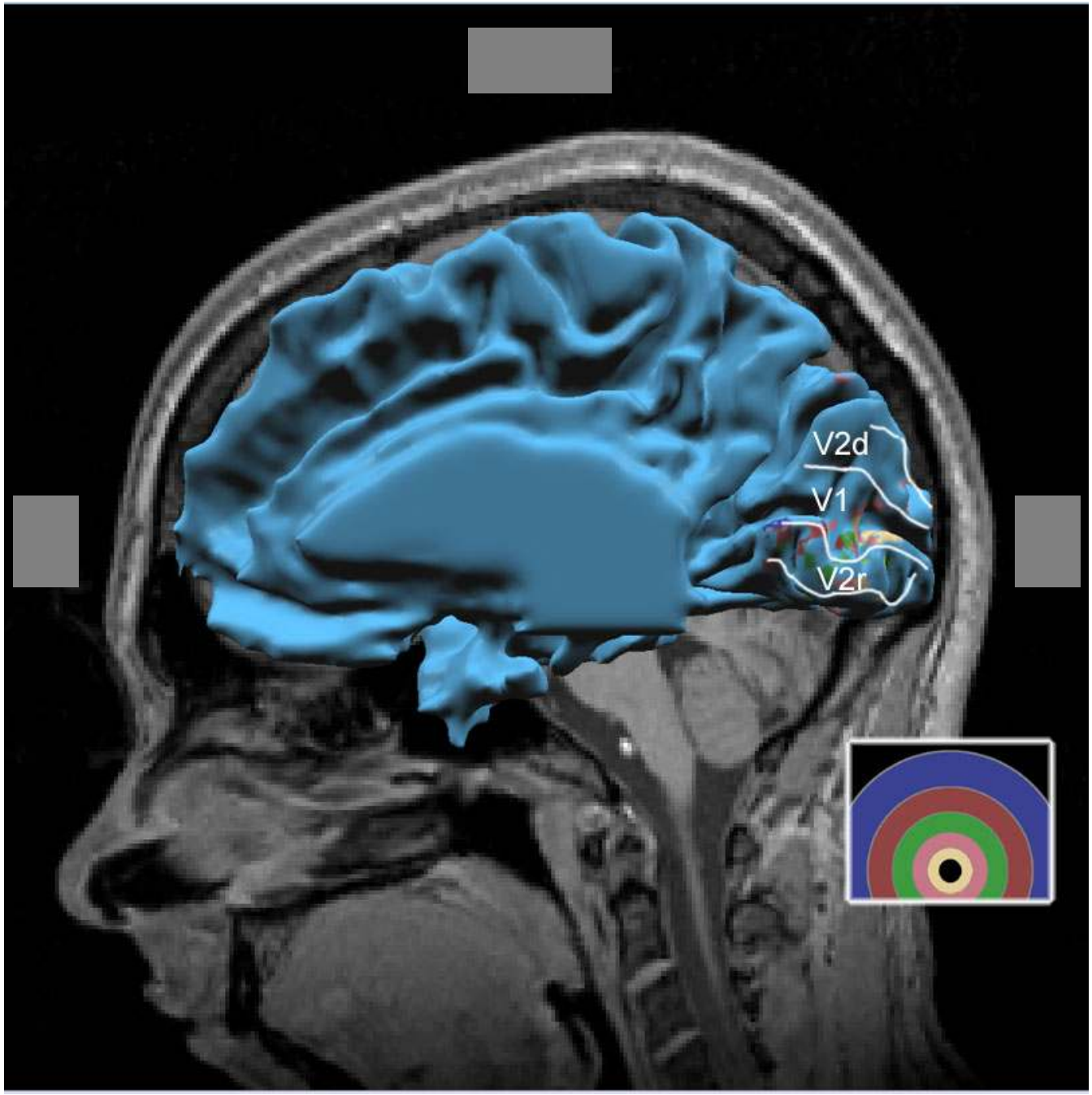
Functional MRI, fMRI
(Spatial and Time Domain)

Evoked Responses, ER, EP, EEG
(Time Domain)

Around year 2000:
Caltech's 3.0 T Trio Siemens magnetic scanner



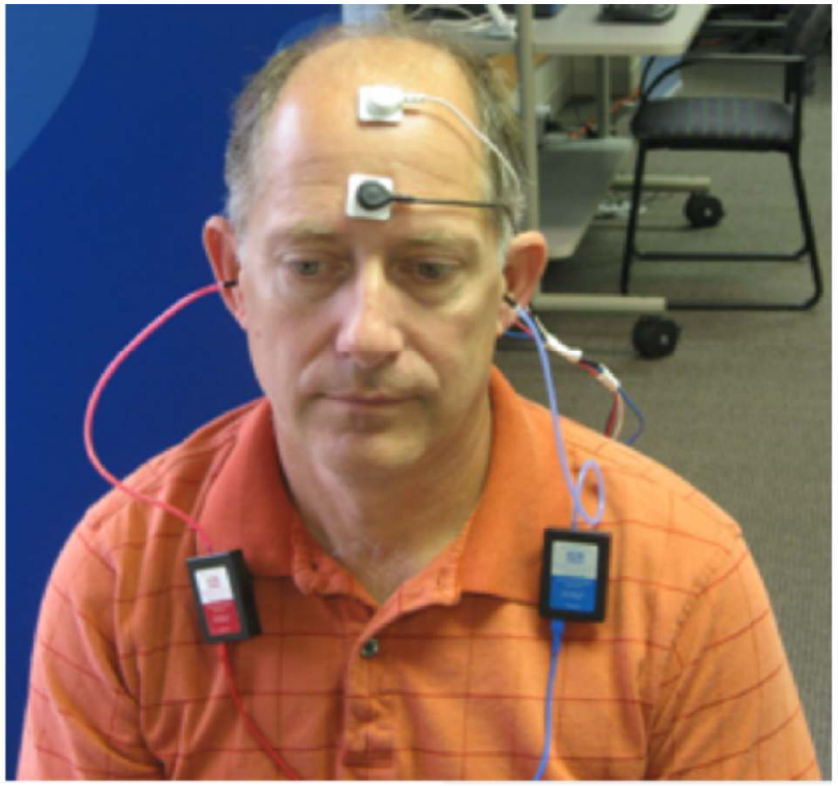



V2d
V1
V2r

Auditory brainstem responses

Talk no. 4 – Hearing Loss, Diagnostic Methods in Audiology

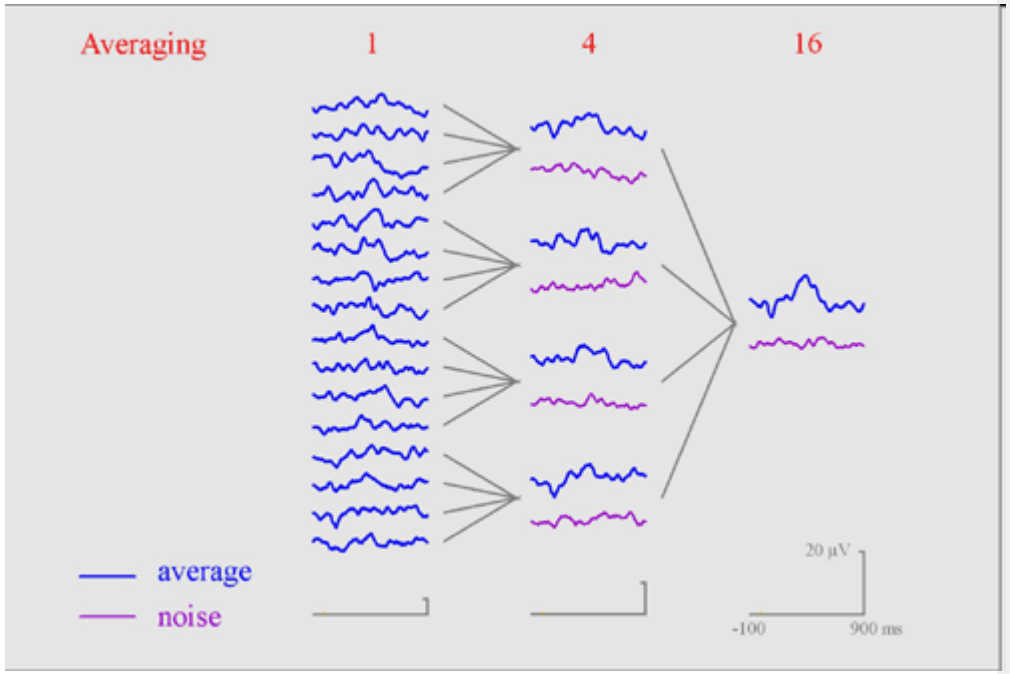
- Auditory brainstem reponses (ABR or BERA) can be recorded by using eletrodes placed on the scalp
- Responses are evoked potentials, i.e. electrical potentials generated in the neural system due to external stimulation (acoustical stimulation in case of ABR)
- Evoking stimulus is a transient signal (click)

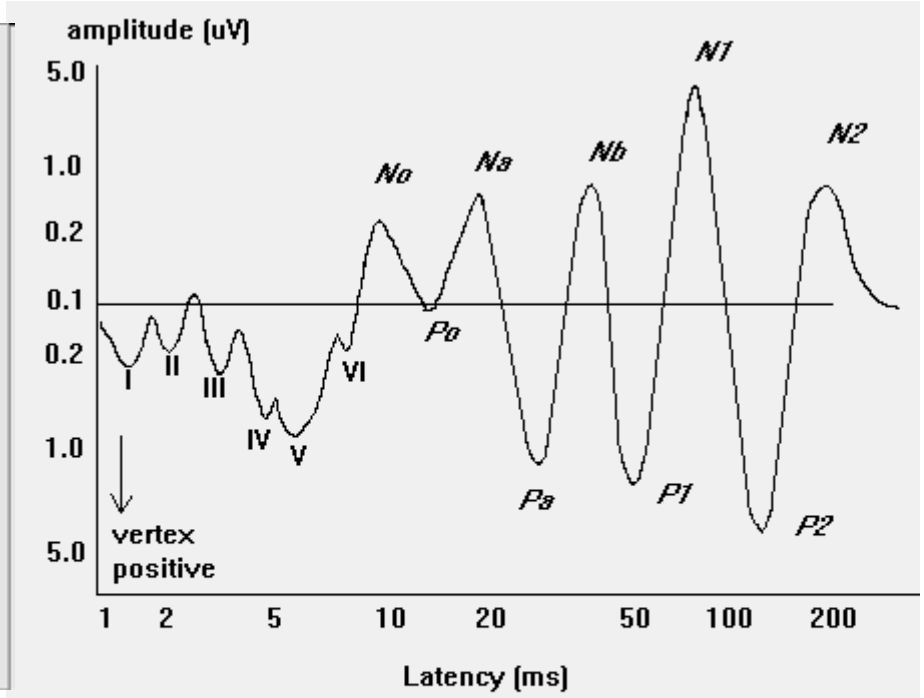


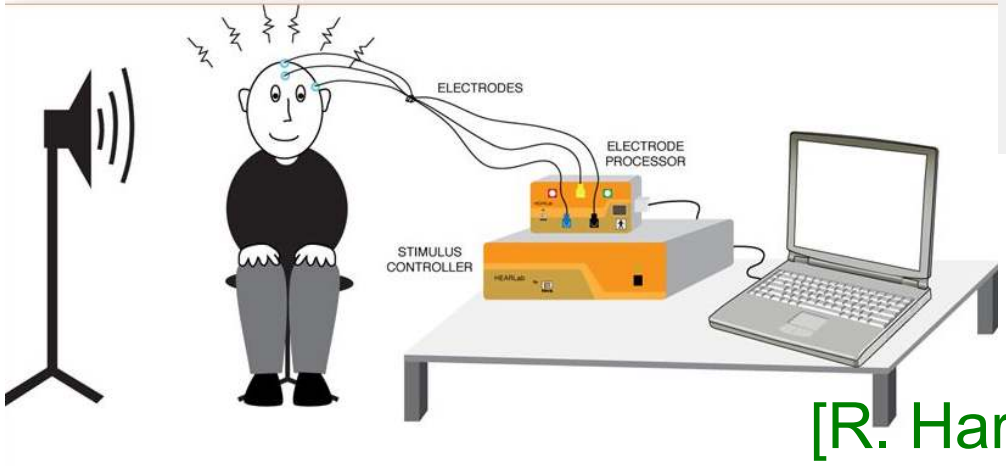
Taken from https://www.audiologyonline.com/articles/evoked-potentials-part-1-good-23607

Auditory and Visual Cortical Evoked (Response) Potentials

AEP – Auditory EP
VEP – Visual EP





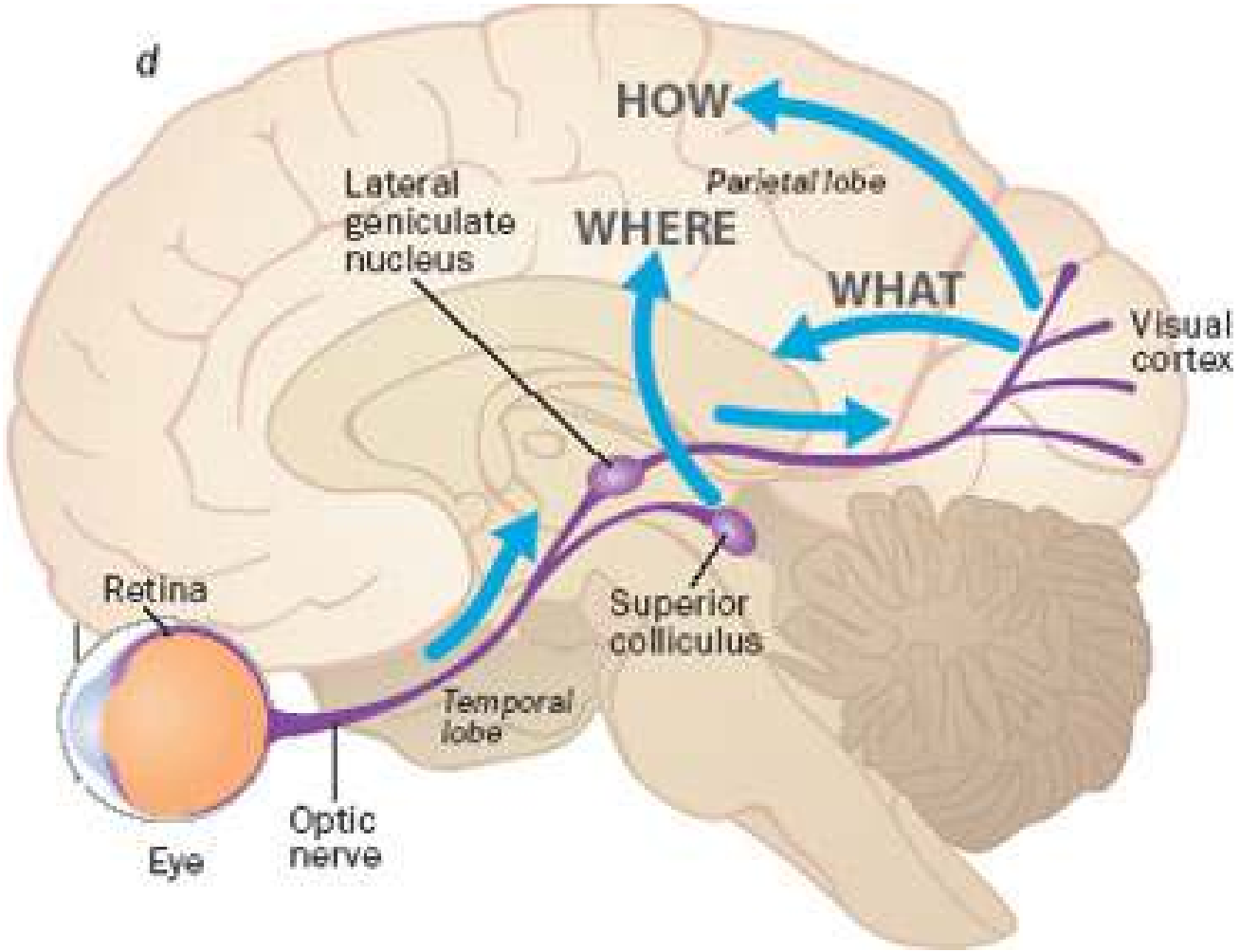


Repetition rate in brainstem ER audiometry

Can be of low freq. sound (40 Hz).CZ:BERA,EN:ABR

[R. Hari et al., Exp. Brain Res., 1980]

Overview of visual pathway



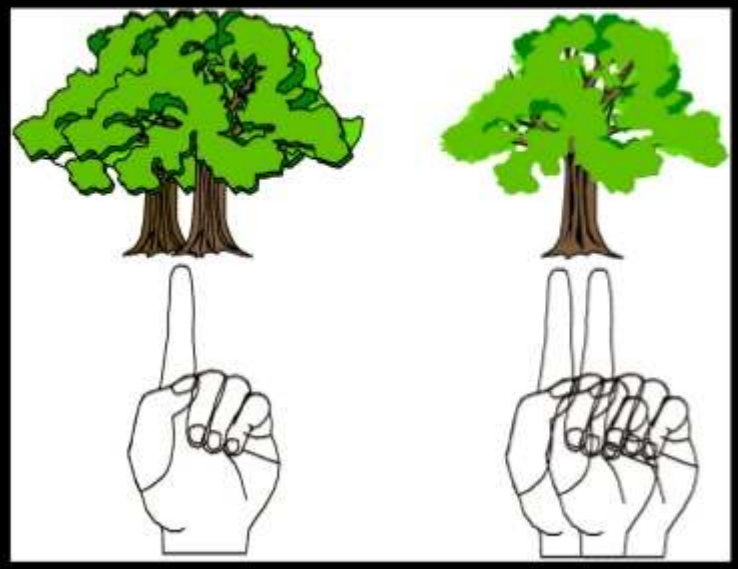
Binocular Focusing is Realized by Eye Con- and Di-Vergence

Vergence eye movements

Either blur or retina disparity will generate vergence.

Latency for vergence movements is ~160 ms.

Maximum velocity is 20°/sec.



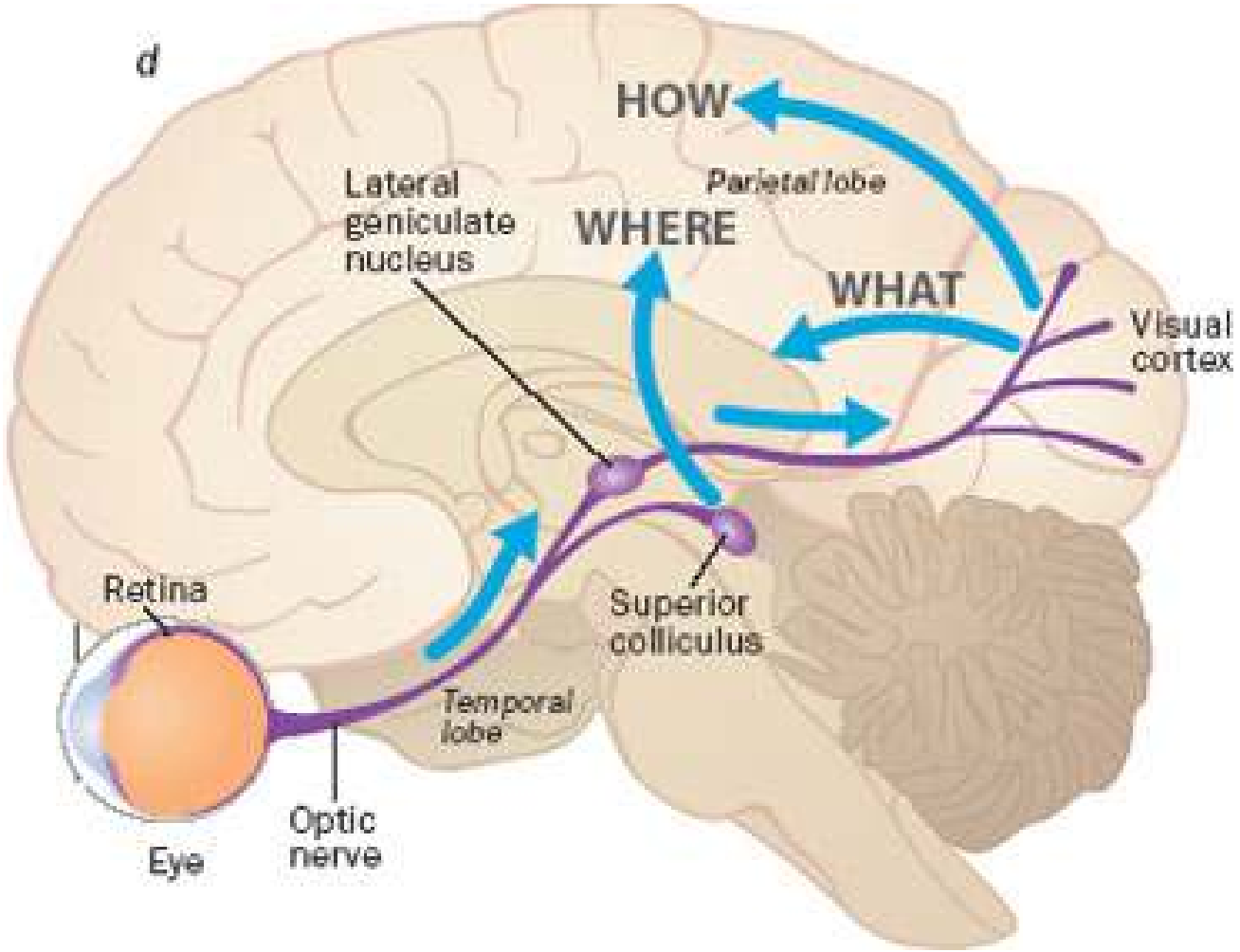
(Con)vergence disorder is called strabism.

Binocular Rivalry in Conflicting Images To Left and Right Eye

What Functional Purpose This May Have?

- Not All Visual Areas Contain Consciously Accessible Representation –> Eye Rivalry

Blindsight (= slepo-zrakost…)



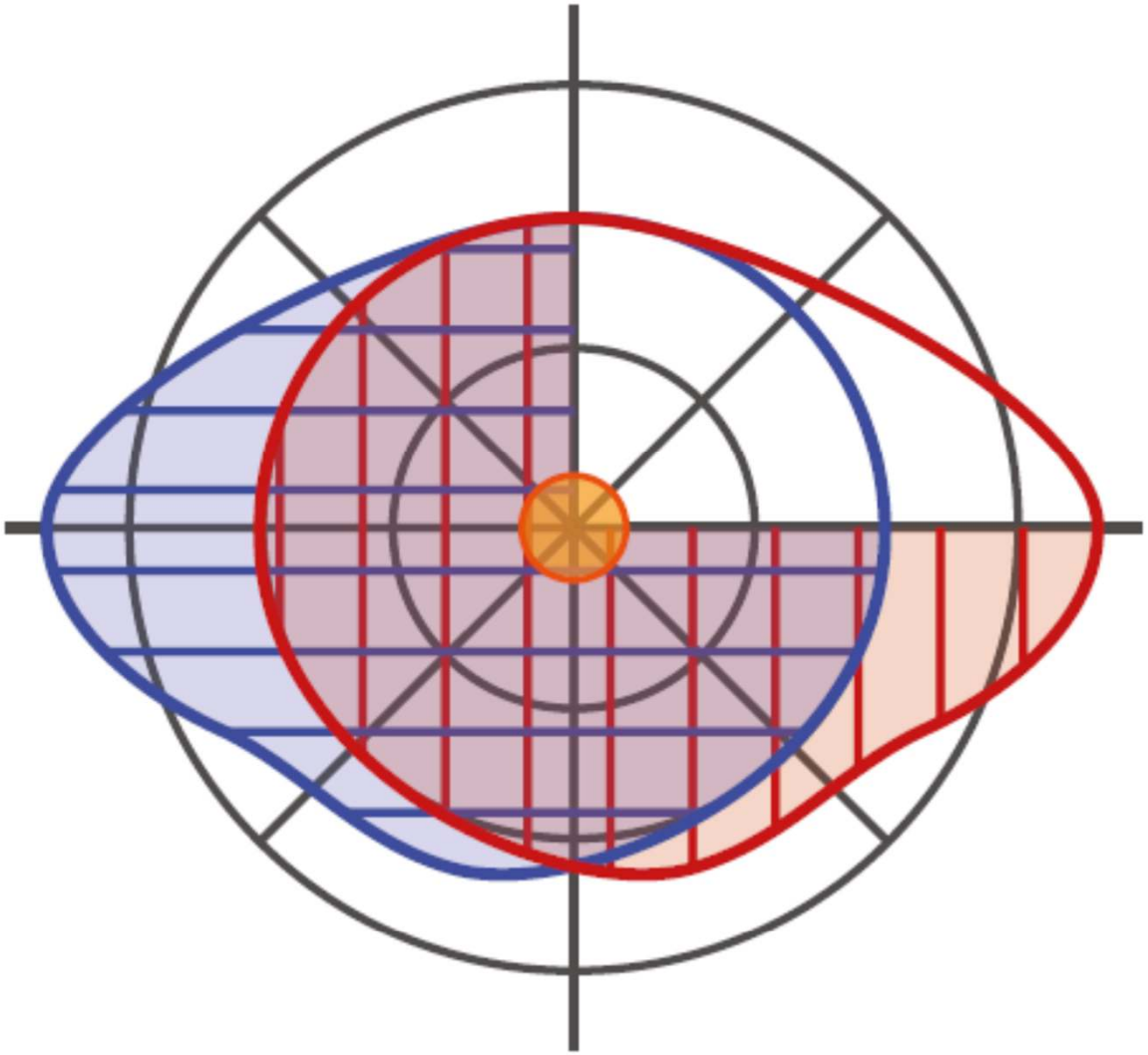
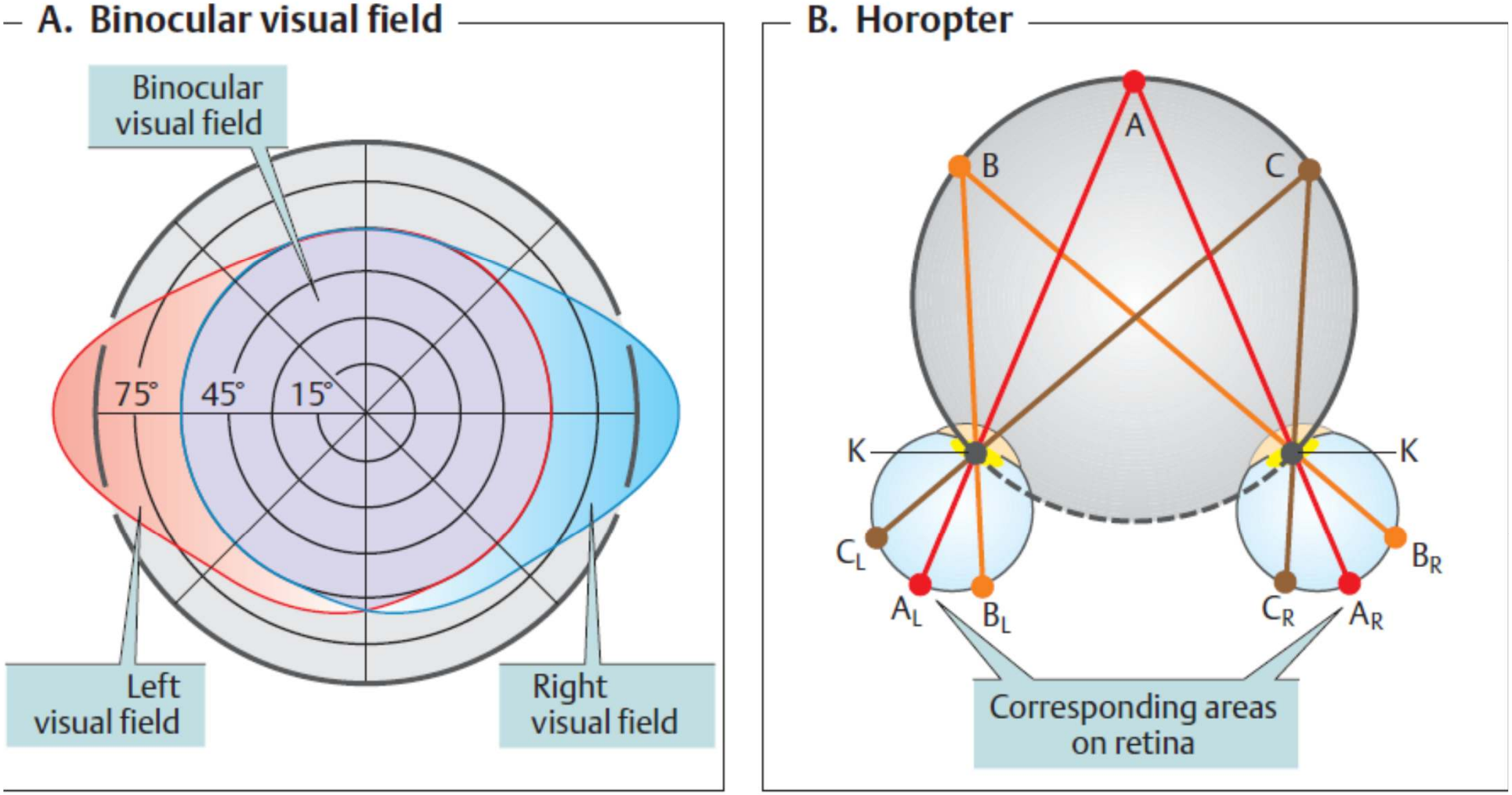
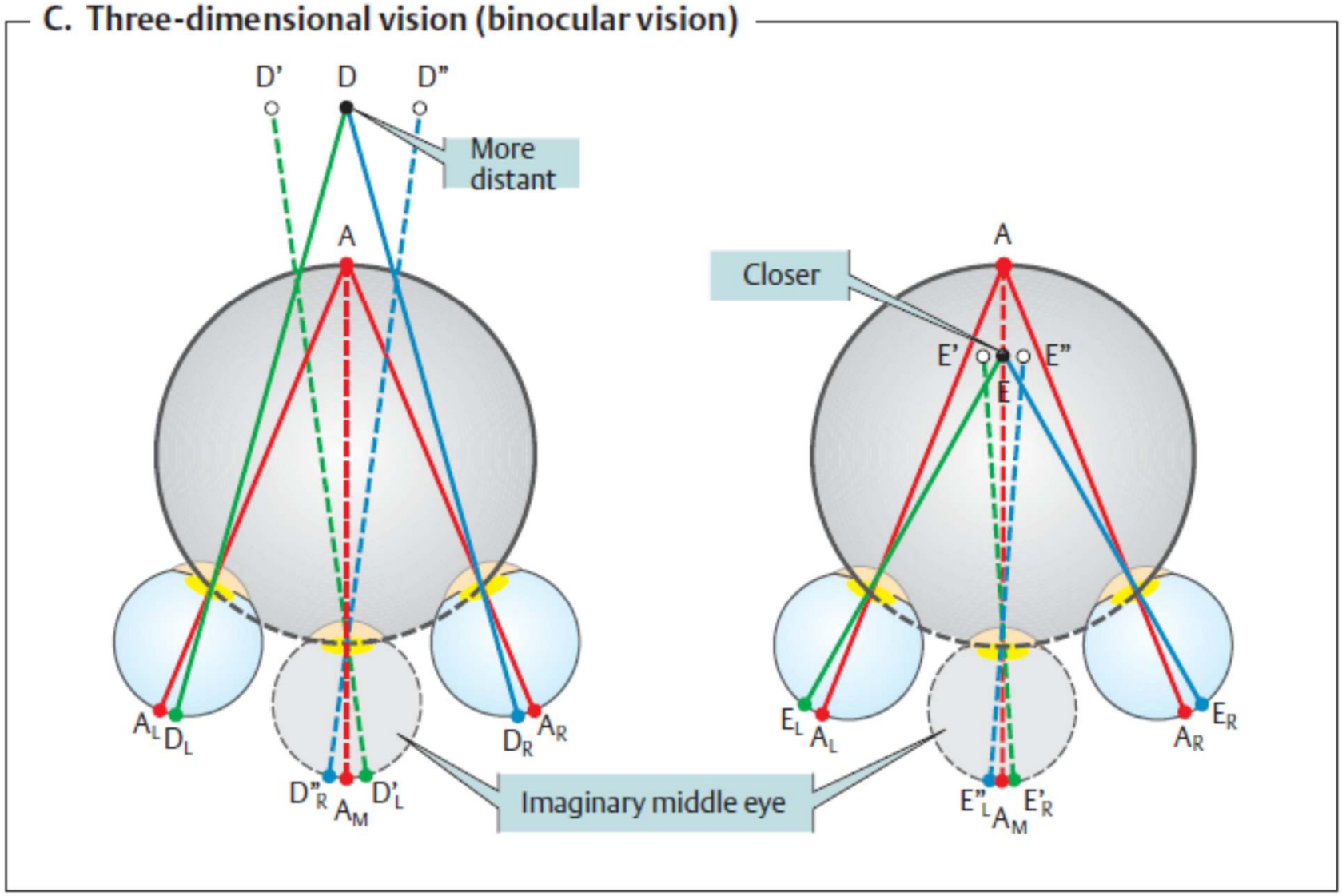


Fig. 2.3 Binocular visual field, subjective view. The binocular visual field spans 40,000 deg ^{2}. The homonymous visual defect typically affects one quadrant (here top right) while the region of best visual acuity (fovea) is spared, due to the overlap of left and right optic radiation

Binocular Fusion

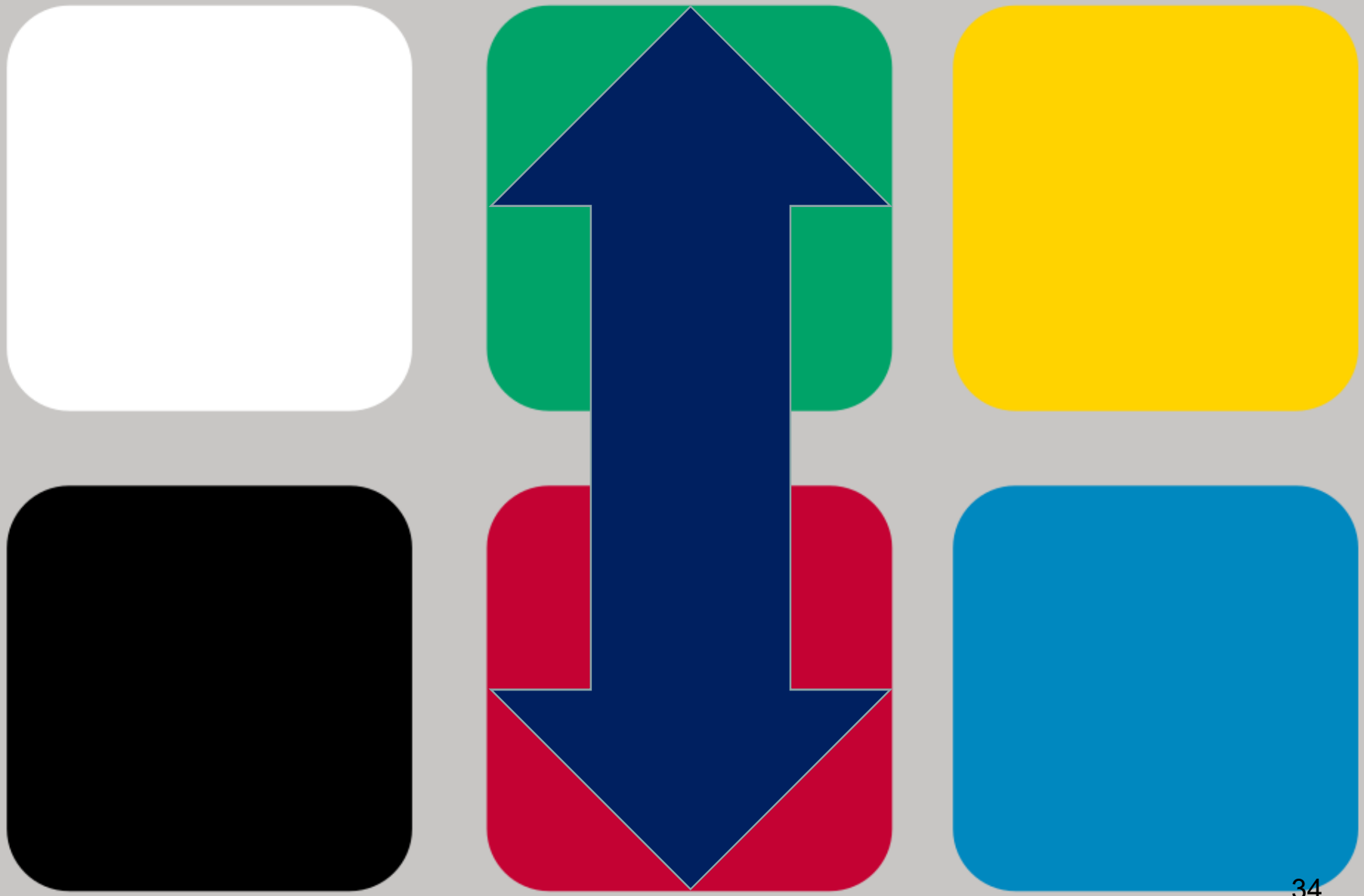


Binocular Fusion

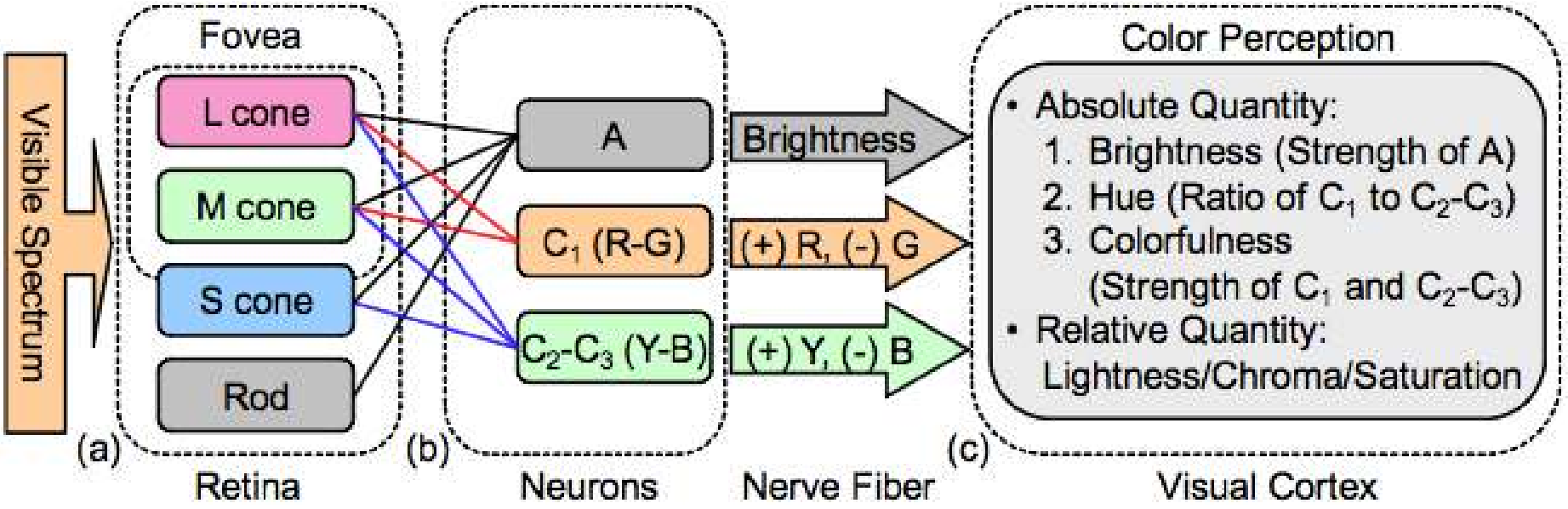


Geometry of disparities using the Cyclopean Eye

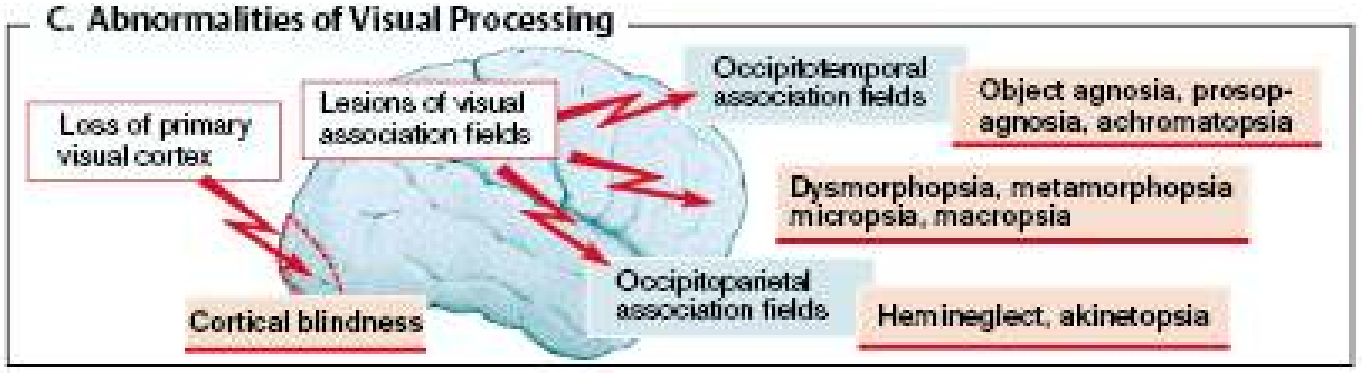
Color Opponent Processes

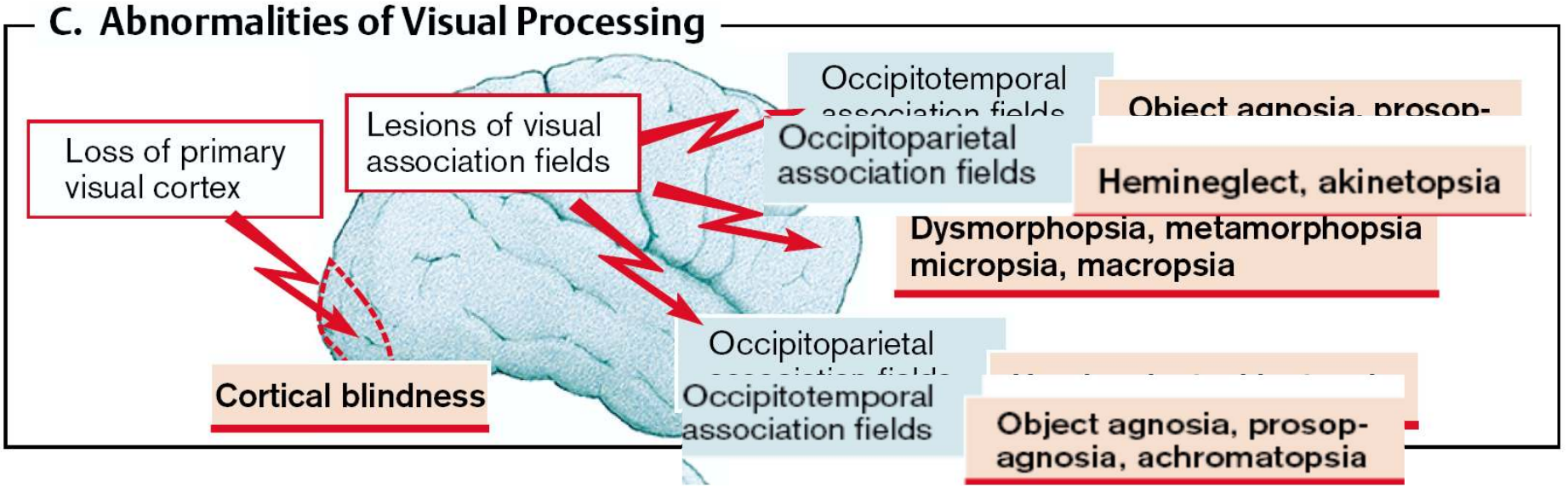


Color Opponent Processes



Understanding and Interpretation Difficulties, Reprinting Errors, Et Cetera...





Disorders of Visual Association Cortices

Atlas of Patophysiology, 1st English edition, 2000, p. 327

Summary – Visual Cortex

- Primary and Secondary Visual Areas
- Synthetic Overview: Image Processing, Receptive Fields, Physiological ‘Laws’
- Not All Visual Areas Contain Consciously Accessible Representation – Eye Rivalry
- Magnocellular and Parvocellular Pathways
- V1, V2, V3, MT and other areas
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- Features not Residing in Unique Areas: Stereo Disparity, Color
- Features Located To areas: Dorsal (Location and Motion) versus Ventral (Object) Streams
- Controversies
- Processing Hierarchy of the Visual Cortex

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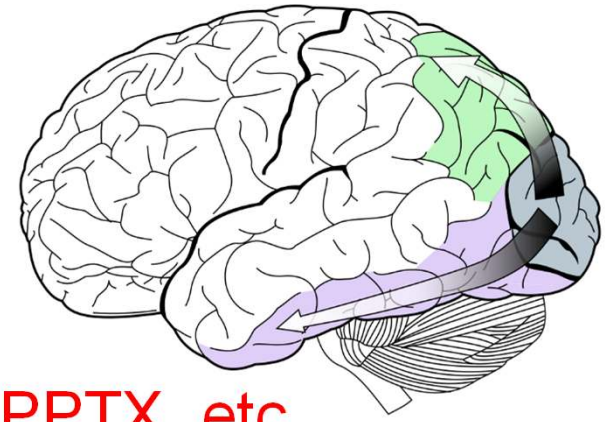
Thanks for your attention



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END

OF THE LECTURE