

Comparative Aspects of Visual and Auditory Central Processing

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Hearing Research

Molecular Physiology of Hearing (Prof. Knipper)

what we need our senses for :

imagine you hear two voices outside in the hallway...

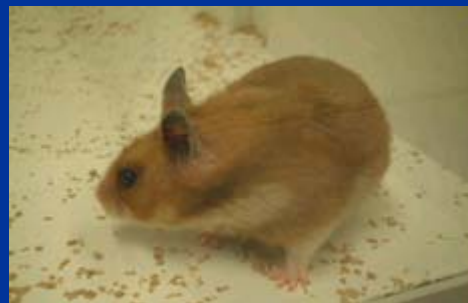
sounds, views, touches, odours ...

all contribute to conscious or unconscious individual recognition (identification of a specific person by a rich, multimodal and individually distinct set of cues and the placement of that individual in a society of many others)

can multiple cues cross-modally be integrated to perform a representation of an individual ?

animals might integrate multiple cues to form a representation of an individual

imagine you *smell* two *cage mates* outside in the hallway...

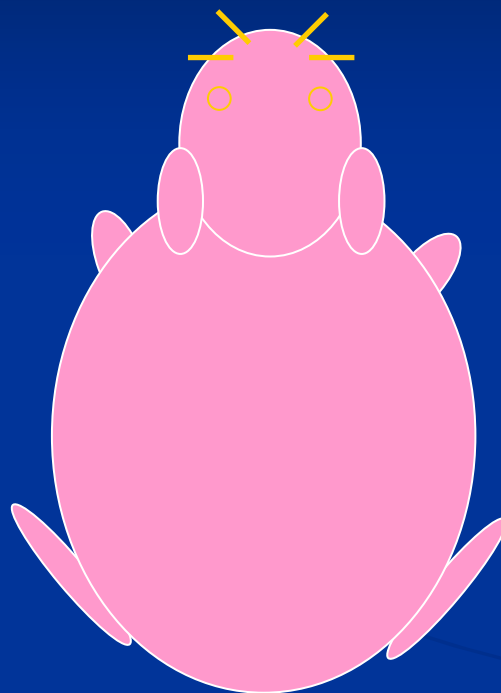
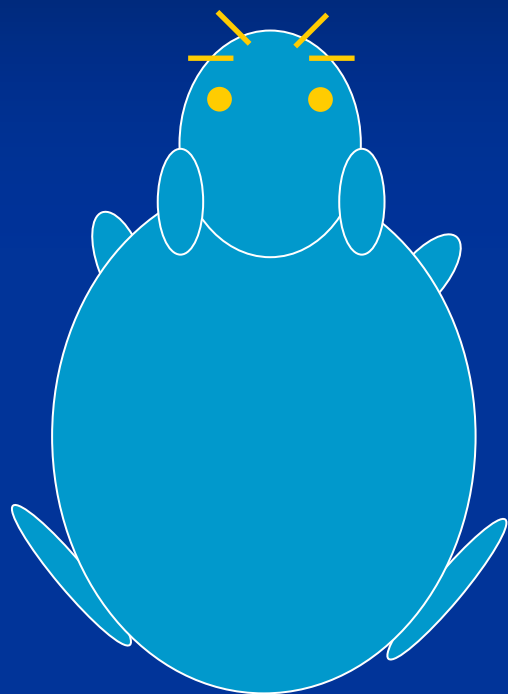


Johnston & Bullock 2001

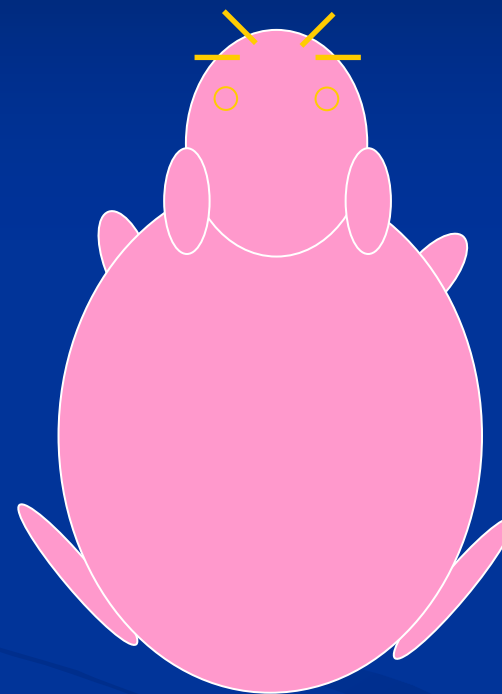


Johnston Lab

golden hamsters (*Mesocricetus auratus*)

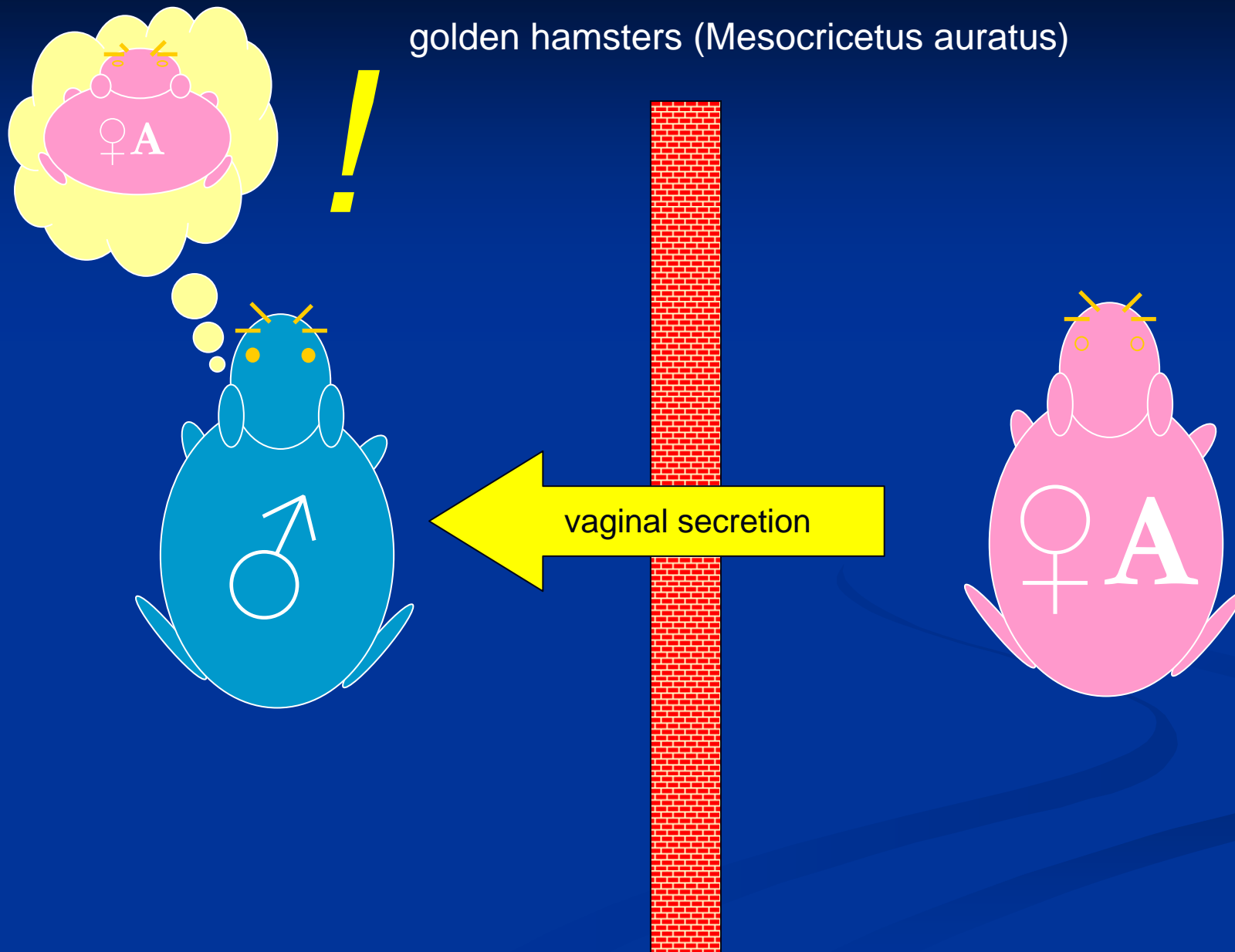


A

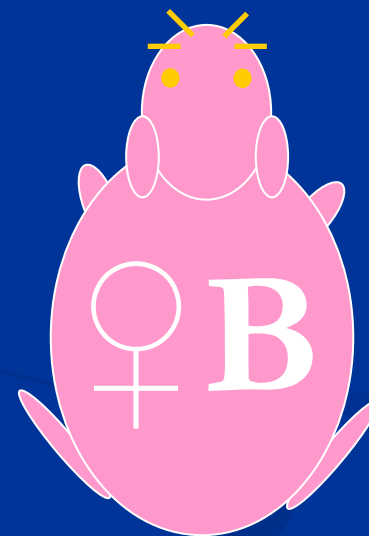
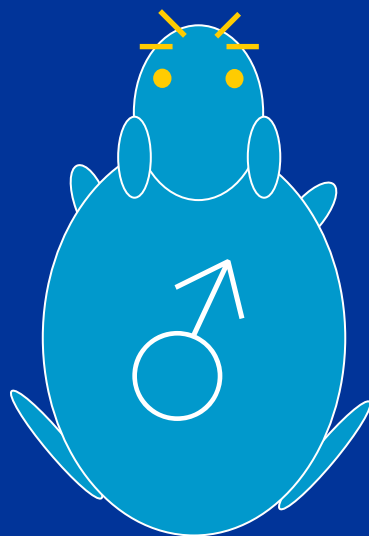


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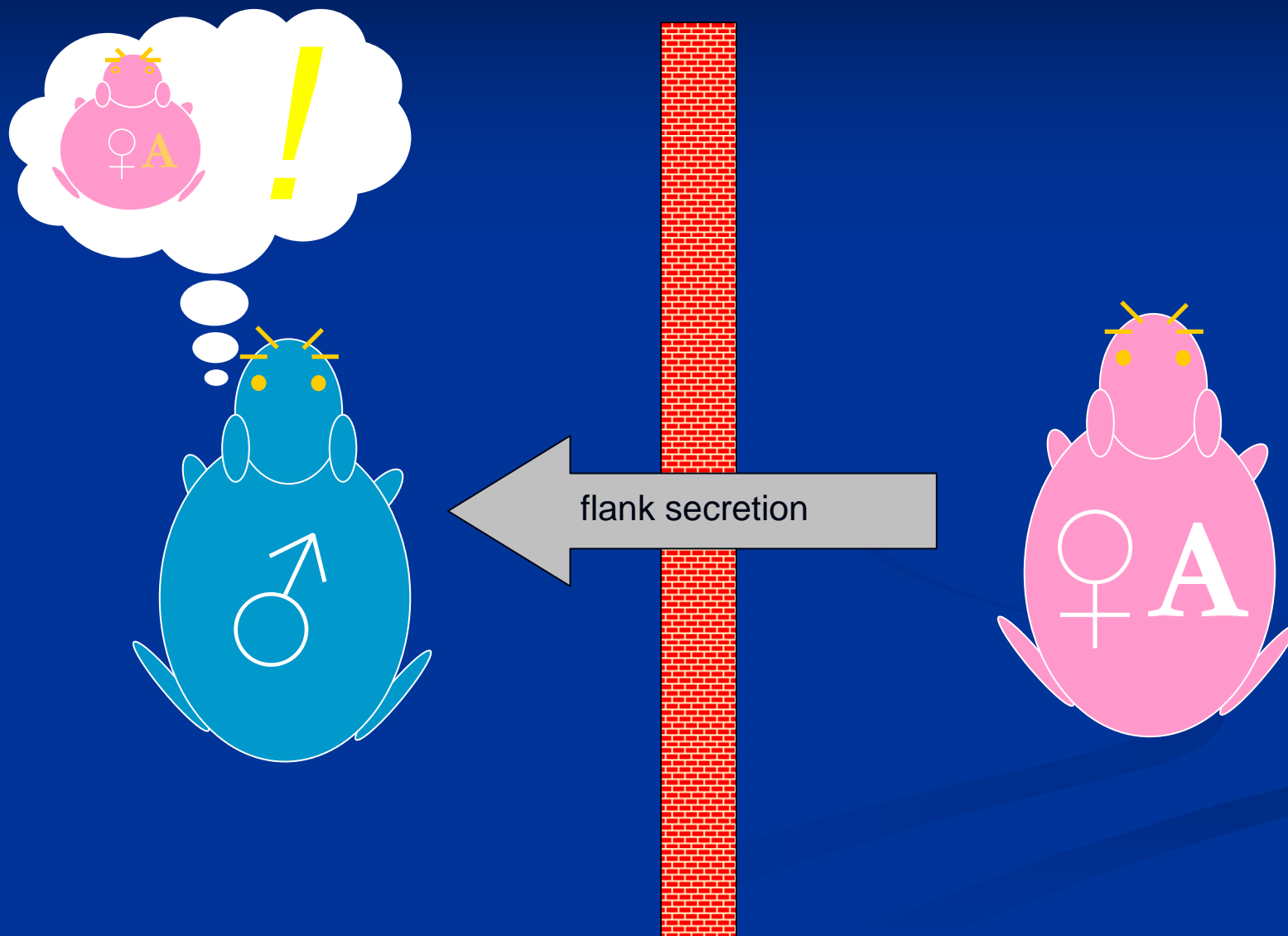
golden hamsters (*Mesocricetus auratus*)



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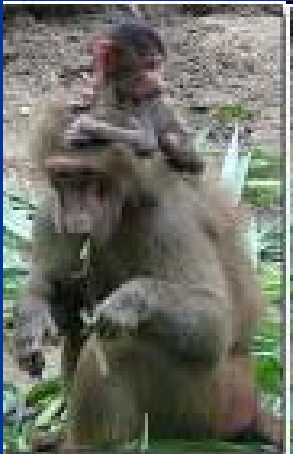
hamsters have an integrated, multiodor memory
of other individuals

The vomeronasal organ is involved in discrimination
of individual odors by males but not by females
(in golden hamsters *Johnston & Peng 2000*)

direct physical contact is necessary for such memories
to develop

(more to come later – maybe)

baboon (genus Papio)



naturally,
offspring is with the mother



when the offspring is separated and calls ...



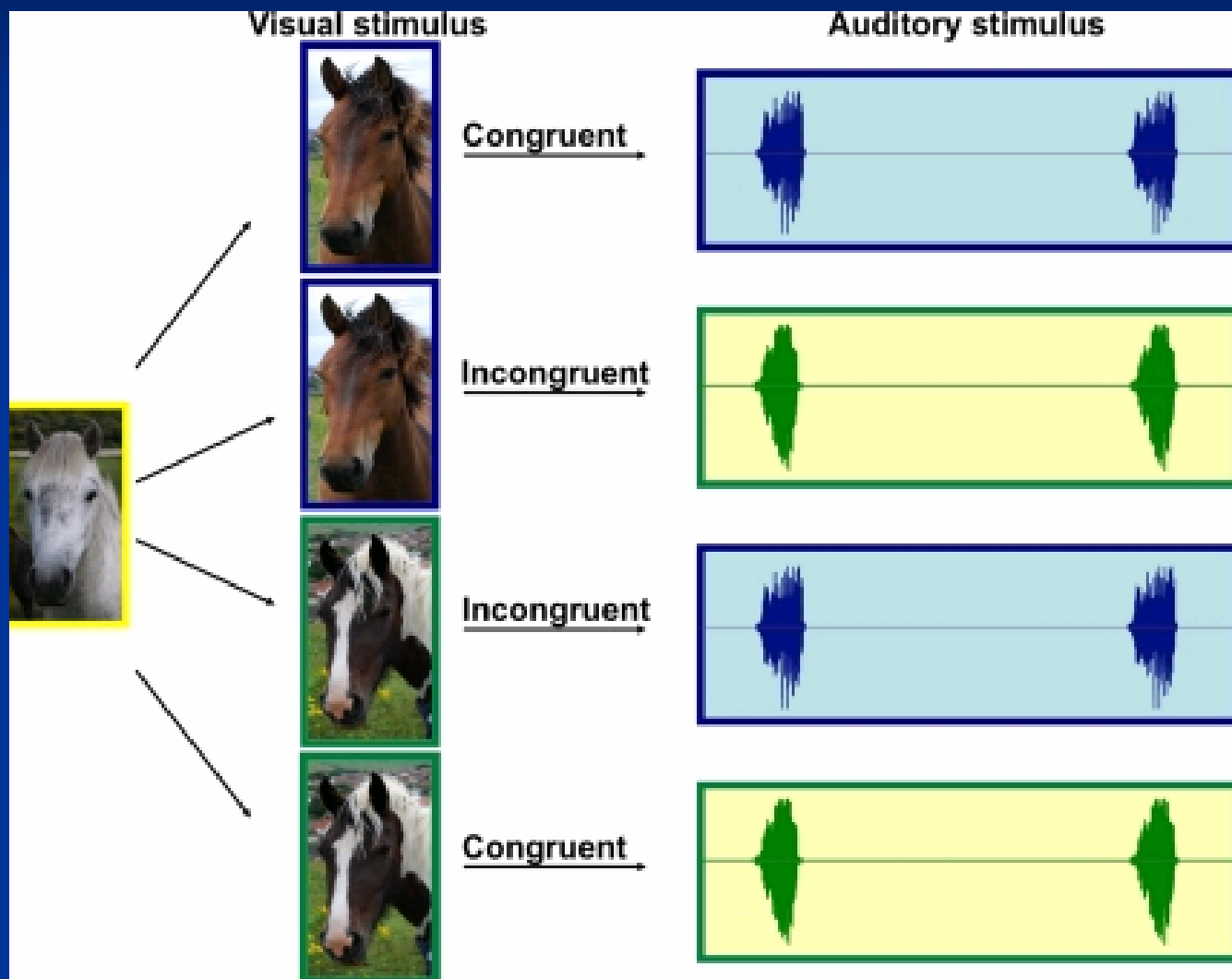
mothers look towards the sound of the vocalization

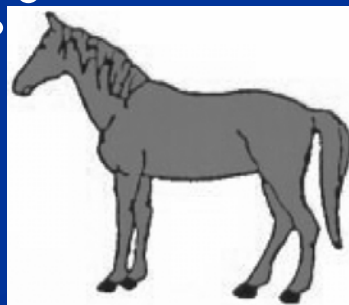
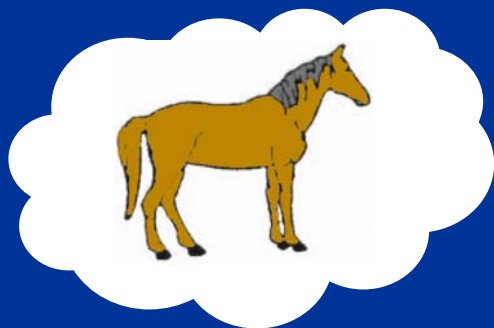
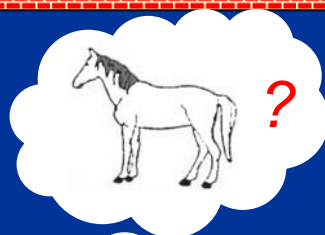
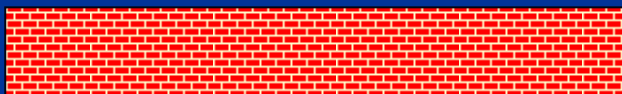
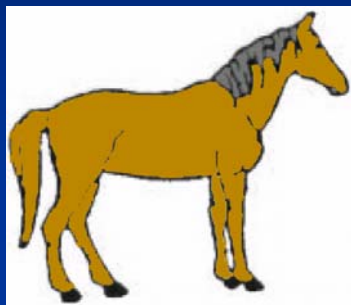


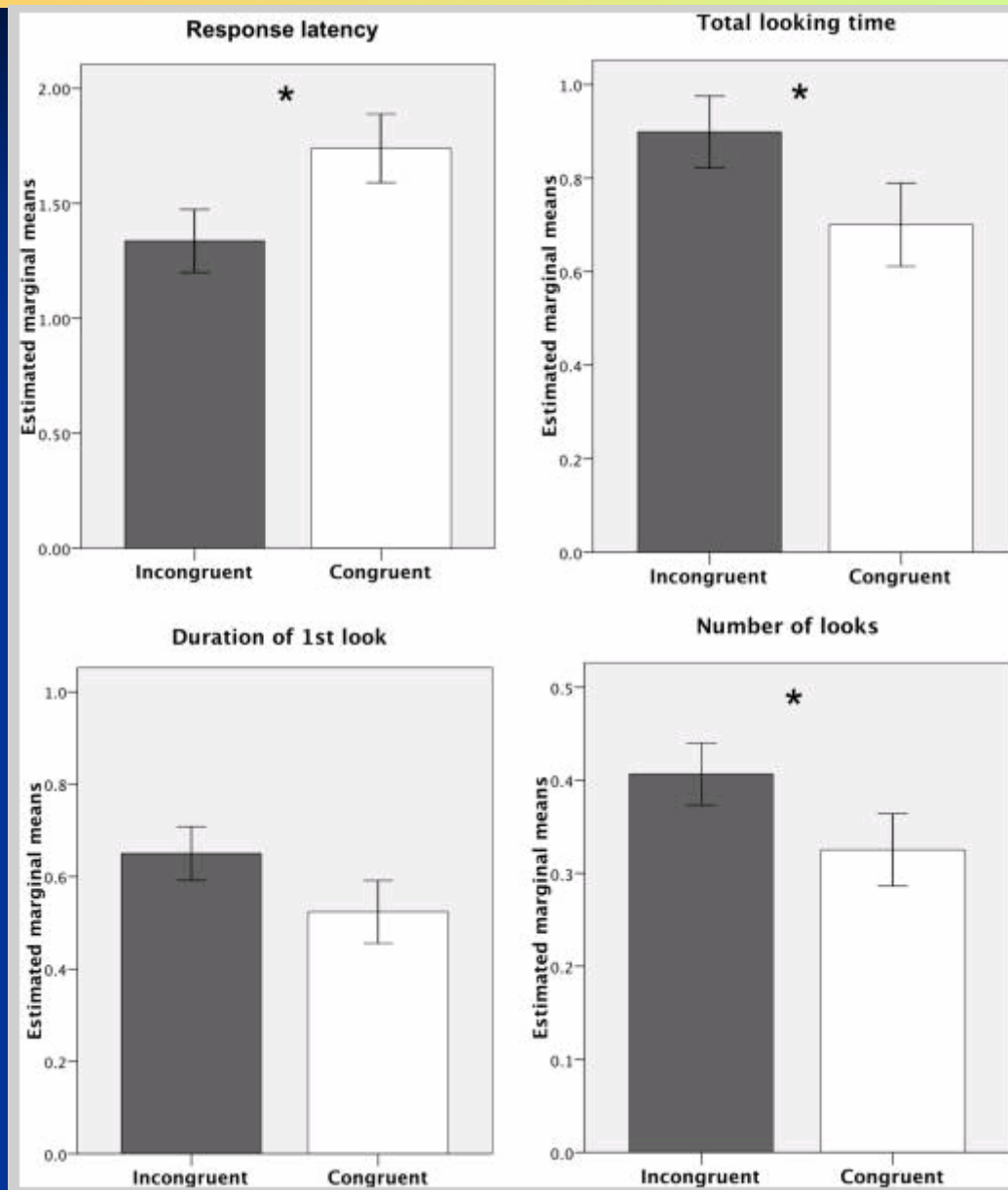
unrelated mothers look towards the mother of the offspring



and where are the horses (*Equus caballus*)







nonhuman animal recognizes members of its own species across sensory modalities

to recognize individuals by e.g. voice or odor
can be helpful to make use of this information when responding to calls according to an individual's mating status, competition or cooperative status, dominance rank

underlying mechanisms ?

underlying mechanisms ?

hearing

>>> activity in brain areas
associated with auditory processing

>>> activity in brain areas associated with
higher-order visual processing

superior temporal sulcus (STS)

recognition of talkers' identity by integration
of visual and auditory information at cross-modal
presentation

what neural mechanisms and brain areas underlie cross-modal integration ?

- 1) extensive unisensory processing
- 2) multissensory („amodal“) integration

‘the auditory system processes the call, the visual system processes the faces and bodies of conspecifics, along with their expressions and actions, and the affective system processes emotional responses. Association areas capture these activations ... storing them for later representational use. When subsequent calls are encoded, they reactivate the auditory component ... which in turn activates the remaining components in other modalities. Thus the distributed property circuit that processed the original situation later represents it conceptually.’ Barsalou (2005)

As a result, “much, if not all, of neocortex is multisensory” (Ghazanfar & Schroeder 2006)

feature detection

visual
auditory
cross modal

object recognition

„feature creatures“ and „frequency freaks“



recognition of distinct
object cues like brightness,
form, size, color, angle



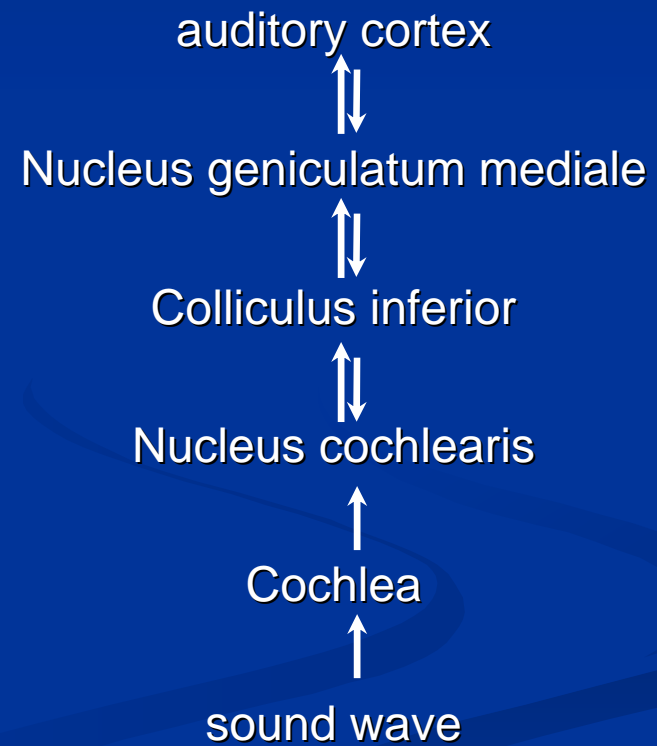
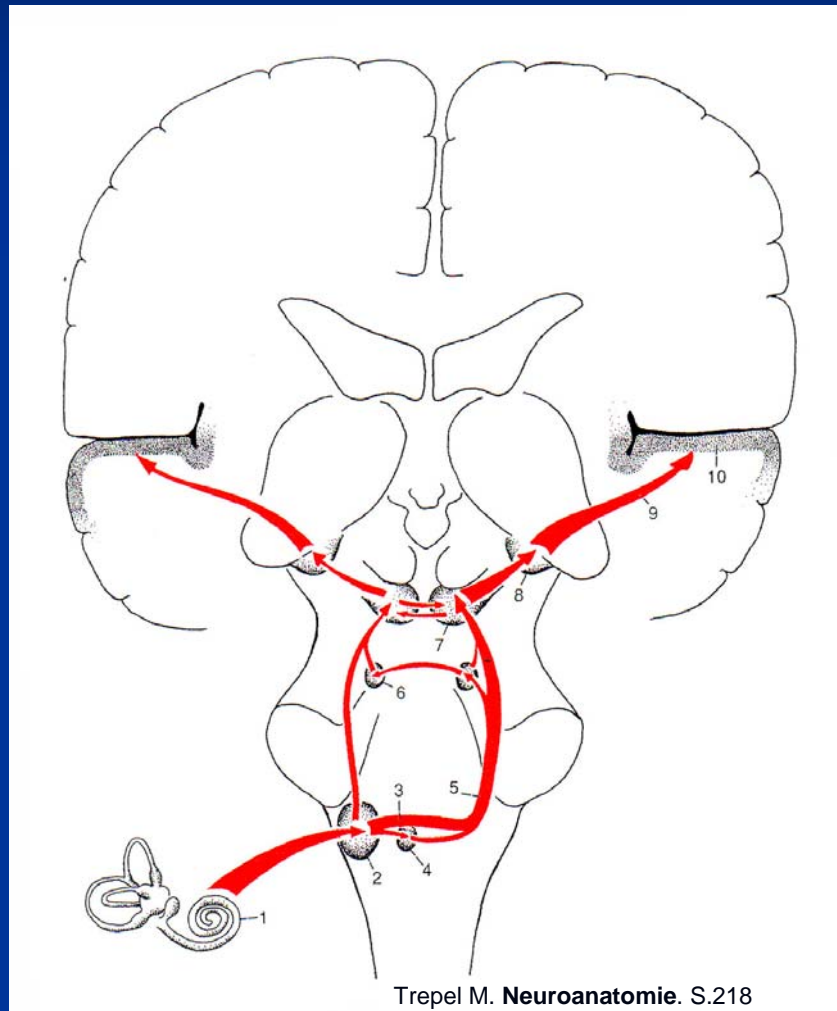
segmentation of images
into space and time
frequencies and
reconstructing objects



object representation and memorizing

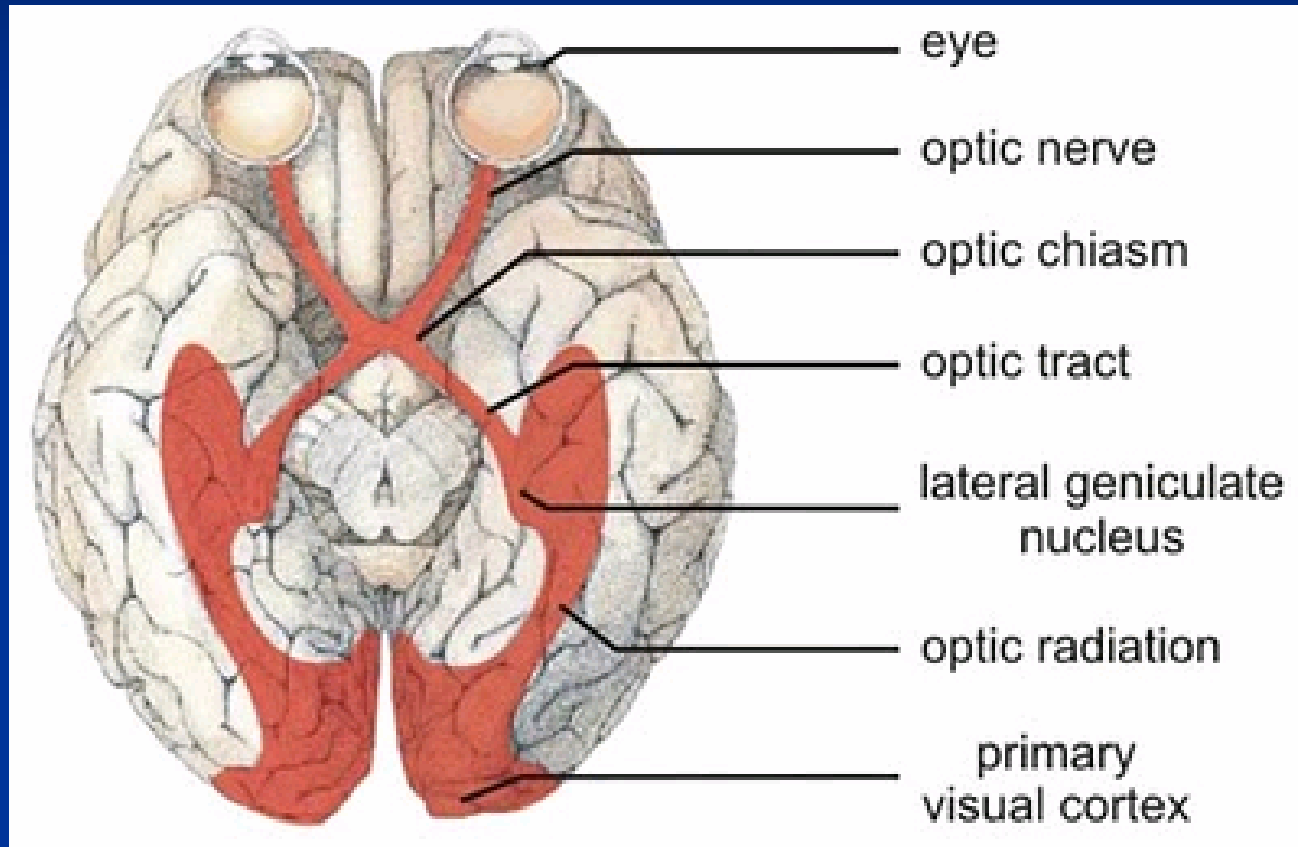
the auditory pathway

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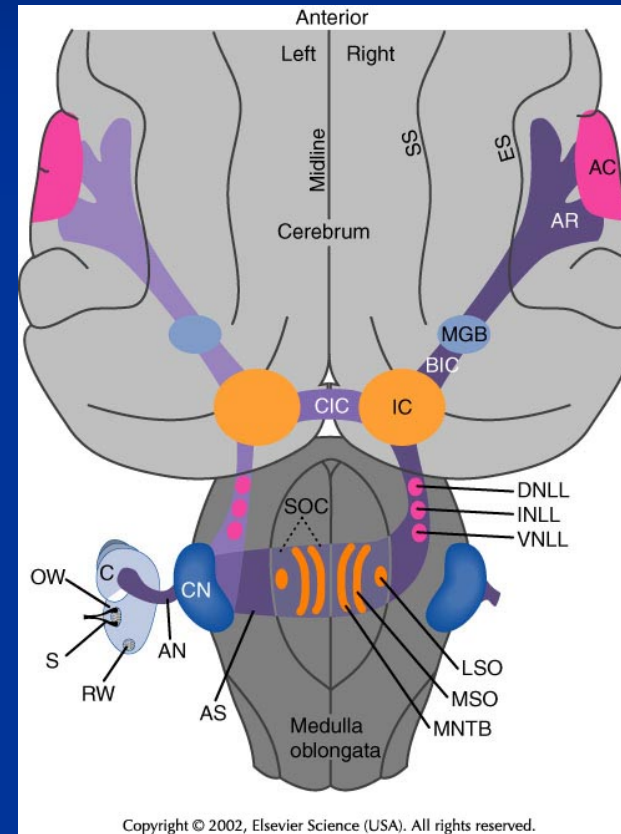
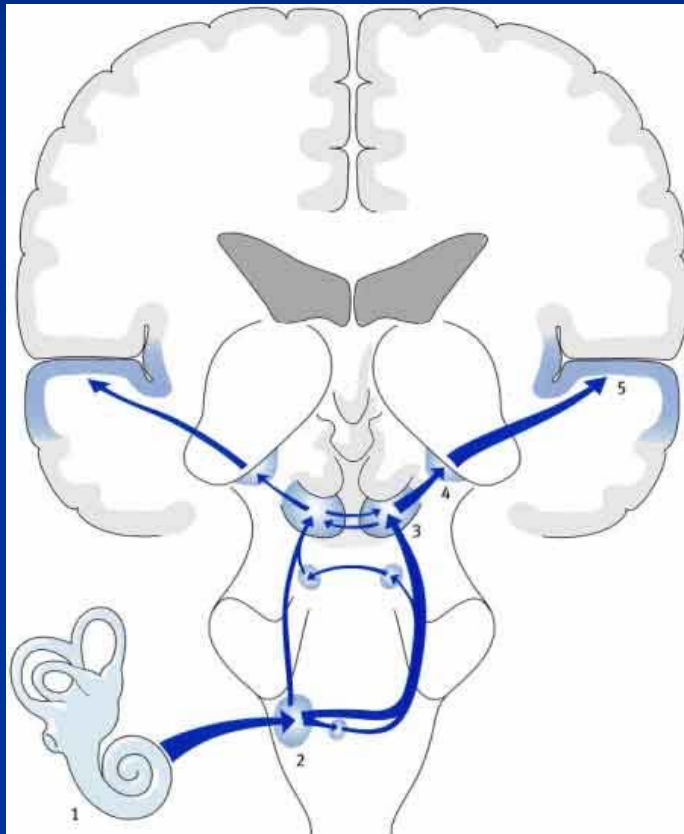
the visual pathway

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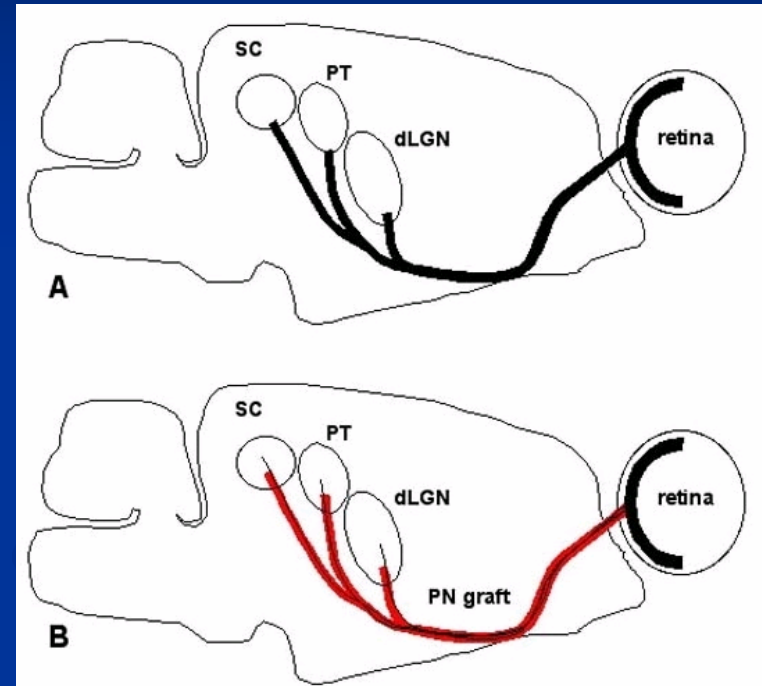
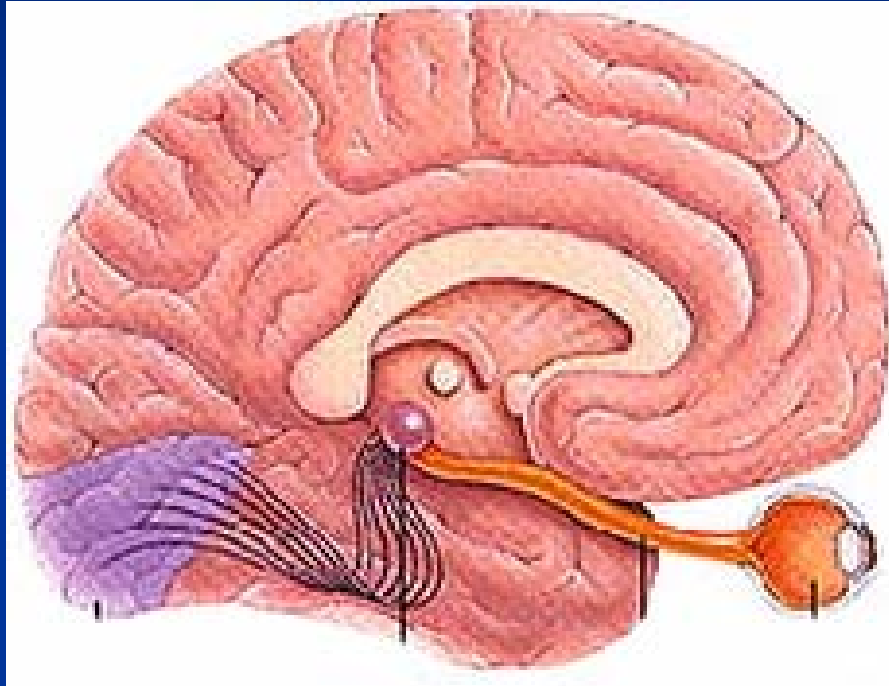
auditory pathway : man / rat

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visual pathway : man / rat

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<http://www.msstrength.com>

(Yves Saave and Frederic Gaillard 2005)

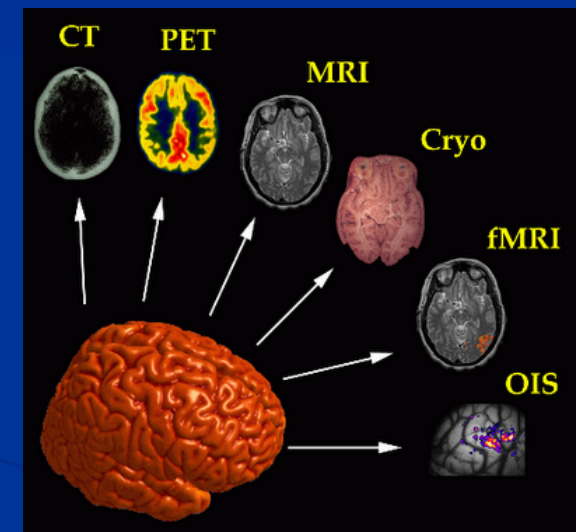
examination of distinct brain functions

animal models

- electrophysiology
- behavioral studies
- anatomical studies

human studies

- anatomical studies (imaging)
- electrophysiology (non invasive)
- perception and sensation (psychophysical)
- studies on patients with brain lesion
- electrophysiology (invasive)



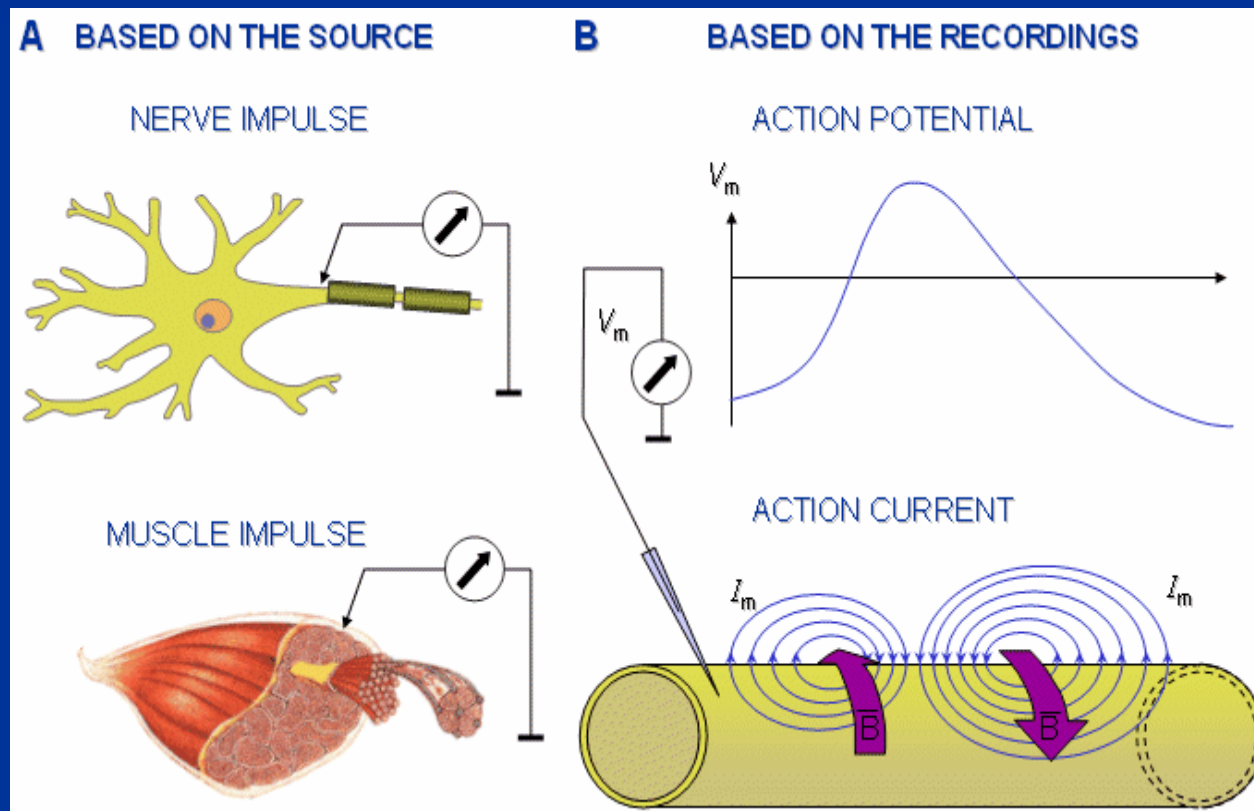
(From socialfiction.org)

animal model : electrophysiology

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bio-potentials

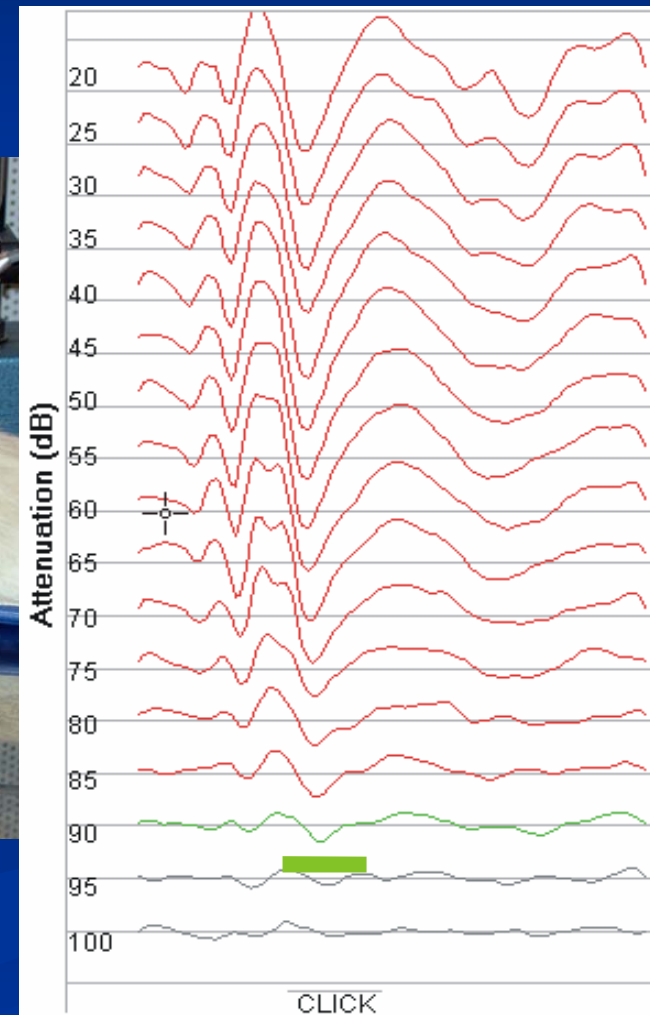
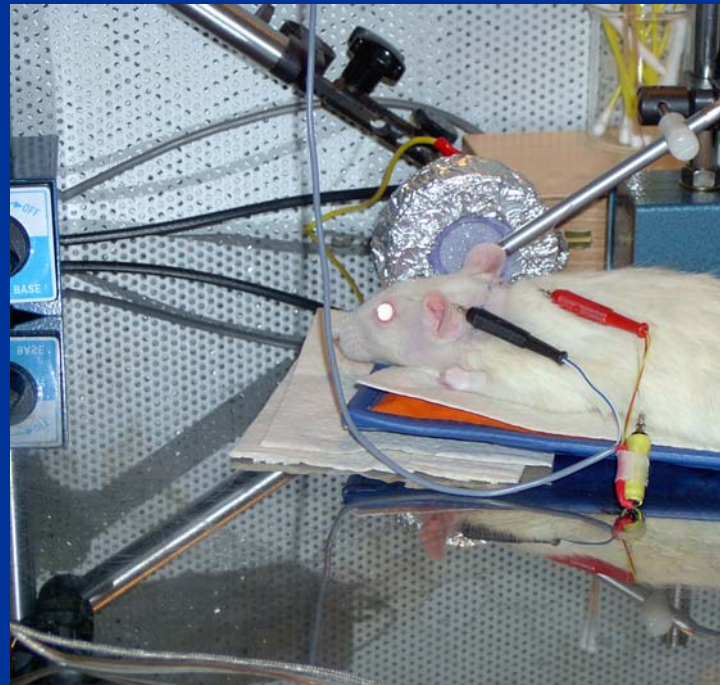
- *an electrical potential that can be measured between two point in living cells, tissues or organisms*
- *all biological processes produce bio-potentials*



animal model : electrophysiology

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brainstem audiometry (ABR, BERA)

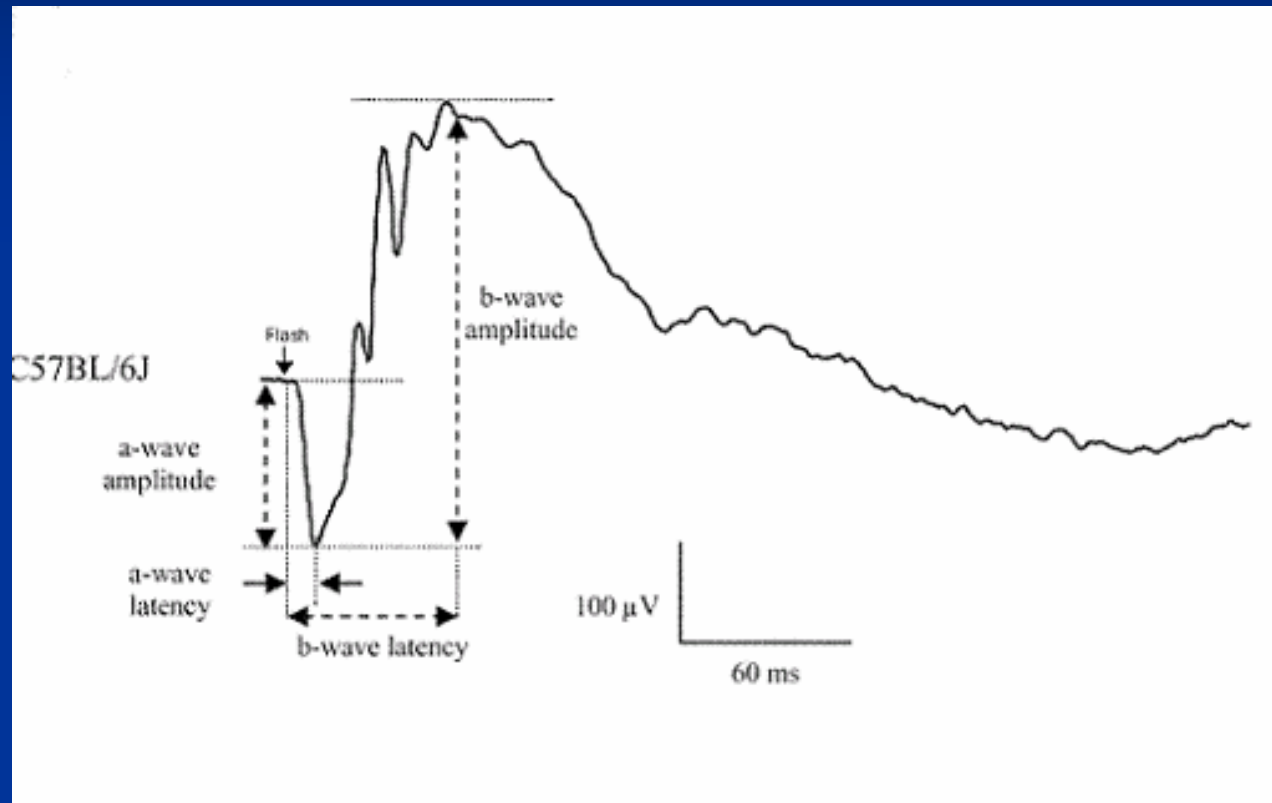


*function of outer ear, middle ear, inner ear
and brainstem*

animal model : electrophysiology

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electro retino gram (ERG)



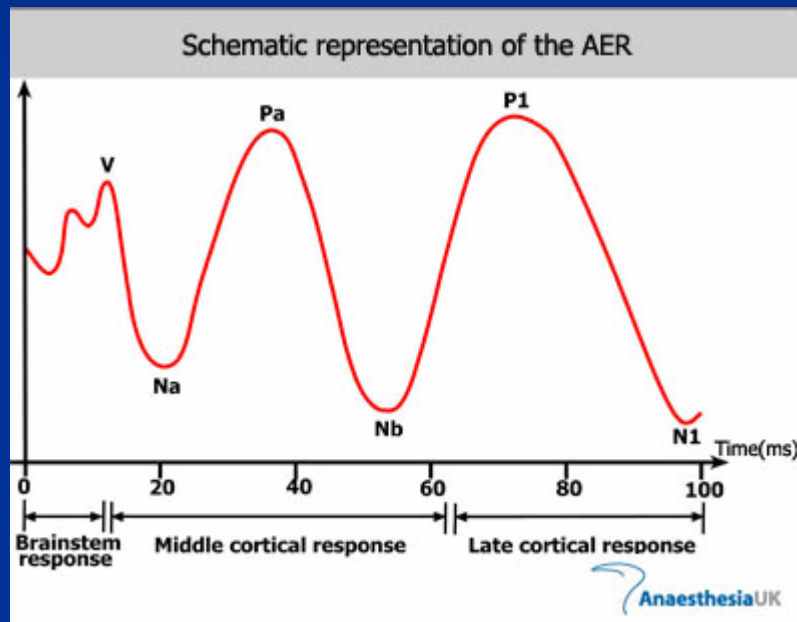
function of retina

www.ics-mci.fr

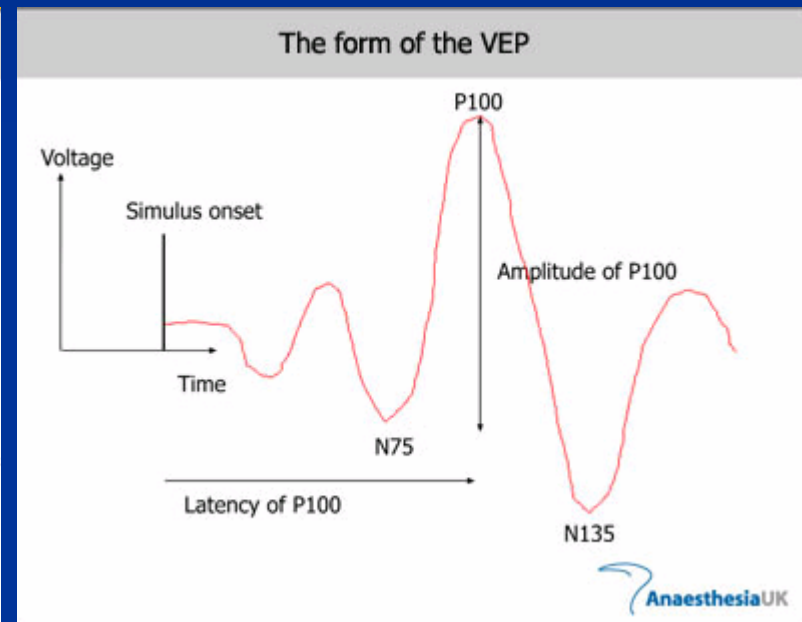
animal model : electrophysiology

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AER and VEP



auditory evoked response

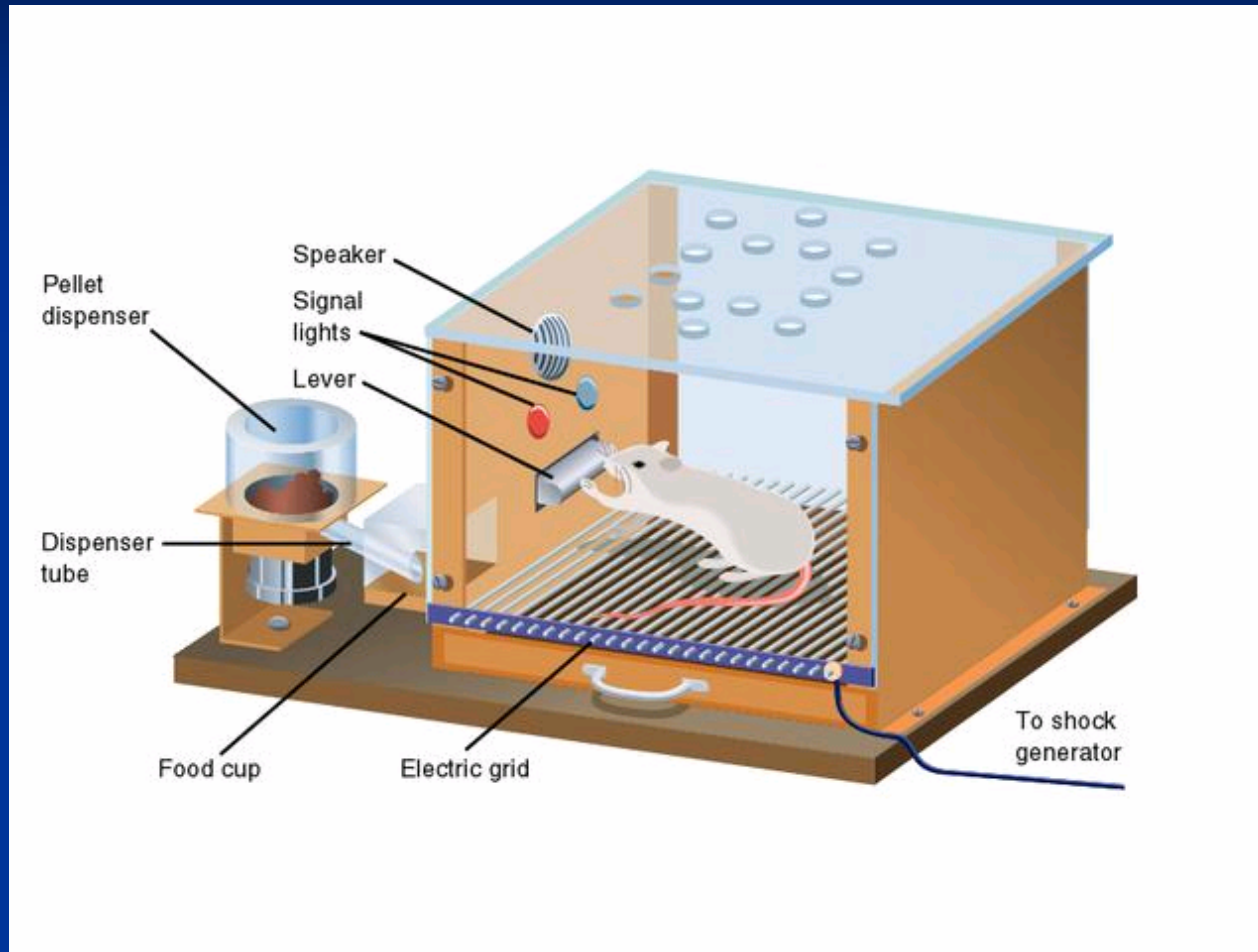


visual evoked potential

function of nerves, tracts, radiation and primary brain areas

animal model : behavioral studies

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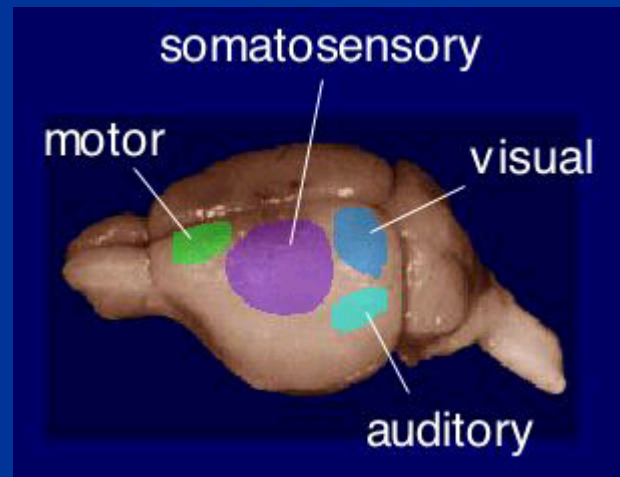
perceptual level of sensory function

<http://members.shaw.ca>

animal model : anatomical studies

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tracing
morphometry
lesion studies
transmitter pharmacology
proteomics and genomics



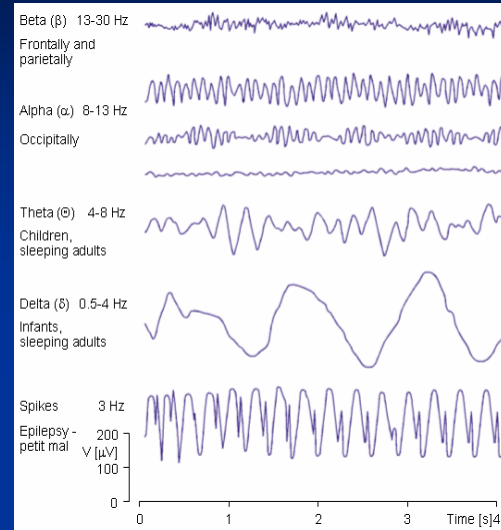
human studies

anatomical studies (imaging)
electrophysiology (non invasive)
perception and sensation (psychophysical)
studies on patients with brain lesion
electrophysiology (invasive)



anatomical studies / non invasive electrophysiology (imaging)

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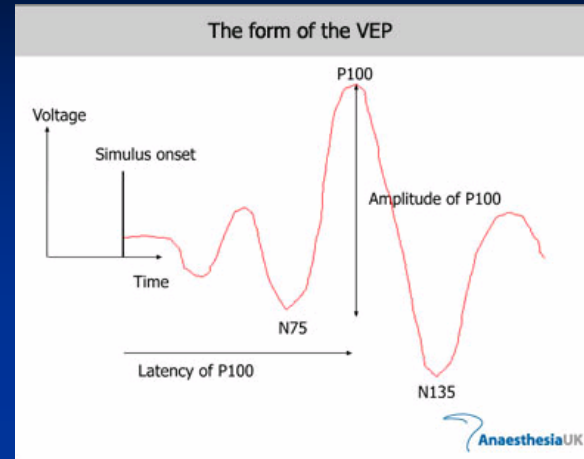
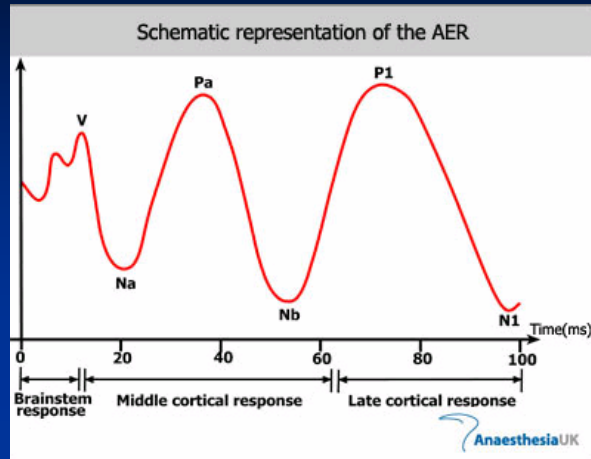


mostly combined with functional studies
EEG, MEG: better temporal resolution
MRI: better spatial resolution

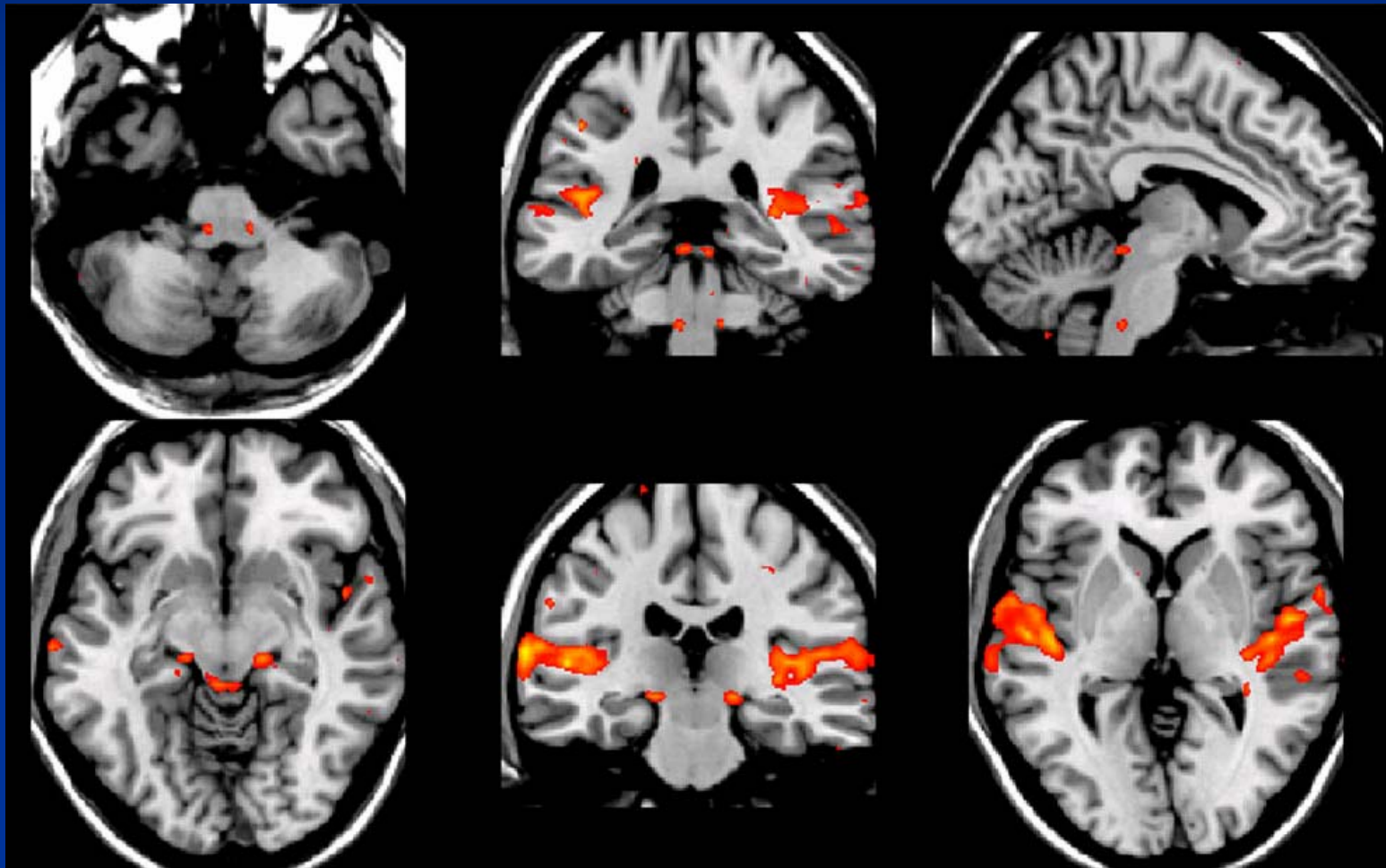


human electrophysiology : ABR, AEP, ERG, VEP,

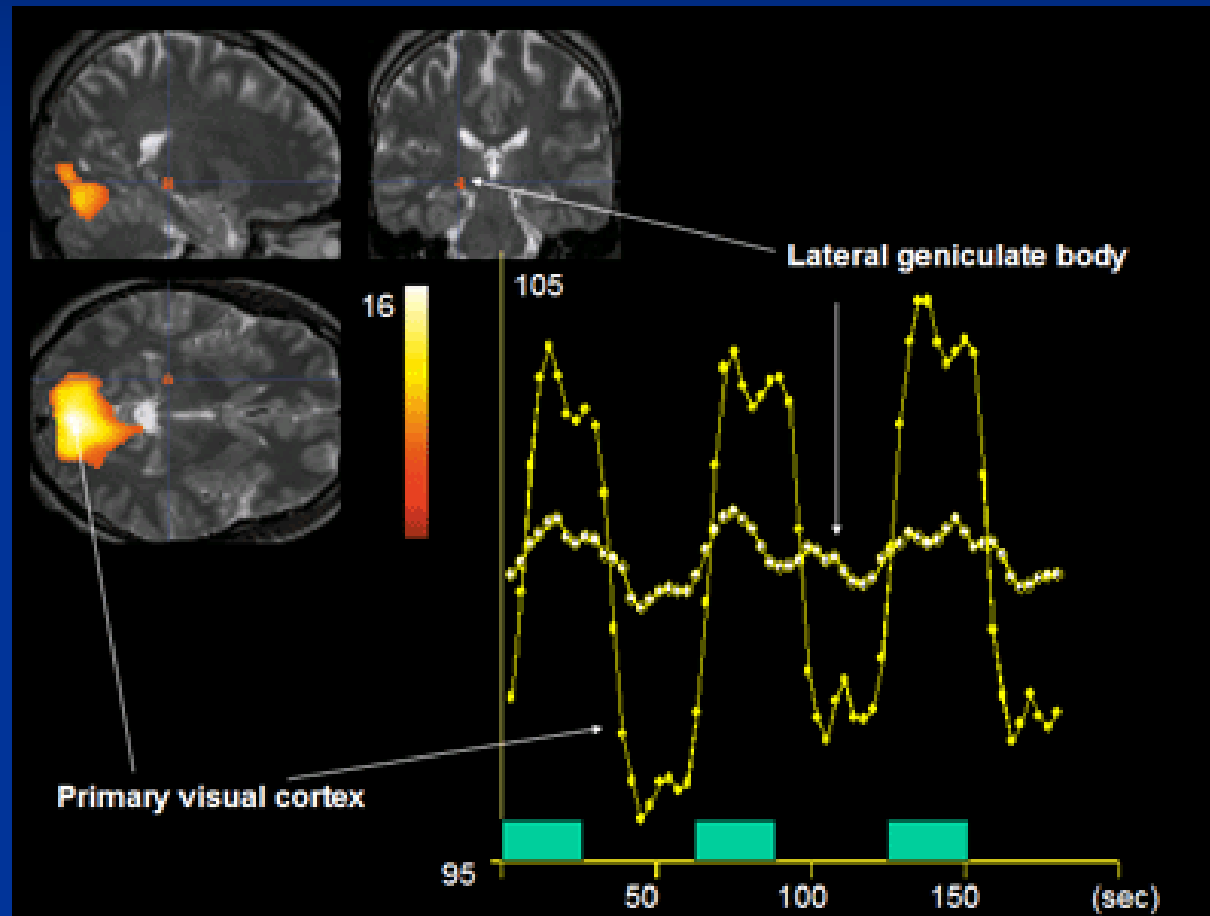
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auditory cortex



visual cortex



perception and sensation : psychophysics

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perceptual threshold
sensation levels

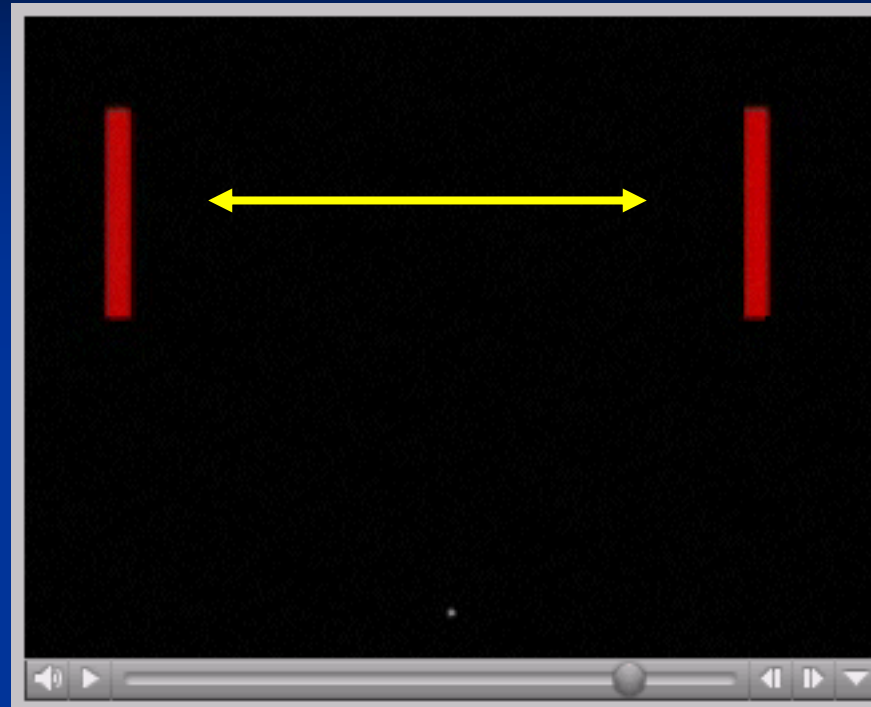
 multimodal integration

examples on multimodal integration:

jumping lines
stroop interference
McGurk effect

jumping lines

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Stroop interference

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BLUE

GREEN

YELLOW

PINK

RED

ORANGE

GREY

BLACK

PURPLE

TAN

WHITE

BROWN

read the color names as fast as possible

Stroop interference

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BLUE	GREEN	YELLOW
PINK	RED	ORANGE
GREY	BLACK	PURPLE
TAN	WHITE	BROWN

read the color names as fast as possible

name the colors as fast as possible



brain damage (stroke, tumors, injury)

block of information flow (local cooling, pharmaka, TMS)

a specific example :
color detection, color discrimination and color sensation

is there a brain center for color **constancy**?

Psychophysical Visual „Channels“

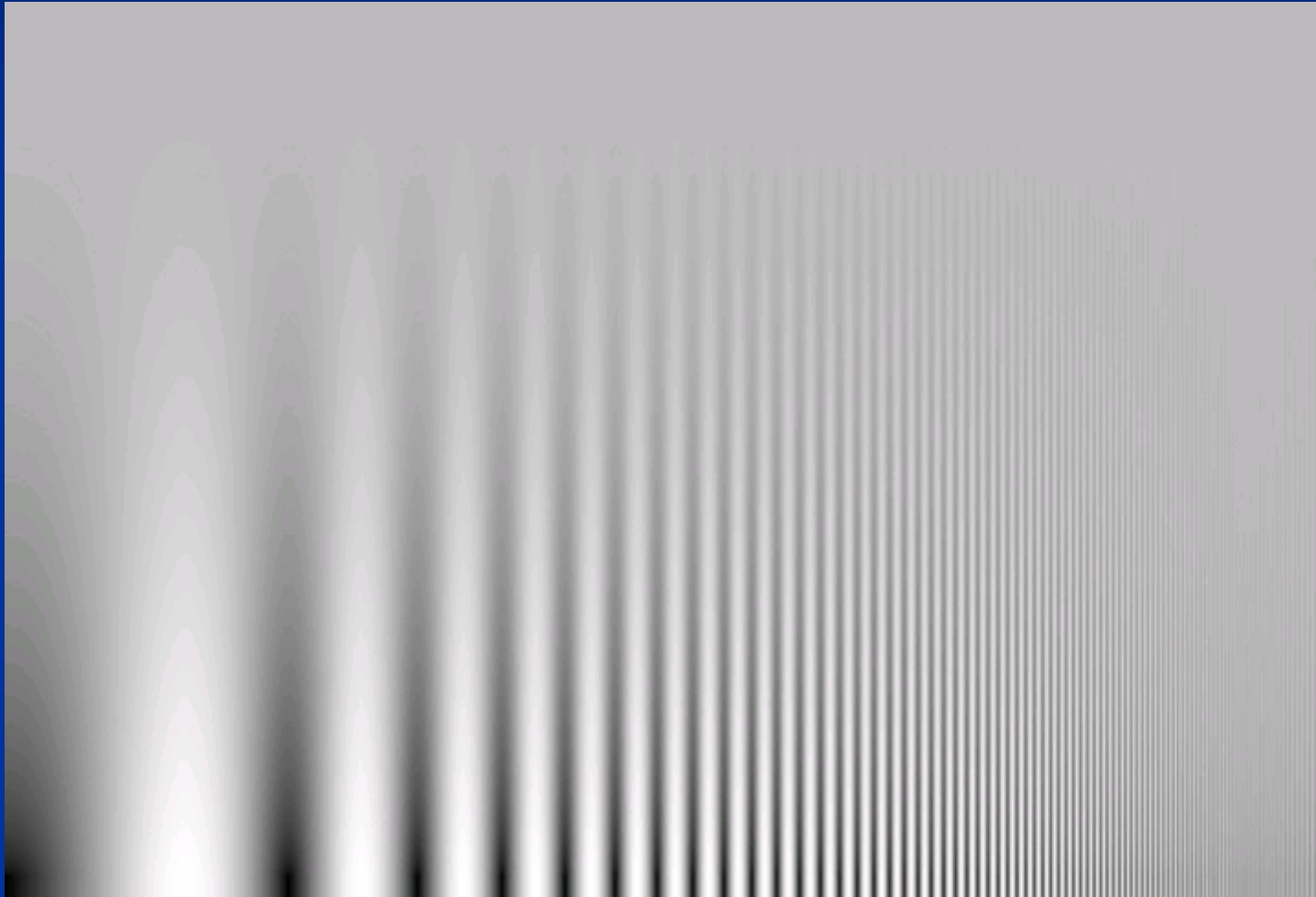
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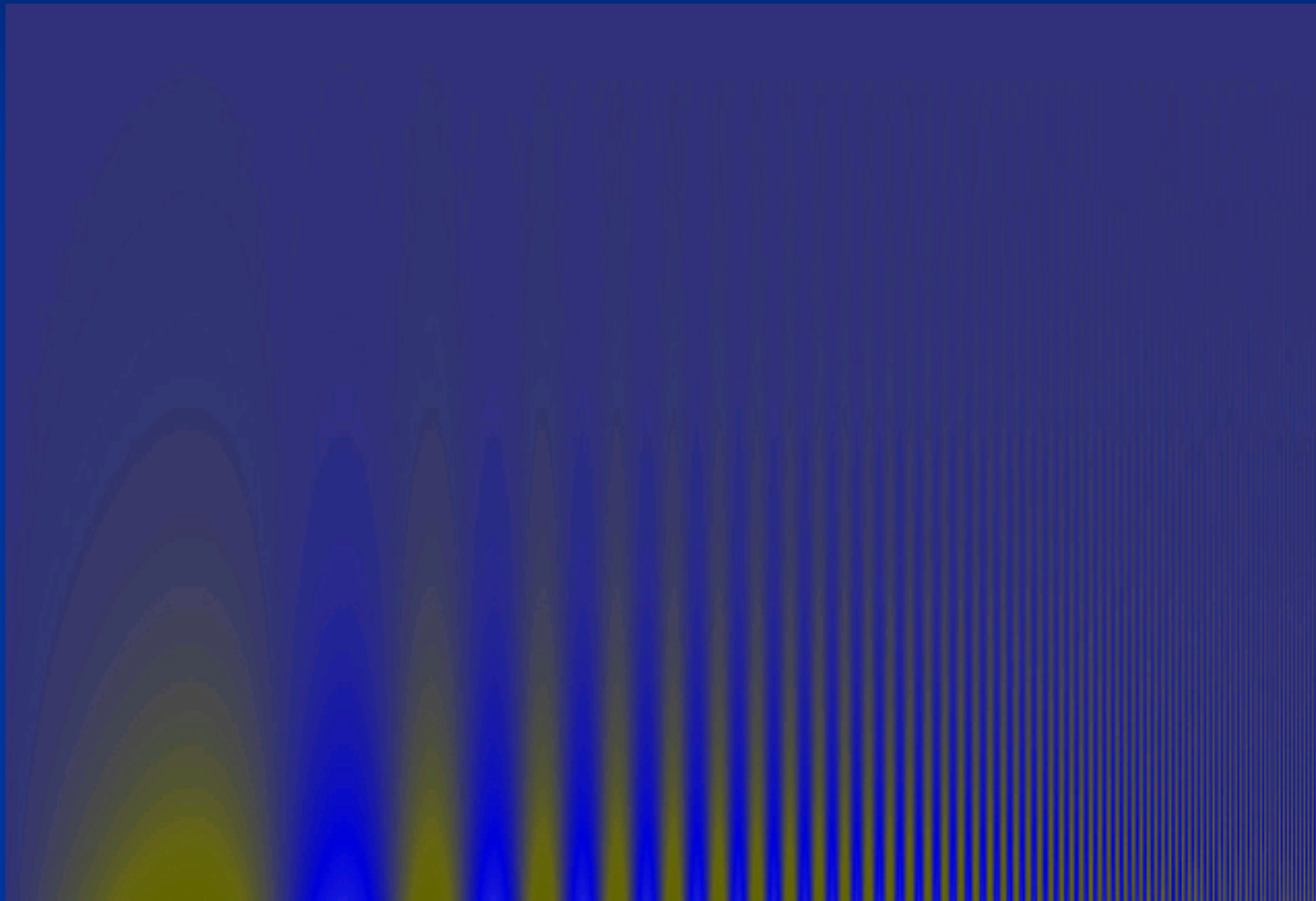
„Luminance“



„Hue / Colour / Chrominance“

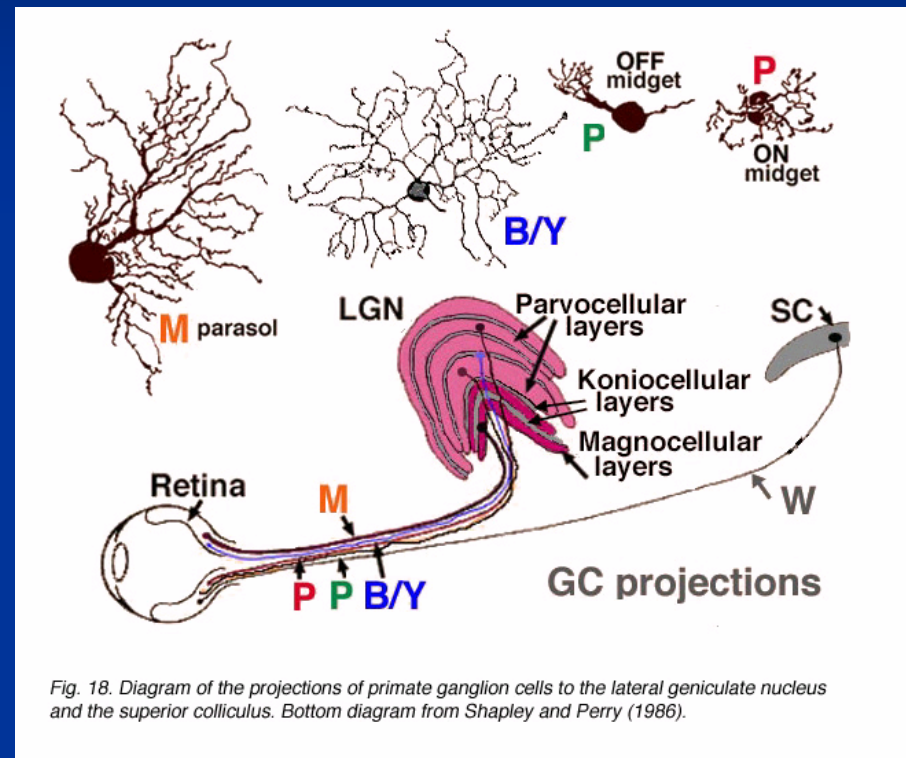
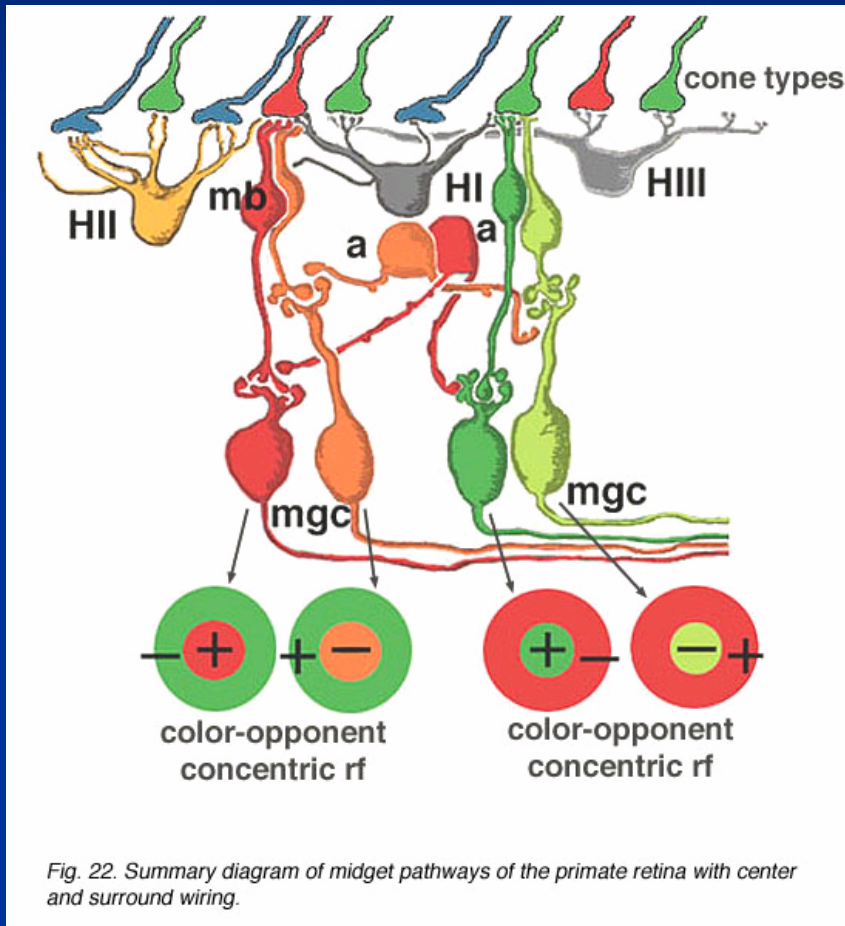






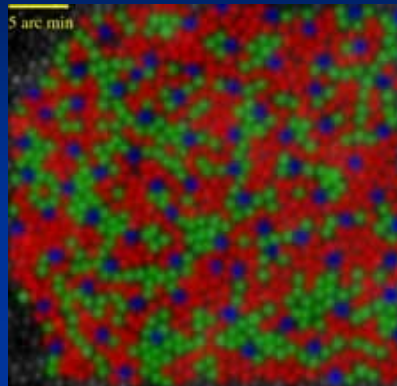
The anatomical correlate for Psychophysical Visual „Channels“

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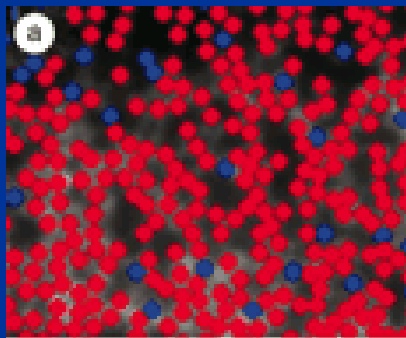


Deuteranomaly, Protanomaly, Dichromats and Trichromats

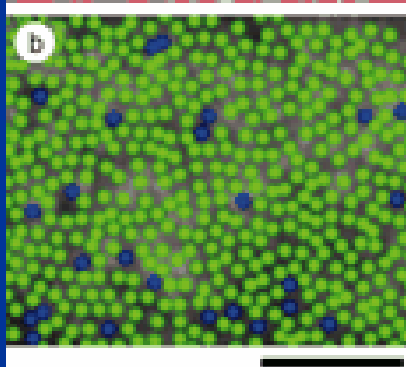
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normal trichromatic



Deuteranomalous and deuteranopic



Protanomalous and protanopic

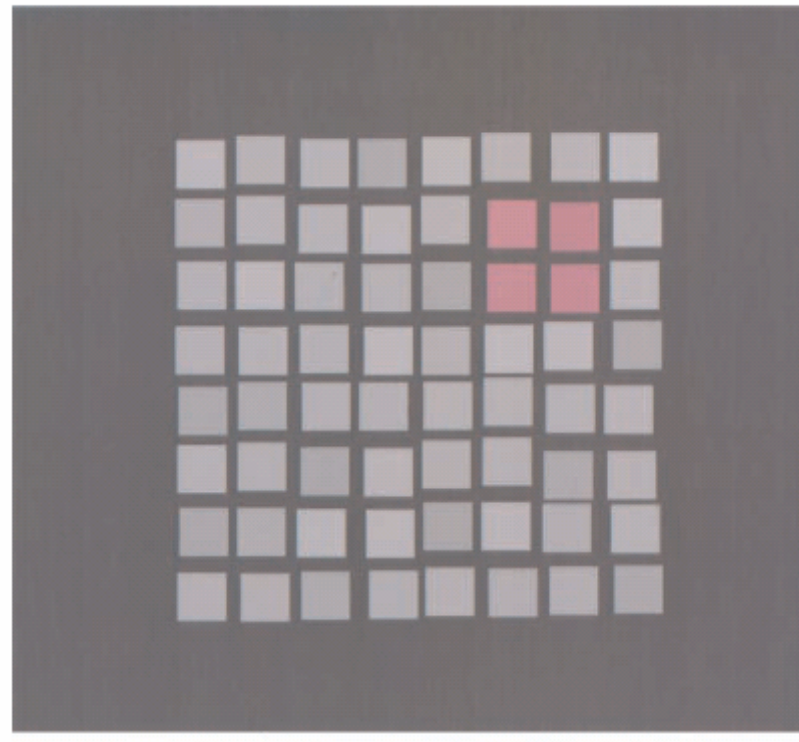
David Williams' Lab
Center for visual science
University of Rochester



Congenital colour vision deficiencies can easily be detected by colour discrimination tests

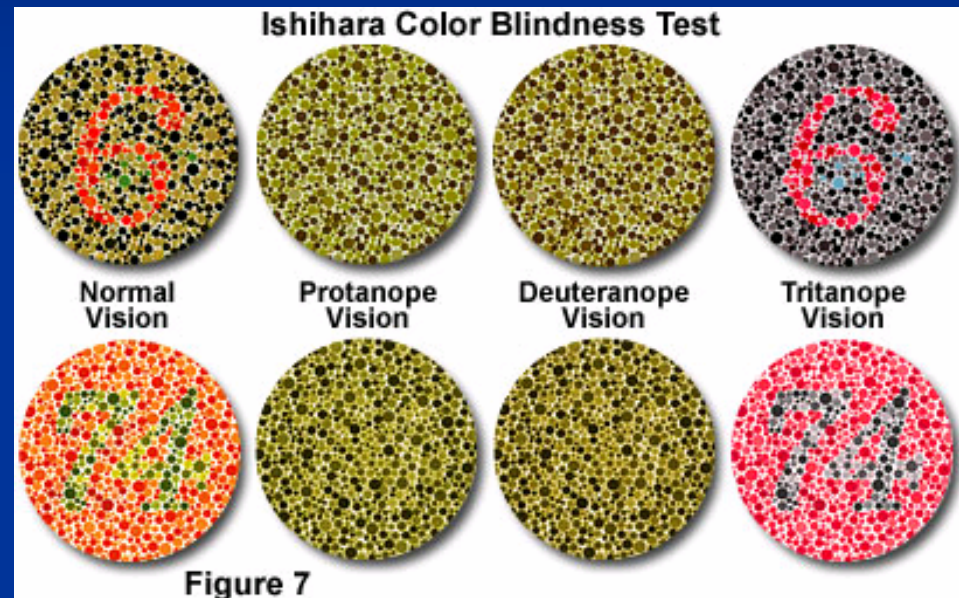
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A Discrimination stimulus



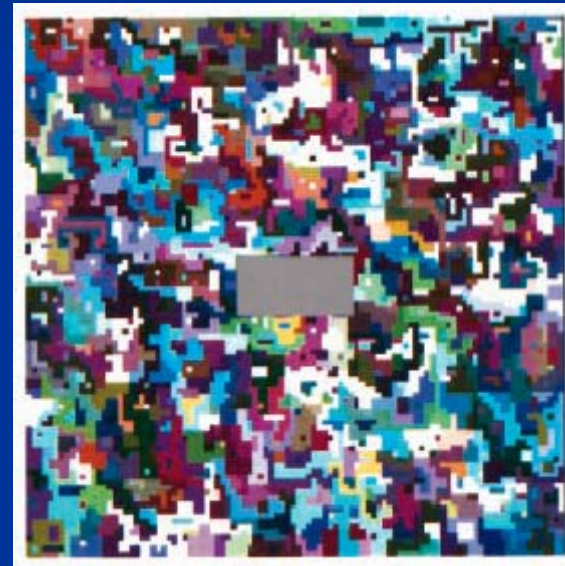
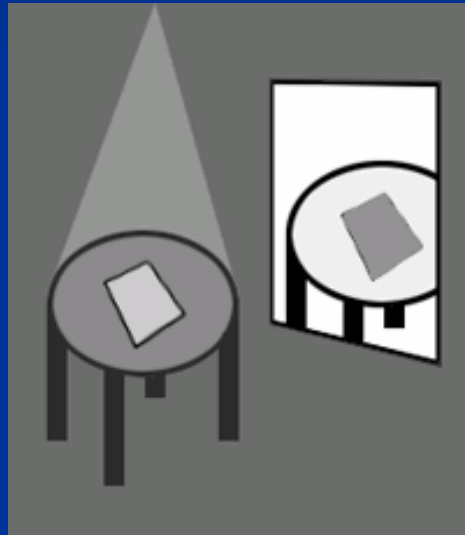
simple colour vision tests for (retinal) colour vision deficiency

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Constancy of visual sensation : Brightness and Colour Constancy

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higher order colour vision tests for central colour vision deficiency

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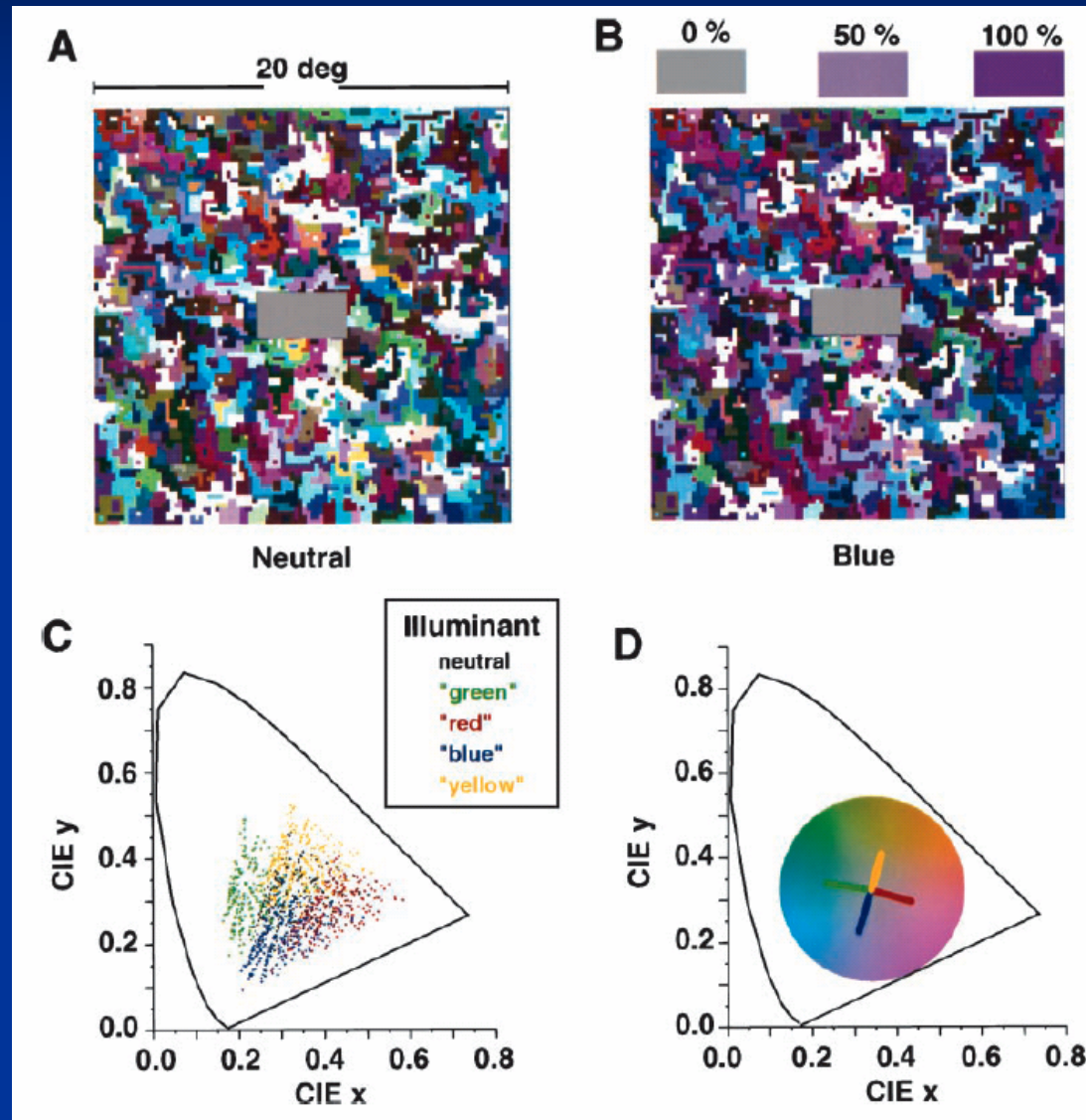


Table 2. Lesion locations and visual deficits for the 27 patients

Case	Hemi-sphere	Optic tract	LGN	Optical Radiation	V1	V2-V3	V4	RoI	Field Defect	Visual defect
AK	right	-	-	(+)	-	-	-	*	○	color constancy
AS	left	-	-	(+)	-	-	-	*	○	color constancy
HR	left	-	-	(+)	-	-	-	*	○	color constancy Mesulam 5 misses, left
GZ	left	-	-	-	-	-	-	-	○	color constancy
RM	right	-	-	-	+	+	(+)	-	◐	color constancy
MS	right	-	-	+	+	+	+	-	◑	Mesulam 5 m., l. & r. luminance discrim.
MM	left	-	-	+	-	-	(+)	+	◒	color & object naming, color-object association
RF	left	-	-	-	-	-	-	+	○	color naming, typical colors, color-object association
WD	right	(+)	(+)	+	-	-	-	+	◑	-
MH	left	-	+	+	-	(+)	(+)	-	◑	color-object association
SL	right	-	-	+	-	-	-	-	◑	-
KH	right	-	-	+	+	+	+	-	◑	-
KB	left	-	-	+	+	+	+	-	◑	object naming, color-object association
GK	left	-	-	+	-	-	-	+	◒	-
AH	left	-	-	-	-	+	-	-	○	-
DW	left	-	(+)	(+)	-	-	-	-	○	-
IH	left	-	(+)	(+)	-	-	-	+	○	-
MK	left	-	-	-	-	-	-	-	◑	-
EL	left	-	-	-	-	-	-	-	○	color-object association
UH	right	-	-	-	-	-	-	-	○	-
RB	left	-	-	-	-	-	-	-	○	-
HP	right	-	-	-	-	-	-	-	-	-
EP	left	-	-	-	-	-	-	-	◑	-
LG	right	-	-	-	-	-	-	-	◑	-
GR	right	-	-	-	-	-	-	-	○	-
ML	left	-	-	-	-	-	-	-	-	-
IL	left	-	-	-	-	-	-	-	○	color & object naming, typical colors

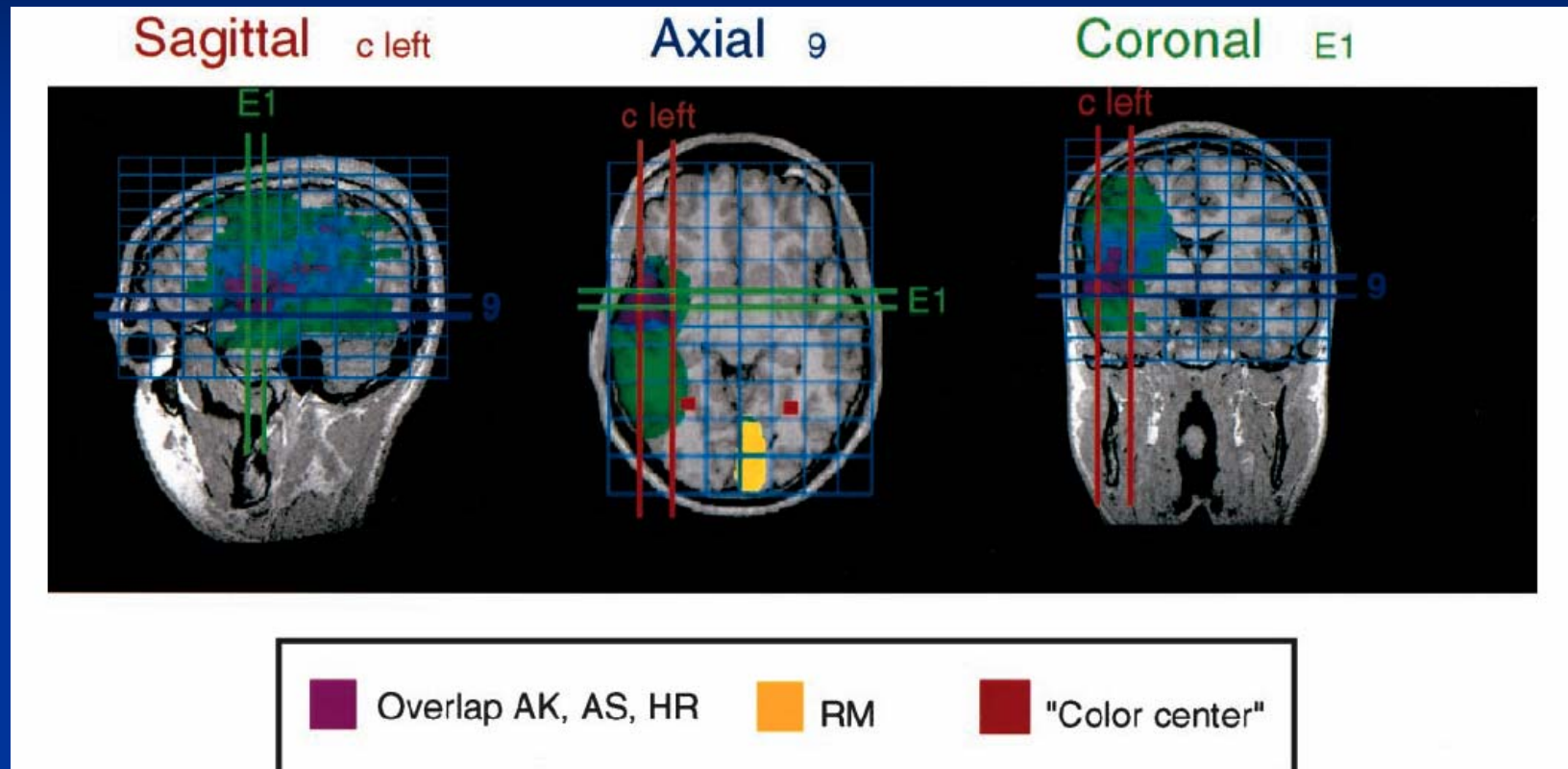
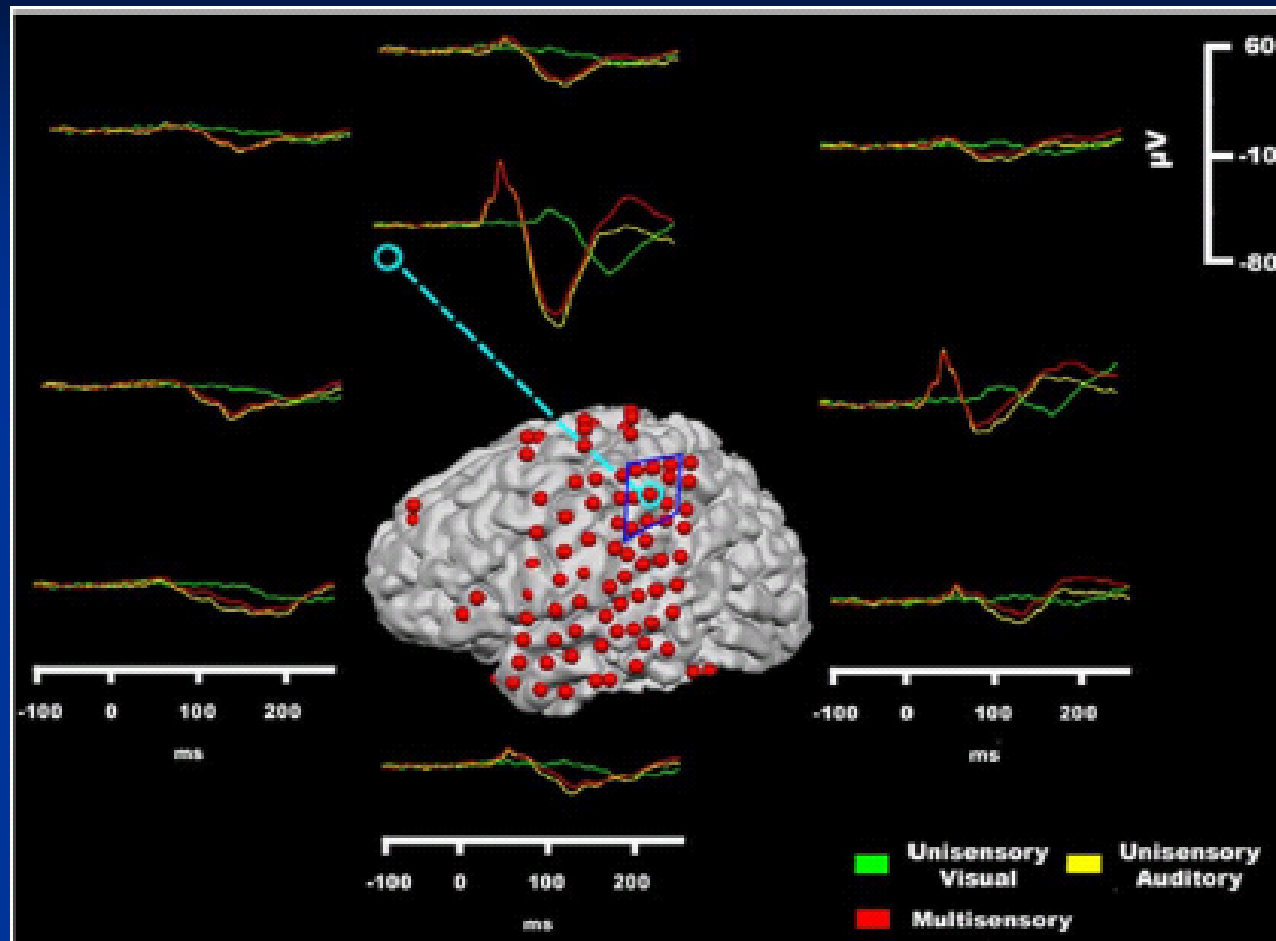


Figure 9. Comparison of the lesion locations (overlap) of patients AK, AS, and HR (*magenta*) and RM (*yellow*) with the approximate location of lesions reported to cause achromatopsia (*red squares*). Sagittal, axial, and coronal views are shown in a Talairach coordinate frame (Talairach and Tournoux, 1988). The *large, green area* indicates the union of the lesions of patients AK, AS, and HR after lateralizing them all to the left hemisphere; *blue*, overlap of the lesions for any two of the patients; *magenta*, intersection of the lesions of all three, centered at Talairach coordinates $\pm c$, E1, and 9 (± 50 , 7, and -8 mm for the standard Talairach brain). The *yellow region* occipitally shows the lesion of patient RM, which was centered on area V2. The *red regions* associated with achromatopsia have been termed the “color center” of the brain (Lueck et al., 1989). Most likely, they correspond to area TEO in monkeys (Heywood and Cowey, 1998).

electrophysiology (invasive)

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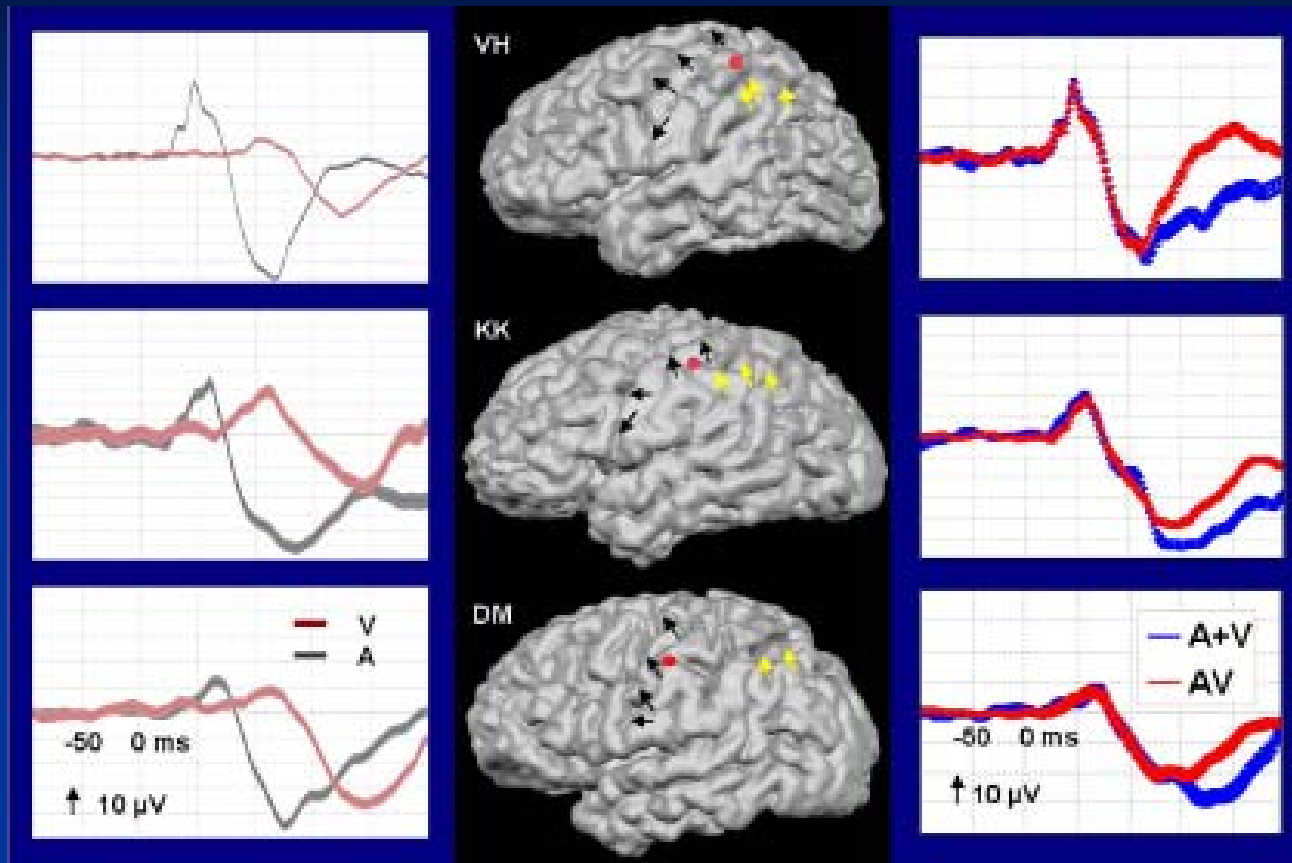


Malholm et al. 2006

superior parietal lobe (SPL)
activation during audio and visual
and audio visual stimulation

electrophysiology (invasive)

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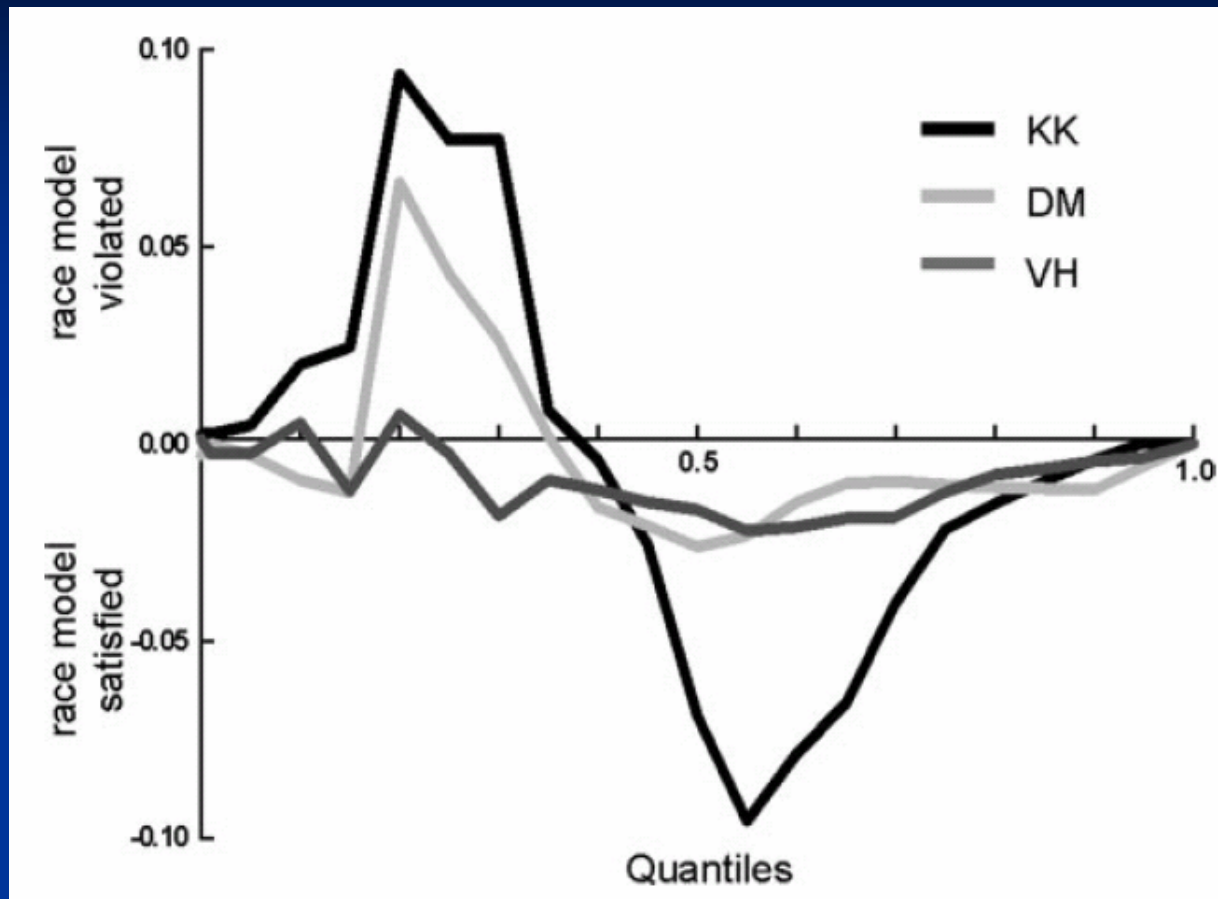


Auditory sensory input latency: 30 ms
Visual sensory input latency: 75 ms
SPL latency: 120-160 ms

Malholm et al. 2006

electrophysiology (invasive)

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the SPL may contribute to supramodal integration of spatial attention and sensory motor transformations

Malholm et al. 2006

Cross-modal or amodal or multimodal integration is used to identify individuals

It works over all sensory modalities: somatosensory, visual, auditory and olfactory

Emotional, social and sensory learning effects play a crucial role for multisensory integration

Congruent presentations helps for identification
incongruent presentations leads to confusion and therefore to changed response times

Multimodal integration takes place after intensive unimodal signal processing in the contributing modality