

Multisensory perception

Malika Auvray

Institut des Systèmes intelligents et Robotique

Sorbonne Université

CNRS UMR 7222

Paris, France



Outline

- 1. From sensation to perception**
- 2. Attention**
- 3. Spatial perception**
- 4. Multisensory interactions**
- 5. Sensory substitution**

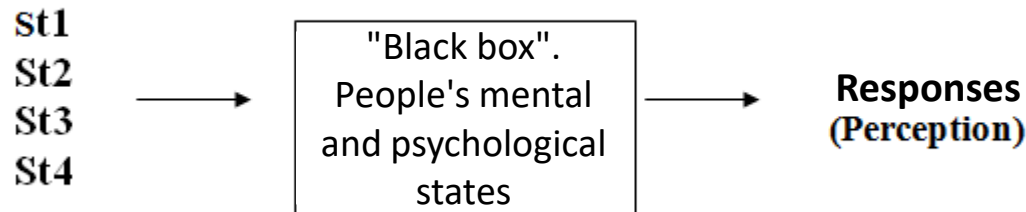
How many senses do we have?

- Vision
- Audition
- Smell
- Taste
- Somesthesia
 - Touch – fine tactile perception
 - Proprioception – relative location of body segments
 - Kinesthesia – perception of body movements
 - Thermoception – perception of heat
 - Nociception – perception of pain
- Balance – vestibular perception



Behaviourism

- Study of the links between stimuli and responses, without taking into account the functioning of the brain considered as a "black box".



- Cognitivism arose as a reaction to the reductionist aspect of behaviorism

Behaviourism

- Stimulus → Response

Before conditioning

Food

Salivation



Bell

No response



During conditioning

Food
+ Bell

Salivation



After conditioning

Bell

Salivation



Cognitivism

- thinking = information processing



- Stimulus → Processing → Response

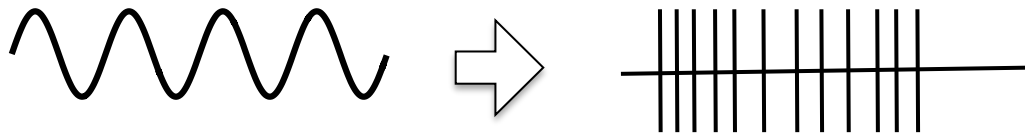
Sensation vs. perception

- Sensation: 1st step – entrance in the nervous system – creation of the signal
- Perception: next steps - interpretation of the signal – ability to extract the relevant information, in a format specific to a sensory modality or in an abstract / multisensory format

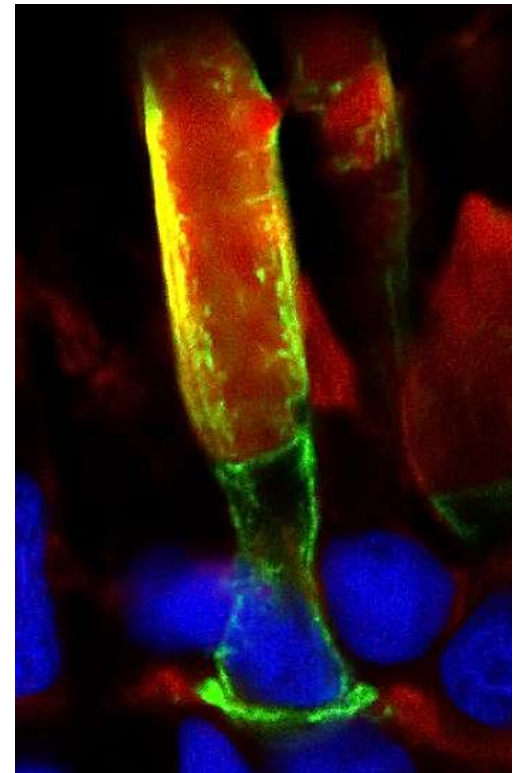
Sensation = transduction

Transduction

Transformation of a physical stimulation (wave) into cellular changes (neurotransmitter, nerve impulses)



Eg: photo-receptor



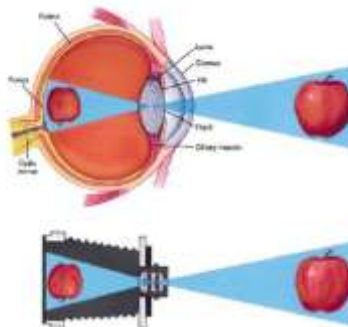
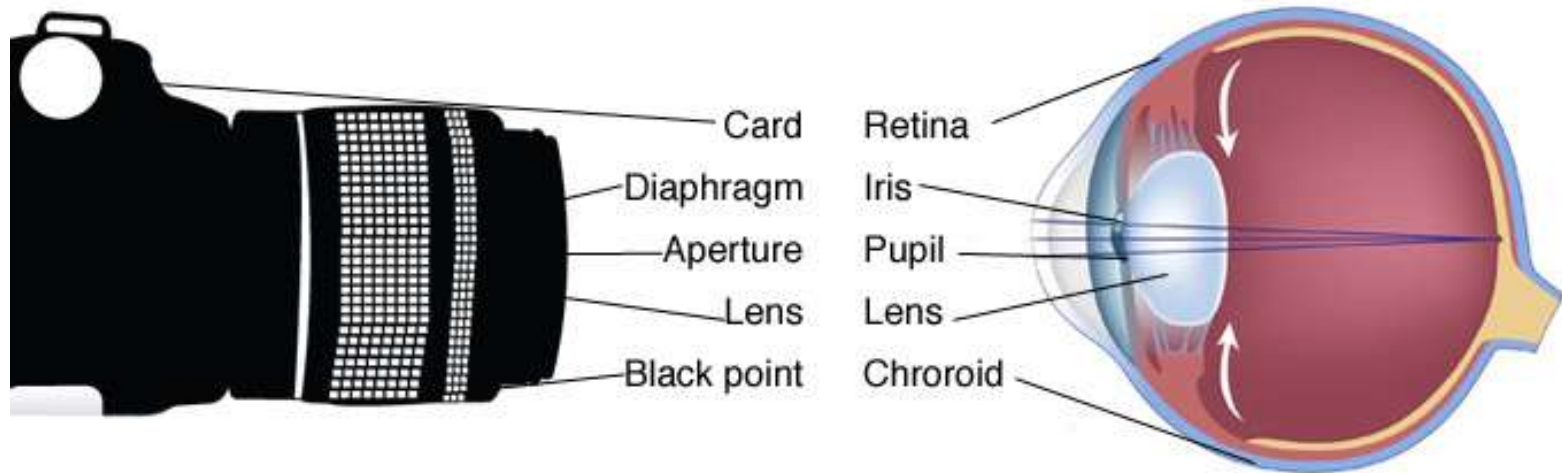
Metaphor of the camera

Eye = camera

Cristalline lens = lens

Iris = diaphragm

Retina = movie





Perception

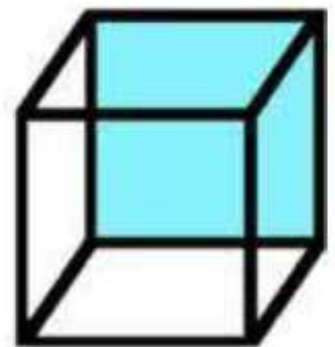
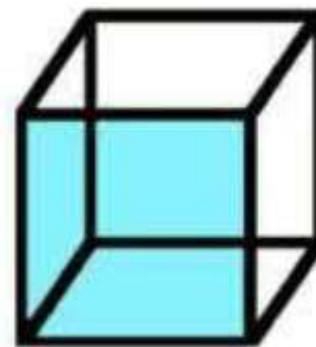
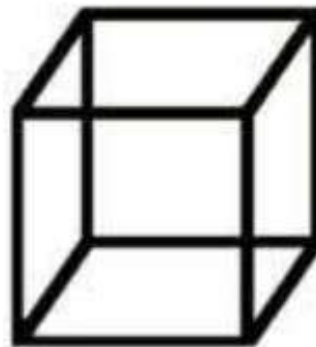
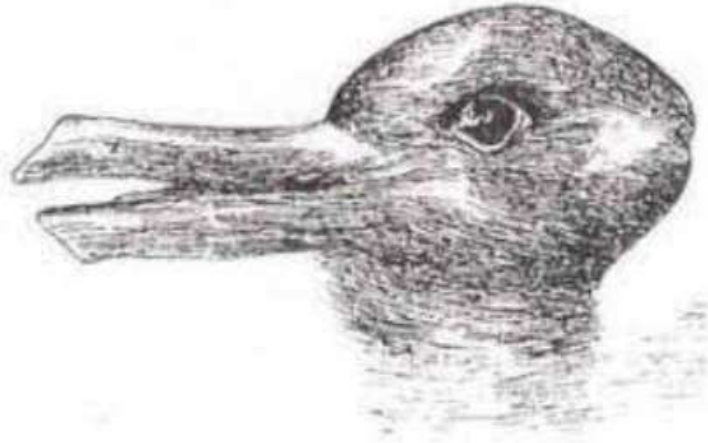
- Not veridical – construction
- Bottom up and top-down processes
- Inferences

-> Examples

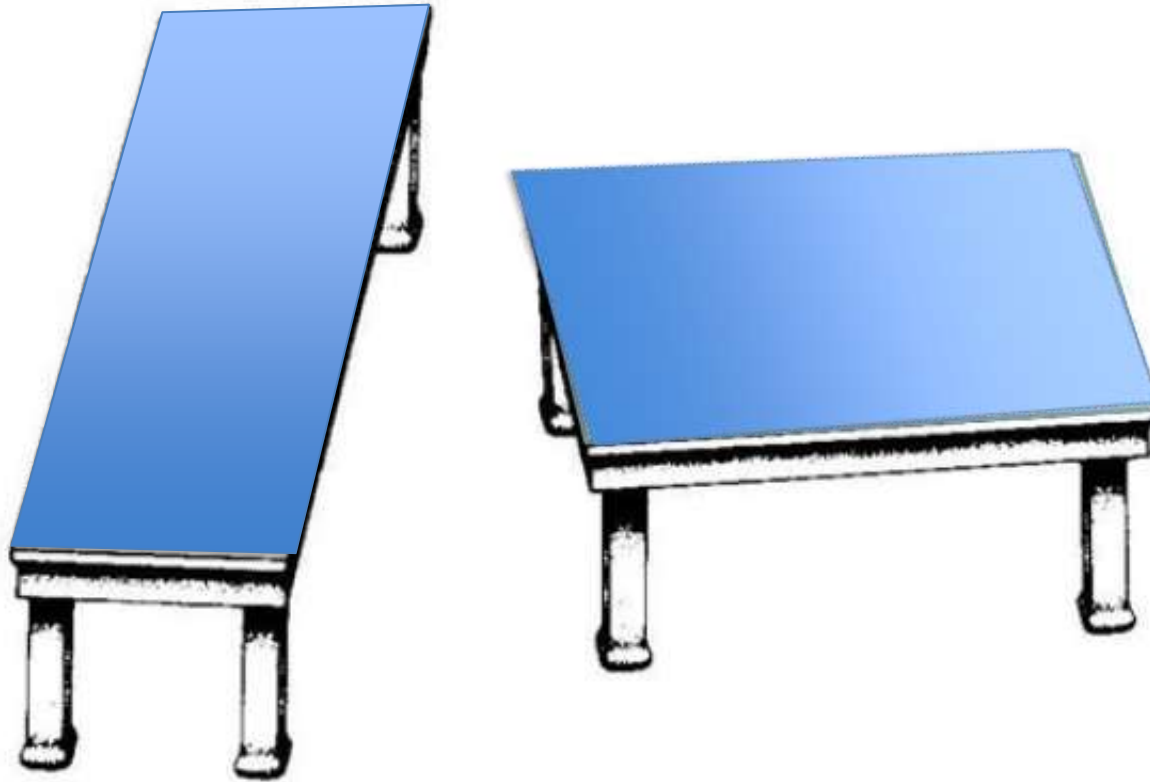
Visual perception: interpretation of shapes



Visual perception: bistability of interpretations



Perception of distances



“Turning the tables”, par Roger Shepard

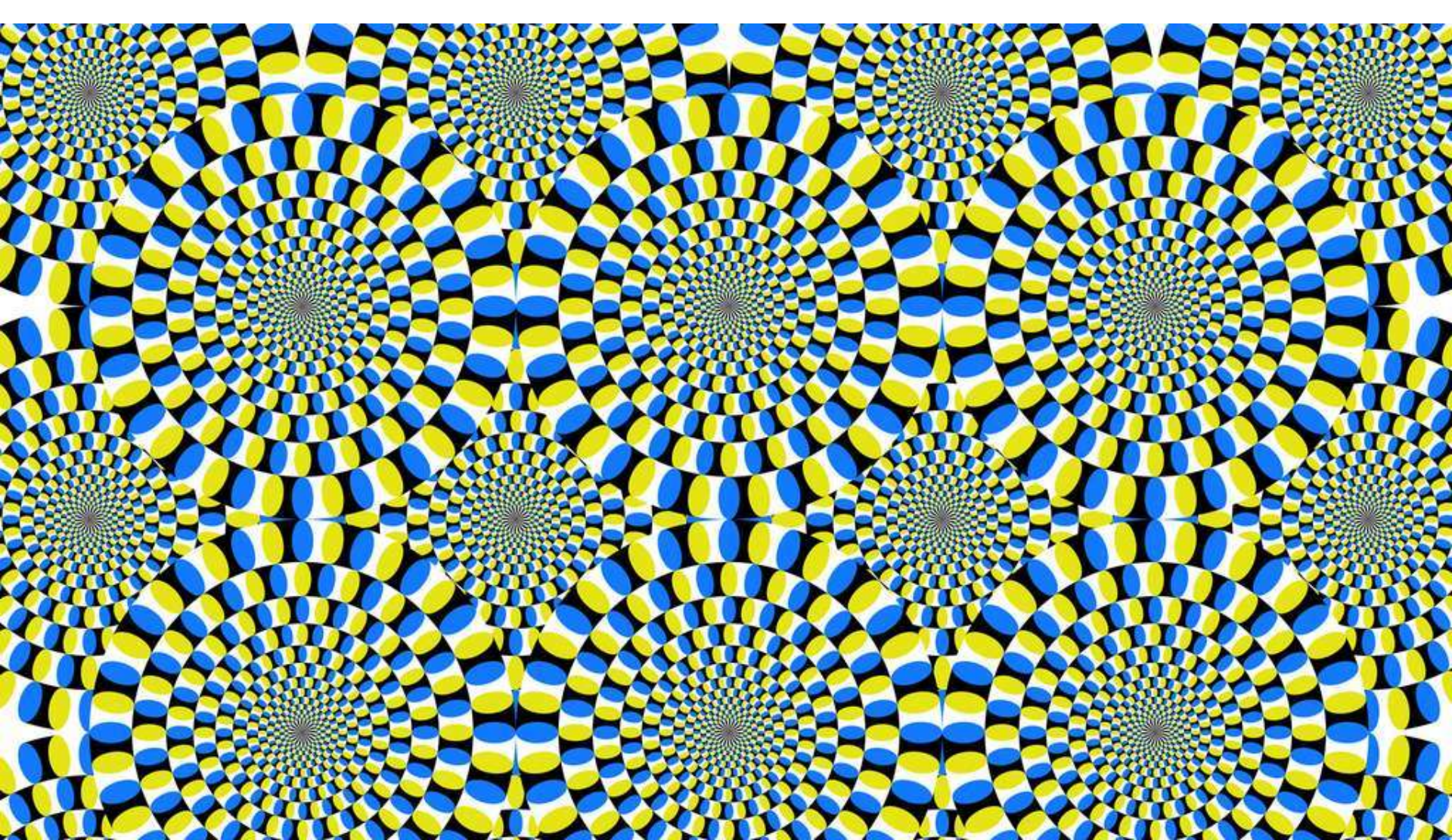
Shepard, R. N. (1990). *Mind sights: W.H. Freeman.*

Traduction française: L'oeil qui pense: Visions, Illusions, Perceptions (Seuil, 2000)

What is the color of this dress?

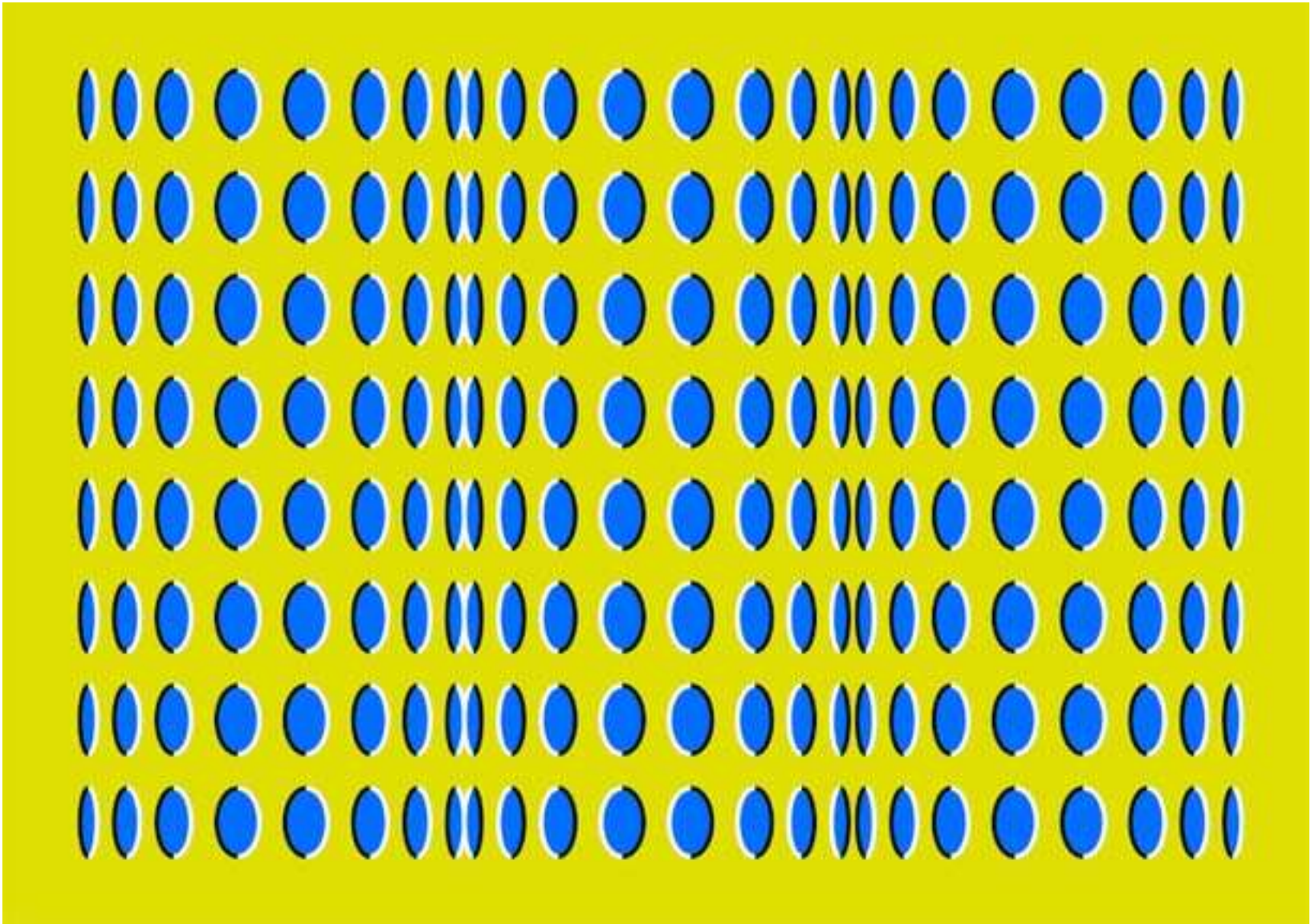


Illusion of movement



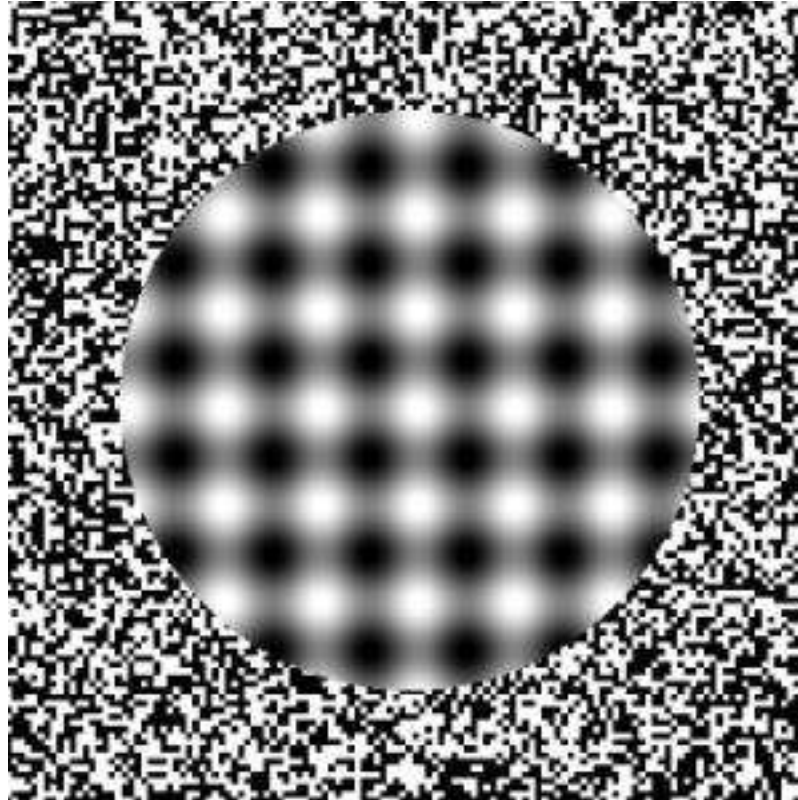
Illusion from Akiyoshi Kitaoka

Illusion of movement



Illusion from Akiyoshi Kitaoka

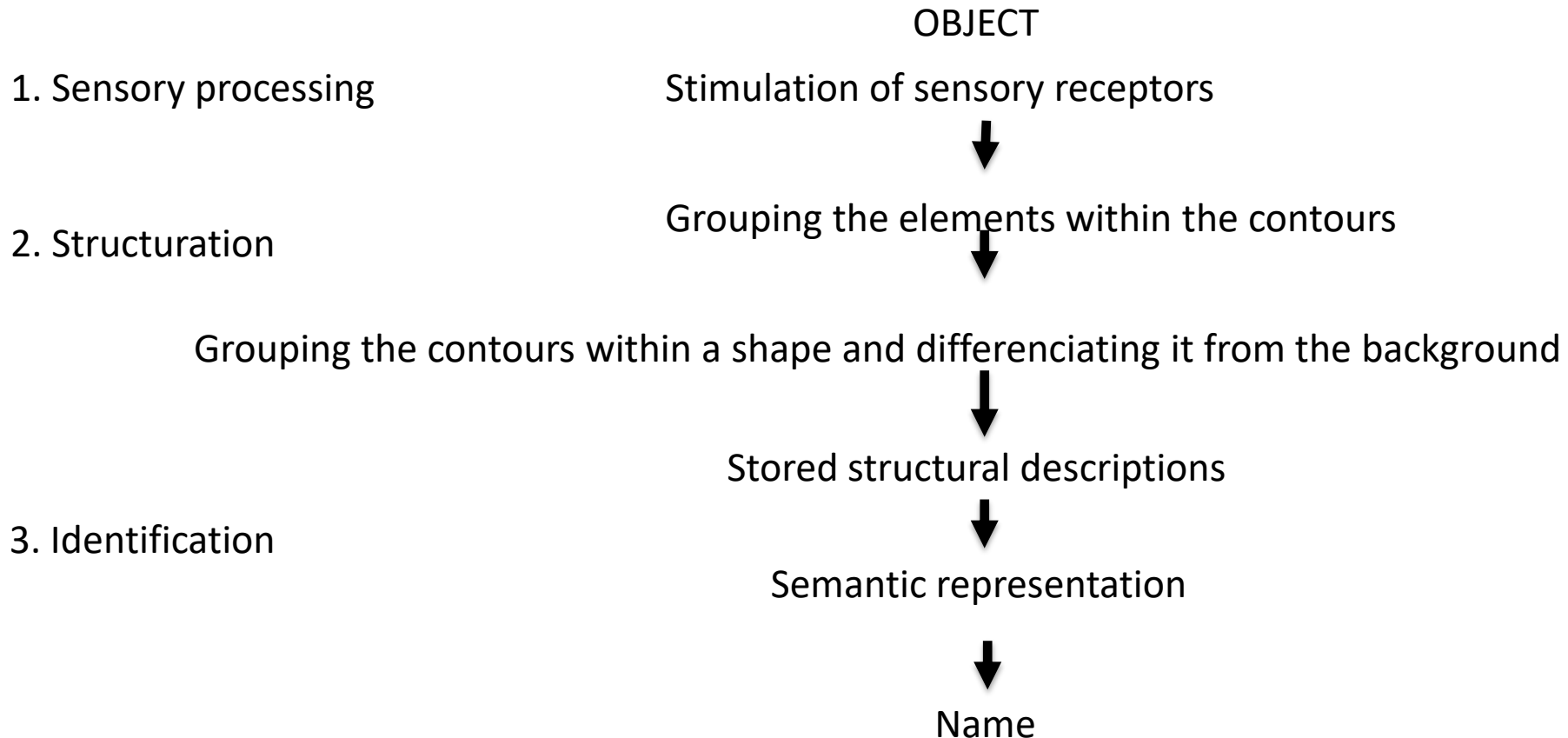
Illusion of movement



Illusion from Akiyoshi Kitaoka

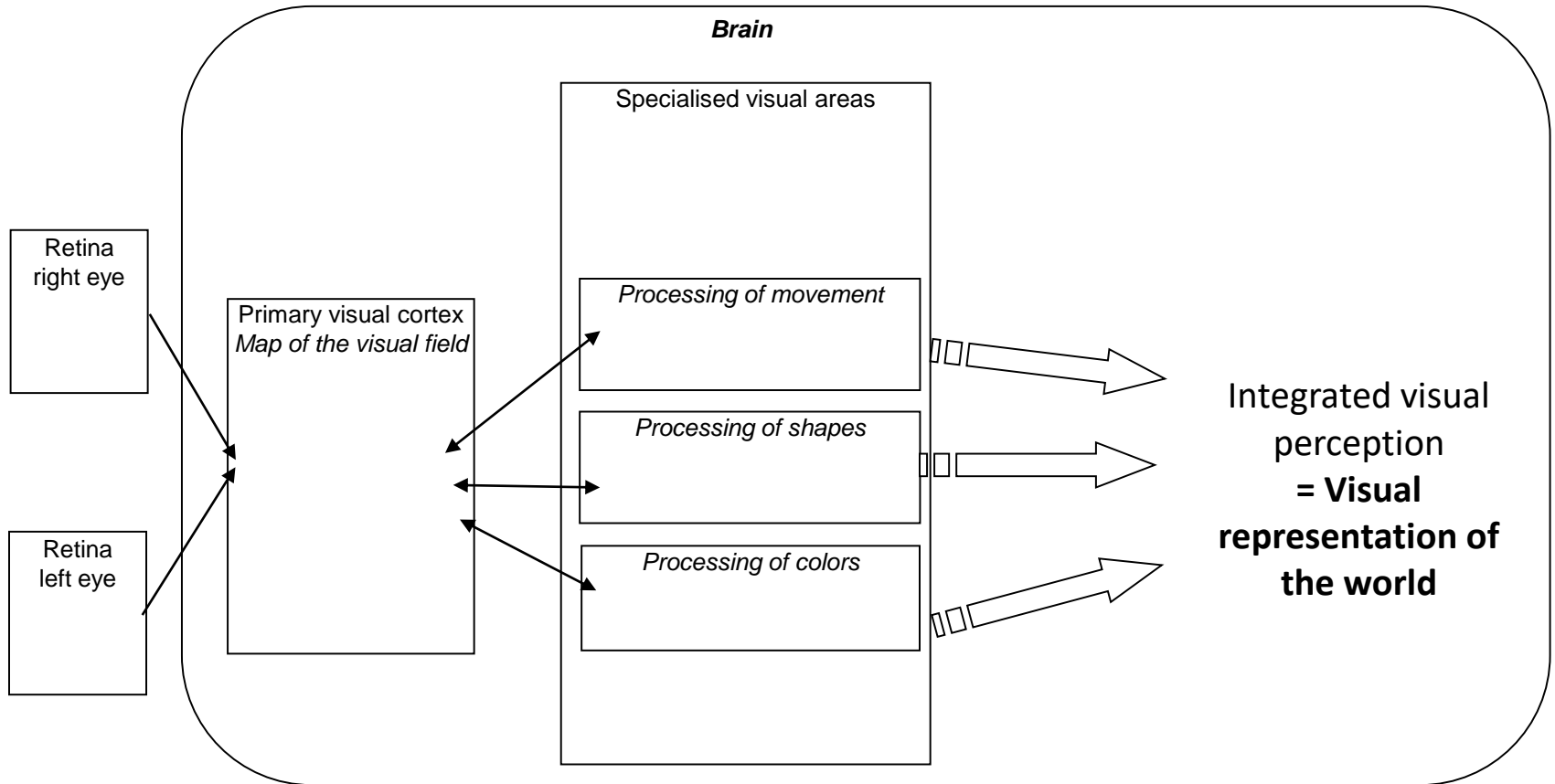
From sensation to perception

Cognitive model of objects visual recognition:



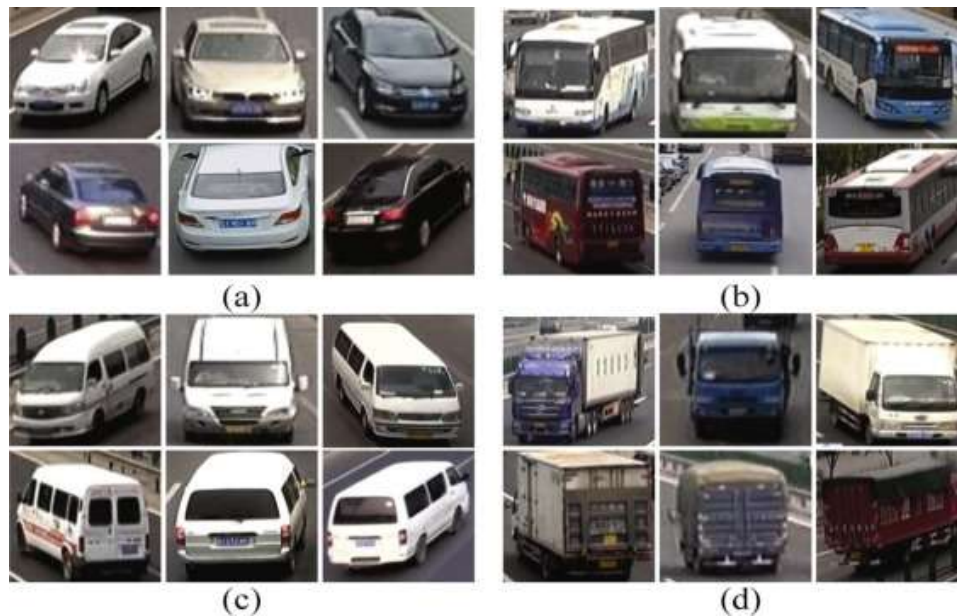
→ Visual perception is not a unitary and indifferenciaded system

From sensation to perception



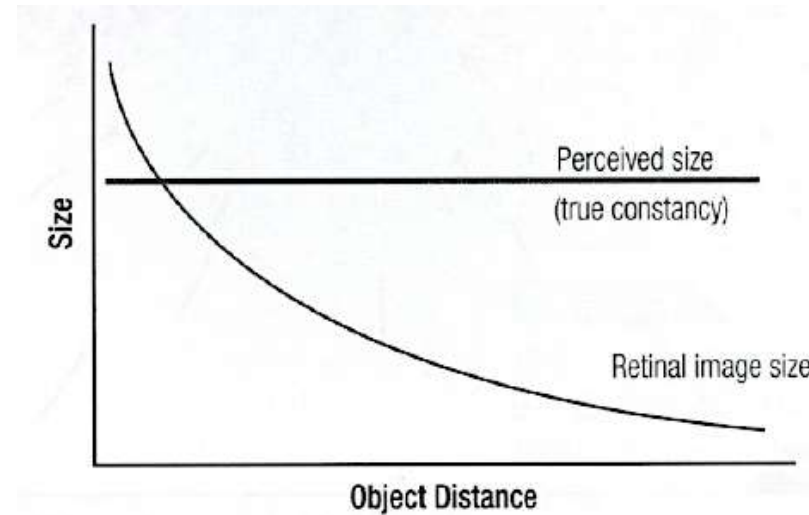
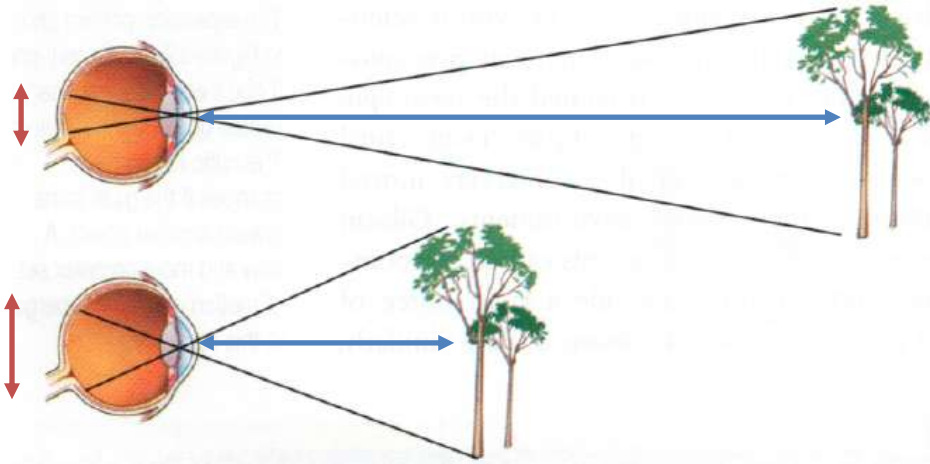
Stages of information processing

- Object recognition
 - Problem of perceptual constancy
 - Shapes, colors, different lightening conditions
 - Viewpoints: Size, distance, different retinal locations and orientations
 - In motion



Size constancy

Integration retinal size - distance

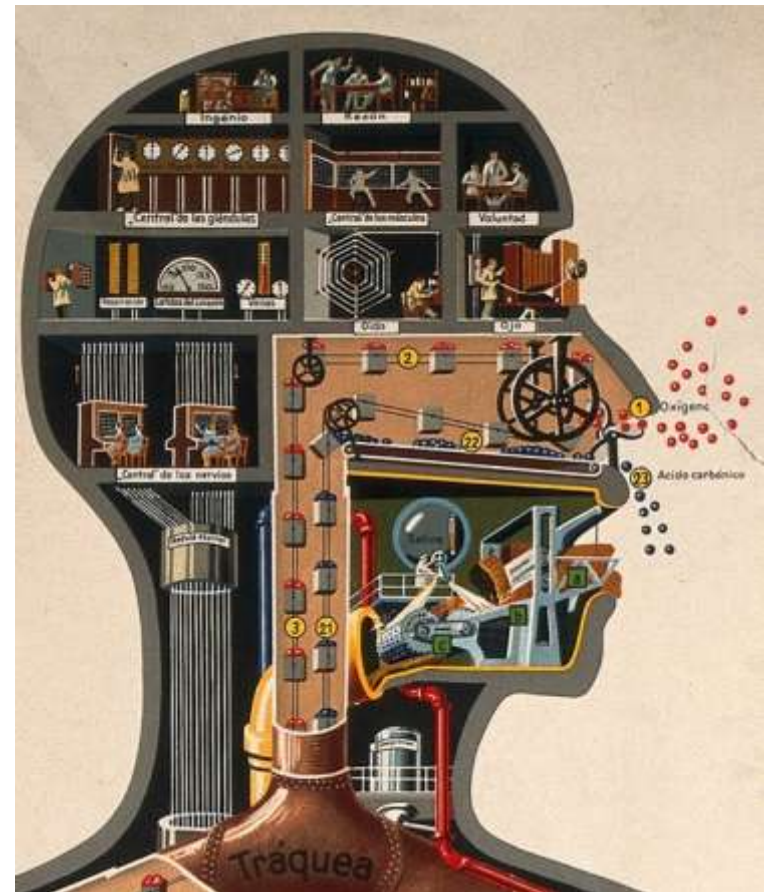


Perceived size

= Retinal size x perceived distance

Stages of information processing

- Separation into visual primitives
 - Depths
 - Orientations
 - Spatial frequencies
 - Colors
 - Local movements



Distance – depth

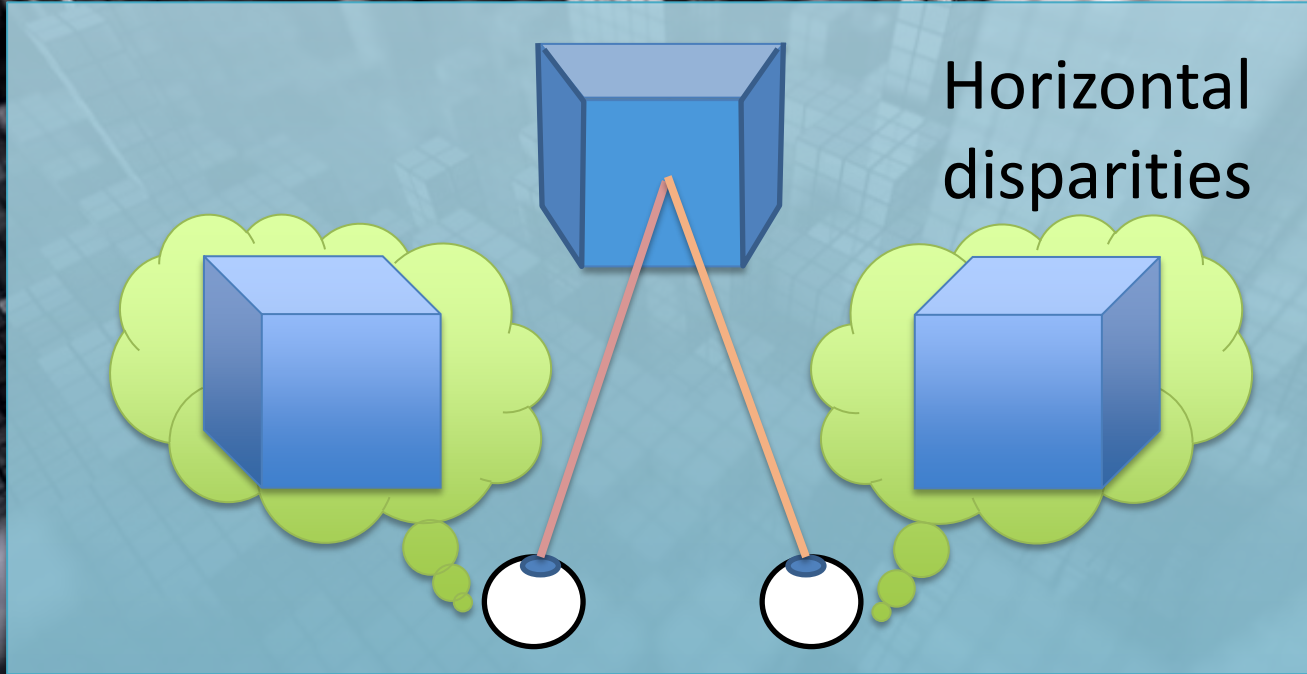
Distance

->

Depth



Cue for depth – stereopsis

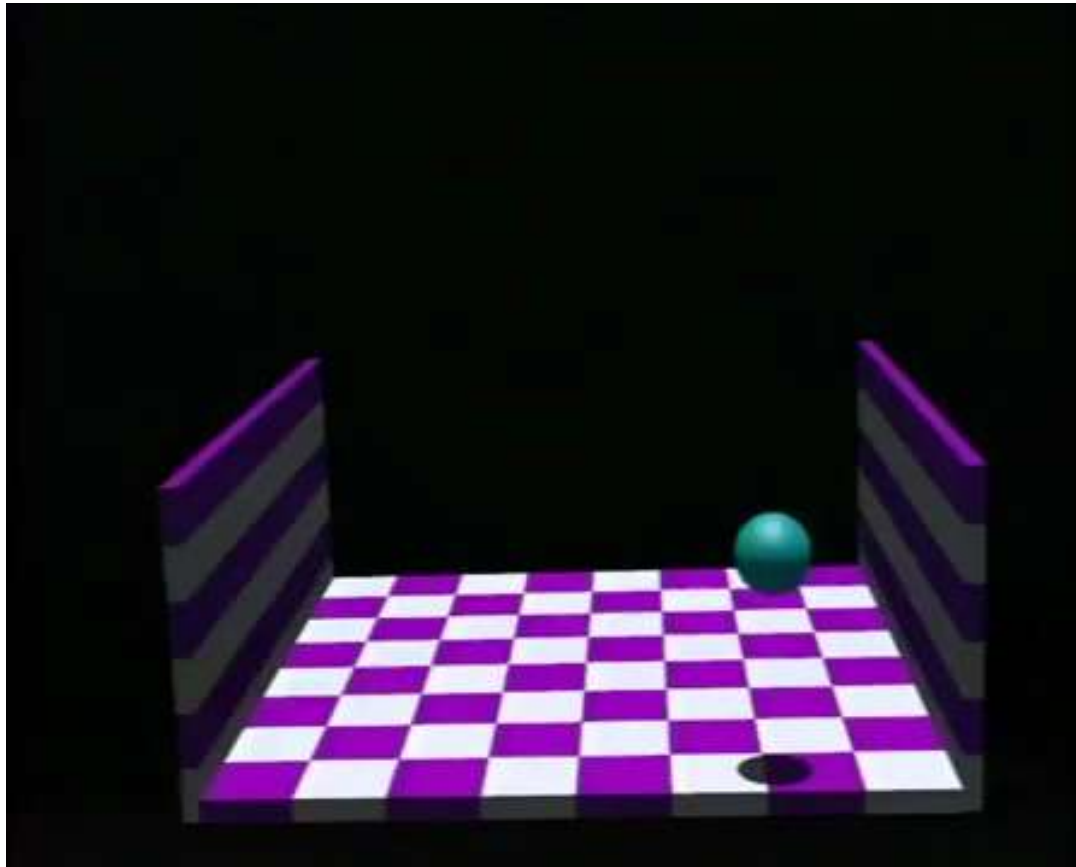


Cue for depth: motion parallax

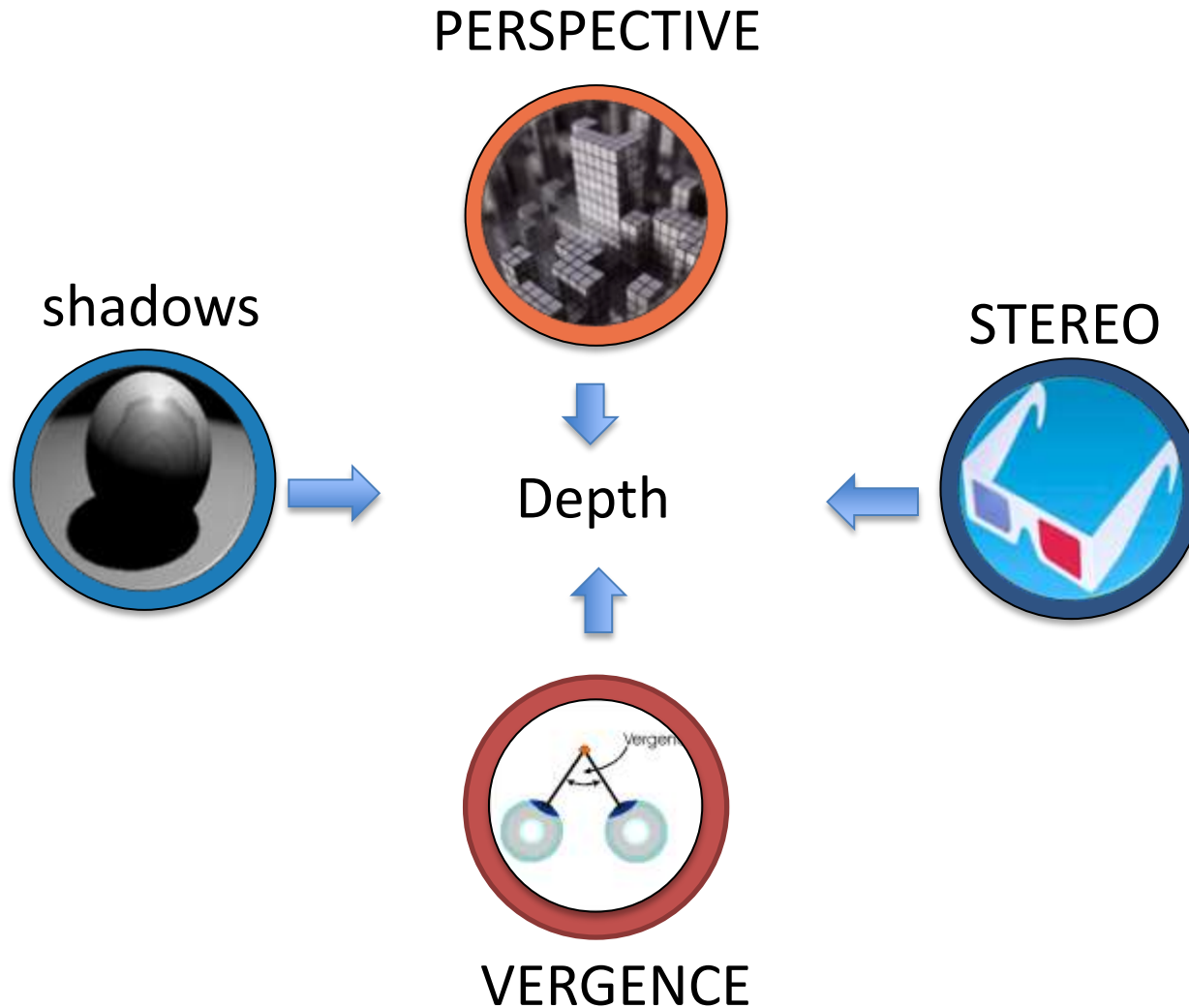


Necessity to know my own displacement speed

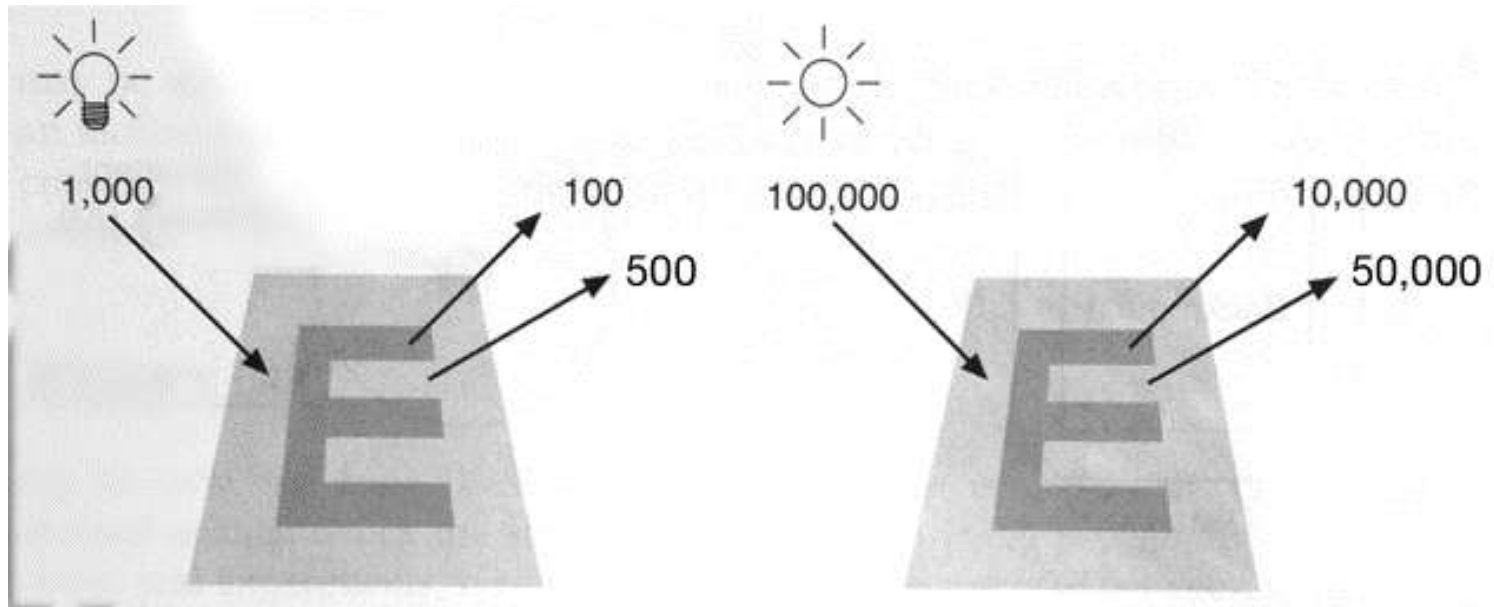
Cue for depth: shadows



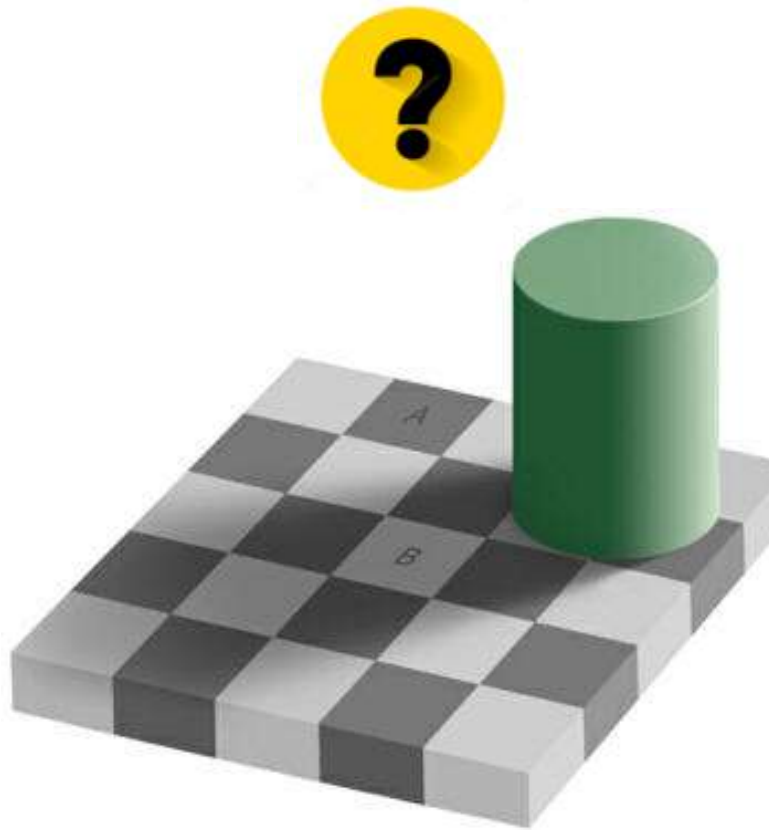
Integration multi-cues / multi-sensory



Importance of contrast

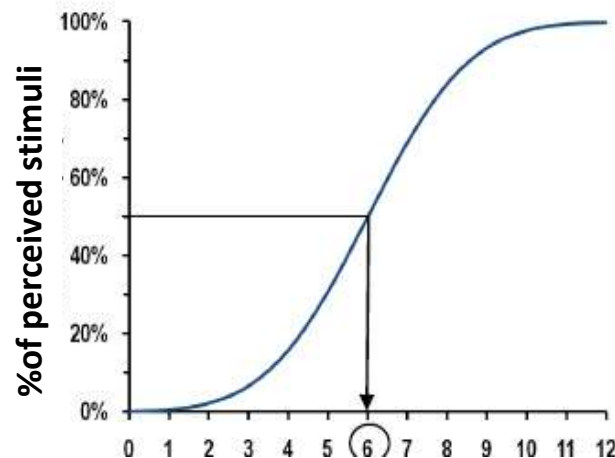


Contrast of local luminance



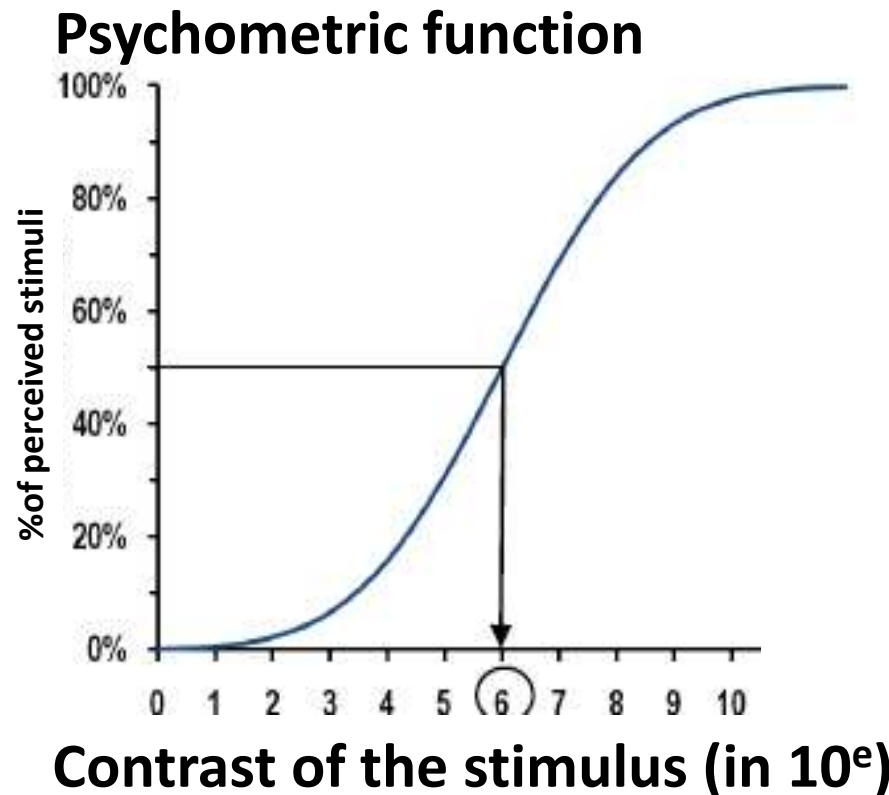
Measuring perception

- Zoom on Psychometric function
- It is a psychometric relationship between a stimulus and judgments about the stimulus, as expressed in a mathematical formula. In the method of constant stimuli, it is the proportion of detection responses as a function of physical magnitude of the stimuli.
- To measure detection thresholds, you present single stimuli, and measure when they are perceived.



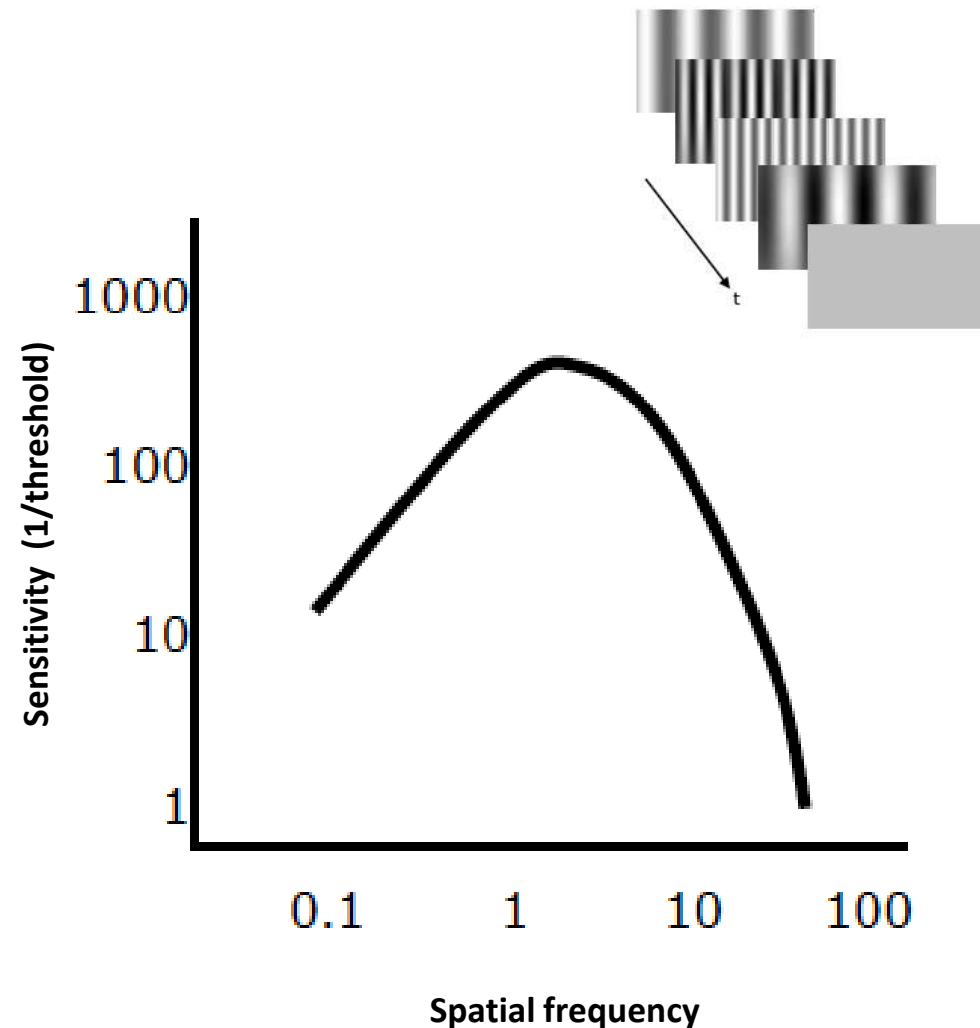
Measuring perception of contrast

- For each frequency, computation of the absolute threshold, first contrast from which the stimulus is perceived.

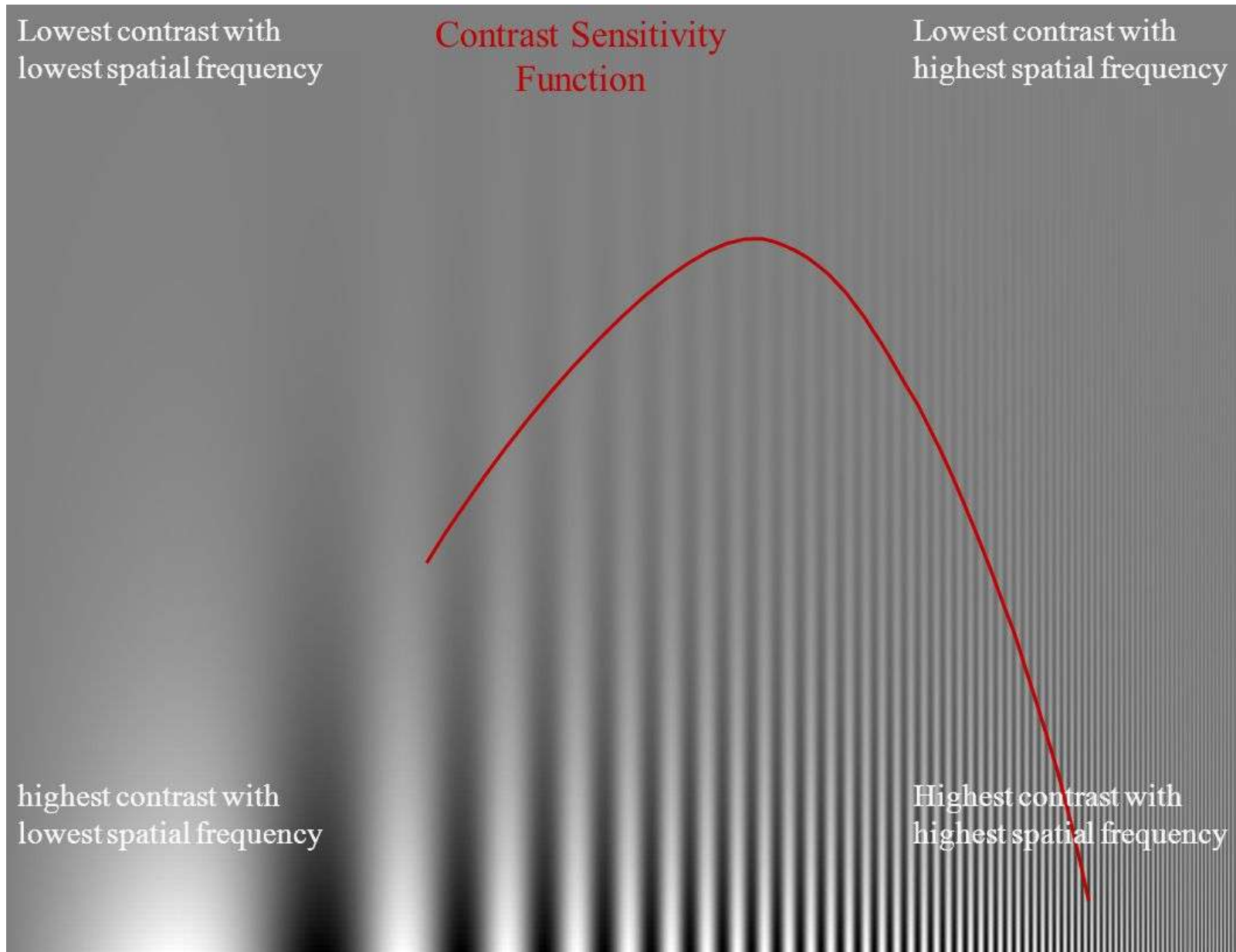


Function of sensitivity to contrast

- Contrast sensitivity curve
- The window of sensitivity depends mainly on spatial frequency and a little on orientation.



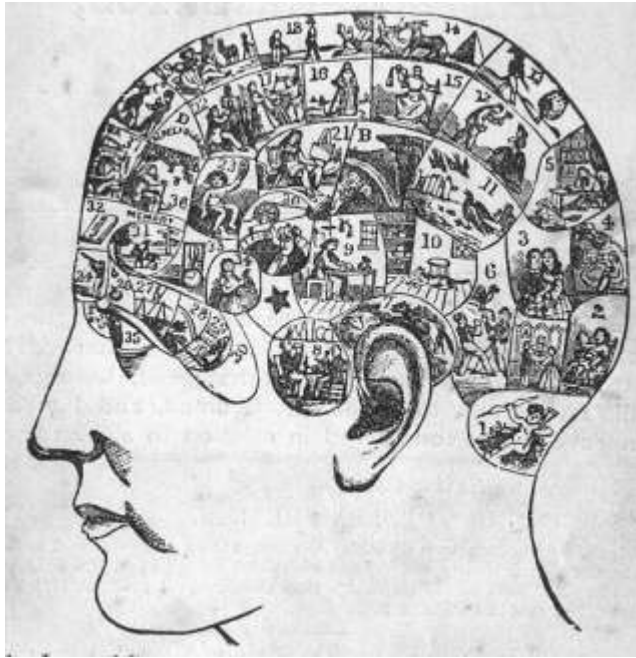
Function of sensitivity to contrast



Measuring tactile perception

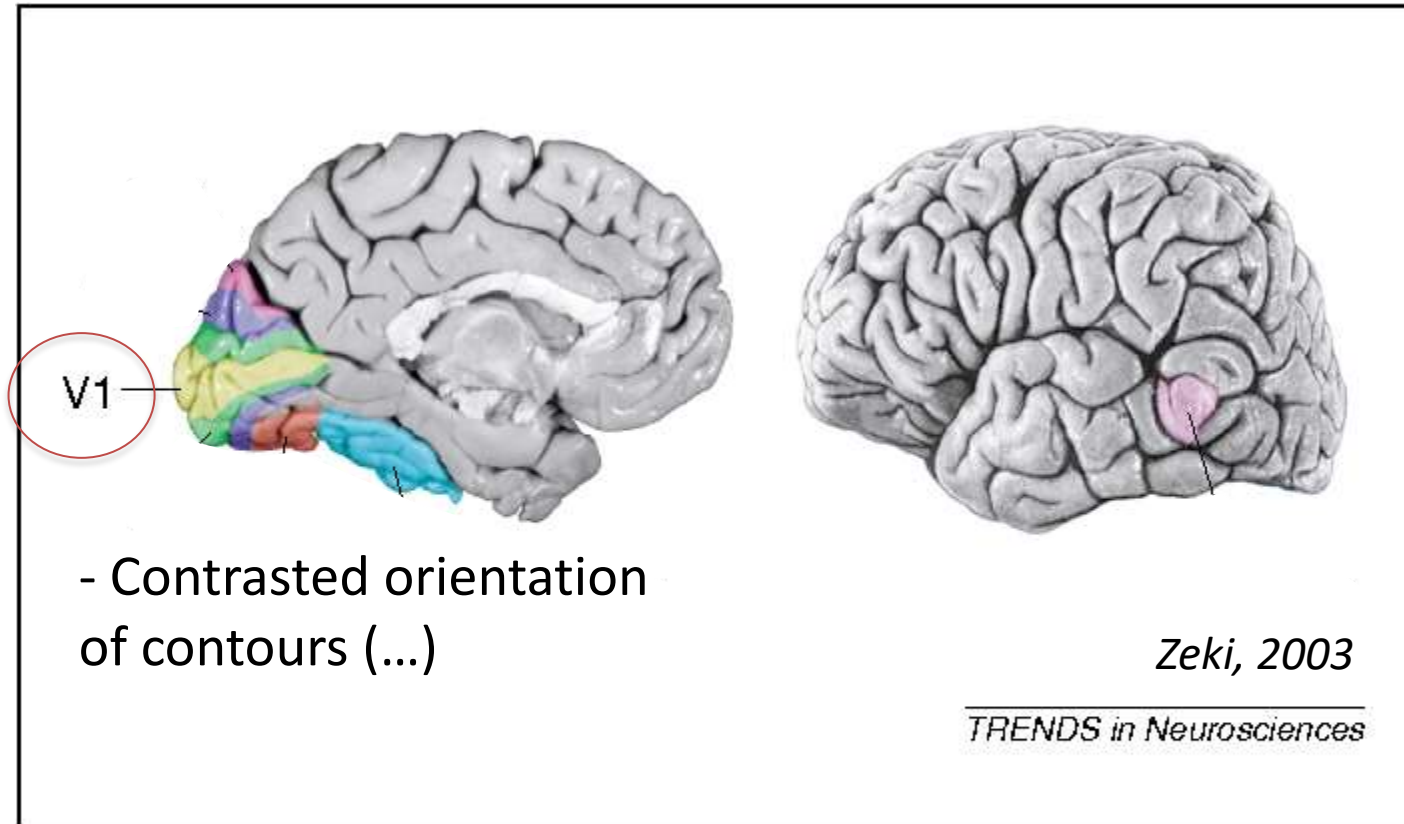
- Expt 1. How would you measure if the minimal distance to detect two different tactile stimuli (ie. the stimuli are perceived as distinct and not as only one) is different on the fingertip and on the arm?
 - Expt 2. How would you measure if the minimal distance to detect two different tactile stimuli on the forearm is similar if you use thermal or mechanical stimulation?
 - Expt 3. How would you measure if the minimal distance to detect two different tactile stimuli on the hand, arm, back, is different in man and women?
 - Expt 4. How would you measure if the minimal distance to detect two different tactile stimuli on the hand, arm, back, is the same in left-handed and right-handed persons?
 - Expt 5. How would you measure if the minimal distance to detect two different tactile stimuli on the dominant finger changes as a function of people's age (take 4 age groups)?
- > Experimental conditions, dependent variables, main factors, experimental plan (random, fixed, counterbalanced blocs / trials), hypothesis.
- > Then which analysis can you run?

Modularity

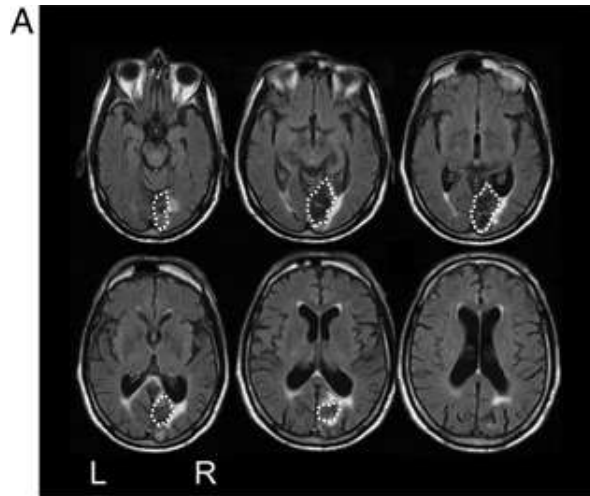


Fonctionnal
and
Anatomical

Local luminance contrast

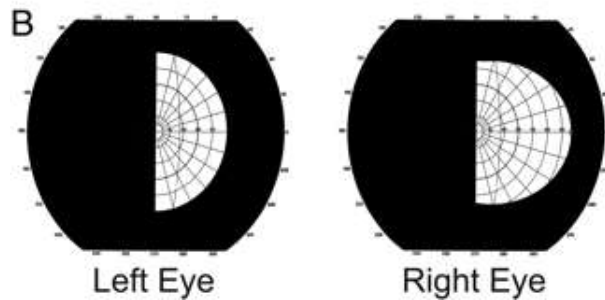


Homonymous hemianopsia



Unilateral retro-chiasmatic lesion / V1

Patient with CB

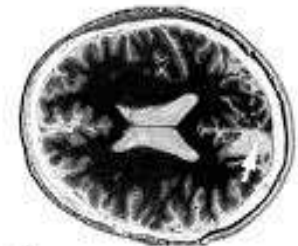


Striemer et al. (2009)

Blindsight

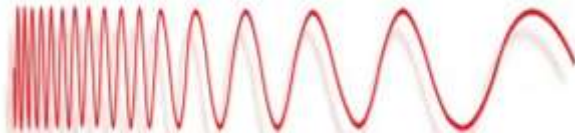


Patient GY, 1989,
lesion in V1



Spectrum - color

Spectrum -> color

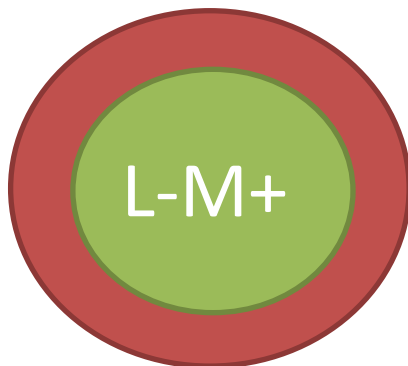
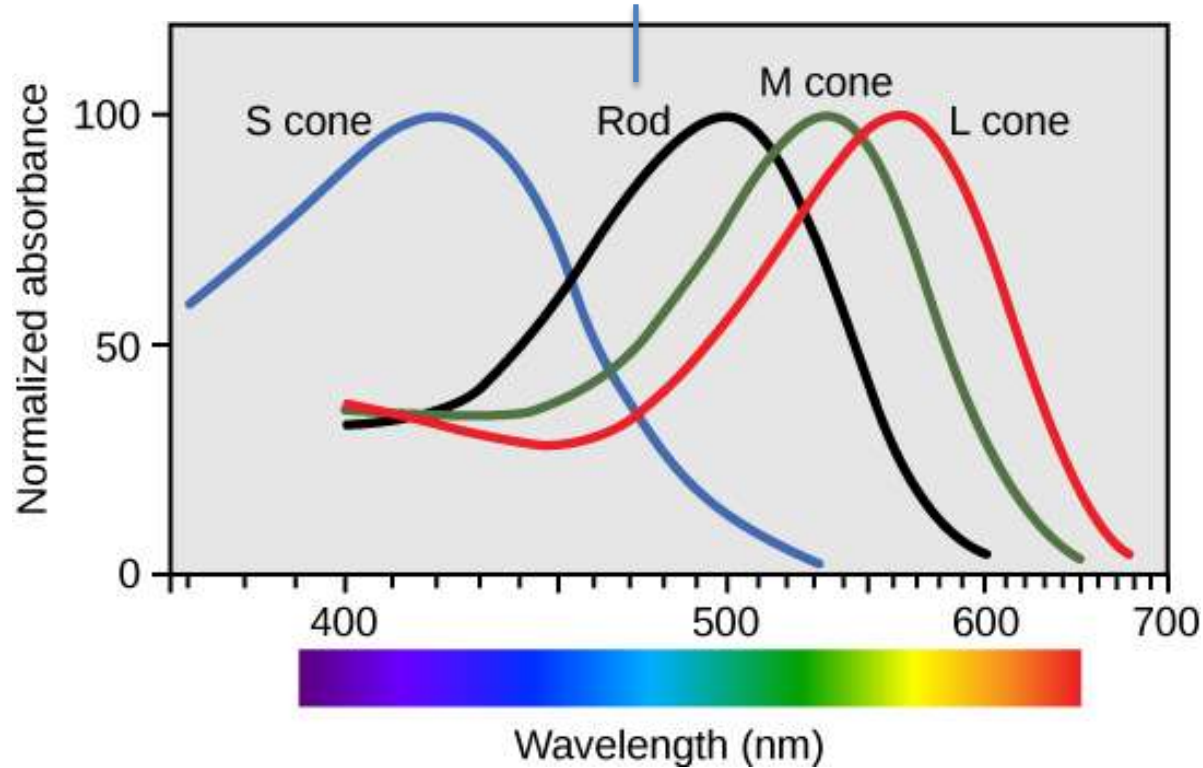


Color: local contrast

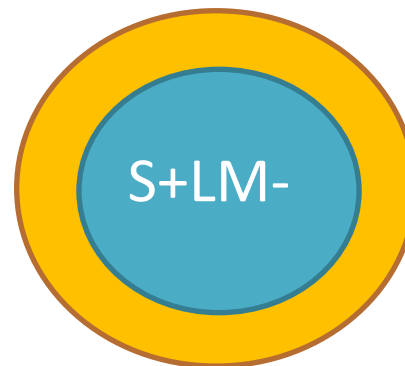


Color: local contrast

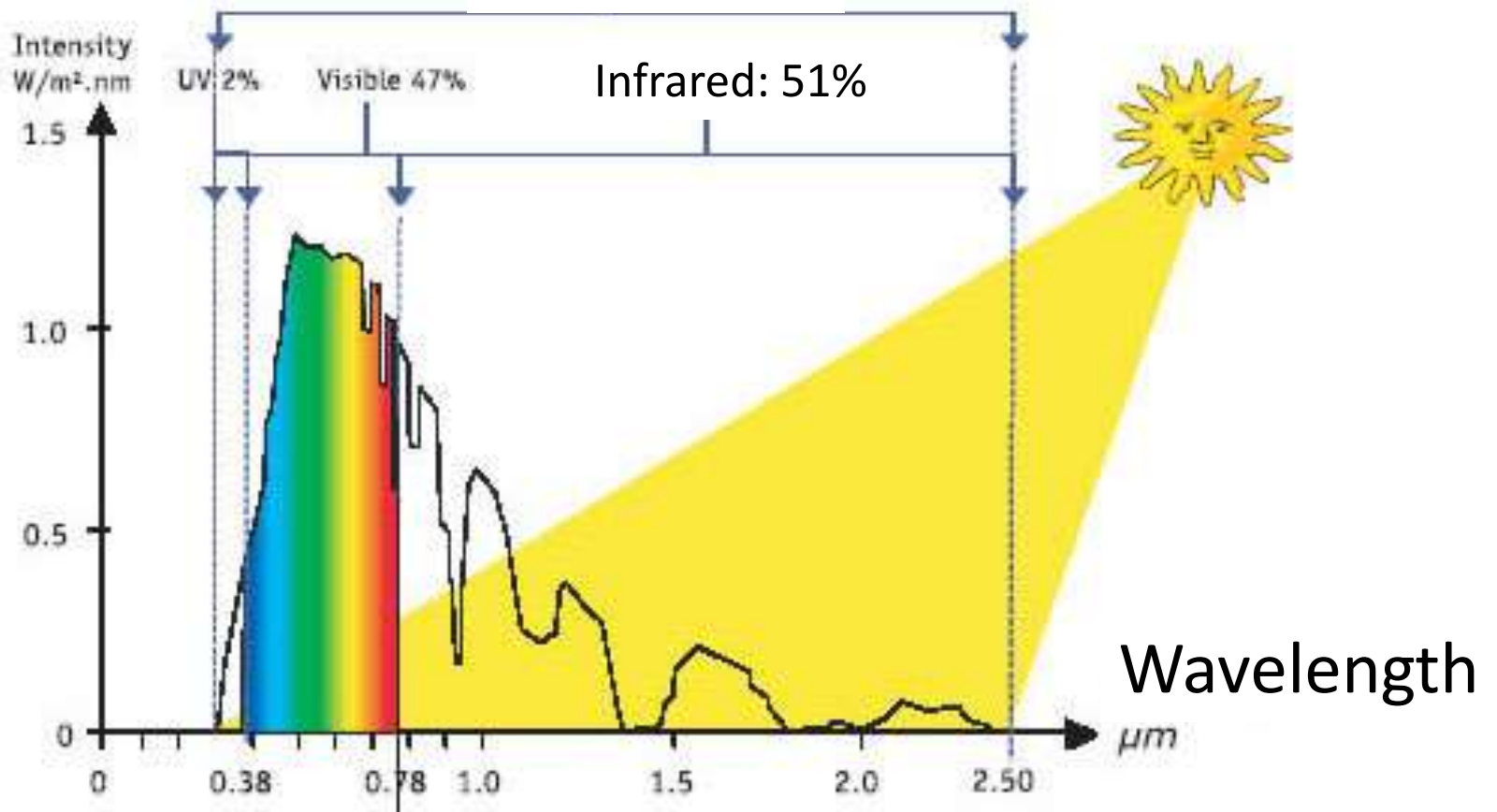
Rods



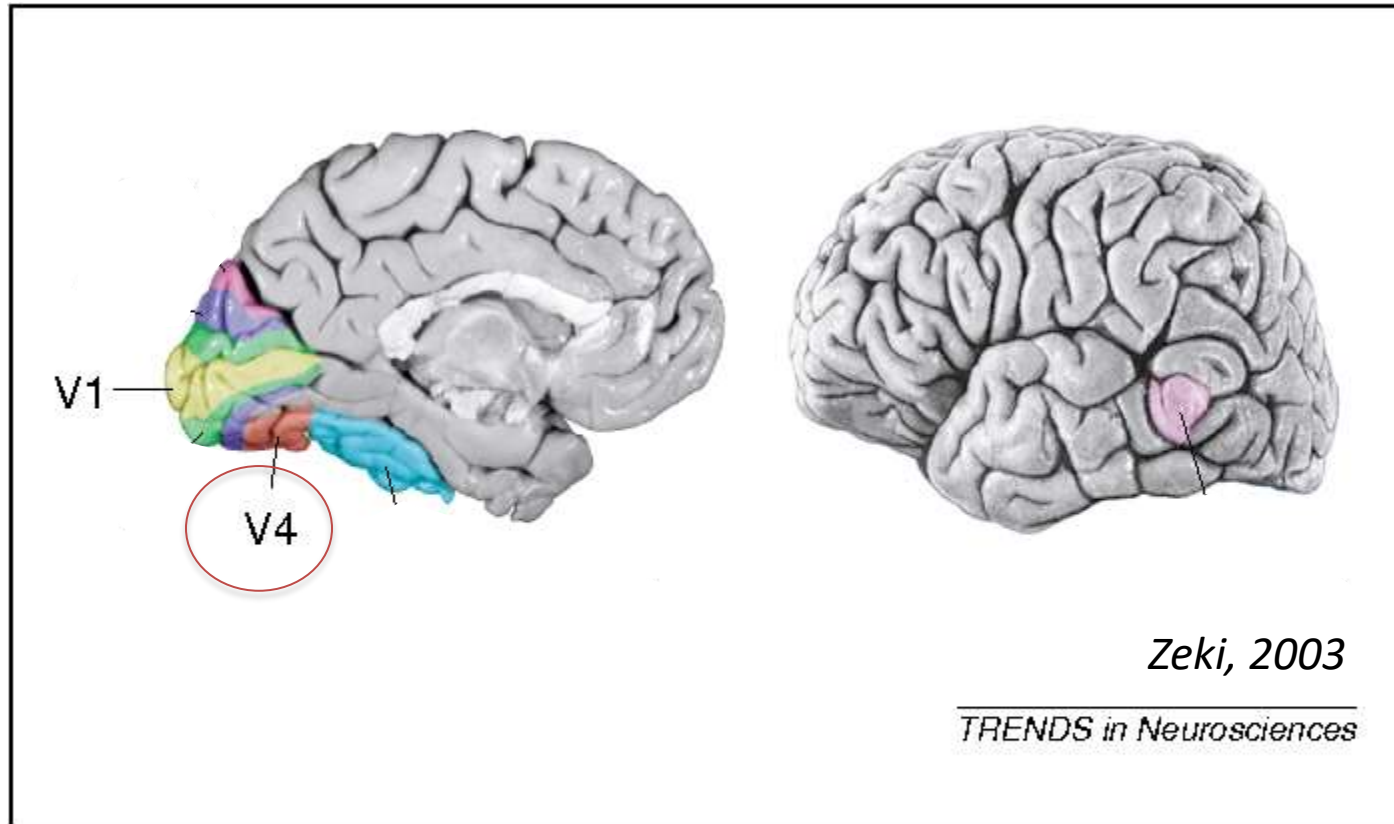
L+M-



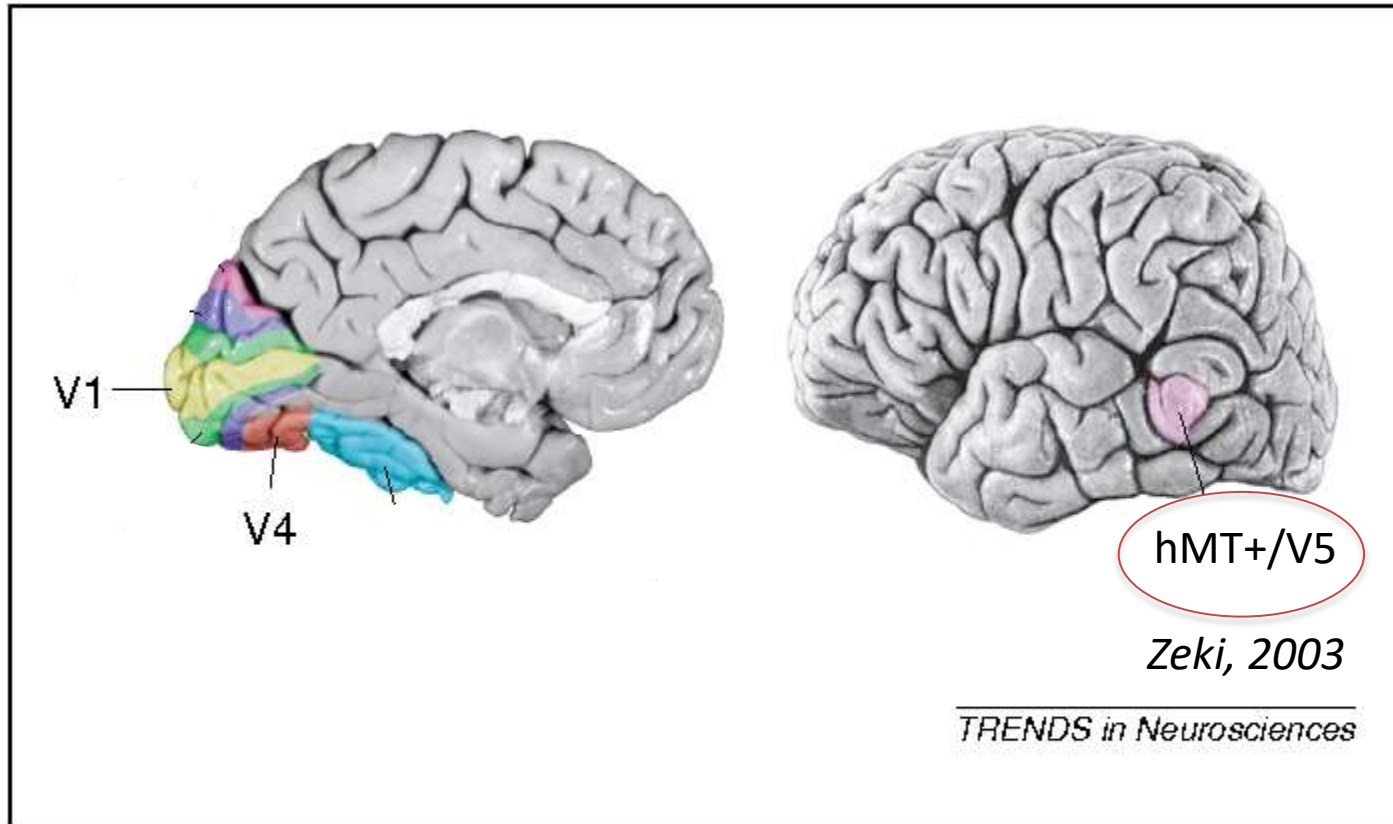
S-LM+



Color: local contrast



Local movements



Cerebral akinetopsia



Blindness to movement
Lesion in hMT+/V5

Grouping

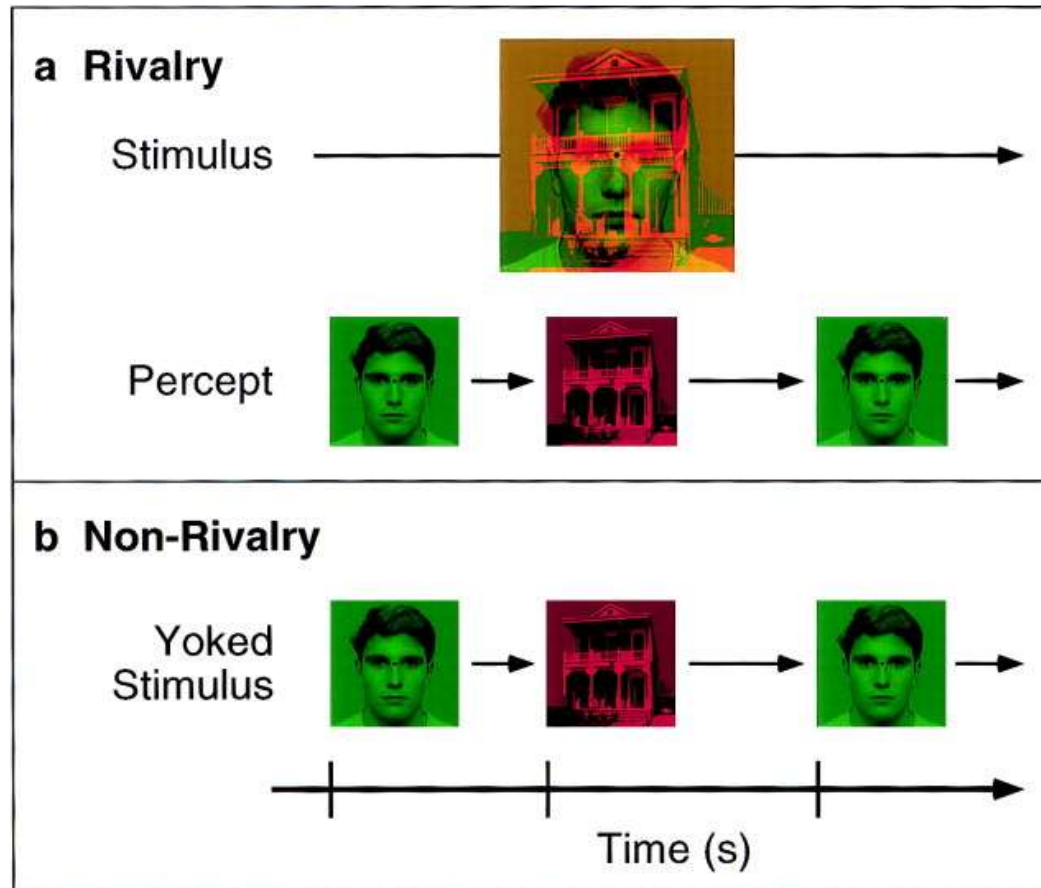


Bistability

- Monocular rivalry (V1)



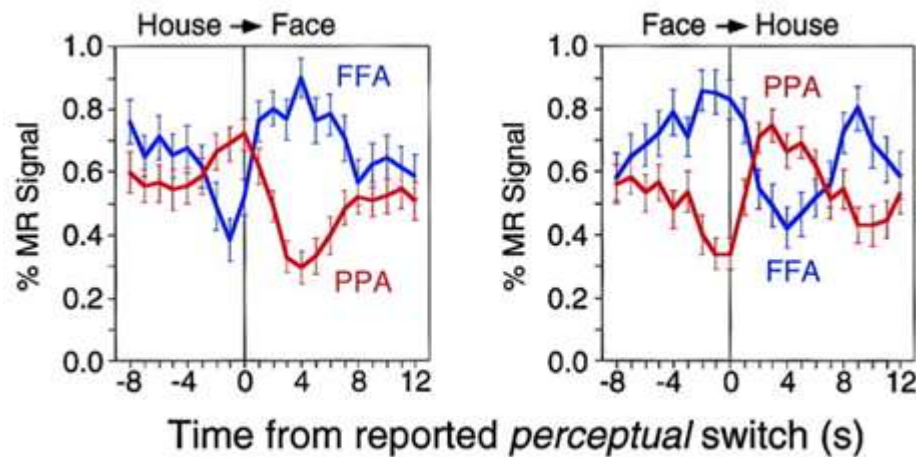
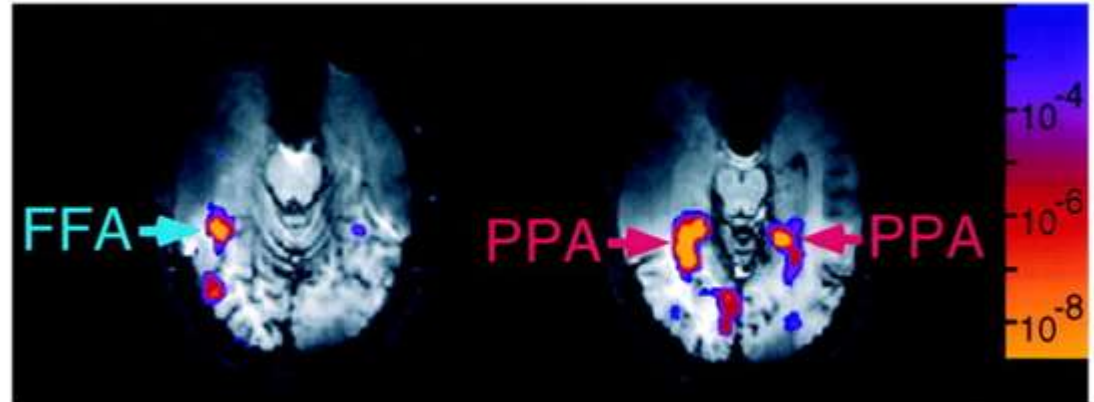
Areas PPA and FFA



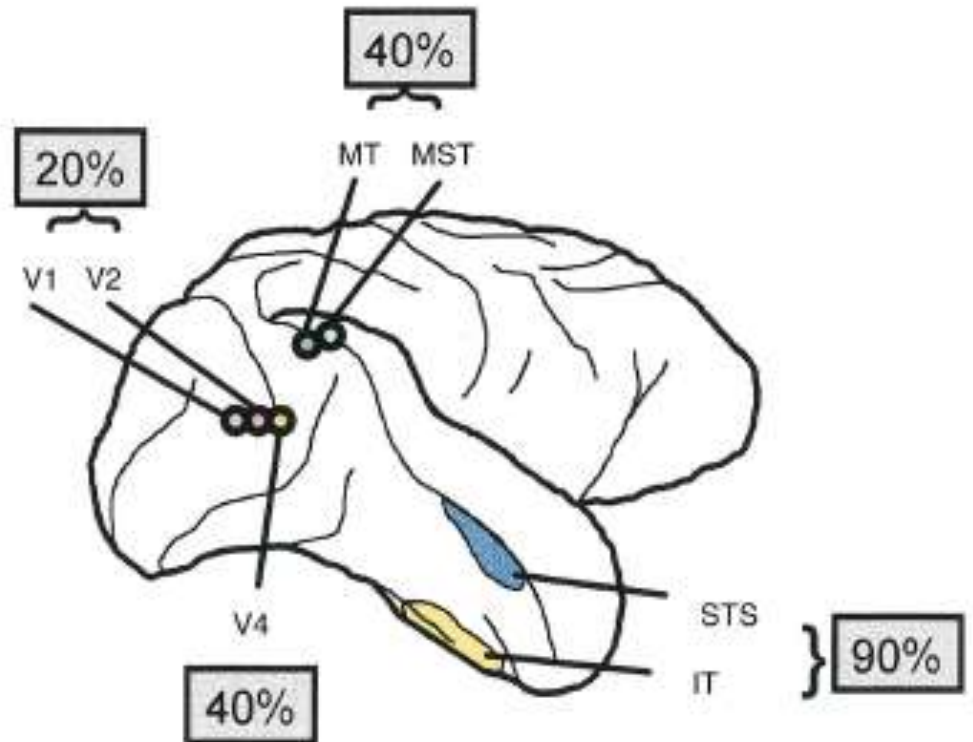
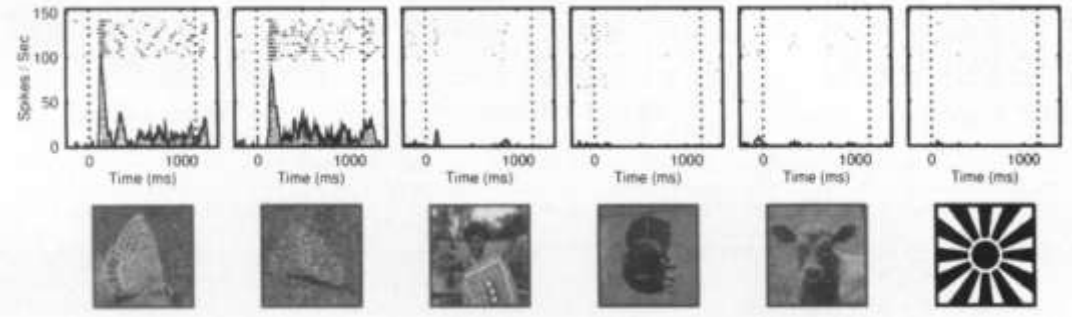
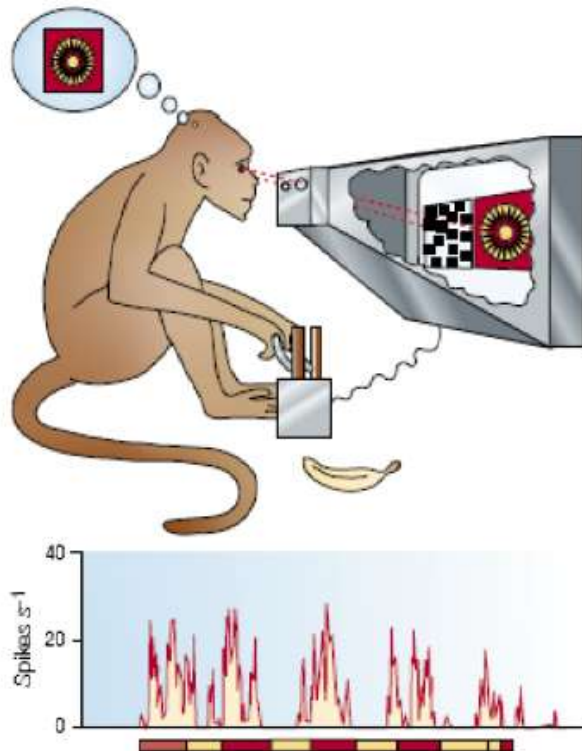
Areas PPA and FFA

PPA =
Parahippocampal
Place Area (*places*)

FFA = Fusiform
Face Area (*faces*)



Unit recordings



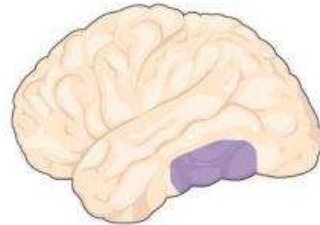
Fusiform gyrus and Infero-Temporal (IT)

Leopold & Logothetis, 1999

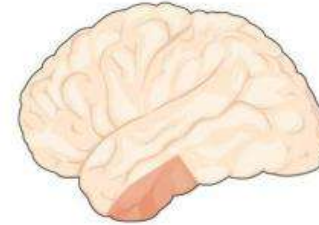
Sheinberg & Logothetis, 1997

Lesions: agnosia

Apperceptive agnosia



Associative agnosia













Inféro-
temporal
(IT)

Ability to copy
or match
visual stimuli







Deficiency of
object perception

Clinical
interpretation

Model	Patient's drawing	Verbal identification of object
		"Circle"
		"Square"
		"Diamond"
		"Three"
		"Four"

Cannot see object parts
as a unified whole

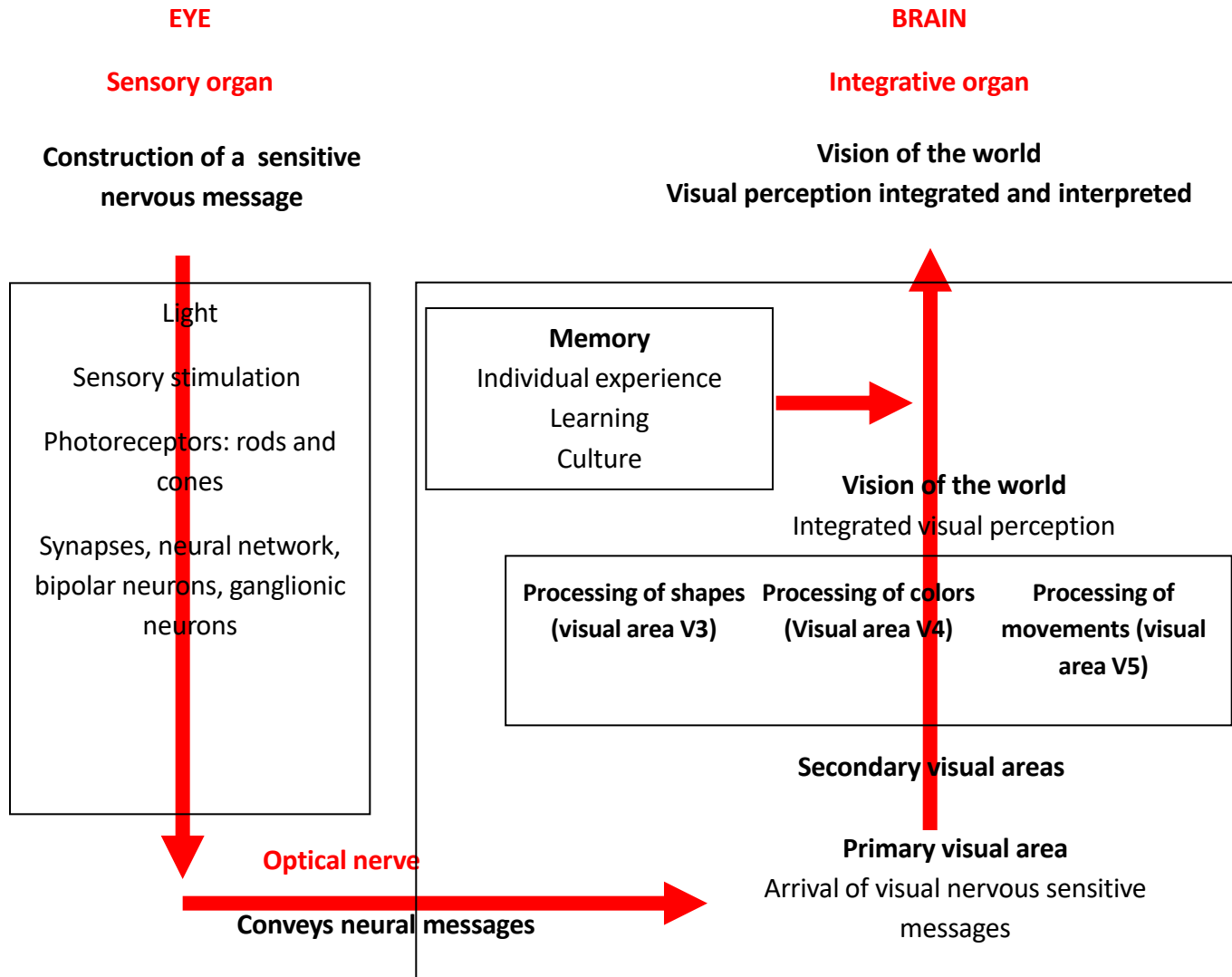
Unable to construct sensory
representations of visual stimuli

Model	Patient's drawing	Verbal identification of object
		—
		—
		—

Cannot interpret, understand,
or assign meaning to objects

Sensory representation is created
normally but cannot be associated
with meaning, function, or utility

Functional schema of visual perception



Summary

- Perceptual separation into different primitives
- Processing by contrasts
- Relative functional and anatomical modularity
- Lesions induce targeted deficits

Problem

If primitives (contours, colours, movement, depth) are separated, why and how do we have a unified perception of these traits (ie in terms of objects)?

