

# Multisensory perception

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# Outline

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

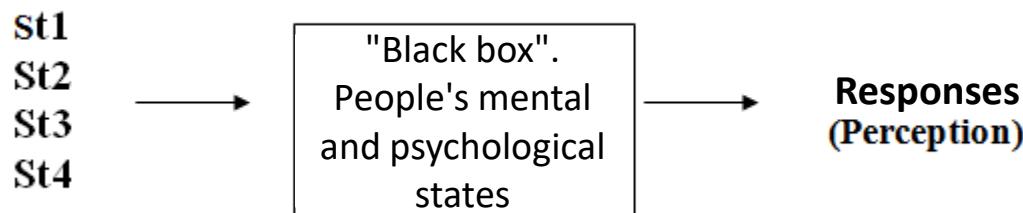
# How many senses do we have?

- 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

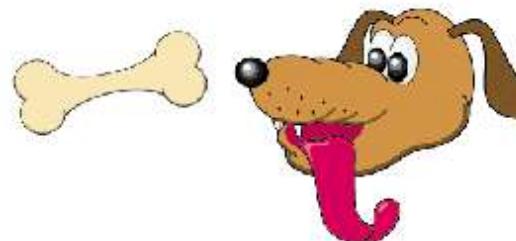
# Behaviourism

- Stimulus → Response

Before conditionning

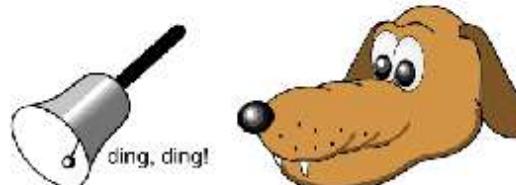
Food

Salivation



Bell

No response



During conditionning

Food  
+ Bell

Salivation



After conditionning

Bell

Salivation



Pavlov, 1927

# Cognitivism

- thinking = information processing



- Stimulus → Processing → Response

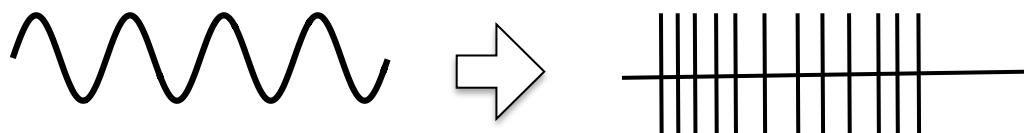
# Sensation vs. perception

- Sensation: 1<sup>st</sup> 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

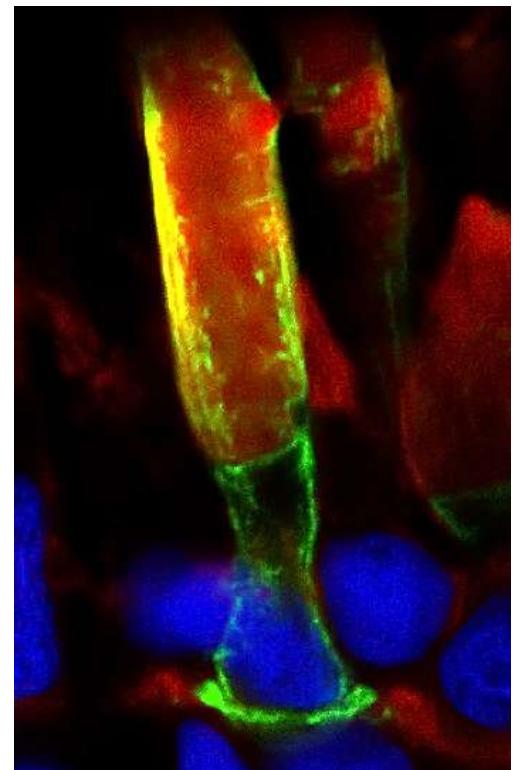
# Sensation = transduction

## Transduction

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



Eg: photo-receptor



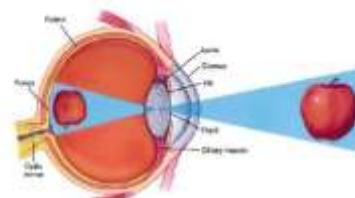
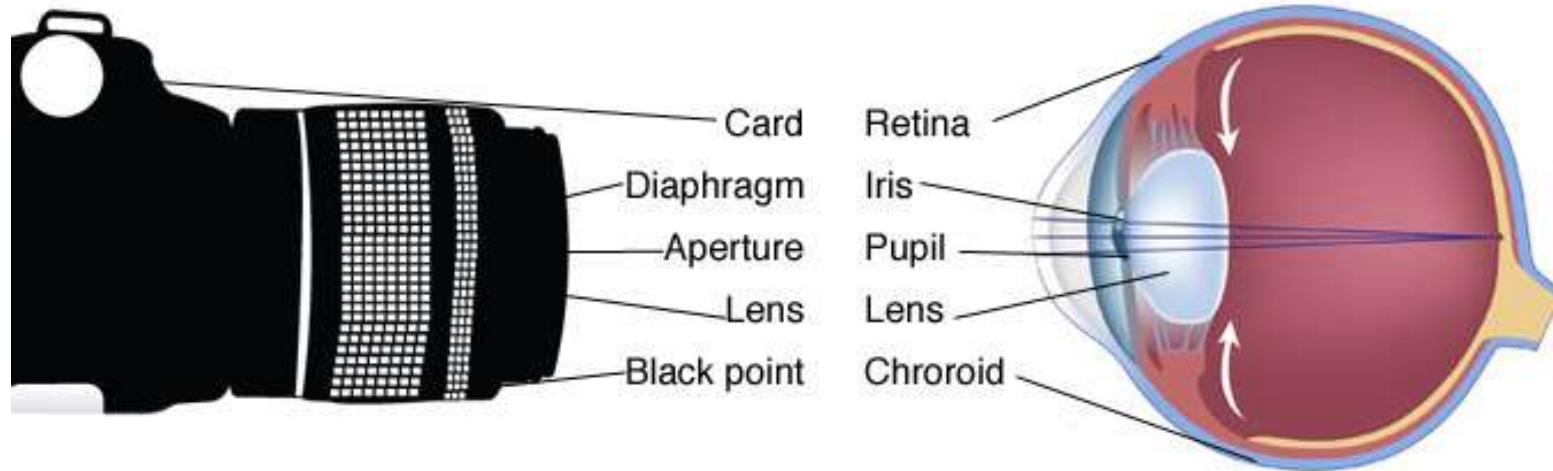
# Metaphor of the camera

Eye = camera

Cristalline lens = lens

Iris = diaphragm

Retina = movie





# Perception

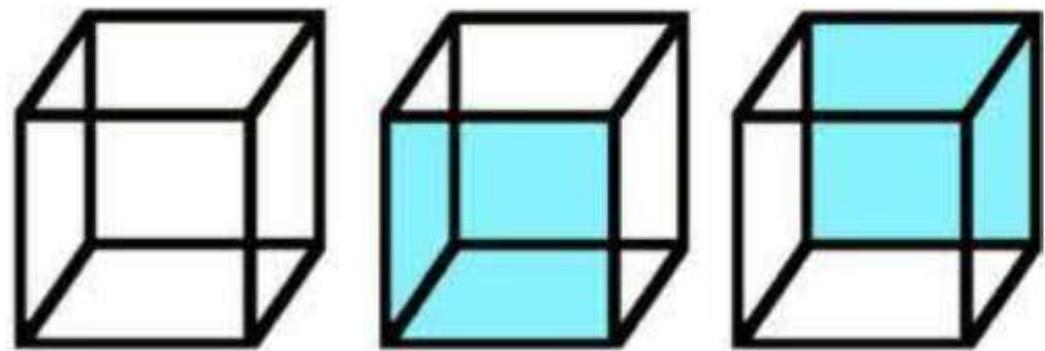
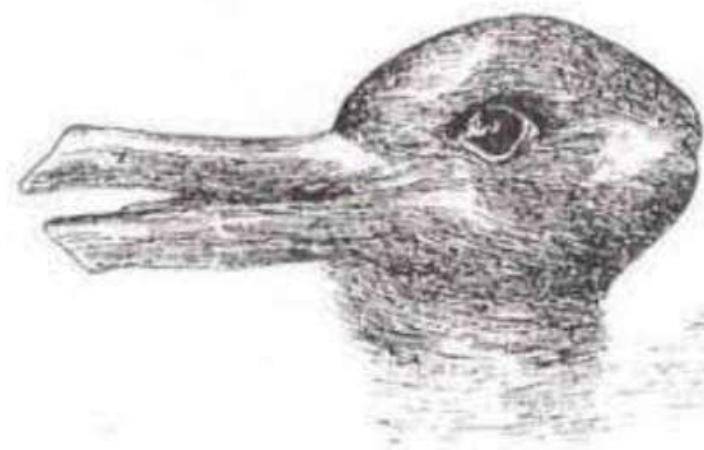
- Not veridical – construction
  - Bottom up and top-down processes
  - Inferences
- > Examples

# Visual perception: interpretation of shapes

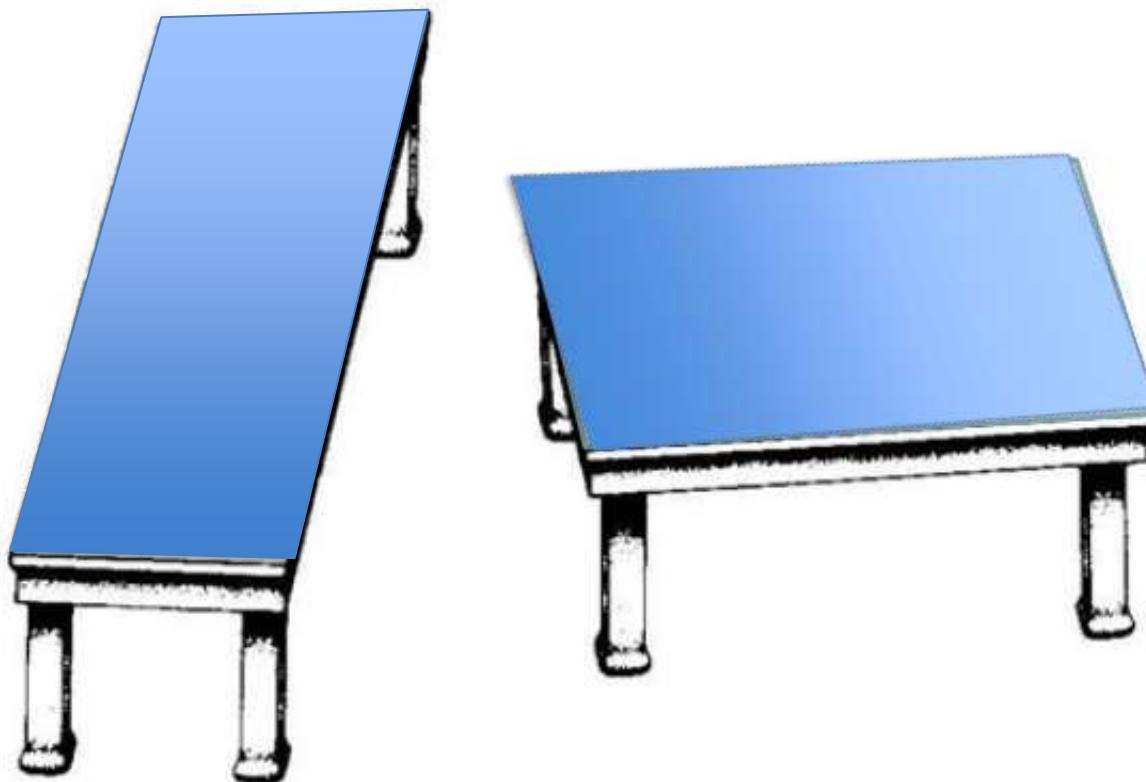


Image from Mooney

# Visual perception: bistability of interpretations



# Perception of distances



“Turning the tables”, par Roger Shepard

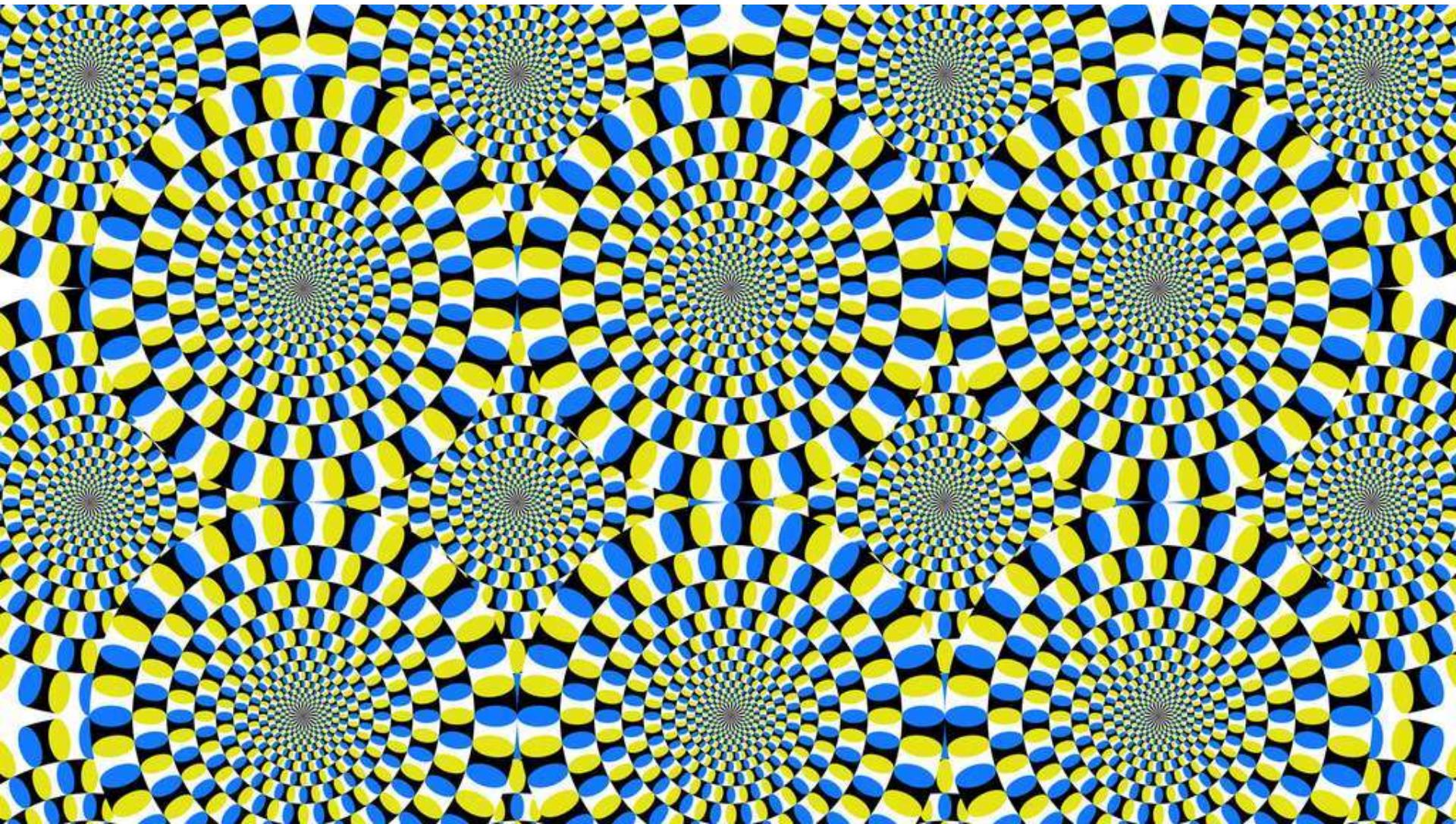
Shepard, R. N. (1990). *Mind sights: W.H. Freeman*.

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

# What is the color of this dress?

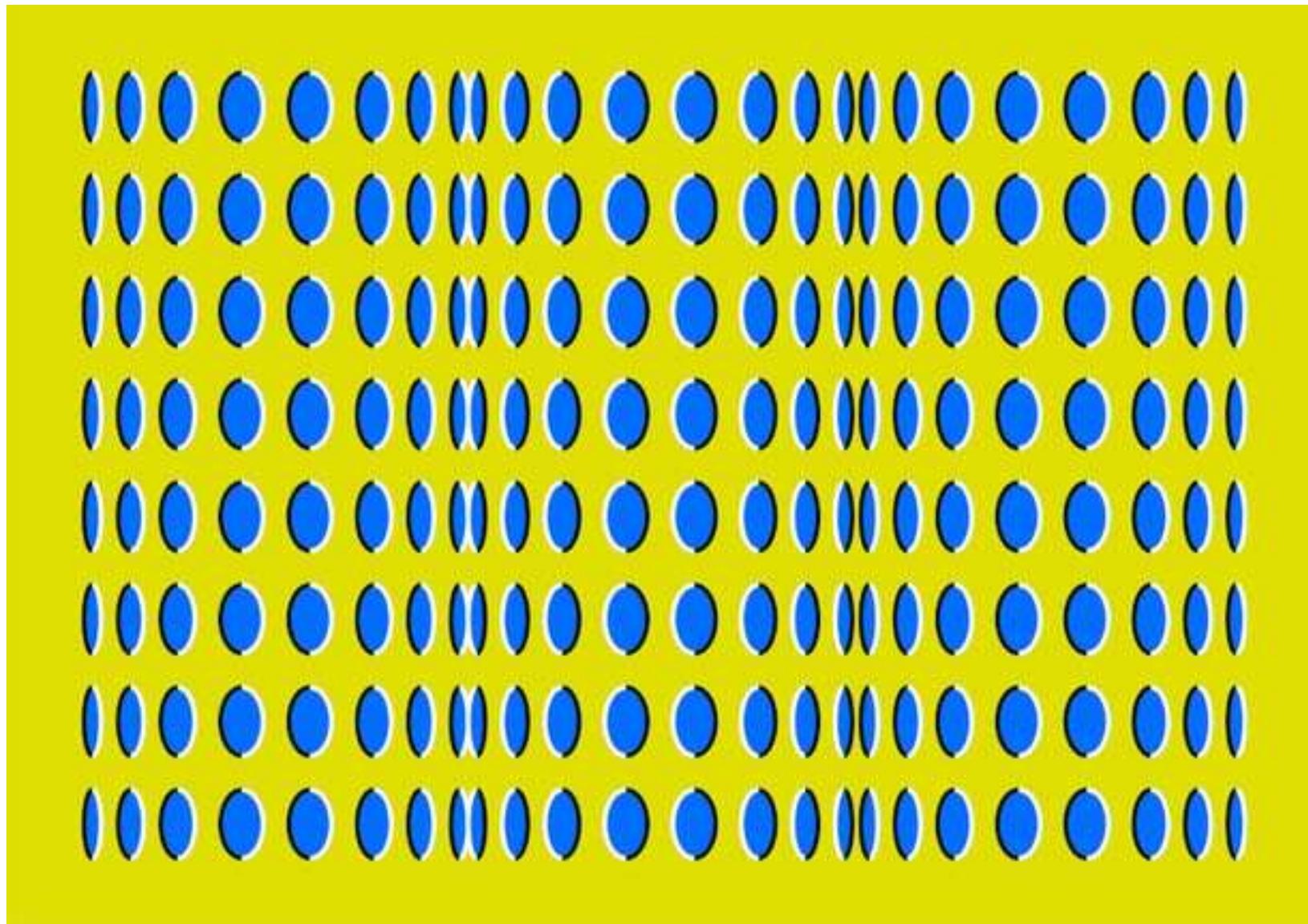


# Illusion of movement



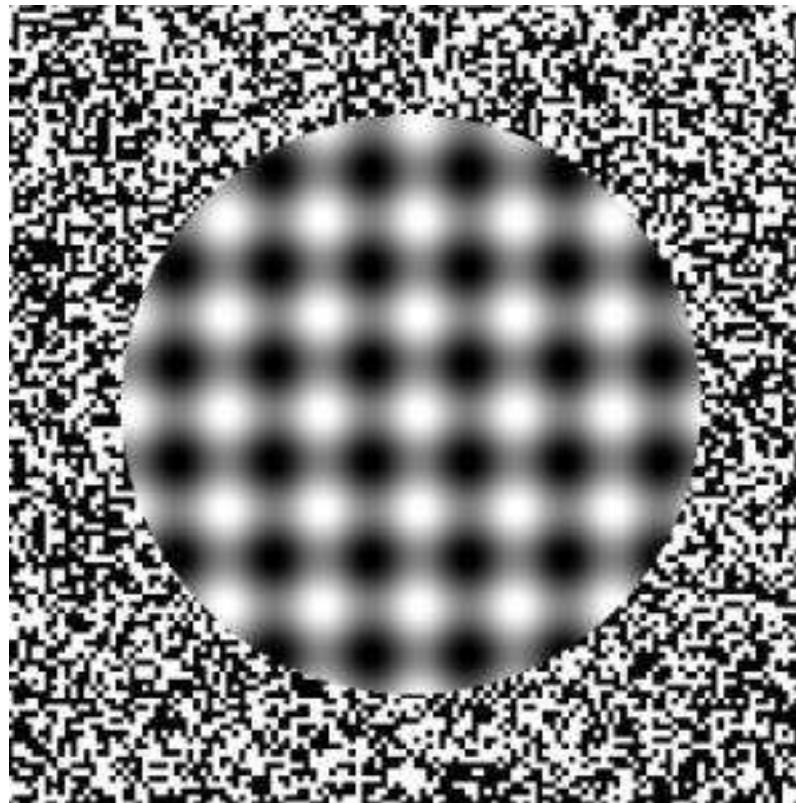
Illusion from Akiyoshi Kitaoka

# Illusion of movement



Illusion from Akiyoshi Kitaoka

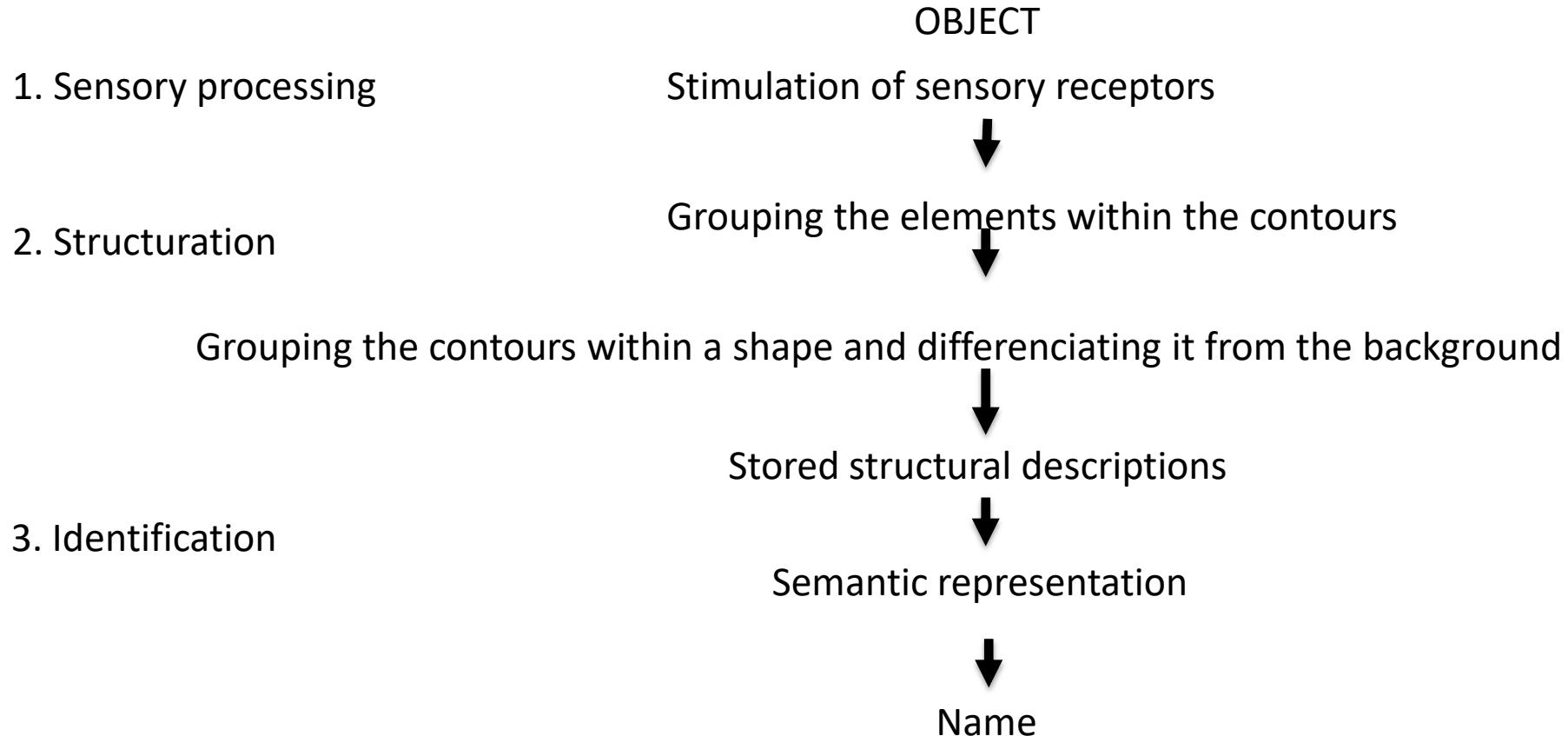
# Illusion of movement



Illusion from Akiyoshi Kitaoka

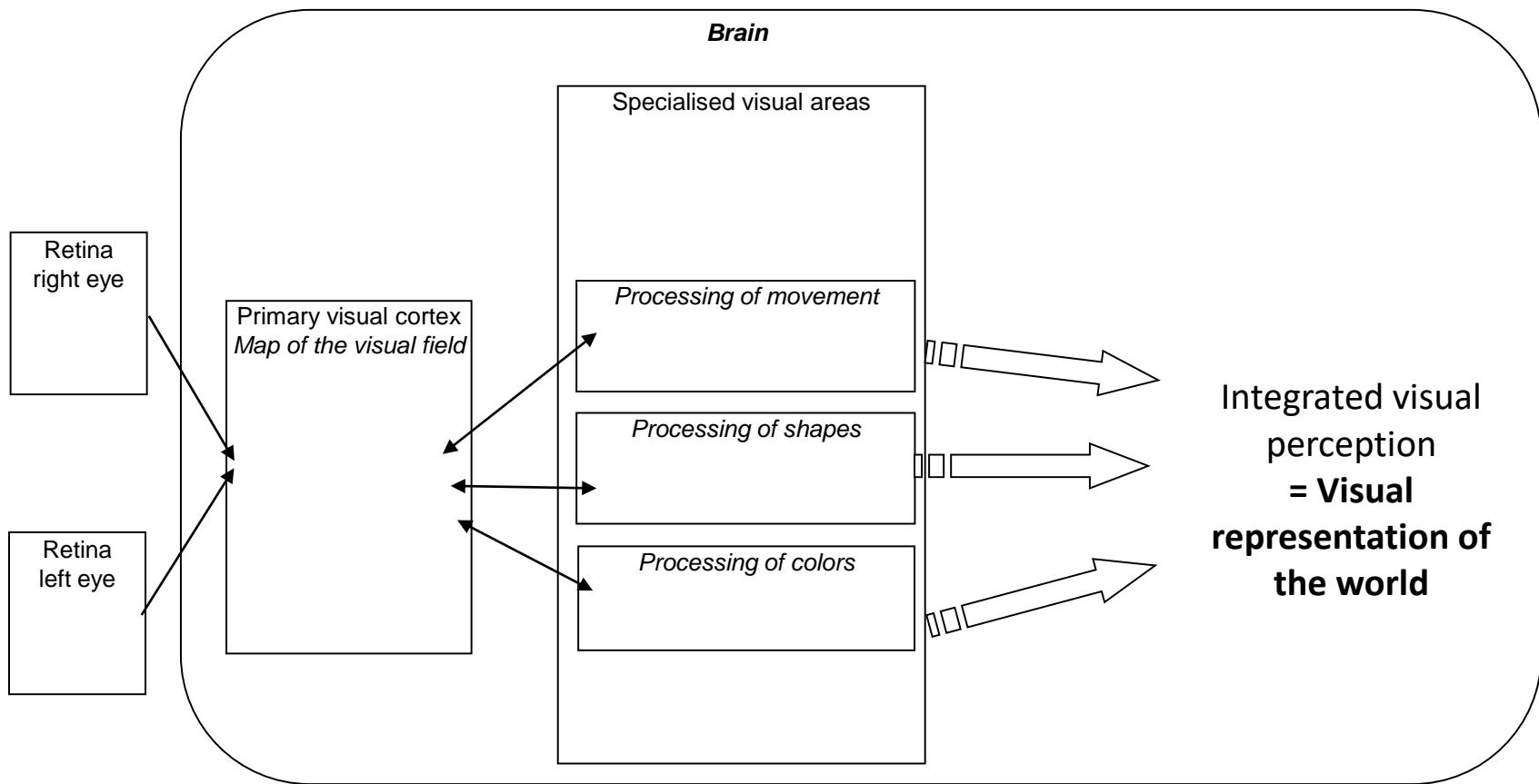
# From sensation to perception

Cognitive model of objects visual recognition:



→ Visual perception is not a unitary and indifferenciated 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



(a)

(b)

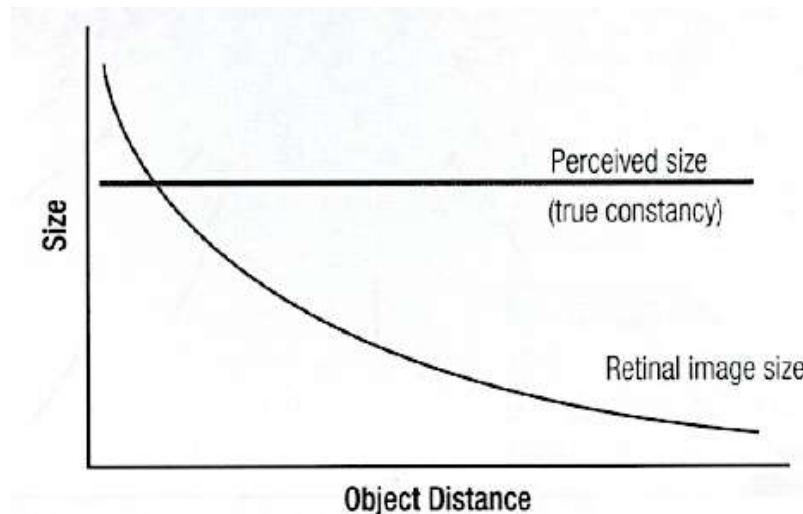
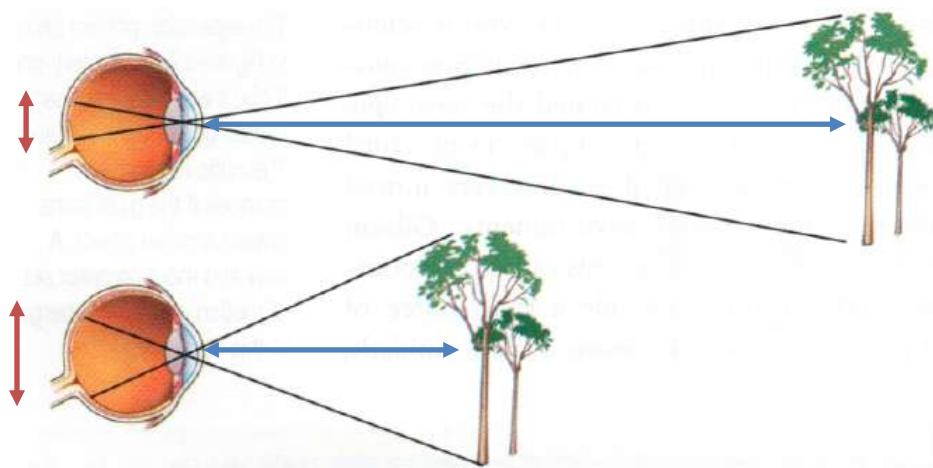


(c)

(d)

# Size constancy

## Integration retinal size - distance

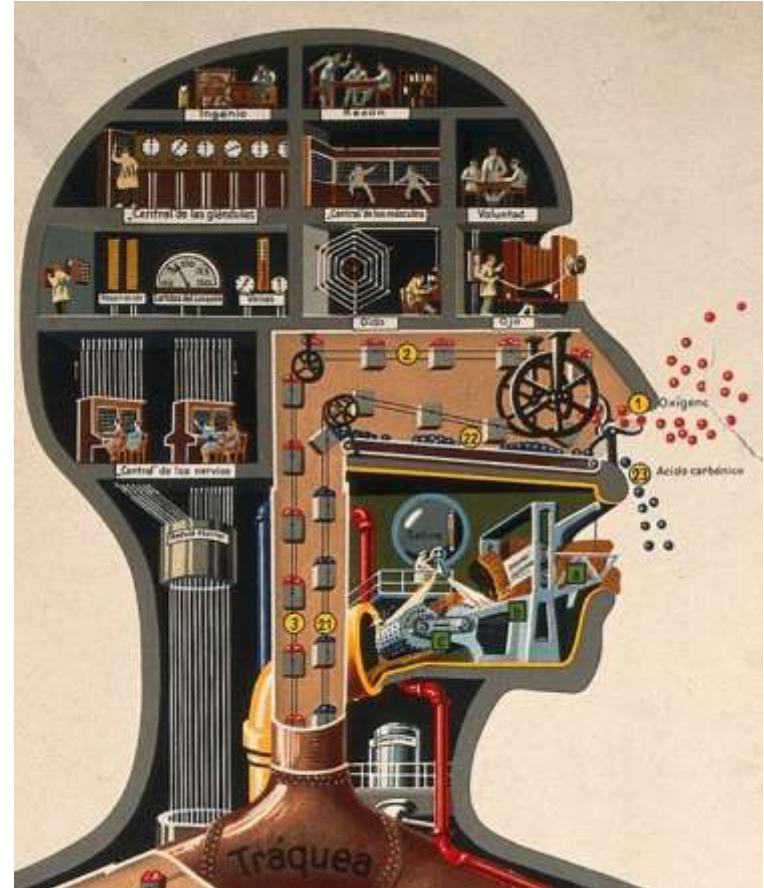


Perceived size

$$= \text{Retinal size} \times \text{perceived distance}$$

# Stages of information processing

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



# Distance – depth

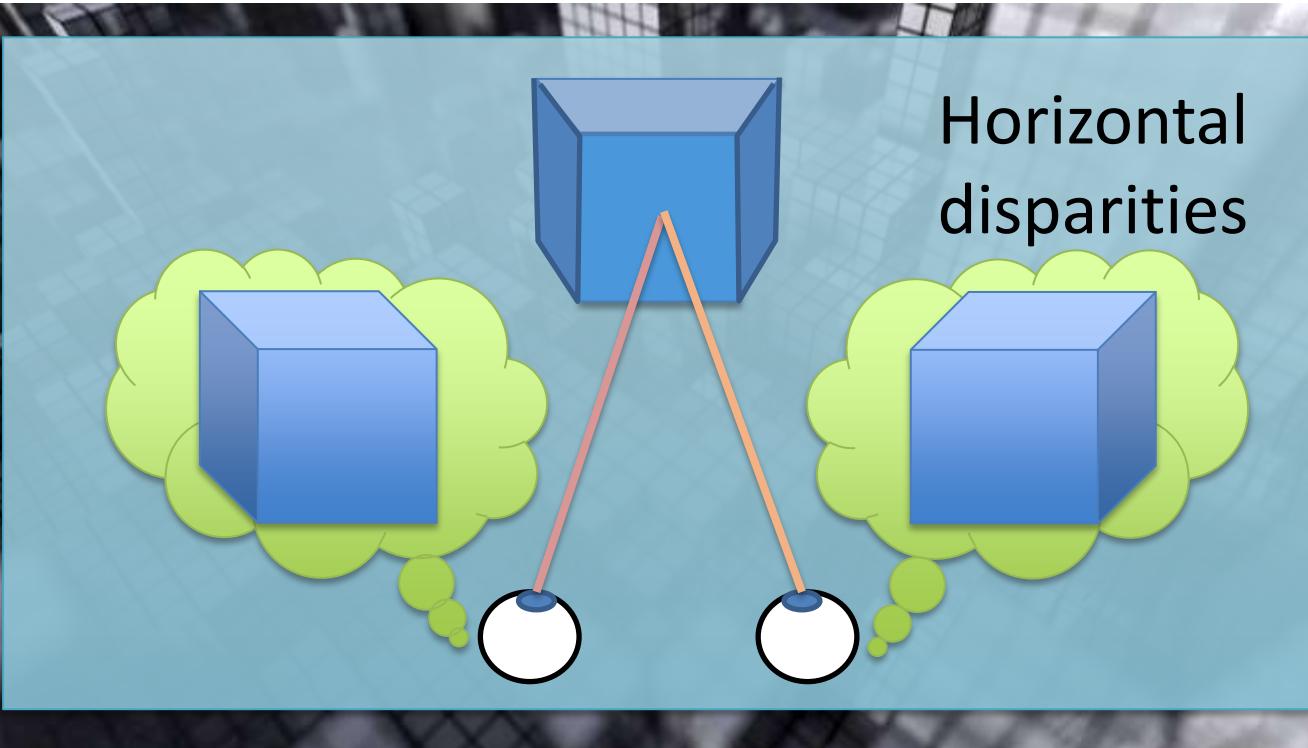
Distance

->

Depth



# Cue for depth – stereopsis



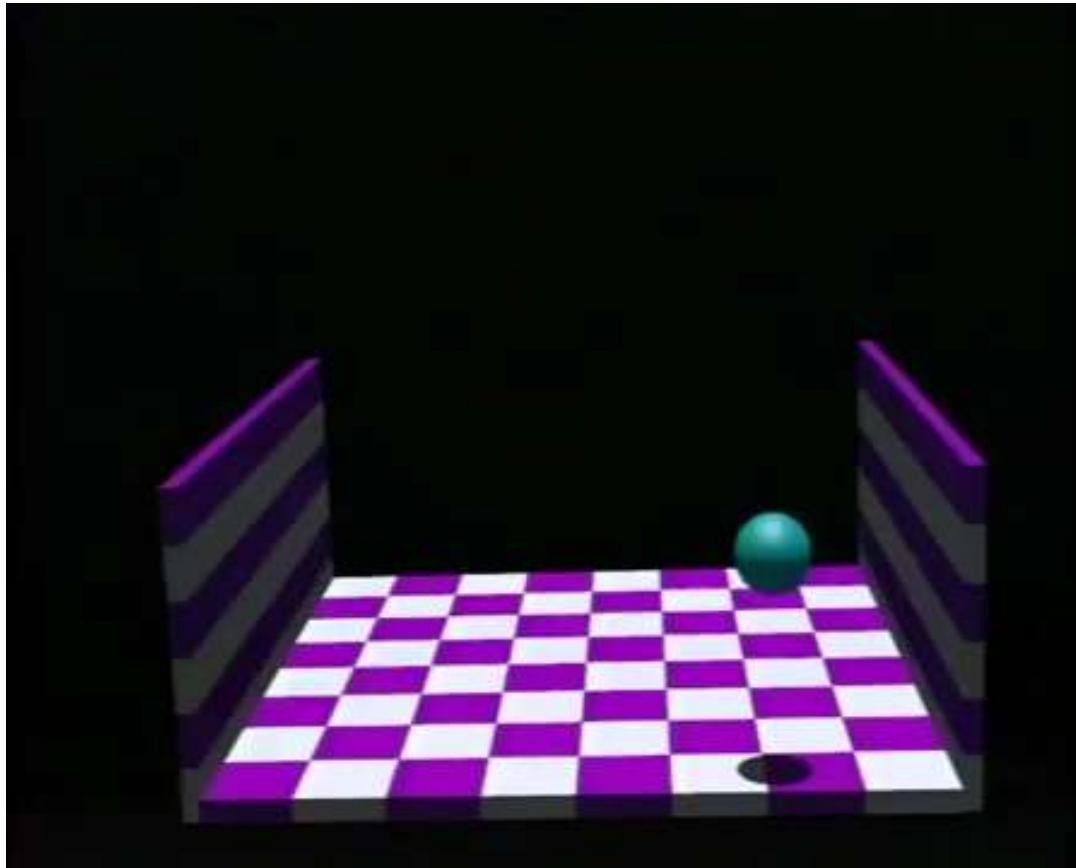
Horizontal  
disparities

## Cue for depth: motion parallax

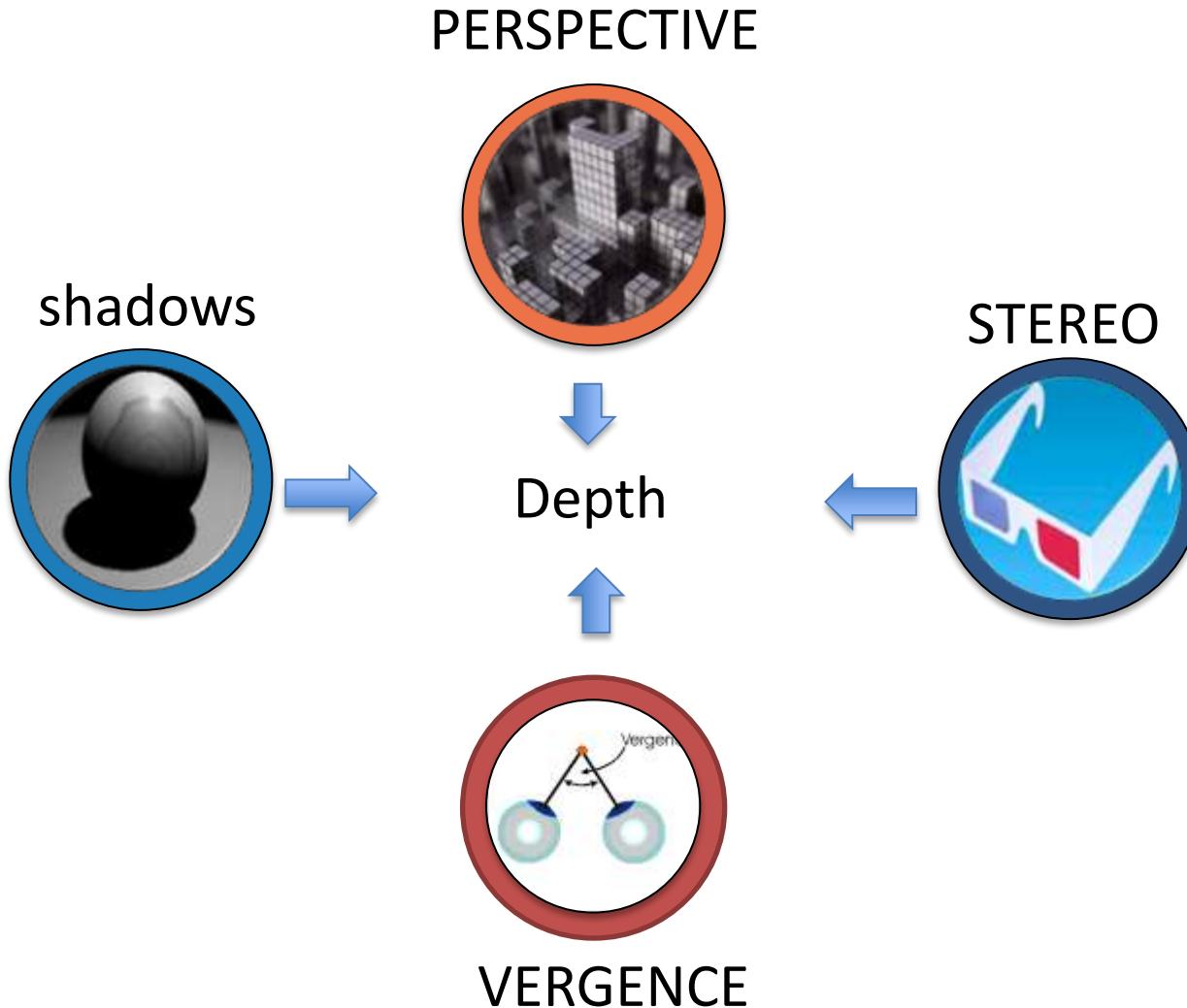


Necessity to know my own displacement speed

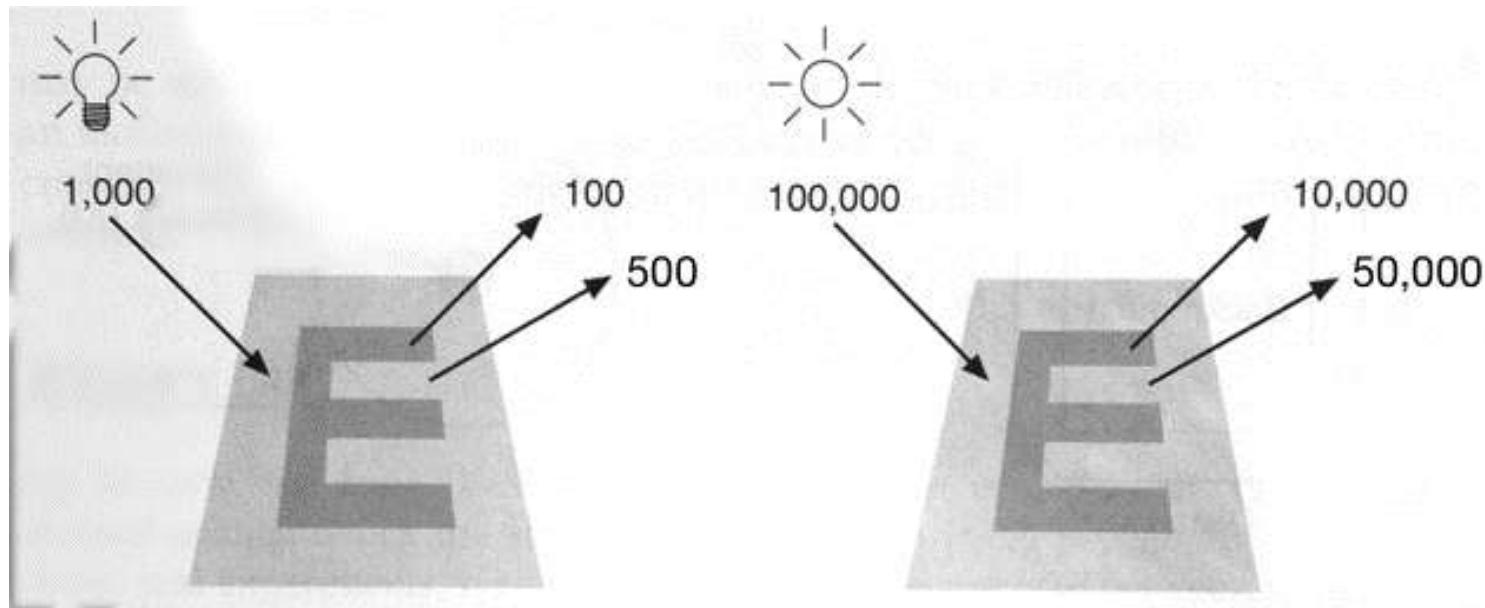
## Cue for depth: shadows



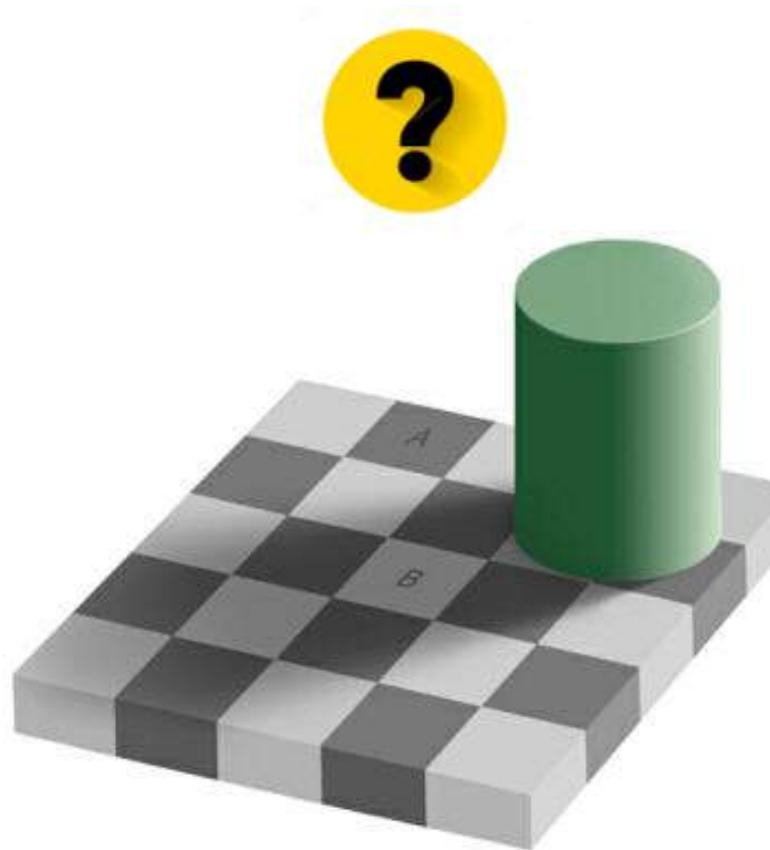
# Integration multi-cues / multi-sensory



# Importance of contrast

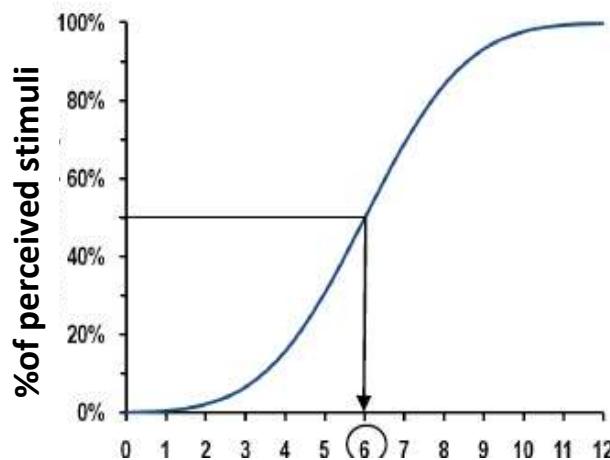


# Contrast of local luminance



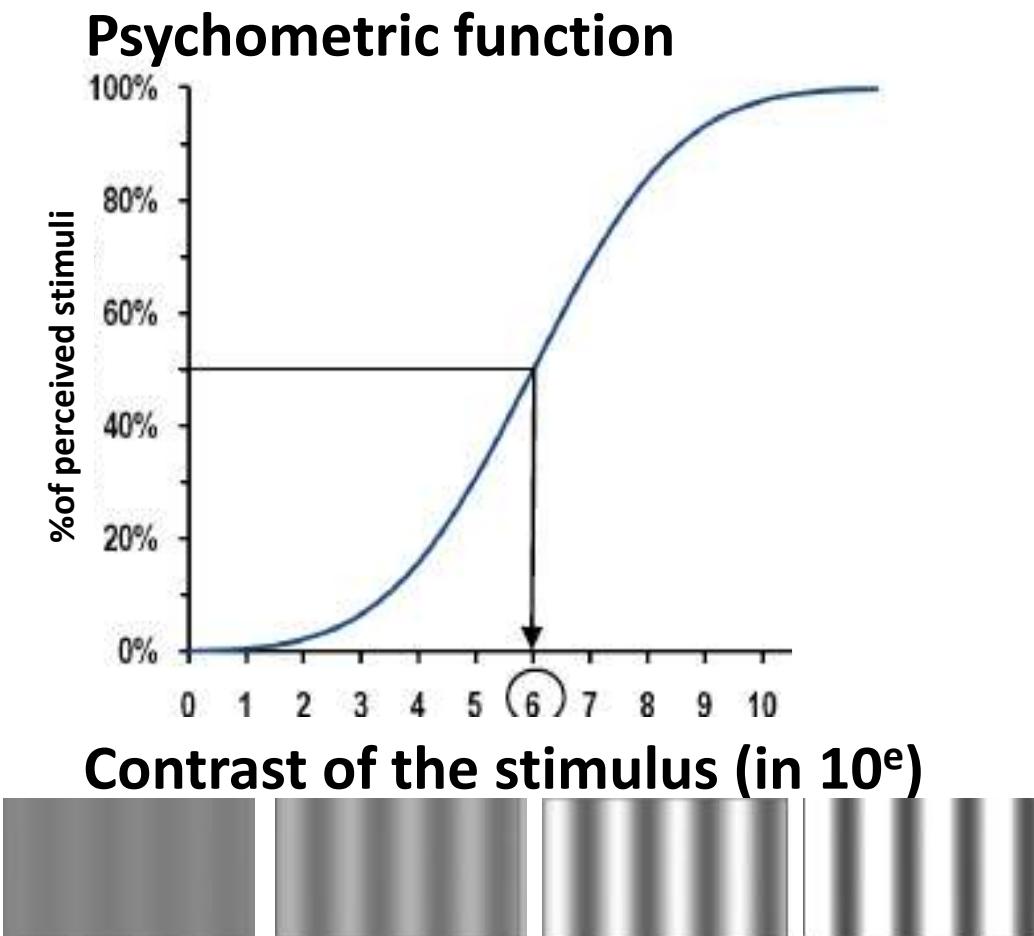
# Measuring perception

- 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.



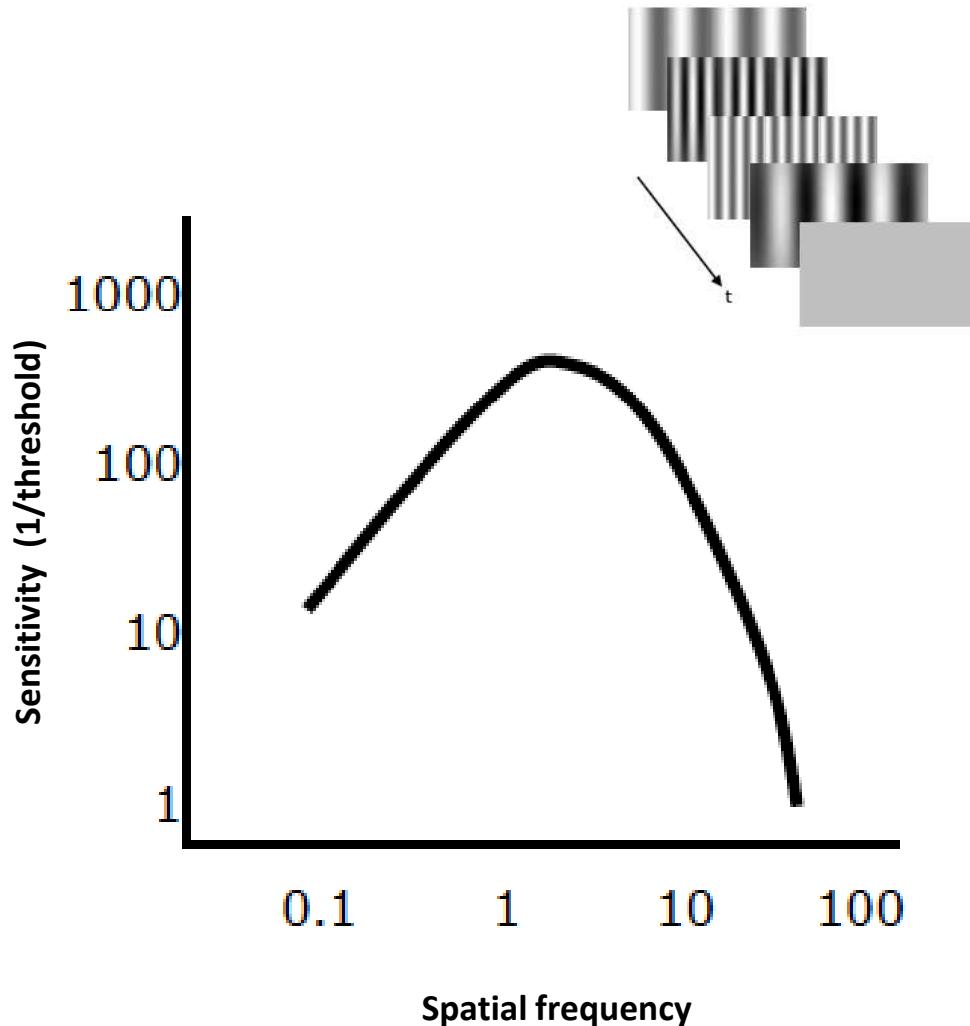
# Measuring perception of contrast

- 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.

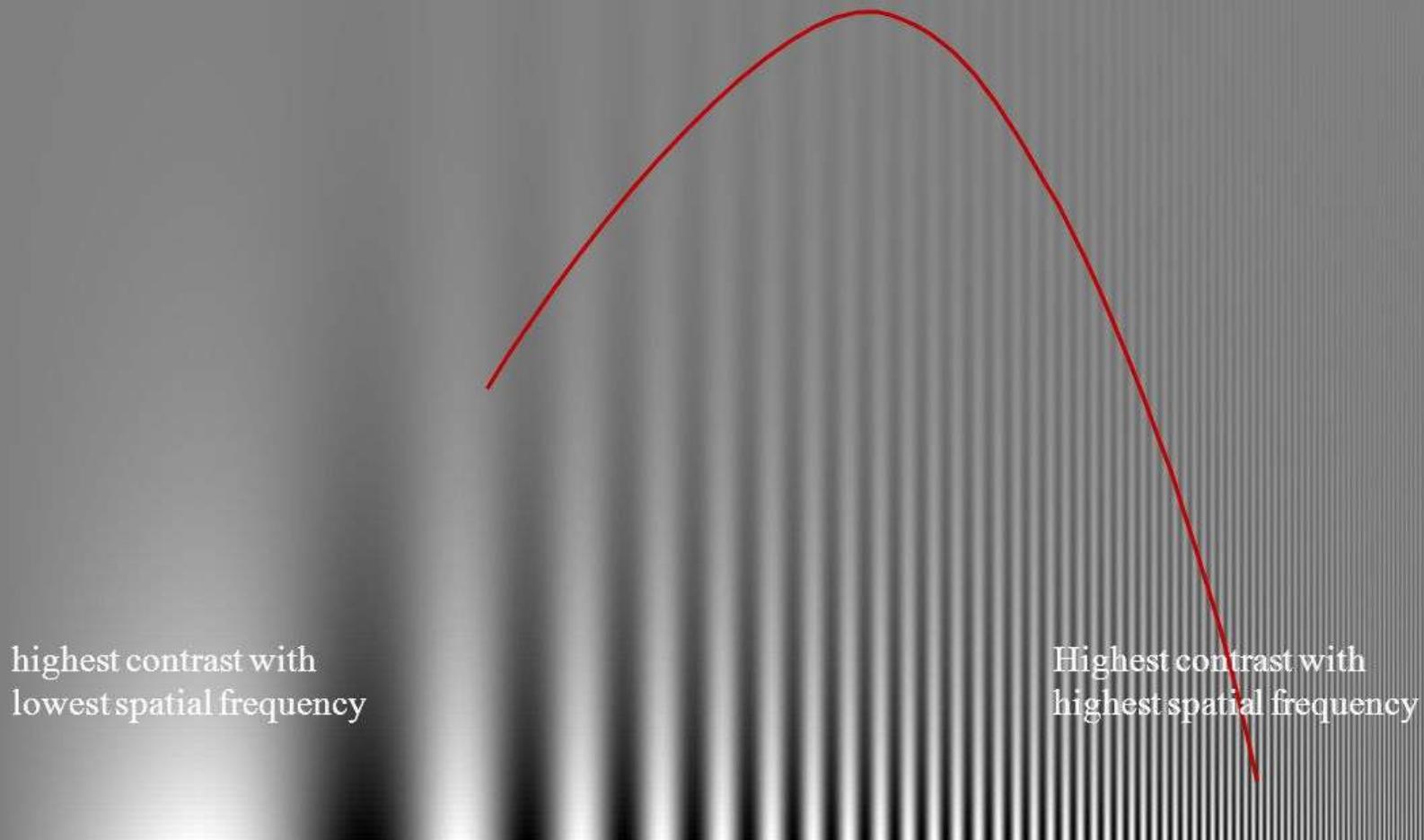


# Function of sensitivity to contrast

Lowest contrast with  
lowest spatial frequency

Contrast Sensitivity  
Function

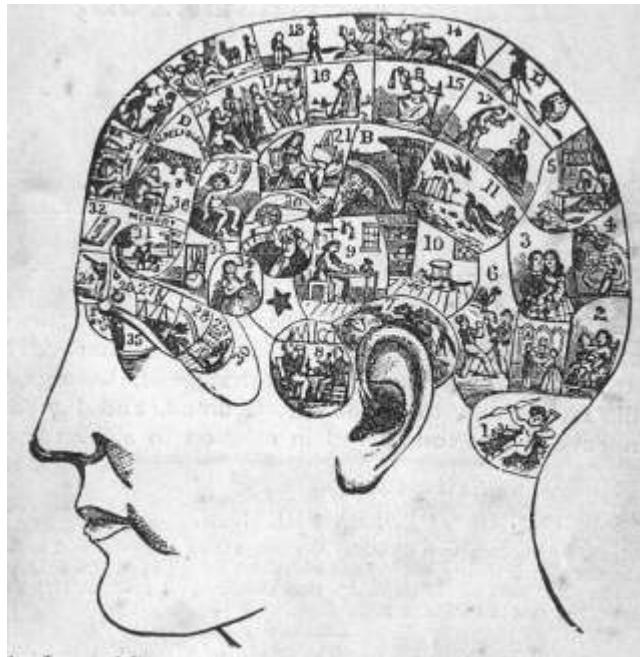
Lowest contrast with  
highest spatial frequency



# Measuring tactile perception

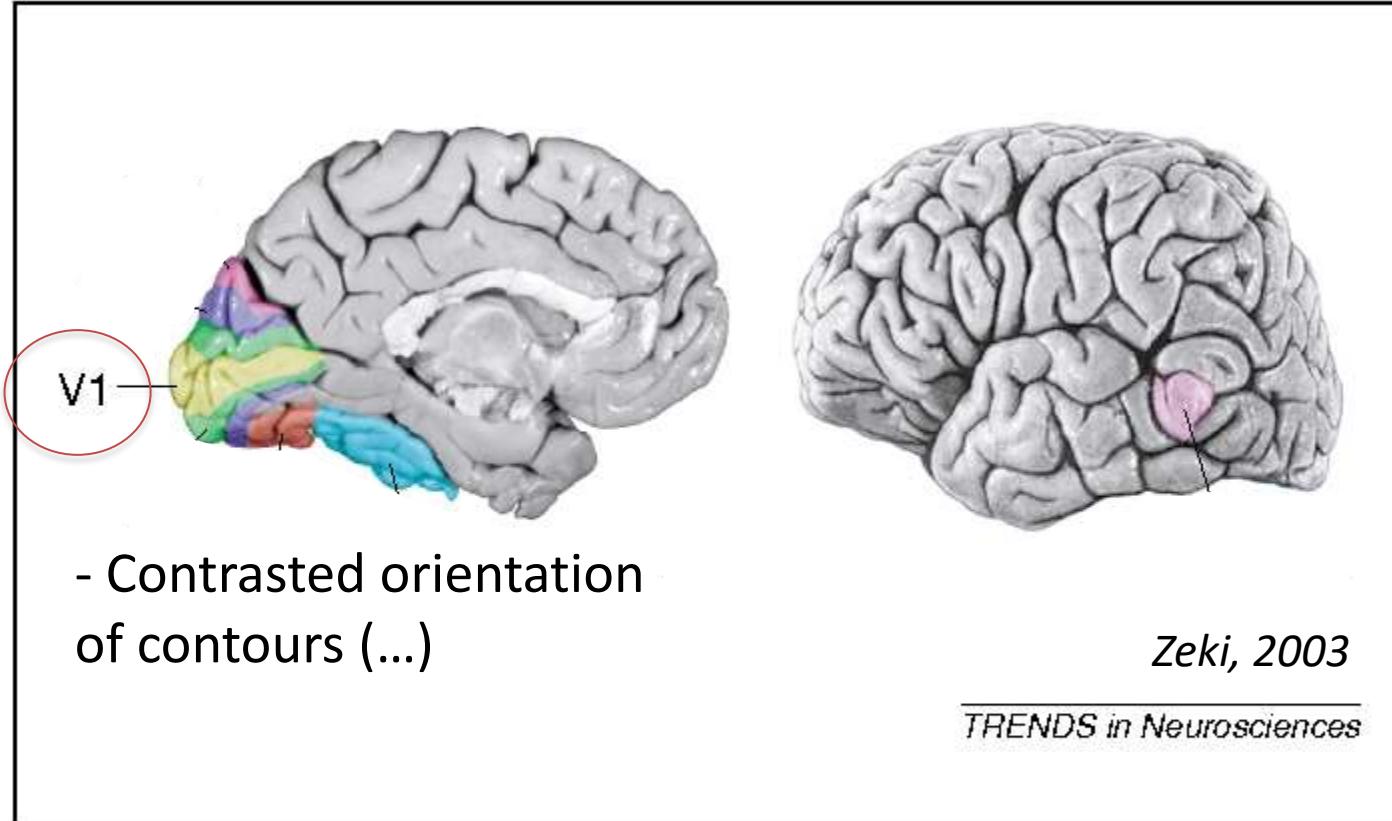
- Expt 1. How would you measure if the minimal distance to detect two different tactile stimuli (ie. the stimuli are perceived as distinct and not as only one) is different on the fingertip and on the arm?
  - Expt 2. How would you measure if the minimal distance to detect two different tactile stimuli 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

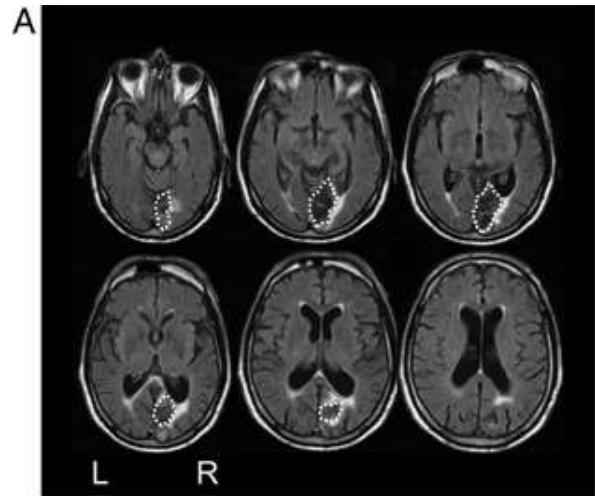


Fonctionnal  
and  
Anatomical

# Local luminance contrast

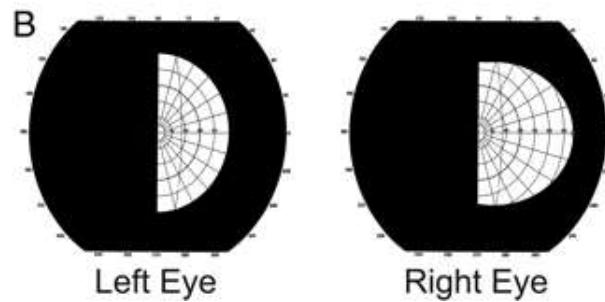


# Homonymous hemianopsia



Unilateral retro-chiasmatic lesion / V1

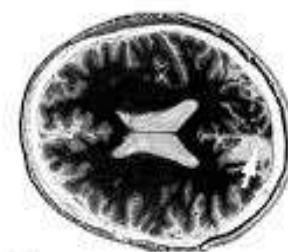
Patient with CB



Striemer et al. (2009)

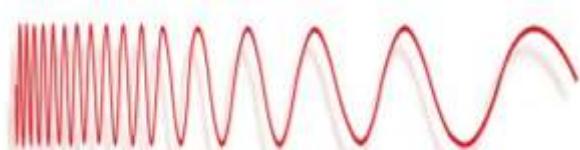
# Blindsight

Patient GY, 1989,  
lesion in V1

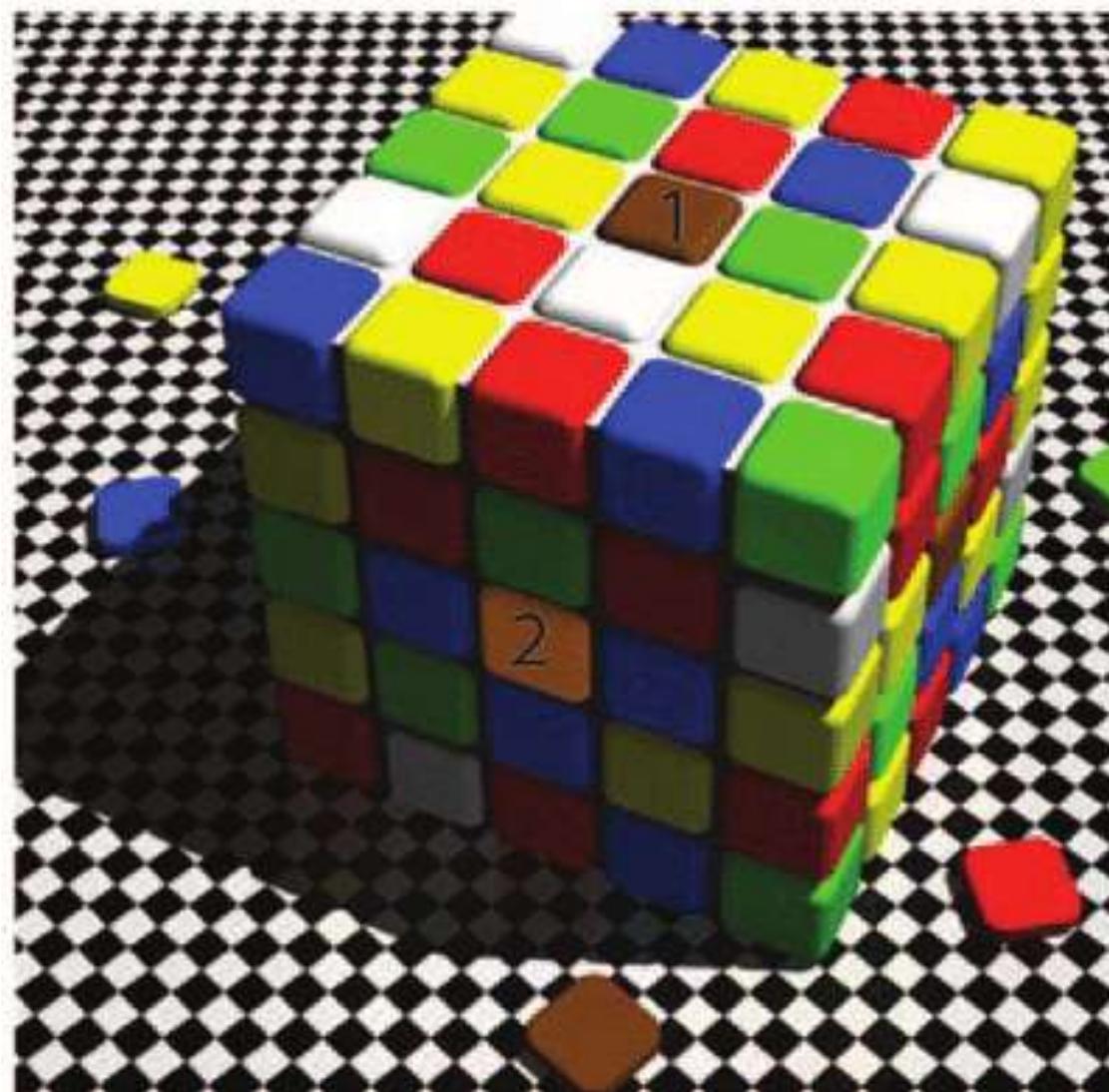


# Spectrum - color

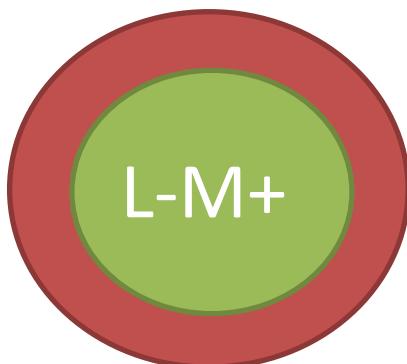
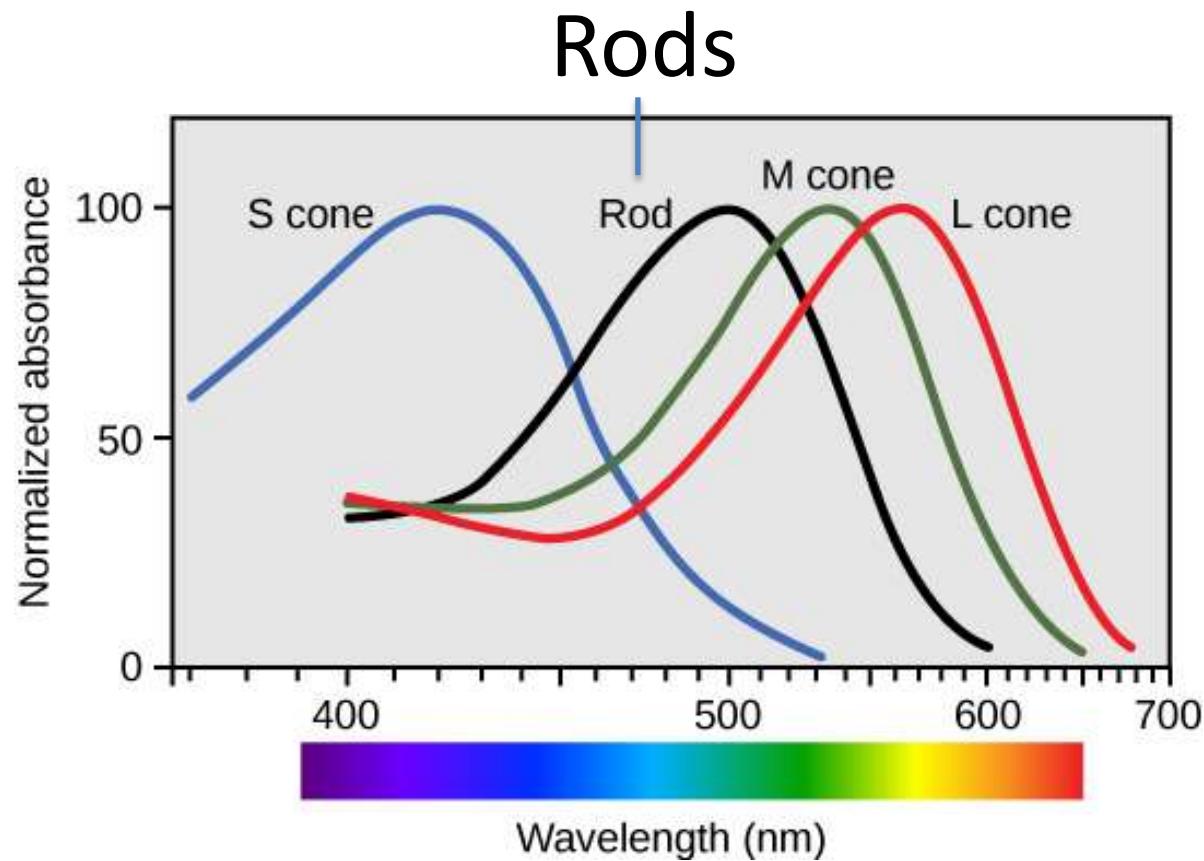
Spectrum → color



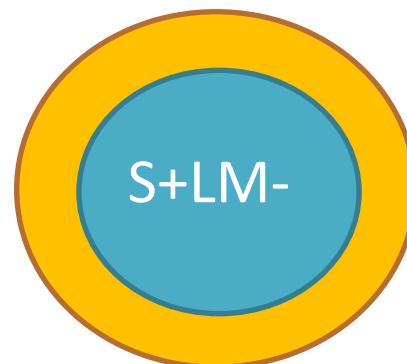
# Color: local contrast



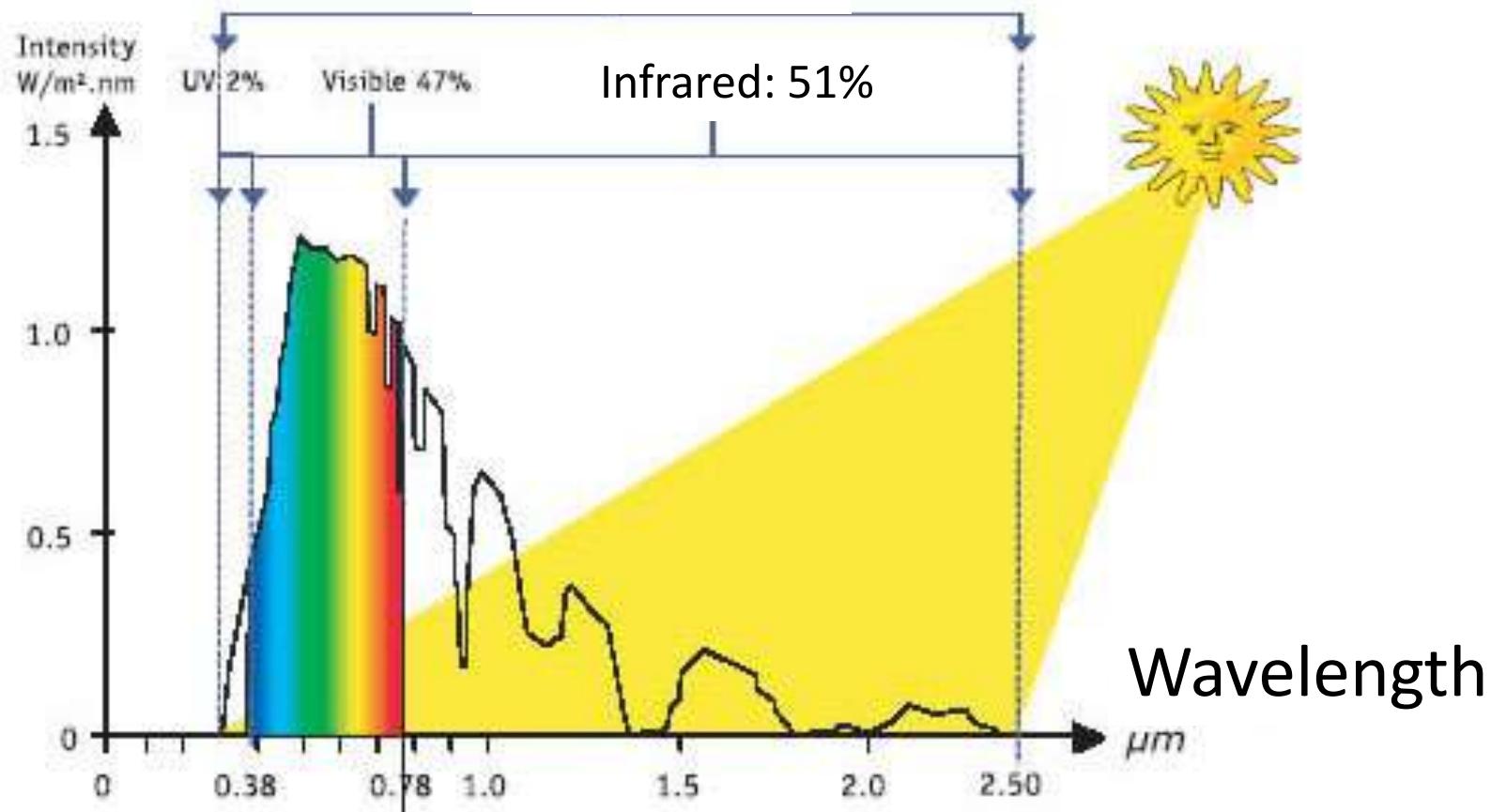
# Color: local contrast



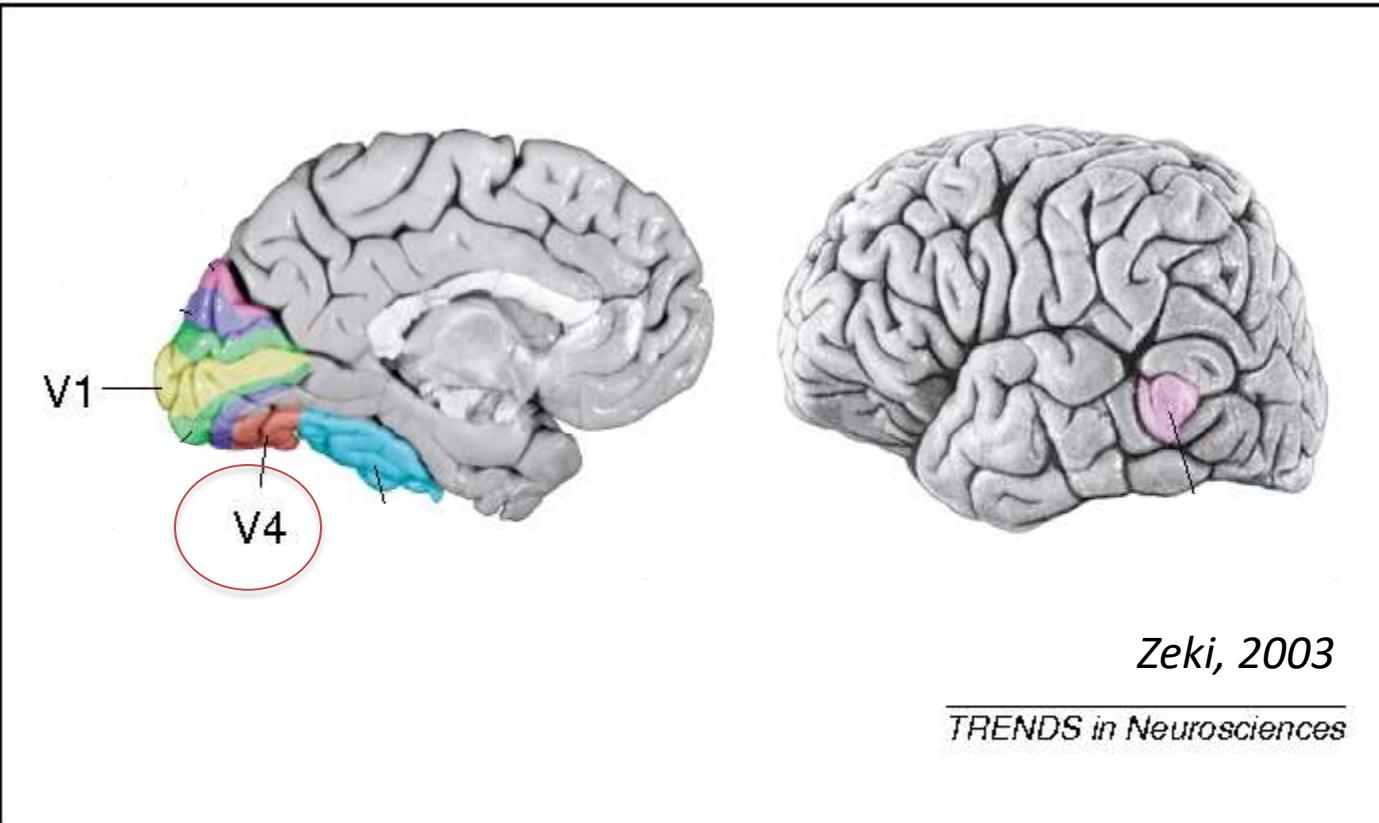
$L+M-$



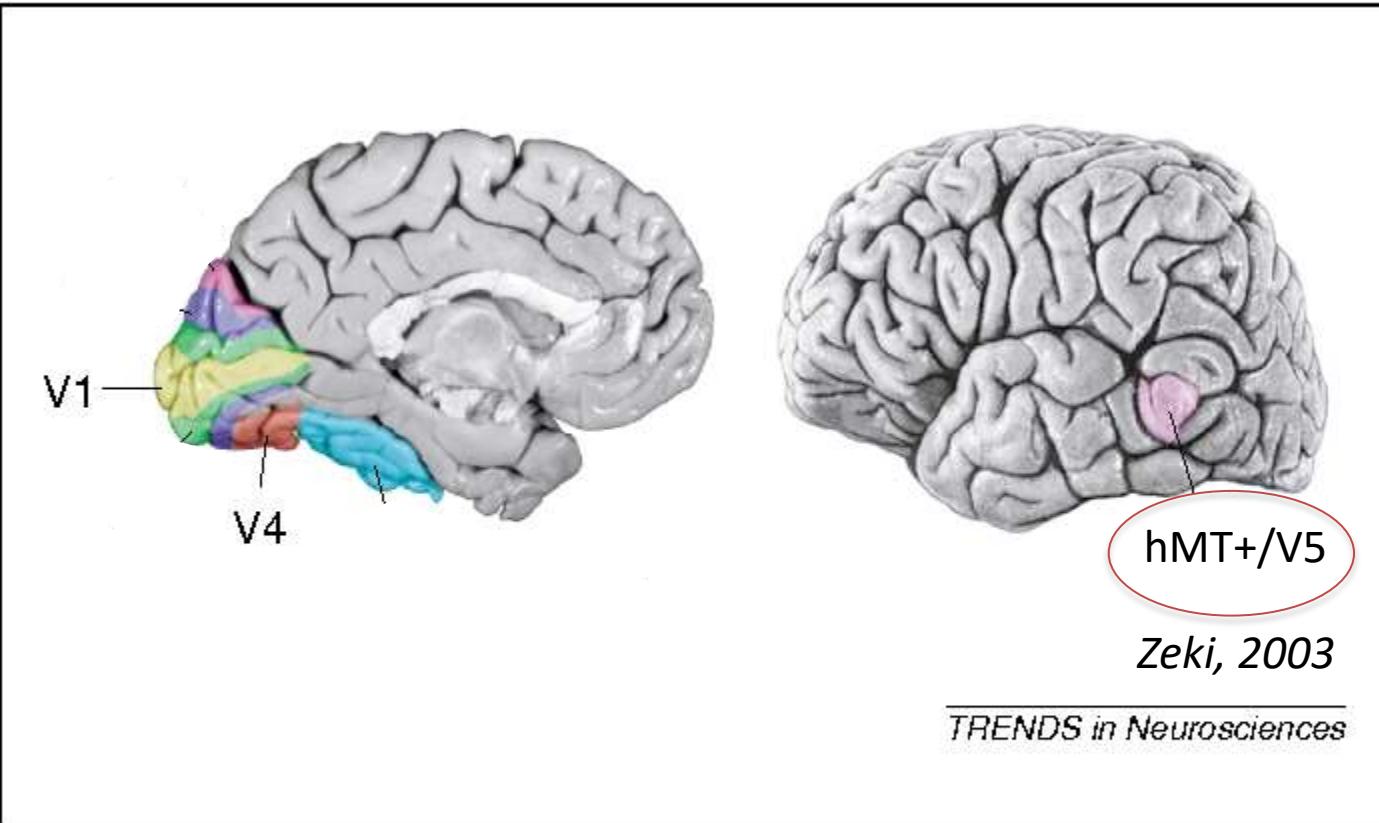
$S-LM+$



# Color: local contrast



# Local movements



# Cerebral akinetopsia



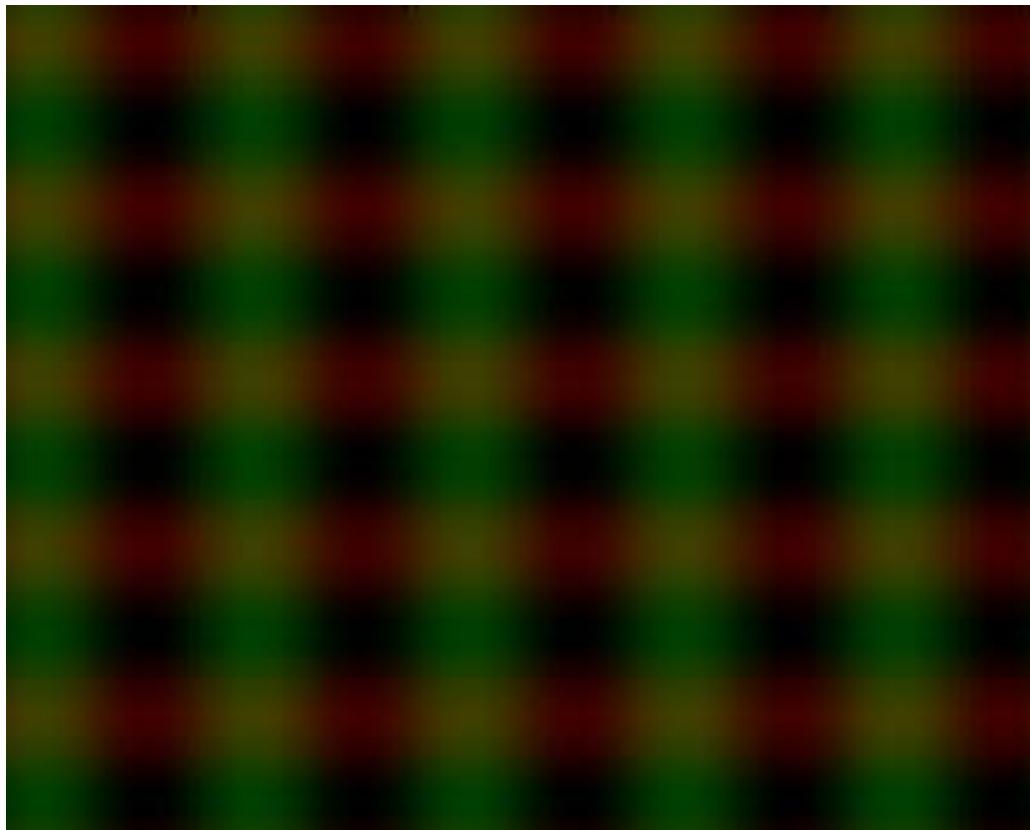
Blindness to movement  
Lesion in hMT+/V5

# Grouping

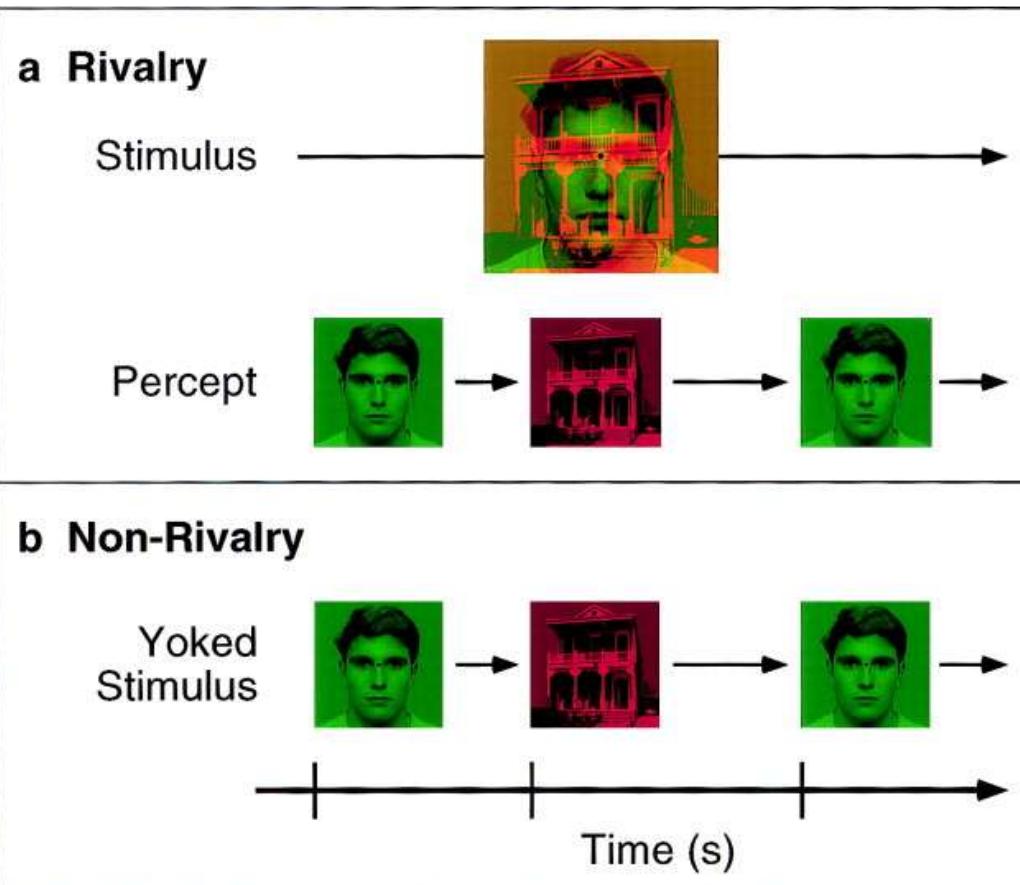


# Bistability

- Monocular rivalry (V1)



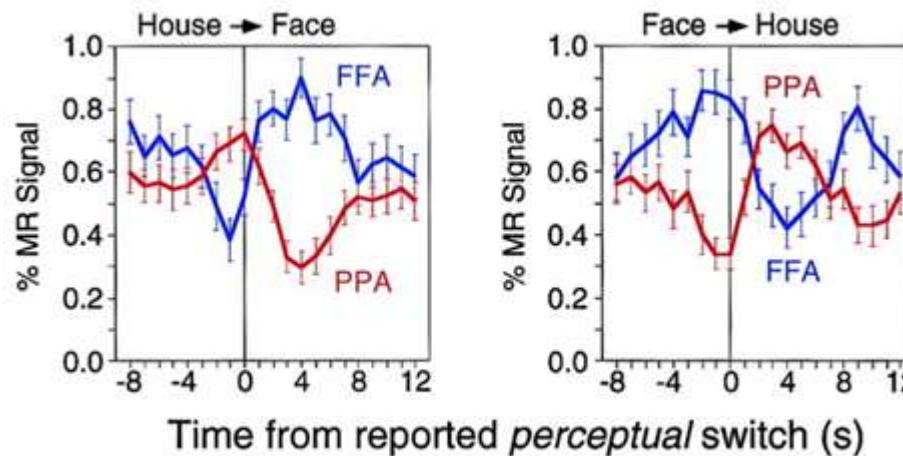
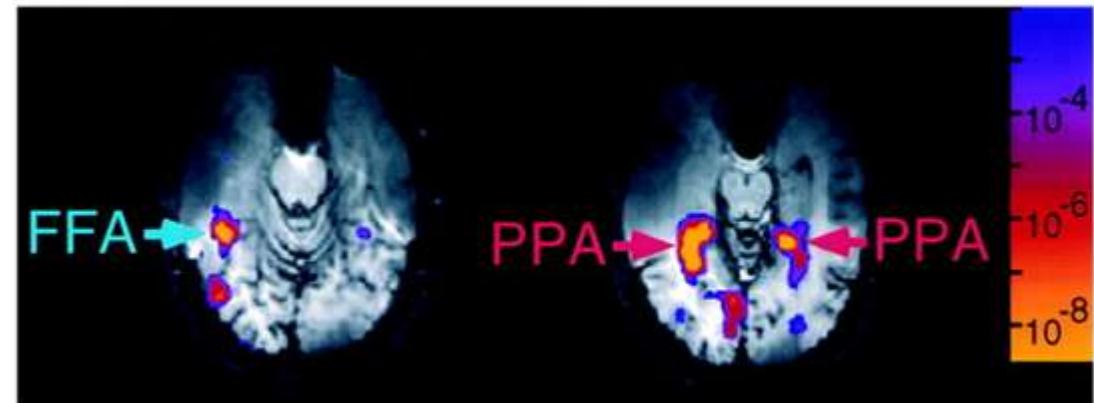
# Areas PPA and FFA



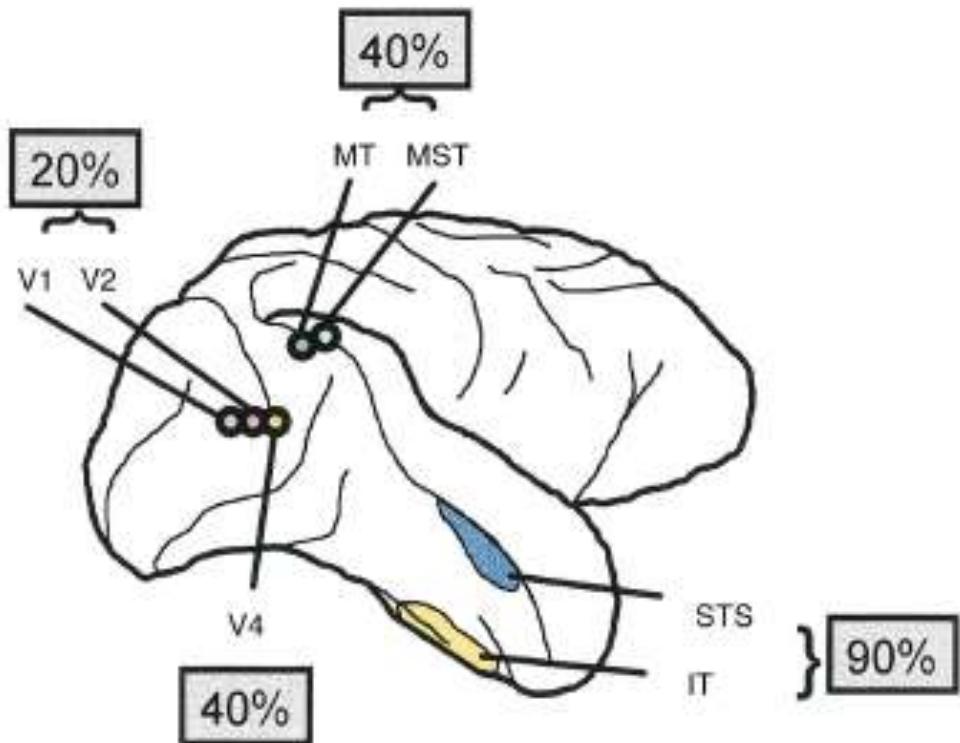
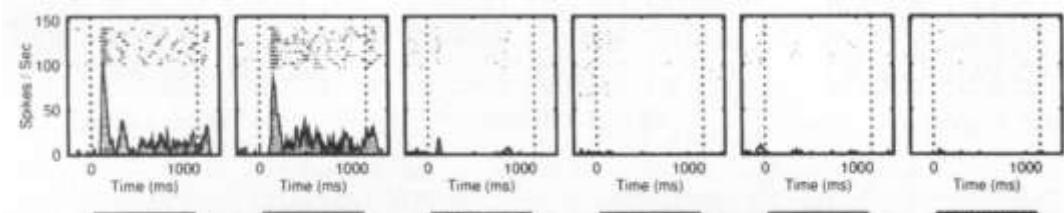
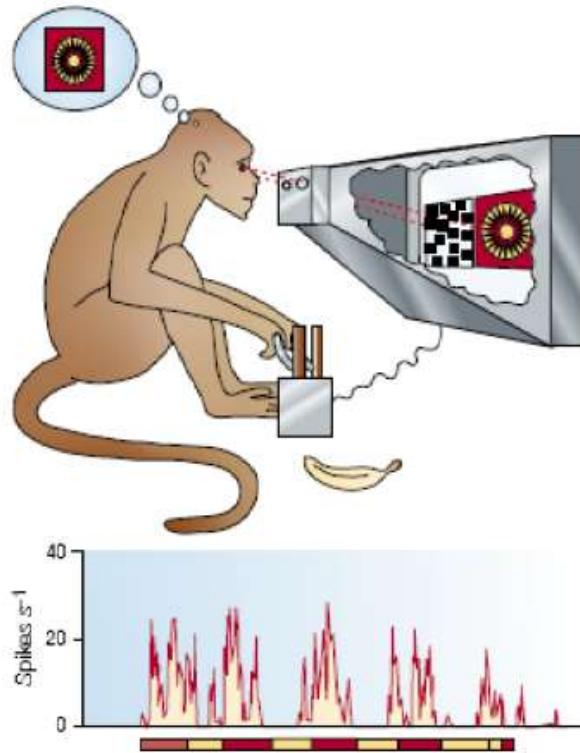
# Areas PPA and FFA

PPA =  
Parahippocampal  
Place Area (*places*)

FFA = Fusiform  
Face Area (*faces*)



# Unit recordings



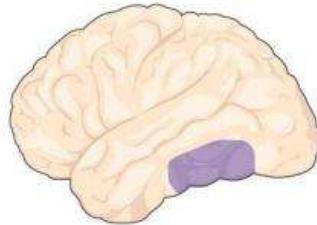
Fusiform gyrus and Infero-Temporal (IT)

*Leopold & Logothetis, 1999*

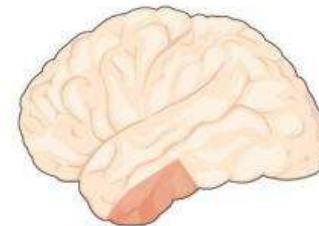
*Sheinberg & Logothetis, 1997*

# Lesions: agnosia

Apperceptive agnosia



Associative agnosia



## Inféro-temporal (IT)

Model

Patient's drawing

Verbal identification of object



"Circle"



"Square"



"Diamond"



"Three"



"Four"

Ability to copy or match visual stimuli

Deficiency of object perception

Clinical interpretation

Cannot see object parts as a unified whole

Unable to construct sensory representations of visual stimuli

Model

Patient's drawing

Verbal identification of object



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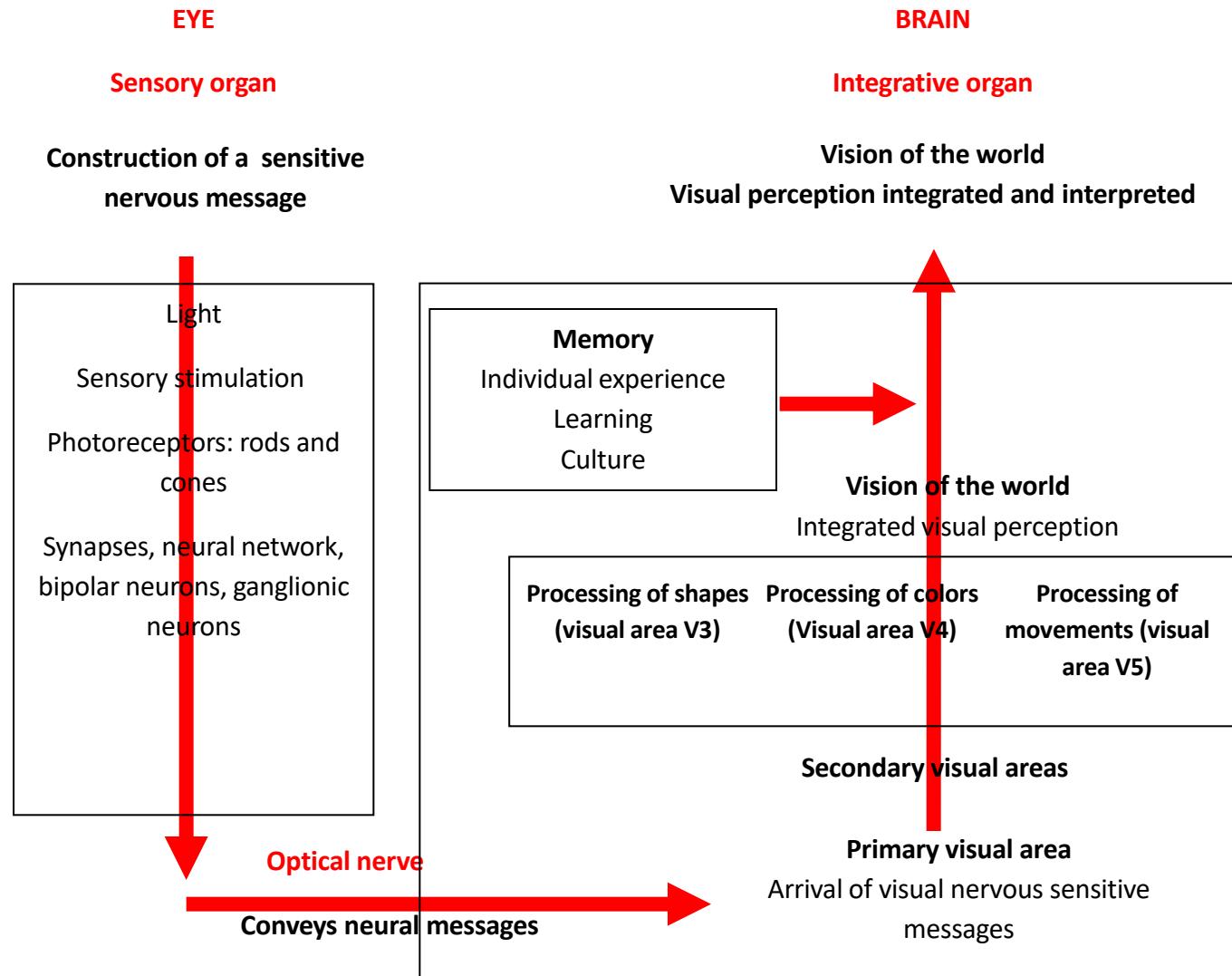


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Cannot interpret, understand, or assign meaning to objects

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 functionnal and anatomical modularity
- Lesions induce targeted deficits

# Problem

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

