ELL 788
Computational Perception & Cognition

July – November 2015

Module 1

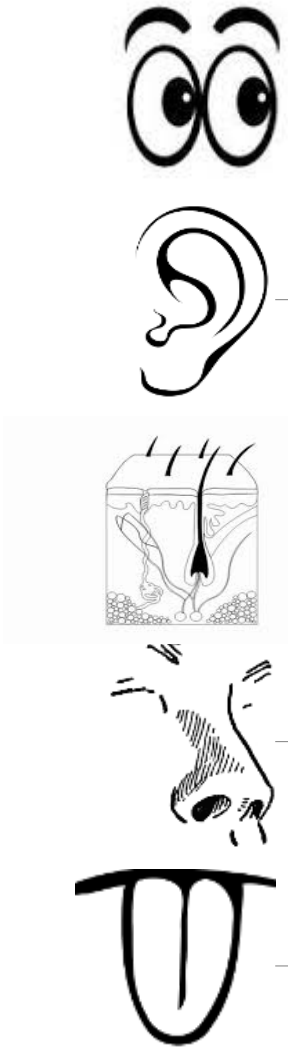
Visual perception
(Part - 1)

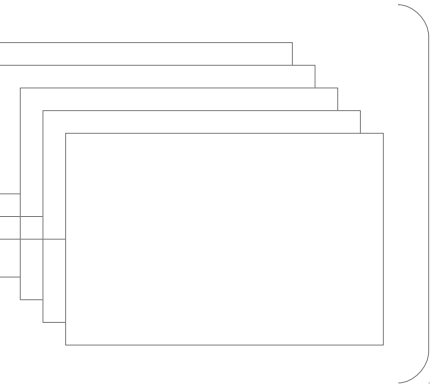
What is 'perception' ?

Perception

- Recognition and interpretation of sensory stimuli based upon our memory.
- It is the way you interpret data around you.
  - The data could come from any sense organ: sight, smell, touch, taste, and hearing.
- Perception is a state of mind – an intended representation of the environment
- Perception is often different from reality

Sensory organs, memory and perception





Sensory Memories

Response to stimulii
(non-linear)

Persistence

Long term

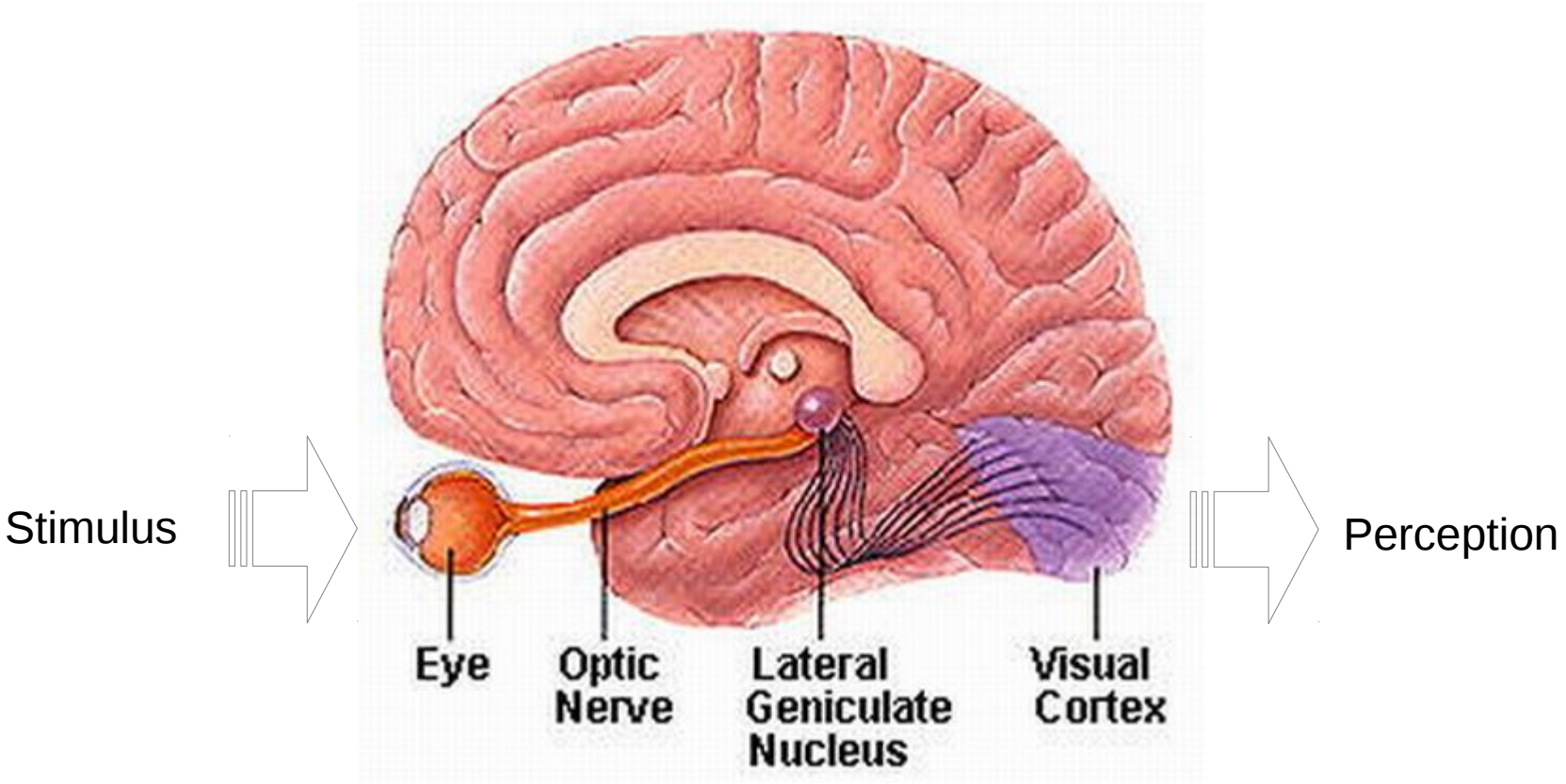
Short term

Memory

Working

Percepts

Human Vision System

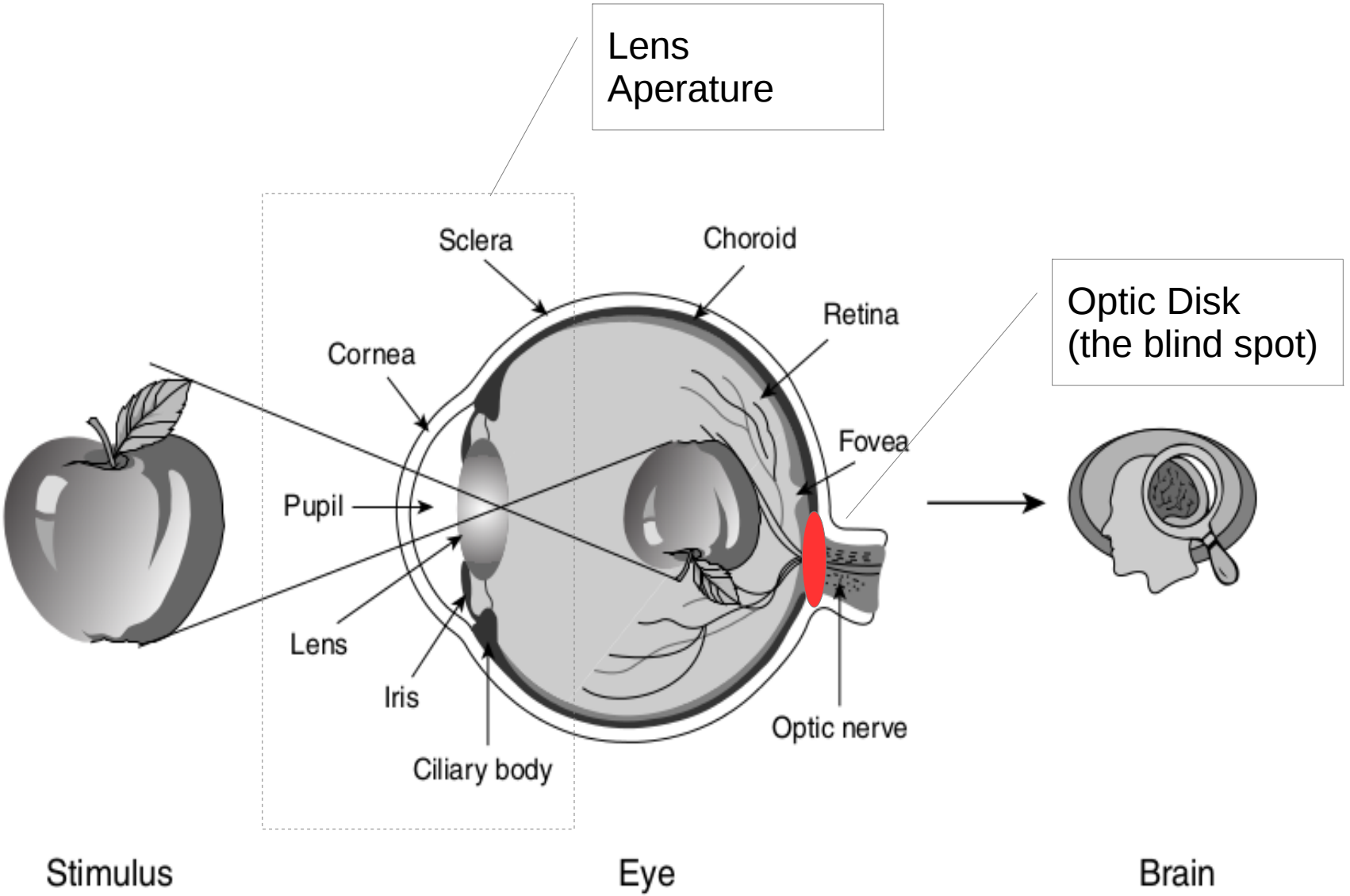


Camera
Image acquisition

CPU
Image Processing

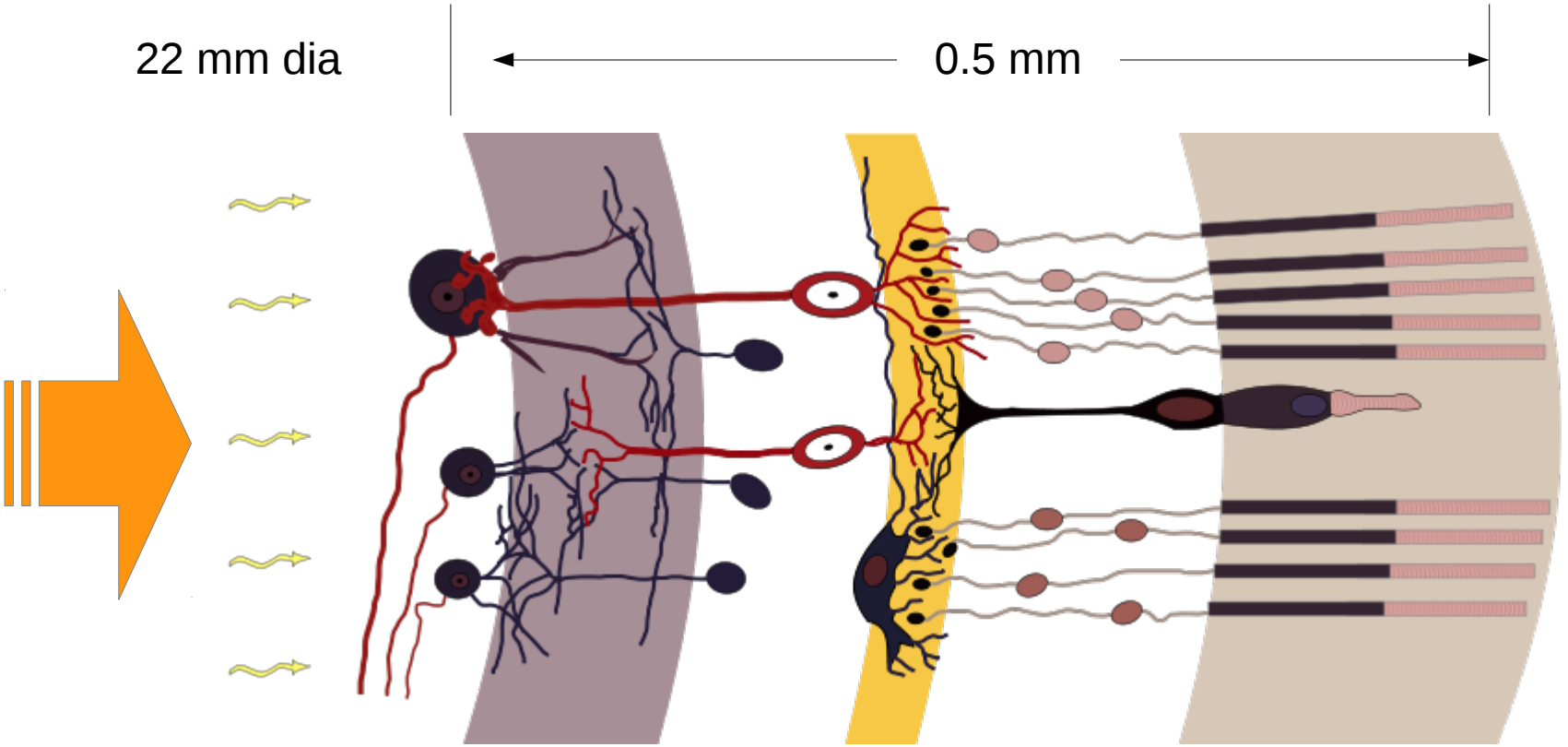
http://www.cs.uu.nl/docs/vakken/ibv/reader/chapter2.pdf

The eye



Source: Friedenberg

The retina

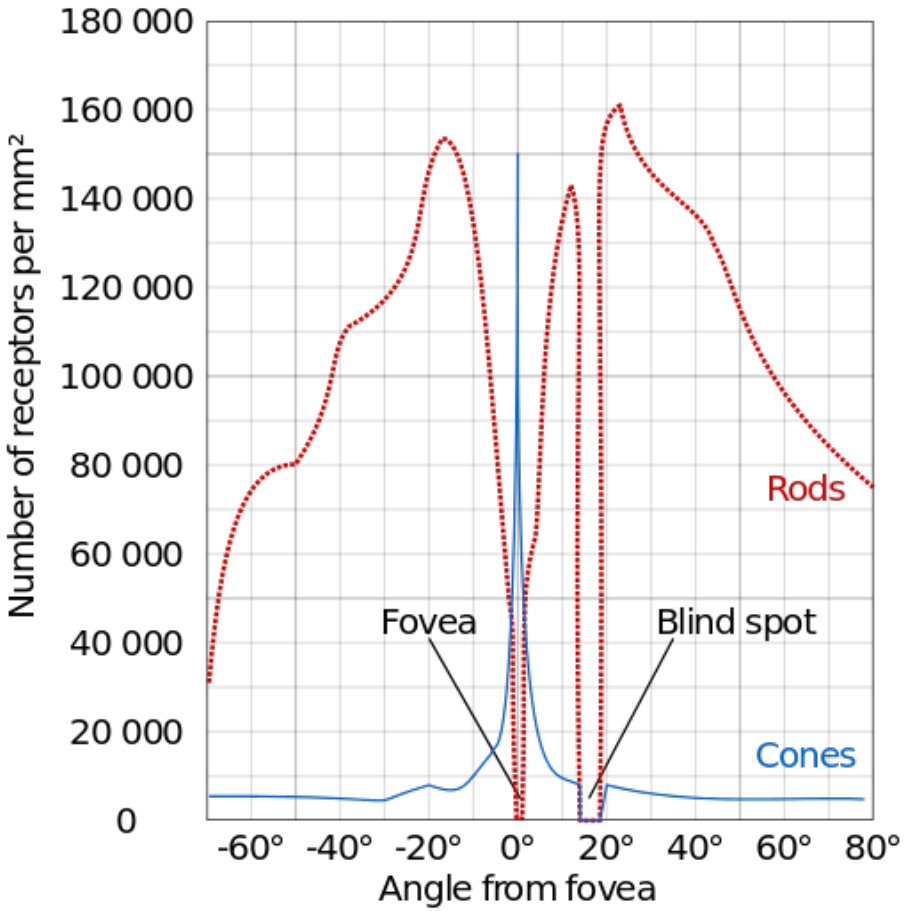


Photoreceptors
Rods (~7 mn) and cones (~100 mn)

Source: "Retina-diagram" by Anka Friedrich via Wikimedia Commons

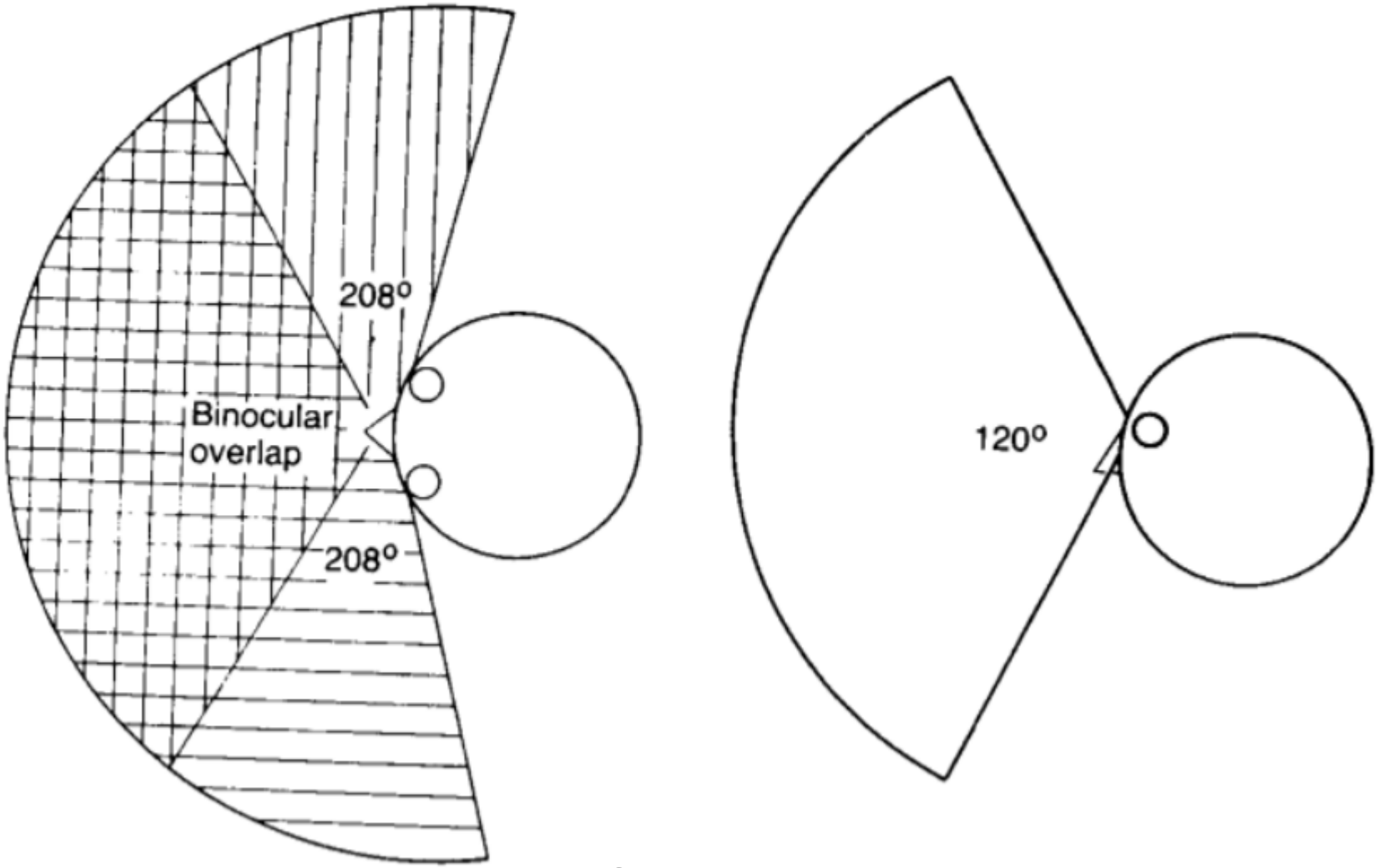
The cones and the rods

- Rods
  - More responsive to light than cones
  - Cannot distinguish colors
  - Night vision
- Cones
  - Three types
  - Can distinguish colors
  - Day vision



"Human photoreceptor distribution" by Cmglee via Wikimedia Commons

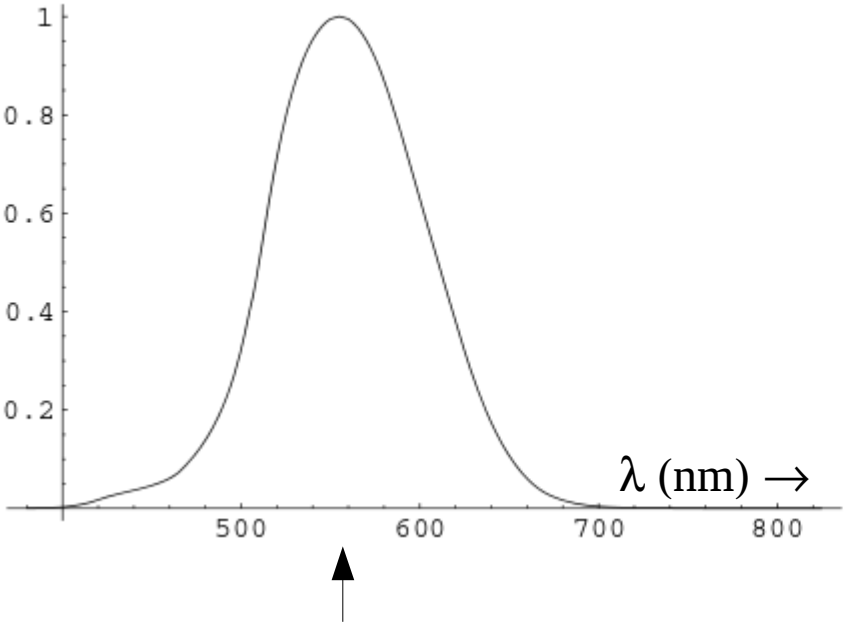
Horizontal and vertical fields of view



Source:
Wade and Swanston. Visual Perception: An introduction.

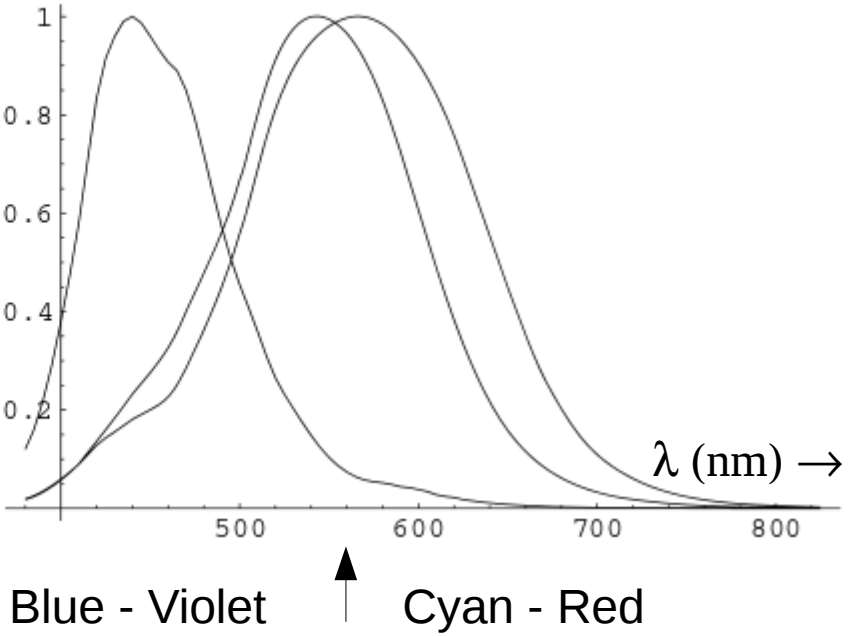
Color sensitivity

Photopic luminous efficiency function



Green (550 nm)

Relative sensitivity of the three types of cones



Blue - Violet Cyan - Red

Green (550 nm)

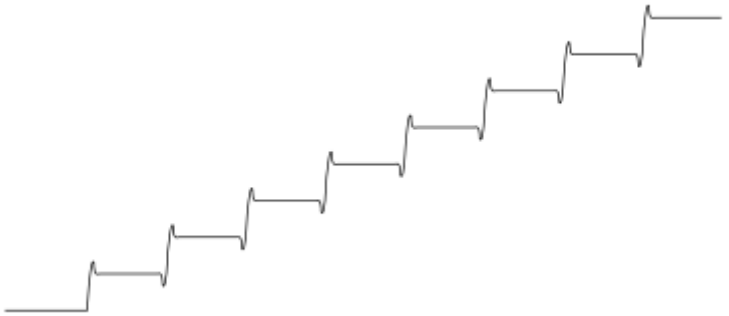
Take-away

- Umbral vision is more sensitive to colors
- Better color resolution at higher illumination
- Respose to colors is non-linear
  - Sensitivity to green is highest
- Luminance of a pixel is not the same as its perceived brightness

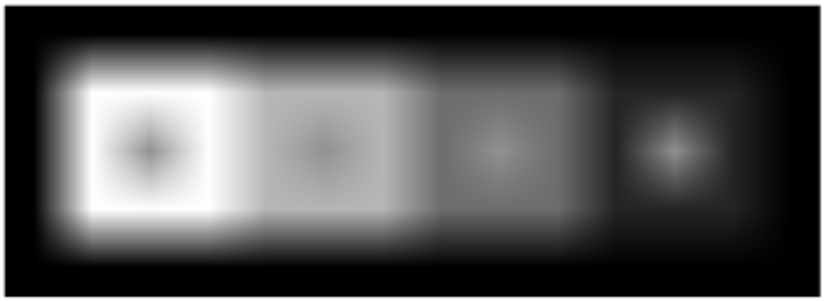
Exercise: How does it influence Color TV / Cellphone Screen Design?

Psychophysical effects

Weber's law: Perceivable difference $\Delta L \mu L$

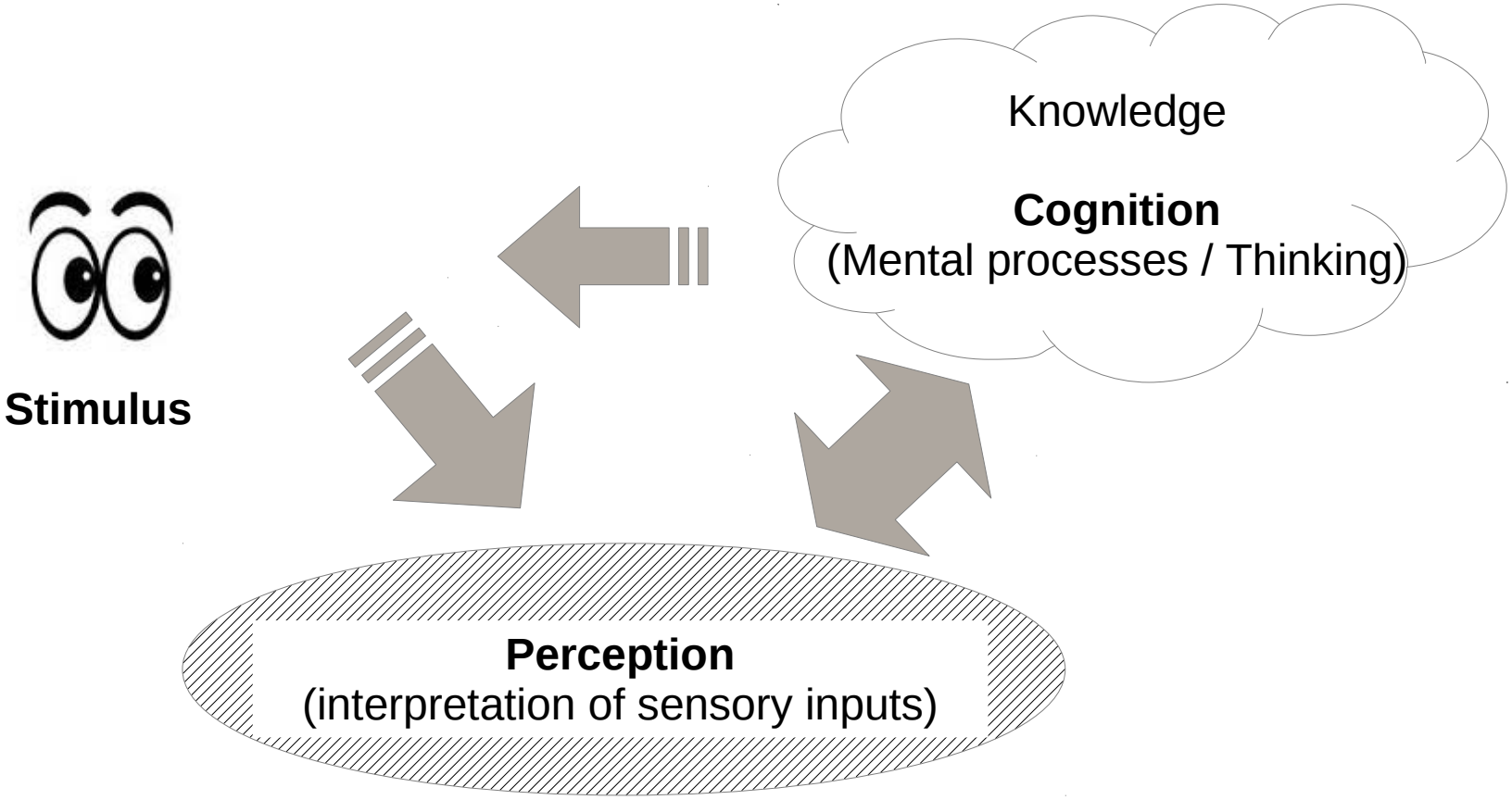


Matchband effect
(Brain adds to contrast)



Simultaneous contrast effect
(Perceived brightness depends on the surroundings)

Stimulus, perception and cognition



Tacca. **Commonalities between Perception and Cognition**
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3227022/

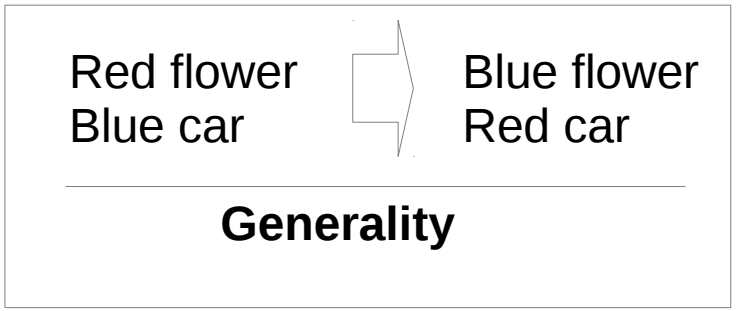
A simple example

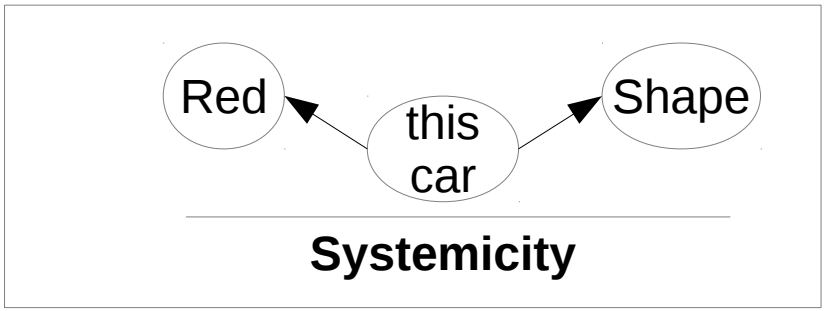
The 'Om' parvat, Uttaranchal

Stimulus

- Exogenous
  - Actually perceived by the sense organs
  - *What is there in the real environment*
- Endogenous
  - Generated by mental process (imagination)
  - *Talking to your friend over telephone generates a mental picture*

Representations: Perceptual and cognitive

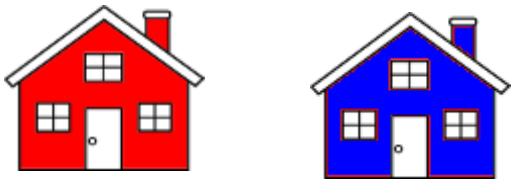




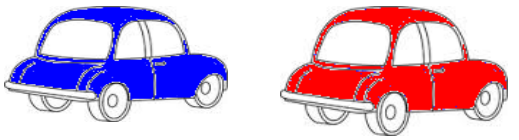
Cognitive *Symbolic (conceptual) representation*

Perceptual *Feature and location based representation*

Feature based
(Primitive features: Color, texture, shape, size ...)



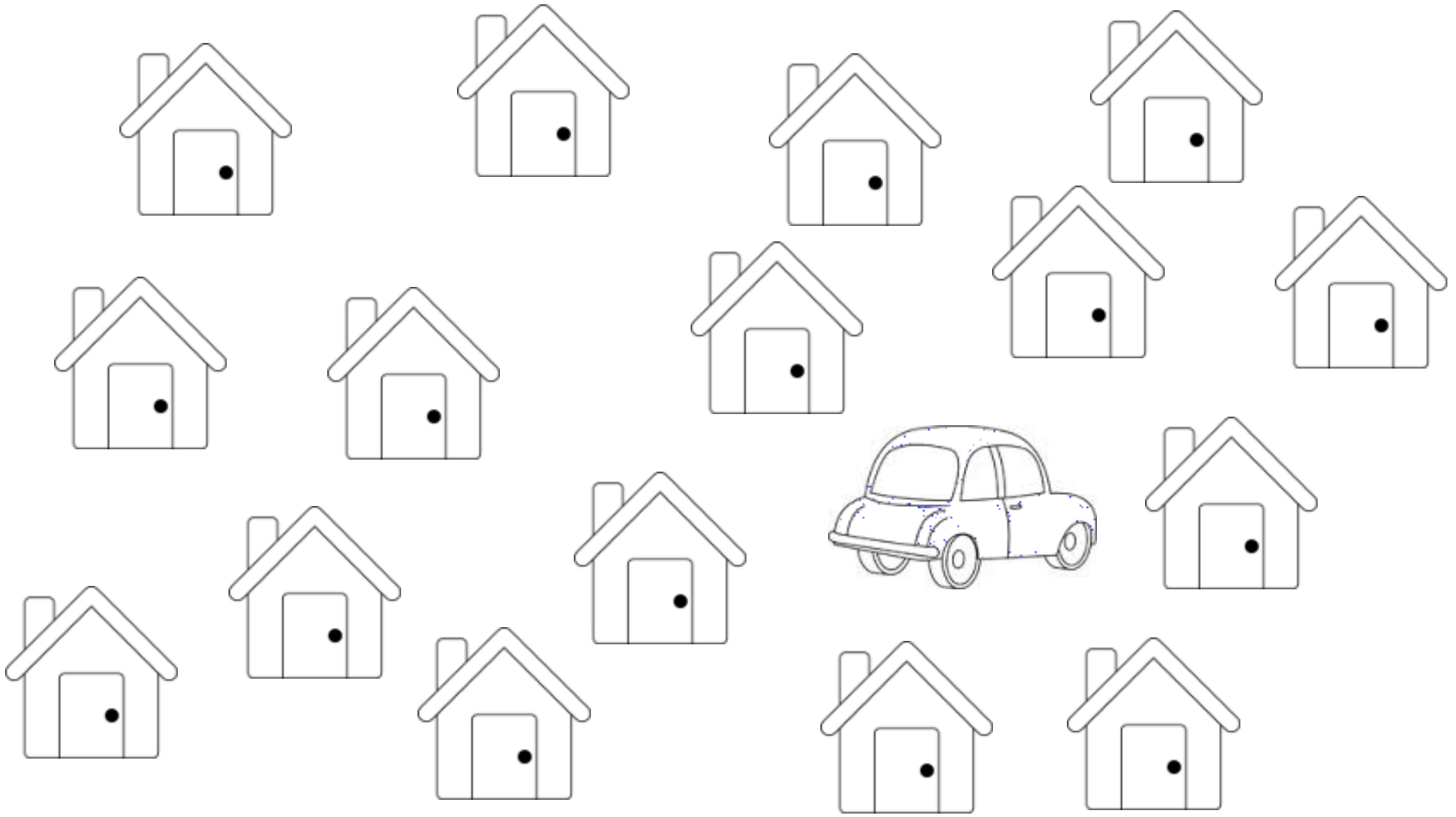
Location



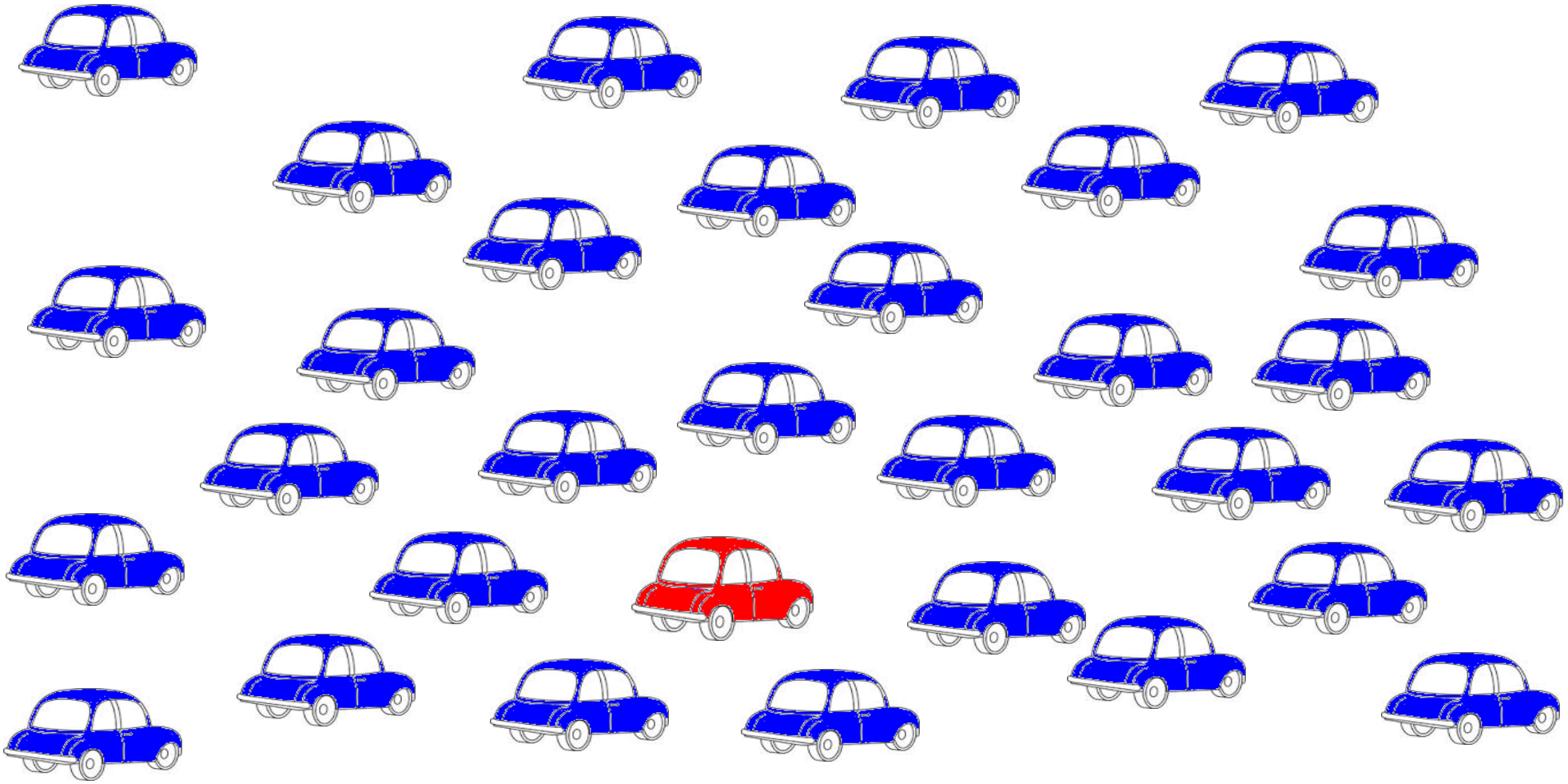
Feature integration

Intermediate symbolic representation ? Circles, straight edges, etc. ?

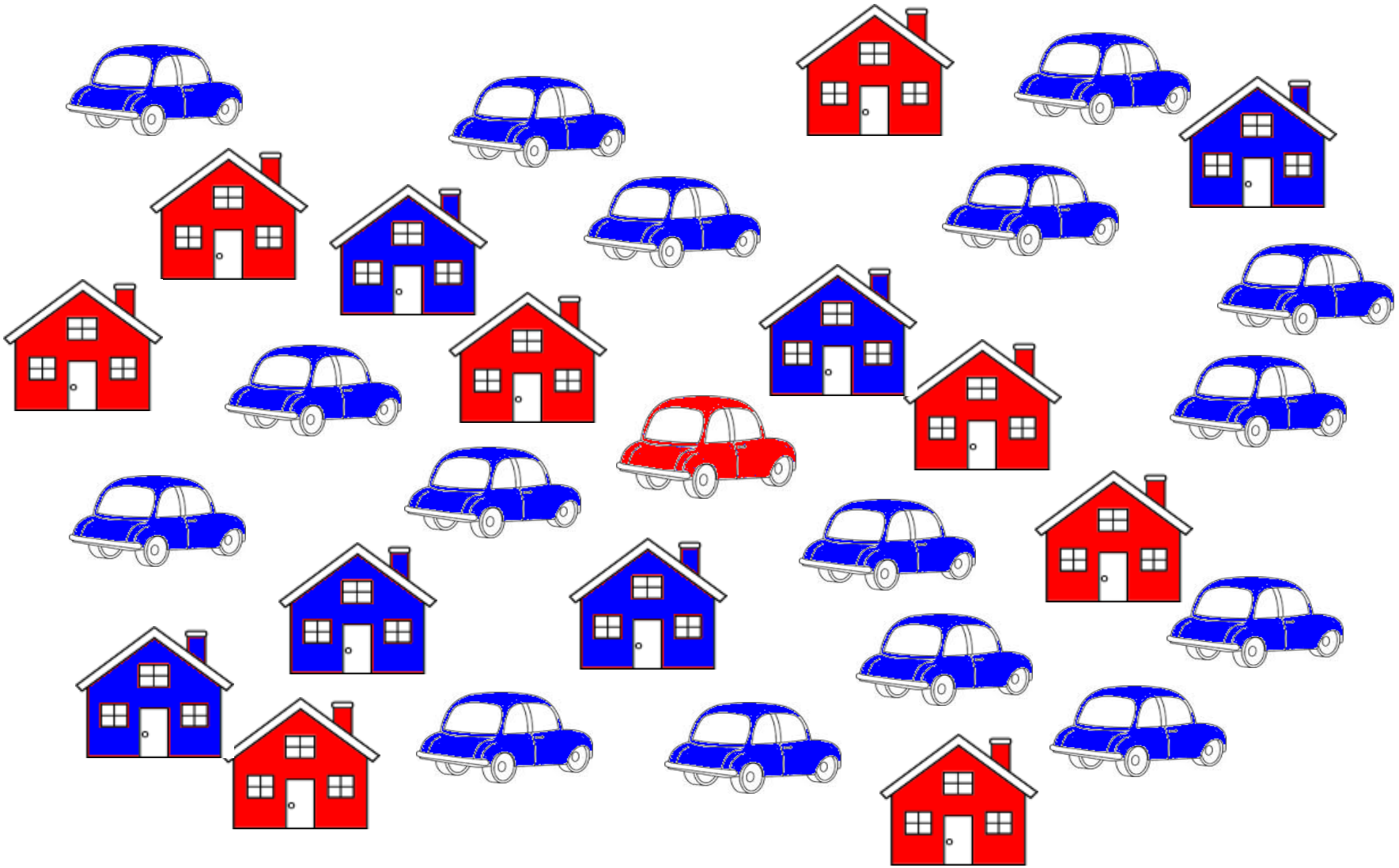
Shape as a primitive feature



Color as a primitive feature

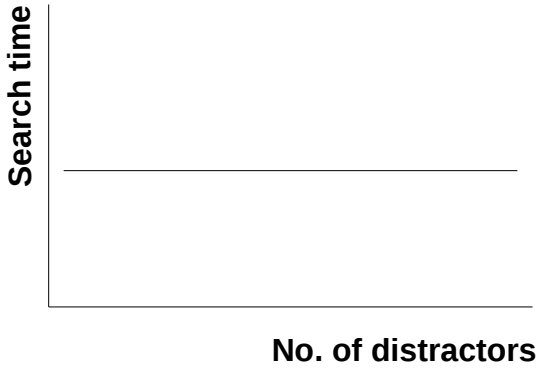


Feature integration

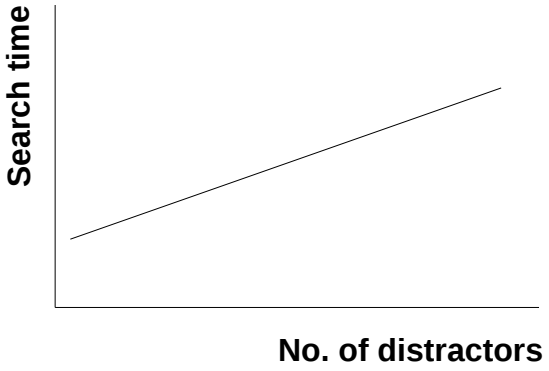


Where is the red car ?

Parrallel search vs. Serial search



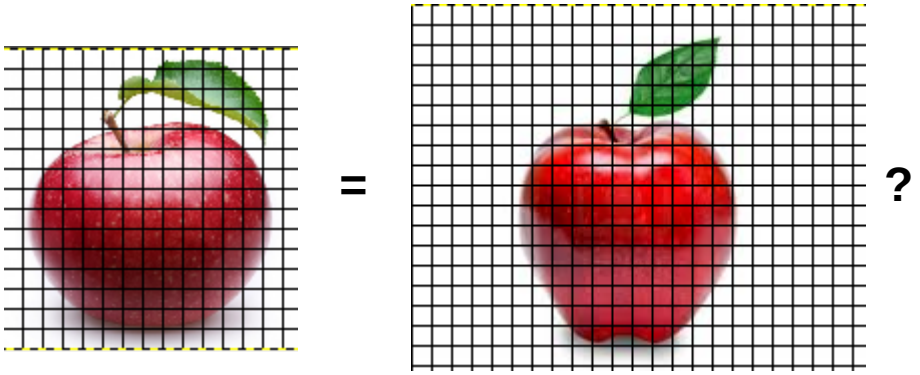
Single feature
(Parallel Search)



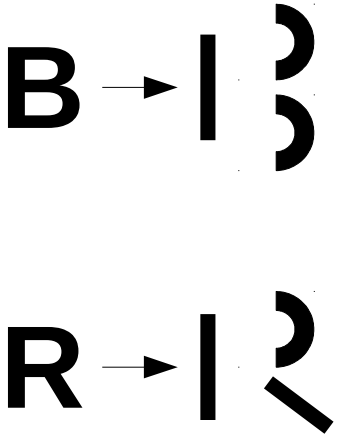
Feature integration
(Serial Search)

Object recognition

Template matching

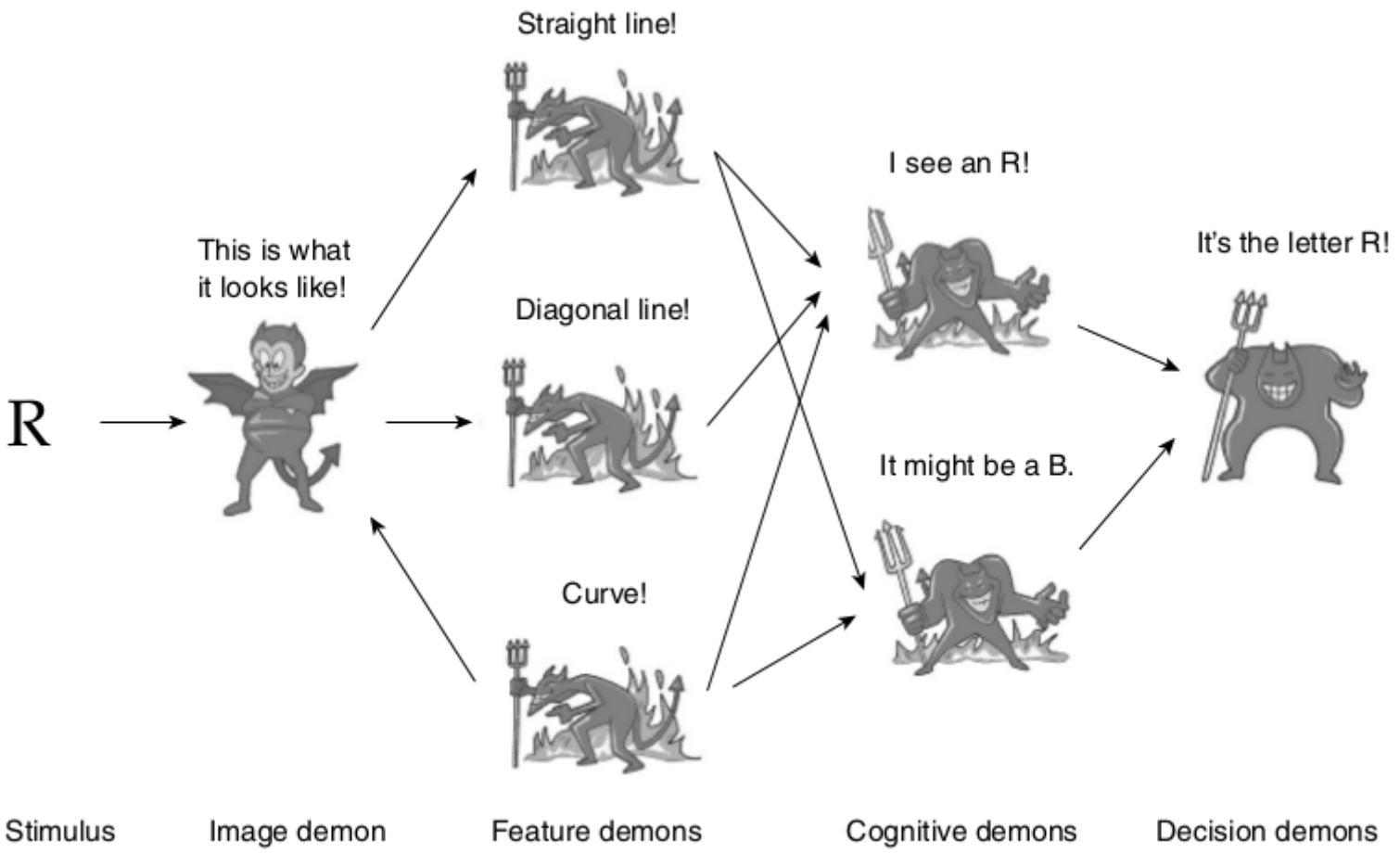


Feature matching and integration



How many templates do we need?

The pandemonium model



Source: Friedenberg

Comments on Pandemonium model

- Aligned with neuro-physiological model
  - Neurons acts as feature detectors
- Explains common mistakes
  - 'B' being taken for '8'
- What is a 'feature'?
  - How to decide which feature to use?
- Bottom-up, data driven
  - Fails to utilize the context

References

- E-book: Fiedenberg. Cognitive Science [Chaps 4-5]
- Introduction to Image Processing [Chap 2: The human visual system] http://www.cs.uu.nl/docs/vakken/ibv/reader/chapter2.pdf

Interesting Reading

- Marr – Nishihara's paper on computational approach to vision http://www.cse.psu.edu/~rcollins/CSE597E/papers/objrecMarrNishihara.pdf
- Tacca. Commonalities between Perception and Cognition http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3227022/
- Ray Kurzweil. The Age of the Spiritual Machine (book)