CSE 40171: Artificial Intelligence

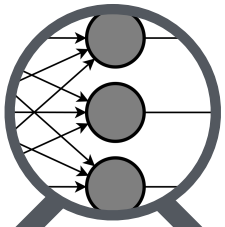
The Brain: Perception

Course Roadmap

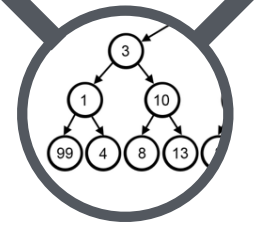
Introduction
(week 1)

Bio. Intelligence
(week 2)

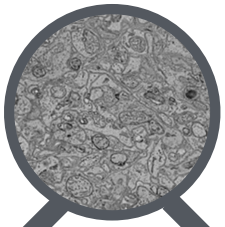
Neural Networks
(week 3)



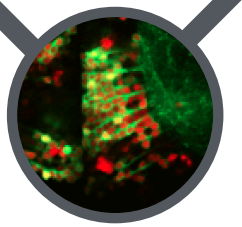
Search Problems
(weeks 4 - 9)



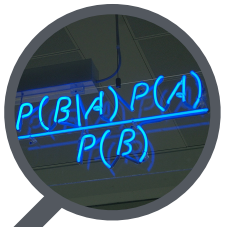
Brain Structure
(weeks 12 - 13)



Brain Function
(weeks 14 - 15)



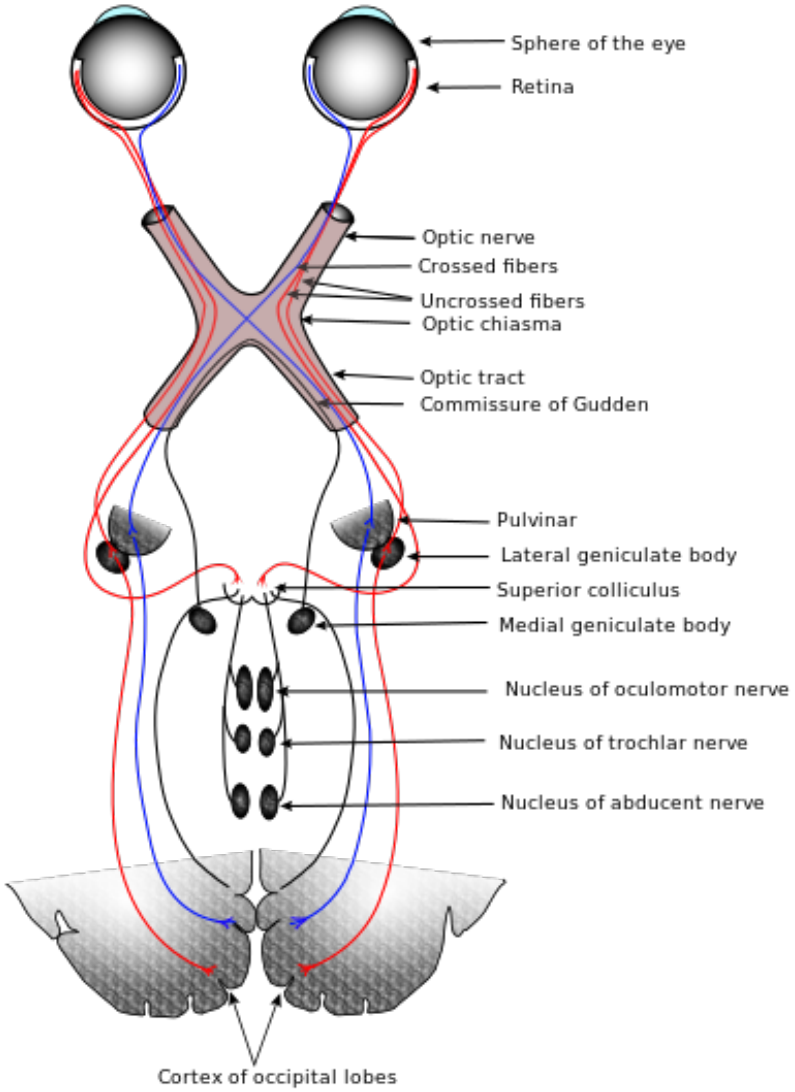
Decisions
(week 16)



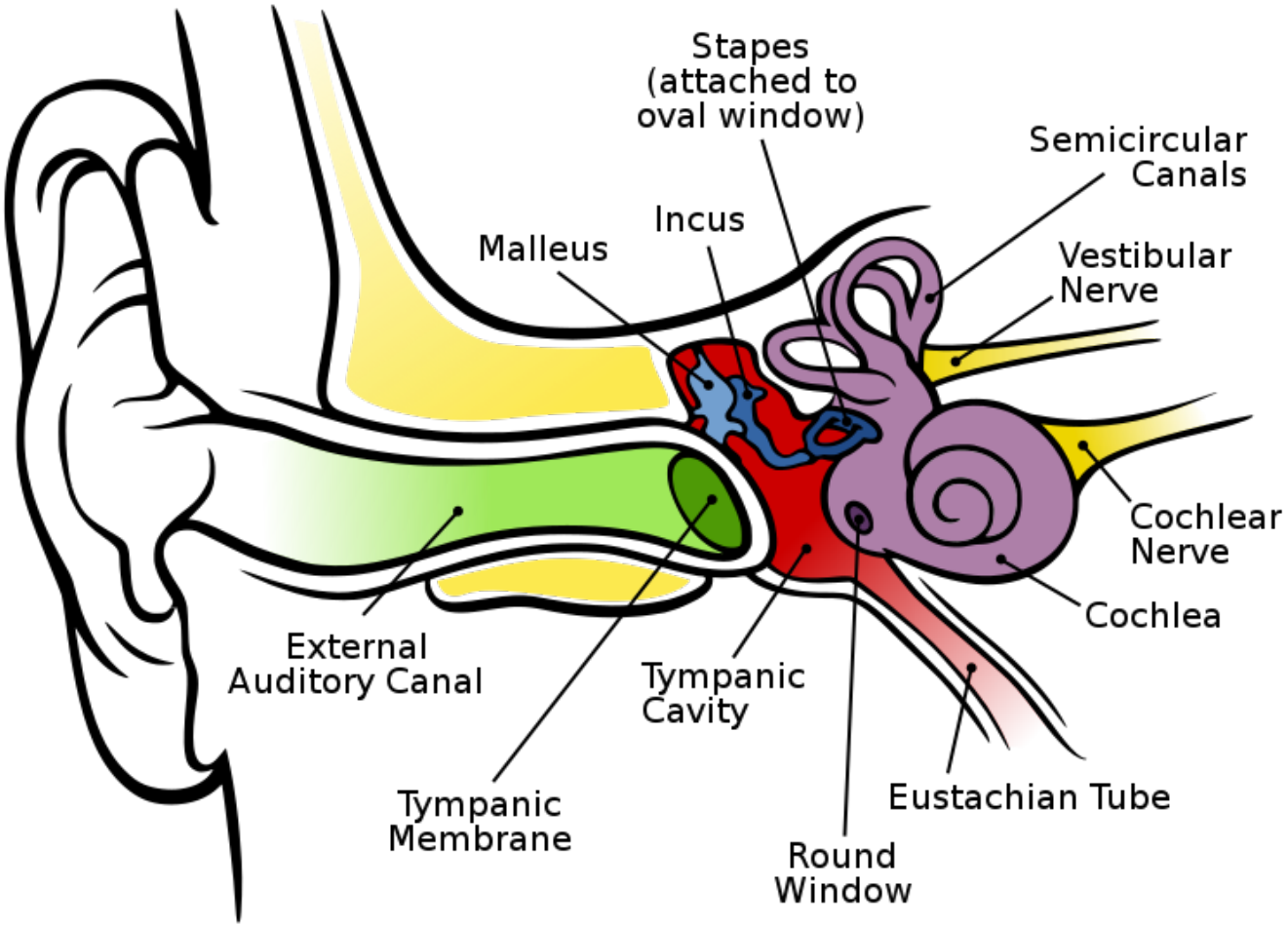
Perception: the organization, identification, and interpretation of sensory information in order to represent and understand the presented information, or the environment.

Schacter, Daniel (2011). Psychology. Worth Publishers.

The Visual System

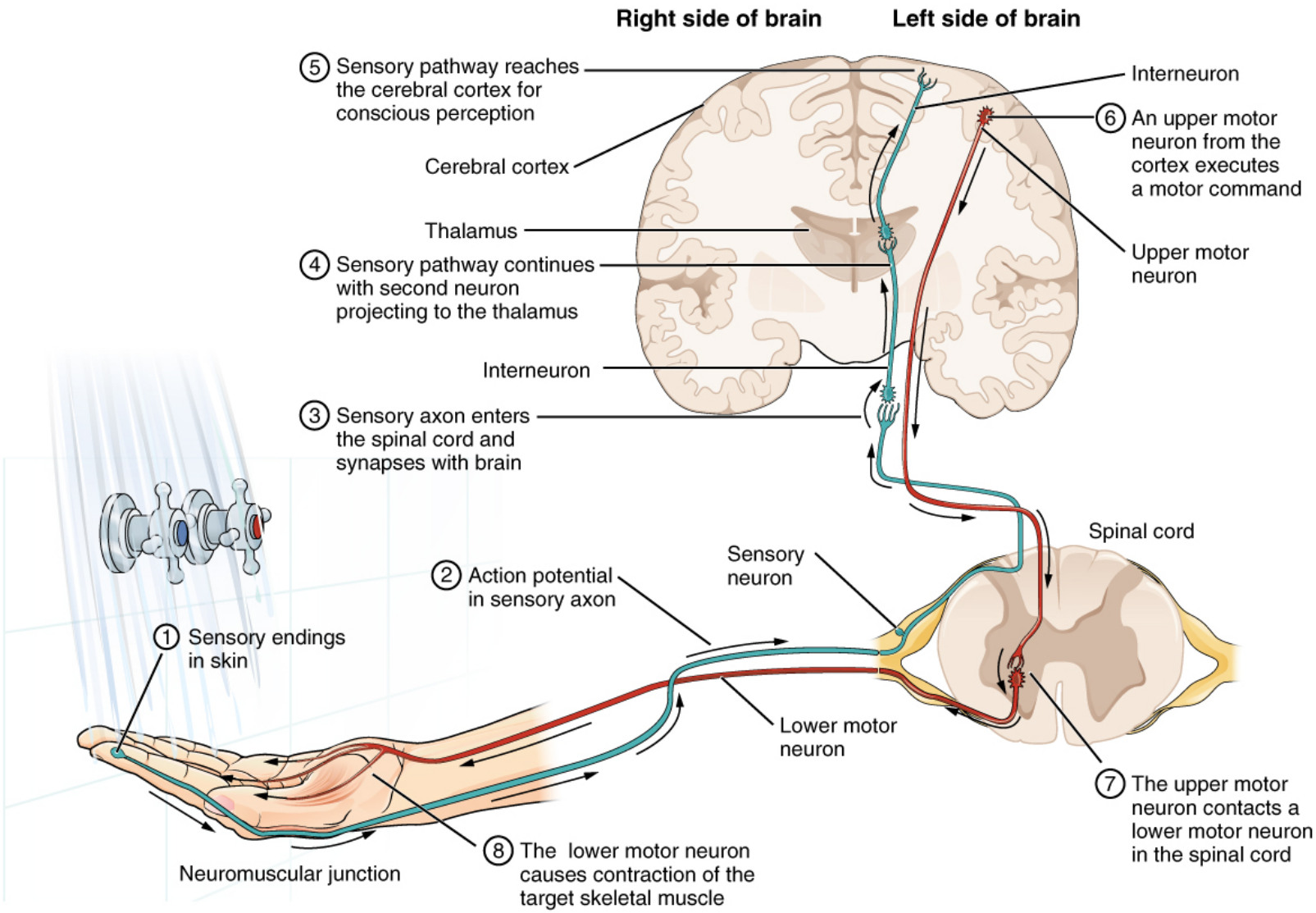


The Auditory System



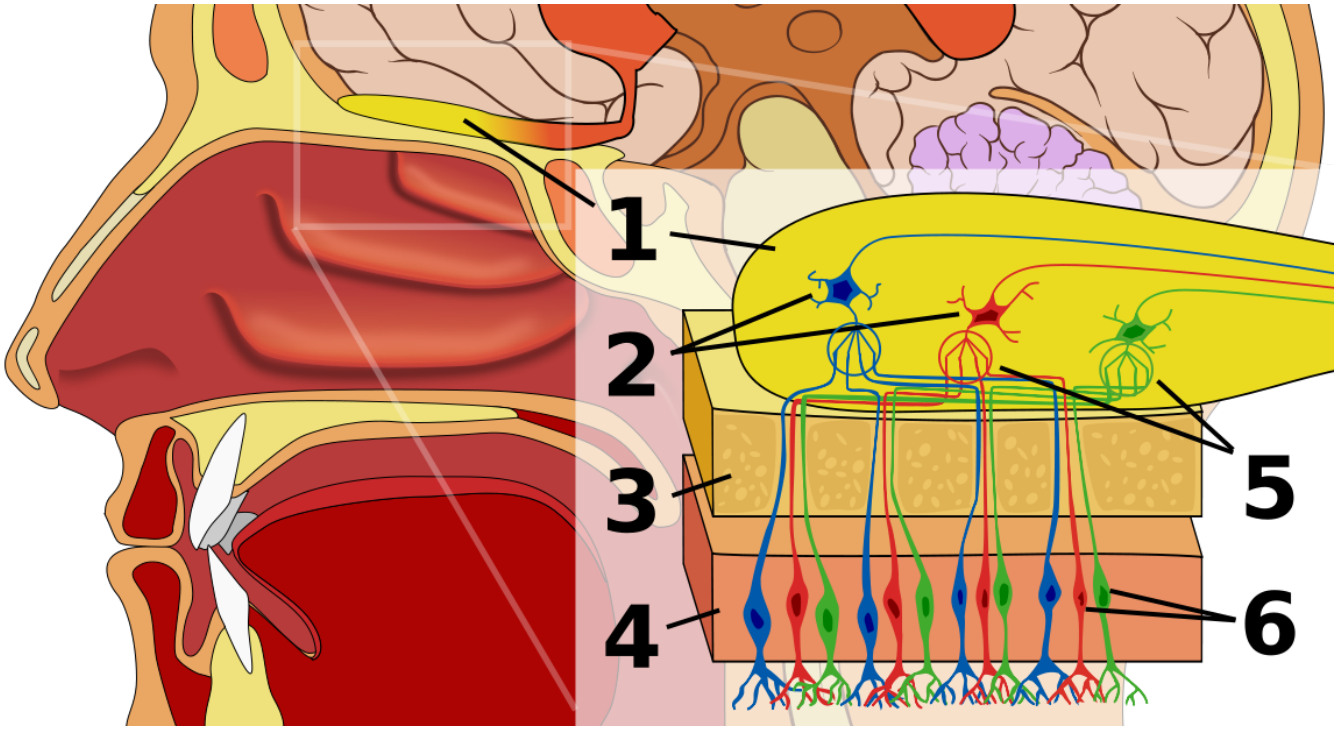
Anatomy of the human ear

The Somatosensory System



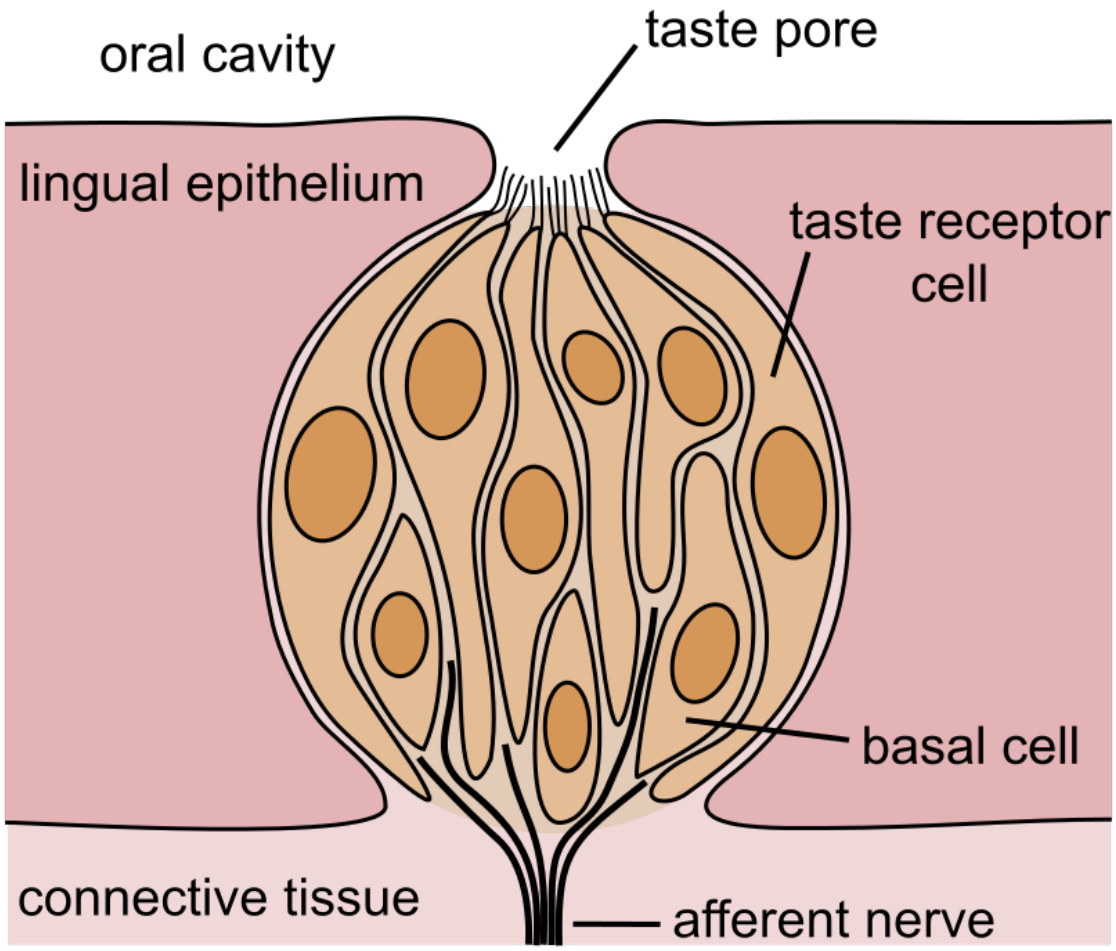
Activation and response in the sensory nervous system

The Olfactory System

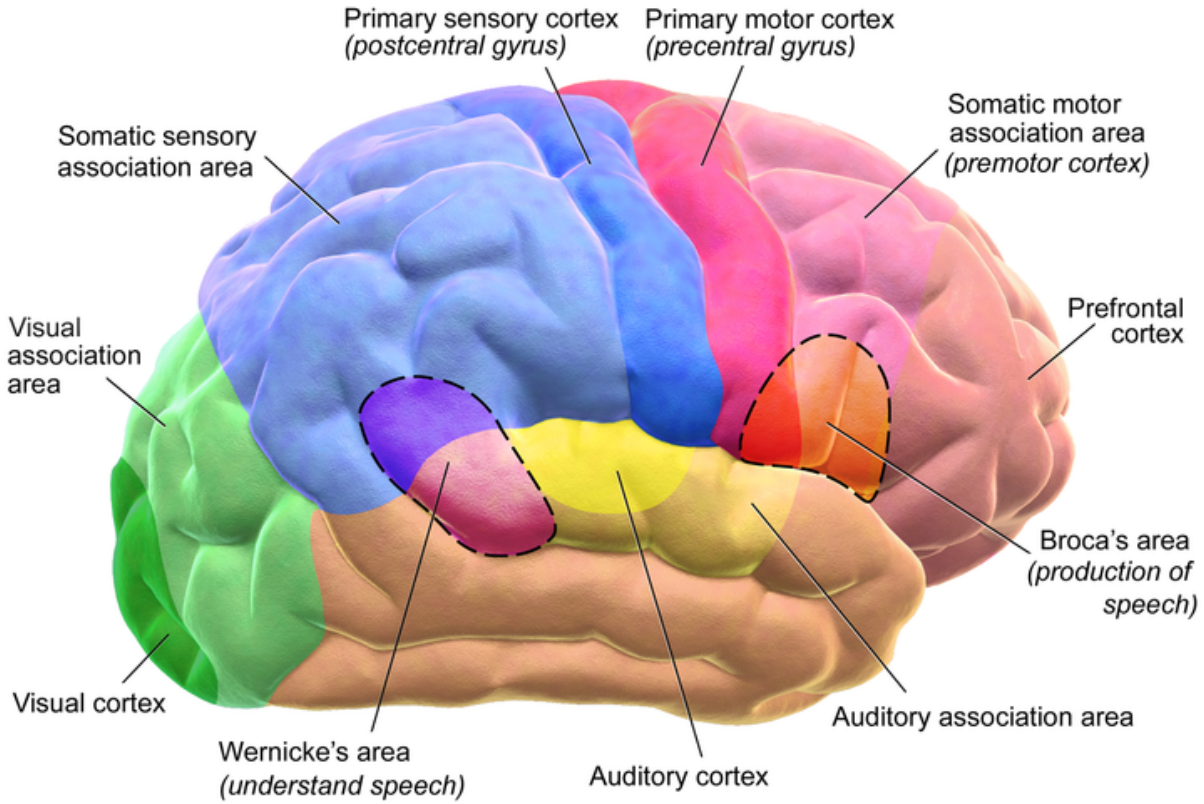


Olfactory system ⓒBY-SA 2.5 Chabacano

The Gustatory System



Taste bud

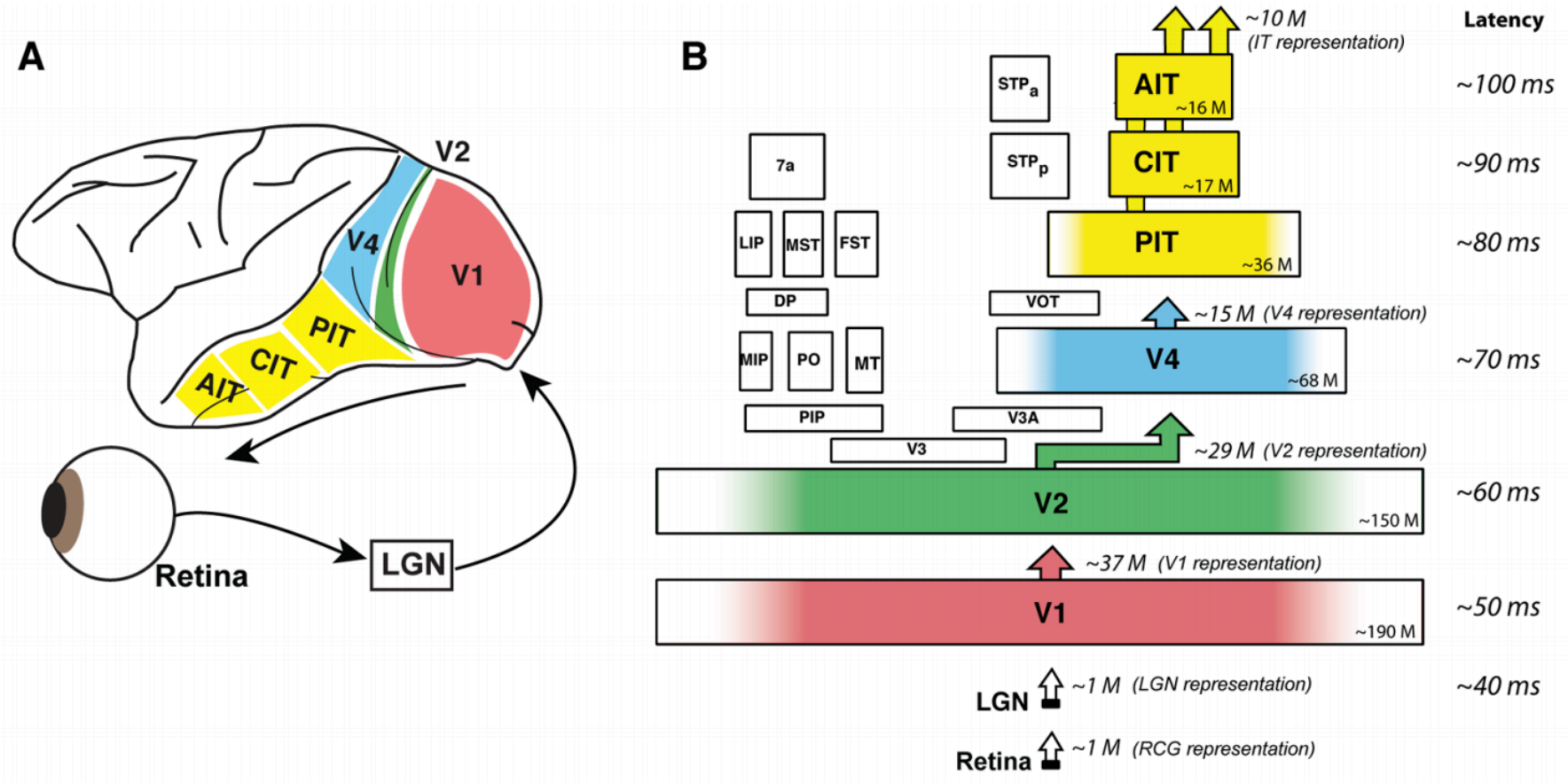


0102 Brain Motor&Sensory (flipped)

How fast is the brain processing sensory information?

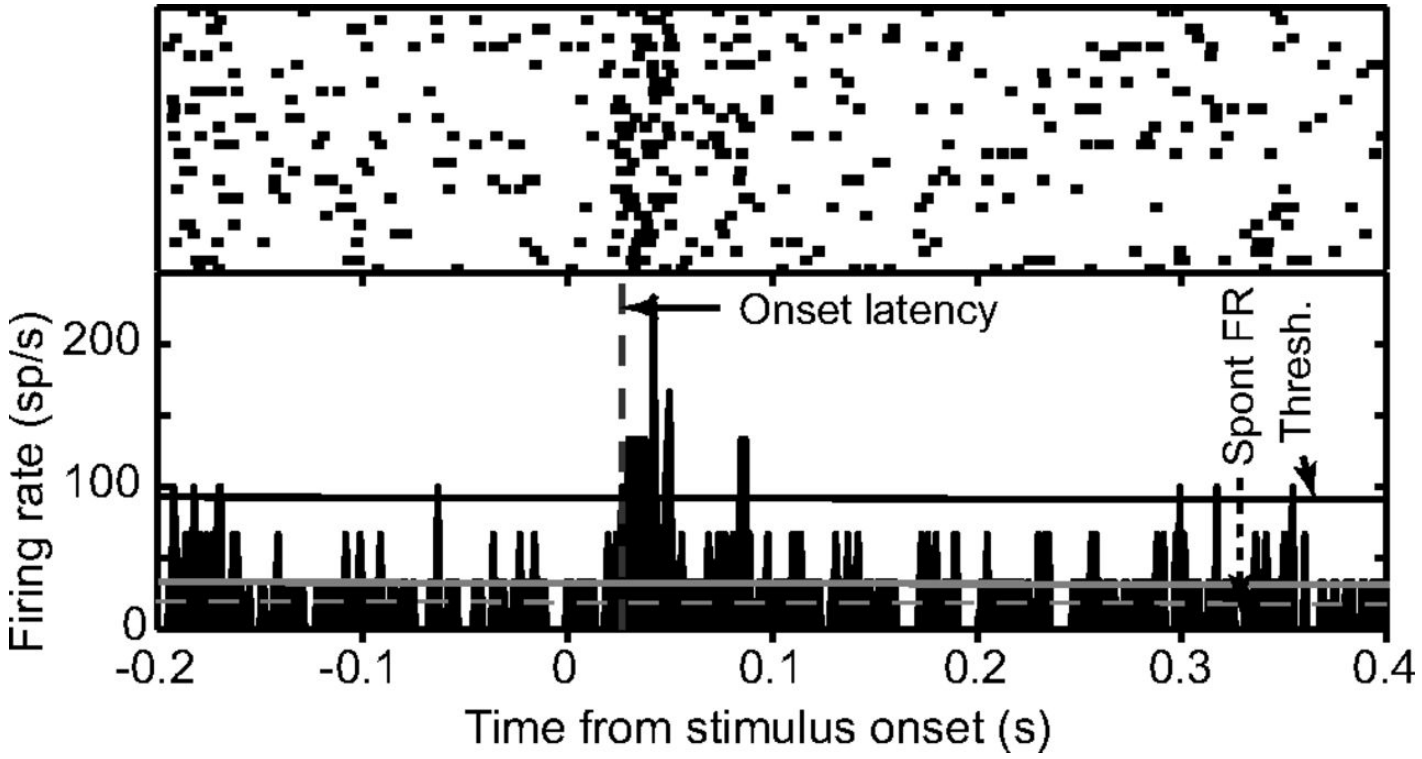
Visual Object Recognition

- With Behavior:
  - ~250 ms in monkeys (Fabre-Thorpe et al. Neuroreport 1998)
  - ~350 ms in humans (Rousselet et al. Nature Neuroscience 2002)
- Direct Neural Surface Recording:
  - ~150 ms (Thorpe et al. Nature1996)



DiCarlo et al. Neuron 2012

Latency of Auditory Cortex in Monkeys



Camalier et al. PNAS 2012

Odor discrimination

- Behavioral studies in vertebrates
  - ~500 ms or less (Junek et al. Neuron 2010)

Is learning involved?

What happens when an animal is raised in the dark?

Visual Object Recognition

Red Delicious ⓒBY-SA 2.0 tanya4keba

Class A

Orange Whole Split ⓒ BY-SA 3.0 Evan-Amos

Class B

Categorical vs. Perceptual Learning

Category Learning: the process of learning internal rules and decision functions that map incoming stimuli onto category labels

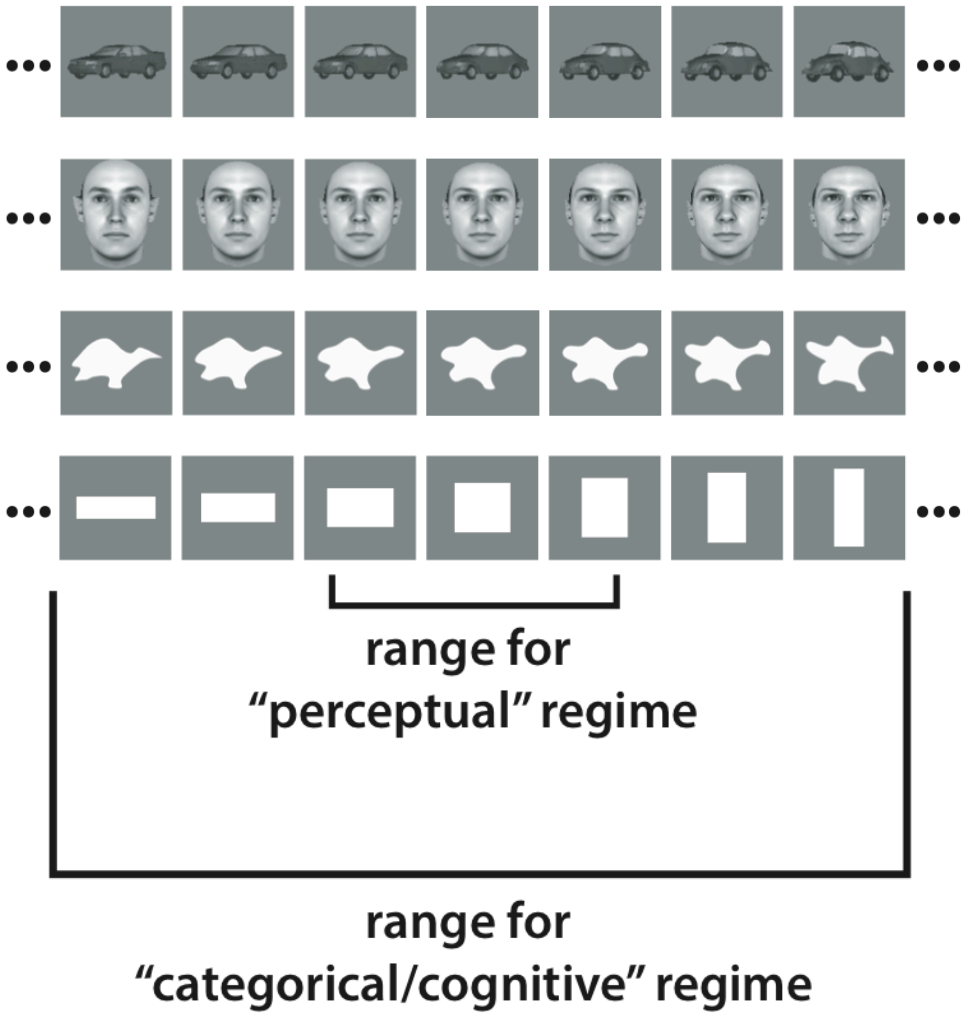
- Likely occurring too rapidly to entail any significant remodeling of underlying perceptual representations
- Underlying perceptual machinery already possesses adequate signal-to-noise ratios to represent stimulus distinctions

Categorical vs. Perceptual Learning

Perceptual Learning: the setting where underlying perceptual representations are not *a priori* adequate to solve the task at hand.

- Characterized by longer training times, sometimes with intervening sleep being required to achieve learning at high levels

Categorical vs. Perceptual Learning: Experiments



How do we measure perceptual thresholds?

Visual Psychophysics

Probe psychological and perceptual thresholds through controlled manipulation of stimuli.

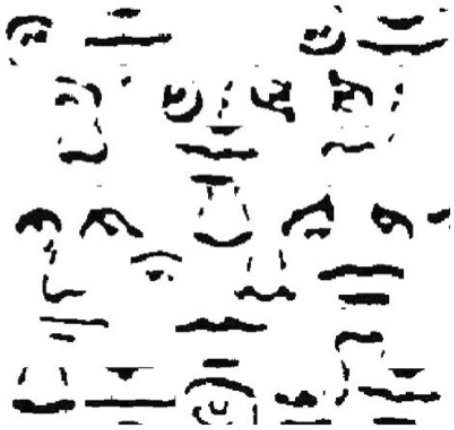
Careful management of stimulus construction, ordering and presentation allows for precise determination of perceptual thresholds.

Canonical Early Example*: minimum threshold for stimulation of an individual photoreceptor.

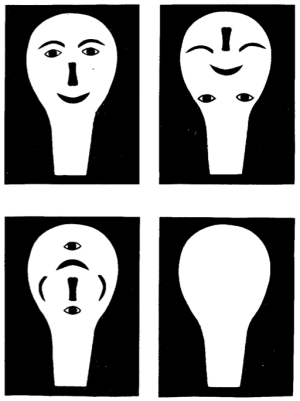
S. Hecht, S. Shlaer, M. Pirenne, “Energy, quanta and vision,” J. Gen. Physiol., 25 (1942), pp. 819–840.

Face Detection

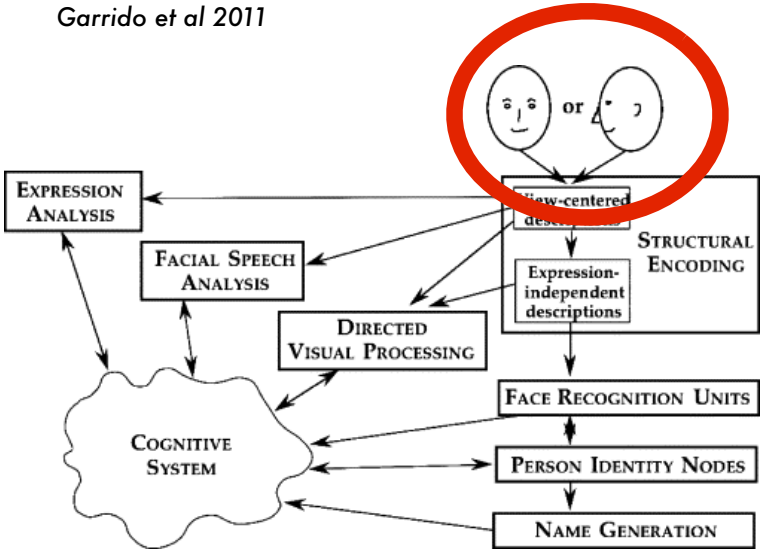
Human



Garrido et al 2011

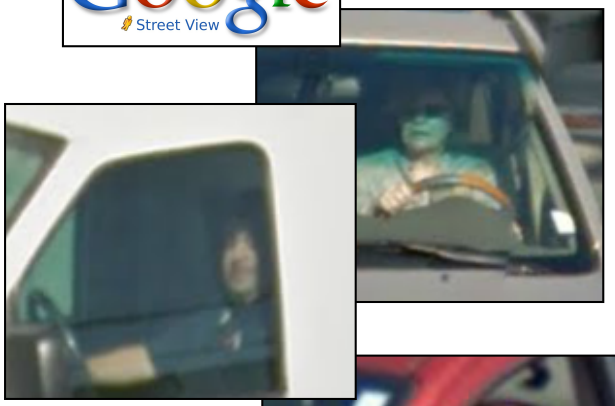


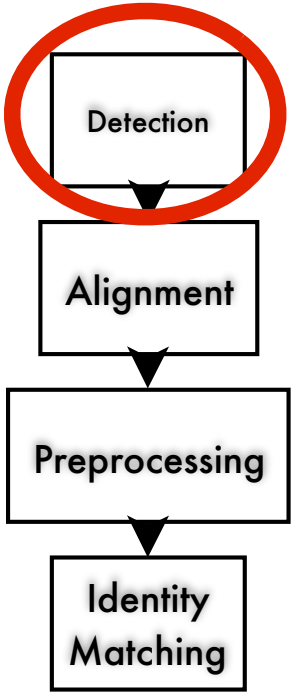
Goren et al 1975



Bruce & Young 1986

Computers

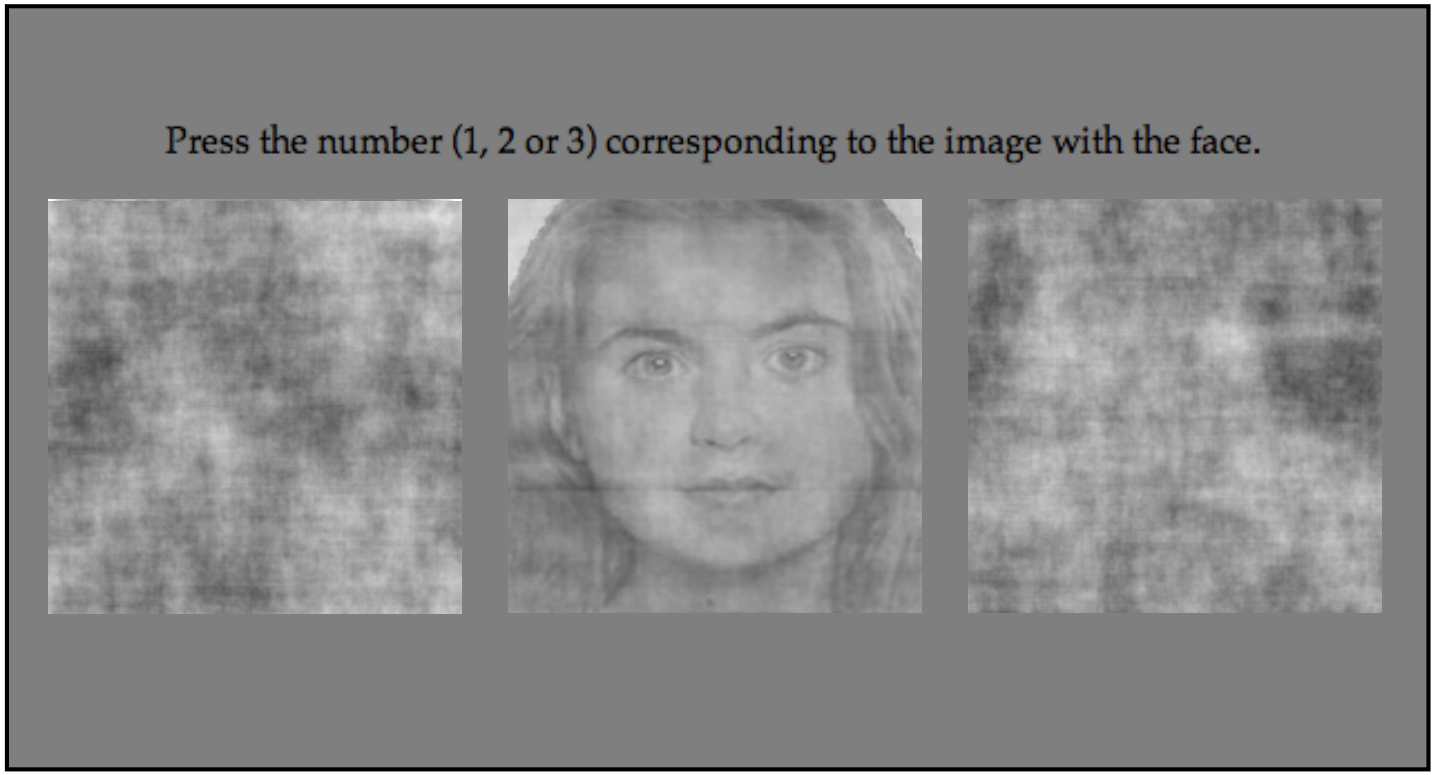




Slide Credit: S. Anthony

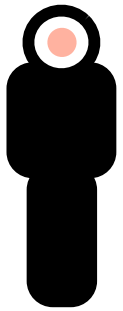
Behavioral Task

3 Alternative Forced Choice



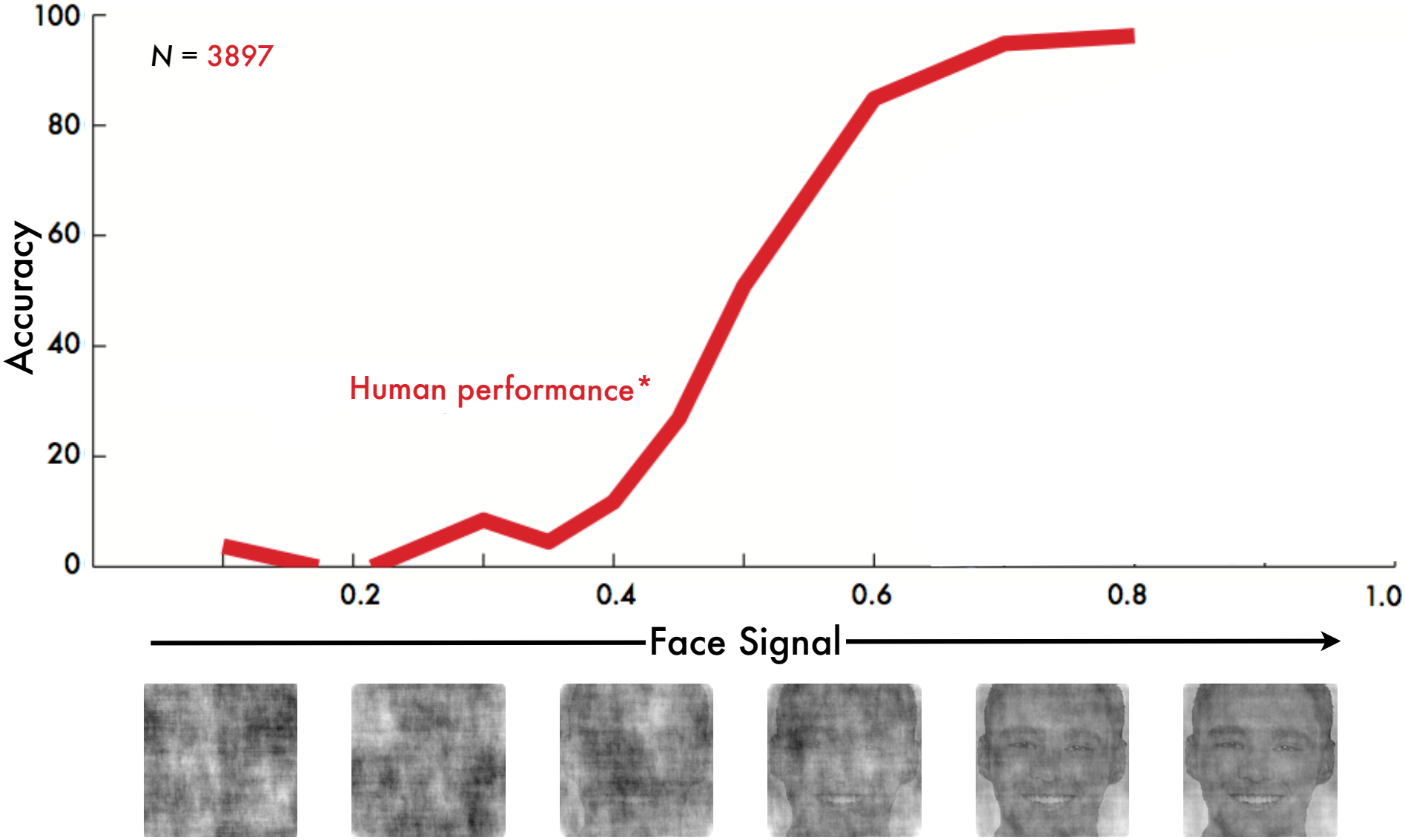
TESTMYBRAIN

Scheirer et al. T-PAMI 2014



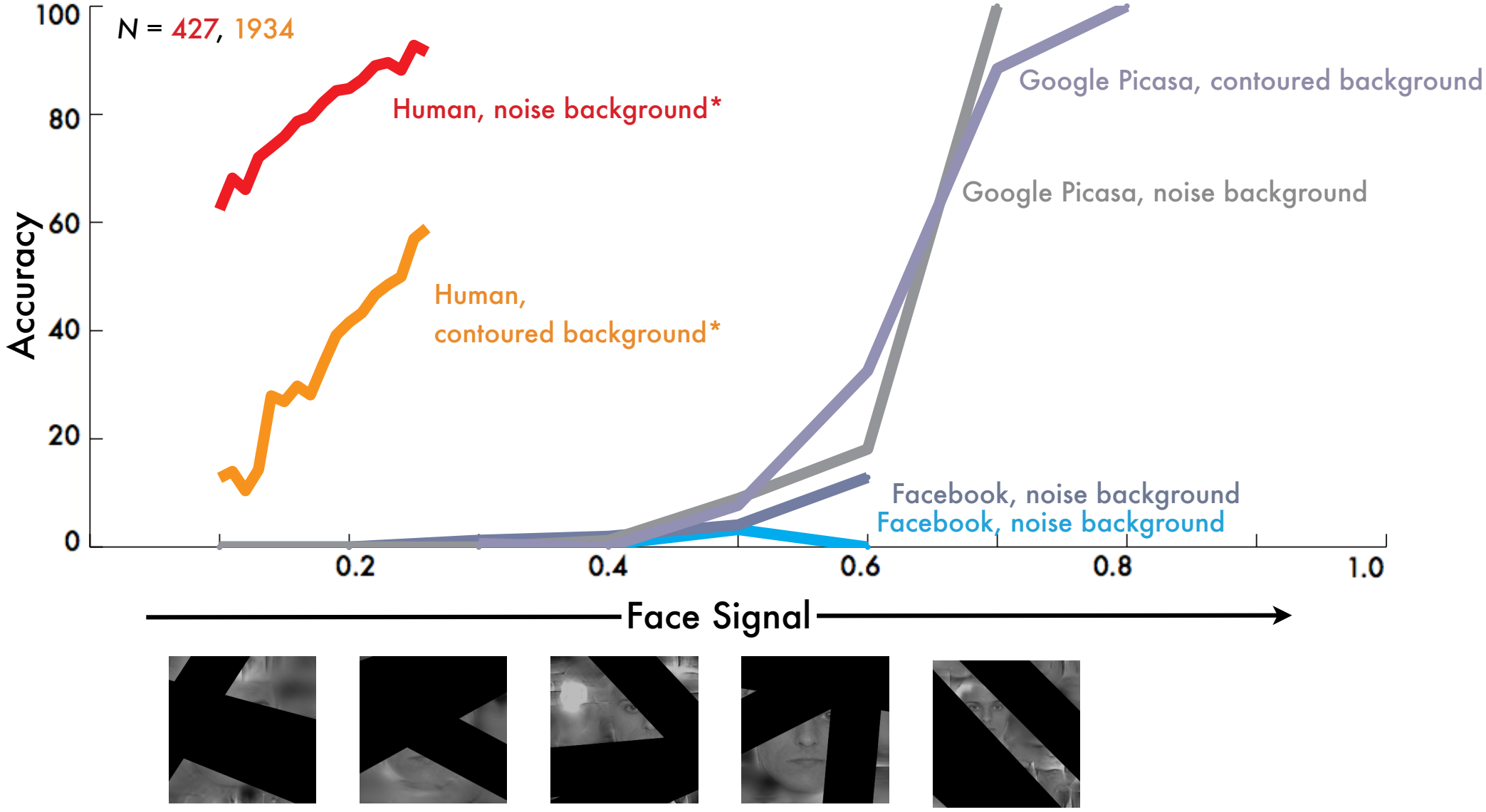
vs.

Noise



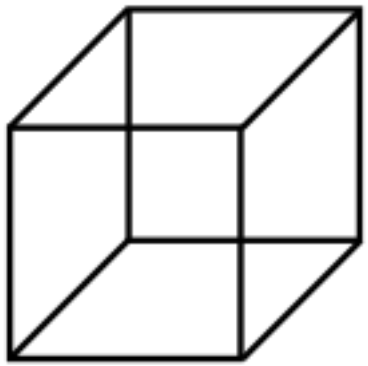
* normalized so chance is zero

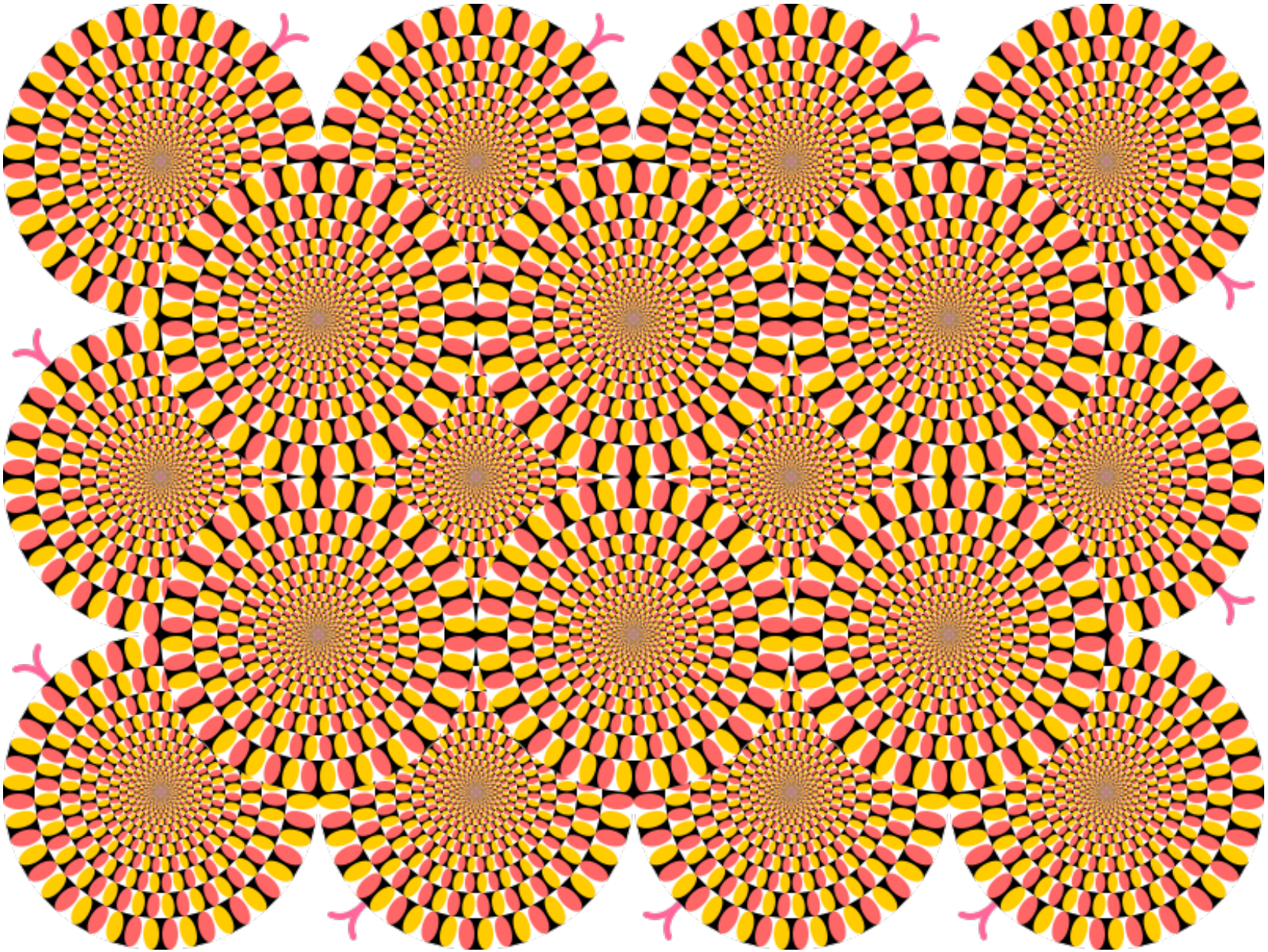
vs. Occlusion



* normalized

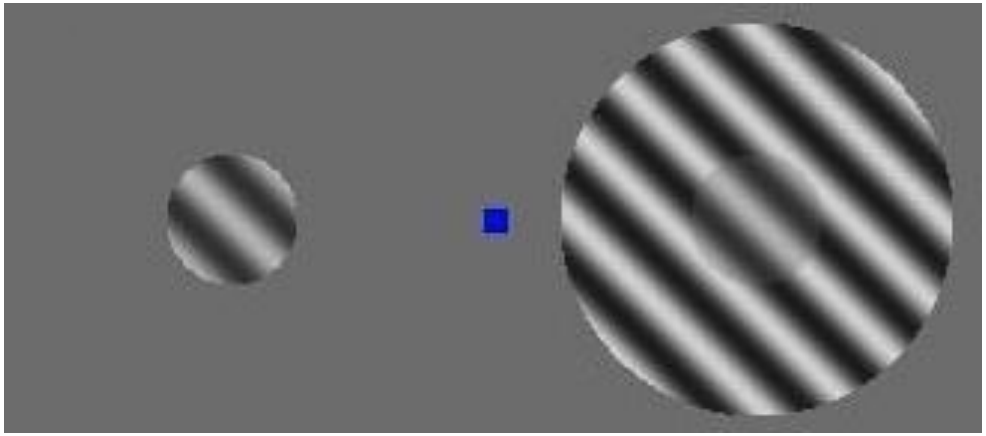
Optical Illusions





An optical illusion similar to *Rotating Snakes*

Surround Suppression



Flashlag Effect

http://visionlab.harvard.edu/Members/Alumni/David/flash-lag.htm

Perception & AI: Marr

Levels of Analysis

1. Computational Level: what does the system do?

2. Algorithmic / Representational Level: how does the system do what it does?

3. Implementation / Physical Level: how is the system physically realized?

Marr, *Vision*, MIT Press 1982

Stages of Vision

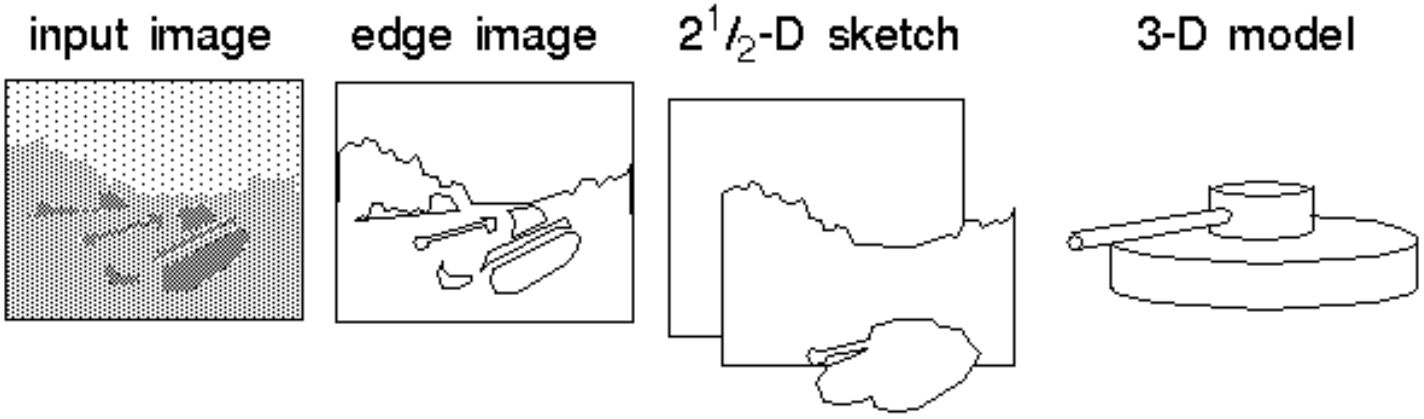
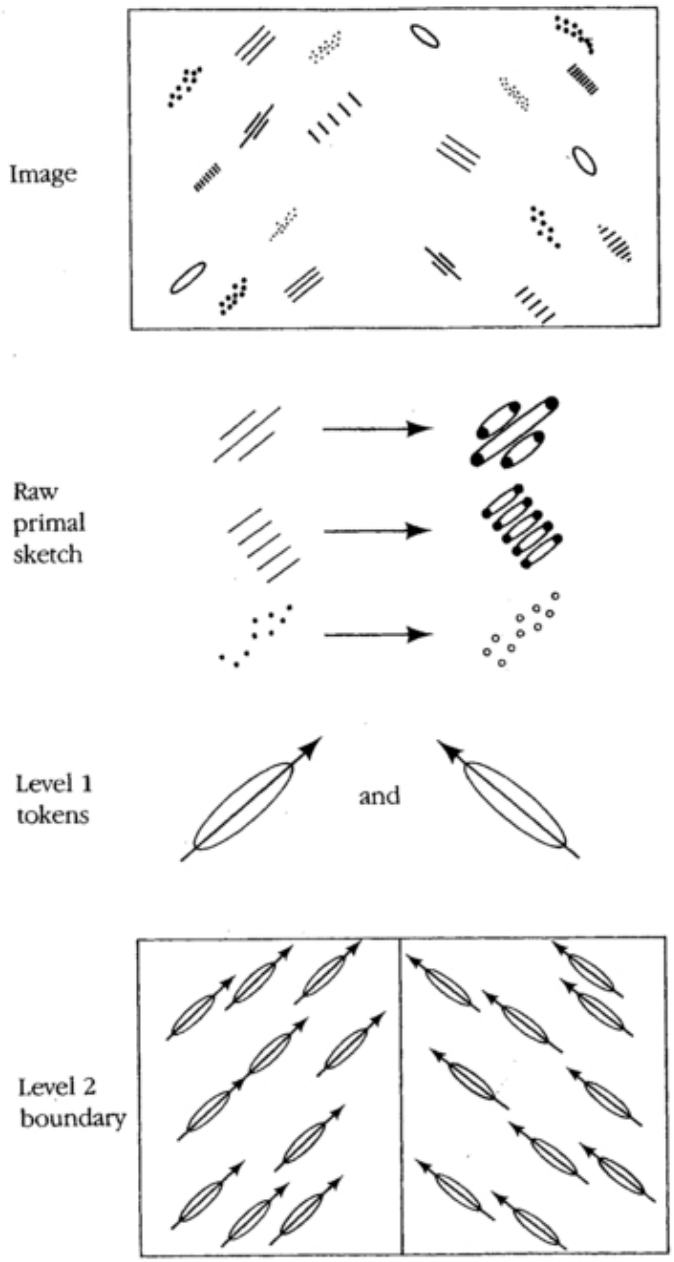
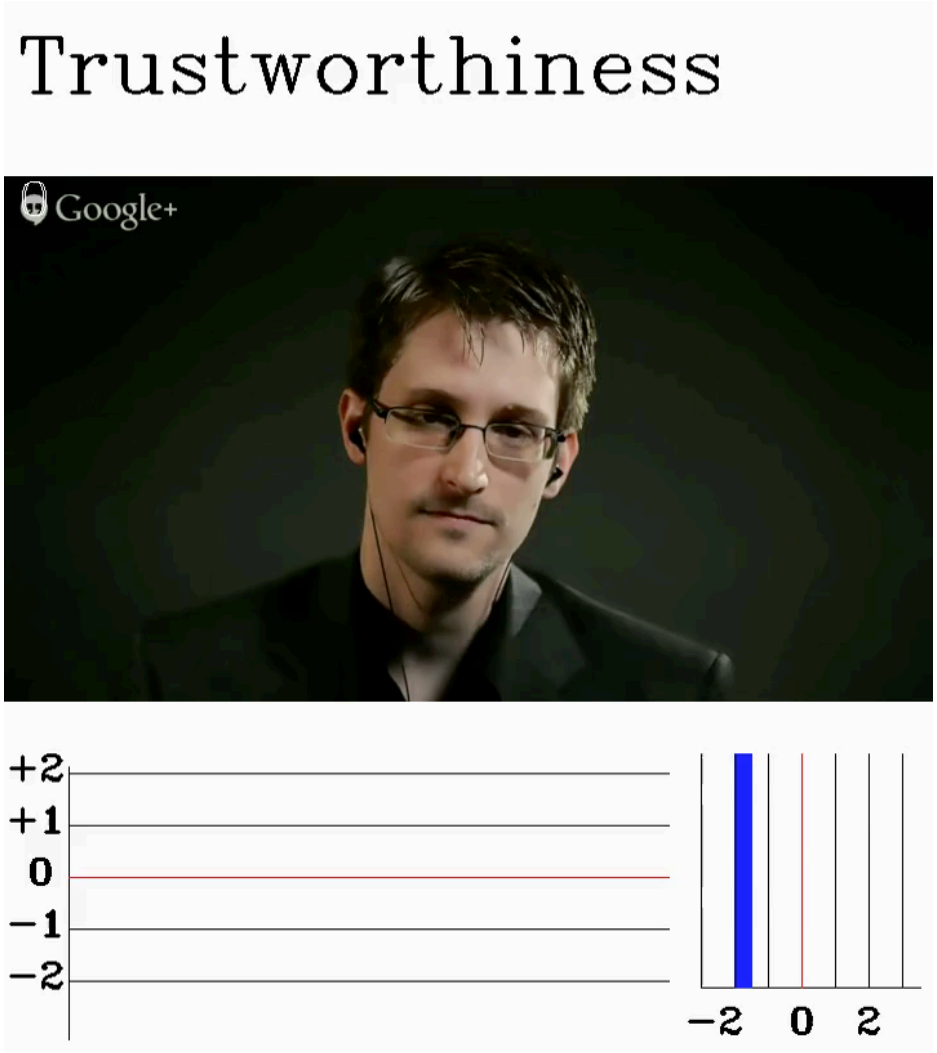


Image credit: S. Lehar (http://www.doc.gold.ac.uk/~mas02fl/MSC101/Vision/Marr.html)



Marr, *Vision*, MIT Press 1982

Computer Vision: Perception



McCurie *et al.*, IEEE FG, 2017