COGS 101A: Sensation and Perception

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Department of Cognitive Science

UCSD

Lecture 1:

Introduction, Administration, Motivation, Chapter 1
Course Information

- Class web page: http://cogsci.ucsd.edu/~desa/101a/index.html
- Professor: Virginia de Sa
  - I’m usually in Chemistry Research Building (CRB) 214 (also office in CSB 164)
  - Office Hours: to be determined
  - email: desa at ucsd
  - Research: Perception and Learning in Humans and Machines
At your Assistance

TAS:

- Jelena Jovanovic
- Katherine DeLong

IAS:

- Jennifer Becker
- Lydia Wood

We will discuss office hours at the next class
Course Goals

• To appreciate the difficulty of sensory perception

• To learn about sensory perception at several levels of analysis

• To see similarities across the sensory modalities

• To become more attuned to multi-sensory interactions
Grading Information

- 25% each for 2 midterms
- 32% comprehensive final
- 3% each for 6 lab reports - due at the end of the lab
- Bonus for participating in a psych or cogsci experiment AND writing a paragraph description of the study

You are responsible for knowing the lecture material and the assigned readings. Read the readings before class and ask questions in class.
Academic Dishonesty

The University policy is linked off the course web page.

You will all have to sign a form in section

For this class:

- Labs are done in small groups but writeups must be in your own words

- There is no collaboration on midterms and final exam
Proposed Schedule

is on the webpage
Introduction to/Review of the Visual System: Outline

- Show you different techniques to studying the visual system (at different levels of analysis)

- Anatomy and Physiology of the visual system

- Show you evidence of top-down processing

- Echo concepts from Chapter 1
Which is harder for us to do?

Program a computer to play chess at the Grand Master level

or

Program a computer to have vision as good as a 2 year old
Which is harder for us to do?

Program a computer to play chess at the Grand Master level

or

Program a computer to have vision as good as a 2 year old

• Vision is hard

• Vision is much more than the eye.
“Having often forgot which was the Cat, and which the Dog, he was ashamed to ask; but catching the Cat (which he knew by feeling) he was observed to look at her steadfastly and then setting her down, said, So Puss! I shall know you another Time.’” [Cheselden, 1728]

“When ... the experiment was made of giving her a silver pencil case and a large key to examine with her hands; she discriminated and knew each distinctly; but when they were placed on the table, side by side, through she distinguished each with her eye, yet she could not tell which was the pencil case and which was the key.” [Wardrop 1827]

“Thus, for patient TG, telling a circle from a square, or either from a triangle was very difficult; he had to stare at the angles, one at a time, engaging in what we have called “scanning”, to do it.” [Valvo 1971]
Why is vision hard

Vision is hard because there are an infinite number of 3D scenes that could give rise to a particular 2D image

devised by Ted Adelson (see http://web.mit.edu/persci/gaz/)
Why is object recognition hard?
The Eye

Figure from the web (lost ref)
The Eye

Figure from the web (lost ref)
The Eye

Transduction: the transformation of one form of energy to another. The photoreceptors transduce light to electrical signals (voltage changes).
Ganglion cell responses

Figure from the web
Ganglion cell responses

http://zeus.rutgers.edu/~ikovacs/SandP/prepI_3_1.html
Pathway to Cortex

Visual Cortical Areas

Visual Cortical Areas – Human

KEY TO FUNCTION

- **V1**: Primary visual cortex; receives all visual input. Begins processing of color, motion and shape. Cells in this area have the smallest receptive fields.

- **V2, V3 and VP**: Continue processing; cells of each area have progressively larger receptive fields.

- **V3a**: Biased for perceiving motion.

- **V4v**: Function unknown.

- **MT/V5**: Detects motion.

- **V7**: Function unknown.

- **V8**: Processes color vision.

- **LO**: Plays a role in recognizing large-scale objects.

*Note: A V6 region has been identified only in monkeys.*

Scientific American, November 1999 (Vision: A Window on Consciousness)
How do we study Perceptual Systems?

- Physiology
  - Single Cell Electrophysiology – what do neurons respond to?
responses of V1 neurons

movie from

http://info.med.yale.edu/neurobio/mccormick/qt_movie.html
Responses of V1 neurons

FIGURE 4.8  Response of a single cortical cell to bars presented at various orientations.

http://zeus.rutgers.edu/~ikovacs/SandP/prepI_3_1.html
Simple cells in V1
Complex cells in V1

from Mark McCourt’s Psy 486 web page
Ocular dominance and orientation columns

http://www.weizmann.ac.il/brain/images/icecubens.jpg
How do we study Perceptual Systems?

- Physiology
  - Single Cell Electrophysiology – what do neurons respond to?
  - Optical Imaging – what are groups of neurons responding to?
Optical Imaging reveals Orientation/Ocular dominance map
Optical Imaging reveals Orientation/Ocular dominance map

http://www.opt-imaging.com/
Optical Imaging reveals Orientation/Ocular dominance map
Optical Imaging reveals Orientation/Ocular dominance map

from Josh Trachtenberg
(http://phy.ucsf.edu/~joshua/postdoctoral.html)
Parallel Pathways in Visual Cortex

[Mishkin & Ungerleider 1982]
Parallel Pathways in Visual Cortex

[Van Essen & Gallant 1994]
higher-level neurons require more complex stimuli

“optimal patterns” for IT neurons (from Keiji Tanaka) are even more complex but require much less spatial precision
Neurons near the end of the Temporal pathway respond to very complex stimuli.

Figure 3.24
Responses of a neuron in a monkey’s area IT to various...
Determining Function

So we know that neurons in a particular area respond well to a particular kind of stimulation.

Does that tell us that these neurons are telling the animal about these stimuli?
How do we study Perceptual Systems?

- Physiology
  - Single Cell Electrophysiology – what do neurons respond to?
  - Optical Imaging – what are groups of neurons responding to?
  - microstimulation – how does the animal respond when we stimulate?
Microstimulation in MT influences monkey's decision

from Mike Shadlen and http://zeus.rutgers.edu/~ikovacs/SandP/prepl_3_1.html
Visual Cortical Areas

Feedback and Perception

“Feedforward and feedback connections are linked together by reciprocal connections. Much of the understanding of higher order vision rest on understanding the interactions between feedforward and feedback loops and the horizontal connections” [J Bullier, Trieste 2000]

Feedback connections are the substrate for top-down effects
The Visual System is not a fixed feed-forward system

It is influenced by

- prior experience
Influences from past experience

The original image was created by R.C. James. This image was taken from Andy Wilson’s home page which was scanned from David Marr’s book Vision.
Influences from past experience

This image is from Beverly Doolittle
The Visual System is not a fixed feed-forward system

It is influenced by

• prior experience

• surrounding visual scene (and not just immediate)
Simple influences from surrounding scene
What can we learn from visual illusions?

- Visual illusions occur when the brain makes an assumption that is not true.

- The assumption does not reflect a “flaw” in the visual system but represents adaptation to the the way things usually are.

- The brain must make assumptions, in order for you to perceive a 3D world from the 2D images on your retinas.

- By examining illusions and our responses, we can try to “reverse engineer” the visual system to discover the assumptions it makes in order to “see”.
Simple influences from surrounding scene
More involved influences from surrounding scene

http://www.olemiss.edu/courses/psy214/Readings/Illusions/ImageSizeAdjustmentTheory
More involved influences from surrounding scene

http://www1.cs.columbia.edu/~paley/spring03/assignments/HWtmp/sz184/pattern.html
The Visual System is not a fixed feed-forward system

It is influenced by

- prior experience
- surrounding visual scene (and not just immediate)
- recent prior exposure
The McCollough Effect – short term changes in perception

taken from http://cm.bell-labs.com/who/ches/me/
The McCollough Effect

taken from http://cm.bell-labs.com/who/ches/me/
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The Visual System is not a fixed feed-forward system

It is influenced by

• prior experience

• surrounding visual scene (and not just immediate)

• recent prior exposure

• learned familiarity with special objects
The Thatcher Illusion – influence from learned experience with (upright) faces

[Thompson 1980, Perception 9 483-484]
The Thatcher Illusion – influence from learned experience with (upright) faces

[Thompson 1980, Perception 9 483-484]

This illusion was first described by Thompson in 1980. I got this from http://www.essex.ac.uk/psychology/visual/thatcher.html
Influence from learned experience

http://www.princeton.edu/~ftong/
Influence from learned experience

http://www.princeton.edu/~ftong/
Influence from learned experience

http://www.princeton.edu/~ftong/
Influence from learned experience is specific 

[Sinha and Poggio Nature 1996, 384 p 404]
Influence from learned experience is specific

[Sinha and Poggio Perception 2002, 31(1) ]
http://perceptionweb.com/perc0102/sinha.html
The Visual System is not a fixed feed-forward system

It is influenced by

- prior experience

- surrounding visual scene (and not just immediate)

- recent prior exposure

- learned familiarity with special objects

- concurrent input in other sensory modalities (where the relationship has been well learned)
Auditory input can influence Visual Perception


Three bars accompanied by a different number of beeps

Fixate to the cross, and press one of the buttons. You may see a different number of bars with a different number of beeps (especially with "5 beeps"), whereas the visual stimuli are physically identical. (This demo may not work on slow computers. If the bar and beep are not synchronized with "3 beeps", you cannot observe the effect, sorry...)


available at http://neuro.caltech.edu/~kamitani/audiovisualRabbit
Visual input can influence Auditory perception – McGurk Demo

The McGurk Effect was discovered by McGurk and MacDonald in 1976. This demo is courtesy of Dr. Lawrence Rosenblum of University of California, Riverside.
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  - microstimulation – how does the animal respond when we stimulate?

- Psychophysics
  - observe and analyze visual illusions
Visual Cortical Areas

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• Psychophysics
  ✴ observe and analyze visual illusions
  ✴ observe and analyze people with brain damage
  ✴ threshold detection
Fechner’s Classical Psychophysical Techniques

**Absolute threshold:** Smallest amount of stimulus energy needed to detect a stimulus

- Method of Adjustment
- Method of Limits
- Method of Constant Stimuli
## Method of Limits

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### Transition Points

| 3.5 | 2.5 | 2.5 | 1.5 | 2.5 | 2.5 | 1.5 | 1.5 |

Mean Threshold = 2.25

*Figure 11. Threshold determination using the method of limits. A = Ascending limits, D = Descending limits, Y = Yes, the stimulus is seen and N = No, the stimulus cannot be seen.*

from [http://webvision.med.utah.edu/Psych1.html](http://webvision.med.utah.edu/Psych1.html)
Staircase method (variation of method of limits)

Figure 12. Staircase method. Y = Yes, the stimulus can be seen and N = No, the stimulus cannot be seen.
Method of Constant Stimuli

from http://webvision.med.utah.edu/Psych1.html

curve is called a **psychometric** function (measuring mind/brain)
Now commonly called **Just Noticeable Difference (JND)**: smallest detectable increase or decrease in stimulus energy

**Weber’s Law:** \( \frac{DL}{S} = K \)

true for most sensations as long as significantly above threshold

Why does it not hold at threshold?
Summary

Vision is hard.

Our visual system excels because it has learned rules about our world.

We can learn about these rules by examining illusions and aftereffects which reflect the brains processing when the rules don’t hold.