

# Human Abilities: Vision & Cognition

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Prof. James A. Landay  
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Autumn 2025

October 20, 2025

Music: <https://soundcloud.com/dansuneroquette>

# Hall of Fame or Shame?



← → ↻ 🏠 <https://accounts.google.com/SignUp?service=...> 🔍 ⌘ ☆








Apps B CS 147: HCI+D Autu Gates Information N Axess NETGEAR Router WN kimonify » Other Bookmarks

Google [Sign in](#)

## Create your Google Account


One account is all you need

A single username and password gets you into everything Google.

Take it all with you

Switch between devices, and pick up wherever you left off.



**Name**

**Choose your username**

@gmail.com

**Create a password**

**Confirm your password**

**Birthday**

Month  Day  Year

**Gender**



# Hall of Fame! (but still some issues...)



Google Sign in

## Create your Google Account

One account is all you need  
A single username and password gets you into everything Google.

Take it all with you  
Switch between devices, and pick up wherever you left off.

Name  
James Landay

Choose your username  
james...landay@gmail.com  
A fan of punctuation! Alas, usernames can't have consecutive periods.

Create a password  
You can't leave this empty.

Confirm your password

Birthday  
Month Day Year

Gender  
I am...

Mobile phone

Your current email address

Prove you're not a robot  
 Skip this verification (phone verification may be required)

Clearly highlights error (red text & box)

Tells me what I did wrong/how to fix it

In user's language  
(but, **be careful w/ humor**)

Red may be an issue when used alone,  
more later...

# Hall of Fame!



Google

## Create your Google Account

First name  Last name

Username  @gmail.com

! Sorry, your username cannot contain consecutive periods (.)

[Use my current email address instead](#)

Password  Confirm

[Sign in instead](#)

Next



One account. All of Google working for you.

Clearly highlights error (red text & box)

Tells me what I did wrong/how to fix it

In user's language  
(but, **be careful w/ humor**)

Red may be an issue when used alone,  
more later...

New version fixes these 2 problems  
- adds caution icon & removes the humor

# Hall of Fame or Shame?



Nintendo Switch

Connects to TV and use detachable controllers

or

Use as a single all in one device

or

Give another person a controller & share the screen

# Hall of Fame!



Multiple configurations reduces # of physical steps for any one mode

Detachable controllers caters to different play styles/physical abilities

Controller optimizes button placement for minimal movement (Fitts' Law)

# Human Abilities: Vision & Cognition

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# Outline

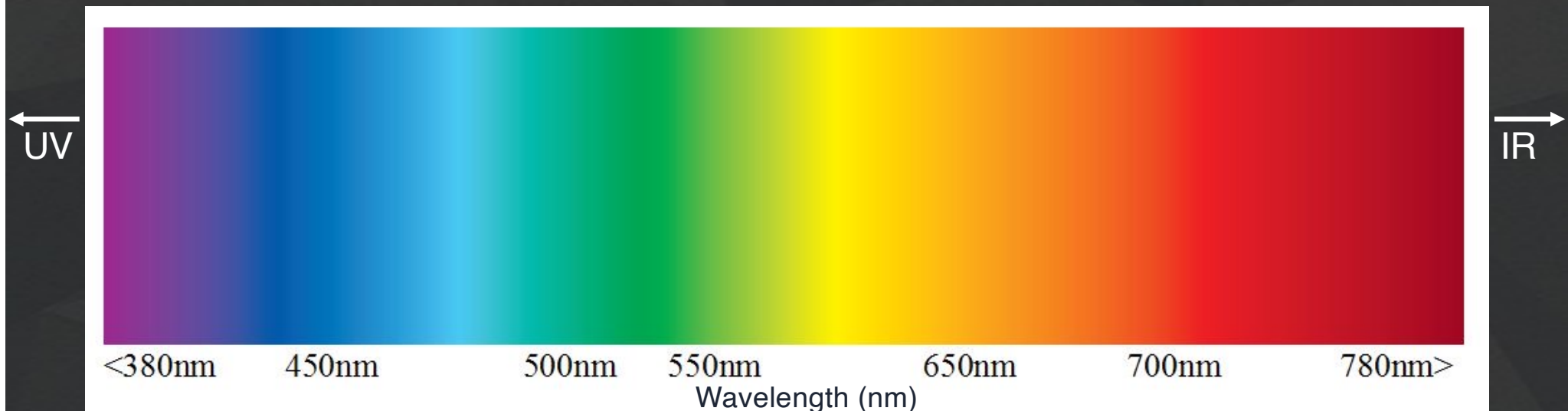
- Human visual system
- Guidelines for design
- Team Break
- Models of human performance (MHP)
- Two in class experiments
- Memory

# Why Study Color?

- 1) Color can be a powerful tool to *improve* user interfaces by communicating key information
- 2) Inappropriate use of color can severely *reduce the performance* of systems we build

# Visible Spectrum

*There is an order to the colors... ROY G. BIV*

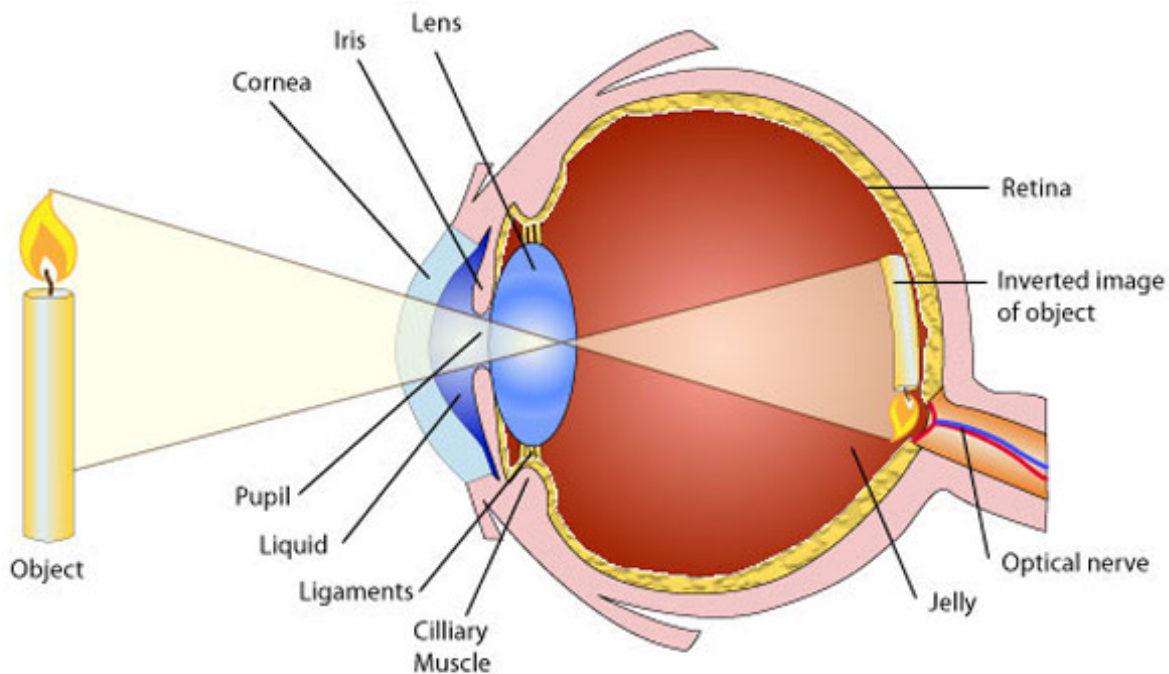


***Do not use that ordering to order data!***

*(next lecture: example of how unusable a map is using this ordering for elevation)*

# Human Visual System

Cross section of Human Eye



Light

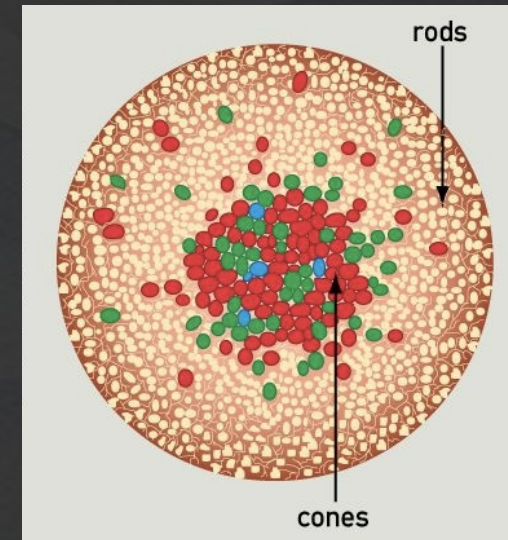
Electric signal

<http://obsessive-coffee-disorder.com/wp-content/uploads/2014/11/eye1.jpg>

- Light passes through lens
- Focused on retina

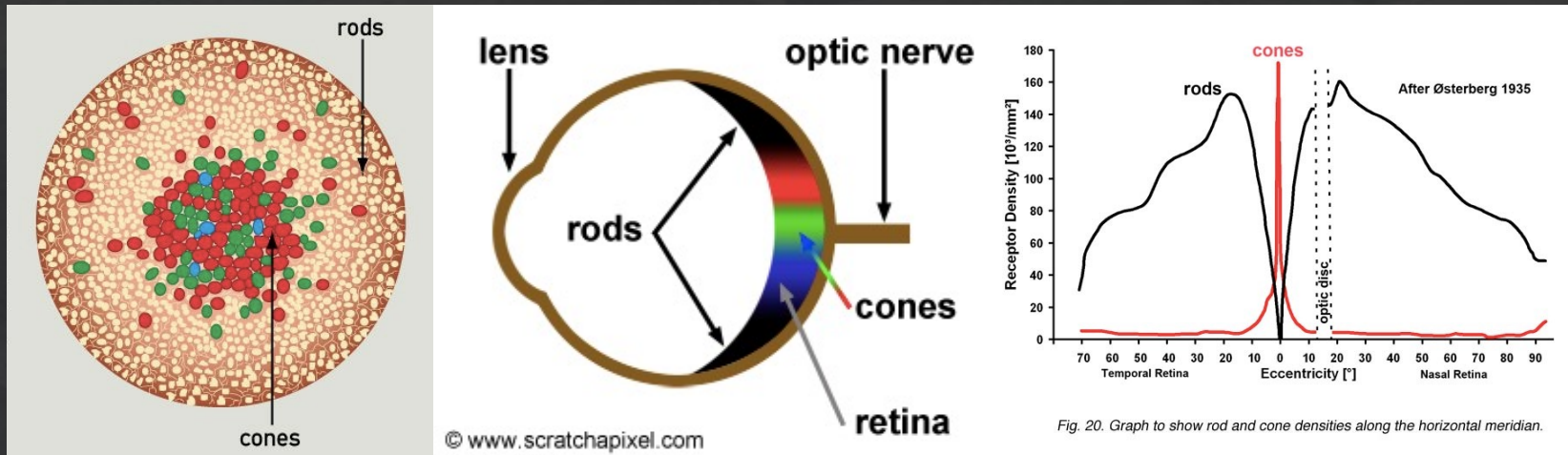
# Retina

- Retina covered with two types of light-sensitive receptors called?
  - rods
    - primarily for night vision & perceiving movement
    - sensitive to broad spectrum of light
    - can't discriminate between colors
    - sense intensity or shades of gray
  - cones
    - used to sense color



# Retina

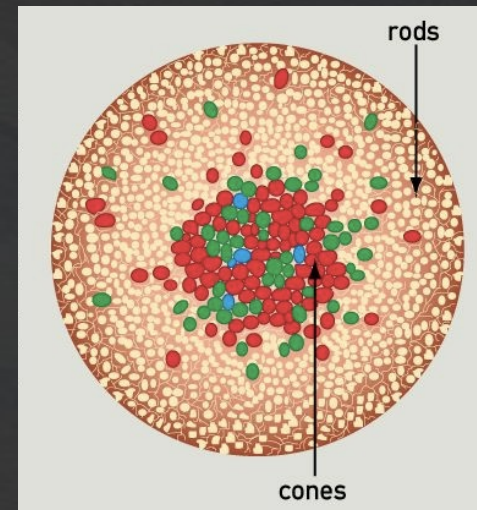
- Center of retina has most of the cones →
  - allows for high acuity of objects focused at center



- Edge of retina is dominated by rods →
  - allows detecting motion of threats in periphery

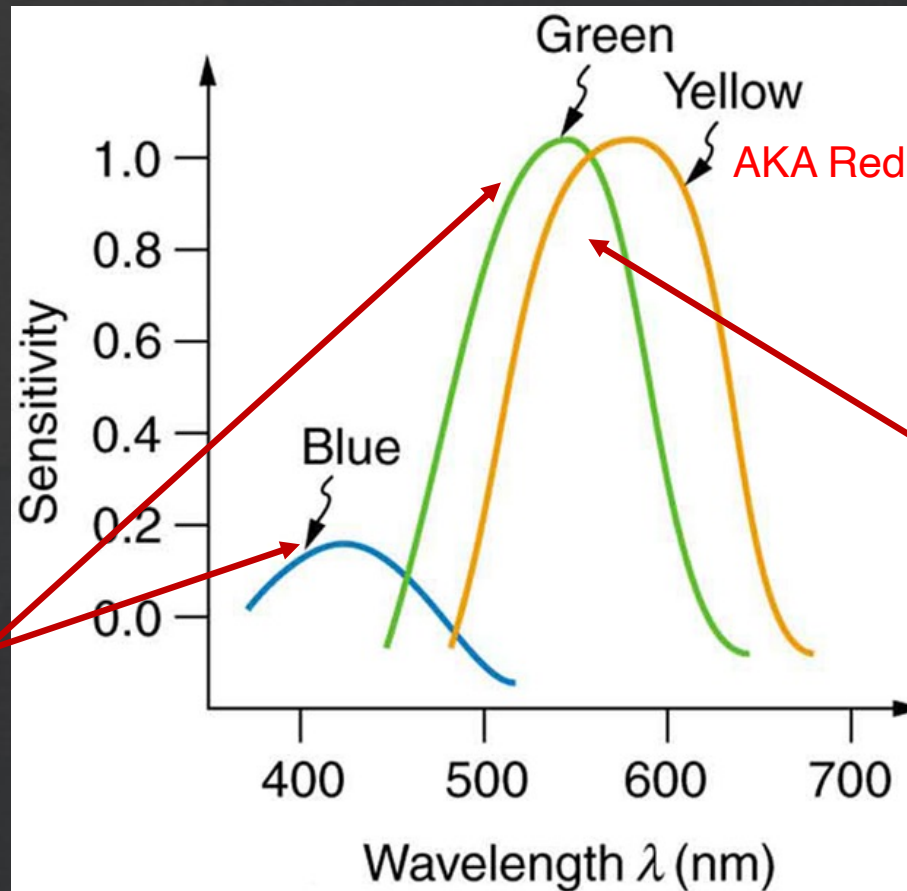
# Color Perception via Cones

- “Photopigments” used to sense color
- 3 types: blue, green, “red” (really yellow)
  - each sensitive to different band of spectrum
  - ratio of neural activity of the 3 → color
    - other colors are perceived by combining stimulation



<http://www.webexhibits.org/causesofcolor/1G.html>

# Color Sensitivity

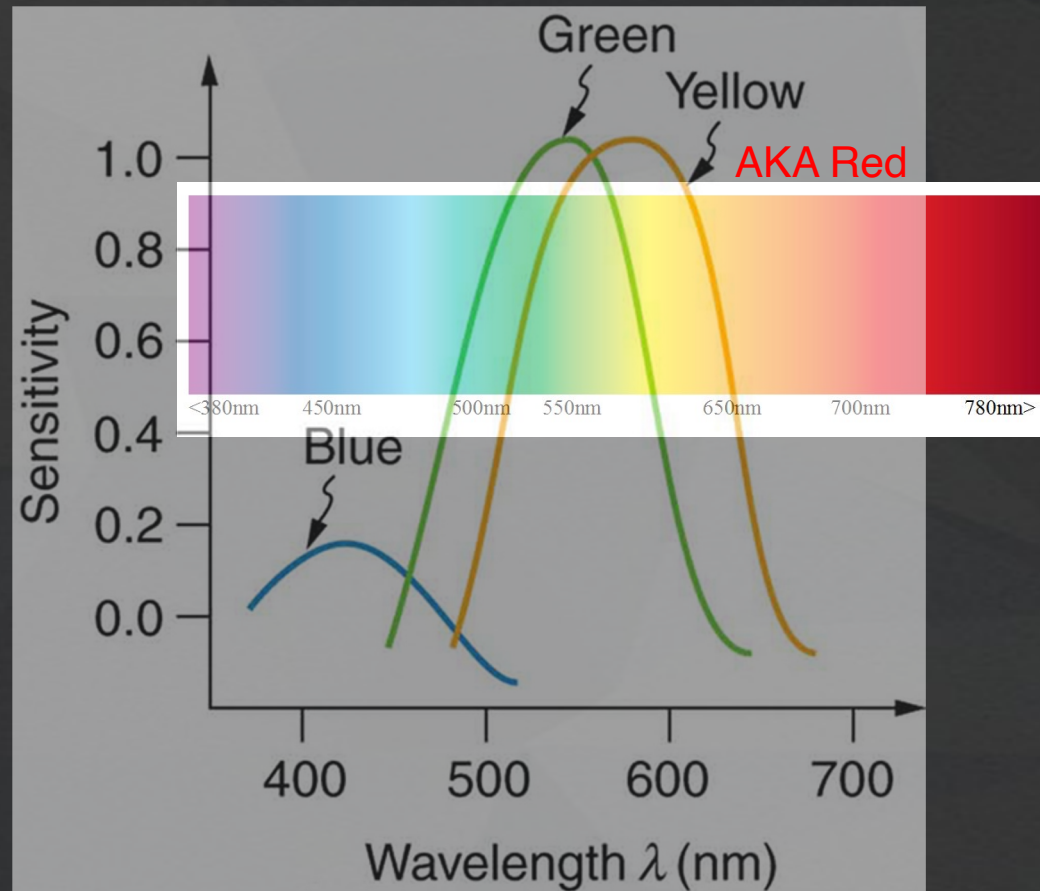


not as sensitive to blue

lots of overlap

<http://archive.cnx.org/contents/d42c807d-a9fa-4e3d-83d0-0f7c745b51a0@4/color-and-color-vision#import-auto-id1844887>

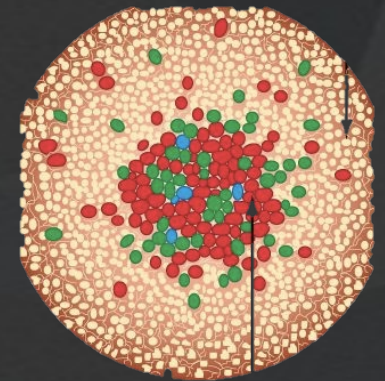
# Color Sensitivity



<http://archive.cnx.org/contents/d42c807d-a9fa-4e3d-83d0-0f7c745b51a0@4/color-and-color-vision#import-auto-id1844887>

# Distribution of Photopigments

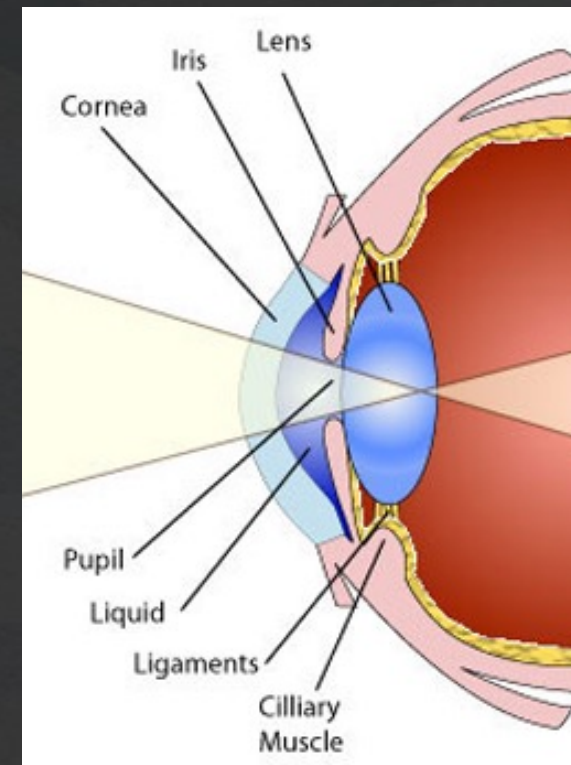
- Not distributed evenly – mainly reds (64%) & very few blues (4%) →
  - insensitivity to short wavelengths (blue)
- Few blue cones in retina center (high acuity) →
  - “disappearance” of small blue objects you fixate on
- As we age lens yellows & absorbs shorter wavelengths →
  - sensitivity to blue is even more reduced
- Implication
  - **don't rely on blue for text or small objects!**



<http://www.webexhibits.org/causesofcolor/1G.html>

# Focus

- Different wavelengths of light focused at different distances behind eye's lens
  - need for constant refocusing → ?
    - causes fatigue
  - be careful about nearby color combinations



# Focus

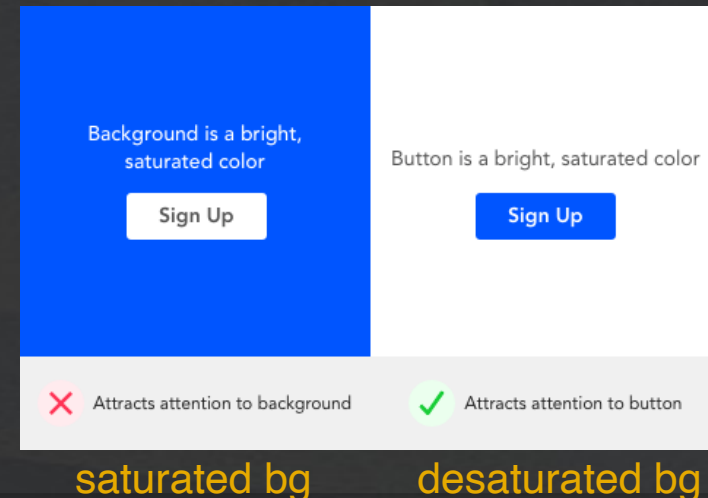
- Different wavelengths of light focused at different distances behind eye's lens
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  - be careful about nearby color combinations
- Pure (saturated) colors require more focusing than less pure (desaturated)
  - don't use saturated colors in UIs unless you really need something to stand out



<https://physics.info/color/>

# Focus

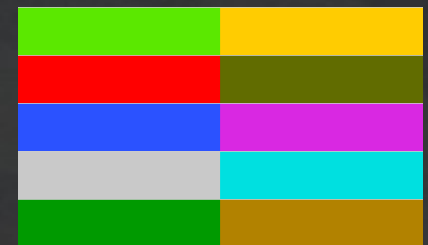
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  - need for constant refocusing → ?
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  - don't use saturated colors in UIs unless you really need something to stand out



# Color Deficiency

(Also known as “color blindness”)

- Trouble discriminating colors
  - besets about 4.5% of population (~8% men, ~1/2% women)
- Two main types
  - different photopigment response – most common
    - reduces capability to discern small color diffs
  - red-green deficiency – best known
    - lack of either green or red photopigment → can't discriminate colors solely dependent on Red & Green
- Key is to avoid single color distinctions

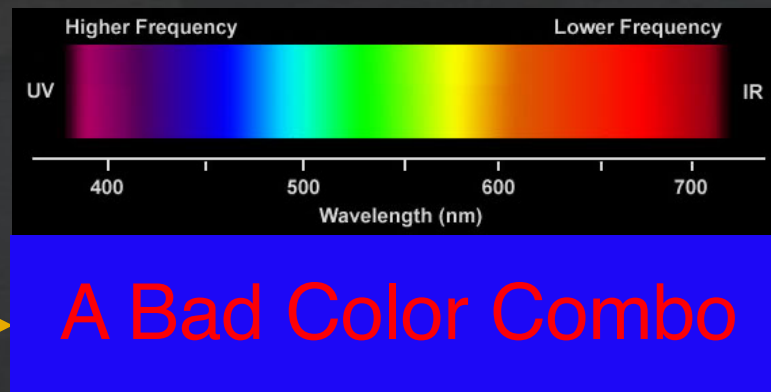


Difficult pairs for severe red deficient person to discern  
<https://www.color-blindness.com/red-green-color-blindness/>

# Color Guidelines

Avoid simultaneous display of highly saturated, spectrally extreme colors

- e.g., no cyans/blues at the same time as reds, why?
  - refocusing!



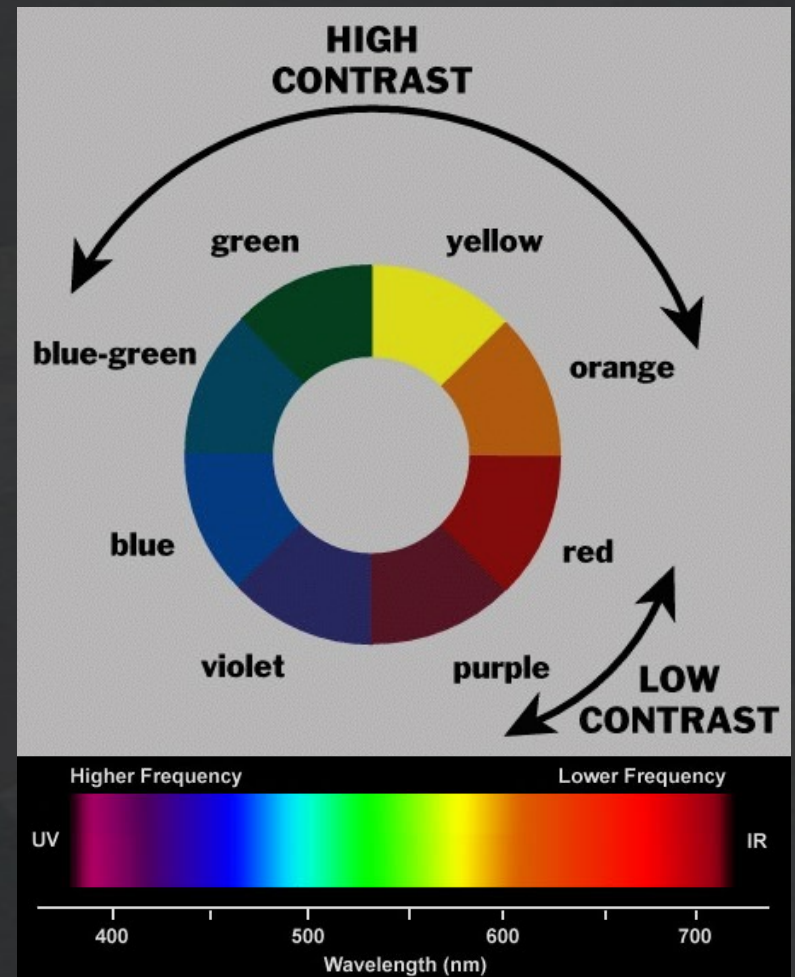
- desaturated combinations are better → pastels

# Use the Hue Circle

Pick non-adjacent colors

– opponent colors  
go well together

red & green  
or  
yellow & blue



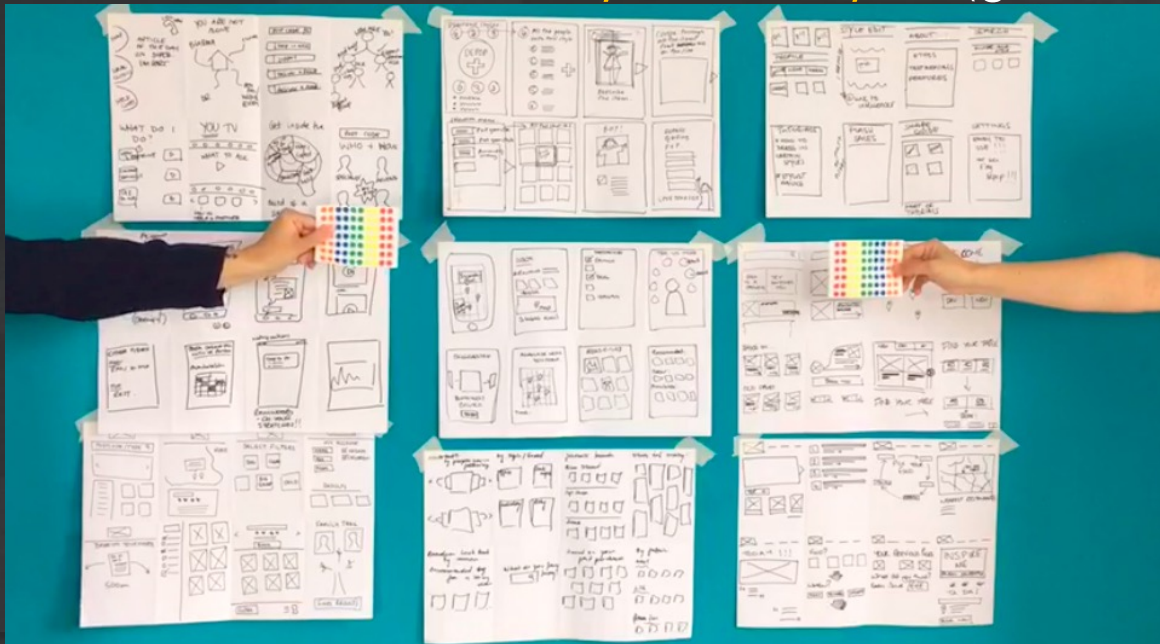
## Color Guidelines (cont.)



- Avoid pure blue for text, lines & small shapes
- Avoid adjacent colors that differ only in blue
- Blue makes a great background color

# Administrivia

- Assignment #5 – Low-fi Prototype & Pilot Usability Test
  - 10-15 rough sketches of 3 different design realizations
    - everyone on team contributes
    - use *different modalities* (e.g., visual, speech, watch) or *different visual UIs input techniques* (gestures, taps, etc.)



# Administrivia

- Assignment #5 – Low-fi Prototype & Pilot Usability Test
  - 10-15 rough sketches of 3 different design realizations
    - everyone on team contributes
    - use *different modalities* (e.g., visual, speech, watch) or *different visual UIs input techniques* (gestures, taps, etc.)
  - pick top 2 realizations & storyboard/task flow more
  - pick best realization & add details to task flow
  - build low-fi prototype of the best & test it w/ at least 1 target (non-Stanford) participant/team member (e.g., four)

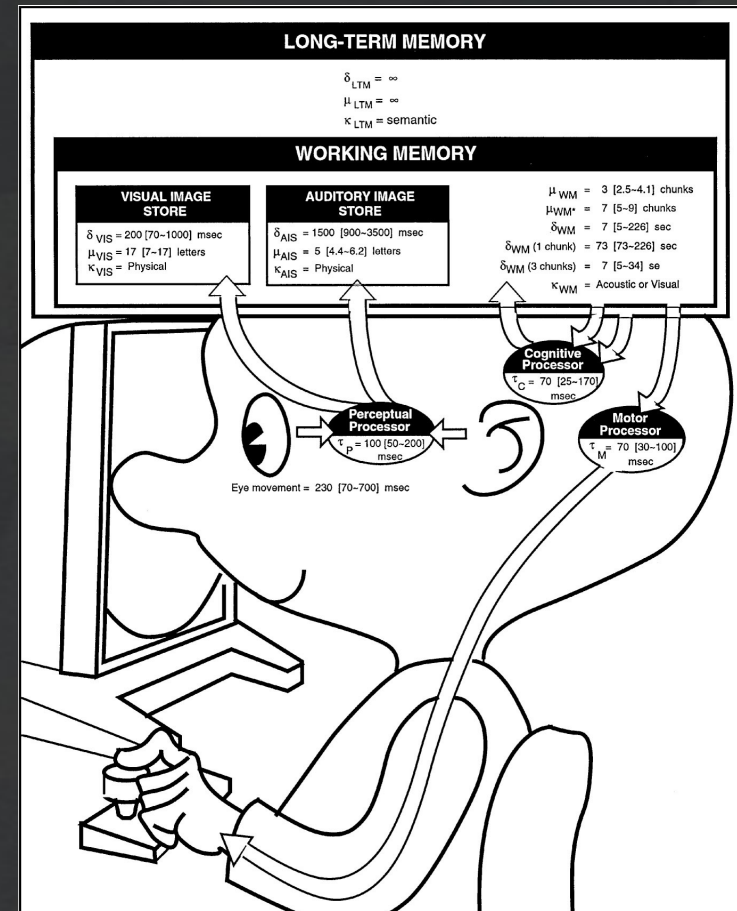
# TEAM BREAK

# The Model Human Processor

Developed by Card, Moran & Newell ('83)

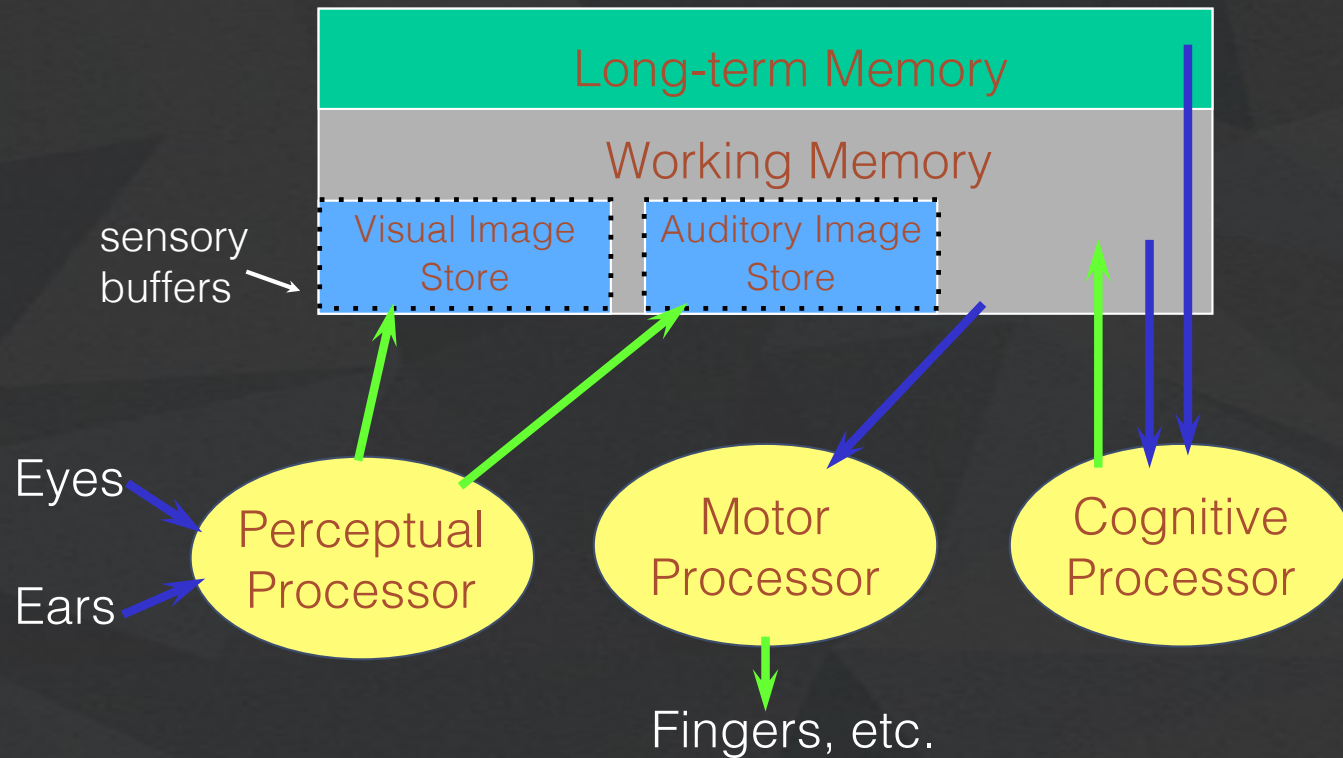
– based on empirical data

- Model can help us test understanding & make predictions
- Underlies other usability techniques
  - GOMS, KLM, tools, etc.



*The Psychology of Human-Computer Interaction by Card, Moran & Newell*

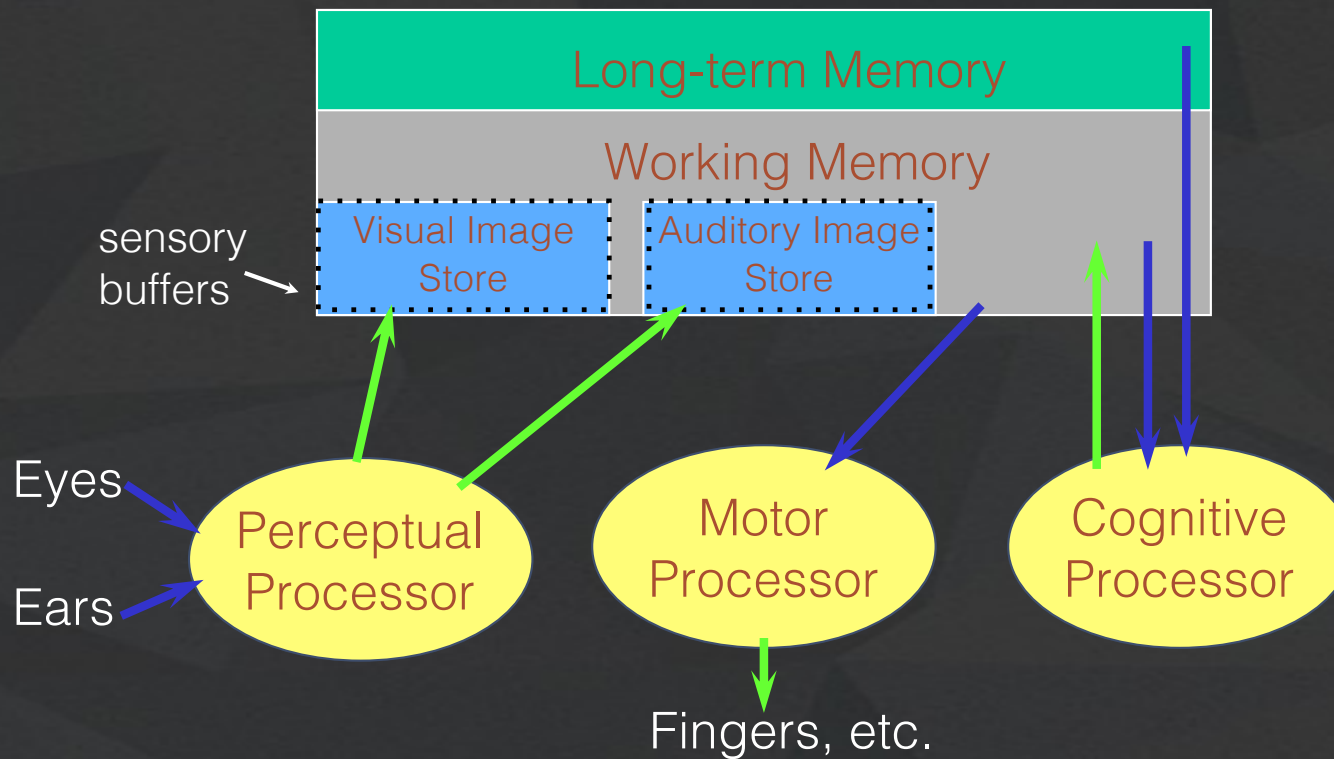
# The Model Human Processor



# MHP Basics

- Parameters
  - processors have cycle time (T) ~ **100 ms**
  - memories have capacity, decay time & type

# What is missing from MHP?

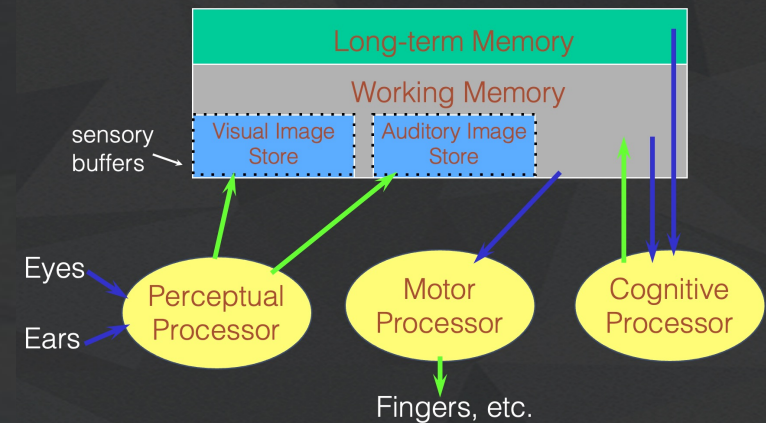


# What is missing from MHP?

- Haptic memory
  - for touch

- Moving from sensory buffers (memory) to WM
  - attention filters stimuli & passes to WM

- Moving from WM to LTM
  - elaboration

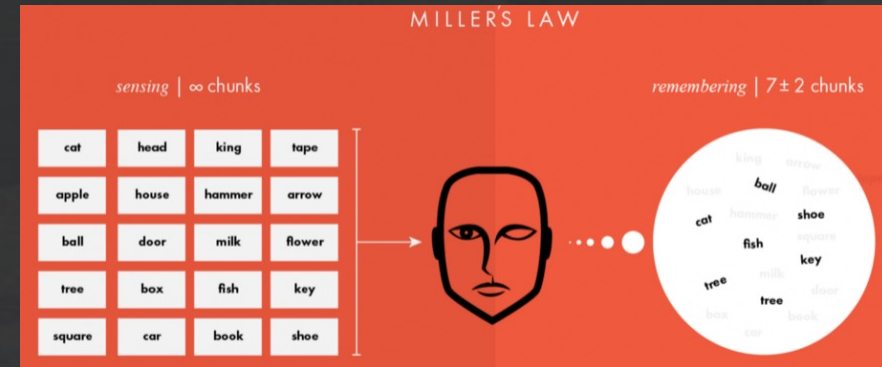




"I'm having trouble with my short term memory...  
I'm here because of my short term memory...  
I'd like to talk to you about my short term memory..."

# Memory

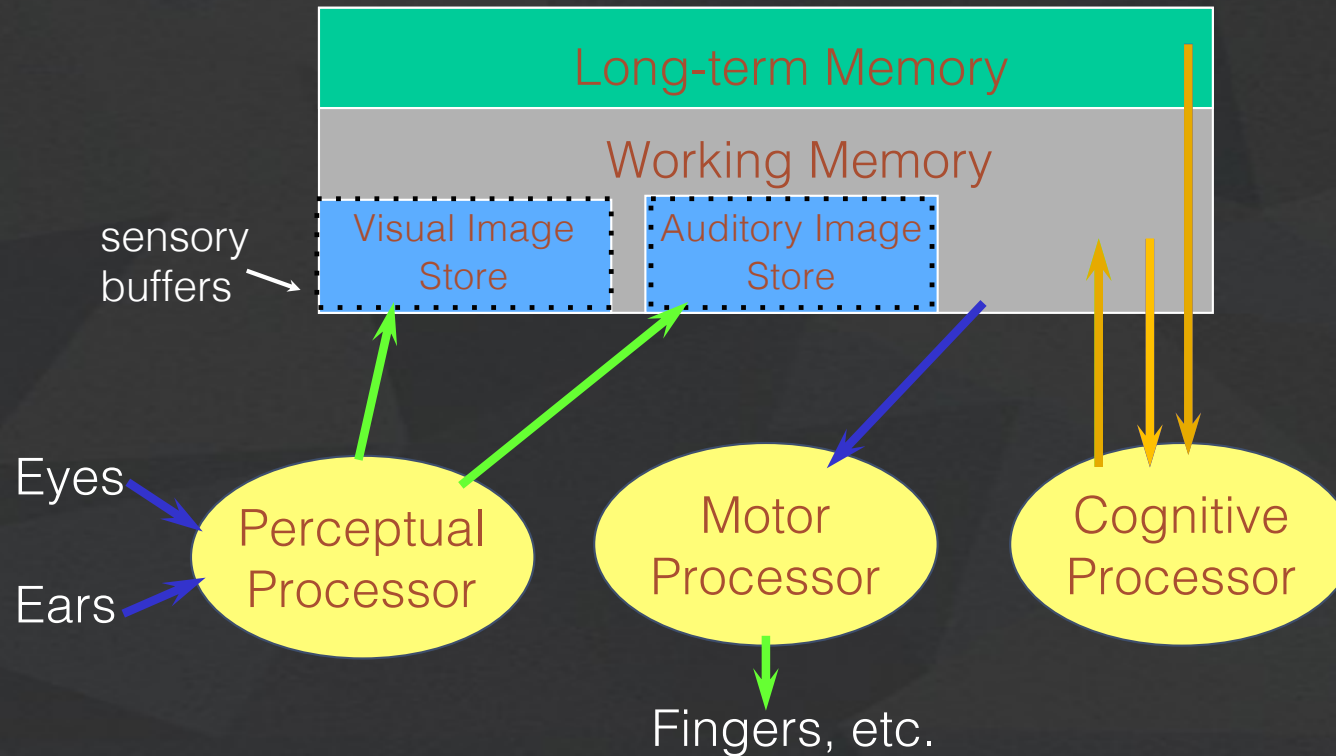
- Working memory (short term)
  - small capacity ( $7 \pm 2$  “chunks”)
    - 6174591765 vs. (617) 459-1765
    - NBCIBMGMC vs. NBC IBM GMC
  - rapid access ( $\sim 70\text{ms}$ ) & decay ( $\sim 200\text{ms}$ )
    - pass to LTM after a few seconds of continued storage
- Long-term memory
  - huge (if not “unlimited”)
  - slower access time ( $\sim 100\text{ms}$ ) w/ little decay



# MHP Principles of Operation

- Recognize-Act Cycle of the CP
  - on each **cycle** contents in WM initiate actions **associatively linked** to them in LTM
  - executed **actions modify** the contents of WM

# MHP Principles of Operation



# MHP Principles of Operation

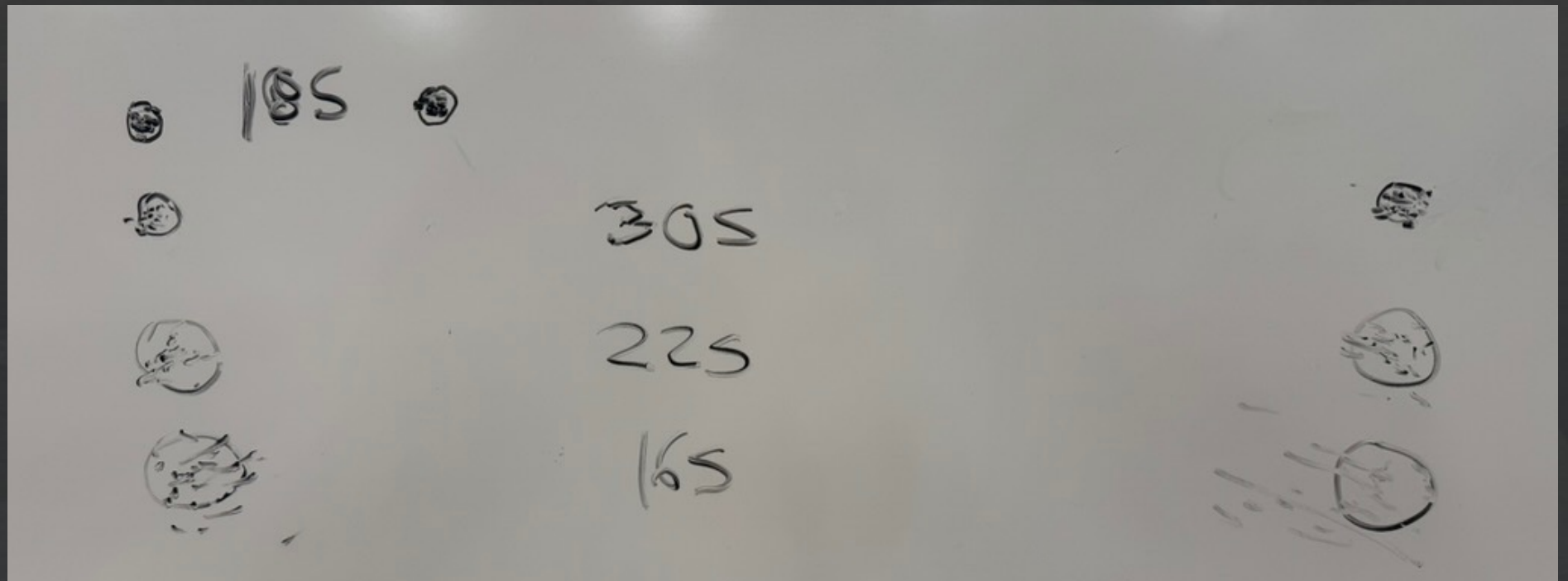
- Recognize-Act Cycle of the CP
  - on each **cycle** contents in WM initiate actions **associatively linked** to them in LTM
  - executed **actions modify** the contents of WM
- Discrimination Principle
  - retrieval is determined by candidates that exist in memory **relative to retrieval cues**
  - **interference** by strongly activated chunks

# Motor Processor Experiment

- Task:  
Quickly tap each target 50 times accurately
- Conditions:
  - Two ½” diameter targets 6” apart
  - Two ½” diameter targets 24” apart
  - Two 2” diameter targets 24” apart
  - Two 2” diameter targets 24” apart (no accuracy required)
- Turn to neighbor: discuss what will happen

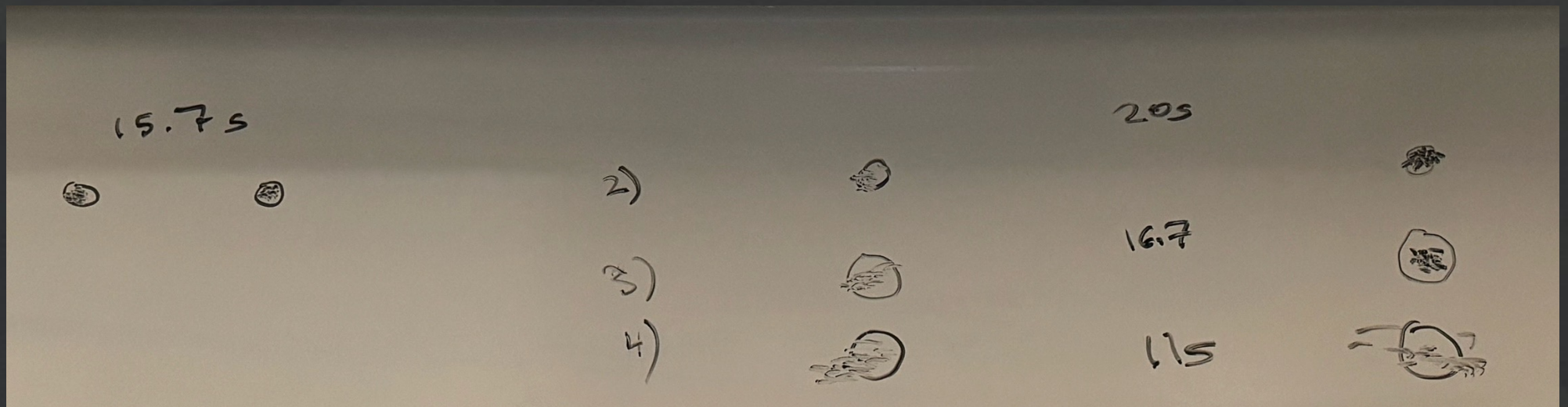
# Experimental Results (2025au)

- Task: Quickly tap each target 50 times accurately



# Experimental Results (2024au)

- Task: Quickly tap each target 50 times accurately



If we plot the data...

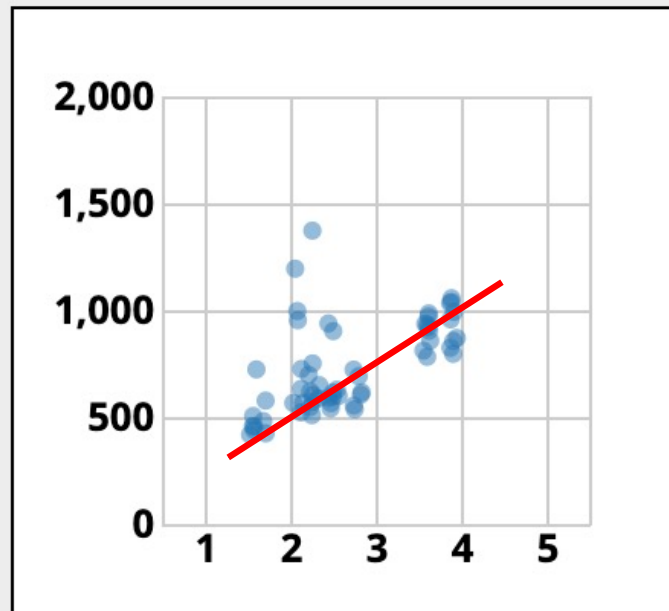


fig. 1e: Time in ms over ID.

Index of Difficulty:  $ID = \log(D/W) + 1$   
D = distance to target, W = width of target (or size)

# Run This Experiment On Your Own

<http://simonwallner.at/ext/fitts/>

# Principles of Operation (cont.)

## Fitts' Law

- moving hand is a series of microcorrections
  - correction takes  $T_p + T_c + T_m = 240$  msec
- time  $T_{pos}$  to move the hand to target size  $S$ , which is distance  $D$  away is given by:

$$T_{pos} = a + b \log_2 (D/S + 1)$$

- summary
  - time to move hand depends only on the *relative precision* ( $D/S$ ) required

# Fitts' Law Example

Pop-up Linear Menu

Today
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

Pop-up Pie Menu



Which will be faster on average?

- pie menu (bigger targets & less distance)

# Pie Menus in Use Today

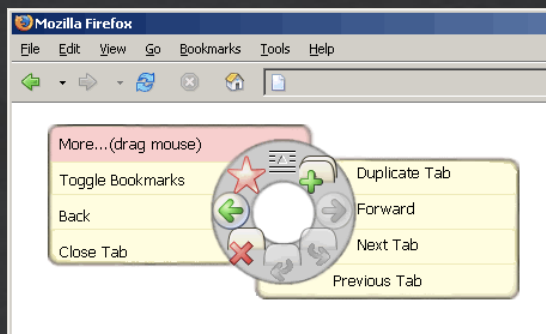
The Sims



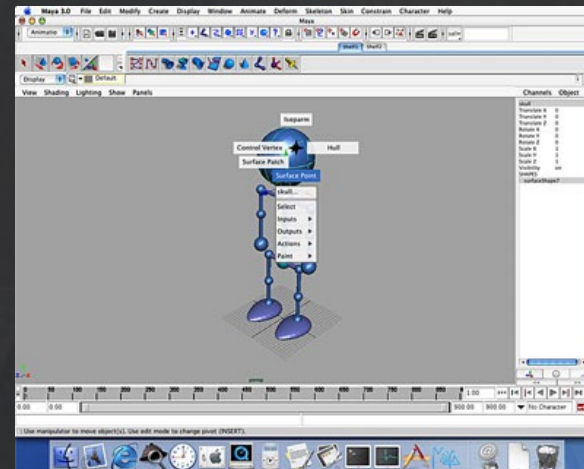
Rainbow 6



Firefox

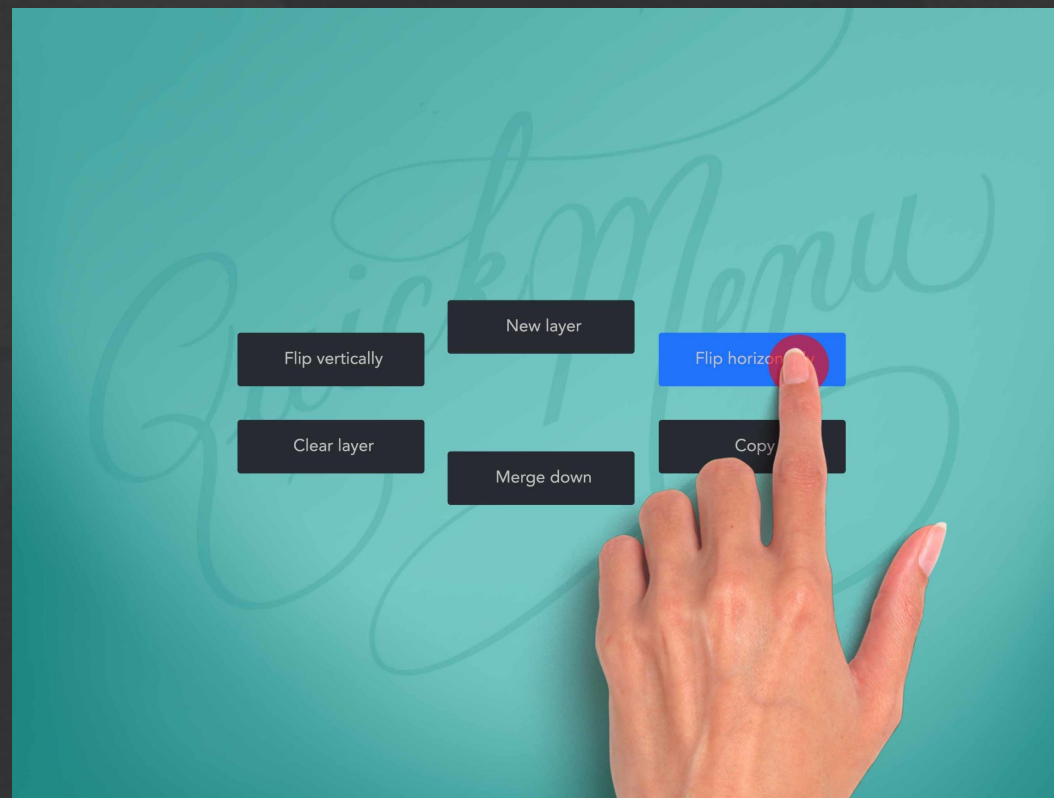


Maya



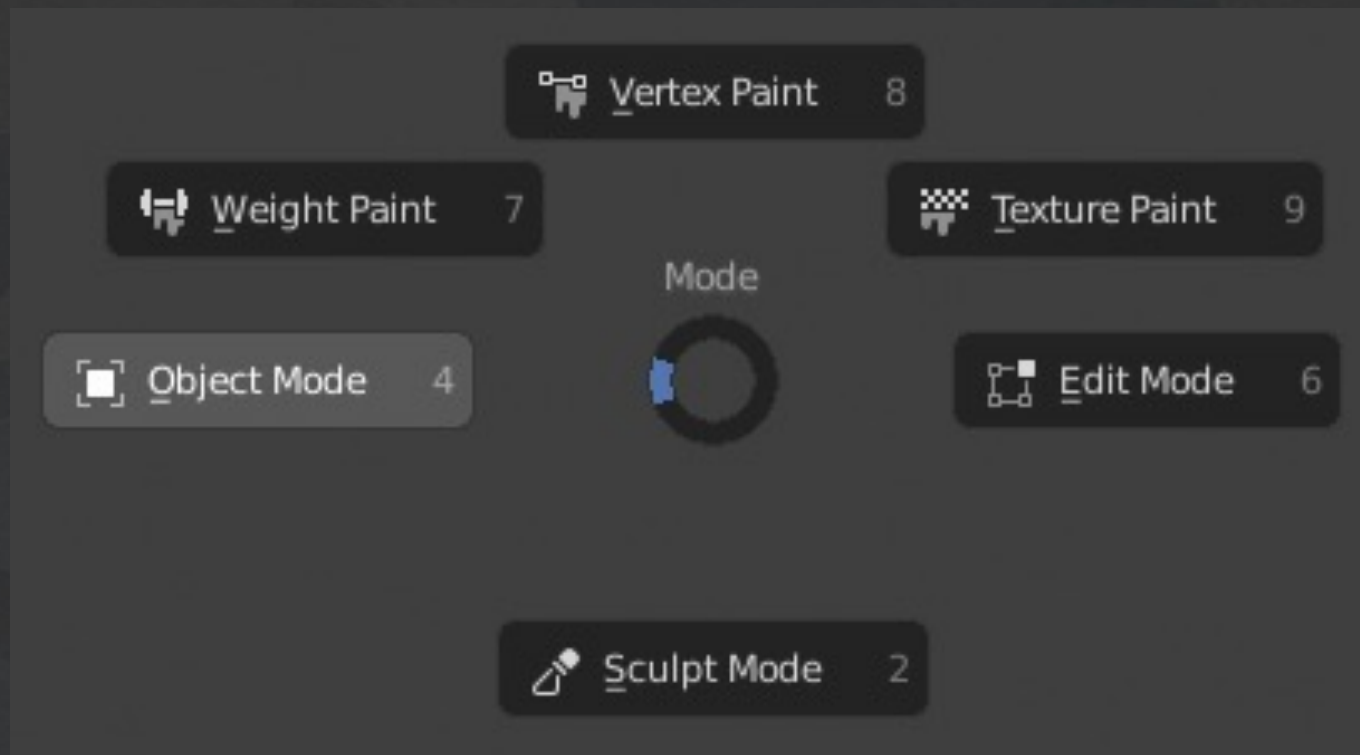
# Procreate QuickMenu (2020-present)

Radial menu for fast tool access on iPad



# Blender Pie Menus (2019-present)

Radial UI for faster modeling workflow



# Fusion 360 Marking Menu (c. 2014-present)

CAD radial gesture menu for 3D modeling



# Steam Input Radial Menu (2016-present)

Controller radial menu system for games



# Apple Watch Is a Negative Fitts' Law Example



# Apple Watch Is a Negative Fitts' Law Example



# Volunteer for Experiment

<https://faculty.washington.edu/chudler/java/ready.html>

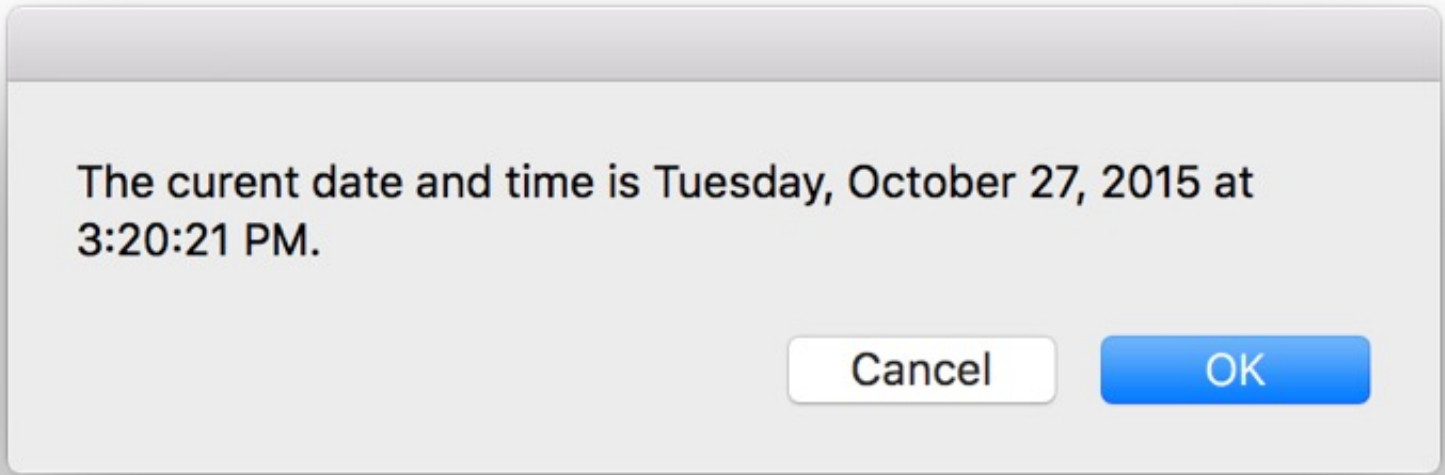
# Volunteer for Experiment

## Stroop Effect

- interference in your working memory

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

# Memory Interference in Action: *Cultural*



The curent date and time is Tuesday, October 27, 2015 at  
3:20:21 PM.

Cancel

OK

# Memory Interference in Action: *Cultural*

The curent date and time is Tuesday, October 27, 2015 at  
3:20:21 PM.

Cancel

OK

# Memory Interference in Action: *Labels/Terms*

\* LOA Fiscal Year:

\* LOA Name:

Agency / Editor: VO / Project

Project:

Task:

Expenditure Type:

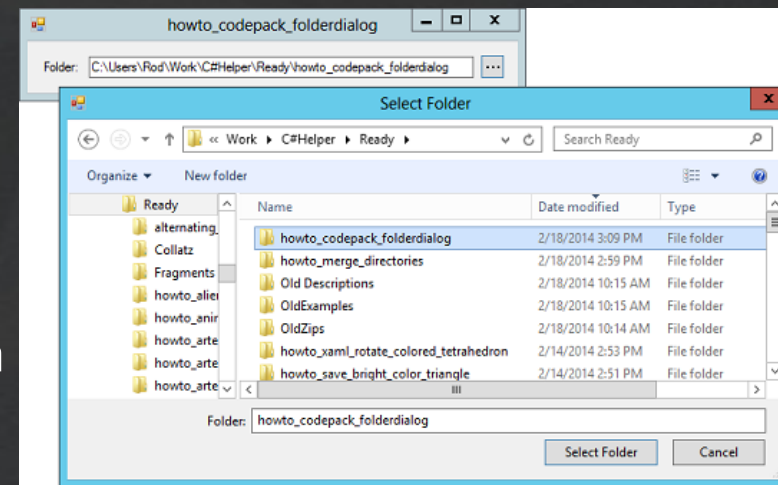
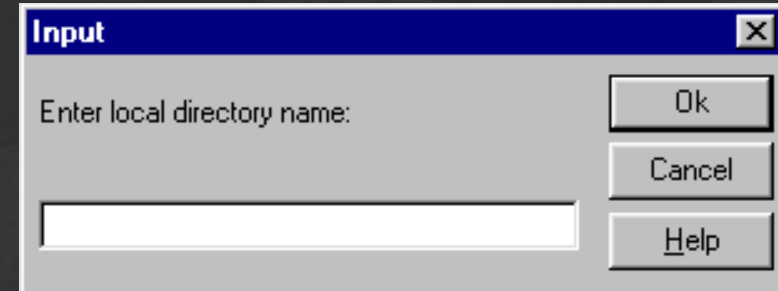
Expenditure Org:

# Memory

- Interference
  - two strong cues in working memory
  - link to different chunks in long term memory
- Why learn about memory?
  - know what's behind many HCI techniques
  - helps you understand what users will “get”
  - aging population of users

# Design UIs for Recognition over Recall

- Recall
  - info reproduced from memory
  - e.g., command name & semantics
- Recognition
  - presentation of info provides knowledge that info has been seen before
    - e.g., command in menu reminds you
  - easier because of cues to retrieval
    - cue is related to item or situation learned in
    - e.g., hints, icons, labels, menu names, etc.



# Human Abilities Summary

- Color can be helpful, but pay attention to
  - how colors combine
  - limitations of human perception
  - people with color deficiency
- Model Human Processor
  - perceptual, motor, cognitive processors + memory
  - model allows us to make predictions
- Memory
  - three types: sensory, WM & LTM
  - interference can make hard to access LTM
  - cues in WM can make it easier to access LTM
- Key time to remember from MHP: ~100 ms cycle time & memory access time

# Further Reading

## Vision and Cognition

- Books
  - *The Psychology Of Human-Computer Interaction*, by Card, Moran, & Newell, Erlbaum, 1983
  - *Human-Computer Interaction*, by Dix, Finlay, Abowd, and Beale, 1998.
  - *Perception*, Irvin Rock, 1995.
- Pages 66-99 of “Cognitive Aspects in Interaction Design”, from *Interaction Design*, 3rd Edition by Rogers, Sharp, & Preece
- Applying Fitts’ Law to Mobile Interface Design by Justin Smith

# Next Time

- Lecture
  - Visual Information Design
- Watch Scott Klemmer's HCIOnline lectures:
  - 6.1 Visual Design (7:37)
  - 6.2 Typography (10:47)
  - 6.3 Grids & Alignment (17:33)
- Studio
  - Low-fi presentations – what was surprising???
  - Sketching/Visual Design Exercise