# Human Abilities: Vision & Cognition

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Winter 2022

February 9, 2022

# Hall of Fame or Shame?

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



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
James

Last name
Landay

Username
james...landay                    @gmail.com

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

Use my current email address instead

Password
••••••••

Confirm
•••••••

Sign in instead          Next
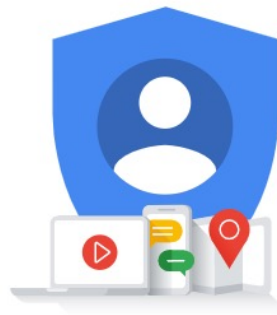
One account. All of Google working for you.

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 no humor

# Hall of Fame or Shame?

# Hall of Shame!



## Like

- error message prominent with different color & shape

## Wish

- where is the error?
- what's wrong with it?
- parse & fix it yourself!

# Hall of Shame!



**Contact Information**

**Our Customer Loyalty Team is available 24/7 on all support channels for anything you need!**

**1. CALL the Zappos Customer Loyalty Team:**
1-800-927-7671

**2. TEXT the Zappos Customer Loyalty Team:**
Text CHAT to 1-833-927-7898 to chat with the Zappos Customer Loyalty Team by text.

By texting CHAT, you consent to receive text messages (including automated and marketing messages) from or on behalf of Zappos at your mobile number provided. Consent is not a condition of any purchase. Text STOP to end your chat. Message & data rates may apply.

**3. CONNECT WITH LIVE HELP:**
Ask your question right now with a member of the Zappos Customer Loyalty Team.
Go ahead - start a conversation now!

**Frequently Asked Questions:** Answers to our most commonly asked questions: Frequently Asked Questions
Haga click aquí para preguntas frecuentes en español

**ADDITIONAL INQUIRES:**
**Brand Inquiries:**
Feature your brand on the website! Please direct all brand inquiries via email to: merchinitiatives@zappos.com.

**Press Inquiries:**
Please direct all media inquiries via email to: pr@zappos.com

## Update (today)

- no longer have that form
  (uses phone, SMS, live chat)

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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*
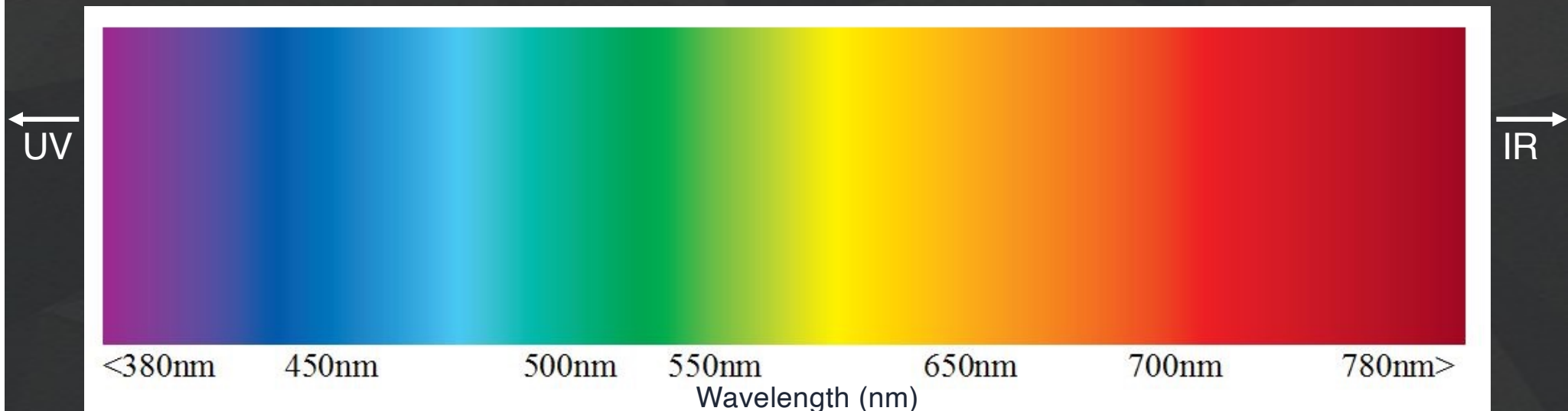


*But remember, **do not use that ordering** to order data!*
*(recall Tufte's example of how unusable a map is using this ordering for elevation)*

# Human Visual System



Cross section of Human Eye

Light — Electric signal

http://obsessive-coffee-disorder.com/wp-content/uploads/2014/11/eye1.jpg
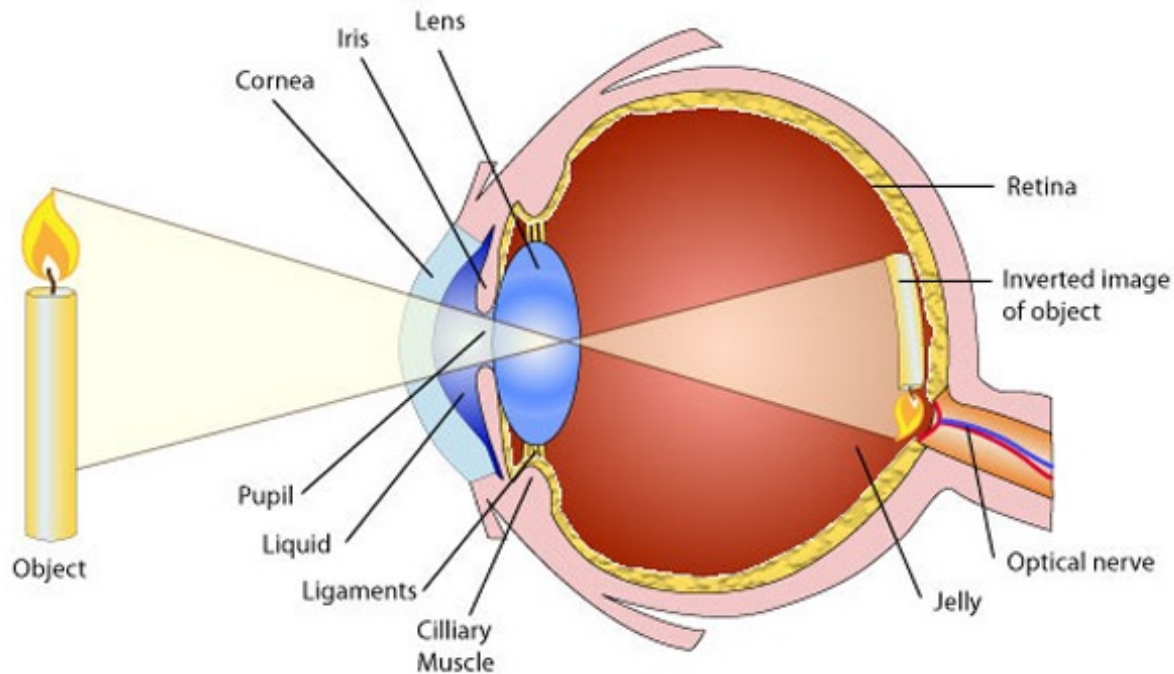
- Light passes through lens

- 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 to intensity or shades of gray

  - cones
    - used to sense color



http://www.webexhibits.org/causesofcolor/1G.html
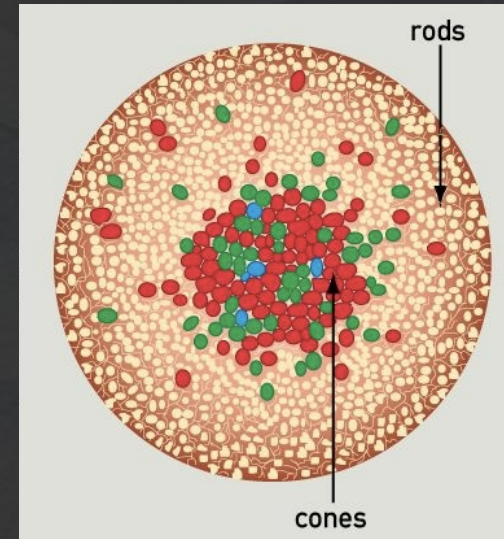
# Retina

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



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

http://webvision.med.utah.edu/imageswv/Ostergr.jpeg

Fig. 20. Graph to show rod and cone densities along the horizontal meridian.
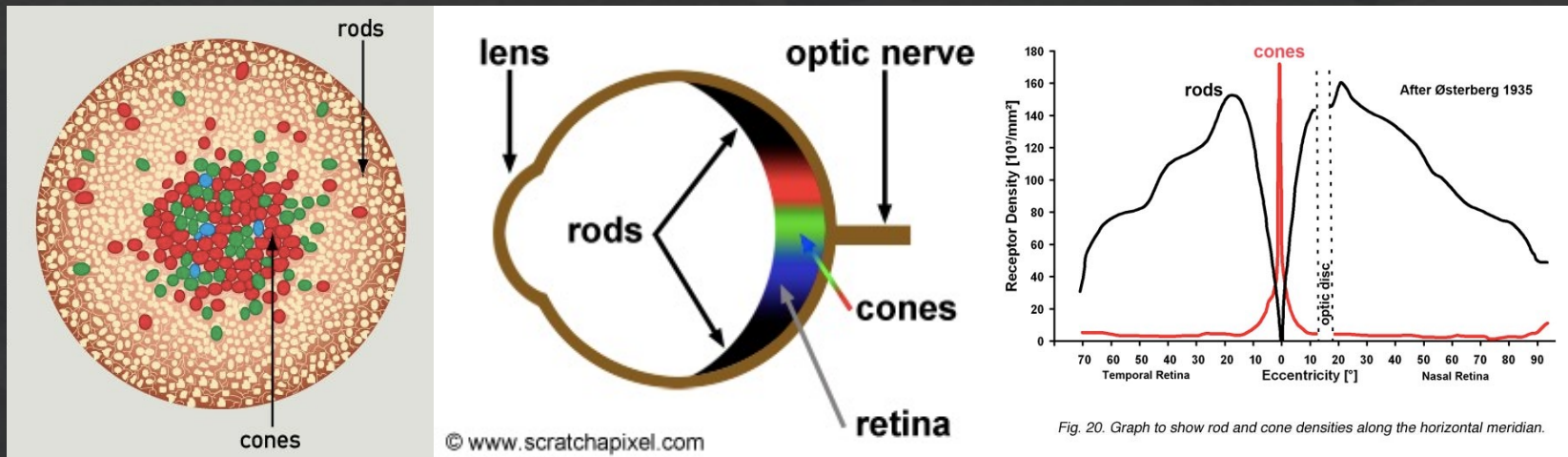
- Edge of retina is dominated by rods →
  - allows detecting motion of threats in periphery

# 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
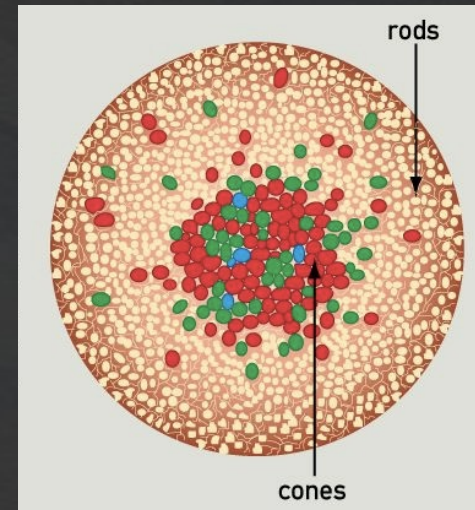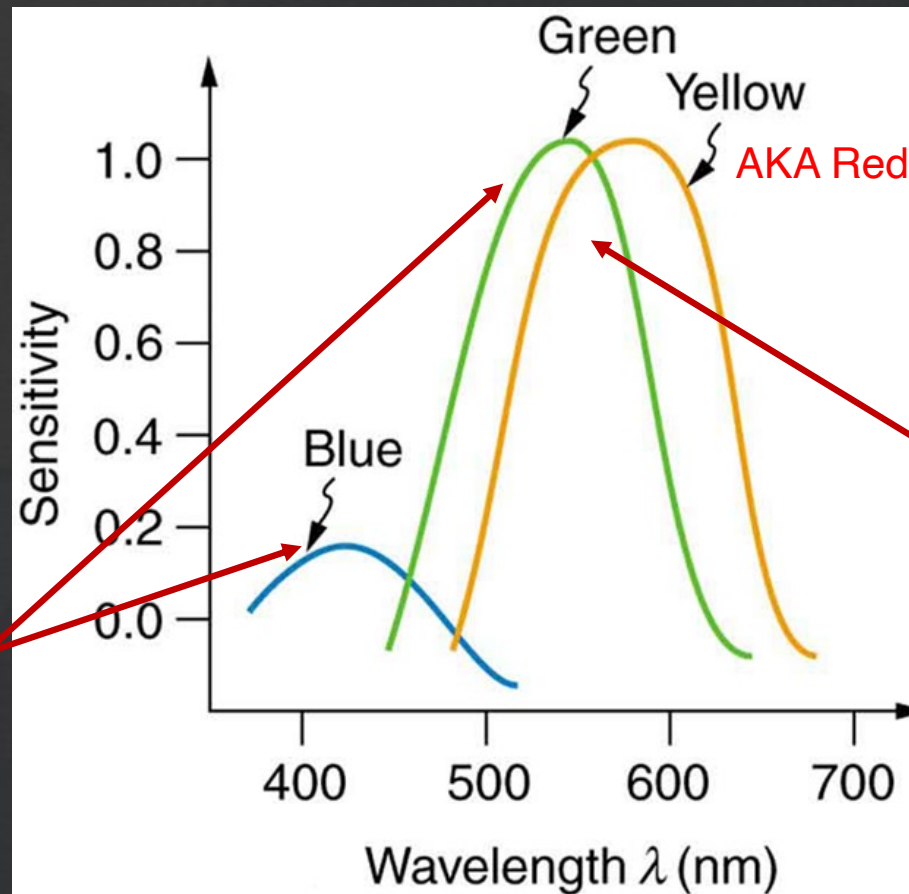
# Color Sensitivity



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

# Color Sensitivity



http://retina.umh.es/webvision/imageswv/spectra.jpeg
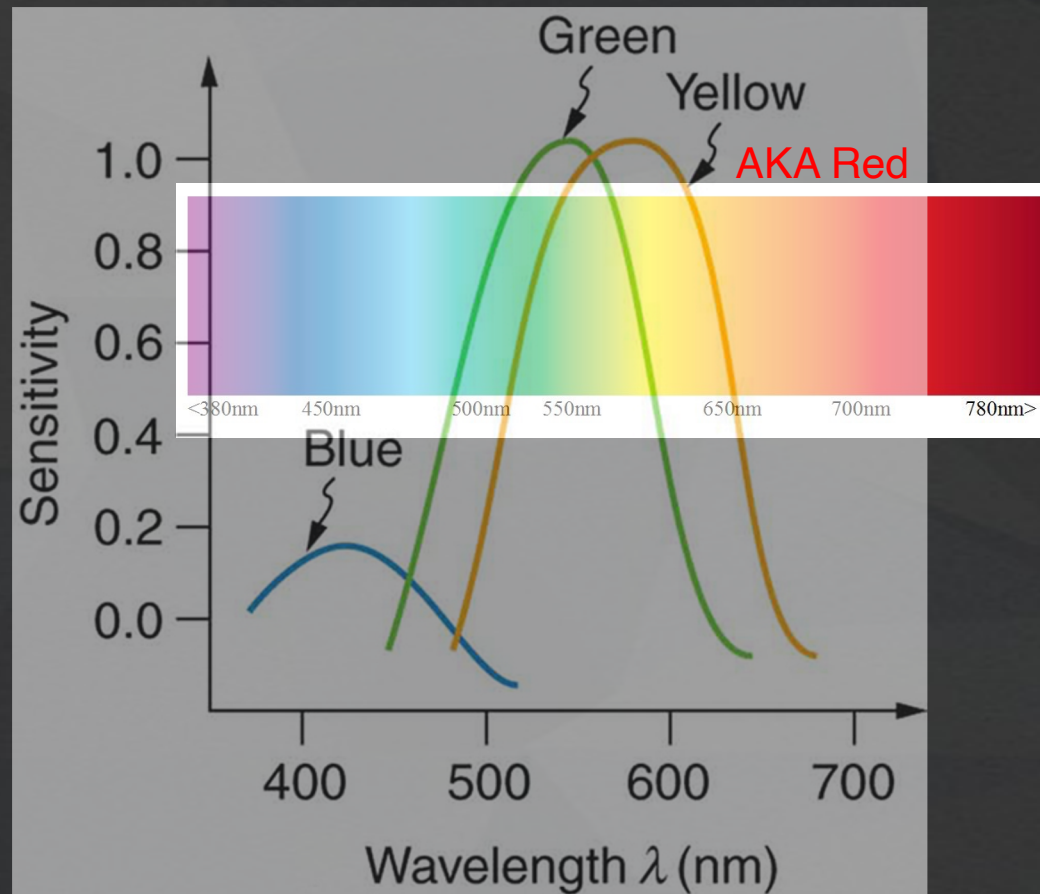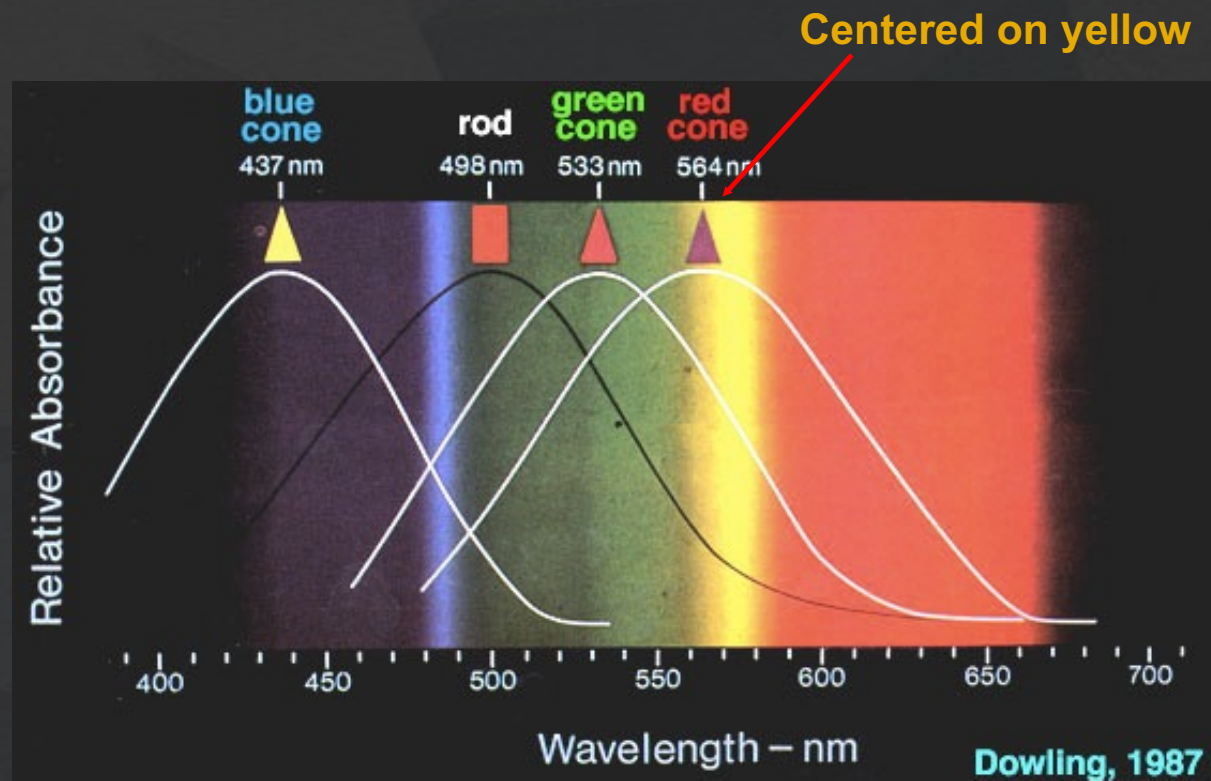
# Distribution of Photopigments

- 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!
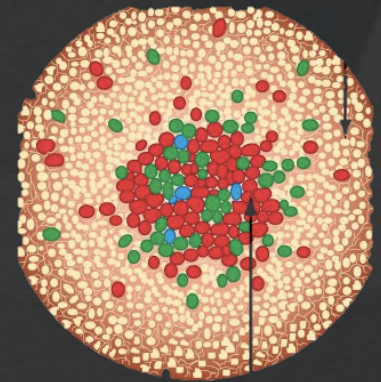
http://www.webexhibits.org/causesofcolor/1G.html

# Focus

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

# Focus

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



additive color mixing

green
yellow
cyan          white          red
blue          magenta

https://physics.info/color/

# Focus

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



Background is a bright, saturated color

**Sign Up**

Button is a bright, saturated color

**Sign Up**

✗ Attracts attention to background　　✓ Attracts attention to button

saturated　　　　desaturated

# Color Deficiency
# (Also known as "color blindness")

- Trouble discriminating colors
  - besets about 4.5% of population (~8% men, ~.5% women)
- Two main types
  - different photopigment response most common
    - reduces capability to discern small color diffs
  - red-green deficiency is best known
    - lack of either green or red photopigment → can't discriminate colors solely dependent on Red & Green

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!



bad →  The Falklands Society
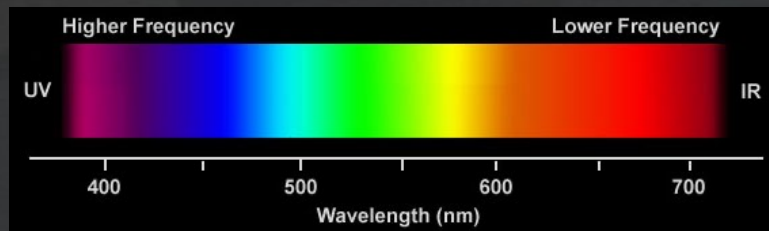
- desaturated combinations are better → pastels

# Use the Hue Circle

Pick non-adjacent colors

– opponent colors
go well together

red & green

or

yellow & blue
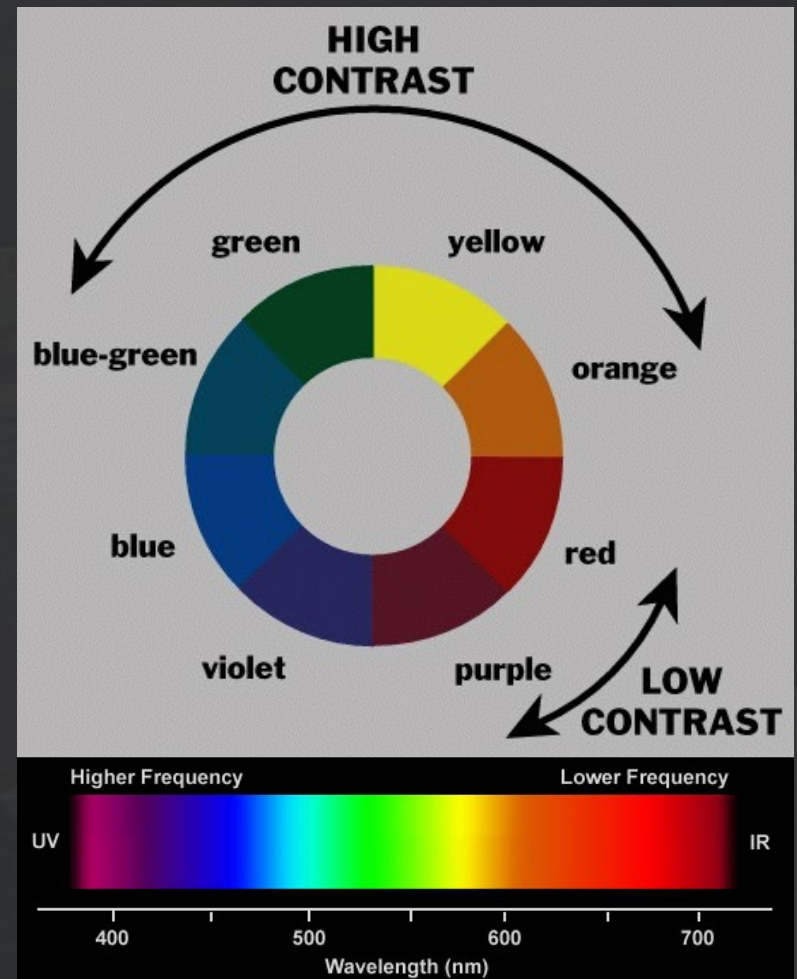
# Color Guidelines (cont.)



- Avoid pure blue for text, lines & small shapes
- Avoid adjacent colors that differ only in blue

- Blue makes a great background color

# Color Guidelines (cont.)

- Size of detectable changes in color varies
  - hard to detect changes in reds, purples, & greens
  - easier to detect changes in yellows & blue-greens
  - older users need higher brightness levels

- Hard to focus on edges created by only color
  - use both brightness & color differences

- Avoid single-color distinctions
  - mixtures of colors should differ in 2 or 3 colors
  - helps color-deficient observers

# Administrivia

| Feb 7–11 | Accessible Design Workshop Saturday, Feb. 12 | Designing the Future: Early and Future Visions of HCI (PPT) (Recording) As We May Think by Vannevar Bush Tools For Thought (Ch 9), Engelbart Demo Listen and Read: Of Mice and Men, 99% Invisible, Episode 149 (21 minutes) | Human Abilities (PPT) "Cognitive Aspects in Interaction Design", pages 66-99 from Interaction Design, 3rd Edition by Rogers, Sharp, & Preece Listen: Wait Wait... Tell Me!, 99% Invisible, Episode 369 (36 minutes) | Midterm Review |
| --- | --- | --- | --- | --- |
| Feb 14–18 | A7 Heuristic Evaluation (individual) due by studio (Feb 17-18) A8 Hi-fi Prototype (group) Midway due by studio week 9 (Mar 3-4) Complete due by studio week 10 (Mar 10-11) Writeup due Saturday Mar 12 | Heuristic Evaluation (with in-class exercise) (PPT) How to Conduct a Heuristic Evaluation by Jakob Nielsen | Conceptual Models and Interface Metaphors (PPT) "The Psychology of Everyday Things" (Ch 1) from The Design of Everyday Things by Donald Norman Midterm Review (Evening Thurs 2/17) (PPT) | A9 Heuristic Evaluation due end of studio day (Feb 17-18 @ 11:59PM) |
| Feb 21–25 | | Presidents' Day (No Class) | Midterm | Project Group Work |

# Administrivia

| | | | | |
|---|---|---|---|---|
| **Feb 28–Mar 4** | A10 Poster and Pitch Slide (group)<br><br>Draft due Monday Mar 7<br>Final due Wednesday Mar 9 | 1) Usability Testing (PPT)<br>2) Accessibility (PPT)<br><br>Optional: Inclusive Design<br><br>Optional: "Disability Studies as a Source of Critical Inquiry for the Field of Assistive Technology" | Design Patterns (PPT)<br><br>The Design of Sites by van Duyne, Hong, & Landay:<br>1) "Making the Most of Web Design Patterns" (Ch 2)<br>2) "Up-Front Value Proposition" (Pattern C2)<br>3) "Process Funnel" (Pattern H1)<br>4) "Meaningful Error Messages" (Pattern K13) | A8 Presentation<br><br>Project Group Work |
| **Mar 7-11** | | Guest Q&A<br>Tracy Chou (Stanford '09/'10), CEO at Block Party | Smart Interfaces for Human-Centered AI (PPT) | 30-Second Pitch and Demo Practice<br><br>Project Expo (PPT) |

## Final Due Items

Students are required to attend the **project expo on Friday Mar 11 at 6:00-9:30 PST. Final writeups are due Mar 12.**

# Administrivia

- Final workshop – Accessibility – Saturday at 1PM
  - we will be giving a few bonus points for projects that do a good job of addressing accessibility
- Watch the previous two (Figma Basics & Design Systems) if you have not already (links on the calendar)

# TEAM BREAK

# The Model Human Processor

Developed by Card, Moran & Newell ('83)

– based on empirical data
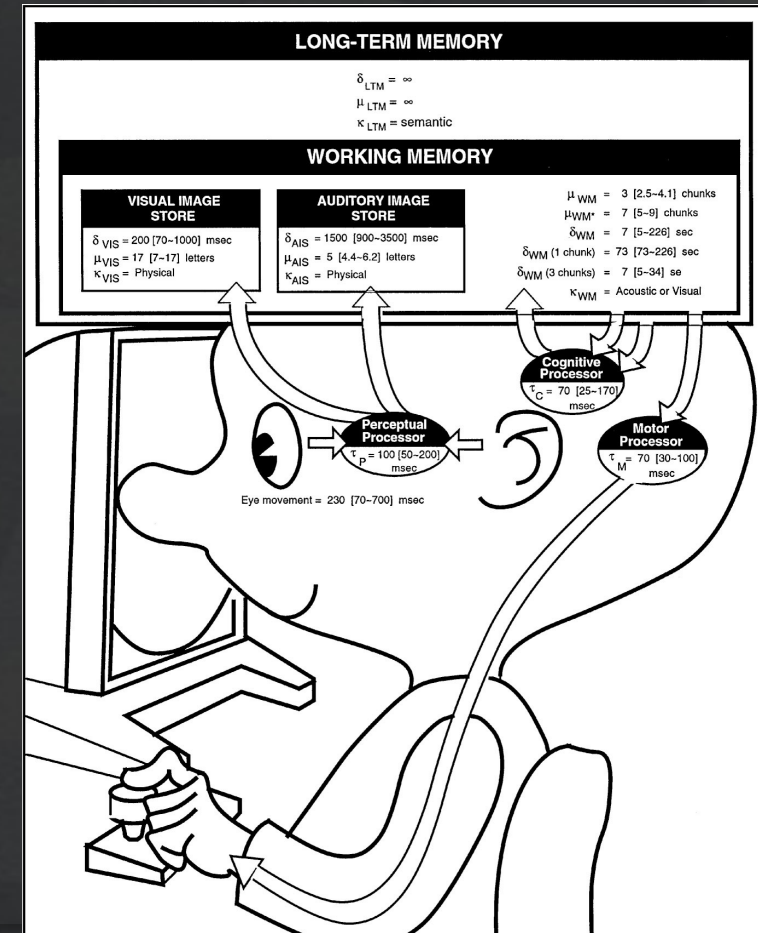
# The Model Human Processor
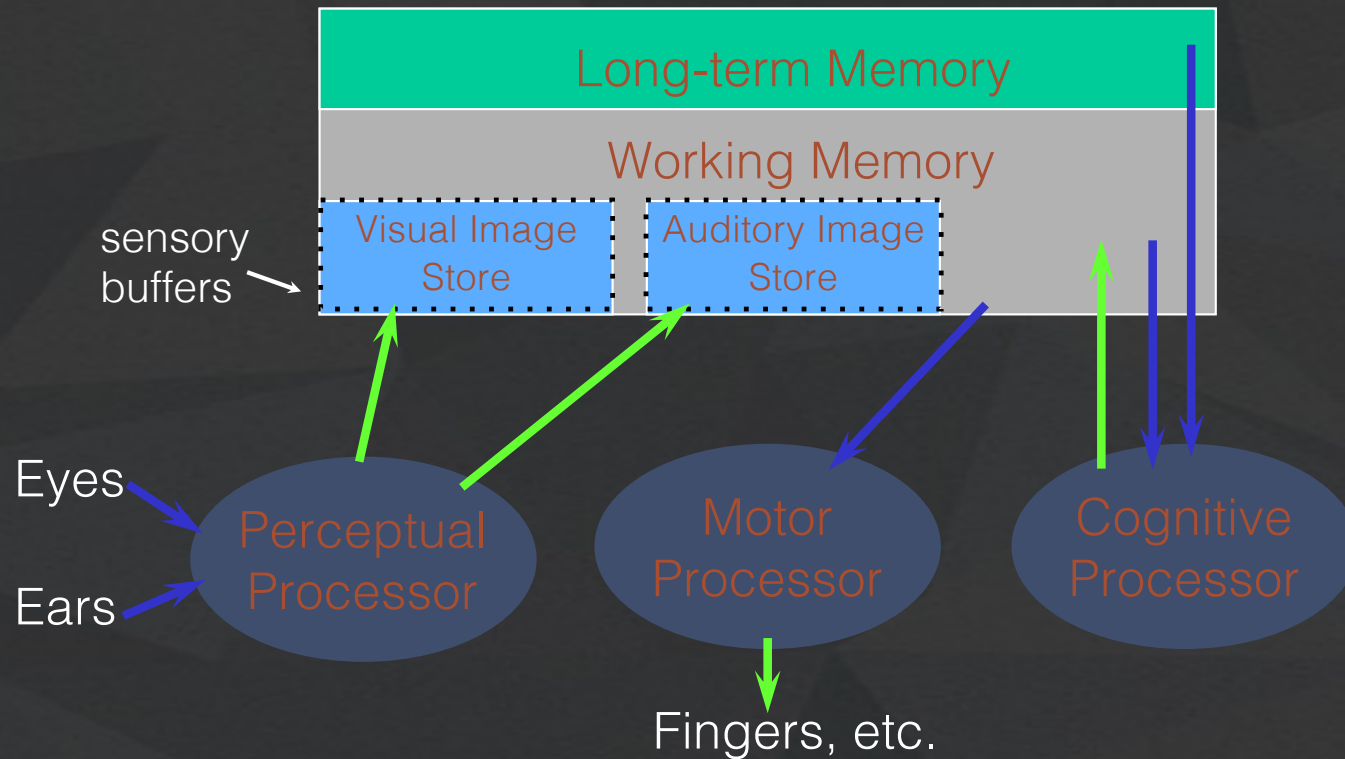
# MHP Basics

- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
    - pressing key in response to light (serial)
    - driving, reading signs & hearing at once (parallel)

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

# What is missing from MHP?
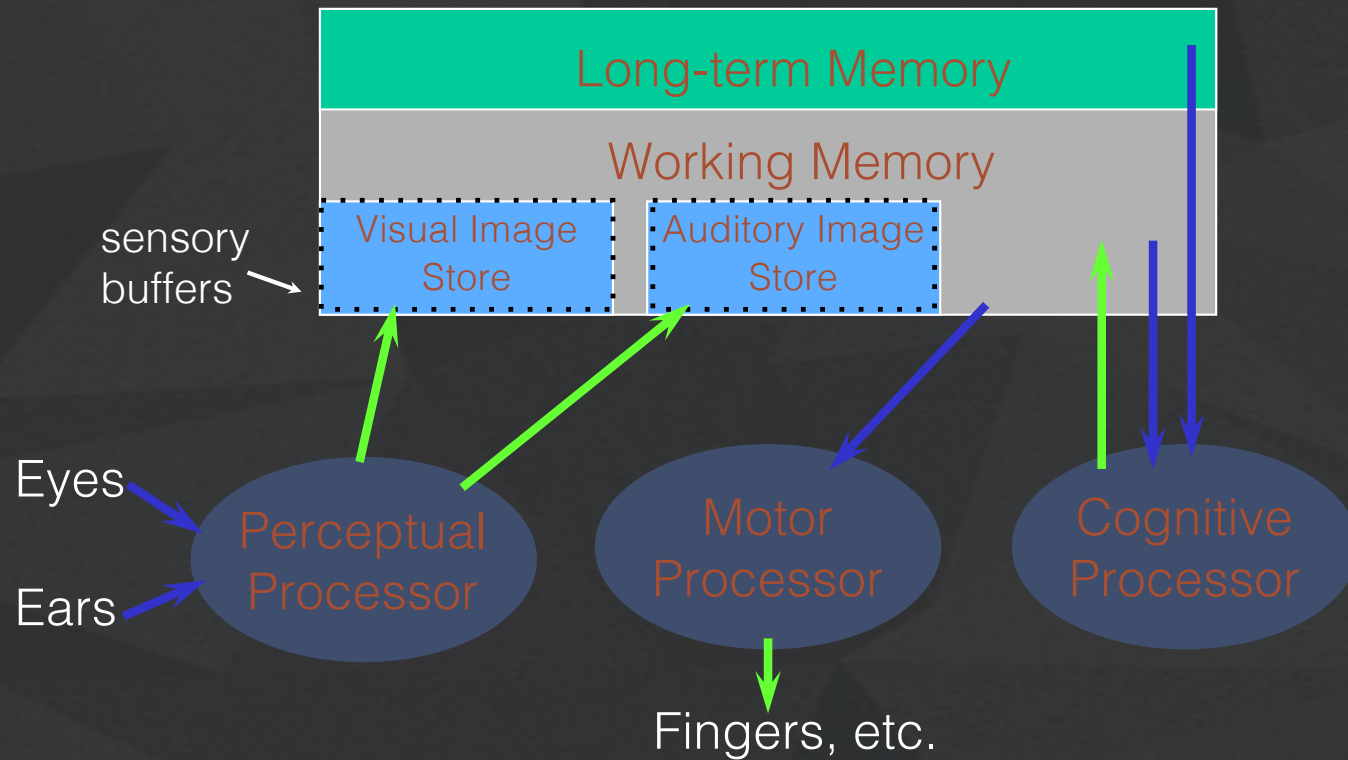
# What is missing from MHP?



- Haptic memory
  - for touch

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

- Moving from WM to LTM
  - elaboration
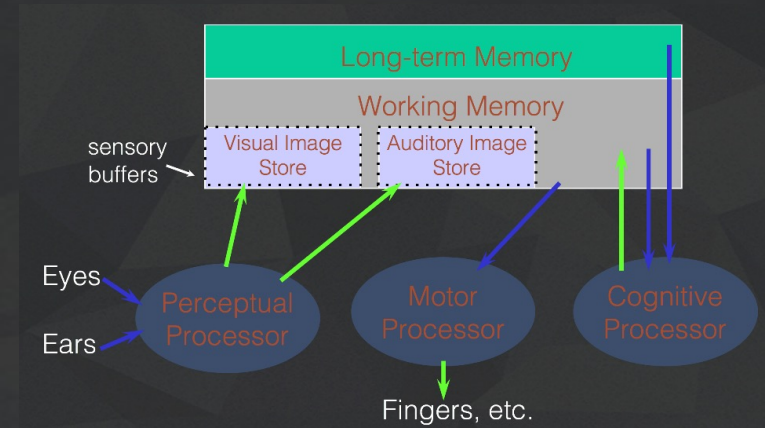
" I'm having trouble with my short term memory... ...
I'm here b'coz of my short term memory... ...
I 'd like to talk to you about my short term memory..."

# Memory

- Working memory (short term)
  - small capacity (7 ± 2 "chunks")
    - 6174591765 vs. (617) 459-1765
    - NBCIBMGMC vs. NBC IBM GMC
  - rapid access (~70ms) & decay (~200 ms)
    - pass to LTM after a few seconds of continued storage

- Long-term memory
  - huge (if not "unlimited")
  - slower access time (~100 ms) w/ little decay
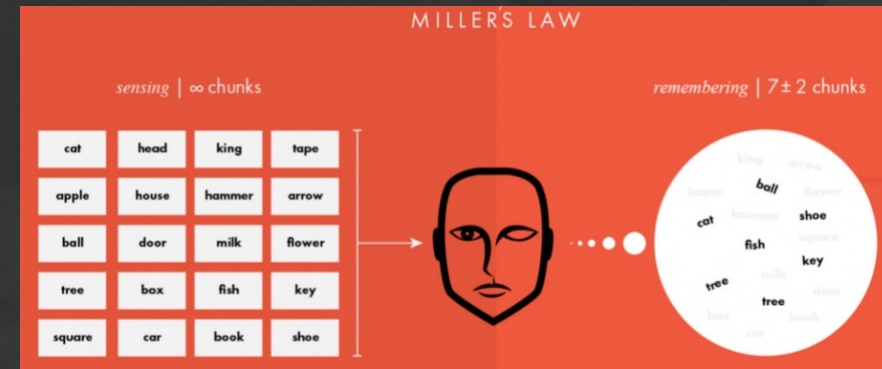


MILLER'S LAW

sensing | ∞ chunks

remembering | 7 ± 2 chunks

# MHP Principles of Operation

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

# MHP Principles of Operation
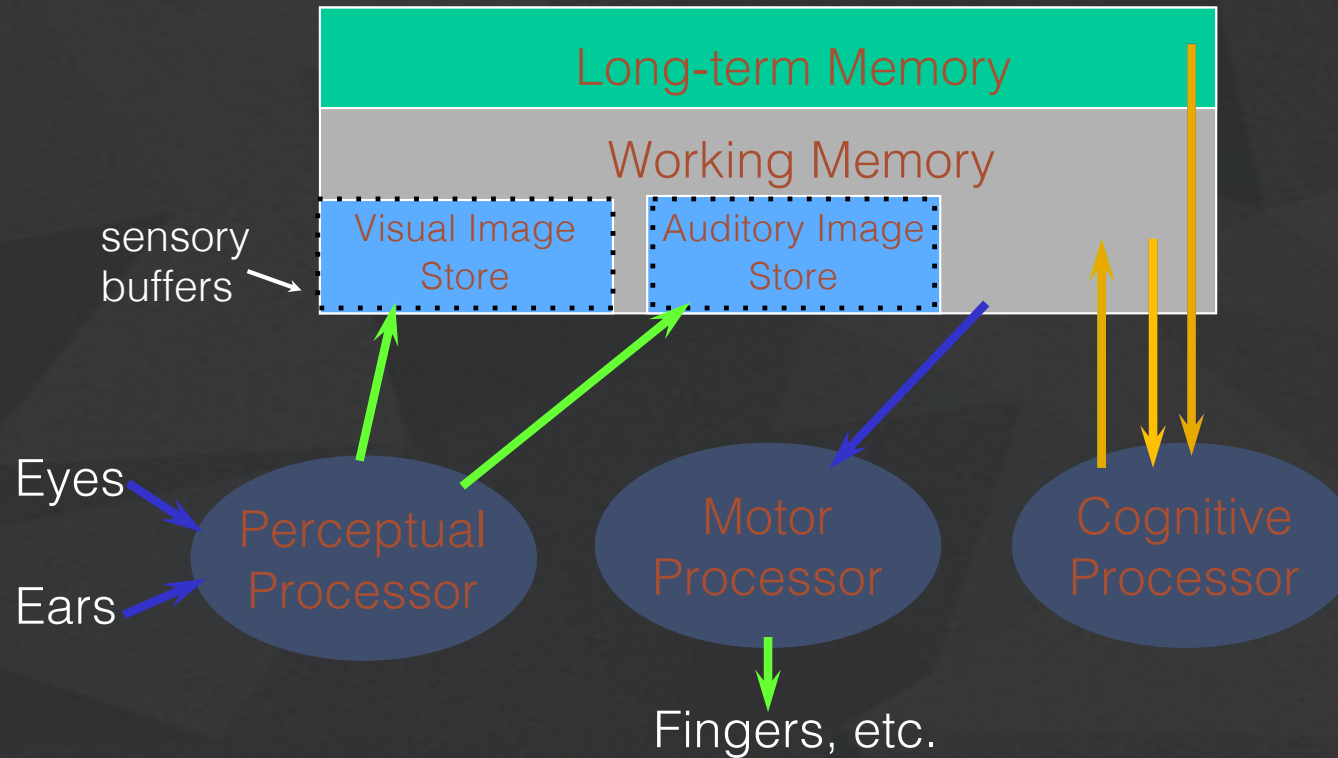
# MHP Principles of Operation

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

# Volunteer for Experiment

# http://simonwallner.at/ext/fitts/

# Volunteer for Experiment

## http://simonwallner.at/ext/fitts/

# Volunteer for Experiment
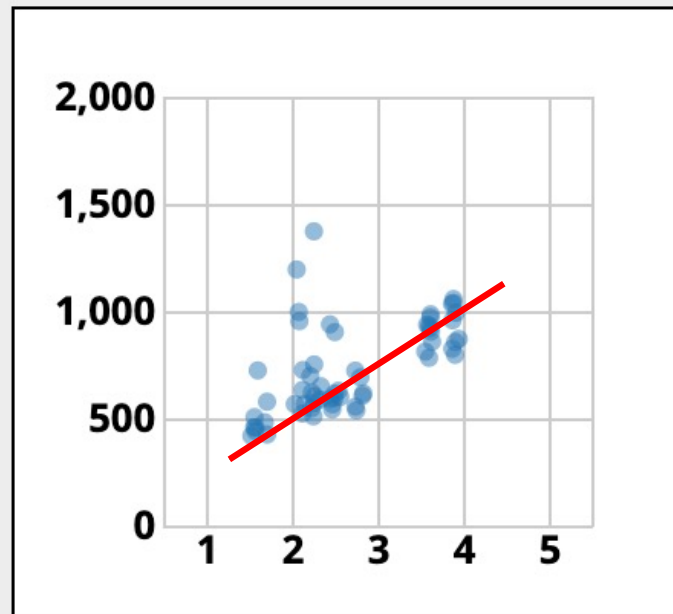


fig. 1e: Time in ms over ID.

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

# 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

- Task:

  Quickly tap each target 50 times accurately

# Experimental Results (last year)

- Task:

    Quickly tap each target 50 times accurately
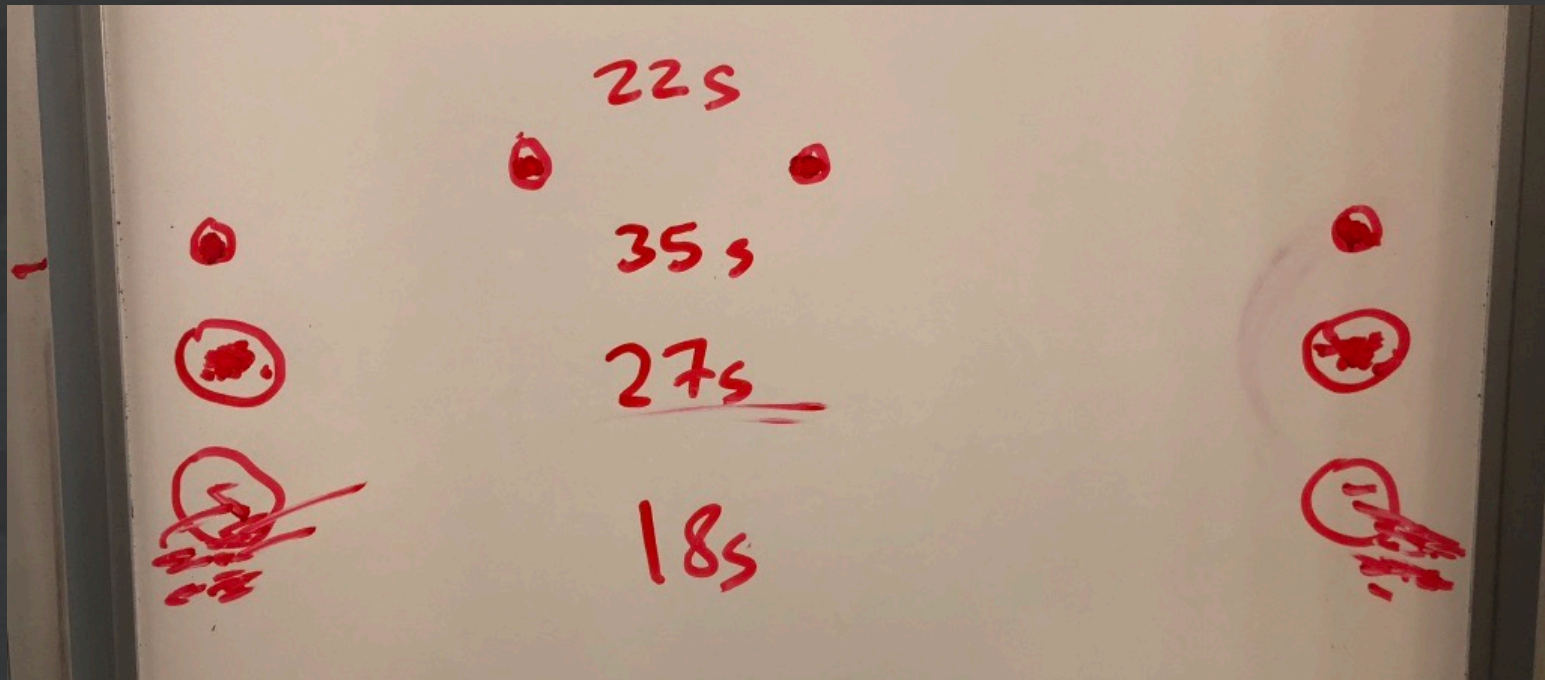
# Experimental Results (2 years ago)

- Task:

  Quickly tap each target 50 times accurately



30 sec

48 sec

31 sec

21 sec (lots of spread)
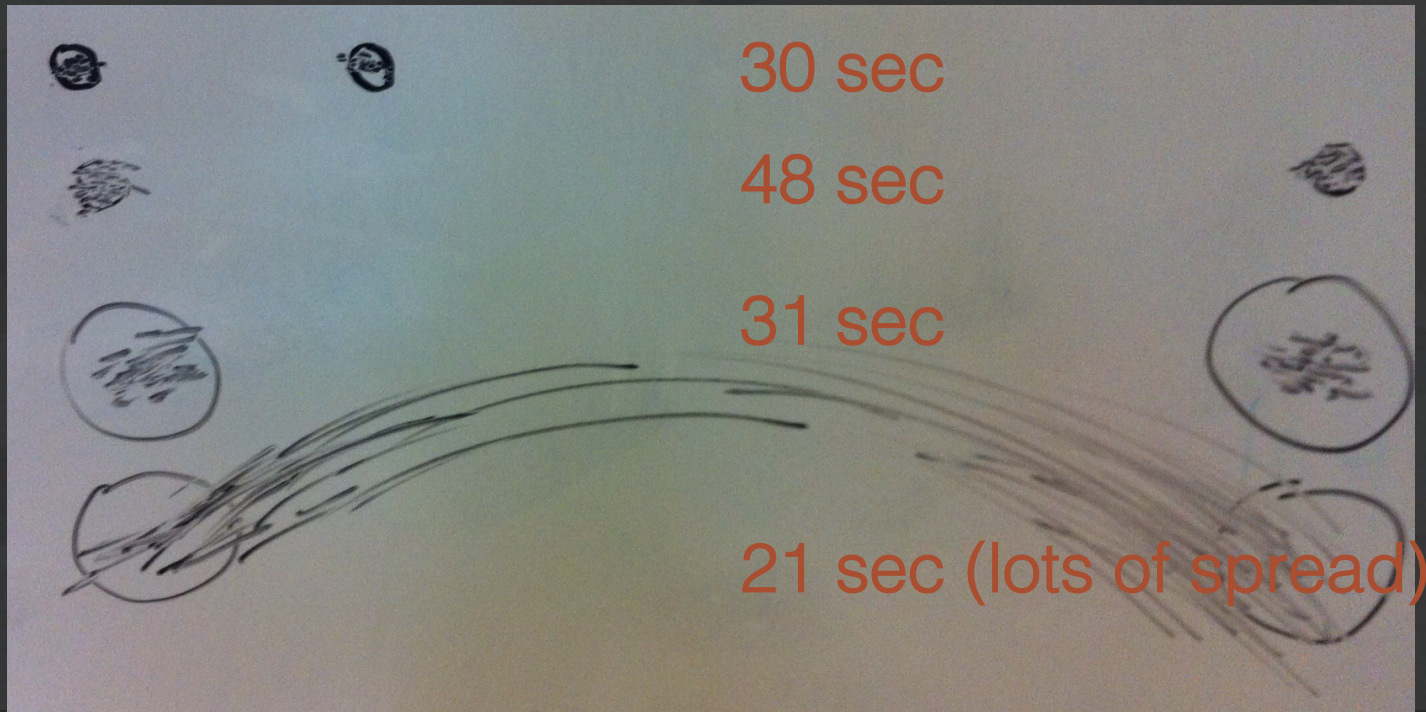
# Experimental Results (3 years ago)

- Task:

  Quickly tap each target 50 times accurately



dt+UX: Design Thinking for User Experience Design, Prototyping & Evaluation
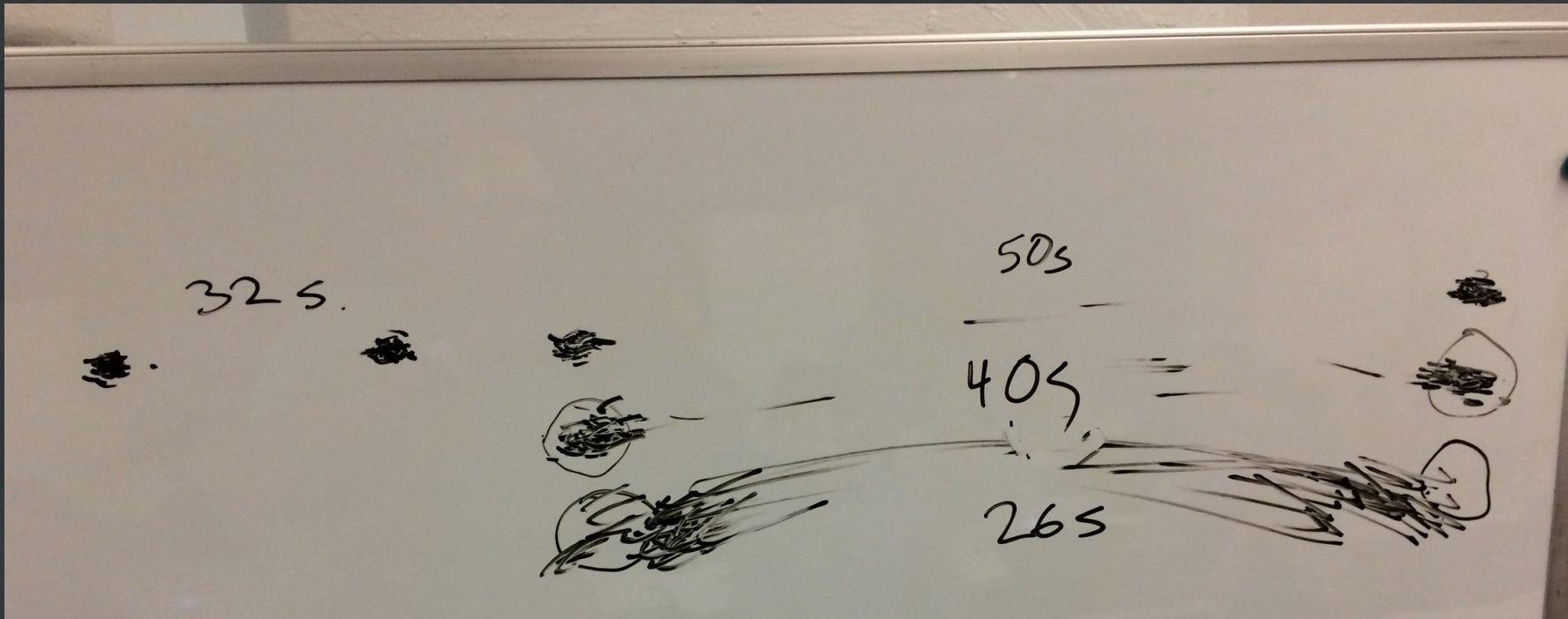
# Principles of Operation (cont.)

Fitts' Law

- moving hand is a series of microcorrections
  - correction takes Tp + Tc + Tm = 240 msec
- time Tpos to move the hand to target size S, which is distance D away is given by:

  Tpos = a + b log2 (D/S + 1)


- summary
  - time to move the hand depends only on the *relative precision* 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
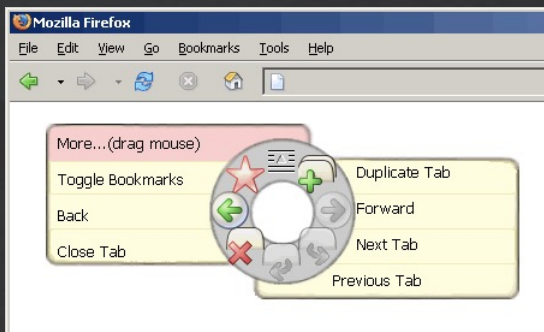
Maya
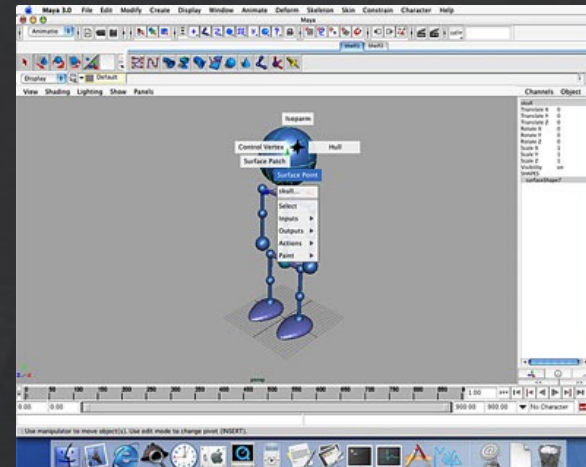
# Apple Watch Is a Negative Fitts' Law Example
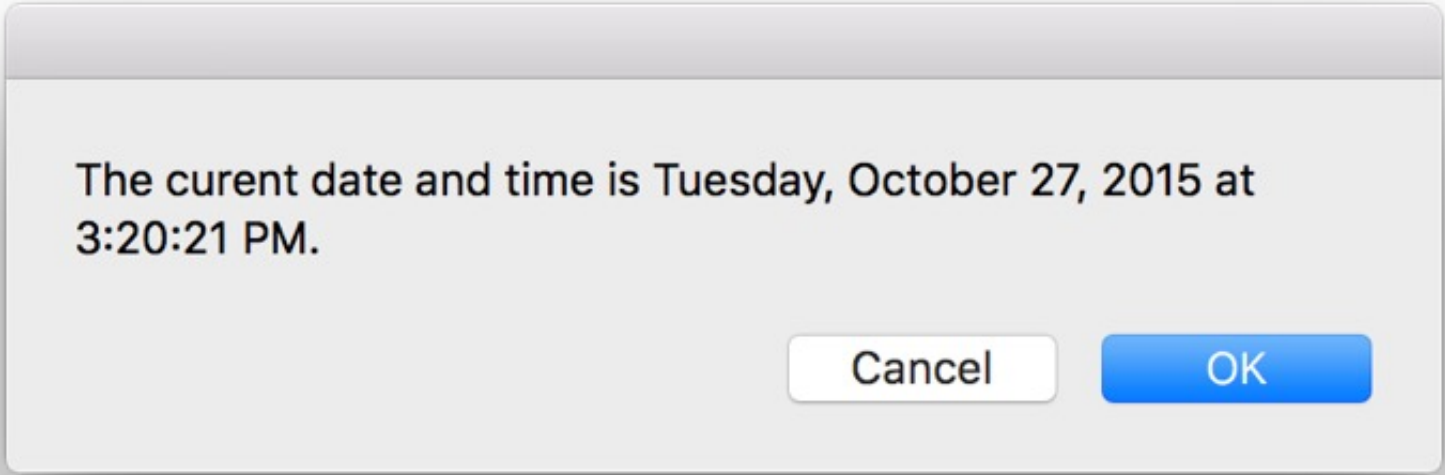
# Apple Watch Is a Negative Fitts' Law Example

# Volunteer for Experiment
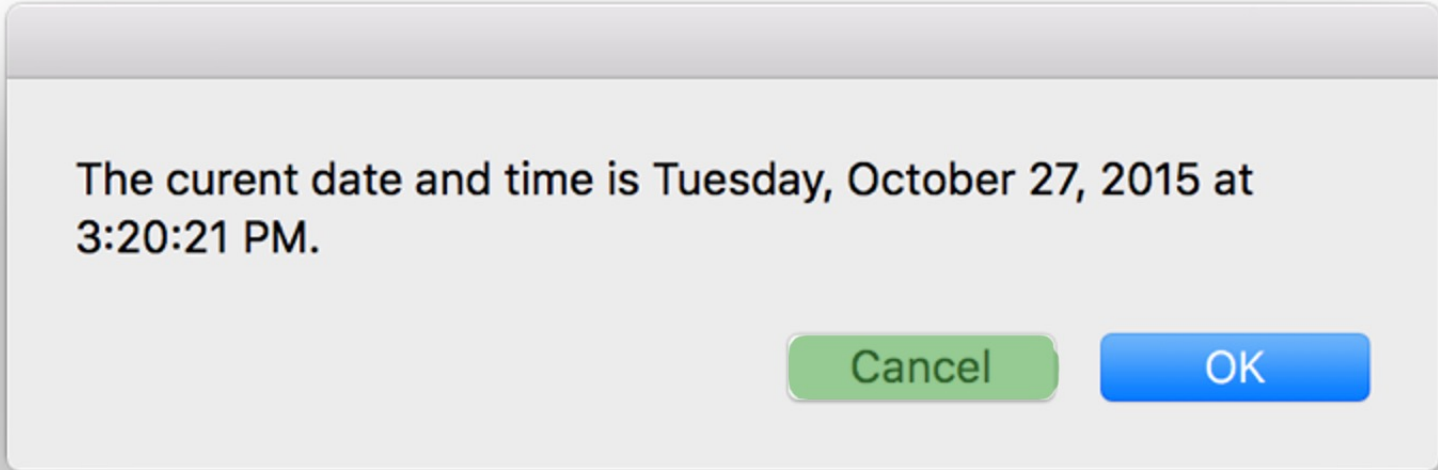
https://faculty.washington.edu/chudler/java/ready.html

dt+UX: Design Thinking for User Experience Design, Prototyping & Evaluation

# 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*

# Simple Experiment

- Volunteer
- Start saying *colors* you see in list of words
  - when slide comes up
  - as fast as you can
- Say "done" when finished
- Everyone else time it...

Paper
Home
Back
Schedule
Page
Change

# Simple Experiment

- Do it again
- Say "done" when finished

Bandana
Forward
Home
Test
Basket
Paper

# Simple Experiment

- Do it again
- Say "done" when finished

<span style="color:red">Yellow</span>

<span style="color:blue">White</span>

<span style="color:yellow">Black</span>

<span style="color:green">Blue</span>

<span style="color:black">Red</span>

<span style="color:white">Green</span>
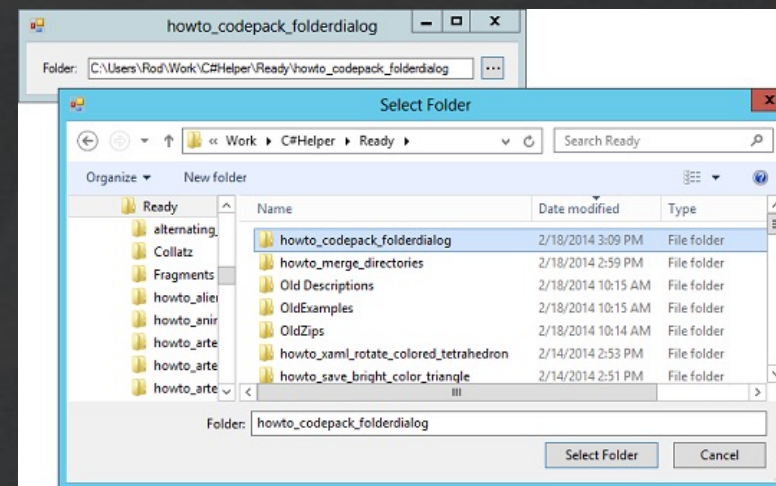
# Memory

- 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.
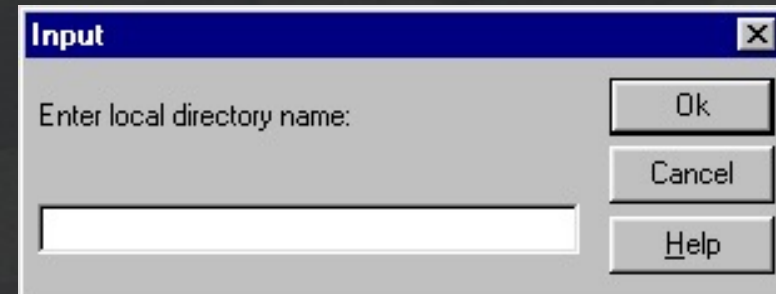
# Human Abilities Summary

- 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
  - Heuristic Evaluation

- ## Read
  - <u>How to Conduct a Heuristic Evaluation</u> by Jakob Nielsen

- ## Studio
  - Midterm review
  - Medium-fi prototype feedback from TAs