Human Abilities: Vision & Cognition

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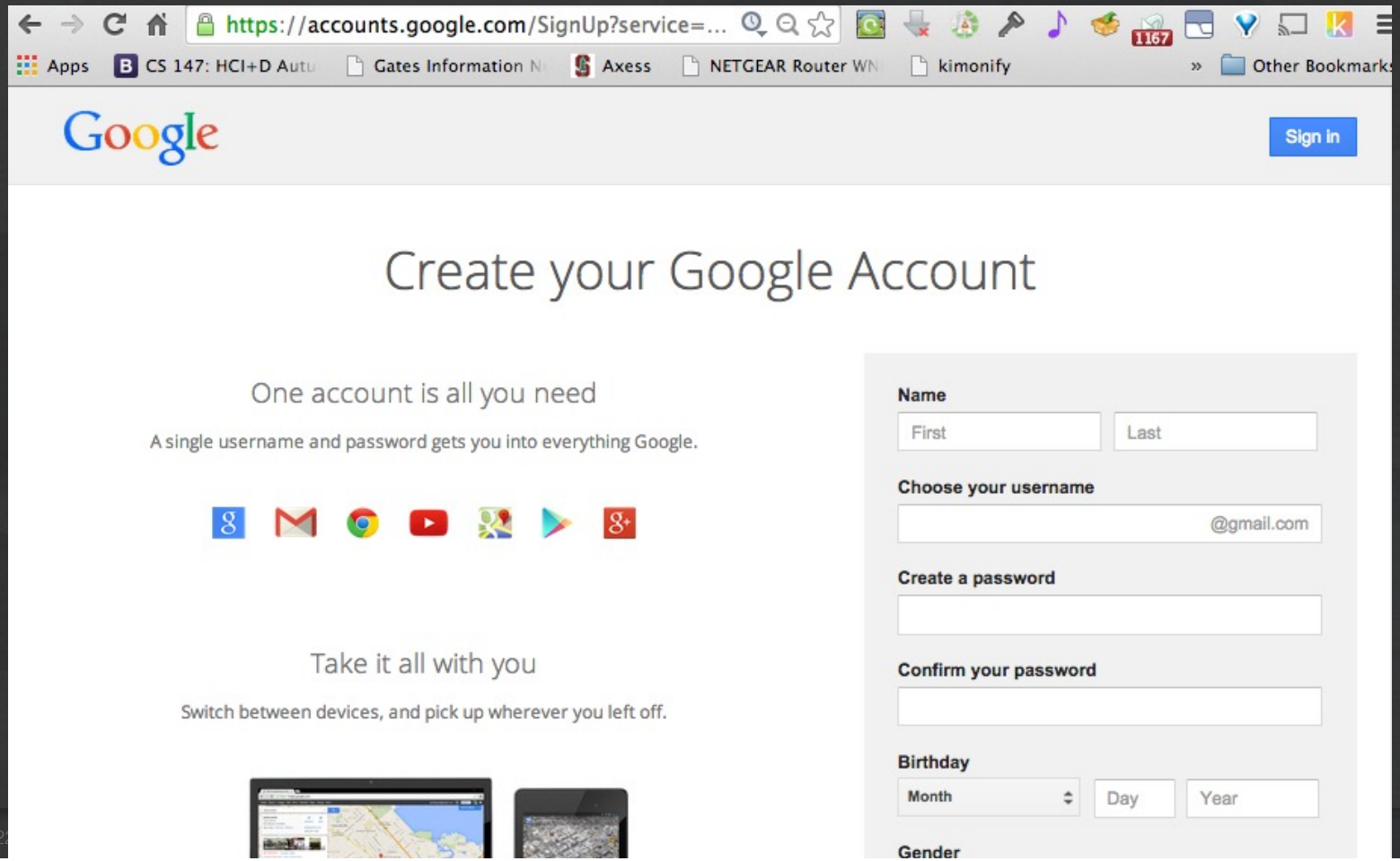
Autumn 2022

November 2, 2022

Hall of Fame or Shame?



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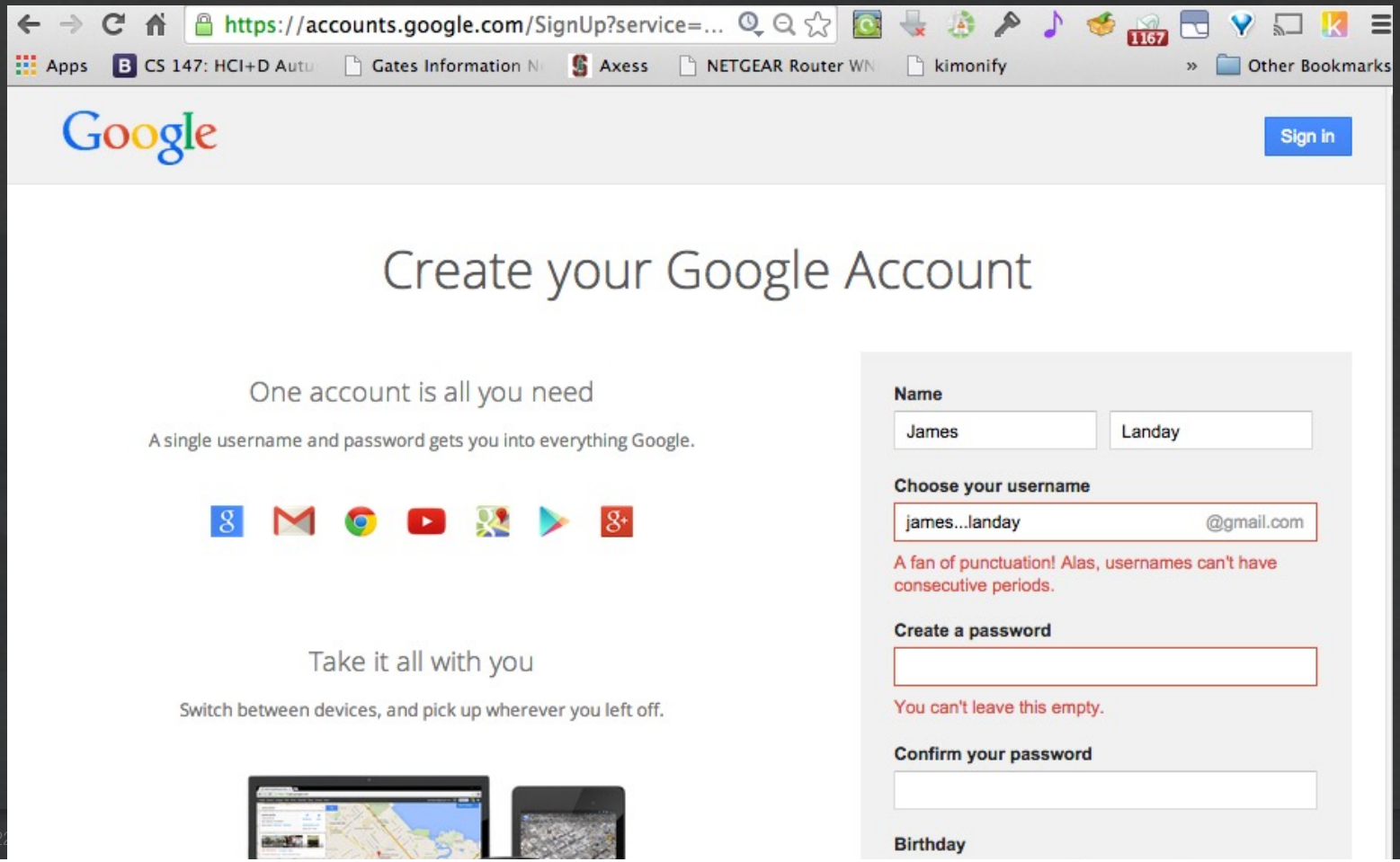
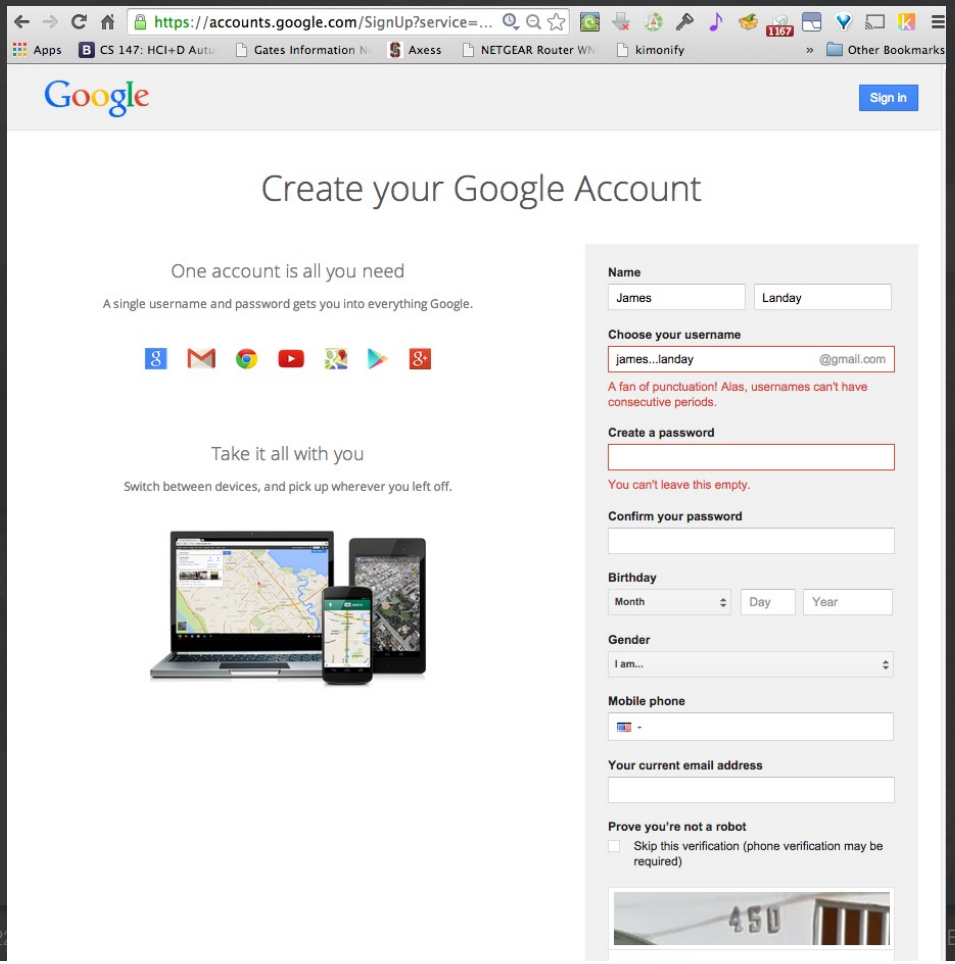


Hall of Fame! (but still some issues…)



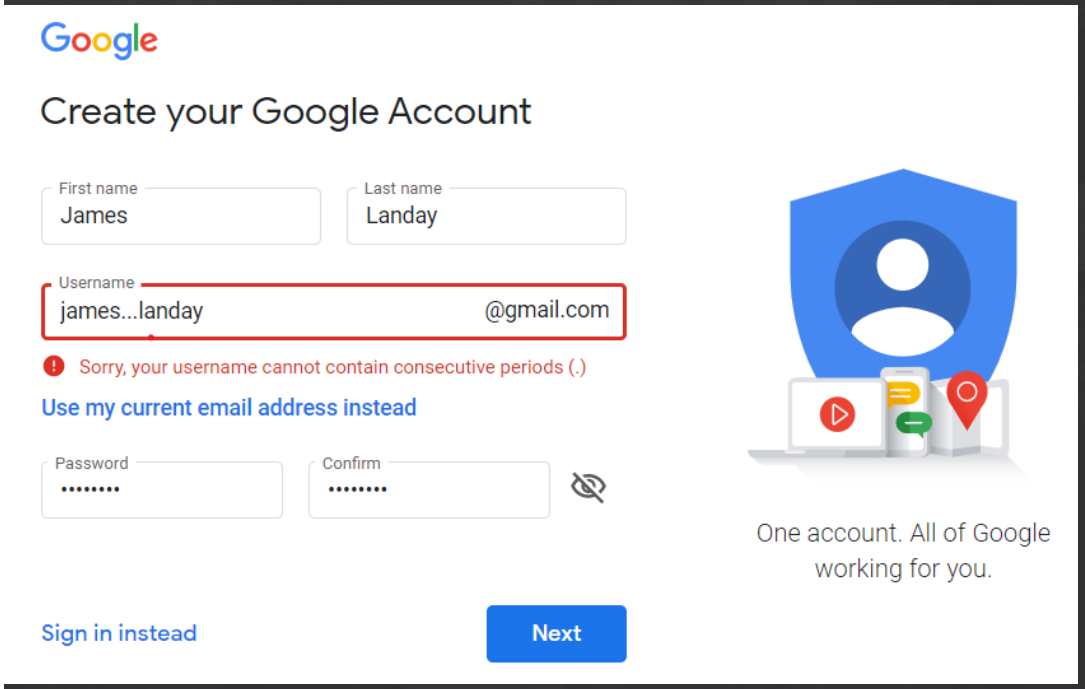
Clearly highlights error (red text & box)

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!



Clearly highlights error (red text & box)

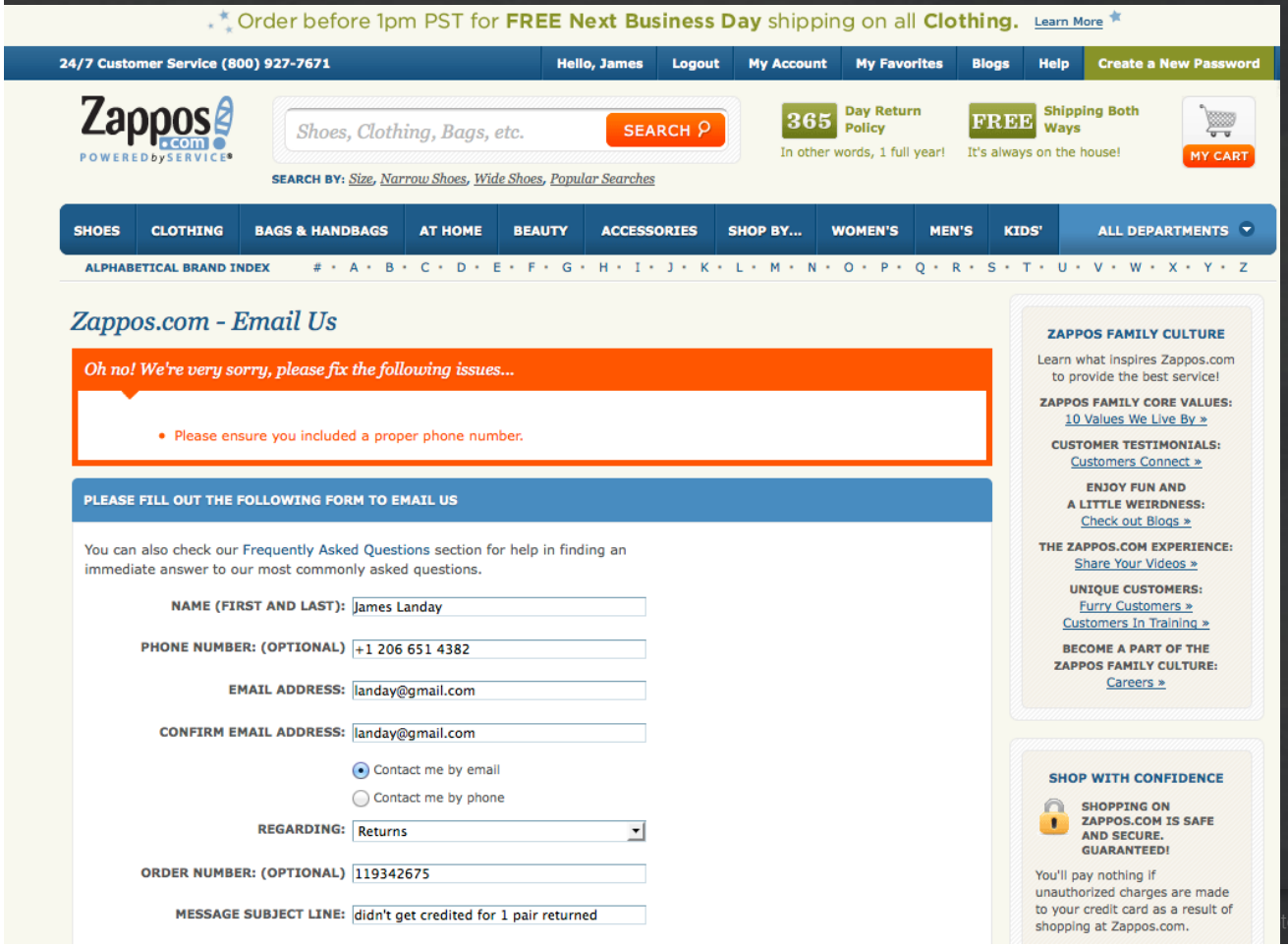
Tells me what I did wrong/how to fix it

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

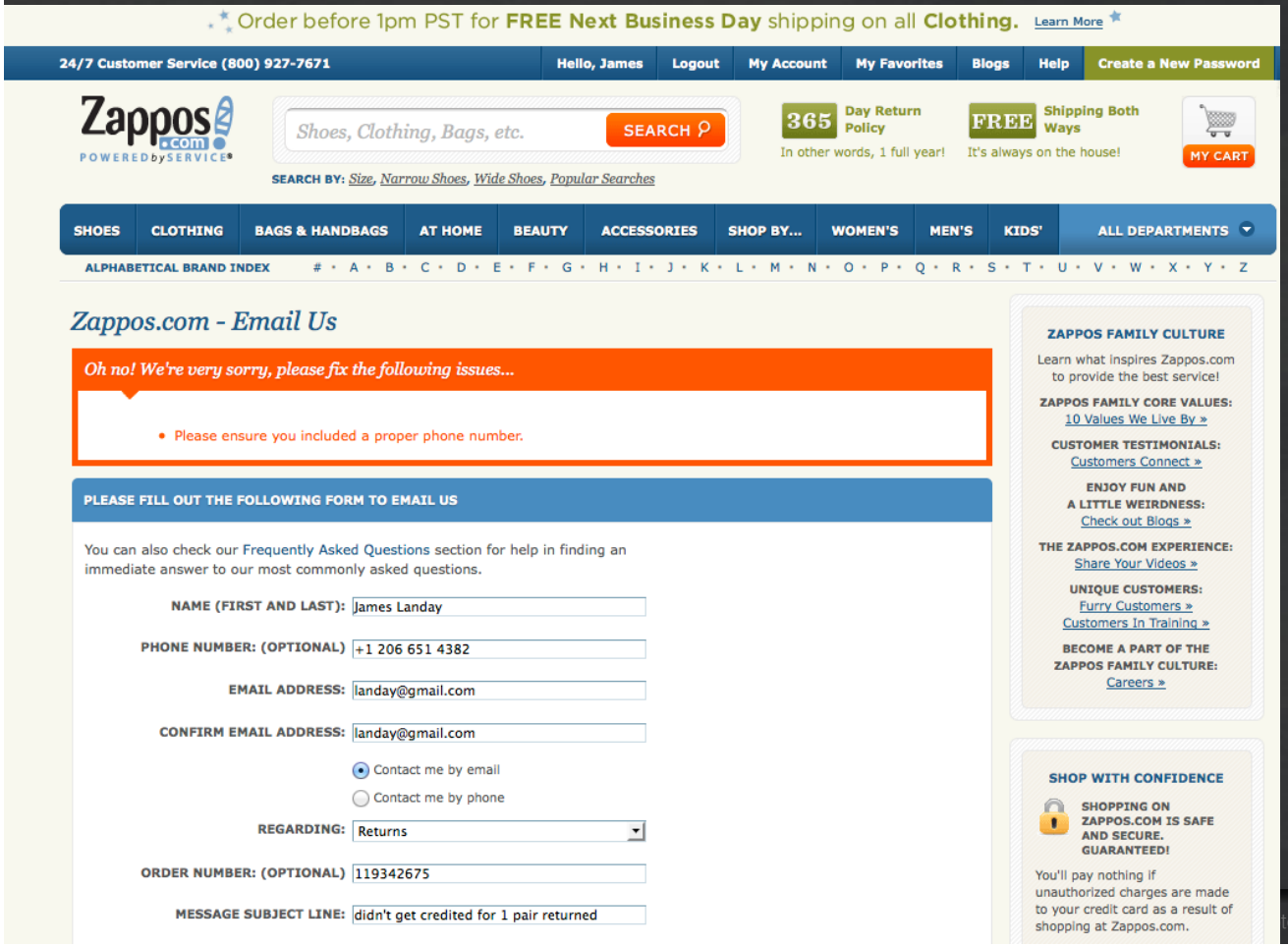
Red may be an issue when used alone, more later...

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

Hall of Fame or Shame?



Hall of Shame!



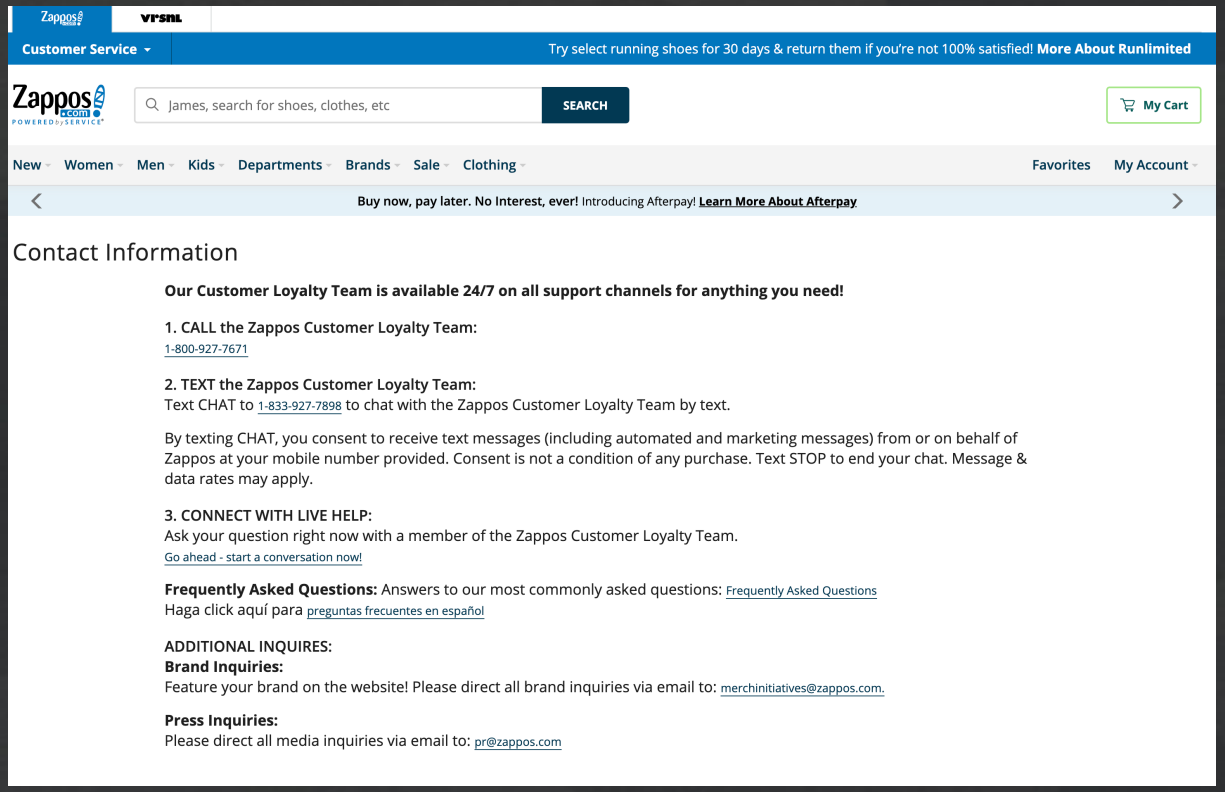
Like

- error message prominent with different color & shape

Wish

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

Hall of Shame!



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

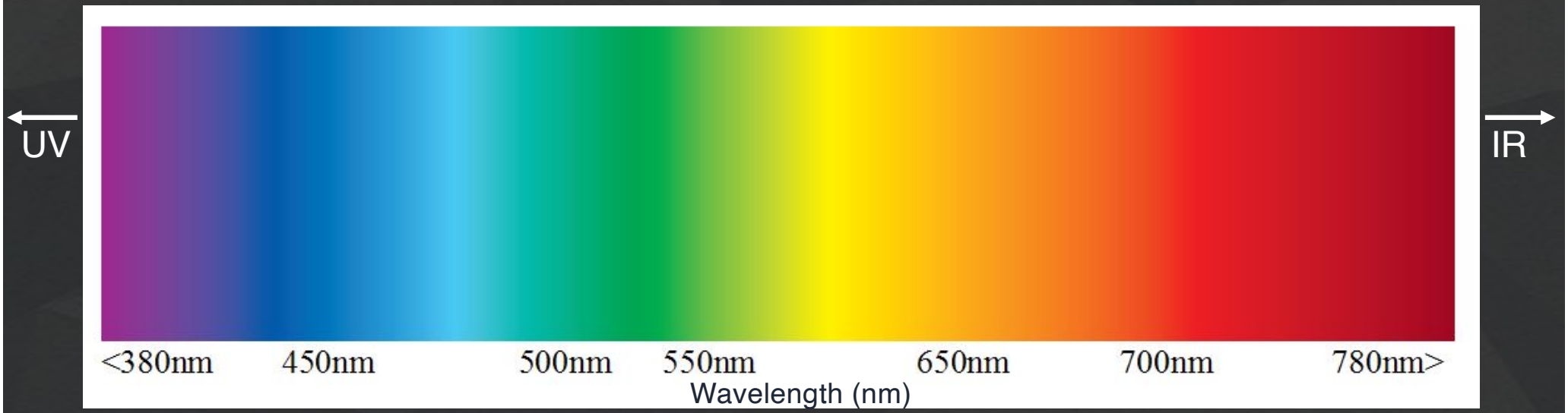
Why Study Color?

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

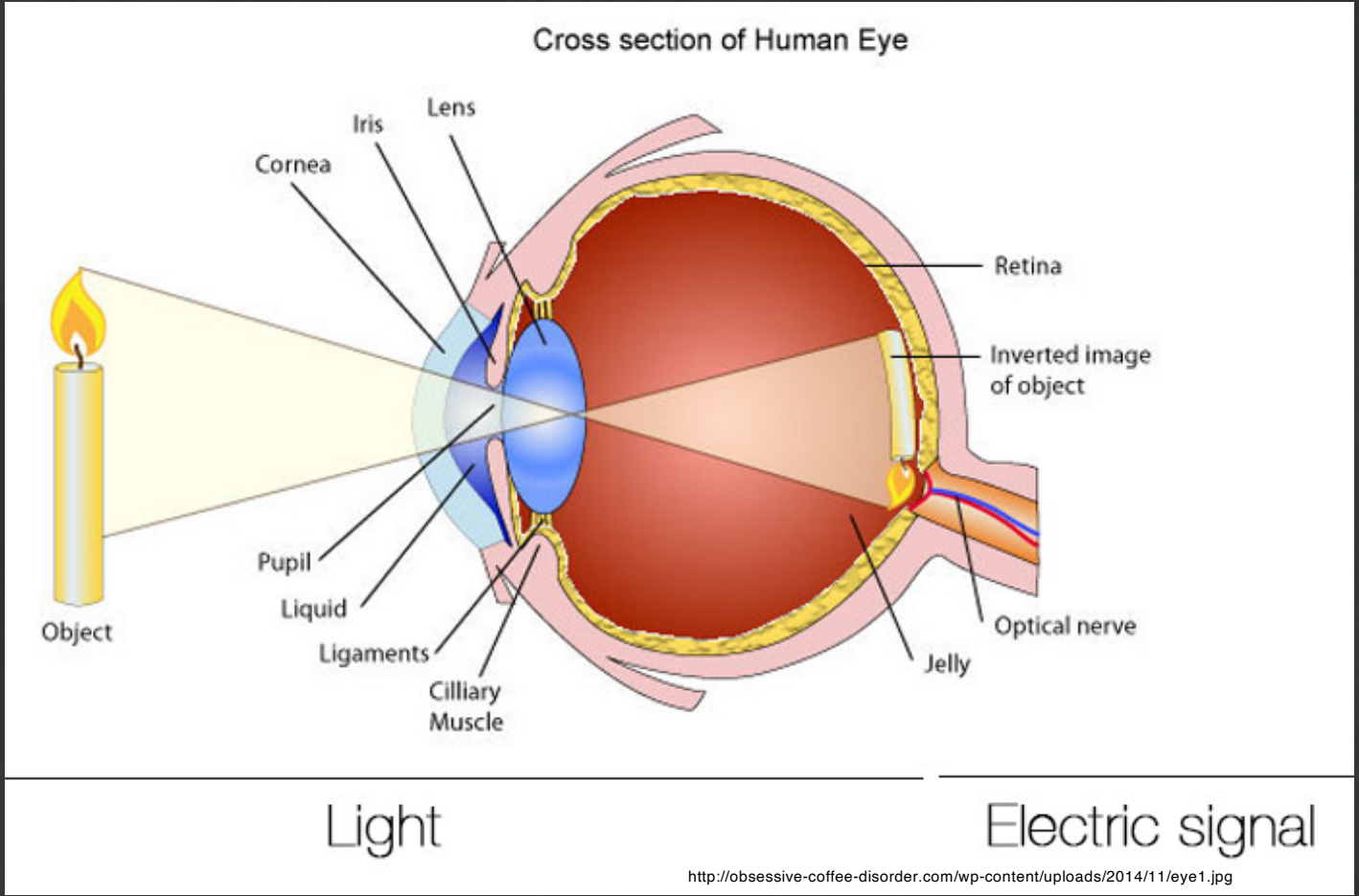
Visible Spectrum

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

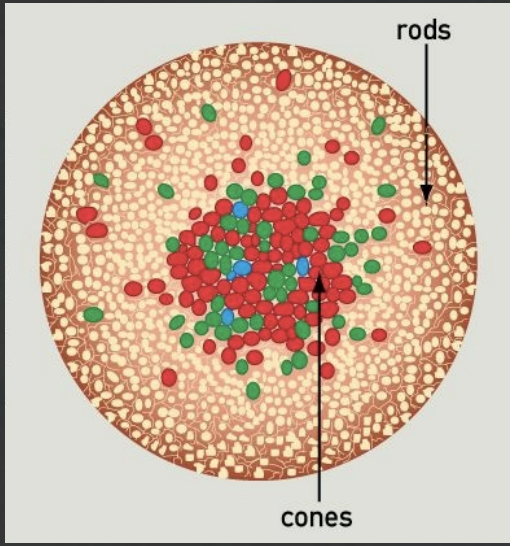


http://obsessive-coffee-disorder.com/wp-content/uploads/2014/11/eye1.jpg

- Light passes through lens
- Focused on retina

Retina

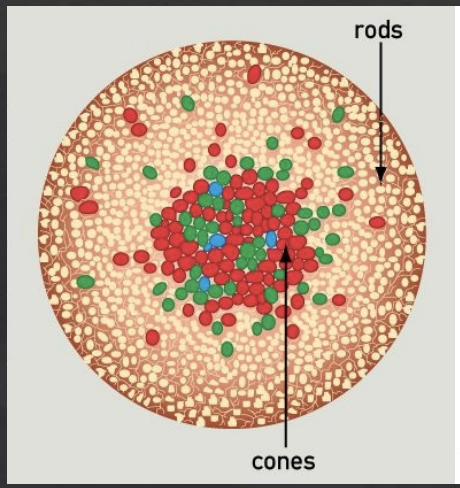
- Retina covered with two types of light-sensitive receptors called?
  - rods
    - primarily for night vision & perceiving movement
    - sensitive to broad spectrum of light
    - can't discriminate between colors
    - sense to intensity or shades of gray
  - cones
    - used to sense color



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



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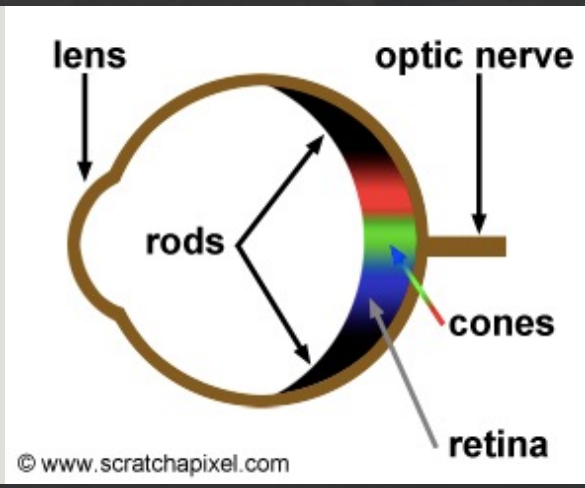
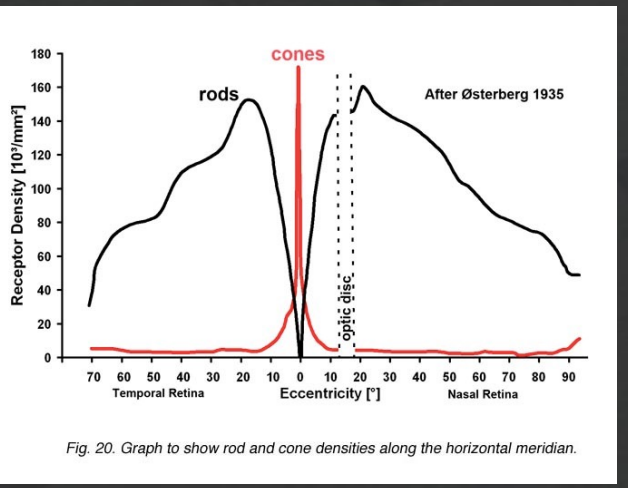


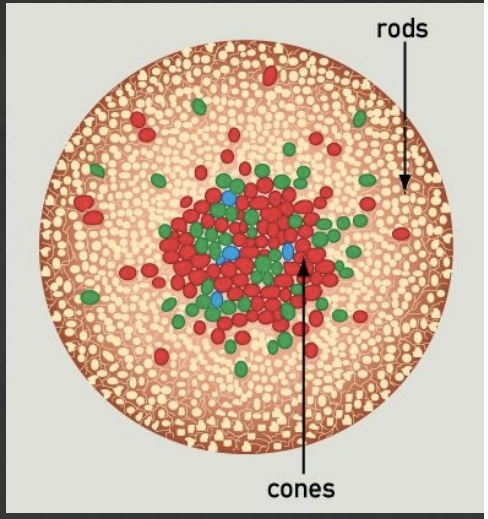


http://webvision.med.utah.edu/imageswv/Ostergr.jpeg

- 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



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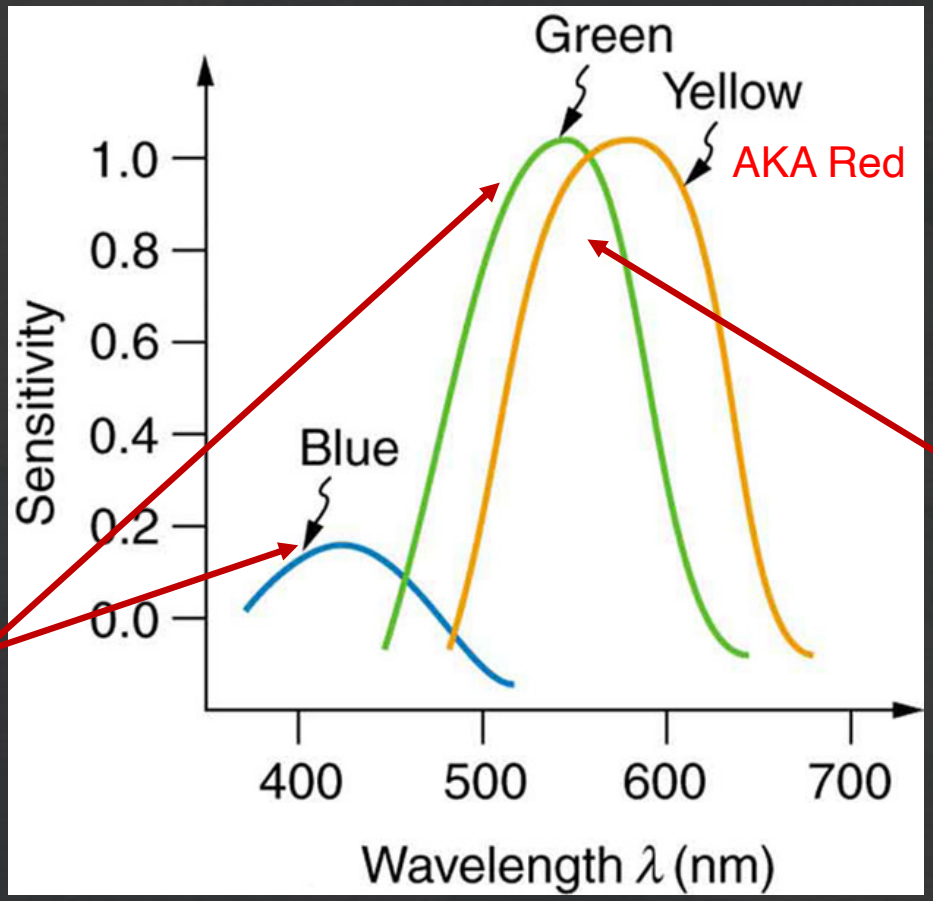
Color Sensitivity

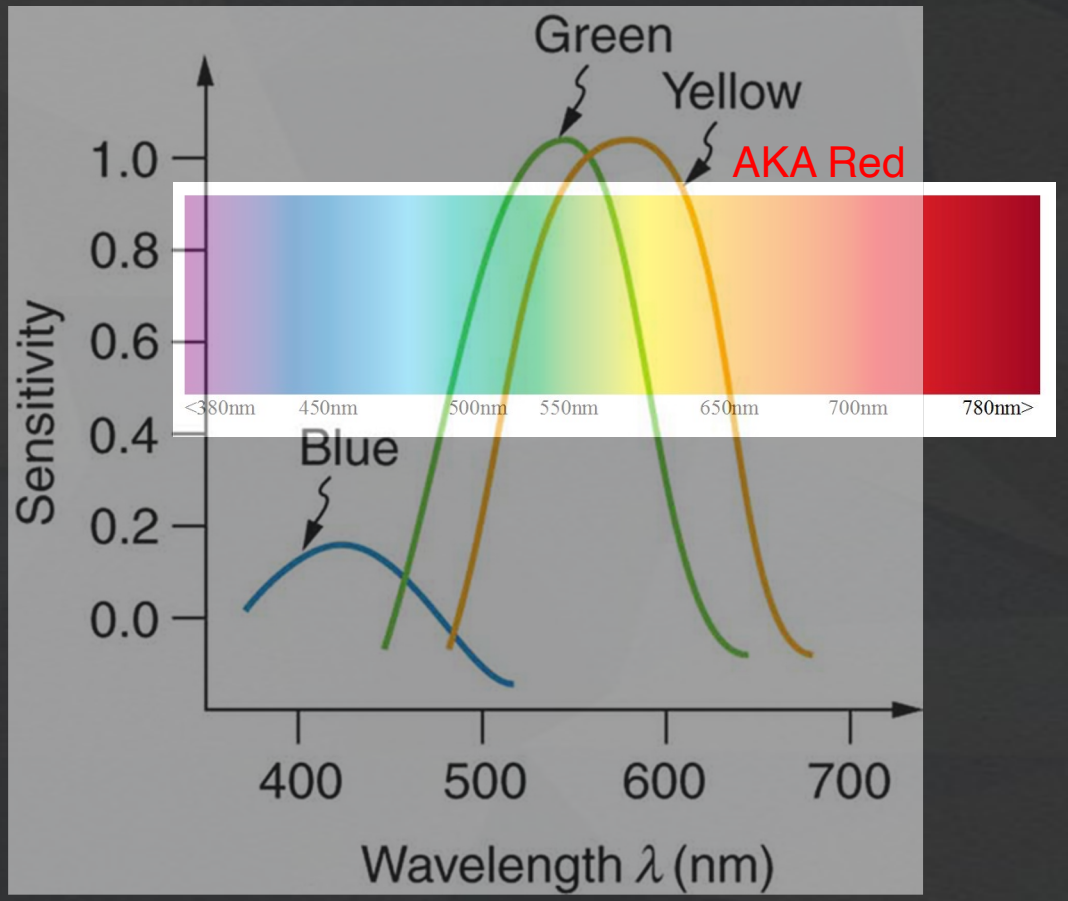


not as sensitive to blue

lots of overlap

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

Color Sensitivity



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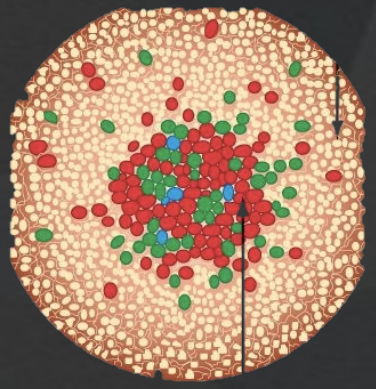
Distribution of Photopigments

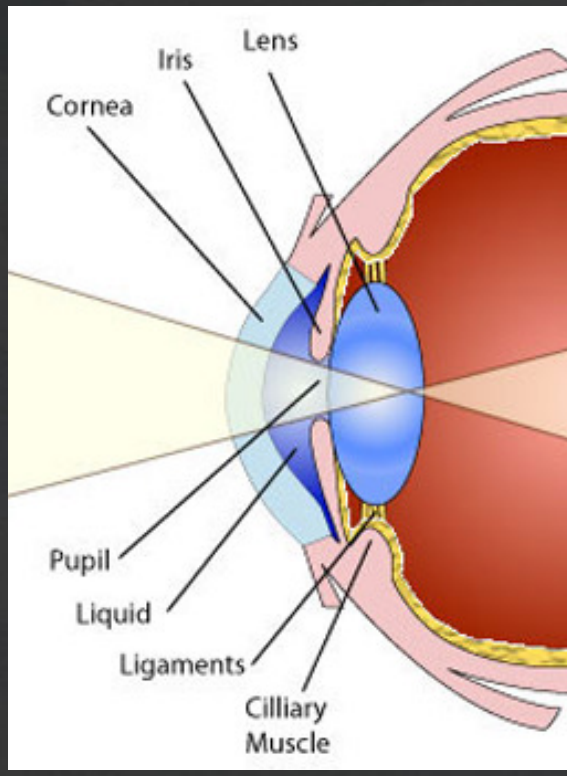
- Not distributed evenly – mainly reds (64%) & very few blues (4%) →
  - insensitivity to short wavelengths (blue)
- Few blue cones in retina center (high acuity) →
  - "disappearance" of small blue objects you fixate on
- As we age lens yellows & absorbs shorter wavelengths →
  - sensitivity to blue 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



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- 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/

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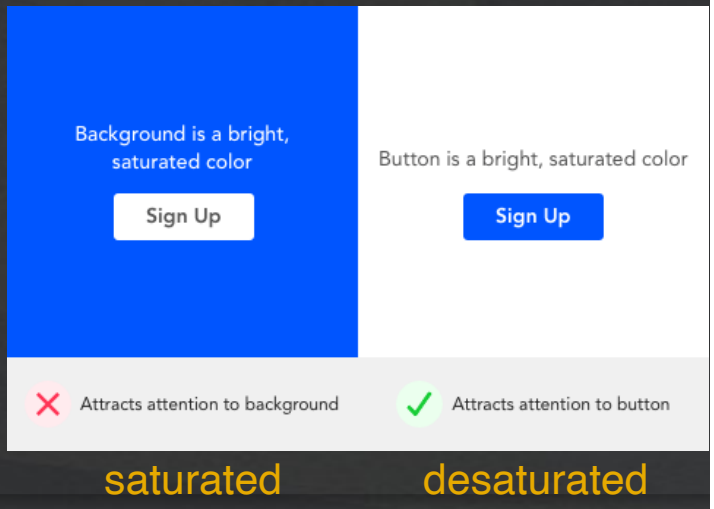
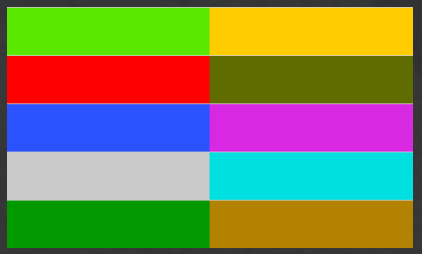


Color Deficiency
(Also known as “color blindness”)

- 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
- Key is to avoid single color distinctions

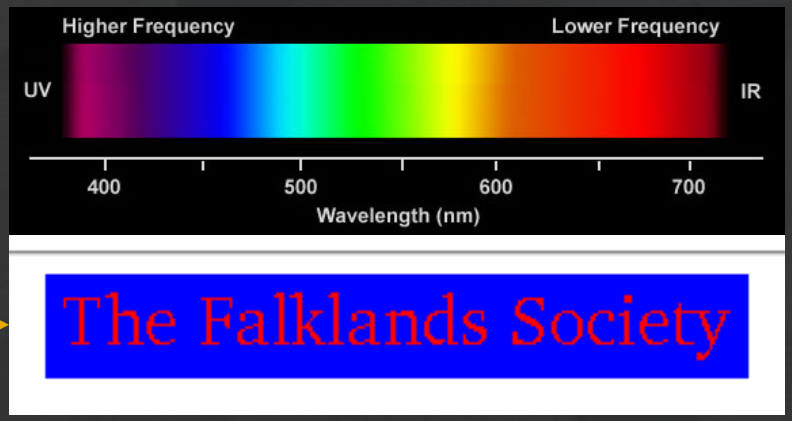


Difficult pairs for severe red deficient person to discern
https://www.color-blindness.com/red-green-color-blindness/

Color Guidelines

Avoid simultaneous display of highly saturated, spectrally extreme colors

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



bad →

- desaturated combinations are better → pastels

Use the Hue Circle

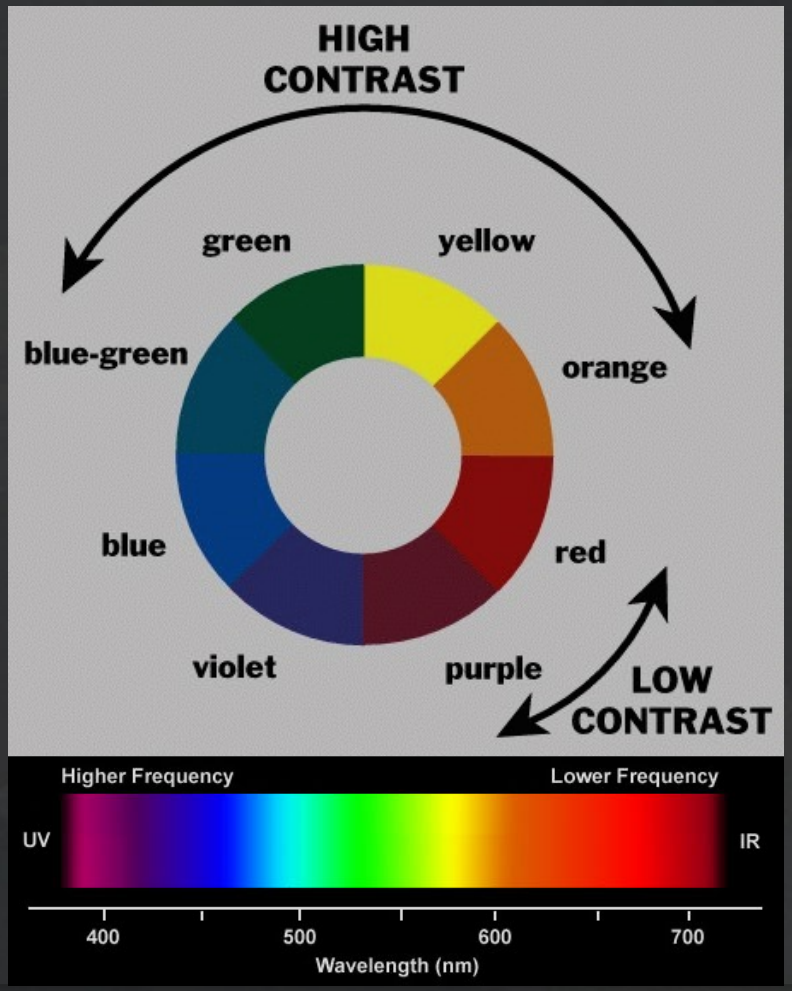
Pick non-adjacent colors

– 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

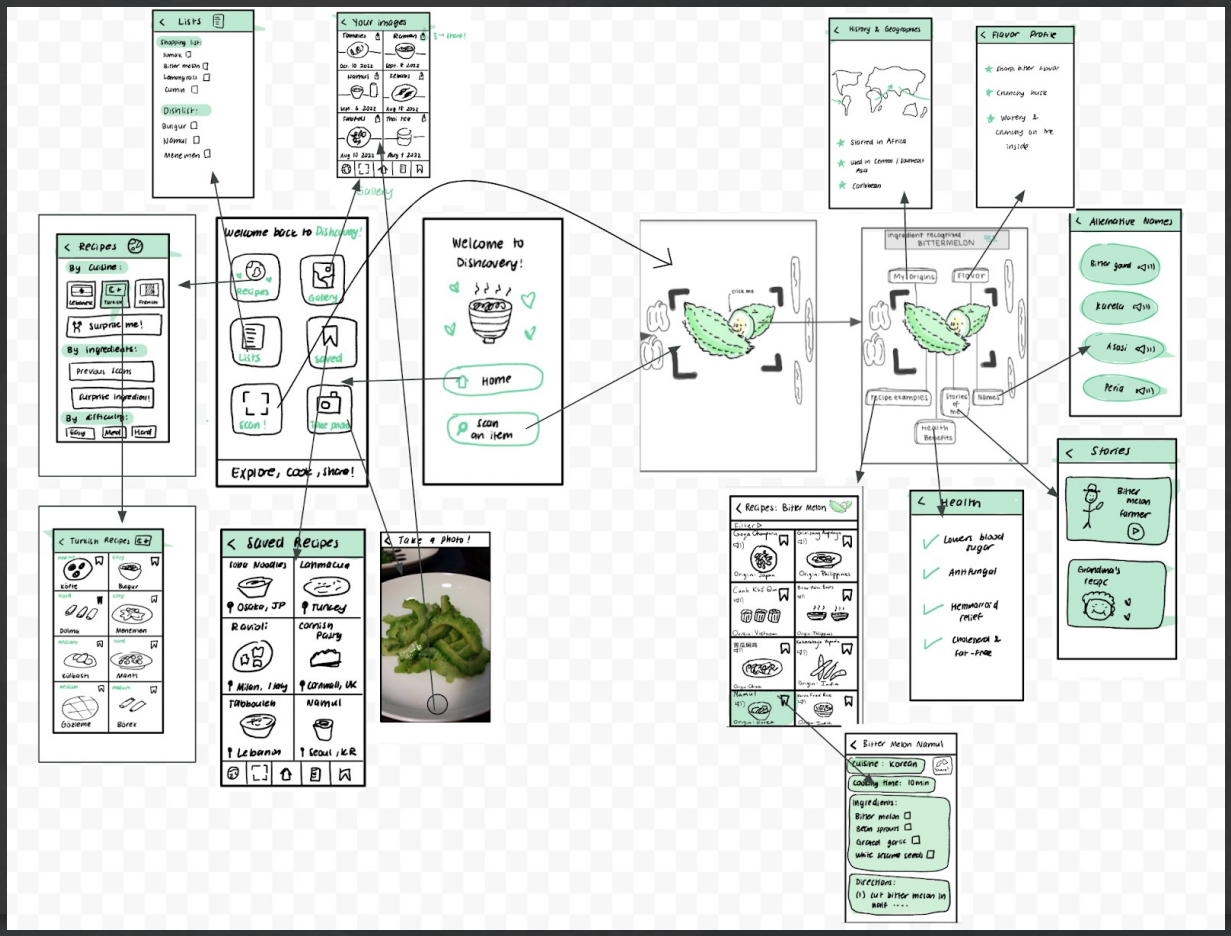
Administrivia

Oct 31-Nov 4	Accessible Design Workshop (Recording) Saturday, Nov. 5	Designing the Future: Early and Future Visions of HCI 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 "Learning From Design Critiques" by Fowler and Haskins "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)	Half-way Review with Outside Experts
Nov 7-11	A7 Heuristic Evaluation (individual) A8 Hi-fi Prototype (group) Midway due by studio week 9 (Dec 1-2) Video demo due by Wed week 10 (Dec 7) Complete due by studio week 10 (Dec 8-9) A11 Final Report (group) Writeup due Sunday Dec 11	Heuristic Evaluation (with in-class exercise) How to Conduct a Heuristic Evaluation by Jakob Nielsen	Conceptual Models and Interface Metaphors "The Psychology of Everyday Things" (Ch 1) from The Design of Everyday Things by Donald Norman	A9 Heuristic Evaluation due Friday, Nov. 11 @ 11:59pm
Nov 14-18	None	Usability Testing/Midterm Review Optional: Inclusive Design Optional: "Disability Studies as a Source of Critical Inquiry for the Field of Assistive Technology"	**Midterm**	Project Group Work

Administrivia

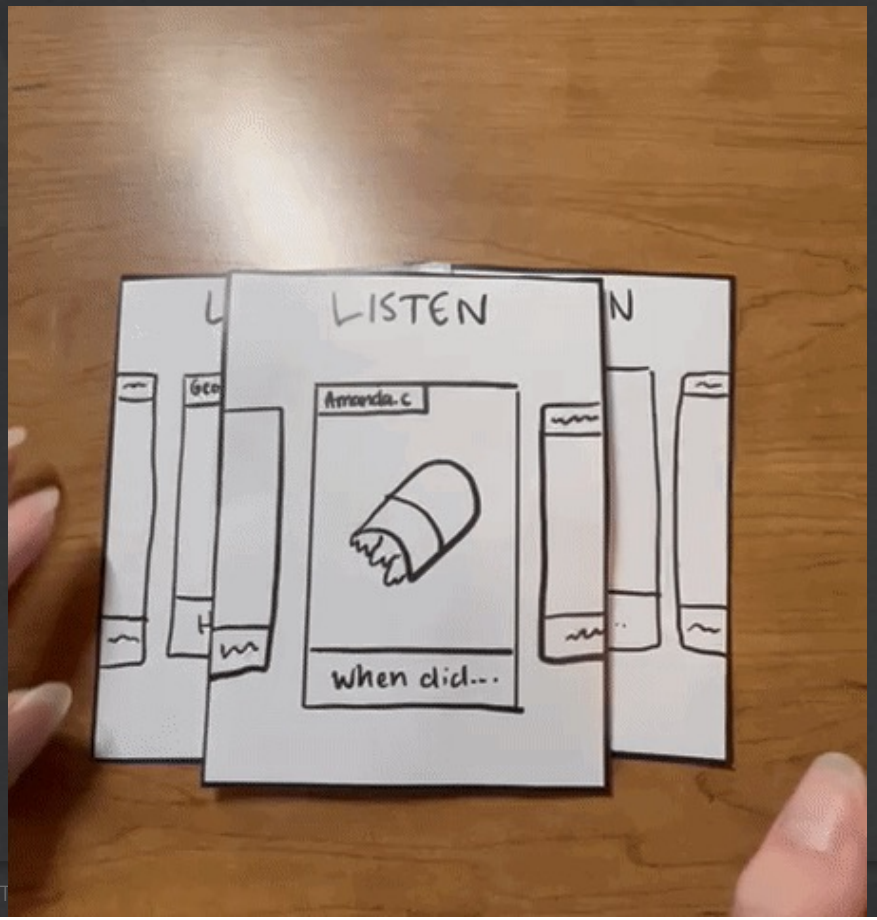
Nov 21-25		**Thanksgiving (No Class)**		
Nov 28-Dec 2	A10 Poster and Pitch Slide (group) **Draft due Mon., Dec. 5** **Final due Wed. Dec. 7**	Design Patterns **The Design of Sites by van Duyne, Hong, & Landay:** **1) "Making the Most of Web Design Patterns" (Ch 2)** **2) "Up-Front Value Proposition" (Pattern C2)** **3) "Process Funnel" (Pattern H1)** **4) "Meaningful Error Messages" (Pattern K13)**	Guest Lecture	A8 Presentation Project Group Work
Dec 5-9		Guest Lecture	Smart Interfaces for Human-Centered AI	30-Second Pitch and Demo Practice Project Expo from 6-9 PM

Dishcovery's Bird's Eye View of the Prototype



StoreaTime's Low-Fi Prototype Construction

Tested scrolling and swiping interactions



Administrivia

- Grading
  - buckets are weighed in the rubric so two minuses are not equal
  - note: each team member's contribution will be assessed at the end of class & grades adjusted appropriately
- Final workshop – Accessibility – coming soon
  - 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)

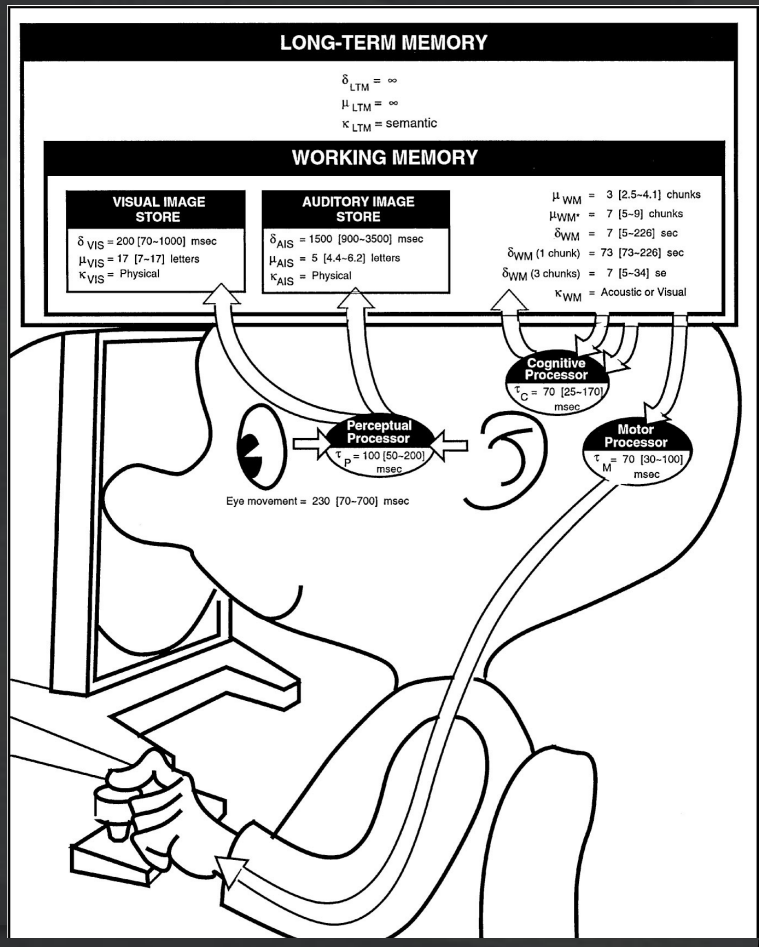
TEAM BREAK

The Model Human Processor

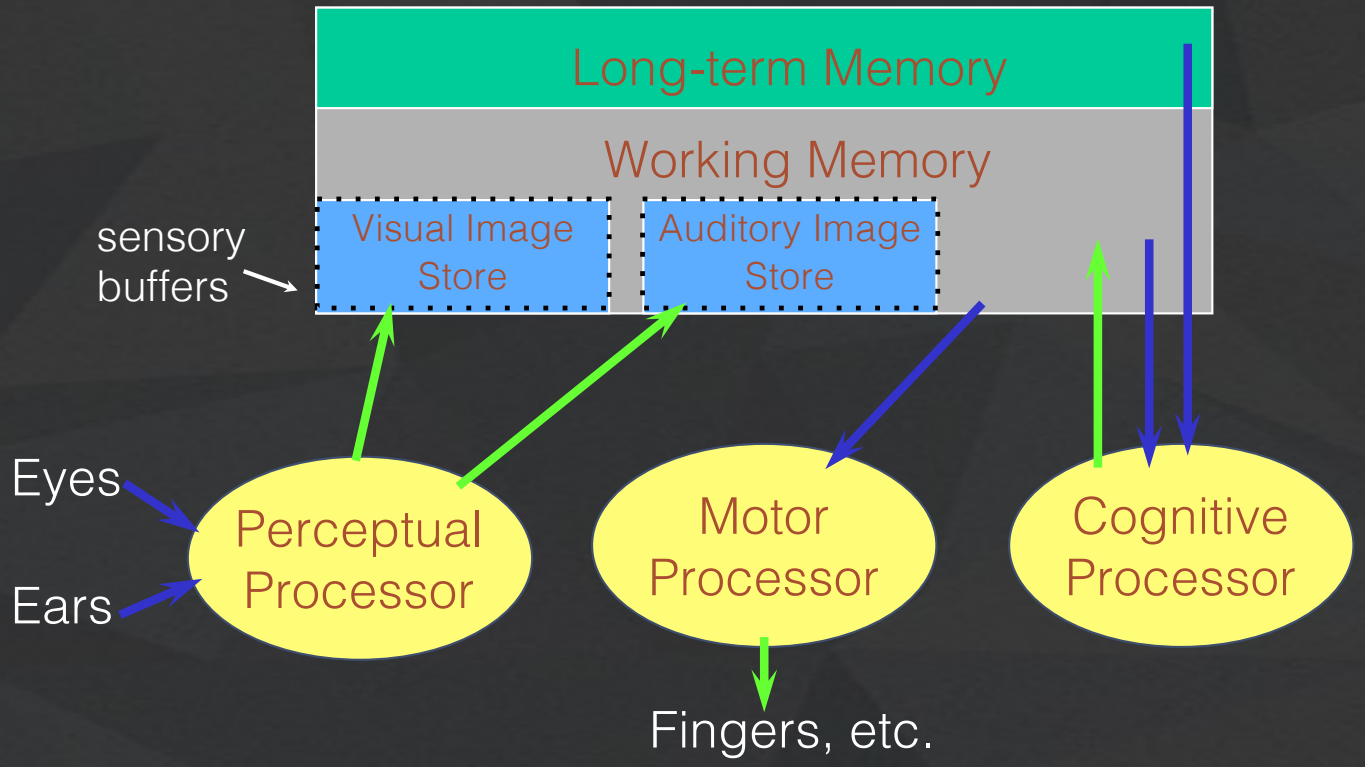
Developed by Card, Moran & Newell (’83)

- based on empirical data

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



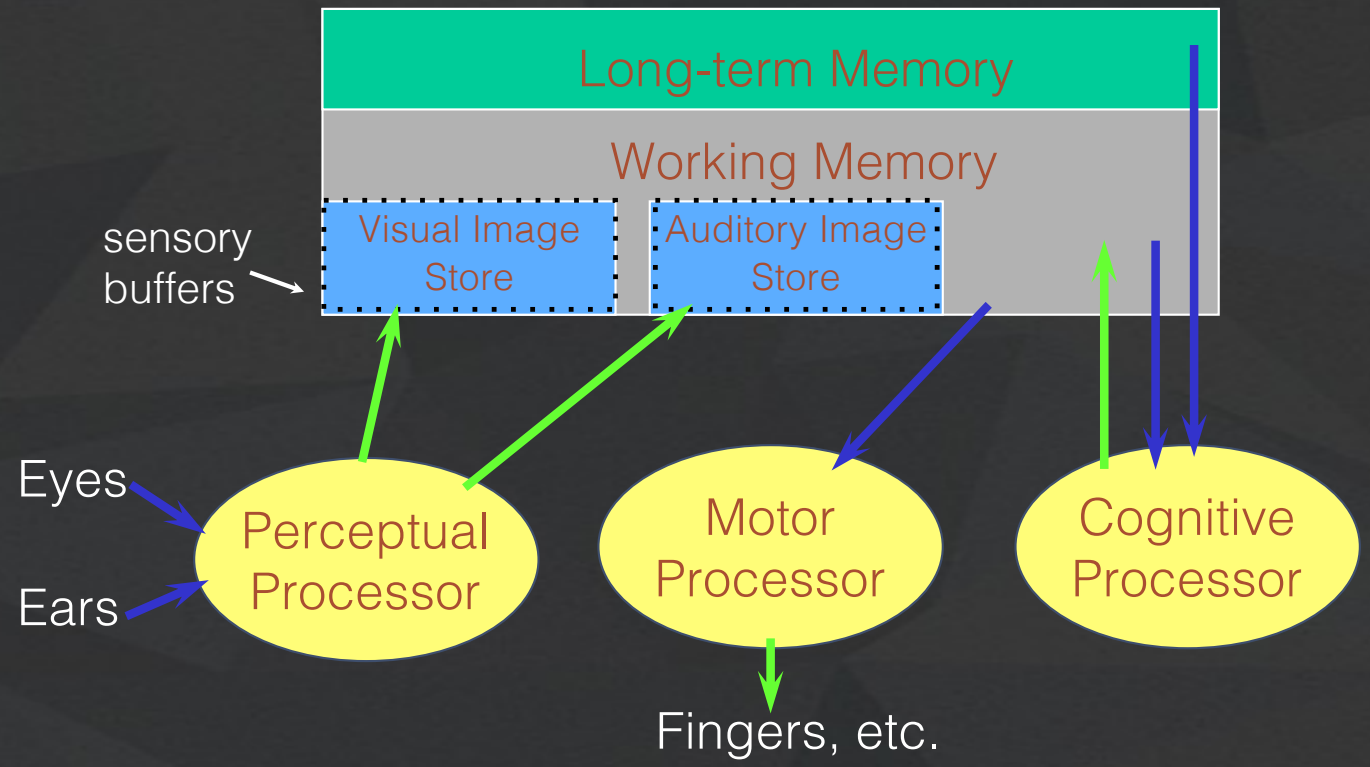
The Model Human Processor



MHP Basics

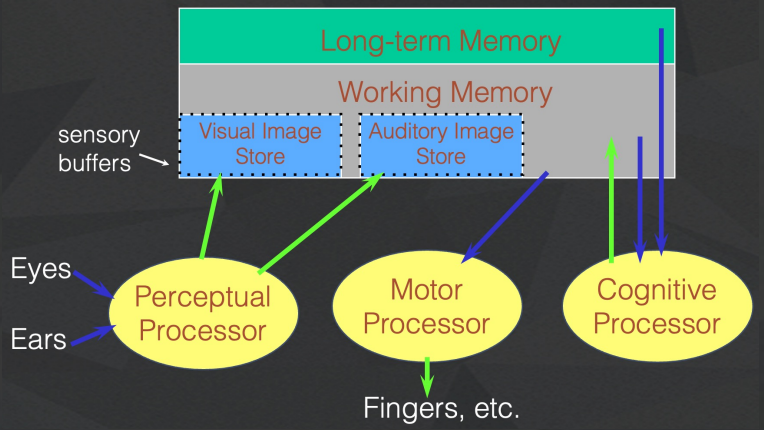
- Parameters
  - processors have cycle time (T) ~ 100 ms
  - memories have capacity, decay time & type

What is missing from MHP?



What is missing from MHP?

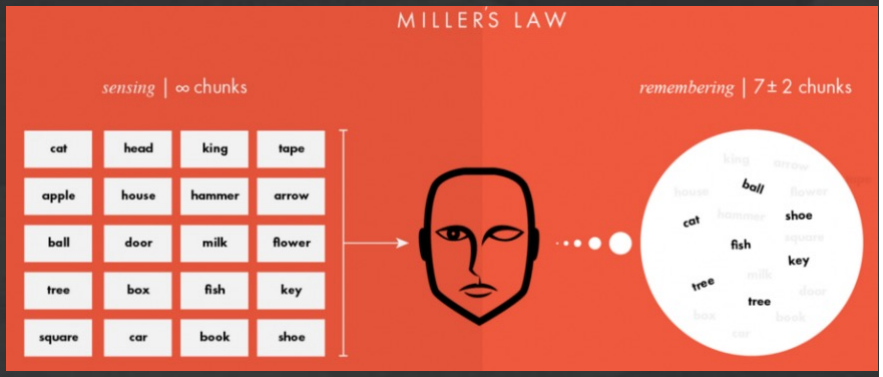
- Haptic memory
  - for touch
- Moving from sensory memory to WM
  - attention filters stimuli & passes to WM
- Moving from WM to LTM
  - elaboration



" 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

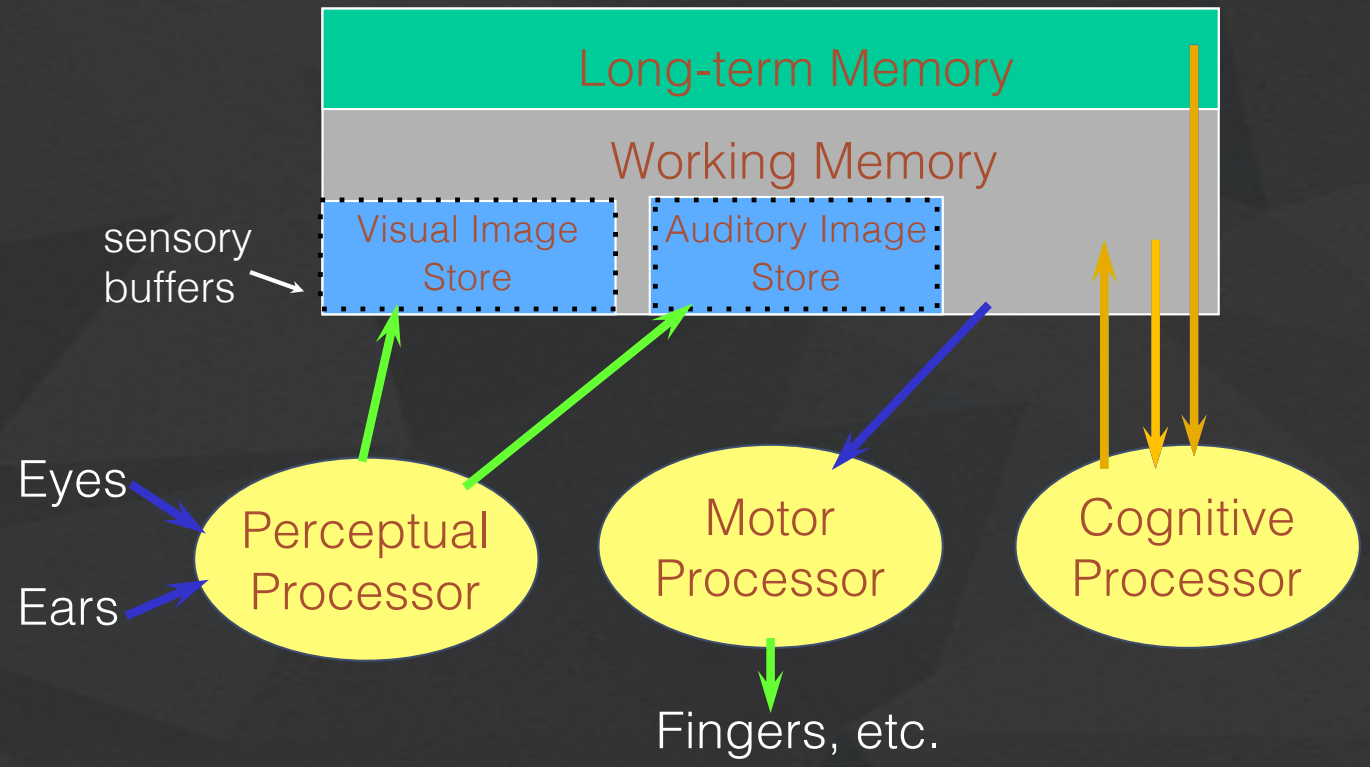


- Long-term memory
  - huge (if not “unlimited”)
  - slower access time (~100 ms) w/ little decay

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

Experiment

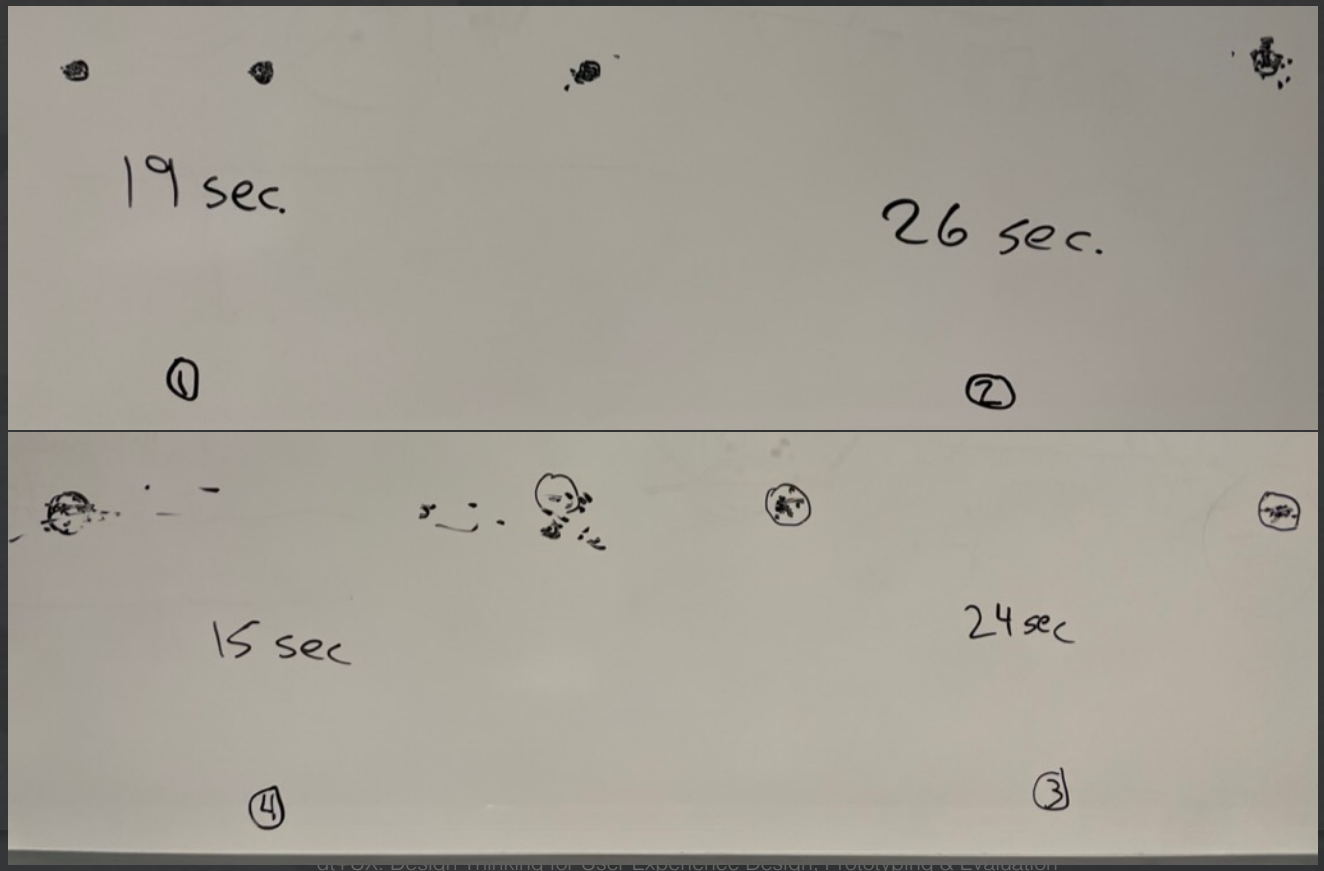
- Task:
  Quickly tap each target 50 times accurately

- 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

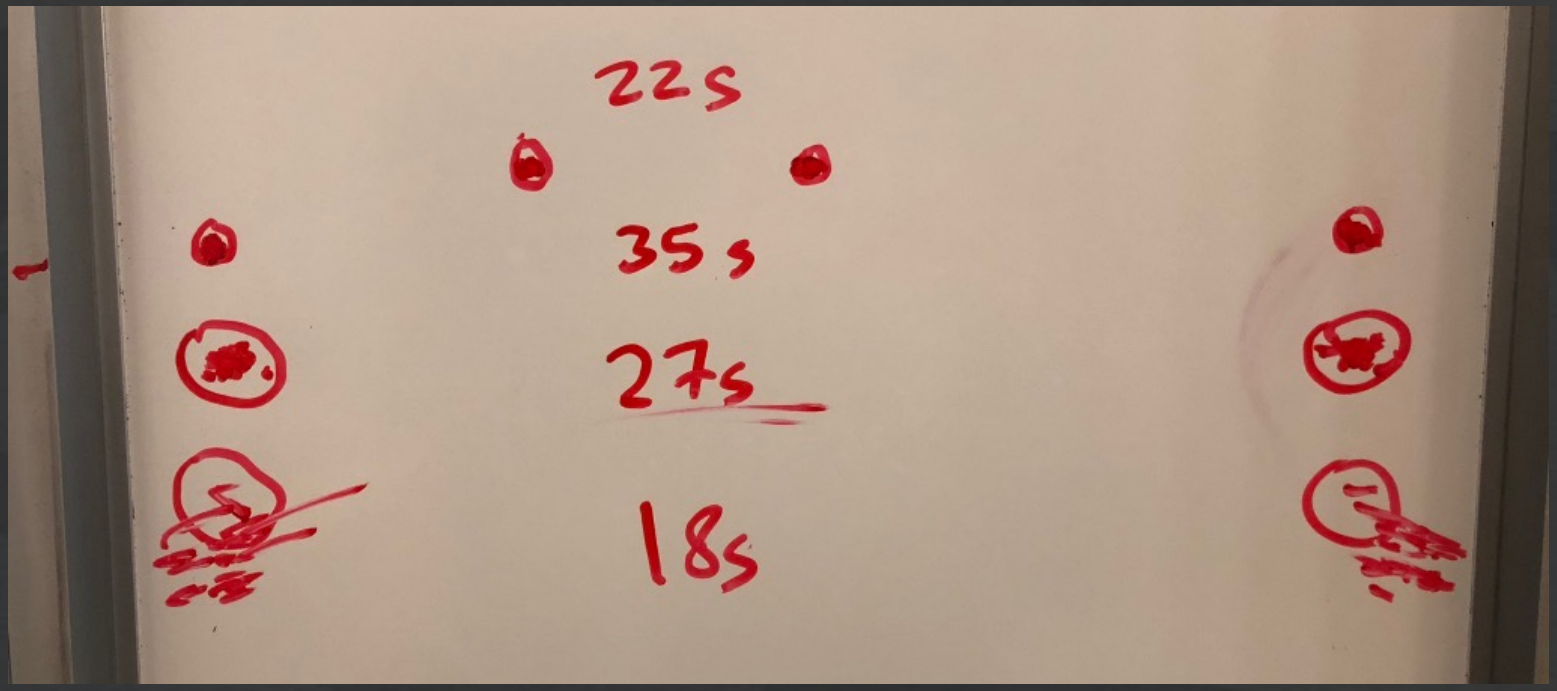
- Task: Quickly tap each target 50 times accurately



Experimental Results (pre-covid)

- Task:

  Quickly tap each target 50 times accurately



If we plot the data…

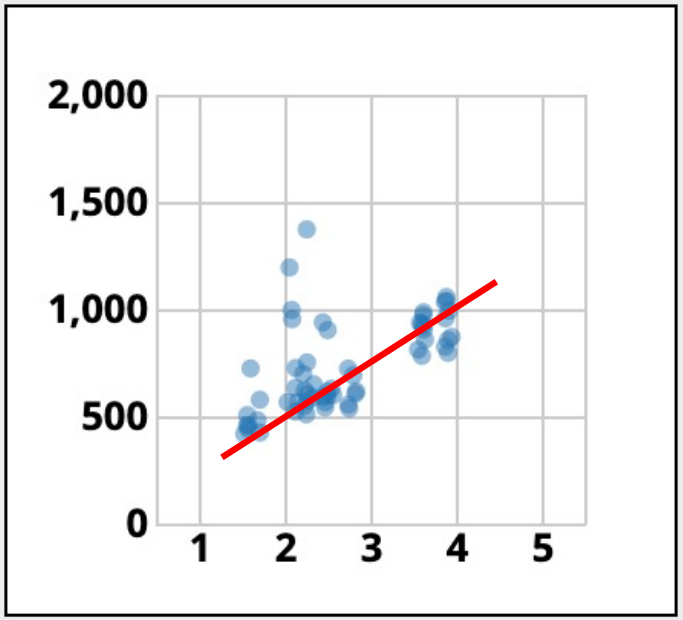


fig. 1e: Time in ms over ID.

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 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

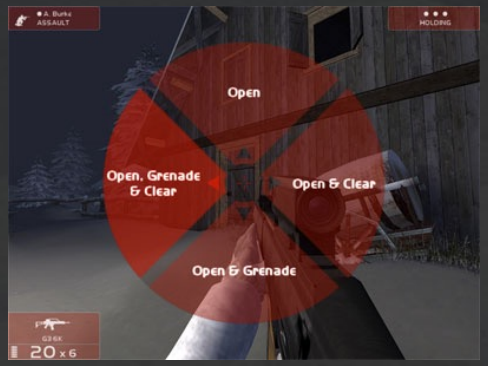
Which will be faster on average?

- pie menu (bigger targets & less distance)

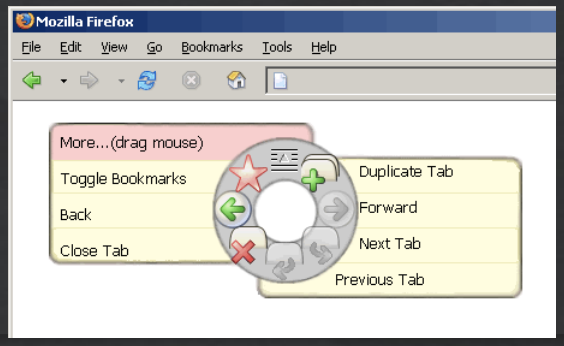
Pie Menus in Use Today

The Sims

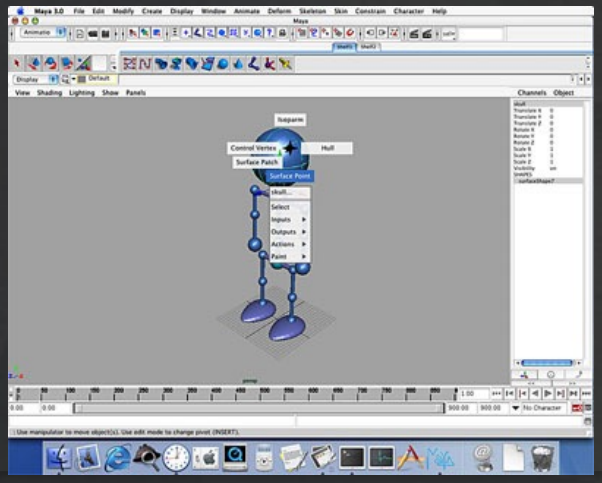
Rainbow 6



Firefox



Maya



Apple Watch Is a Negative Fitts' Law Example

Apple Watch Is a Negative Fitts' Law Example

Volunteer for Experiment

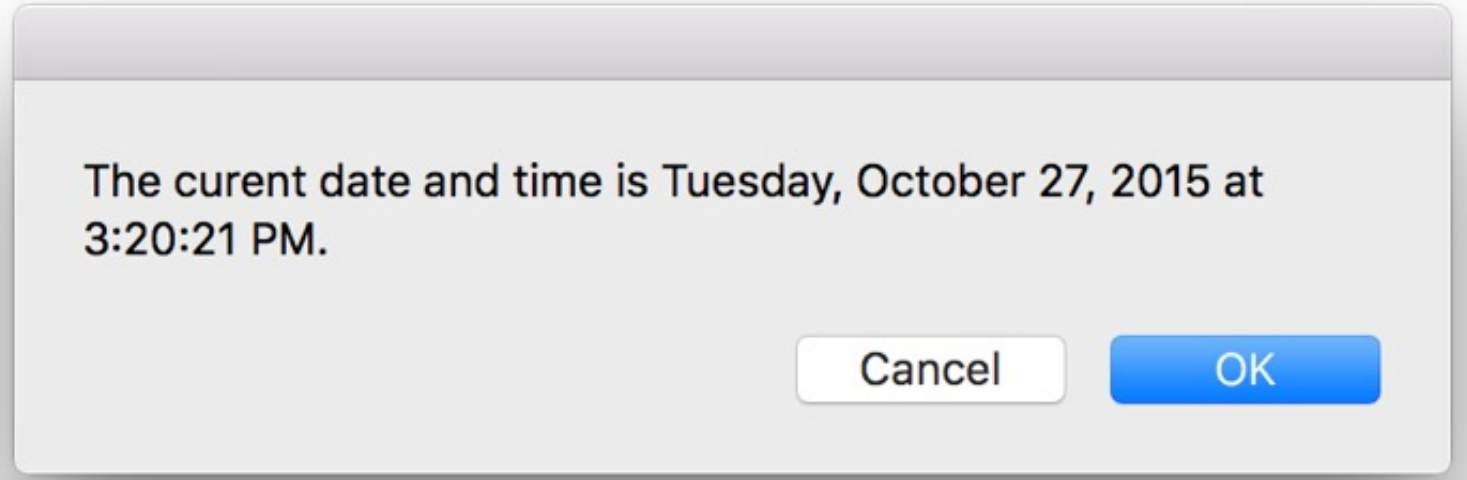
https://faculty.washington.edu/chudler/java/ready.html

Volunteer for Experiment

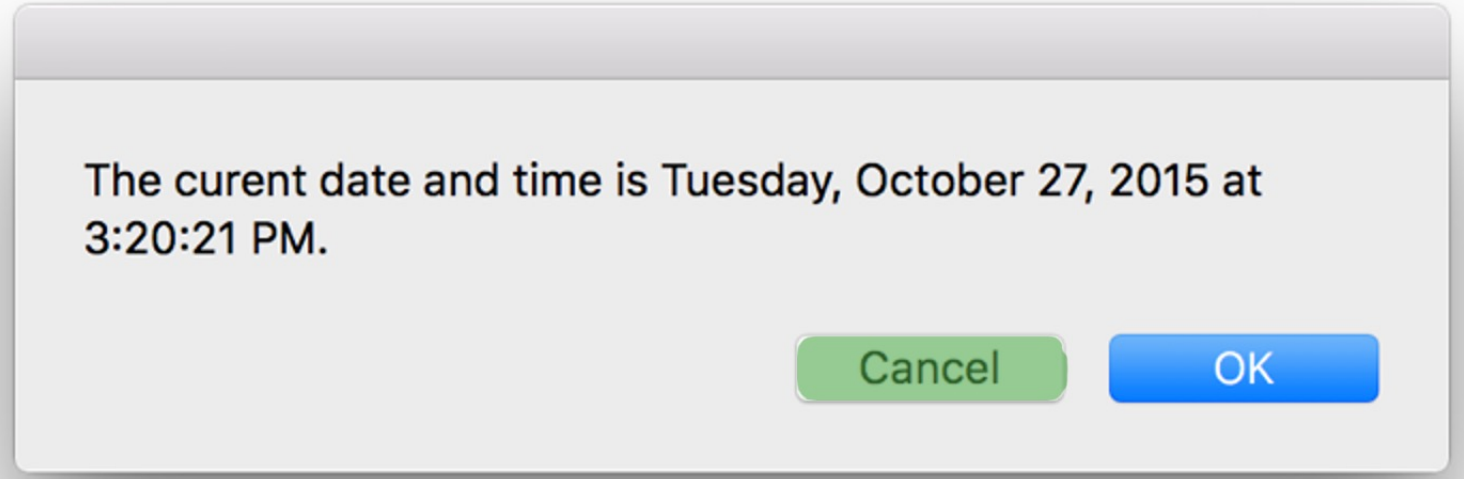
Stroop Effect

- interference in your working memory

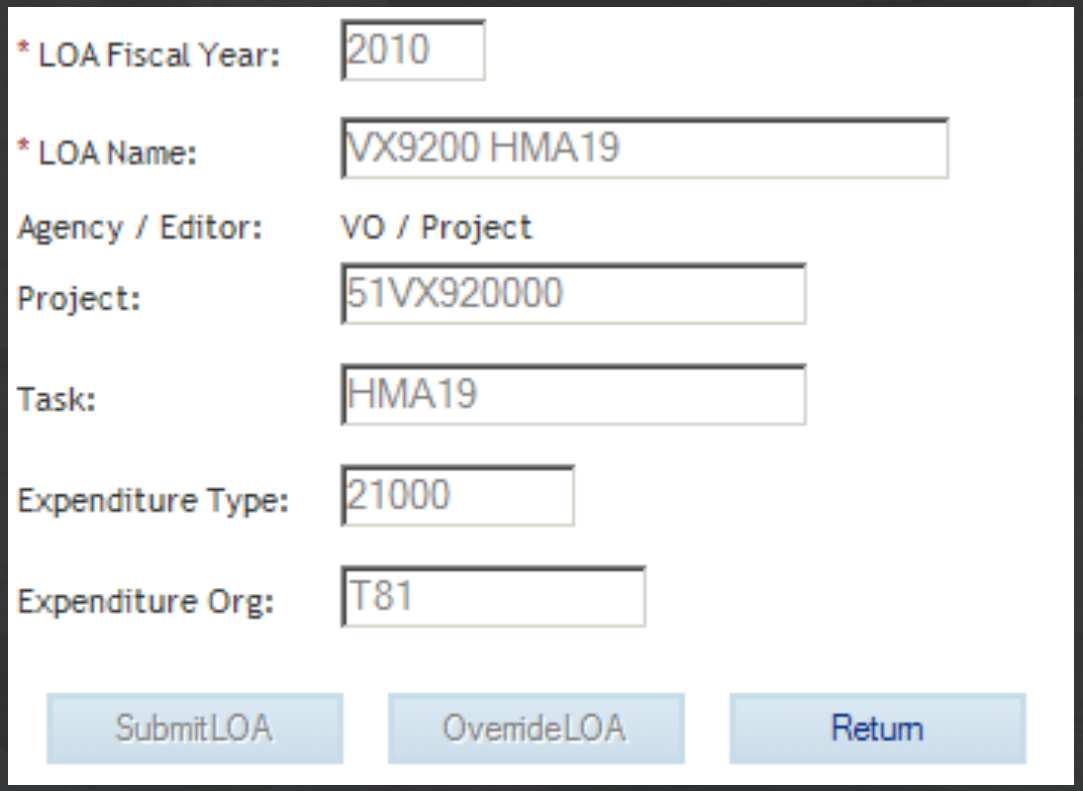
Memory Interference in Action: *Cultural*



Memory Interference in Action: *Cultural*



Memory Interference in Action: *Labels/Terms*



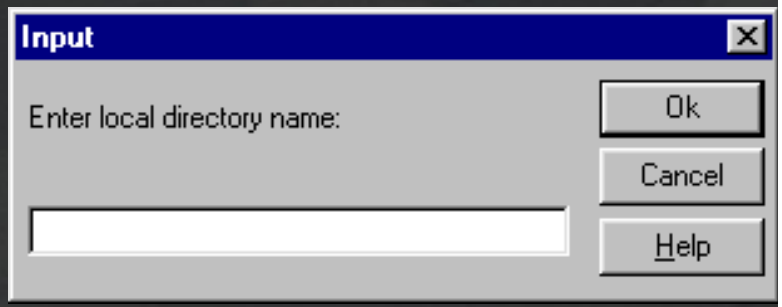
Memory

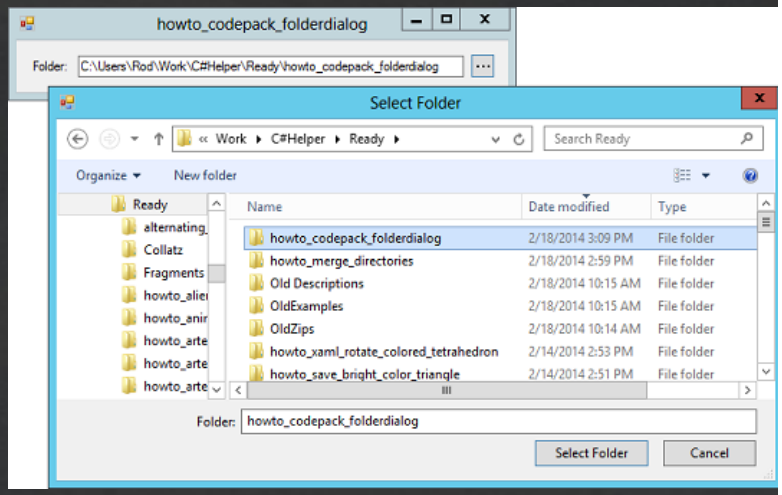
- Interference
  - two strong cues in working memory
  - link to different chunks in long term memory

- 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
  - How to Conduct a Heuristic Evaluation by Jakob Nielsen
- Studio
  - Midterm review
  - Medium-fi prototype feedback from TAs & visitors