dt +UX DESIGN THINKING FOR USER EXPERIENCE DESIGN + PROTOTYPING + EVALUATION

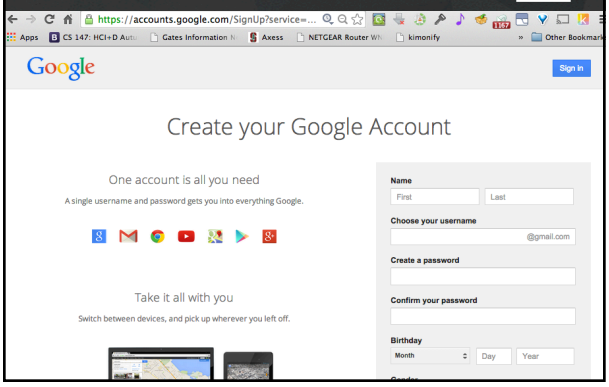
Human Abilities: Vision & Cognition

Prof. James A. Landay
Computer Science Department
Stanford University

Autumn 2017

November 6, 2017

Hall of Fame or Shame?



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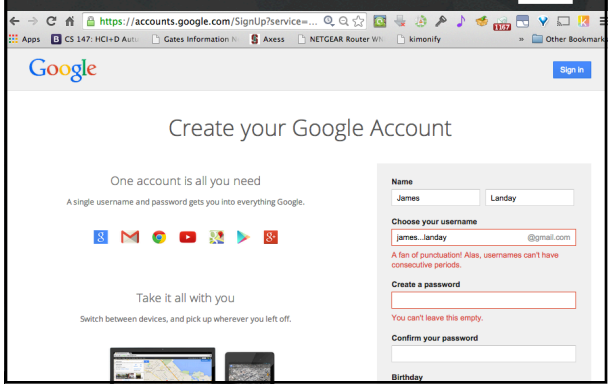
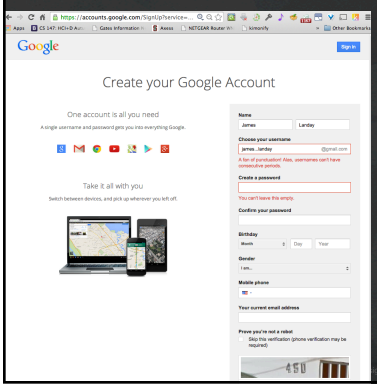
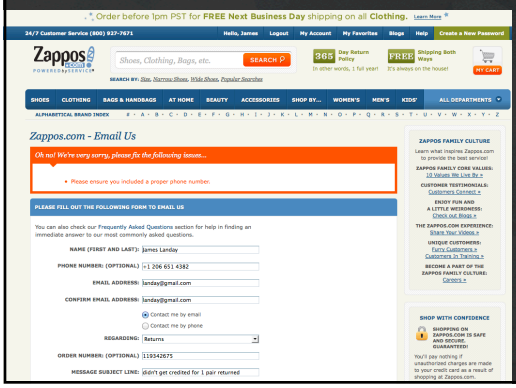


Hall of Fame!



- Clearly highlights error (red text & box)
- Tells me what I did wrong/how to fix it
- In user's language (careful w/ humor)
- Red may be issue, more later..

Hall of Fame or Shame?



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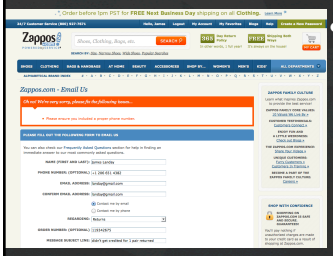

- Error Messages
  - where is the error?
  - what's wrong with it?
  - parse & fix it yourself!

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Outline

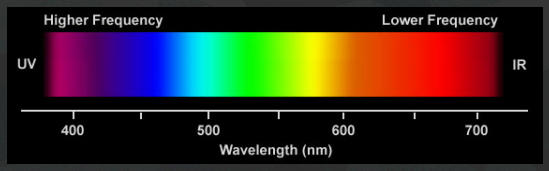
- Human visual system
- Guidelines for design
- Team Break
- Two in class experiments
- Models of human performance (MHP)
- Memory

Why Study Color?

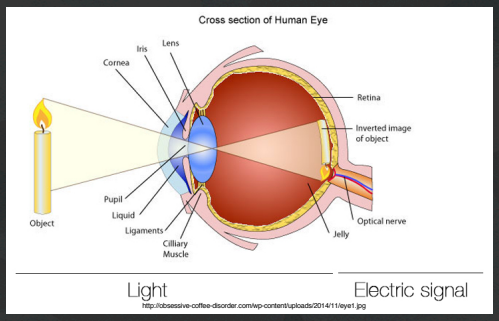
1) Color can be a powerful tool to ***improve*** user interfaces by communicating key information

2) Inappropriate use of color can severely *reduce* ***the performance*** of systems we build

Visible Spectrum



Human Visual System



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

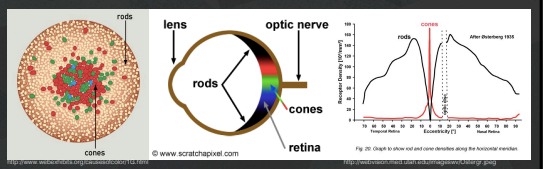
- Light passes through lens
- Focused on retina

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 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

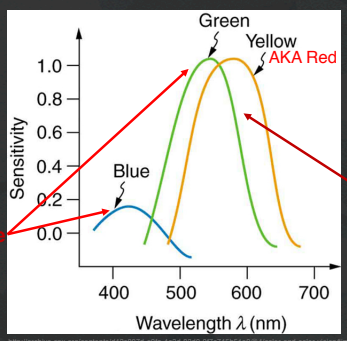


Edge of retina is dominated by rods →
- allows detecting motion of threats in periphery

Color Perception via Cones

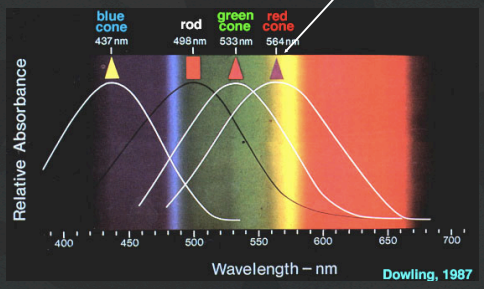
- "Photopigments" used to sense color
- 3 types: blue, green, "red" (really yellow)
  - each sensitive to different band of spectrum
  - ratio of neural activity of the 3 → color
    - other colors are perceived by combining stimulation

Color Sensitivity



http://archive.cnx.org/contents/d42c807d-a9fa-4e35-83d0-0f7c745b51a0@4/color-and-color-vision#import-auto-id1844887

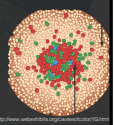
Color Sensitivity



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)

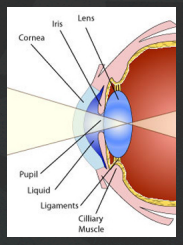


http://www.webexhibits.org/causesofcolor/1G.html

- 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!**

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

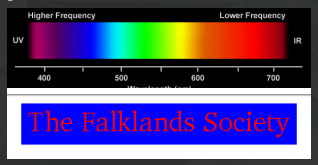
http://www.pallasweb.com/color.html

Color Deficiency
(Also known as "color blindness")

- Trouble discriminating colors
  - besets about 9% of population
- 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 dependent on R & G

Color Guidelines

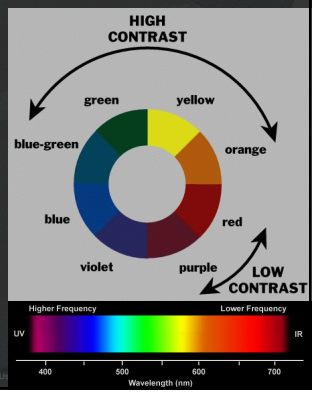
Avoid simultaneous display of highly saturated, spectrally extreme colors
- e.g., no cyans/blues at the same time as reds, why?
  - refocusing!



- 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
- also 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

TEAM BREAK

Administrivia

- Quiz 2 grades
  - Average: 3.25 / 4
  - Median: 3 / 4
  - Std. Dev.: .5
  - Range 2-4
- Have your Heuristic Evaluation ready to go when you arrive in studio Thur/Fri

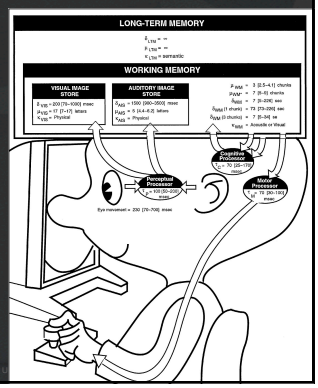
To show this poll

1. Install the app from pollev.com/app
2. Start the presention

Still not working? Get help at pollev.com/app/help
or
Open poll in your web browser

The Model Human Processor

- Developed by Card, Moran & Newell ('83)
  - based on empirical data



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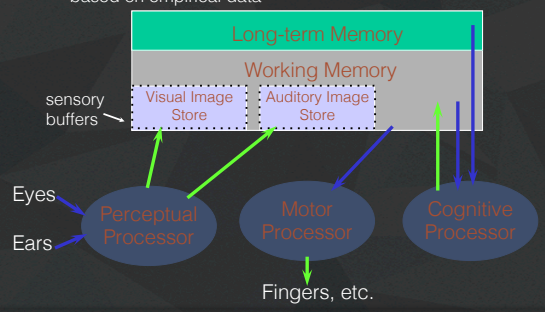
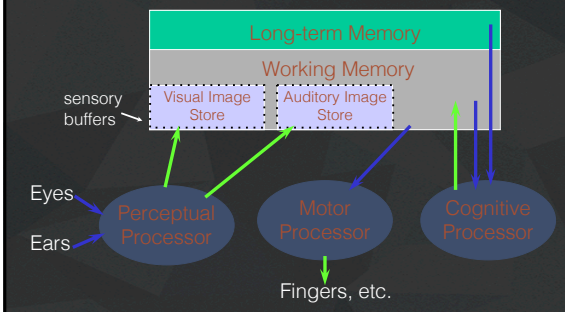


MHP Basics

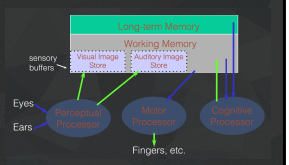
- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
    - pressing key in response to light (serial)
    - driving, reading signs & hearing at once (parallel)
- Parameters
  - processors have cycle time (T) **~ 100 ms**
  - memories have capacity, decay time & type

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..."

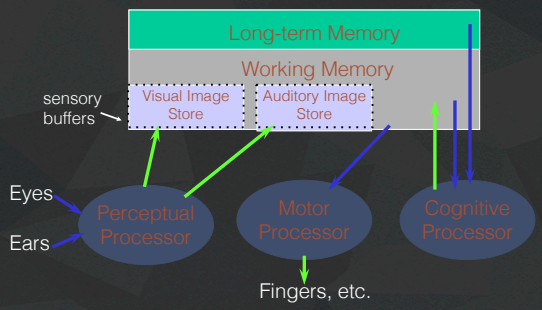
Memory

- 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

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

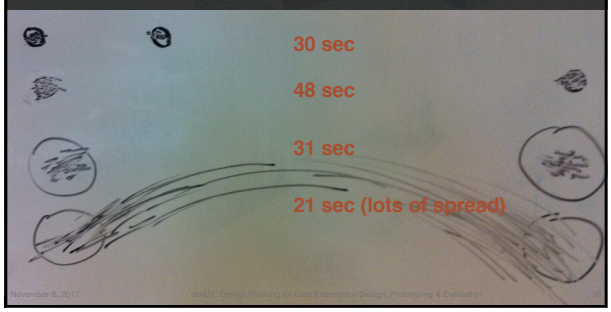
- Recognize-Act Cycle of the CP
  - on each cycle contents in WM initiate actions associatively linked to them in LTM
  - actions modify the contents of WM
- Discrimination Principle
  - retrieval is determined by candidates that exist in memory relative to retrieval cues
  - interference by strongly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

Experiment

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

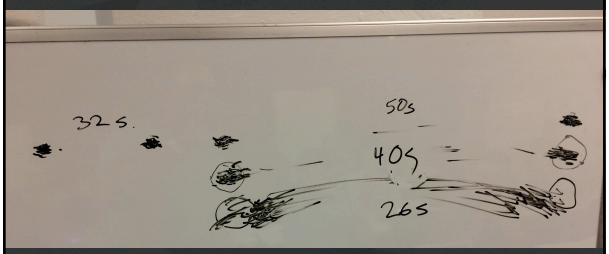
Experimental Results

- Task:
  Quickly tap each target 50 times accurately



Experimental Results

- Task:
  Quickly tap each target 50 times accurately



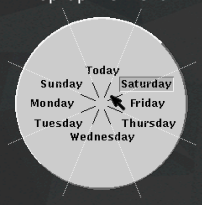
Principles of Operation (cont.)

- 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 the hand depends only on the ***relative precision*** required

Fitts' Law Example

Pop-up Linear Menu

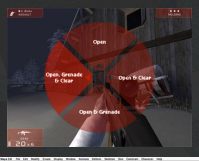
Pop-up Pie Menu



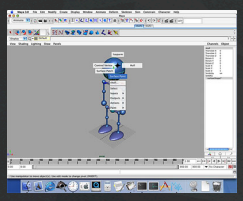
- Which will be faster on average?
  - pie menu (bigger targets & less distance)

Pie Menus in Use Today

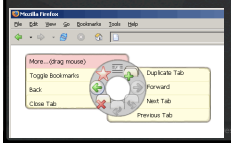
The Sims



Rainbow 6



Maya



Apple Watch

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

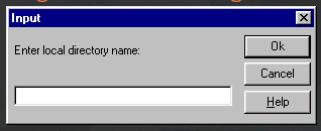
- Do it again
- Say "done" when finished

Yellow
White
Black
Blue
Red
Green

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 of semantics
  - easier because of cues to retrieval
    - cue is anything related to item or situation where learned
    - e.g., giving 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: sensor, 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 and 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

- Conceptual Models & Interface Metaphors
  - Read "The Psychology of Everyday Things" (Ch. 1), from *The Design of Everyday Things* by Donald Norman
- Studio
  - Ad-hoc group heuristic evaluation
  - Must be present to get credit on assignment