Human Abilities: Vision & Cognition

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Hall of Fame or Shame?

Create your Google Account

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, more later...

Hall of Shame!

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

- Retina covered with two types of light-sensitive receptors called rods and cones.
  - Rods: primarily for night vision and 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

- AKA Red not as sensitive to blue
  - lots of overlap

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!

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

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 solely 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
- 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

• Quiz 2 grades
  - Average 4.3 / 5
  - Median 5 / 5
  - Std. Dev .83
  - Range 2-5

• Have your Heuristic Evaluation ready to go when you arrive in studio Thur/Fri

Pop Quiz

No notes, do not look up info, do not share to people outside of this room


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) \( \sim 100 \text{ ms} \)
  - memories have capacity, decay time & type

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

Memory
- Working memory (short term)
  - small capacity (7 ± 2 “chunks”)
  - 6174591765 vs. (617) 459-1765
  - NBC/IBM/MGM 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

- 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 (no accuracy required)

- Turn to neighbor: discuss what will happen

Experimental Results

- Task: Quickly tap each target 50 times accurately

  22 s
  35 s
  27 s
  18 s

Experimental Results (Last Year)

- Task: Quickly tap each target 50 times accurately

  30 sec
  48 sec
  31 sec
  21 sec (lots of spread)
Experimental Results (2 years ago)

- Task:
  Quickly tap each target 50 times accurately

Principles of Operation (cont.)

Fitts’ Law

- moving hand is a series of microcorrections
- correction takes $T_p + T_c + T_m = 240 \text{ msec}$
- time $T_{pos}$ to move the hand to target size $S$, which is distance $D$ away is given by:
  $$T_{pos} = a + b \log_2 \left( \frac{D}{S} + 1 \right)$$

- summary
  - time to move the hand depends only on the relative precision required

Fitts’ Law Example

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

Pie Menus in Use Today

Apple Watch Is a Negative Fitts’ Law Example

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…
Simple Experiment

- Do it again
- Say “done” when finished

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

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Design UIs for Recognition over Recall

- **Recall**
  - info reproduced from memory
  - e.g., command name & semantics

- **Recognition**
  - presentation of info provides knowledge
  - 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: 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**


- **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