Human Abilities: Vision & Cognition

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Hall of Fame or Shame?

Create your Google Account

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 last 2 problems

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...

No feedback
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

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>UV</th>
<th>IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;380</td>
<td>350</td>
<td>500</td>
</tr>
<tr>
<td>500</td>
<td>550</td>
<td>650</td>
</tr>
<tr>
<td>650</td>
<td>700</td>
<td>780</td>
</tr>
</tbody>
</table>

Human Visual System

- Light passes through lens
- Focused on retina

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

Centered on yellow

- 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!

Distribution of Photopigments

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

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

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

Color Guidelines

Avoid simultaneous display of highly saturated, spectrally extreme colors

- e.g., no cyan/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
    - 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

- React Native workshop for Monday, Nov. 11th, 5-7pm, location TBD

Administrivia

- Human-Machines Interface Design

The Model Human Processor

Developed by Card, Moran & Newell ('83)
- based on empirical data
CS 147: dt+UX – Design Thinking for User Experience Design, Prototyping & Evaluation
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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 \( (T) \approx 100 \text{ ms} \)
  - 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 \( (7 \pm 2 \text{ “chunks”}) \)
  - \( 617 459 1765 \text{ vs. } (617) 459-1765 \)
  - NBC/IBM/GMC vs. NBC IBM GMC
  - rapid access \( (-70\text{ms}) \) & decay \( (-200\text{ ms}) \)
  - pass to LTM after a few seconds of continued storage
- Long-term memory
  - huge (if not “unlimited”)
  - slower access time \( (-100\text{ ms}) \) 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
  - 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 (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
  - 30 sec
  - 48 sec
  - 31 sec
  - 21 sec (lots of spread)

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:
    $$T_{pos} = a + b \log_2 \left( \frac{D}{S} + 1 \right)$$
- 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

Simple Experiment

- Do it again
- Say “done” when finished

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

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


- 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