Human Abilities: Vision & Cognition

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Autumn 2017
November 6, 2017

Hall of Fame or Shame?

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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

- 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.

Human Visual System

- Light passes through lens
- Focused on retina

Retina

- Retina covered with two types of light-sensitive receptors called:
  - Rods
  - Cones
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

- 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

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 → fatigue
- 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 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

The Model Human Processor

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

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?

- 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
    - NBCIBMGM vs. NBC IBM GMC
  - rapid access (~70ms) & decay (~200ms)
    - pass to LTM after a few seconds of continued storage
- Long-term memory
  - huge (if not “unlimited”)
  - slower access time (~100ms) 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

- **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

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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**

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Experimental Results

- **Task:**
  - Quickly tap each target 50 times accurately

  - 30 sec
  - 48 sec
  - 31 sec
  - 21 sec (lots of spread)

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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

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Fitts’ Law Example

- 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...

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 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
  - Human-Computer Interaction, by Dix, Finlay, Abowd, and Beale, 1998


- 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