Human Abilities: Vision & Cognition

Hall of Shame!

- Design based on a top retailer's site
- In study, user could not get by this screen, why?
- Color deficiency – can't distinguish between red & green
- How to fix? – redundant cues

Outline

- Review
- Human visual system
- Guidelines for design
- Models of human performance (MHP)
- Memory

Video Prototype Review

- Prototype dimensions
  - representation, precision, interactivity, evolution
- Video prototypes illustrate how customers will interact w/ system
  - quick to build, inexpensive, shows context of use
- How to create a video prototype
  - create use scenario in words
  - develop storyboard of each action/event w/ annotations explaining what is happening in scene. Put each element on a card.
  - shoot a video clip for each storyboard card
  - use title cards to separate clips
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

- Light passes through lens
- Focussed on retina

Retina

- Retina covered with light-sensitive receptors:
  - 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

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**

![Graph showing color sensitivity with a lot of overlap between yellow and blue wavelengths.](http://www.cs.gsu.edu/classes/hypgraph/color/coloreff.htm)

- Not as sensitive to blue
- Really yellow

**Distribution of Photopigments**

- Not distributed evenly – mainly reds (64%) & very few blues (4%) →
  - Insensitivity to short wavelengths (blue)
- No 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!

**Color Sensitivity & Image Detection**

- Most sensitive to the center of the spectrum
  - Blues & reds must be brighter than greens & yellows
- Brightness determined mainly by R+G
- Shapes detected by finding edges
  - We use brightness & color differences
- Implication
  - Hard to deal with blue edges & shapes

**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 then less pure (desaturated)
  - Don’t use saturated colors in UIs unless you really need something to stand out (stop sign)

**Color Deficiency**

- 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

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 red & green in the periphery (no RG cones)
- Avoid pure blue for text, lines, & small shapes
  - also avoid adjacent colors that differ only in blue
- Avoid single-color distinctions
  - mixtures of colors should differ in 2 or 3 colors
  - helps color-deficient observers

Using the Hue Circle

- Pick non-adjacent colors
  - opponent colors go well together
  - (red & green) or (yellow & blue)

Why Model Human Performance?

- To test understanding
- To predict influence of new technology

The Model Human Processor

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

One Minute Break
MHP Basics

- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
  - pressing key in response to light
  - driving, reading signs, & hearing at once
- Parameters
  - processors have cycle time (T) ~ 100-200 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

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

Memory

- Working memory (short term)
  - small capacity (7 ± 2 “chunks”)
    - 6174591765 vs. (617) 459-1765
    - DECIBMGC vs. DEC 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

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

- Which will be faster on average?
  - pie menu (bigger targets & less distance)
**Pie Menus in Use Today**

- The Sims
- Rainbow 6
- Maya

**Perception**

- Stimuli that occur within one PP cycle fuse into a single concept
  - frame rate needed for movies to look real?
  - time for 1 frame < Tp (100 msec) → 10 frame/sec.
- Perceptual causality
  - two distinct stimuli can fuse if the first event appears to cause the other
  - events must occur in the same cycle

**Perceptual Causality**

- How soon must red ball move after cue ball collides with it?
  - must move in < Tp (100 msec)

**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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**Stage Theory**

- Working memory is small & temporary
- Maintenance rehearsal – rote repetition
  - not enough to learn information well
- Chunking / elaboration moves to LTM
  - remember by organizing & relating to already learned items

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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 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.

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**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
    - e.g., perceive distinct events in same cycle as one
- **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:** 100 ms

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**Further Reading**

**Vision and Cognition**

- **Books**
- **Articles**
Next Time

• Conceptual Models & Interface Metaphors

• Read
  – Norman Chapter 1 (subset)