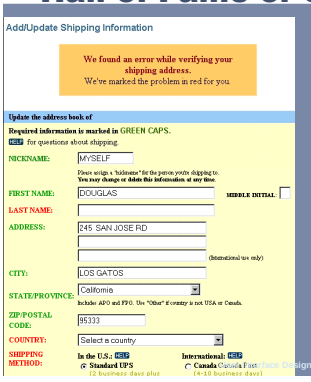
User Interface Design, Prototyping, and Evaluation

Human Abilities: Vision & Cognition

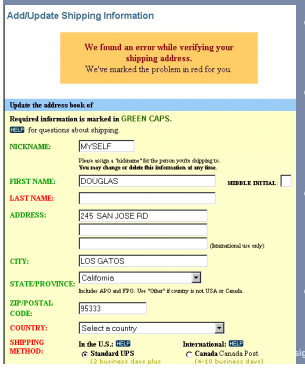
Prof. James A. Landay
University of Washington
Autumn 2008

October 21, 2008

Hall of Fame or Shame?



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

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Outline

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

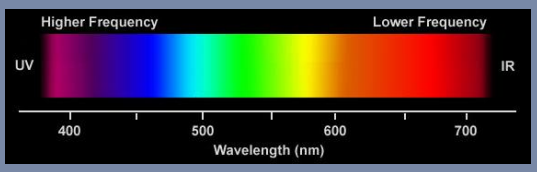
Video Prototype Review

- 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

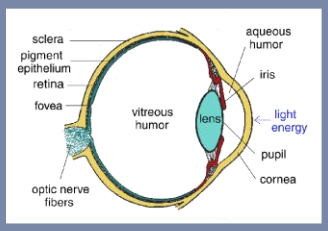
Why Study Color?

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

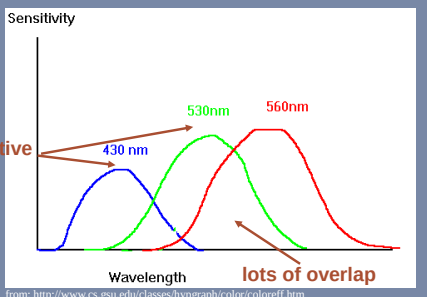
Retina

- Center of retina has most of the →
  - allows for high acuity of objects focused at center
- Edge of retina is dominated by →
  - allows detecting motion of threats in periphery

Color Perception via Cones

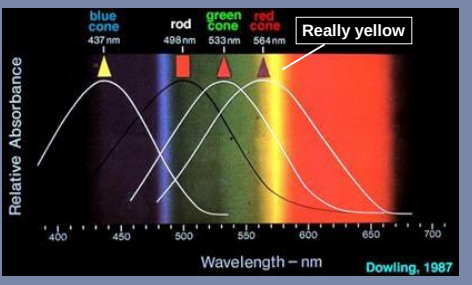
- "Photopigments" used to sense color
- 3 types: blue, green, "red" (really yellow)
  - each sensitive to different band of spectrum
  - ratio of neural activity of the 3 → color
    - other colors are perceived by combining stimulation

Color Sensitivity



from: http://www.cs.gsu.edu/classes/hypgraph/color/coloreff.htm

Color Sensitivity



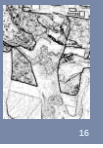
from http://insight.med.utah.edu/Webvision/index.html

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 w/ 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 (AKA "color blindness")

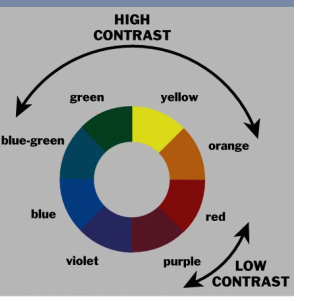
- Trouble discriminating colors
  - besets about 9% of population
- Two main types
  - *different photopigment response* most common
    - reduces capability to discern small color diffs
  - *red-green deficiency* is best known
    - lack of either green or red photopigment → can't discriminate colors 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

Using the Hue Circle

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



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

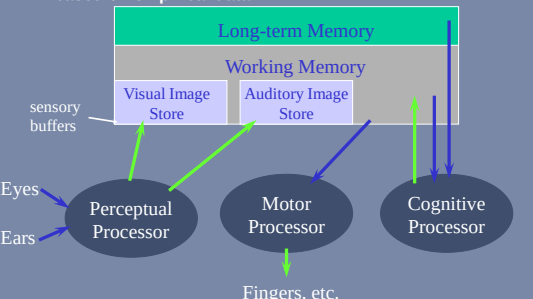
One Minute Break

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



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

Memory

- Working memory (short term)
  - small capacity (7 ± 2 "chunks")
    - 6174591765 vs. (617) 459-1765
    - DECIBMGMC 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

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

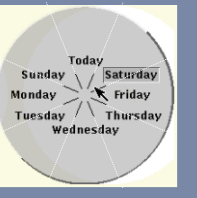
Principles of Operation (cont.)

- 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

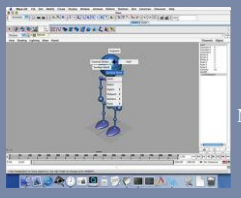


- Which will be faster on average?
  - pie menu (bigger targets & less distance)

Pie Menus in Use Today

The Sims

Rainbow 6

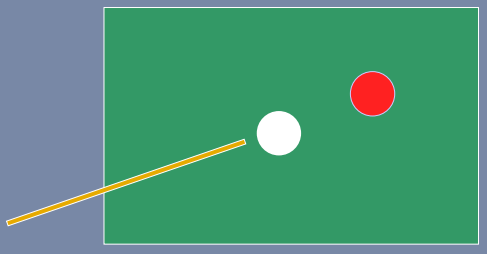


Maya

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…

Paper
Home
Back
Schedule
Page
Change

Simple Experiment

- Do it again
- Say "done" when finished

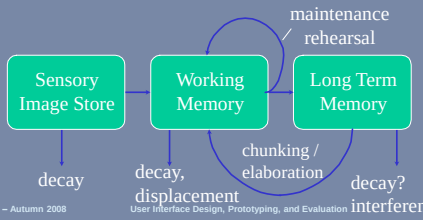
Yellow
White
Black
Blue
Red
Green

Memory

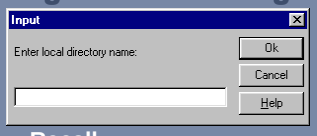
- Interference
  - two strong cues in working memory
  - link to different chunks in long term memory
- Why learn about memory?
  - know what's behind many HCI techniques
  - helps you understand what users will "get"
  - aging population of users

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



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
    - 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

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.
- Articles
  - "Using Color Effectively (or Peacocks Can't Fly)" by Lawrence J. Najjar, IBM TR52.0018, January, 1990, http://mime1.marc.gatech.edu/mime/papers/colorTR.html

Next Time

- **Conceptual Models & Interface Metaphors**
- **Read**
  - **Norman Chapter 1 (subset)**