Human Abilities: Vision & Cognition

刘哲明
Prof. James A. Landay
Computer Science Department
Stanford University

Winter 2022
February 9, 2022
Hall of Fame or Shame?

Create your Google Account

One account is all you need
A single username and password gets you into everything Google.

Take it all with you
Switch between devices, and pick up wherever you left off.

Name
First
Last

Choose your username
@gmail.com

Create a password

Confirm your password

Birthday
Month
Day
Year

Gender
Hall of Fame or Shame?

Create your Google Account

One account is all you need
A single username and password gets you into everything Google.

Take it all with you
Switch between devices, and pick up wherever you left off.

Choose your username
A fan of punctuation! Also, usernames can't have consecutive periods.

Create a password
You can't leave this empty.

Confirm your password

Birthday
Hall of Fame! (but still some issues…)

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…
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...

New version fixes these 2 problems
- adds caution icon & removes no humor
Hall of Fame or Shame?

Zappos.com - Email Us

Oh no! We're very sorry, please fix the following issues...

- Please ensure you included a proper phone number.

Please fill out the following form to email us

You can also check our Frequently Asked Questions section for help in finding an immediate answer to our most commonly asked questions:

NAME (FIRST AND LAST): James Landay
PHONE NUMBER (OPTIONAL): 1 206 651 4382
EMAIL ADDRESS: landay@gmail.com
CONFIRM EMAIL ADDRESS: landay@gmail.com
REGARDING:
ORDER NUMBER (OPTIONAL): 11514267
MESSAGE SUBJECT LINE: didn't get credited for 1 pair returned

Zappos Family Culture
Learn what inspires Zappos.com to provide the best service.
Zappos Family Core Values: I O Values We Live By
Customer Testimonials: I Customer Care
Enjoy fun and a little weirdness: Check Out Blog
The Zappos.com Experience: I Share Your Video
Unique Customers: I Becoming a Customer
Customers in Training: I Become a Part of the Zappos Family Culture: I Careers

Shop with confidence
Shopping on Zappos.com is safe and secure, guaranteed!
You'll pay nothing if unauthorized charges are made to your credit card as a result of shopping at Zappos.com.
Hall of Shame!

Like
- error message prominent with different color & shape

Wish
- where is the error?
- what’s wrong with it?
- parse & fix it yourself!
### Hall of Shame!

**Update (today)**
- no longer have that form
(uses phone, SMS, live chat)

### Contact Information

1. **CALL the Zappos Customer Loyalty Team:**
   1-800-937-7671

2. **TEXT the Zappos Customer Loyalty Team:**
   Text CHAT to 1-833-607-7686 to chat with the Zappos Customer Loyalty Team by text.

   By texting CHAT, you consent to receive text messages (including automated and marketing messages) from or on behalf of Zappos at your mobile number provided. Consent is not a condition of any purchase. Text STOP to end your chat. Message & data rates may apply.

3. **CONNECT WITH LIVE HELP:**
   Ask your question right now with a member of the Zappos Customer Loyalty Team.
   Go ahead - start a conversation now!

   **Frequently Asked Questions:** Answers to our most commonly asked questions: [Frequently Asked Questions](https://www.zappos.com)
   Haga click aquí para [preguntas frecuentes en español](https://www.zappos.com)

   **ADDITIONAL INQUIRIES:**
   **Brand Inquiries:**
   Feature your brand on the website! Please direct all brand inquiries via email to: [merchandising@zappos.com](mailto:merchandising@zappos.com)

   **Press Inquiries:**
   Please direct all media inquiries via email to: [press@zappos.com](mailto:press@zappos.com)
Human Abilities: Vision & Cognition

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Winter 2022
February 9, 2022
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

There is an order to the colors… ROY G. BIV

But remember, **do not use that ordering** to order data!
(recall Tufte’s example of how unusable a map is using this ordering for elevation)
Human Visual System

- Light passes through lens
- Focused on retina

Cross section of Human Eye

Object

Light

Electric signal

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 to intensity or shades of gray
  - cones
    - used to sense color

http://www.webexhibits.org/causesofcolor/1G.html
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

http://www.webexhibits.org/causesofcolor/1G.html
Color Sensitivity

not as sensitive to blue

lots of overlap

AKA Red

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

http://archive.cnx.org/contents/d42c807d-a9fa-4e3d-83d0-0f7c745551ad@4/color-and-color-vision/import-auto-id1844887
Color Sensitivity

http://retina.umh.es/webvision/imageswv/spectra.jpeg
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!

http://www.webexhibits.org/causesofcolor10.html
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

https://physics.info/color/
Focus

• Different wavelengths of light focused at different distances behind eye’s lens
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• Pure (saturated) colors require more focusing than less pure (desaturated)
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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

Difficult pairs for severe red deficient person to discern
[Link to website: https://www.color-blindness.com/red-green-color-blindness/]
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
<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 7–11</td>
<td>Accessible Design Workshop&lt;br&gt;Saturday, Feb. 12</td>
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<tr>
<td></td>
<td>Designing the Future: Early and Future Visions of HCI (PPT) (Recording)</td>
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<td>As We May Think by Vannevar Bush&lt;br&gt;Tools For Thought (Ch 9), Engelbart Demo</td>
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<td>Listen and Read: Of Mice and Men, 99% Invisible, Episode 149 (21 minutes)</td>
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<td>Feb 14–18</td>
<td>A7 Heuristic Evaluation (individual)&lt;br&gt;due by studio (Feb 17-18)</td>
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<td>A8 Hi-fi Prototype (group)&lt;br&gt;Midway due by studio week 9 (Mar 3-4)&lt;br&gt;Complete due by studio week 10 (Mar 10-11)&lt;br&gt;Writeup due Saturday Mar 12</td>
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<td>Heuristic Evaluation (with in-class exercise) (PPT)&lt;br&gt;How to Conduct a Heuristic Evaluation by Jakob Nielsen</td>
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<td>Conceptual Models and Interface Metaphors (PPT)&lt;br&gt;“The Psychology of Everyday Things” (Ch 1) from The Design of Everyday Things by Donald Norman</td>
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<tr>
<td></td>
<td>A9 Heuristic Evaluation&lt;br&gt;due end of studio day (Feb 17-18 @ 11:59PM)</td>
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<td>Feb 21–25</td>
<td>Presidents' Day (No Class)</td>
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<td>Midterm</td>
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<td>Midterm Review (Evening Thurs 2/17) (PPT)</td>
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<td>Project Group Work</td>
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</tbody>
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Winter 2022  

dt+UX: Design Thinking for User Experience Design, Prototyping & Evaluation  

29
## Administrivia

### Feb 28- Mar 4
- A10 Poster and Pitch Slide (group)
  - Draft due Monday Mar 7
  - Final due Wednesday Mar 9
- 1) Usability Testing (PPT)
- 2) Accessibility (PPT)
  - Optional: Inclusive Design
  - Optional: "Disability Studies as a Source of Critical Inquiry for the Field of Assistive Technology"
- Design Patterns (PPT)
  - The Design of Sites by van Duyne, Hong, & Landay:
    1) "Making the Most of Web Design Patterns" (Ch 2)
    2) "Up-Front Value Proposition" (Pattern C2)
    3) "Process Funnel" (Pattern H1)
    4) "Meaningful Error Messages" (Pattern K13)
- A8 Presentation Project Group Work

### Mar 7-11
- Guest Q&A
  - Tracy Chou (Stanford ’09/’10), CEO at Block Party
- Smart Interfaces for Human-Centered AI (PPT)
- 30-Second Pitch and Demo Practice
  - Project Expo (PPT)

## Final Due Items

Students are required to attend the **project expo on Friday Mar 11 at 6:00-9:30 PST.** Final writeups are due Mar 12.
Administrivia

• Final workshop – Accessibility – Saturday at 1PM
  – we will be giving a few bonus points for projects that do a good job of addressing accessibility

• Watch the previous two (Figma Basics & Design Systems) if you have not already (links on the calendar)
The Model Human Processor

Developed by Card, Moran & Newell (’83)
- based on empirical data
The Model Human Processor

Long-term Memory

Working Memory

- Visual Image Store
- Auditory Image Store

Perceptual Processor

Motor Processor

Cognitive Processor

sensory buffers

Eyes

Ears

Fingers, etc.
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 \( T \) \( \sim 100 \) ms
  - memories have capacity, decay time & type
What is missing from MHP?

- Long-term Memory
- Working Memory
  - Visual Image Store
  - Auditory Image Store
- Perceptual Processor
  - Eyes
  - Ears
- Motor Processor
  - Fingers, etc.
- Cognitive Processor
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
"I'm having trouble with my short term memory... ...
I'm here b'coz of my short term memory... ...
I 'd like to talk to you about my short term memory..."
Memory

• Working memory (short term)
  - small capacity (7 ± 2 “chunks”)
    • 6174591765 vs. (617) 459-1765
    • NBCIBMGM 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
MHP Principles of Operation

Long-term Memory

Working Memory

Visual Image Store

Auditory Image Store

Perceptual Processor

Motor Processor

Cognitive Processor

Eyes

Ears

sensory buffers

Fingers, etc.
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
Volunteer for Experiment

http://simonwallner.at/ext/fitts/
Volunteer for Experiment

http://simonwallner.at/ext/fitts/
Volunteer for Experiment

Index of Difficulty: $ID = \log\left(\frac{D}{W}\right) + 1$

$D =$ distance to target, $W =$ width of target (or size)
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
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

Firefox

Maya
Apple Watch Is a Negative Fitts’ Law Example
Apple Watch Is a Negative Fitts’ Law Example
Volunteer for Experiment

https://faculty.washington.edu/chudler/java/ready.html
Memory Interference in Action: Cultural

The current date and time is Tuesday, October 27, 2015 at 3:20:21 PM.
Memory Interference in Action: *Cultural*

The current date and time is Tuesday, October 27, 2015 at 3:20:21 PM.

[Dialog box with options: Cancel and OK]
Memory Interference in Action: *Labels/Terms*

- **LOA Fiscal Year:** 2010
- **LOA Name:** VX9200 HMA19
- **Agency / Editor:** VO / Project
- **Project:** 51VX920000
- **Task:** HMA19
- **Expenditure Type:** 21000
- **Expenditure Org:** T81

SubmitLOA  OverrideLOA  Return
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
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
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

• Lecture
  – Heuristic Evaluation

• Read
  – How to Conduct a Heuristic Evaluation by Jakob Nielsen

• Studio
  – Midterm review
  – Medium-fi prototype feedback from TAs