Introduction to HCI

Human Abilities and Sketching

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Today

- Quiz [5 min]
- Discussion of readings [10 min]
- Lecture [50 min]
- Project discussions [10 min]
Discussion on requirement readings [10 min]

• A randomly assigned team will summarize and discuss readings:
  • What you learned?
  • What surprised you?
  • How can you use this knowledge in your project?
Learning goals

• Understand human abilities, perception and action subsystems.
• Understand models and theories of human performance and abilities.
  • Attention, divided attention, color, focus, motor, etc.
• Be able to identify and apply knowledge of human abilities in designing interfaces for humans.
• Understand vision systems, change blindness examples, and how related to interface design.
• Explain fitts’ law, how to revisit an interface considering this principle, and how else fitts’ law can be used.
Human-centered design

• Beyond understanding the tasks (task-centered design), the type of users (persona-based design) that we want to support, as well as an appropriate conceptual model

• We must understand human abilities in order to do detailed interface and interaction design
Is this a good interface?
How do we characterize human abilities?

• Where do we start?
• With a model of the human.
Model Human Processor (MHP): one model for perception → memory → cognition

- Long-term Memory (LTM)
- Working Memory (WM)
  - Visual Image Store
  - Auditory Image Store
  - Haptic Image Store

Cognitive Processor

Attention filters what gets through...

Motor Processor (action)

WORLD

Perception & action subsystems

• Subsystems may operate in parallel (theory):

Input (perception):
  • **Visual** subsystem for what we see (most studied)
  • **Acoustic** subsystem for what we hear
  • **Haptic** subsystem for what we feel

Output (action):
  • **Vocal (articulatory)** subsystem for what we speak
  • **Motor** subsystem for how we move
  • **Brain waves!** Think to interact (brain-computer interfaces)
Smellmap: Amsterdam

Kate McLean, IEEE vis 2014, art program
https://visap.uic.edu/2014/art/Smellmap.pdf
Analogies to a computer system

• Can be a helpful way to think about it:

• Perception, audition, motor control = **system I/O**
  • Each has associated memory (“cache”)
  • Limits on input speed (“sample rate”) and throughput capacity

• Cognition = **CPU**
  • Includes multi-level main memory
  • Multithreading? *we don’t really understand how this works in people*

Use analogy with caution:
some systems do NOT work this way.
Takeaways for this lecture

• When designing for humans, you need to factor in knowledge of their abilities.

• There are many models and theories of human performance / ability, we will touch on only a few today.

• This lecture brings together content from 4 different lectures in HCI. Each of those lectures only scratches the surface, so this one is even more abridged.
Attention

• Attention is a filter on perceptual input.

• It’s one important mechanism for information moving between types of memory
  • (image store -> working memory -> long term memory)
Perceptual limitations

The following is intended to illustrate just how bad our senses really are
Example: change blindness

• In upcoming images,
  • Image will blink or flicker
  • Image changes with each blink

*Raise your hand as soon as you identify change*

Images from o’regan, rensink & clark 1999
Airplane
Diners
Airplane without blink:
Diners without blink:
Vision system: like a camera?

Seems like it:

*Camera*: keep steady, adjust focal lens length

*Eye*: focal point always moving, yet we perceive the world as being sharp and in focus

But how does it really work?

*Camera*: film is exposed all at once by light from scene

*Eye*: electrical signals travel to brain, which *gradually + selectively updates* a mental image of a scene

→ *camera is a poor metaphor for vision!*
How does this relate to interface design?

• What are some everyday situations where ‘change blindness’ occur?

• For those situations, how might you help by changing the design?
Divided Attention
pre-attentive lessons

- rapid visual search (≤ 10 msec/item)
- easy to attend to
- makes symbols distinct
- based on simple visual attributes
- faces etc are not pre-attentive
color can substantially *improve* user interfaces…

but inappropriate use can severely *reduce* usability
Johannes Itten, color theory

Itten theorized seven types of color contrast by:

(1) **hue**
(2) **value**
(3) **temperature**
(4) **complements**
(5) **simultaneous contrast**
(6) **saturation**
(7) **extension**
Itten leading his students in physical exercise
human visual system

- light passes through lens
- focused on retina
Retina

- Center of retina (fovea) has most of the cones
  - Allows for high acuity of objects focused at center

- Edge of retina (periphery) is dominated by rods
  - Allows detecting motion in periphery
Trichromacy theory

- Color vision is three dimensional, because there are three cone-receptor types in the retina.
- Cone receptors: short, medium, long (really more yellow)

From Ware (2013). Information Visualization, Perception for design.
Digital Image Processing Lecture

Rich Radke, Rensselaer Polytechnic Institute: https://www.youtube.com/watch?v=eK4ZAsKgCg4
How we see colors

Colm Kelleher: https://www.youtube.com/watch?v=l8_fZPHasdo
Focus

• Wavelengths of light focus at different distances behind eye’s lens

→ Need for constant refocusing (causes fatigue)

Most people see the red closer than the BLUE but some see the opposite effect

reproduced from Ware (2013). Information Visualization, Perception for design
But Trichromacy theory
Insufficient...

Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.
Older users need brighter colors.

Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.

Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.
Older users need brighter colors.

Showing small yellow text on a white background is a bad idea. Pure yellow excites both our M and L cones, making yellow the brightest of colours. Need a lot of luminance contrast

reproduced from Ware (2013). Information Visualization, Perception for design
Color channels: opponent process theory

Input from cones processed into three distinct channels immediately after receptors

From Ware (2008). Visual Thinking for Design. p68
luminance “channel”

• Carries ~2/3 more details than either of the chromatic channels
• Therefore chromatic channels alone not suitable for fine details, small fonts, etc.

Implications:
• Luminance contrast critical for fine details
• Harder to focus on edges created by color alone
  • Best to use both luminance & color differences
Color guidelines

• Generally want to avoid single-color distinctions and encodings (color blindness)

• E.G.  Better than
Color Guideline

• Don’t rely on color (changes) in the periphery to “grab attention”
color guidelines

• large areas: low saturation
• small areas: high saturation (strong contrast with background)
• Red objects are processed pre-attentively (10 ms or less per item) – they “pop out” – we attend to them first.
• Attention and color are related!
ColorBrewer
• Compare the ‘swipe left to close’ interaction over ‘select the x to close’ interaction. Which do you think is better?
Fitts’ Law
Paul Fitts, 1954

\[ MT = a + b \log_2 \left( \frac{D}{W} + 1 \right) \]

Movement Time
Index of Difficulty (ID [bits])

Index of Performance \((IP) = ID/MT \) (bits/s)

A simple mathematical model of human pointing performance
Fitts’ Law
Paul Fitts, 1954

Task difficulty for selecting a target (such as a menu item or icon)

is proportional to the distance \((D)\) to the target and

inversely proportional to the width \((W)\) of the target
How ELSE can we use Fitts’ Law?

So what can we do with this information?

50 years of data

<table>
<thead>
<tr>
<th>Device</th>
<th>Study</th>
<th>$IP$ (bits/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand</td>
<td>Fitts (1954)</td>
<td>10.6</td>
</tr>
<tr>
<td>Mouse</td>
<td>Card, English, &amp; Burr (1978)</td>
<td>10.4</td>
</tr>
<tr>
<td>Joystick</td>
<td>Card, English, &amp; Burr (1978)</td>
<td>5.0</td>
</tr>
<tr>
<td>Trackball</td>
<td>Epps (1986)</td>
<td>2.9</td>
</tr>
<tr>
<td>Touchpad</td>
<td>Epps (1986)</td>
<td>1.6</td>
</tr>
<tr>
<td>Eyetracker</td>
<td>Ware &amp; Mikaelian (1987)</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Table Reference:
Other aspects of motor…
Tactile findability: “touch” keyboards

physical keys

“soft” keys have other benefits

tactus “bubble” keyboard: best of both?
Back to this interface...

- Absence of visual chunking (gestalt theory), didn’t cover today
- Visual differentiation of icons is poor
- Poor balance of work space and tool space
Key takeaways

• When doing your research, ask yourself what aspect of human ability impact your design?
• If you are designing a…
• usable security system that involves passwords -> human memory
• biomedical tele-surgery device -> haptics and motor
• e-book reader for elderly people -> vision, motor, cognition changes across the lifespan
On deck...

- Next class is canceled due to Monday schedule

- Second project milestone: Ideate
  - due on Oct 15th
Johannes Itten, artwork