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.
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.
User Interface Design Process: Evolving Iterations

Understand USERS:
- who they are
- their key tasks

Understand DESIGN:
- design space and risks
- choose design approach

REFINE Design:
- by element
- considering task
- varied contexts

CONFIRM & debug:
- performance in real use

Examine existing:
- user tasks & objectives
- contexts
- interfaces

Make use of:
- requirements
- task analysis
- real & virtualized users
- technology options
- company IP

Evaluate w/:
- observation
- task walk-throughs
- many kinds
- ethnography
- interviews, questionnaires
- task analysis

Make use of:
- graphical design
- interface guidelines
- style guides
- real & virtualized users

Evaluate w/:
- usability testing – controlled, uncontrolled
- heuristic evaluation

Med/ high fidelity prototyping methods

Evaluate with:
- observation
- interview/quest
- participatory interaction
- task walk-throughs

low fidelity prototyping methods

Make use of:
- tests able medium-fidelity prototypes

Mid Design

Release!

Field testing

Early Design

Mid Design

Later Design

Pre Design

PRODUCTS

• user and task descriptions
• design requirements

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• requirements
• task analysis
• real & virtualized users
• technology options
• company IP

• graphical design
• interface guidelines
• style guides
• real & virtualized users

• usability testing – controlled, uncontrolled
• heuristic evaluation

• observation
• interview/quest
• participatory interaction
• task walk-throughs

• low fidelity prototyping methods

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

CONFIRM & debug:
- performance in real use

Release!

Field testing

Early Design

Mid Design

Later Design

Pre Design

PRODUCTS

• user and task descriptions
• design requirements

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• requirements
• task analysis
• real & virtualized users
• technology options
• company IP

• graphical design
• interface guidelines
• style guides
• real & virtualized users

• usability testing – controlled, uncontrolled
• heuristic evaluation

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification

MATERIALS / METHODS

• observation
• ethnography
• interviews, questionnaires
• task analysis

• throw-away prototypes
• design direction
• risk analysis

• testable medium-fidelity prototypes

• alpha/beta systems or complete specification
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

Attention filters what gets through…

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)
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 CPSC 344 and 444. Each of those lectures only scratches the surface, so this one is even more abridged.
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 member)
ONE EXAMPLE OF 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
(Ron Rensink of this dept)
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 ($\leq 10$ msec/item)
- easy to attend to
- makes symbols distinct
- based on simple visual attributes
- faces etc are not pre-attentive
COLOR

color can substantially improve user interfaces…

but inappropriate use can severely reduce usability
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

dge of retina (periphery) is dominated by rods
  • allows detecting motion in periphery
TRICHROMACY THEORY

cone receptors used to sense color

3 types: **Short**, **Medium**, **Long** (really more yellow)

- each sensitive to different band of spectrum
- balance of activity between 3 types to achieve all colours in visible spectrum

from Ware (2013). Information Visualization, Perception for design
DISTRIBUTION OF CONES

not distributed evenly

- mainly reds (64%) and greens (32%) & very few blues (4%) insensitive to short wavelengths, e.g. cyan to deep-blue

center of retina (high acuity) has *no* blue cones

- small blue objects you fixate on disappear

![Color Spectrum Diagram]
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 TRICHRROMACY 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.

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 (EX.)

recommended colors for encoding categories of information (e.g., on a map):
COLOR GUIDELINES (EX.)

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

• e.g.  

better than  

•
COLOR GUIDELINE (EX.)

Don’t rely on color (changes) in the periphery to “grab attention”
COLOR GUIDELINES (EX.)

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!
MOTOR
Which ‘Format’ menu bar option is likely to be the faster target to hit on average?
Compare the ‘swipe left to close’ interaction over ‘select the x to close’ interaction. Which do you think is better?
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.
REVISIT...

Top ‘Format’ menu bar is best, because it effectively has infinite width.
What is the target in each case?

Swipe is best, because the full page is the target.
Task difficulty is analogous to information:
→ execution time is interpreted as human rate of processing information
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...
MUSCLE MEMORY – EXAMPLE: DELIBERATELY INTERFERING WITH SPATIOMOTOR LEARNING
TACTILE FINDABILITY: “TOUCH” KEYBOARDS

“soft” keys have other benefits

physical keys

tactus “bubble” keyboard: best of both?
• 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 graduate 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
• ...

KEY TAKEAWAYS (CONT’D)

We have barely scratched the surface today.

To do graduate level design research, you will likely need to be deeply familiar with human-ability theory / laws in one area or another.

Consider for starters:

CPSC 554Y: **Multimodal Interaction**, Dr. Dongwook Yoon (CS), Jan 2018

PSYC 579: **Perception: Visual Display Design**, Dr. Ron Rensink (Psych/CS), Jan 2018

CPSC 547: **Information Visualization**, Dr. Tamara Munzner (CS), Sept 2017

CPSC 543: **Physical Interface Design & Evaluation**, Dr. Karon MacLean (CS), unknown
ON DECK...

• Tues – Ideate Milestone due + presentations (as before)
• Thurs – start prototyping

Reminder:
• Joanna away all next week