Apr 23

Human Performance
10:00 - 11:20 | OUG 136

Apr 24

2c - Design Research Check-In

Nigini's office hours
10:00 - 12:00
Allen Center 338

Apr 25

Task Analysis
10:00 - 11:20 | OUG 136

-Apr 26

Section
10:30 - 11:20 | MGH 058
11:30 - 12:20 | MGH 058
1:30 - 2:20 | MGH 058
2:30 - 3:20 | MGH 058
What we will do today

Human Performance
  Visual System
  Model Human Processor
  Fitts’s Law
  Gestalt Principles
Models

Models describe phenomena, isolating components and allowing a closer look

**Capture essential pieces**
- Model should have what it needs but no more
- Thus avoid underfitting or overfitting model

**Allow us to measure**
- Collect data, put in model, compare model terms

**Allow us to predict**
- The better the model, the better the predictions
Creating Models

One approach

Observe, Collect Data, Find Patterns,
Draw Analogies, Devise Model,
Test Fit to Data, Test Predictions, Revise

Fundamentally an inductive process

From specific observations to broader generalization
Models of human performance

Visual System
Model Human Processor
Fitts’s Law
Gestalt Principles

Biological Model
Higher-Level Model
Model by Analogy
Predict Interpretation
Models of human performance

**Visual System**
Model Human Processor
Fitts’s Law
Gestalt Principles

**Biological Model**
Human Visual System

Light passes through lens, focused on retina, goes to the brain where it gets processed.
If the light is captured by the retina, and optic nerves have to pass through it, shouldn't we have a blind spot?
Blind Spot

1. Close your right eye.
2. Using your left eye, look at each number from 0 to 9, each for a couple of seconds.
3. The star on the left should disappear at some point.

See also: https://faculty.washington.edu/chudler/chvision.html
Blind Spot

Screen

blind spot angle

Person
Visible Spectrum
Another model: Retina

Covered with light-sensitive receptors

**Rods (120 million)**
- Sensitive to broad spectrum of light
- Sensitive to small amounts of light
- Cannot discriminate between colors
- Sense intensity or shades of gray
- Primarily for night vision & perceiving movement

**Cones (6 million)**
- Used to sense color
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
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

What does that mean for you?
Retina

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What does that mean for you?
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

What does that mean for you?
  Peripheral movement is easily distracting
Color Perception via Cones

Photopigments used to sense color

3 types: blue, green, “red” (actually yellow)

Each sensitive to different band of spectrum
Ratio of neural activity stimulation for the three types gives us a continuous perception of color
Distribution of Photopigments

Not distributed evenly
  Mainly reds (64%), Very few blues (4%)
  Insensitivity to short wavelengths (e.g., blue)
  Highly sensitive to long wavelengths (e.g., orange and yellow)

No blue cones in retina center (high acuity)
  Fixation on small blue object yields “disappearance”

Lens yellows with age, absorbs short wavelengths
  Sensitivity to blue is reduced even further
  (Don’t rely on blue for text and small objects!)
Color Sensitivity & Image Detection

Most sensitive to center of spectrum

To be perceived as the same, blues and reds must be brighter than greens and yellows

Brightness determined mainly by red and green

\[ Y = 0.3 \text{ Red} + 0.59 \text{ Green} + 0.11 \text{ Blue} \]

(To calculate grayscales and balance colors!)

Shapes detected by finding edges

We use brightness and color difference

Implication

Blue edges and shapes are hard to detect
Focus

Different wavelengths of light focused at different distances behind eye’s lens

  Constant refocusing causes fatigue

Saturated colors (i.e., pure colors) require more focusing than desaturated (i.e., pastels)
Focus

Different wavelengths of light focused at different distances behind eye’s lens

Constant refocusing causes fatigue

Saturated colors (i.e., pure colors) require more focusing than desaturated (i.e., pastels)

That is why it hurts to read this message!
Color Vision Deficiency

Trouble discriminating colors
  Affects about 9% of population

Two main types
  Different photopigment response most common
    Reduces capability to discern small color differences
  Red-Green deficiency is best known (color blindness)
    Cannot discriminate colors dependent on red and green
Living with Color Vision Deficiencies

Can we guess you age?

http://www.labinthewild.org/studies/color_age/
Overview of what we did

Controlled in-lab study

  Verification that our color vision test picks up on different situational lighting conditions

Online study

  To collect data from people in diverse lighting conditions
  30,000 participants on LabintheWild.org
  5-94 years old
  ~25% took the test outdoors
Main Results

52% of the population is unable to differentiate 10% of the colors in an average website or infographic
Main Results

10% of the population is unable to differentiate 60% of the colors in an average website.
So what do they see?

(a) Original website

(b) Colors pairs that are not differentiable by 20% of the population have been set to black.

(c) Colors pairs that are not differentiable by 10% of the population have been set to black.
So what do they see?

(a) Original website

(b) Colors pairs that are not differentiable by 20% of the population have been set to black.

(c) Colors pairs that are not differentiable by 10% of the population have been set to black.

(d) Original infographic

(e) Colors pairs that are not differentiable by 20% of the population have been set to black.

(f) Colors pairs that are not differentiable by 10% of the population have been set to black.
That means….

Usability issues
  can’t perceive color-coded cues in an interface

Obstacles in information uptake
  e.g., if color-coded charts hinders data interpretation

Reduction of perceived appeal
  e.g., if an image is perceived with a different color palette than intended
Have you ever been color blind?
What can we do about it?
Dual / Redundant Encoding

Apples to Apples

Pandemic

http://danielsolisblog.blogspot.com/2011_03_01_archive.html
Dual / Redundant Encoding

Add/Update Shipping Information

We found an error while verifying your shipping address.
We've marked the problem in red for you.

Update the address book of

Required information is marked in GREEN CAPS.
USE: For questions about shipping.

NICKNAME: MYSELF

Please enter a "nickname" for the person you're shipping to.
You may change or delete this information at any time.

FIRST NAME: DOUGLAS

LAST NAME:

ADDRESS: 245 SAN JOSE RD

CITY: LOS GATOS

STATE/PROVINCE: California

ZIP/POSTAL CODE: 95033

COUNTRY: Select a country

SHIPPING METHOD:

In the U.S.: USPS Standard UPS
International: Canada Post

[2 business days plus (12 business days)] [4-10 business days]
Curious about color stuff?

Radiolab Podcast Episode: Rippin' the Rainbow an Even Newer One
Models of human performance

Visual System

**Model Human Processor**  **Higher-Level Model**

Fitts’s Law

Gestalt Principles
The Model Human Processor

Developed by Card, Moran & Newell (1983)

Based on empirical data
Summarizing human behavior in a manner easy to consume and act upon

Same book that named human computer interaction!
The Model Human Processor

- Long-term Memory
- Working Memory
  - Visual Image Store
  - Auditory Image Store

Sensory Buffers

Eyes

Ears

Perceptual Processor

Motor Processor

Cognitive Processor

Fingers, etc.
Basics of Model Human Processor

Sometimes serial, sometimes parallel
  Serial in action and parallel in recognition
    Pressing key in response to light
    Driving, reading signs, hearing all simultaneously

Parameters
  Processors have cycle time, approximately 100-200ms
  Memories have capacity, decay time, and type
A Working Memory Experiment
Memory

Working memory (also known as short-term)

- Small capacity (7 ± 2 “chunks”)
  - 6174591765 vs. (617) 459-1765
  - BECMSIAIC vs. IBM CIA CSE

- Rapid access (~ 70ms) and 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) with little decay
Activation Experiment

Need a volunteer!
Activation Experiment

Say the COLORS you see in the list of words
  Say as fast as you can
  There will be three columns of words

Say “done” when finished
  Everyone else time how long it takes
Activation Experiment

<table>
<thead>
<tr>
<th>red</th>
<th>green</th>
<th>blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>yellow</td>
<td>yellow</td>
<td>red</td>
</tr>
<tr>
<td>blue</td>
<td>blue</td>
<td>blue</td>
</tr>
<tr>
<td>green</td>
<td>yellow</td>
<td>red</td>
</tr>
<tr>
<td>red</td>
<td>green</td>
<td>green</td>
</tr>
</tbody>
</table>
Activation Experiment

Let's do it one more time!

Say “done” when finished

Timers: reset your clocks!
Activation Experiment

<table>
<thead>
<tr>
<th>ivd</th>
<th>olftcs</th>
<th>fwax</th>
</tr>
</thead>
<tbody>
<tr>
<td>ncudgt</td>
<td>zjdcv</td>
<td>lxngyt</td>
</tr>
<tr>
<td>mkbh</td>
<td>xbts</td>
<td>cfto</td>
</tr>
<tr>
<td>bhfe</td>
<td>cnhdes</td>
<td>fwa</td>
</tr>
<tr>
<td>cnofgt</td>
<td>uhths</td>
<td>dalcrd</td>
</tr>
</tbody>
</table>
Activation Experiment

And one last time!

Say “done” when finished

Timers: reset your clocks!
Model Human Processor Operation

Recognize-Act Cycle of the Cognitive Processor

- Contents in working memory initiate cognitive processes
- Actions modify the contents of working memory

Discrimination Principle

- Retrieval is determined by...
  1. candidates that exist in memory
  2. relative to retrieval cues

Interference is created by strongly activated chunks
Models of human performance

Visual System
Model Human Processor
Fitts’s Law  Model by Analogy
Gestalt Principles
Fitts’s Law (1954)

Models time to acquire targets in aimed movement
  - Reaching for a control in a cockpit
  - Moving across a dashboard
  - Pulling defective items from a conveyor belt
  - Clicking on icons using a mouse

Very powerful, widely used
  - Holds for many circumstances (e.g., under water)
  - Allows for comparison among different experiments
  - Used both to measure and to predict
Reciprocal Point-Select Task
Fitts’s Law: Index of Difficulty (ID)

$$ID = \log_2\left(\frac{A}{W} + 1\right)$$

The difficulty to hit a target varies with the log of the ratio of the movement distance ($A$) to target width ($W$).
Fitts’s Law: Index of Difficulty (ID)

ID = log2\((A / W + 1)\)

The difficulty to hit a target varies with the log of the ratio of the movement distance (A) to target width (W)

Why is it significant that it is a ratio?
Units of A and W don’t matter
Allows comparison across experiments
(Typically reported in "bits")
Fitts’s Law: Linear variation

\[ MT = a + b \log_2(A / W + 1) \]
A Fitts’s Law Experiment

http://simonwallner.at/ext/fitts/
“Beating” Fitts’s Law

It is the law, right?

\[ MT = a + b \log_2(A / W + 1) \]
“Beating” Fitts’s Law

It is the law, right?

\[ MT = a + b \log_2(A / W + 1) \]
“Beating” Fitts’s Law

It is the law, right?

\[ MT = a + b \log_2(A / W + 1) \]

So how can we reduce movement time?

Reduce A?
Increase W?
Considering specific (a) and (b)'s?
Manufacturer Interface

![Font Formatting Interface](image)

<p>| Font |
|------|---|
| <strong>Type, Style and Size</strong> | | |</p>
<table>
<thead>
<tr>
<th>Font</th>
<th>Style</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arial</td>
<td>Regular</td>
<td>8</td>
</tr>
<tr>
<td>Arial Black</td>
<td>Italic</td>
<td>9</td>
</tr>
<tr>
<td>Comic Sans MS</td>
<td>Bold</td>
<td>10</td>
</tr>
<tr>
<td>Courier New</td>
<td>Bold Italic</td>
<td>11</td>
</tr>
<tr>
<td>Franklin Gothic Medium</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Underline style: (none)

Effects:
- Strikethrough
- Double Strikethrough
- Shadow
- Outline
- Small Caps
- All Caps
- Superscript
- Emboss
- Subscript
- Engrave
- Hidden

Preview:

```
Times New Roman
```

Ok  Cancel
Manufacturer Interface

Person with Cerebral Palsy*

(*) fast, spastic (i.e., highly imprecise) movements
Manufacturer Interface

Person with Muscular Dystrophy*

(*) very low muscle strength = slow but accurate movements
Interface Generation As Optimization

In a study with 11 participants with diverse motor impairments:

- Consistently faster using generated interfaces (26%)
- Fewer errors using generated interfaces (73% fewer)
- Strongly preferred generated interfaces
Fitts’s Law Related Techniques

Put targets closer together

Make targets bigger

Make cursor bigger
  - Area cursors
  - Bubble cursor

Use impenetrable edges
Fitts’s Law Examples

Which will be faster on average?

Pop-up Linear Menu

<table>
<thead>
<tr>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
</tr>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
<tr>
<td>Saturday</td>
</tr>
</tbody>
</table>

Pop-up Pie Menu

- Today
- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
Pie Menus in Use

The Sims

Rainbow 6

Maya
Fitts’s Law in Windowing

Windows 95: Missed by a pixel
Windows XP: Good to the last drop

Macintosh Menu
Fitts’s Law in MS Office

Larger, labeled controls can be clicked more quickly

Mini toolbar is close to the cursor

Magic Corner: Office Button in the upper-left corner
Bubble Cursor

Grossman and Balakrishnan, 2005
Fitts’s Law Related Techniques

Gravity Fields
  Pointer gets close, gets “sucked in” to target

Sticky Icons
  When within target, pointer “sticks”

Constrained Motion
  Snapping, holding Shift to limit degrees of movement

Target Prediction
  Determine likely target, move it nearer or expand it
Models of human performance

Visual System
Model Human Processor
Fitts’s Law
Gestalt Principles
   Predict Interpretation
Gestalt Psychology

Described loosely in the context of this lecture and associated work, not a real definition

Perception is neither bottom-up nor top-down, rather both inform the other as a whole!
Gestalt Psychology
Gestalt Psychology
Principle: Proximity

Objects close to each other form a group
Principle: Proximity

http://designmodo.com/use-gestalt-laws-to-improve-your-ux/
Principle: Similarity

Objects that are similar form a group
Principle: Similarity

http://sixrevisions.com/web_design/gestalt-principles-applied-in-design/
Principle: Closure

Even incomplete objects are perceived as whole

Increases regularity of stimuli
Principle: Closure

The Sims

Rainbow 6
Principle: Symmetry

Objects are perceived as symmetrical and forming around a center point
Continuity

Objects are perceived as grouped when they align
  Remain distinct even with overlap
  Preferred over abrupt directional changes
## Models from Different Perspectives

<table>
<thead>
<tr>
<th>Visual System</th>
<th>Biological Model</th>
</tr>
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<tbody>
<tr>
<td>Model Human Processor</td>
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Ask me something!