CSE440: Introduction to HCI

Methods for Design, Prototyping and Evaluating User Interaction

Lecture 07:
Human Performance

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DESIGN
USE
BUILD

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

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	Biological Model
Model Human Processor	Higher-Level Model
Fitts's Law	Model by Analogy
Gestalt Principles	Predict Interpretation

Models of human performance

Visual System

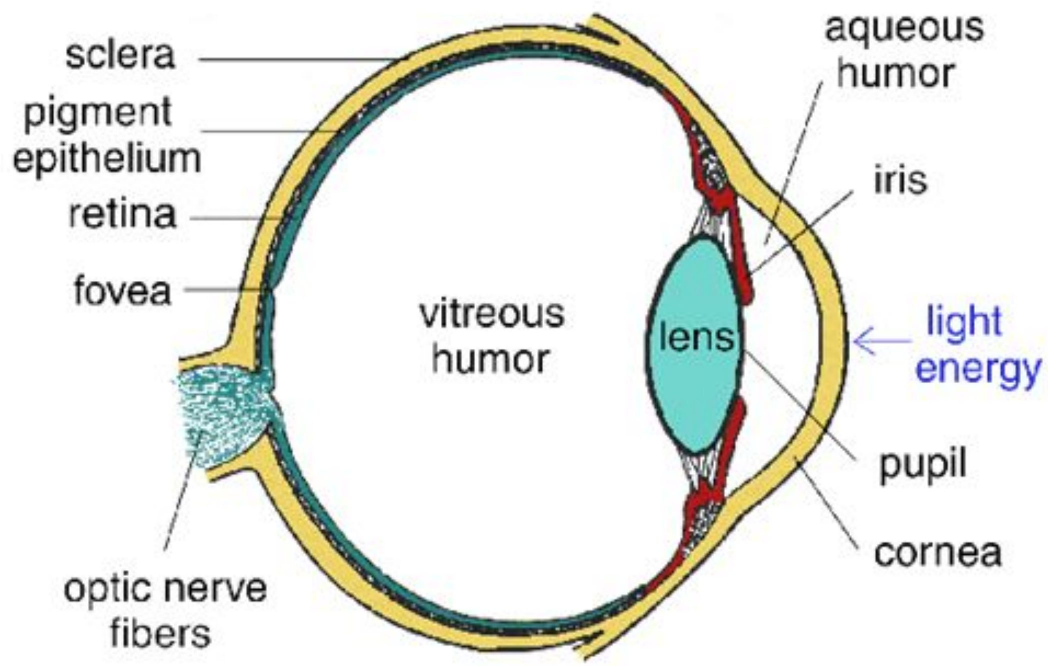
Model Human Processor

Fitts's Law

Gestalt Principles

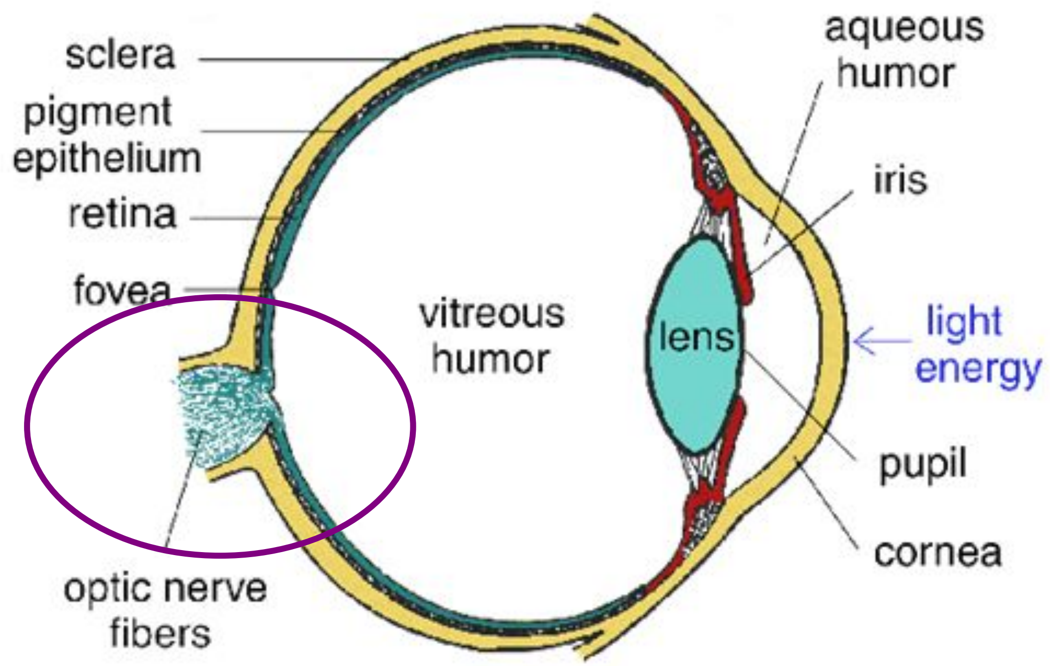
Biological Model

Human Visual System



Light passes through lens, focused on retina, goes to the brain where it gets processed.

Human Visual System



If the light is captured by the retina, and optic nerves have to pass through it, shouldn't we have a blind spot?

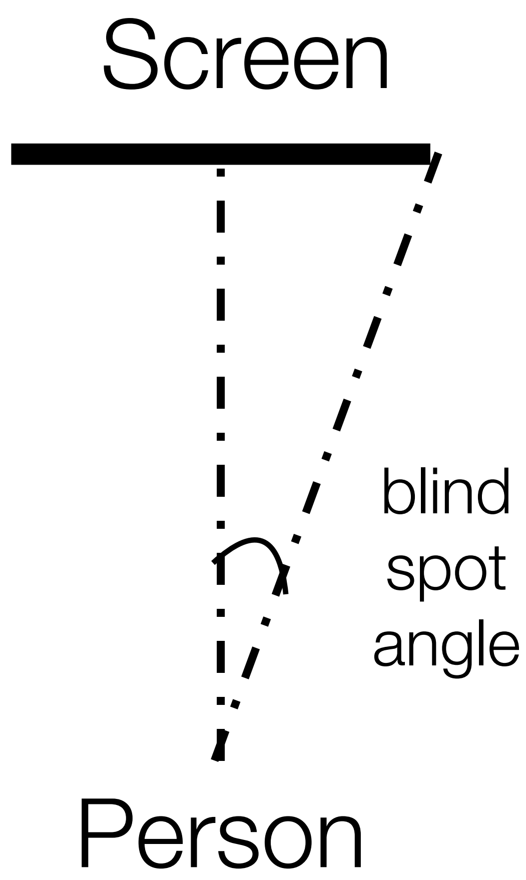
Blind Spot

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.

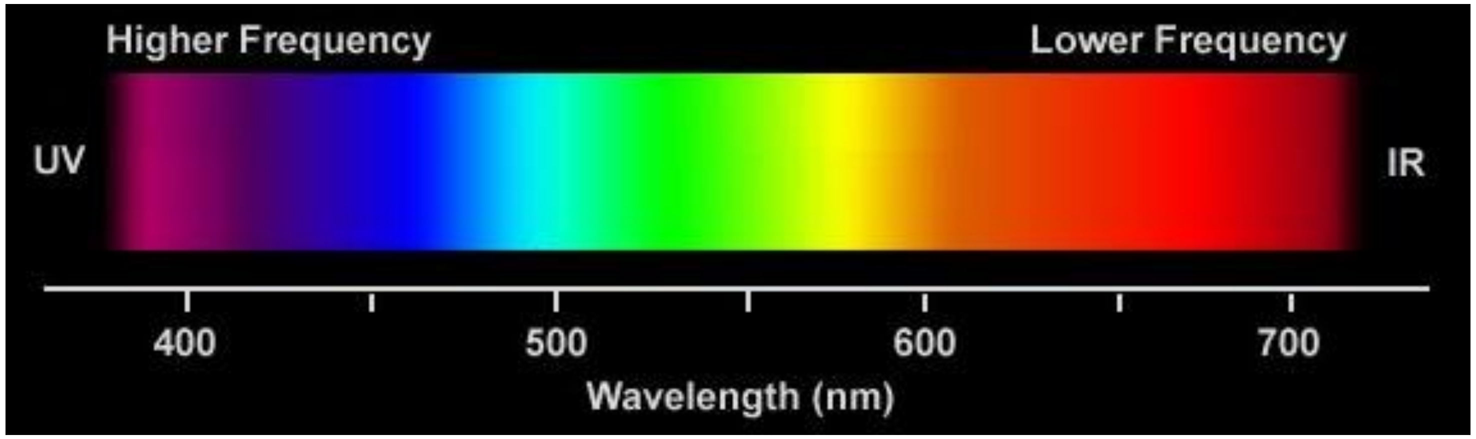
☆ 0 1 2 3 4 5 6 7 8 9

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

Blind Spot



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

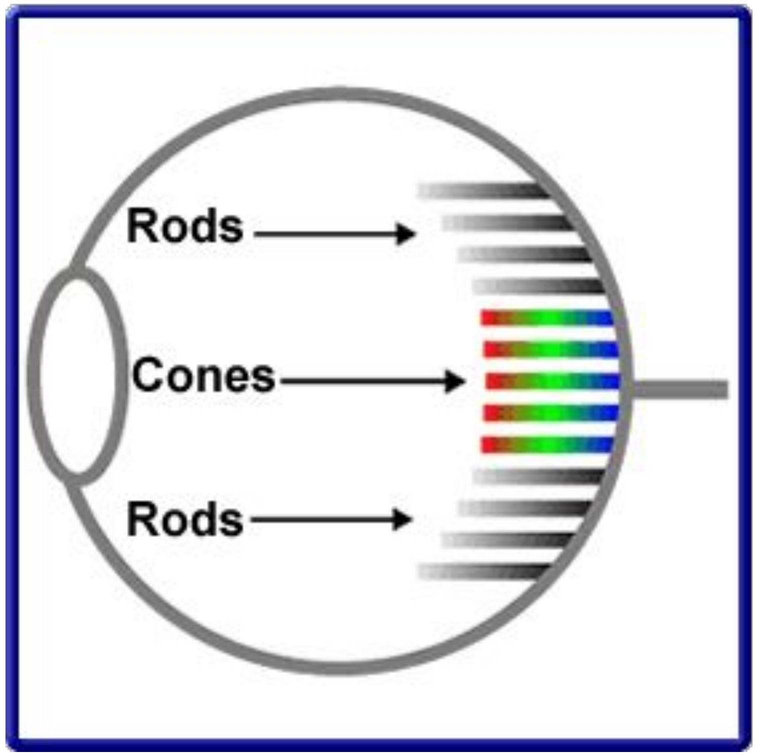
Retina

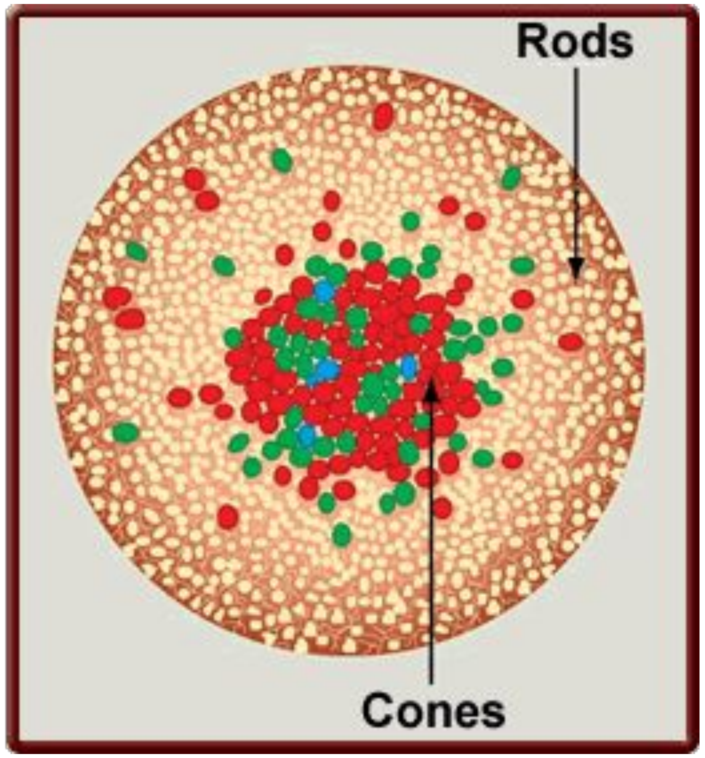
Center of retina has most of the cones

- Allows for high acuity of objects focused at center

Edge of retina is dominated by rods

- Allows detecting motion of threats in periphery





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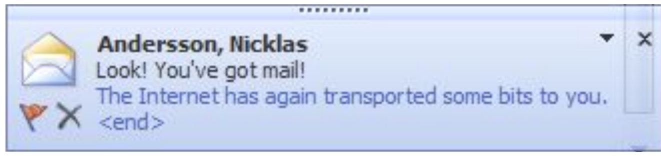
What does that mean for you?

Retina



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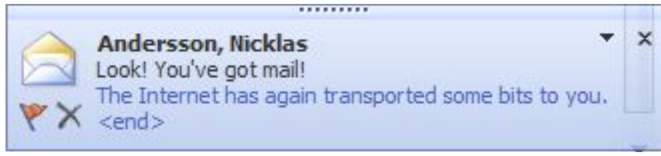

Center of retina has most of the cones

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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!

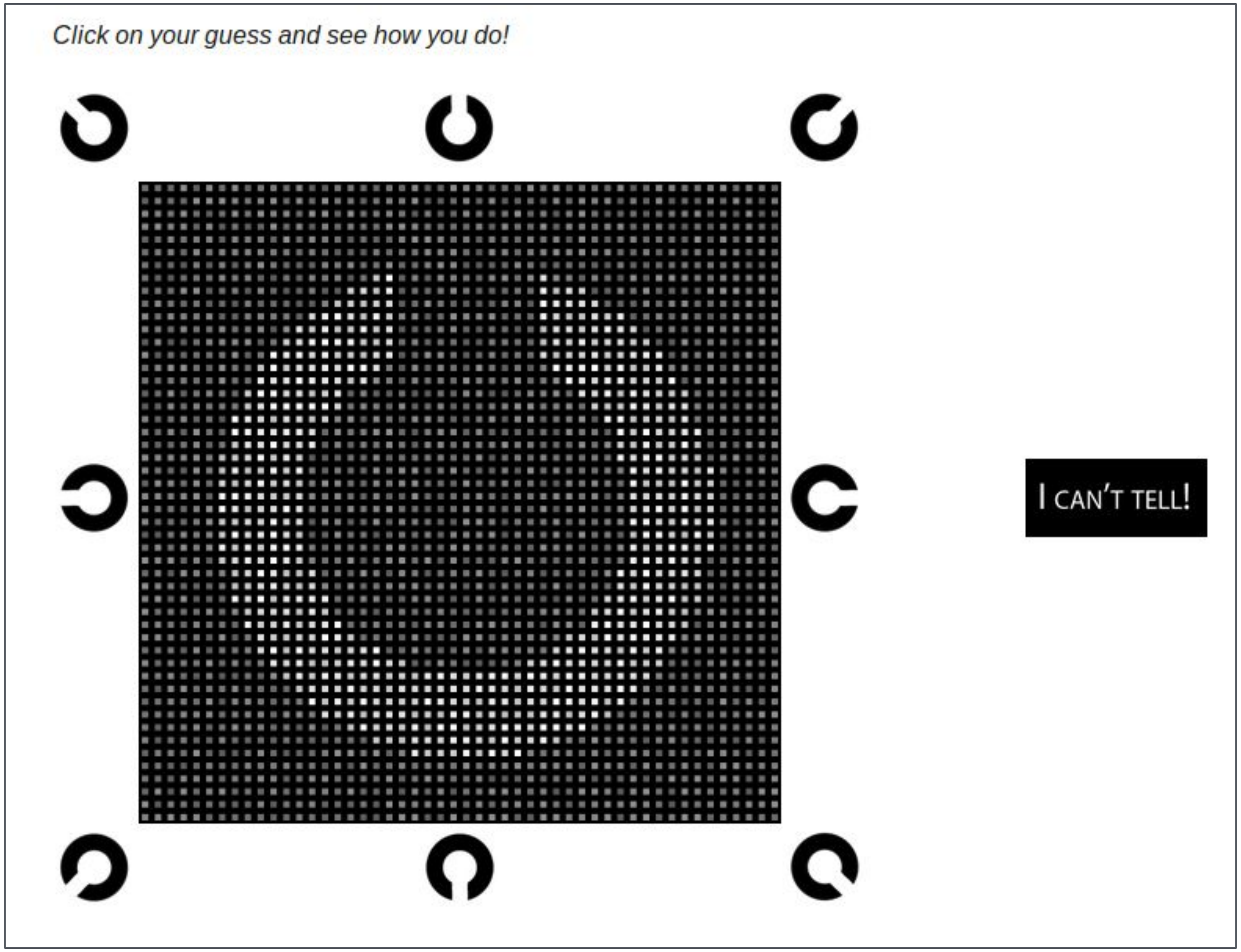
Color Vision Deficiency

- 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

David R. Flatla and Carl Gutwin. 2012. "So that's what you see": building understanding with personalized simulations of colour vision deficiency. In ASSETS '12. ACM, New York, NY, USA, 167-174.

Can we guess you age?



http://www.labinthewild.org/studies/color_age/

Have you ever been color blind?

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

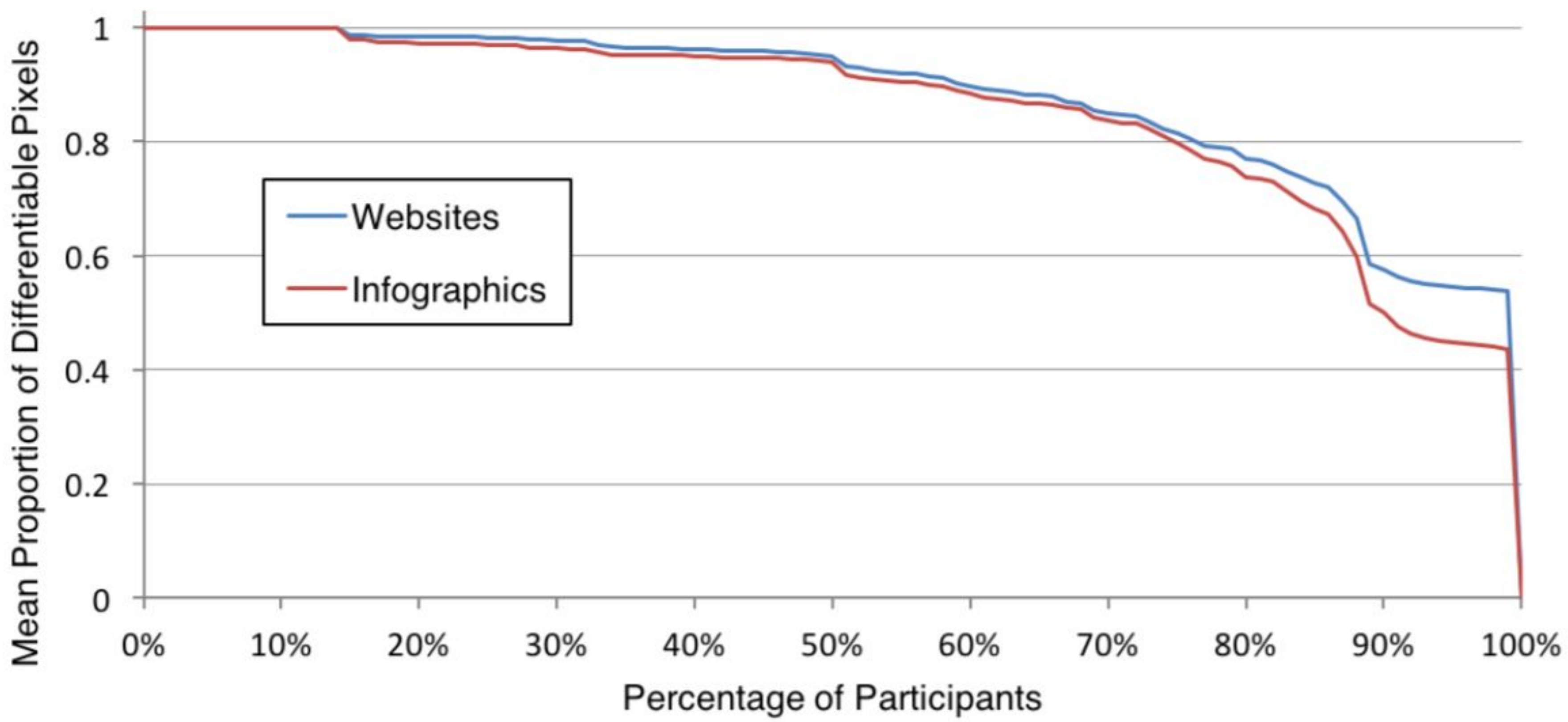
30,000 participants on LabintheWild.org

5-94 years old

~25% took the test outdoors

Main Results

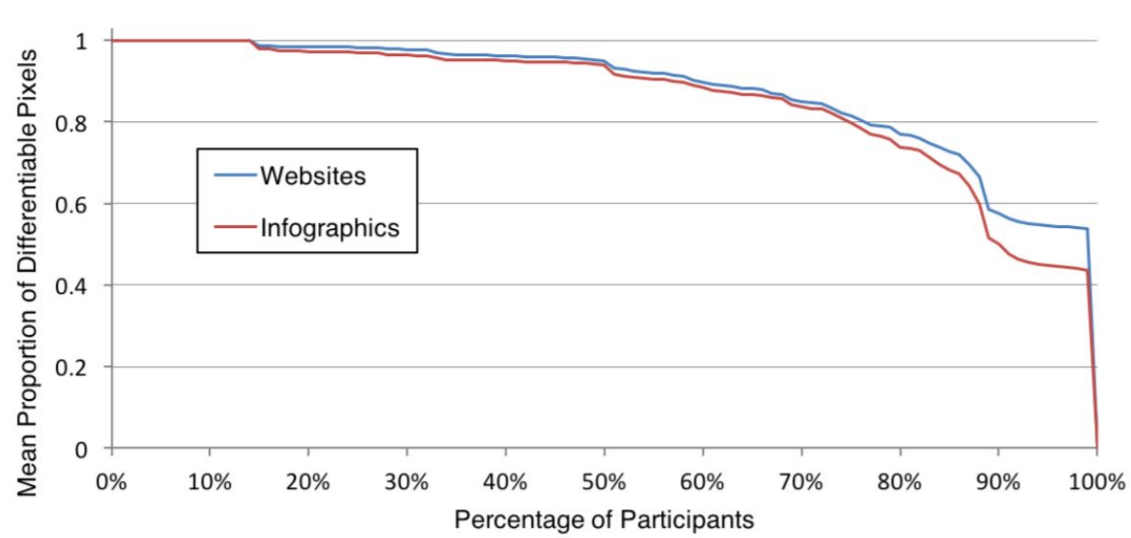
52% of the population is unable to differentiate 10% of the colors in an average website or infographic



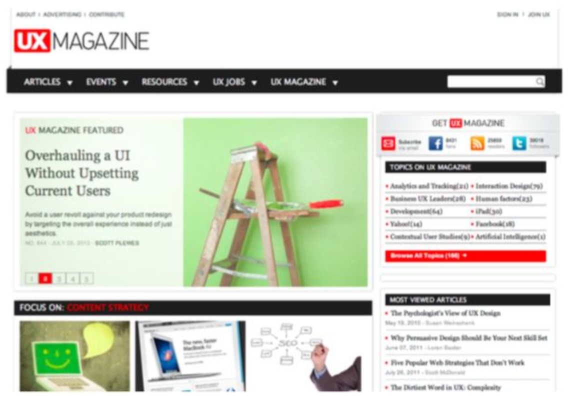
Main Results

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

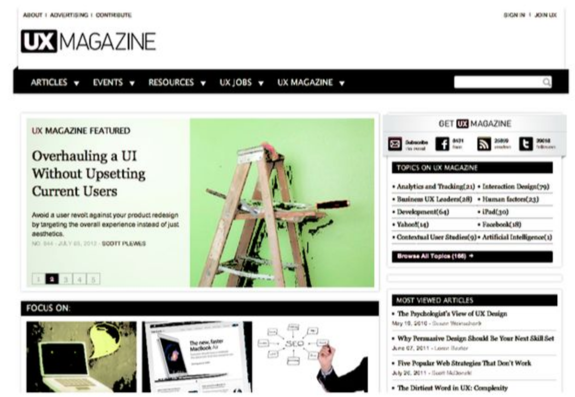
10% of the population is unable to differentiate 60% of the colors in an average website.



So what do they see?



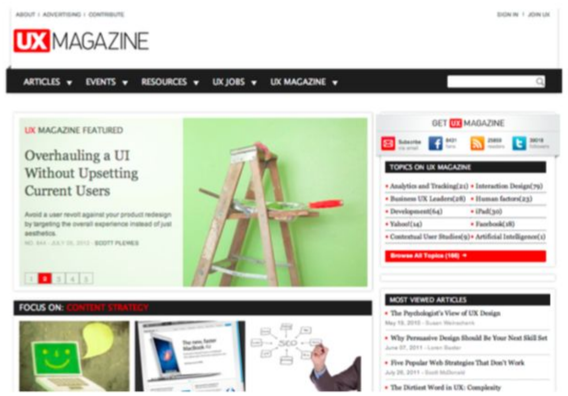
(a) Original website



(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?



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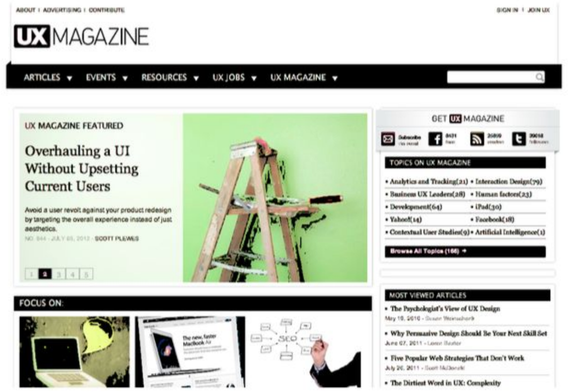

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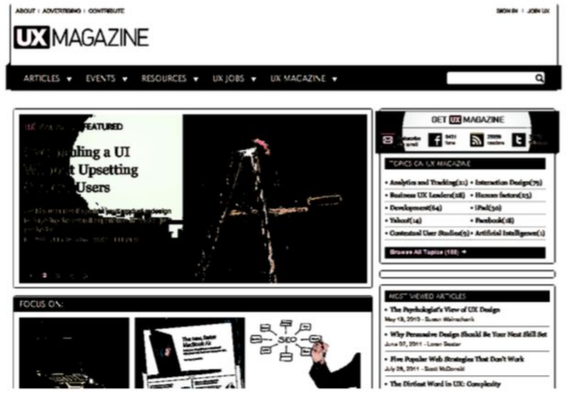

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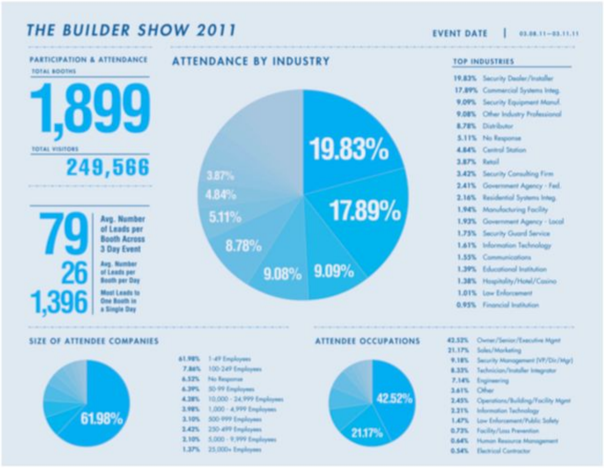
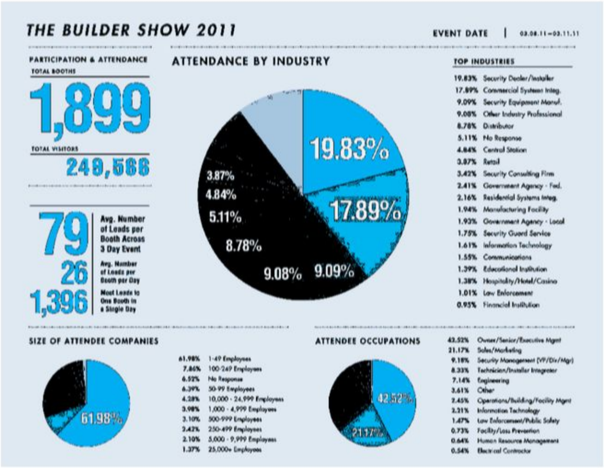
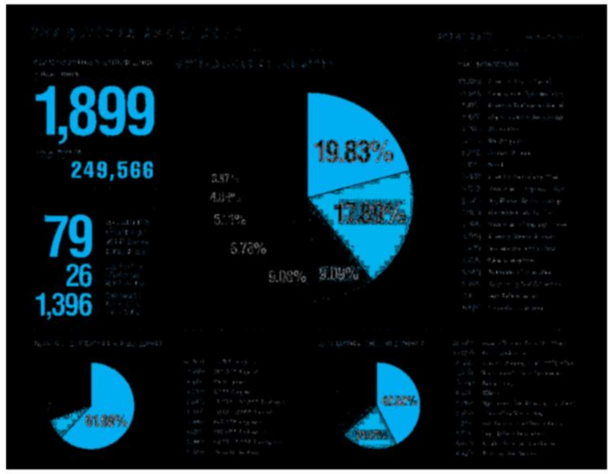


(d) Original infographic

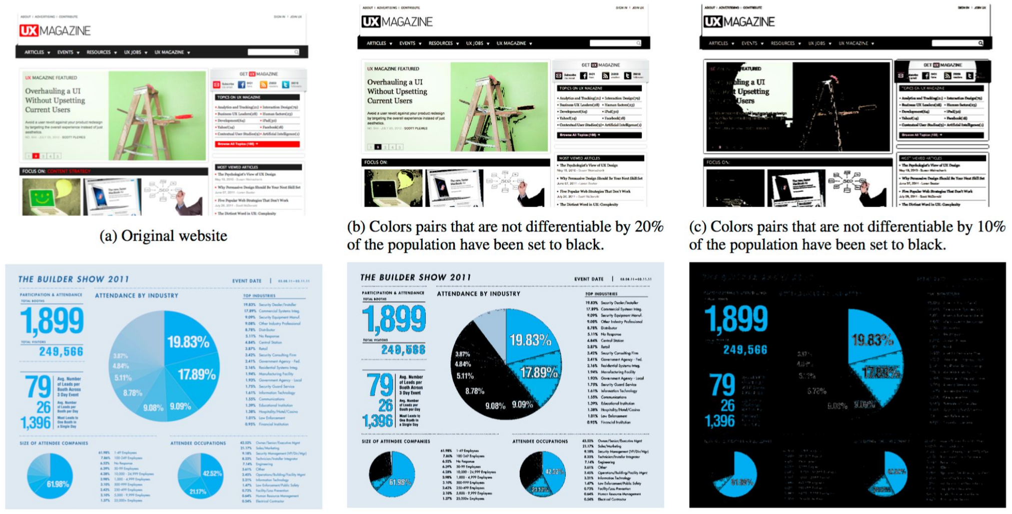


(e) Colors pairs that are not differentiable by 20% of the population have been set to black.



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

That means….



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

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

What can we do about it?

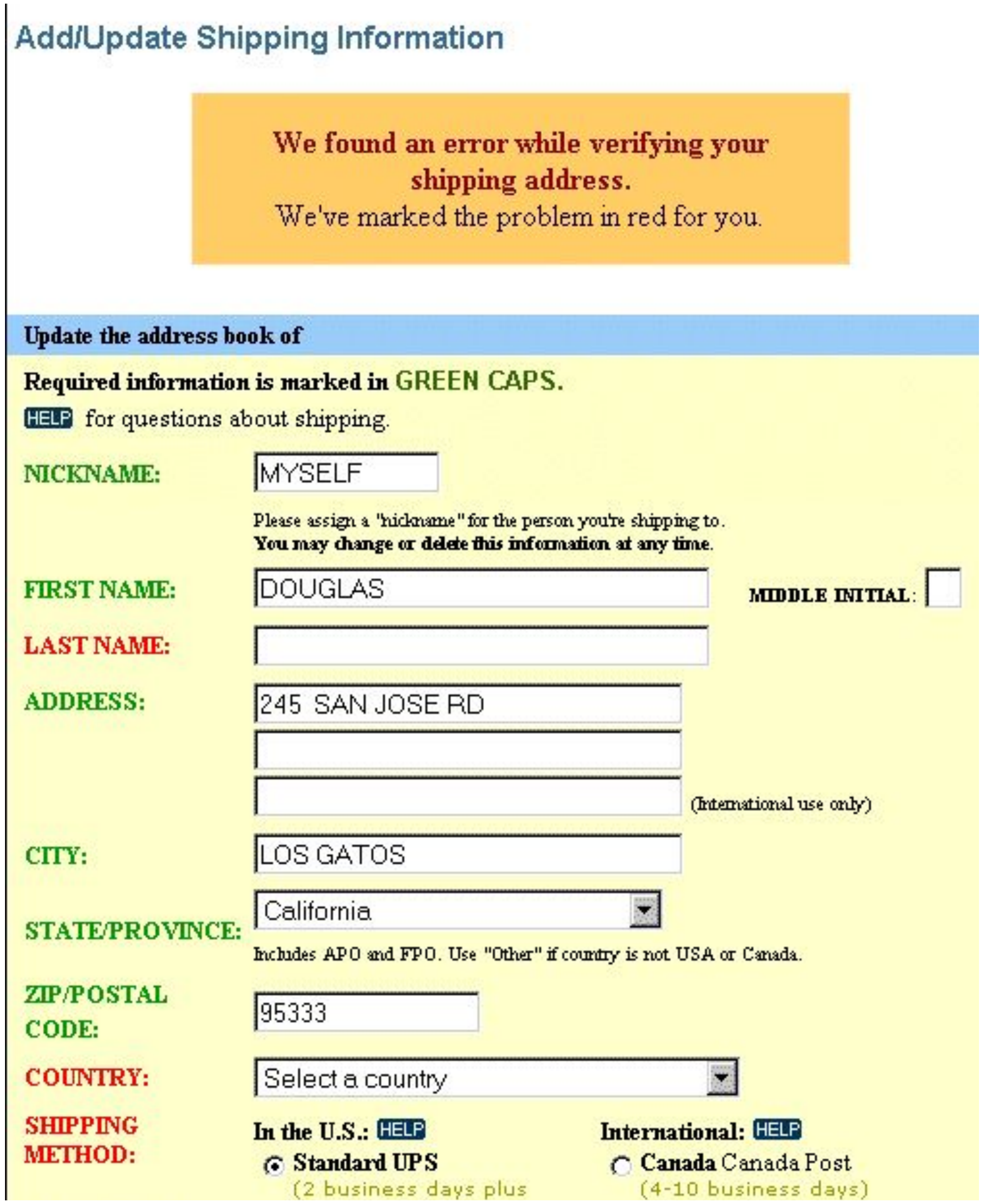
Dual / Redundant Encoding

Apples to Apples

Pandemic

http://danielsolisblog.blogspot.com/2011_03_01_archive.html

Dual / Redundant Encoding



Models of human performance

Visual System

Model Human Processor **Higher-Level Model**

Fitts's Law

Gestalt Principles

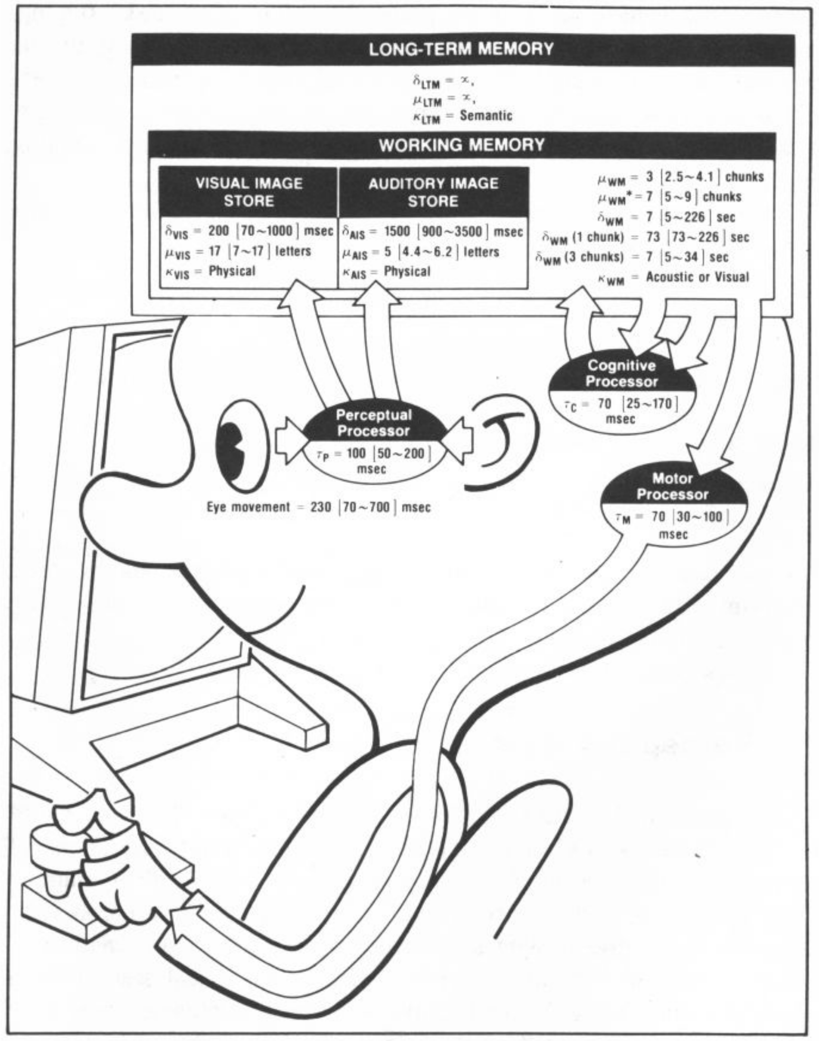
The Model Human Processor

Developed by Card, Moran & Newell (1983)

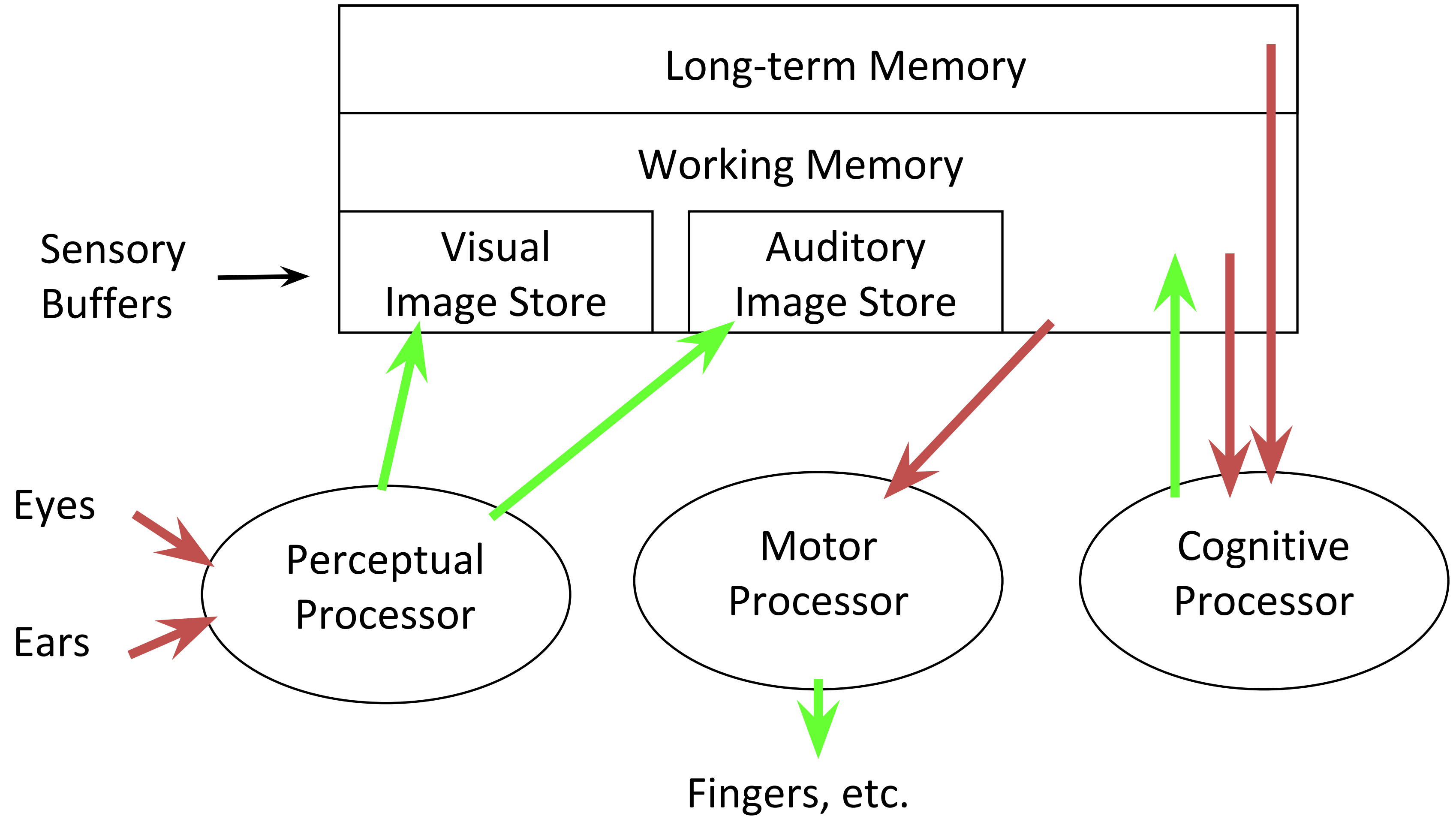
Based on empirical data

Summarizing human behavior in a manner easy to consume and act upon

Same book that named human computer interaction!



The Model Human Processor



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

BMCIACSEI

BM CIA CSE I

IBM CIA CSE

Memory

Working memory (also known as short-term)

- Small capacity (7 ± 2 “chunks”)
  - 6174591765 vs. (617) 459-1765
  - IBMCIACSE 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

red	green	blue
yellow	yellow	red
blue	blue	blue
green	yellow	red
red	green	green

Activation Experiment

Let's do it one more time!

Say “done” when finished

Timers: reset your clocks!

Activation Experiment

ivd	olftcs	fwax
ncudgt	zjdcv	lxngyt
mkbh	xbts	cfto
bhfe	cnhdes	fwa
cnofgt	uhths	dalcrd

Activation Experiment

And one last time!

Say “done” when finished

Timers: reset your clocks!

Activation Experiment

red	red	green
blue	yellow	red
green	green	green
yellow	blue	blue
blue	yellow	yellow

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 candidates that exist in memory relative to retrieval cues

Interference created by strongly activated chunks

Models of human performance

Visual System

Model Human Processor

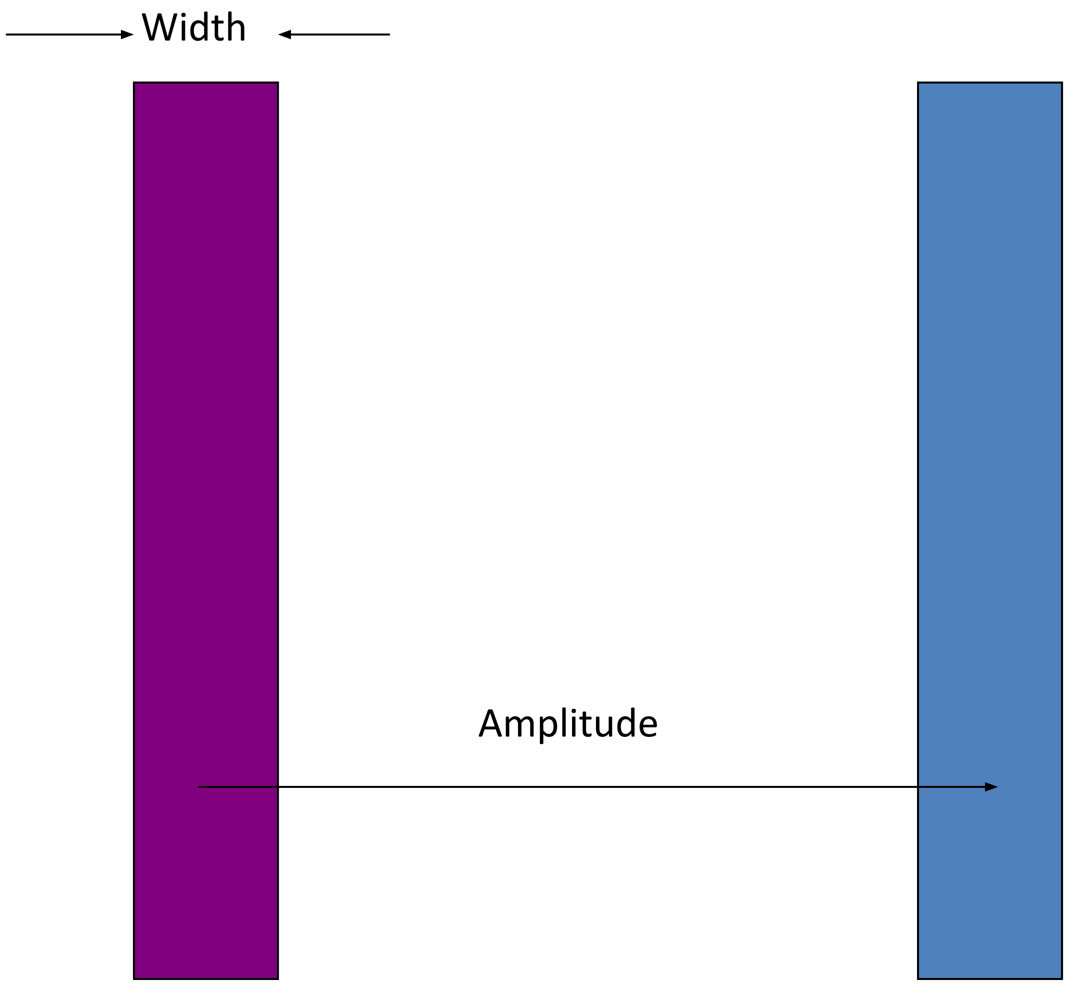
Fitts's Law **Model by Analogy**

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

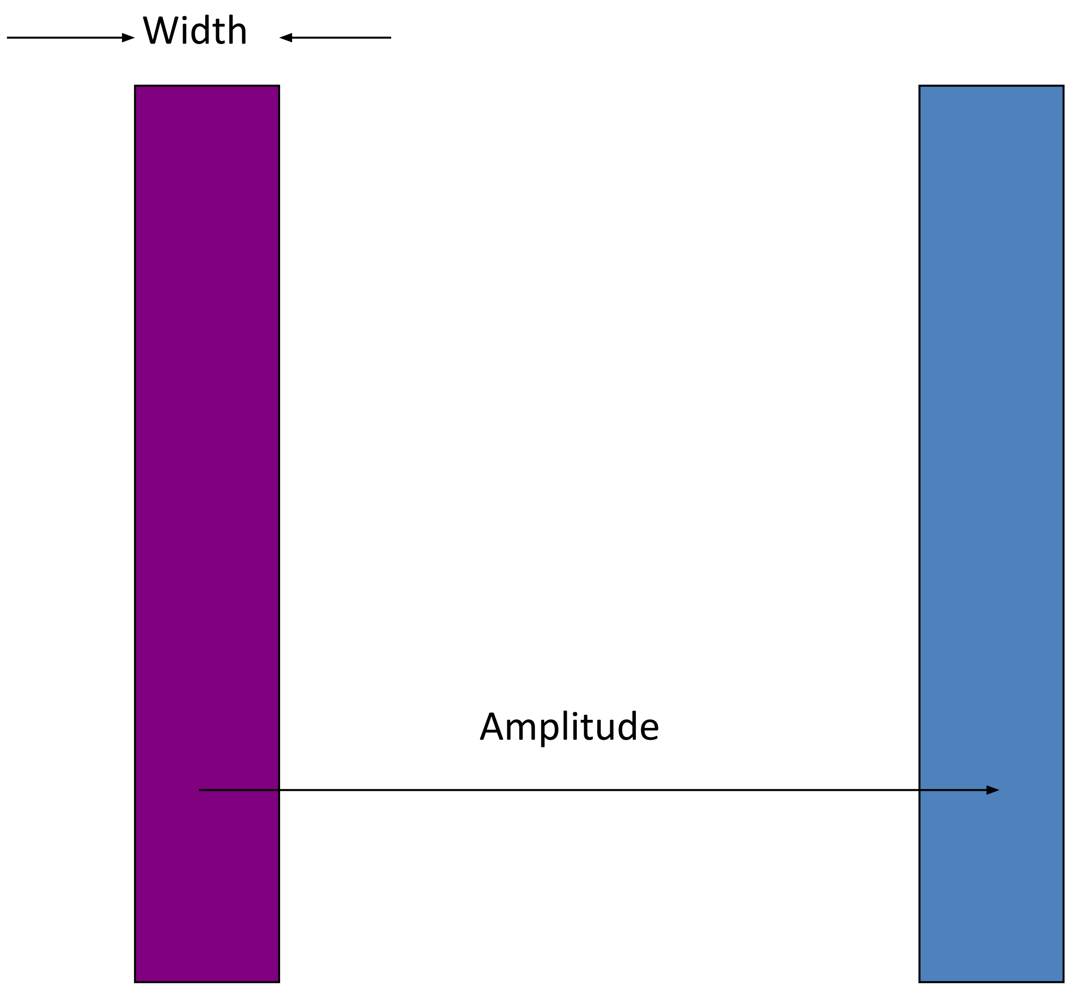
Reciprocal Point-Select Task



Fitts's Law: Index of Difficulty (ID)

ID = 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)



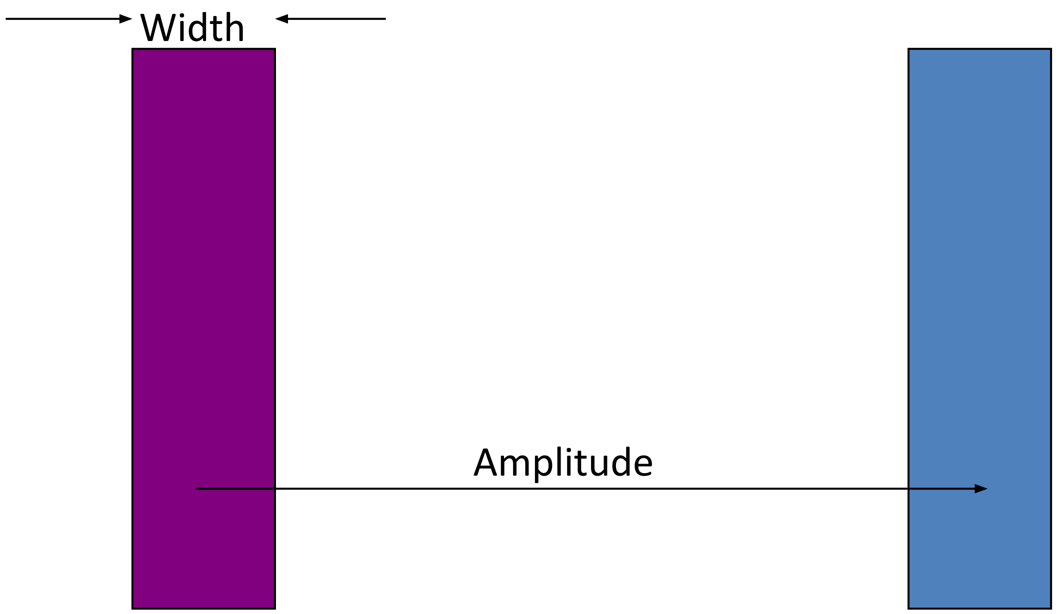
Fitts's Law: Index of Difficulty (ID)

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)

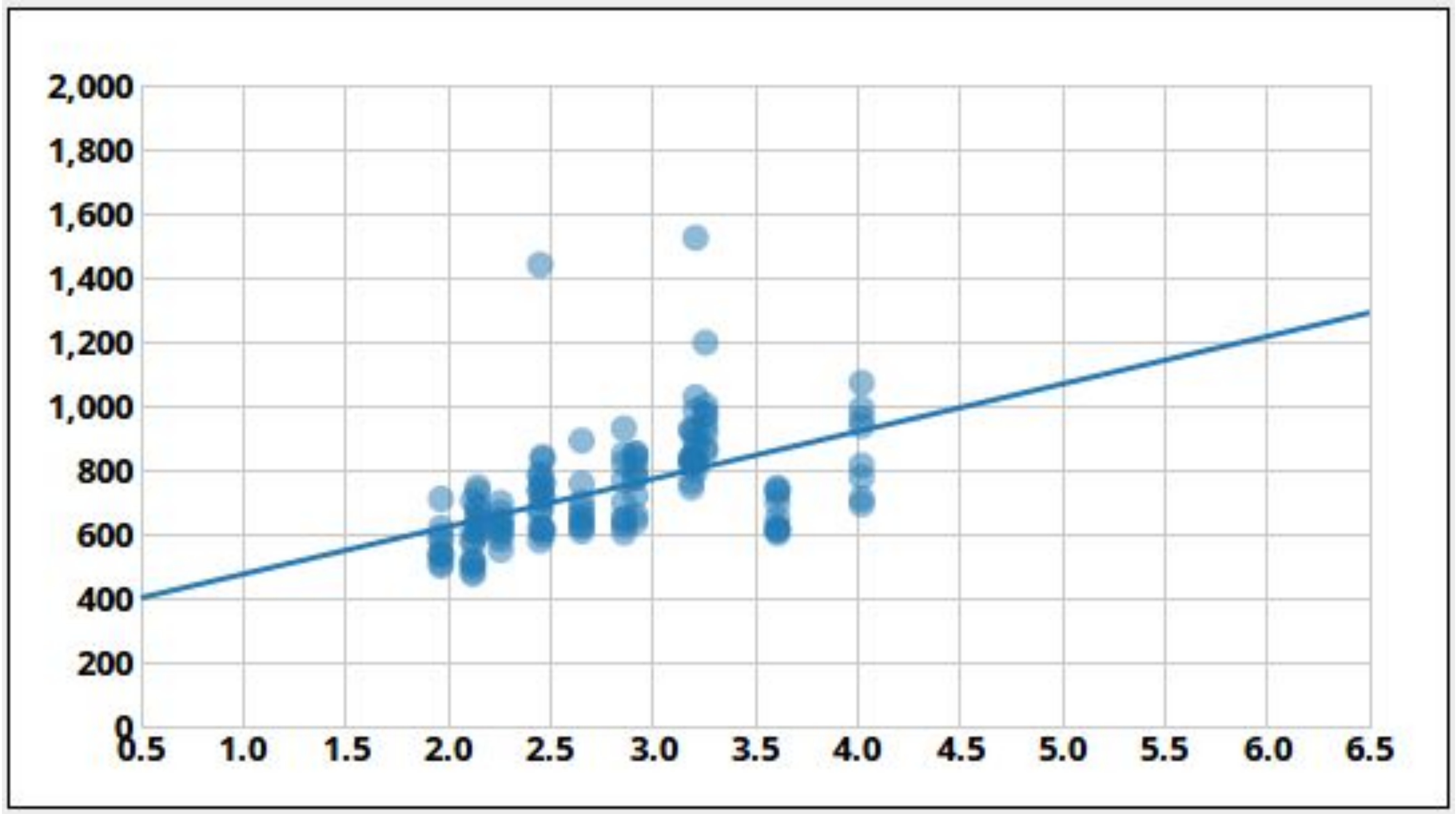
Why is it significant that it is a ratio?

- Units of A and W don't matter
- Allows comparison across experiments
- (Typically reported in "bits")

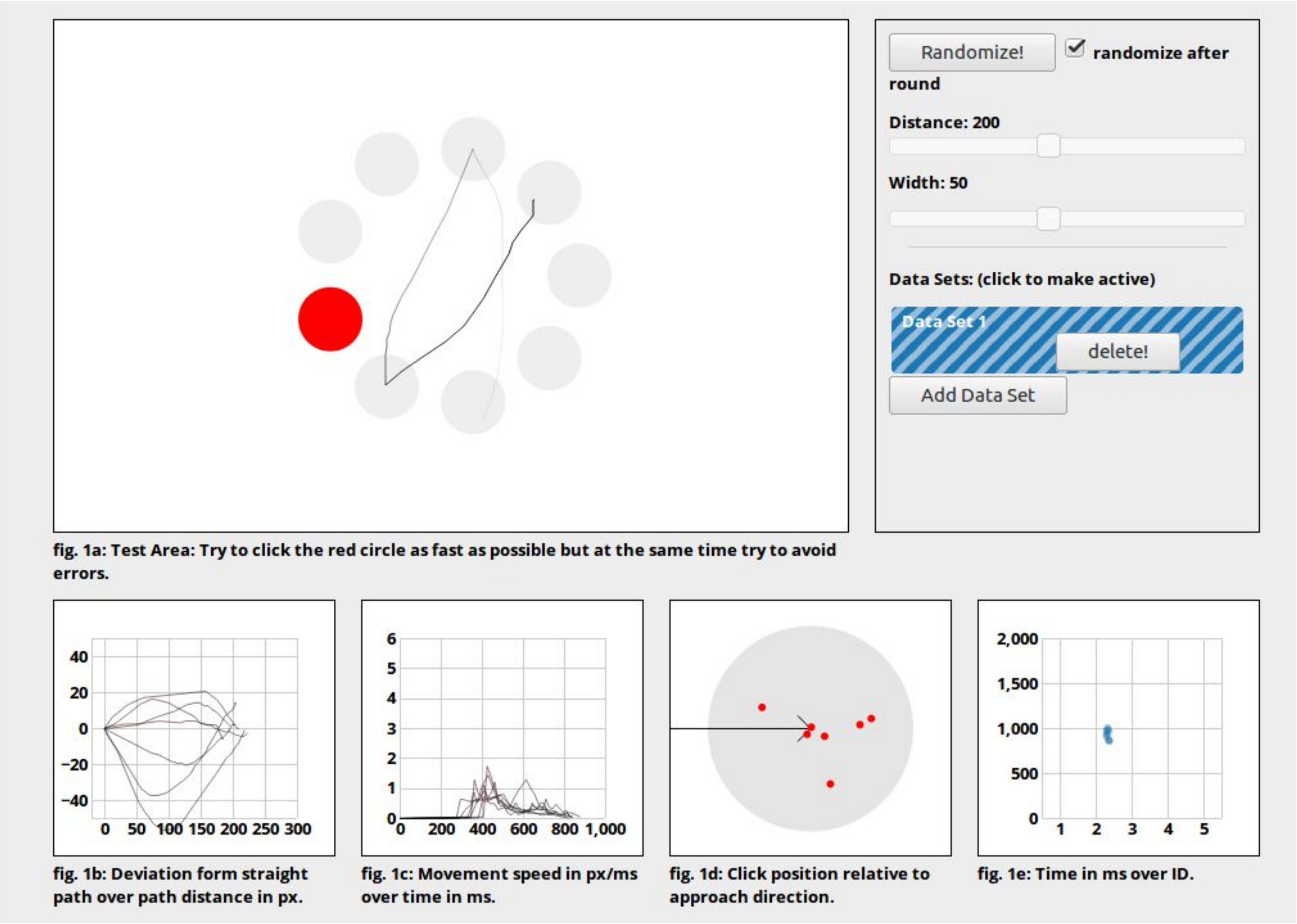


Fitts’s Law: Linear variation

MT = a + b **log2(A / W + 1)**



A Fitts's Law Experiment

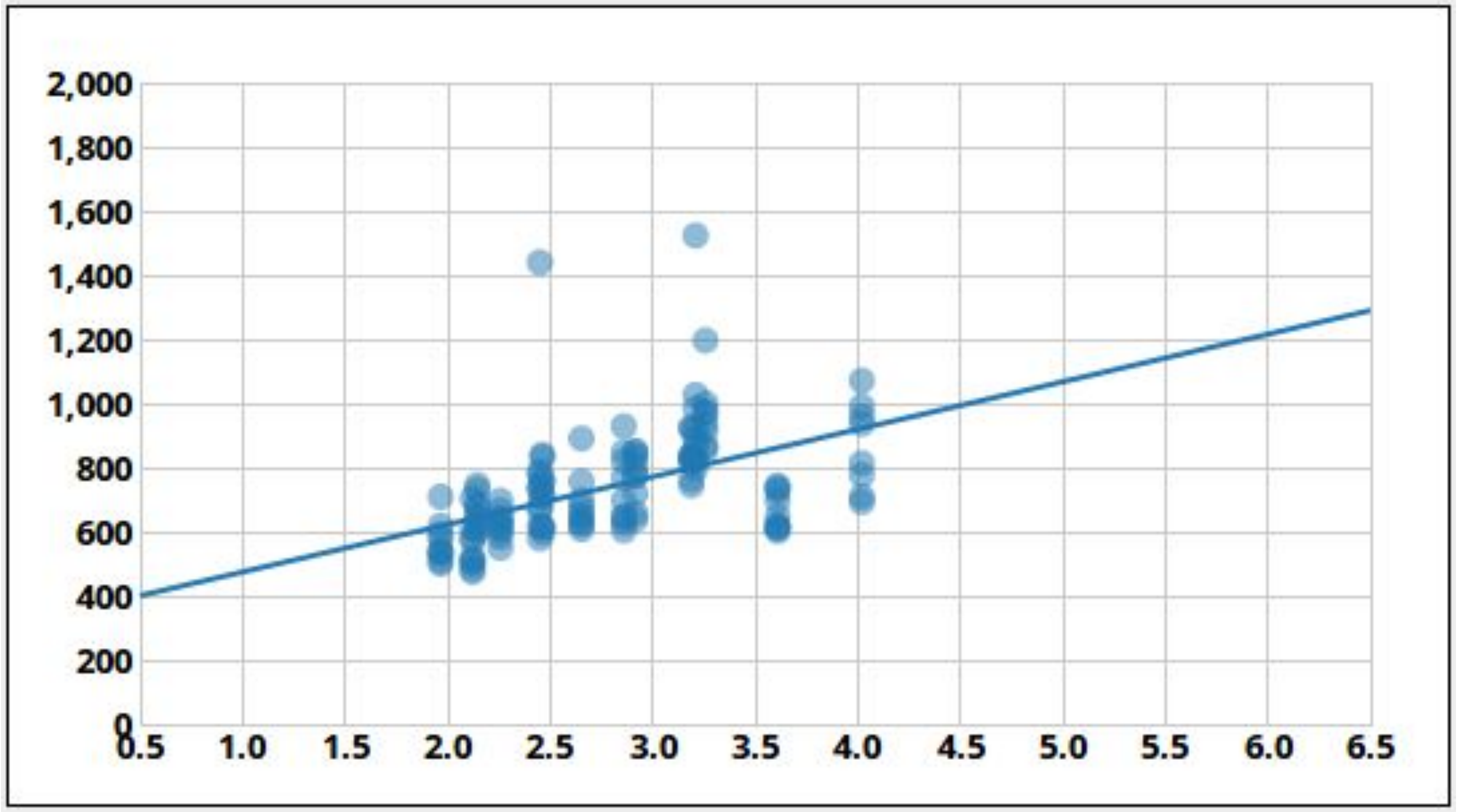


http://simonwallner.at/ext/fitts/

“Beating” Fitts’s Law

It is the law, right?

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



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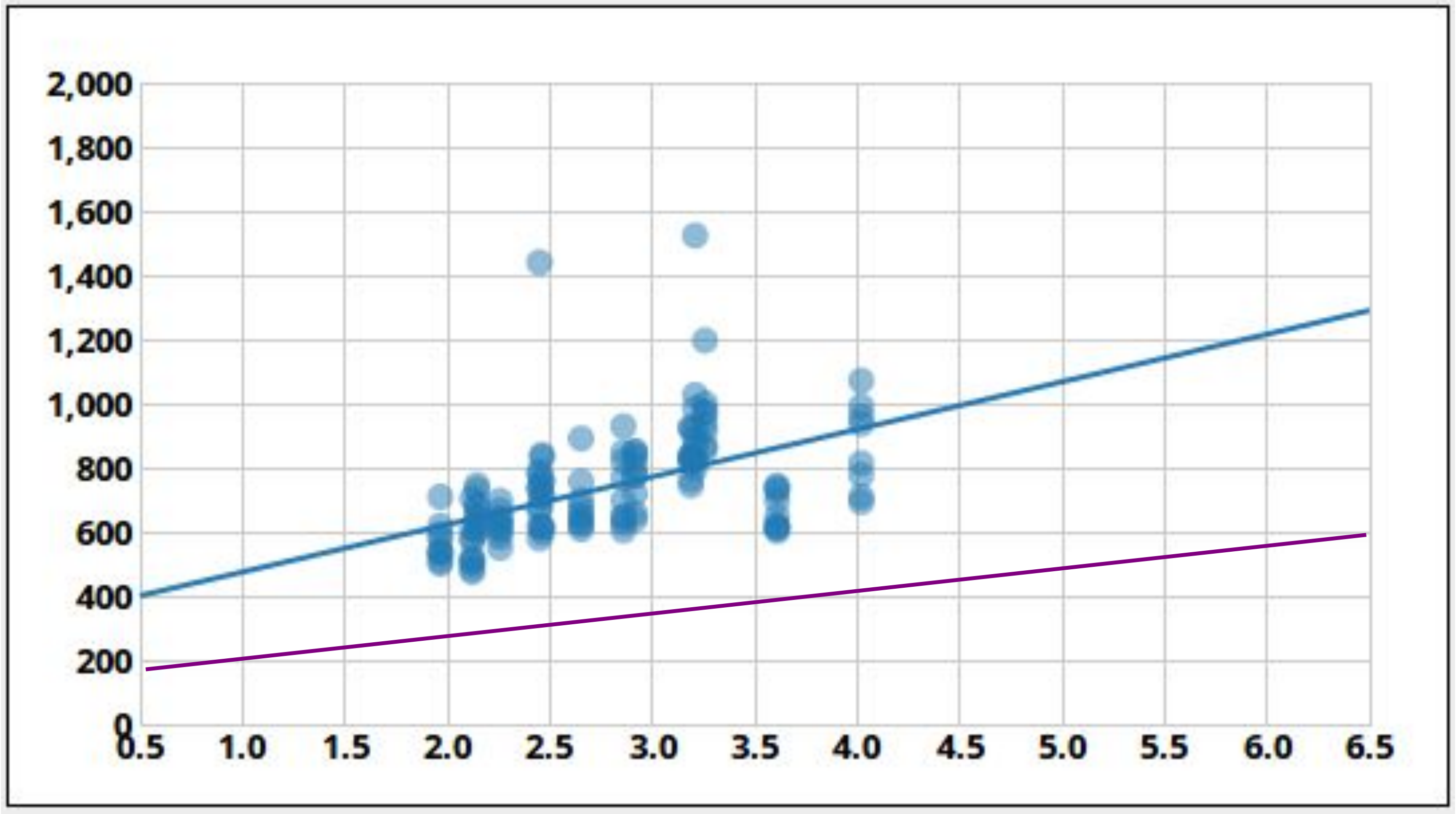


“Beating” Fitts’s Law

It is the law, right?

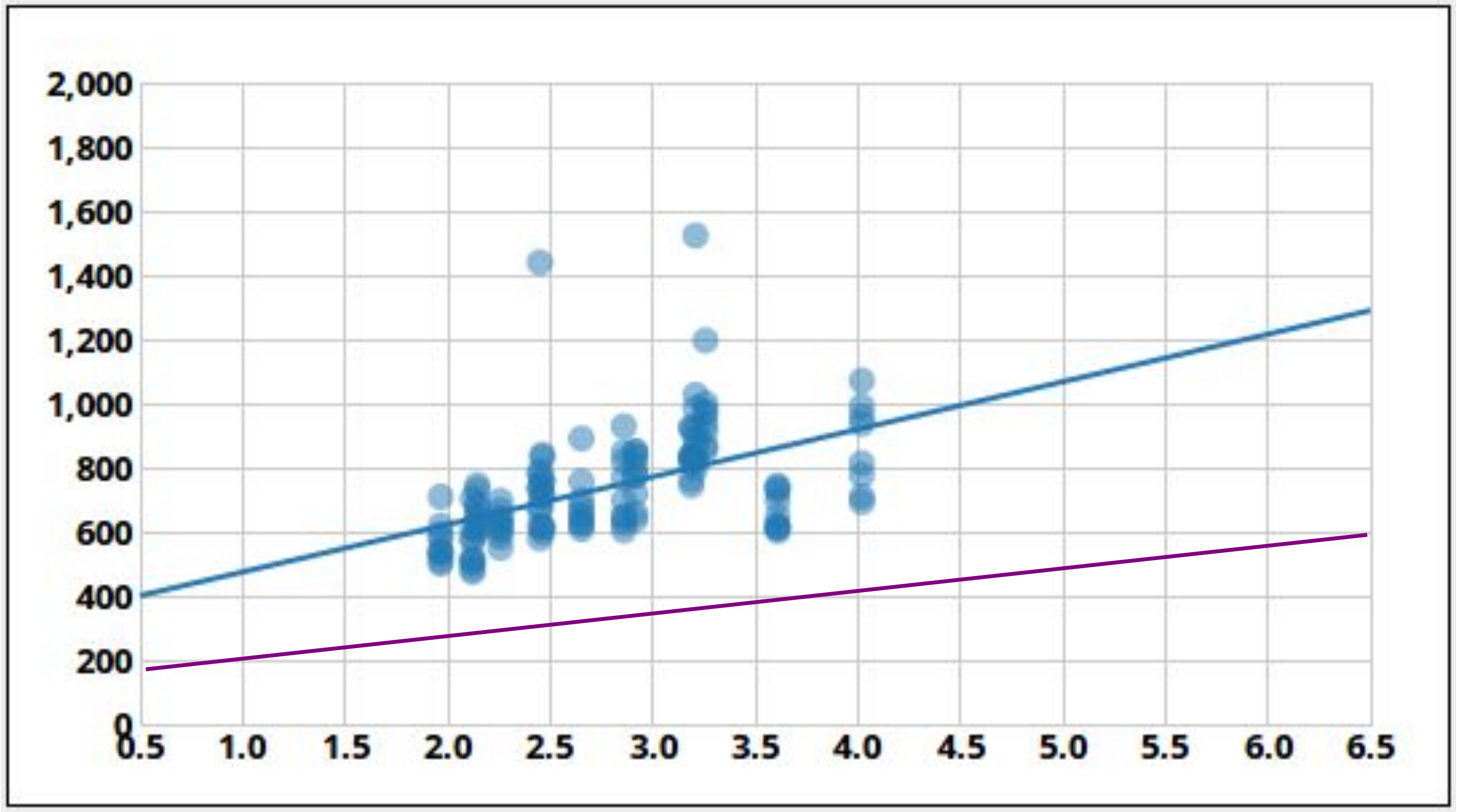
MT = a + b log2(A / W + 1)

So how can we reduce movement time?

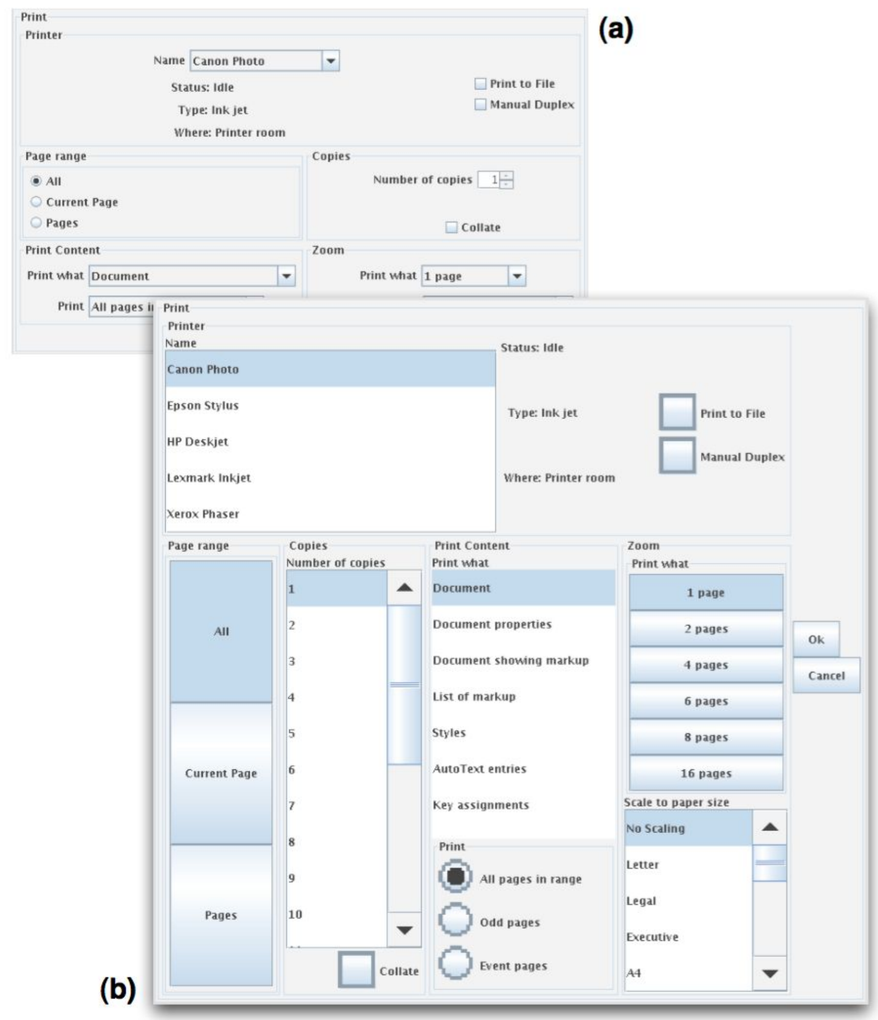
Reduce A?

Increase W?

Considering specific (a) and (b)'s ?

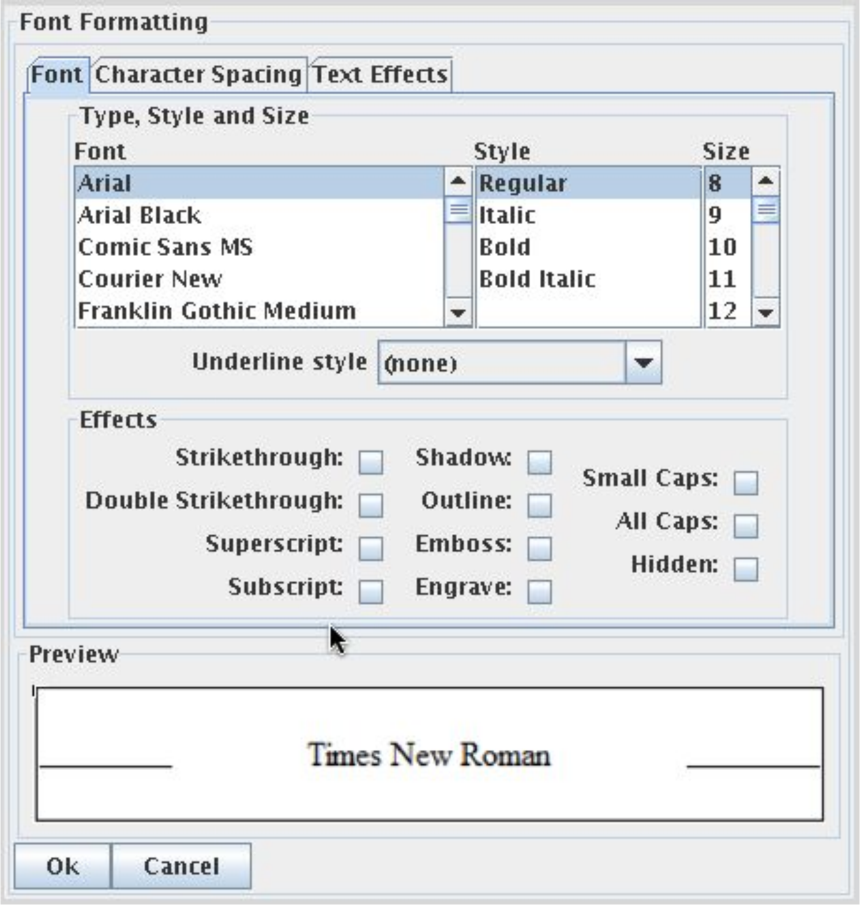


Supple

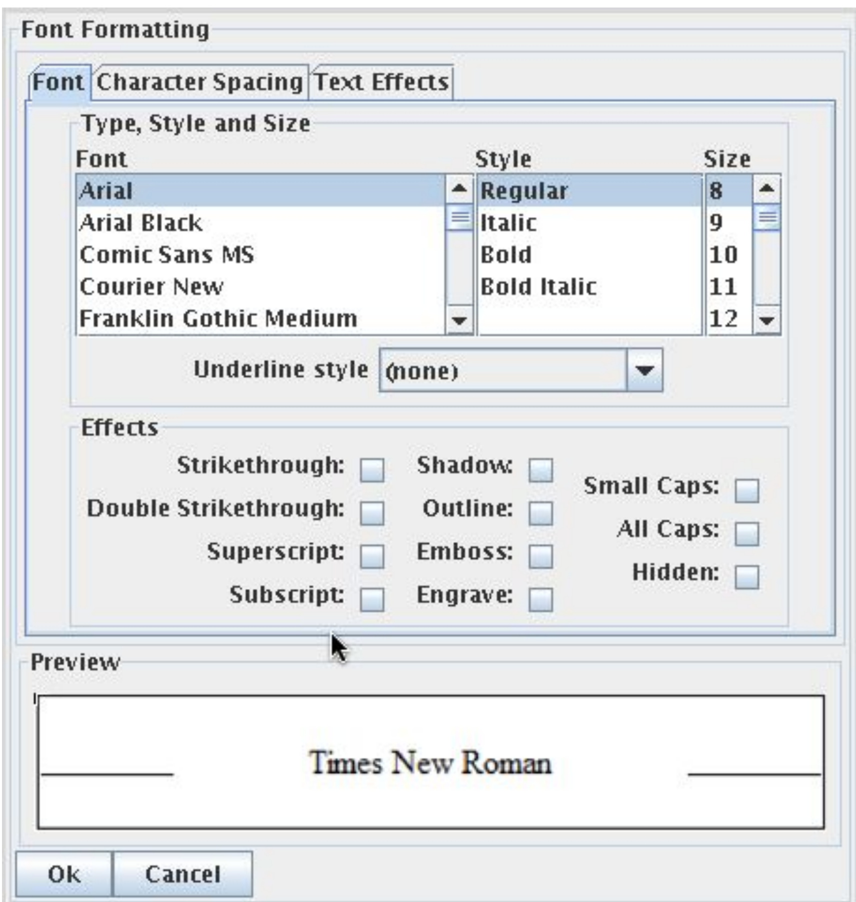


Krzysztof Z. Gajos, Jacob O. Wobbrock, and Daniel S. Weld. Improving the performance of motor-impaired users with automatically-generated, ability-based interfaces. In *CHI '08: Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, pages 1257-1266, New York, NY, USA, 2008. ACM.

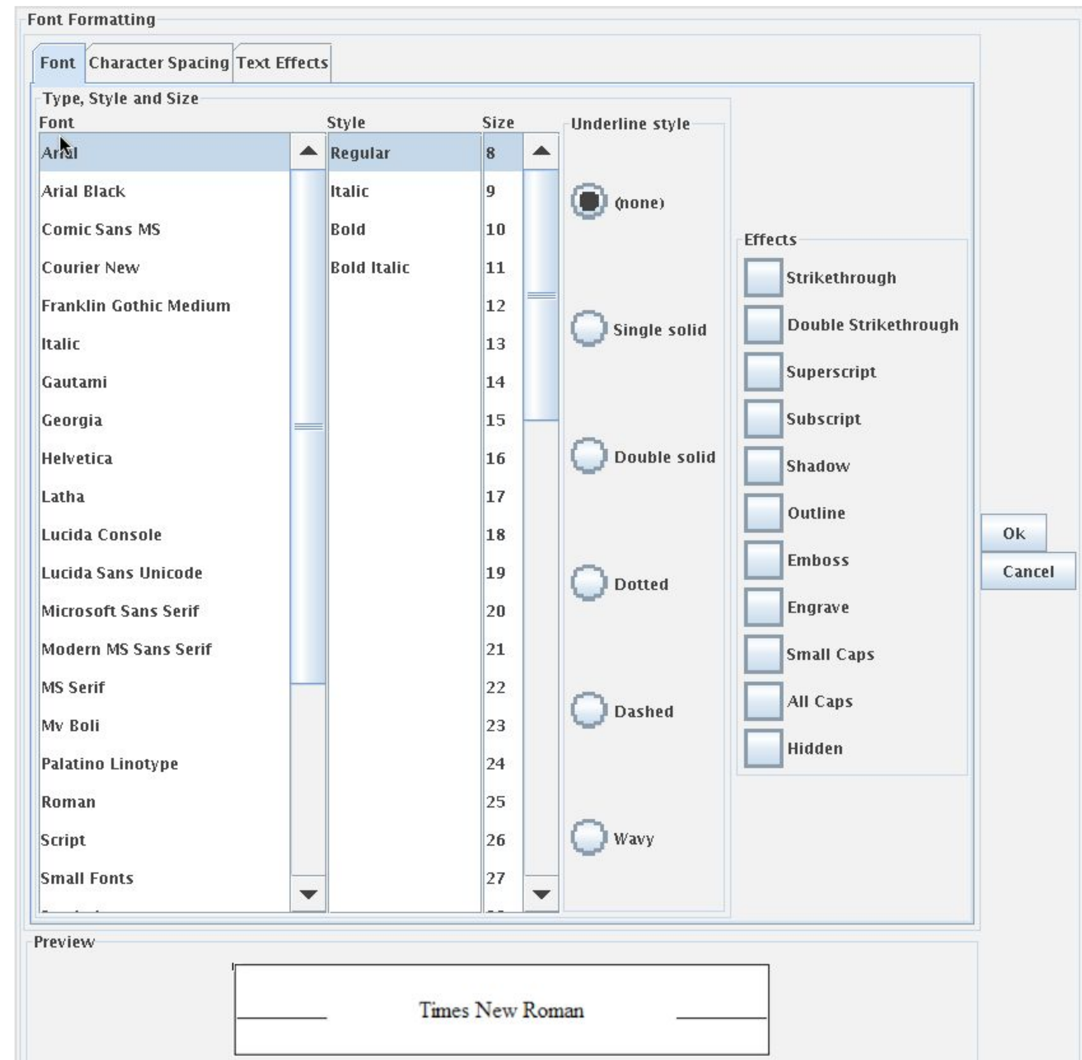
Manufacturer Interface



Manufacturer Interface

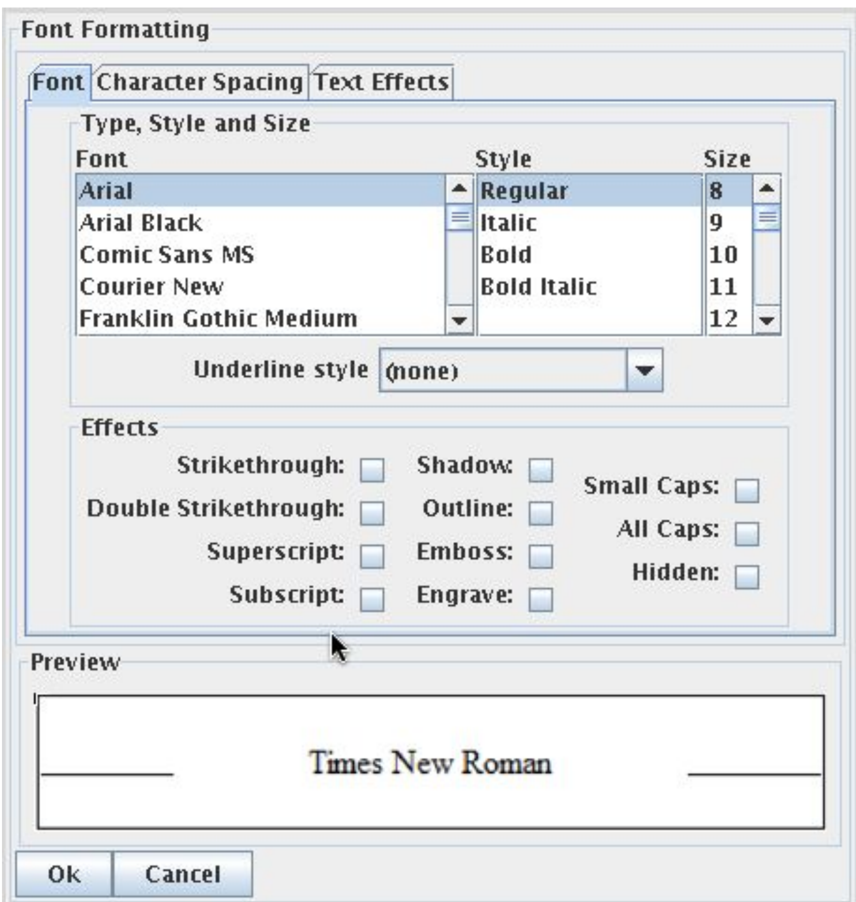


Person with Cerebral Palsy*

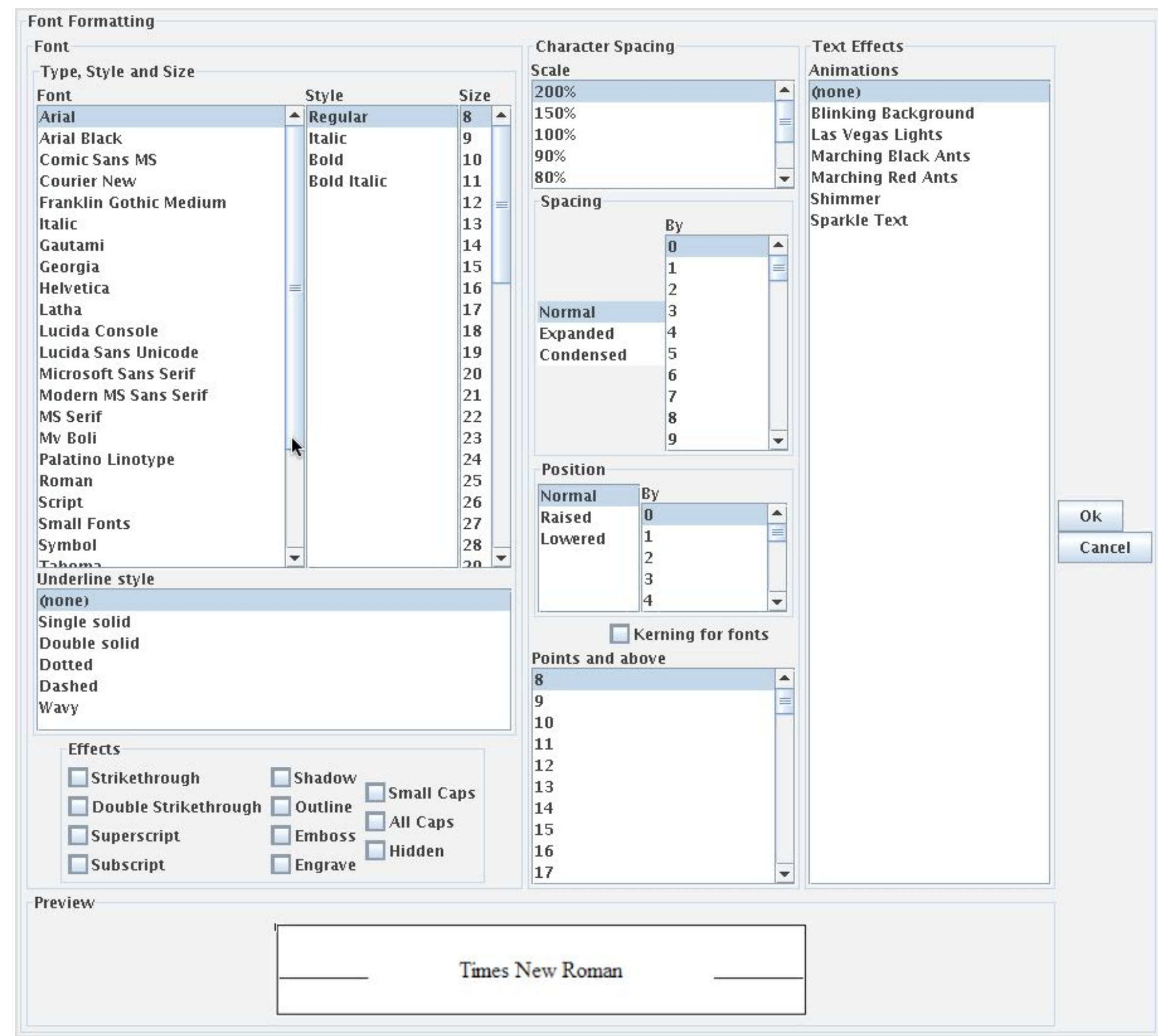


(*) fast, spastic (i.e., highly imprecise) movements

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

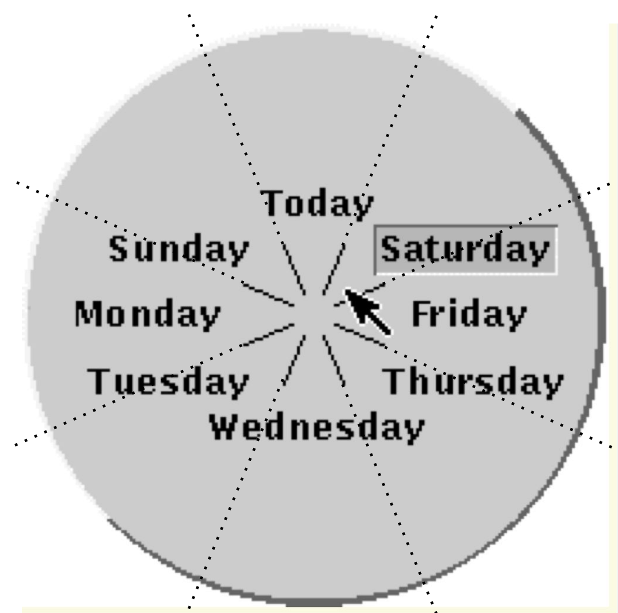
Use impenetrable edges

Fitts's Law Examples

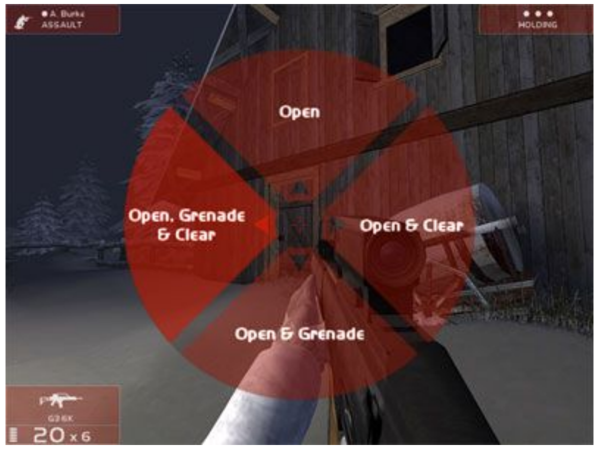
Which will be faster on average?

Pop-up Linear Menu

Pop-up Pie Menu

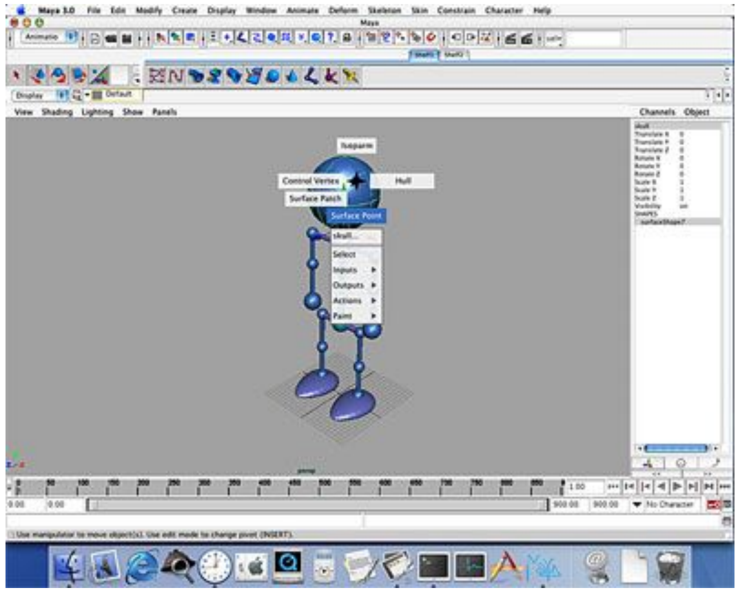


Pie Menus in Use



Rainbow 6

The Sims

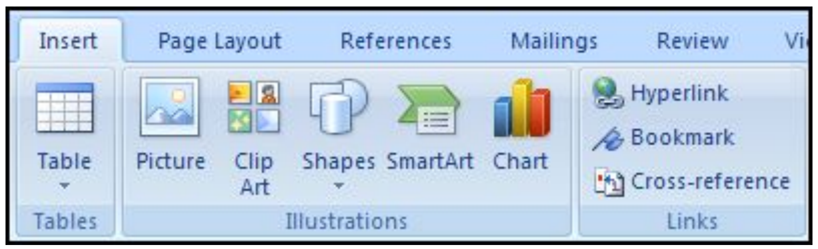

Maya

Fitts's Law in Windowing

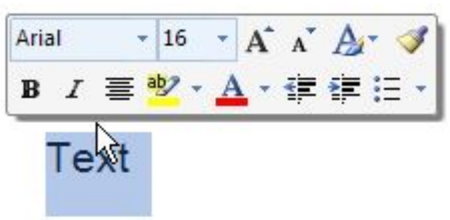
Windows 95: Missed by a pixel
Windows XP: Good to the last drop

Macintosh Menu

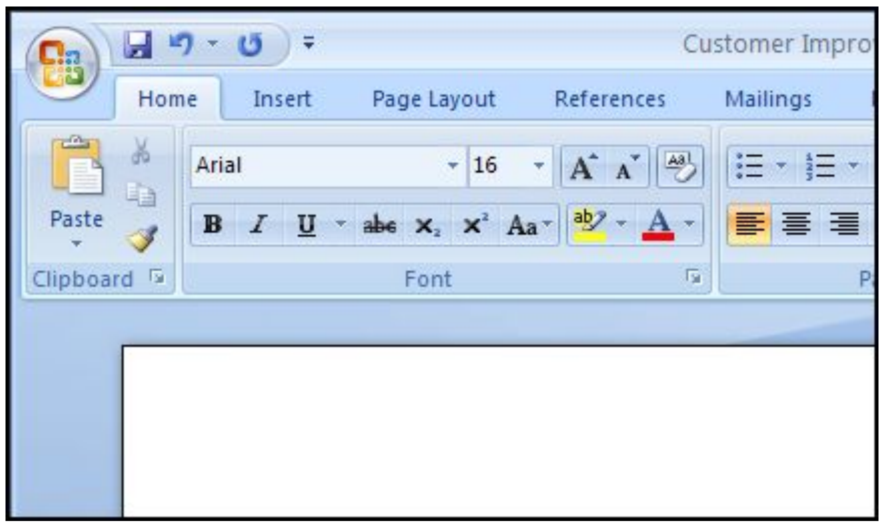
Fitts's Law in MS Office



Larger, labeled controls
can be clicked more quickly

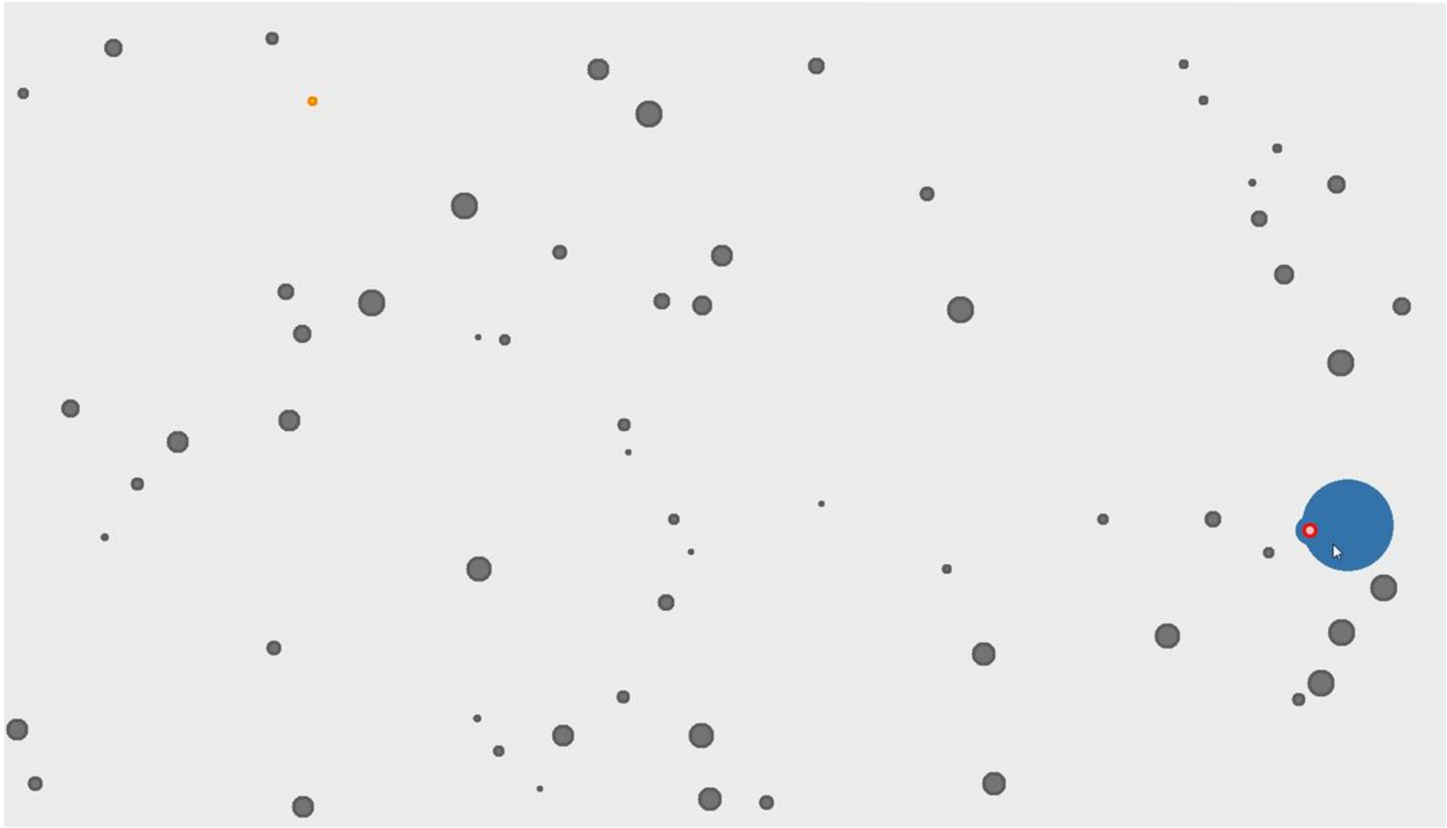


Mini toolbar is close to the cursor



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

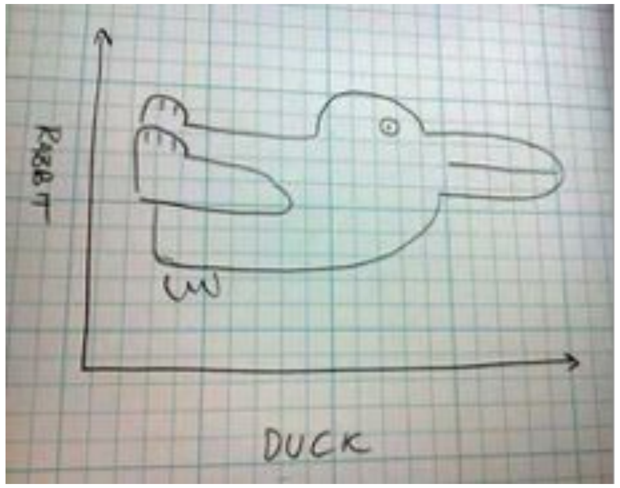
Fitts's Law

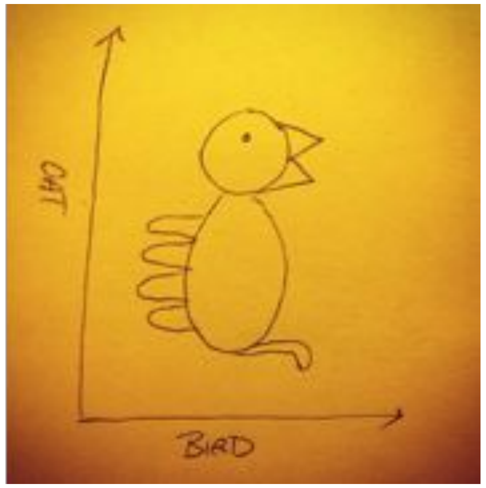
Gestalt Principles **Predict Interpretation**

Gestalt Psychology

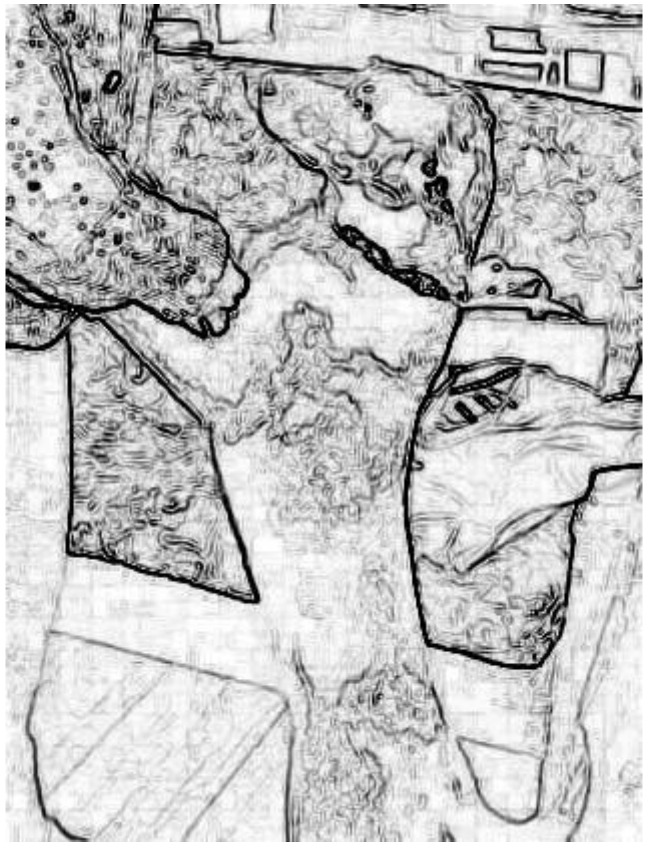
Described loosely in the context of this lecture and associated work, not a real definition

Perception is neither bottom-up nor top-down, rather both inform the other as a whole!





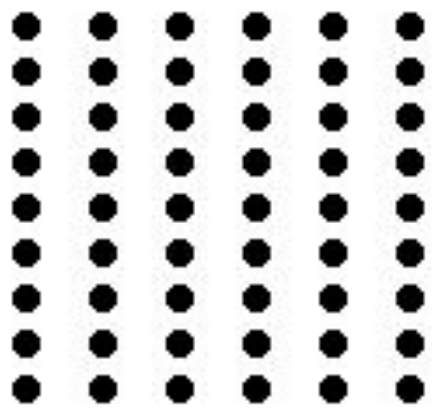
Gestalt Psychology

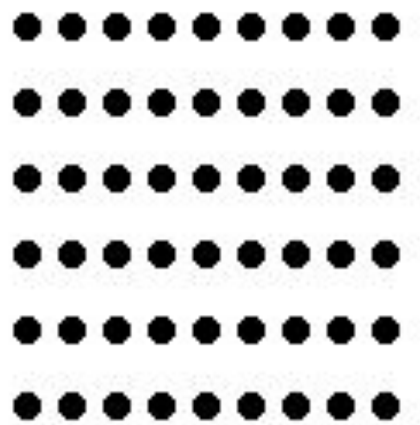


Gestalt Psychology

Principle: Proximity

Objects close to each other form a group



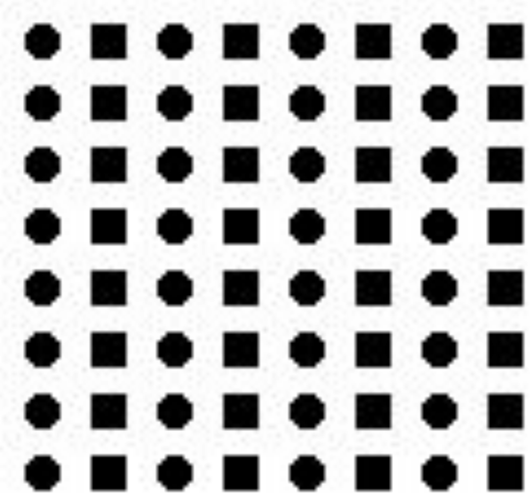


Principle: Proximity

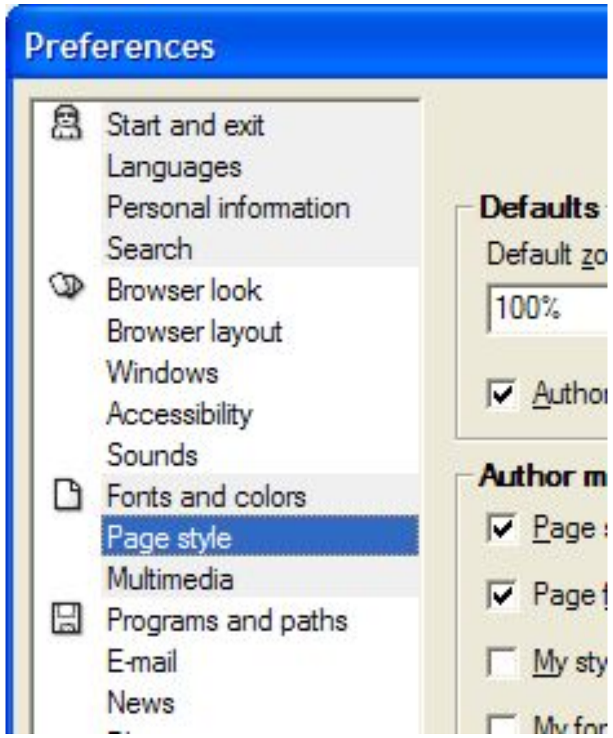
http://designmodo.com/use-gestalt-laws-to-improve-your-ux/

Principle: Similarity

Objects that are similar form a group



Principle: Similarity



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

Principle: Closure

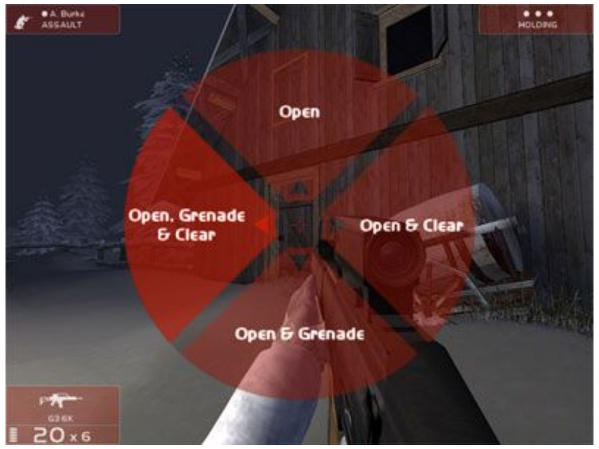
Even incomplete objects are perceived as whole

- Increases regularity of stimuli

Principle: Closure

The Sims

IBM®



Rainbow 6

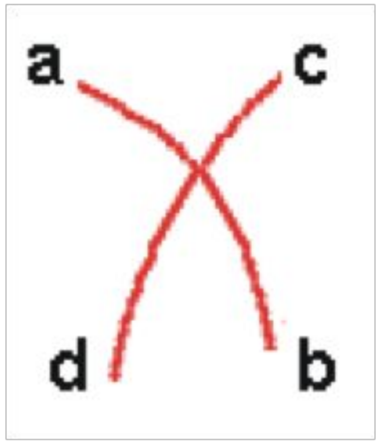
Principle: Symmetry

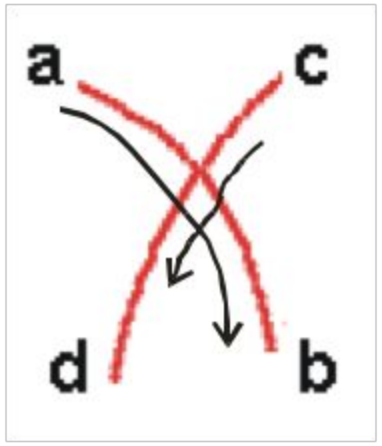
Objects are perceived as symmetrical and forming around a center point

Continuity

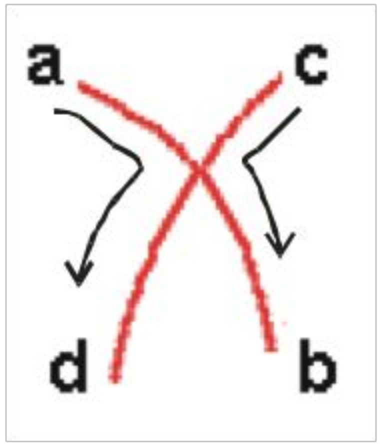
Objects are perceived as grouped when they align

- Remain distinct even with overlap
- Preferred over abrupt directional changes





what most people see



not this

Models from Different Perspectives

Visual System	Biological Model
Model Human Processor	Higher-Level Model
Fitts’s Law	Model by Analogy
Gestalt Principles	Predict Interpretation

Ask me something!