

CS 321: Introduction to HCI

Methods for Design, Prototyping and Evaluating User Interaction

Lecture 10:
Human Performance

Eren Gultepe

The logo for Southern Illinois University Edwardsville (SIUE), featuring the letters "SIUE" in white on a red rectangular background.

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

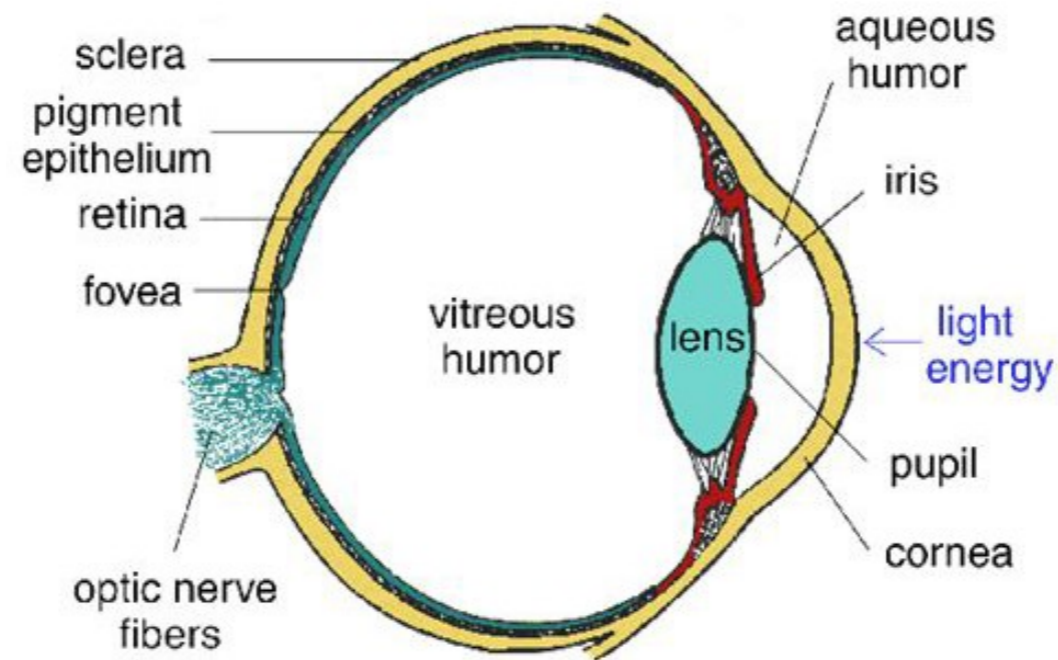
Model Human Processor

Fitts's Law

Gestalt Principles

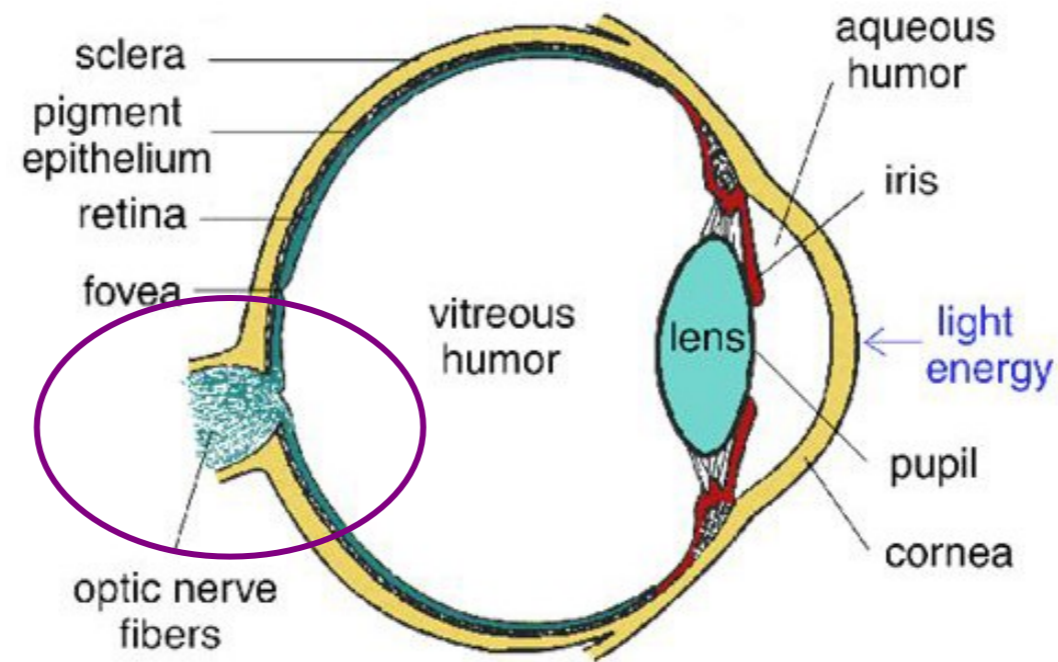
Biological Model

Human Visual System



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

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?

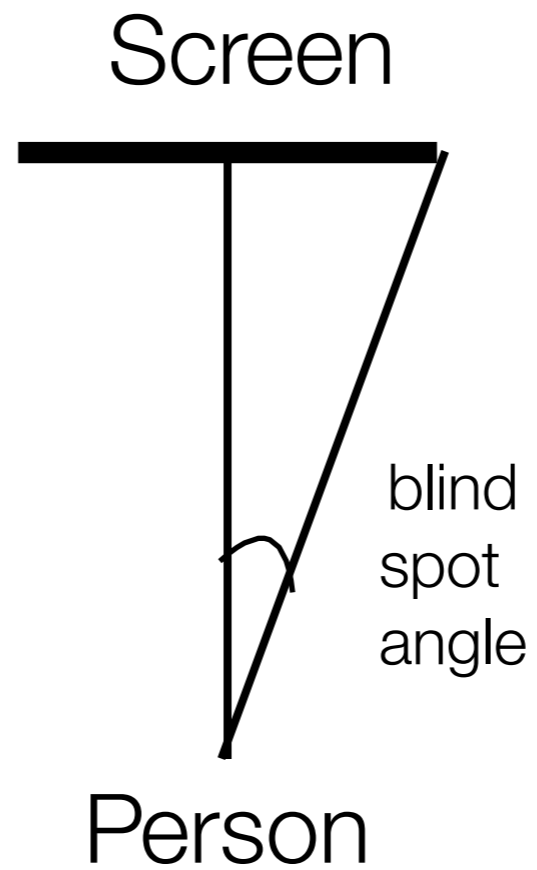
Blind Spot

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.

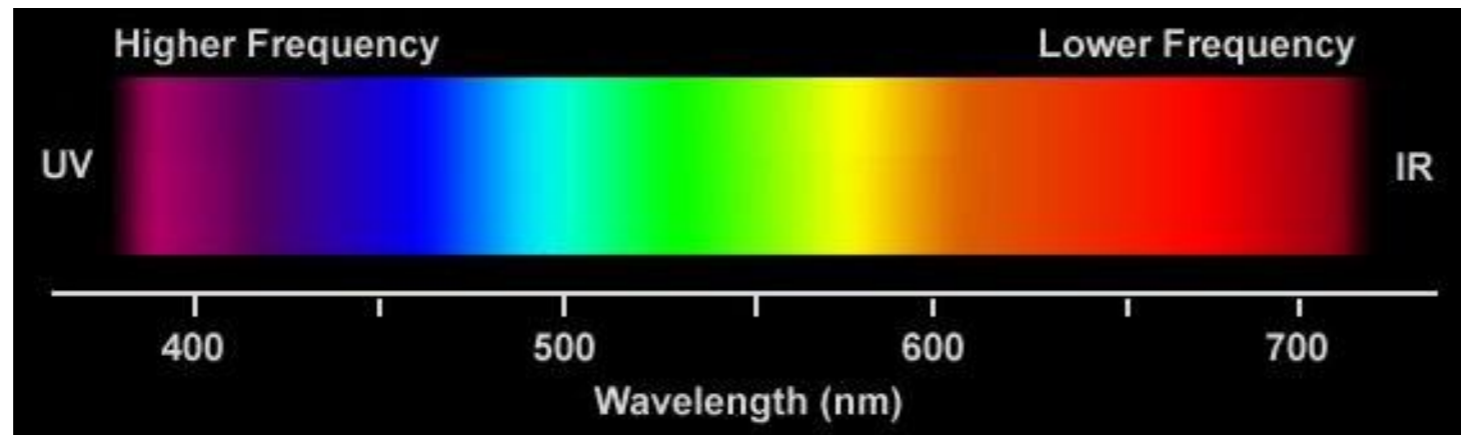


0 1 2 3 4 5 6 7 8 9

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

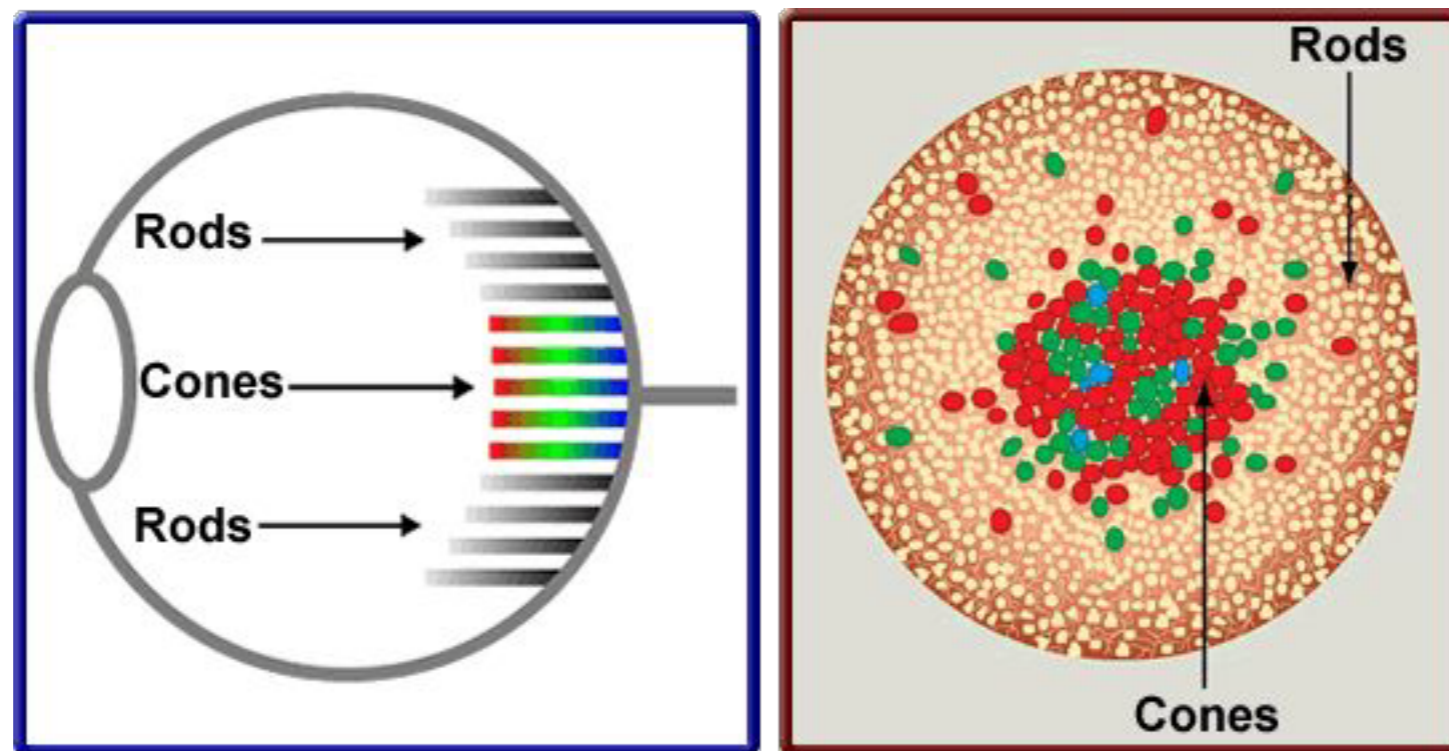
Retina

Center of retina has most of the cones

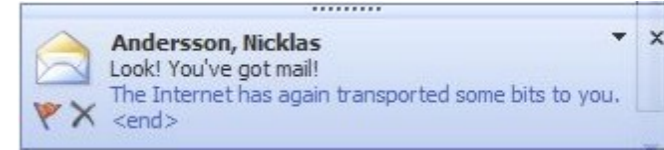
Allows for high acuity of objects focused at center

Edge of retina is dominated by rods

Allows detecting motion of threats in periphery



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)

- use rarely for important/warning messages or alerts (e.g. Stop sign is red)

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)

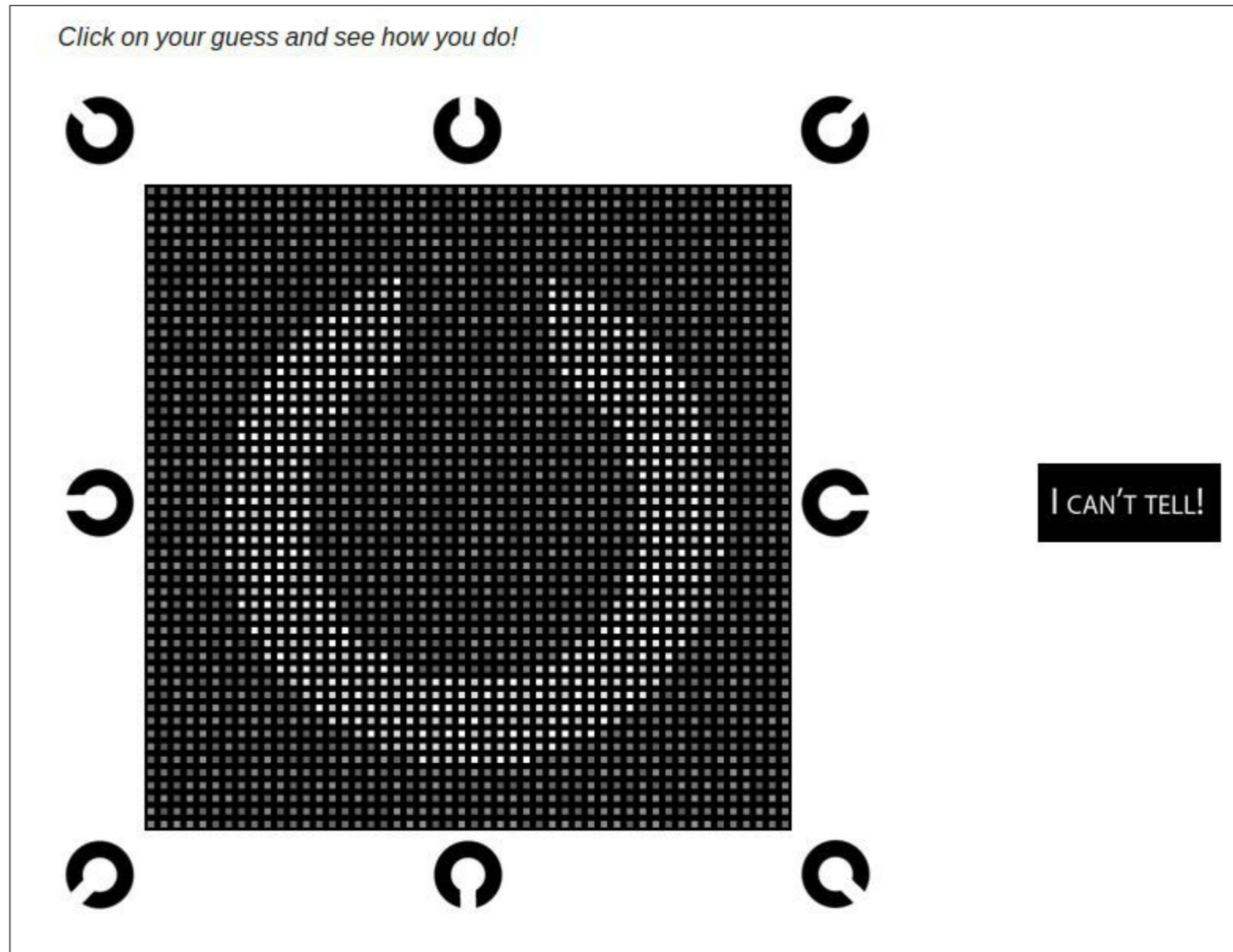
Cannot discriminate colors dependent on red and green

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.

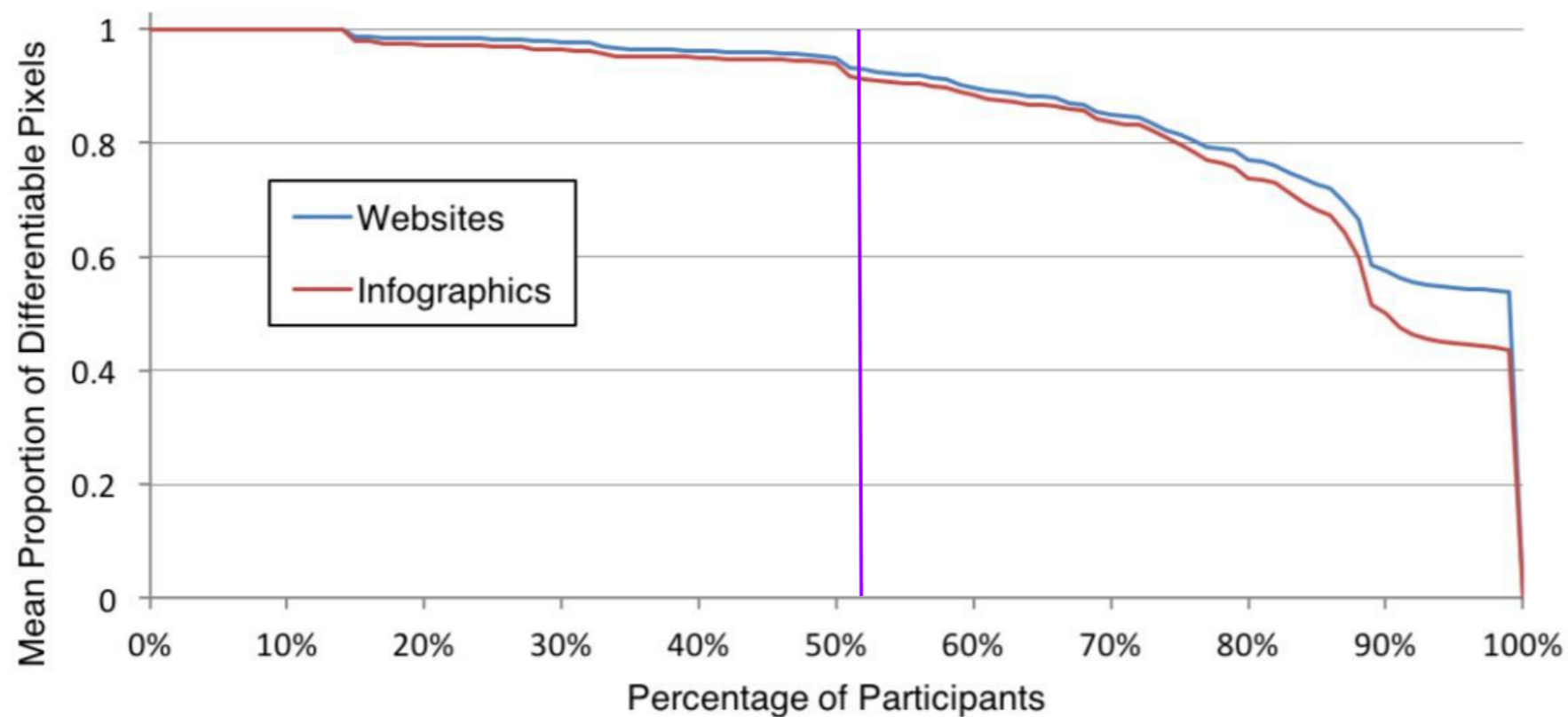
Can we guess your age?



Main Results

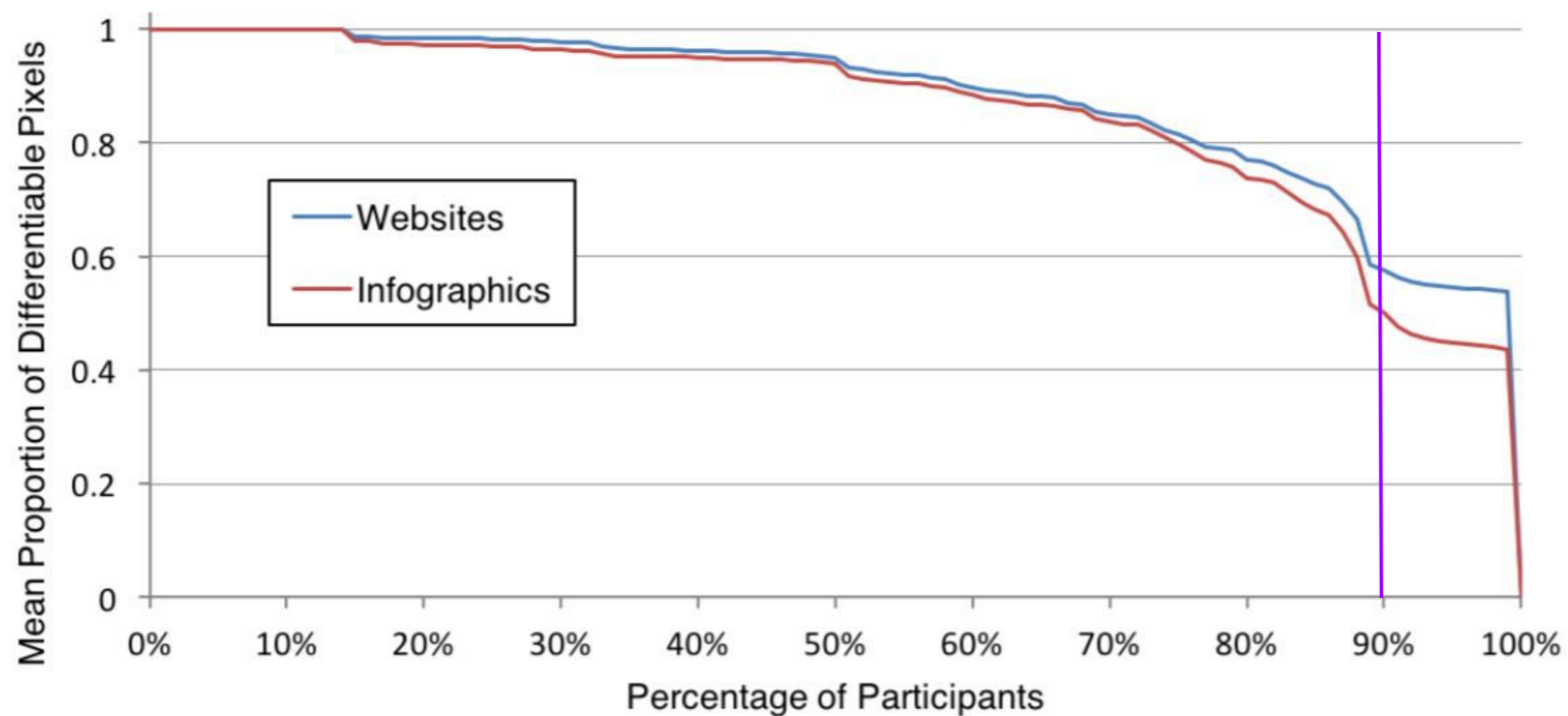
From an online study:

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

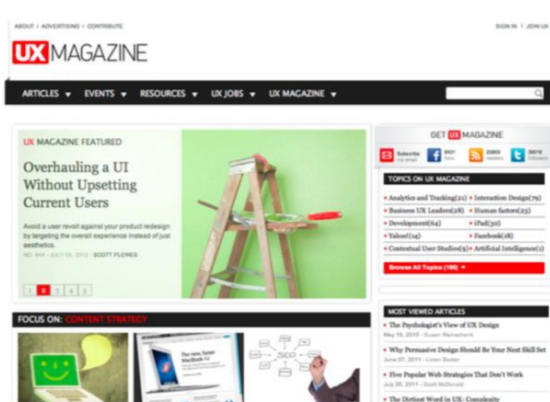


Main Results

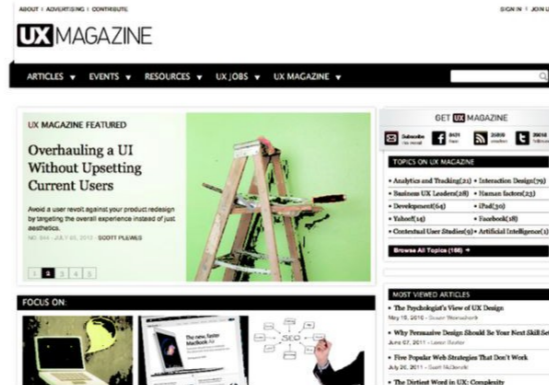
10% of the population is unable to differentiate 60% of the colors in an average website.



So what do they see?



(a) Original website

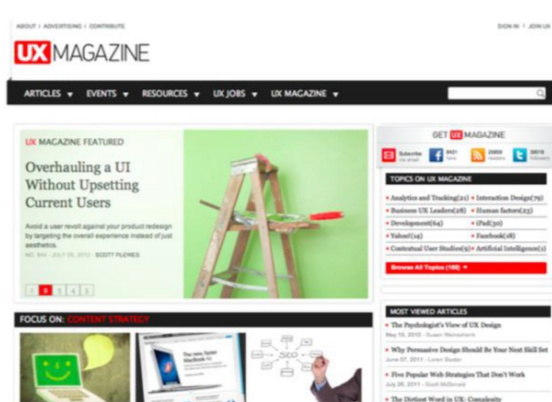


(b) Colors pairs that are not differentiable by 20% of the population have been set to black.

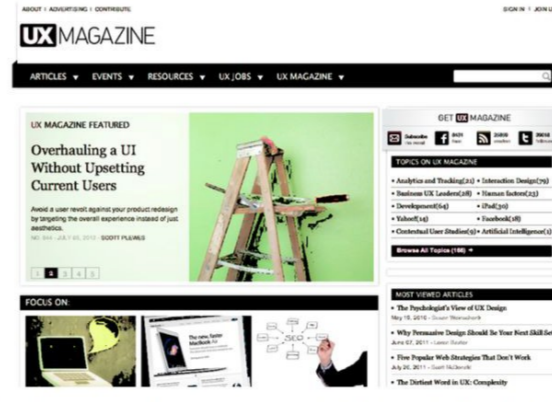


(c) Colors pairs that are not differentiable by 10% of the population have been set to black.

So what do they see?



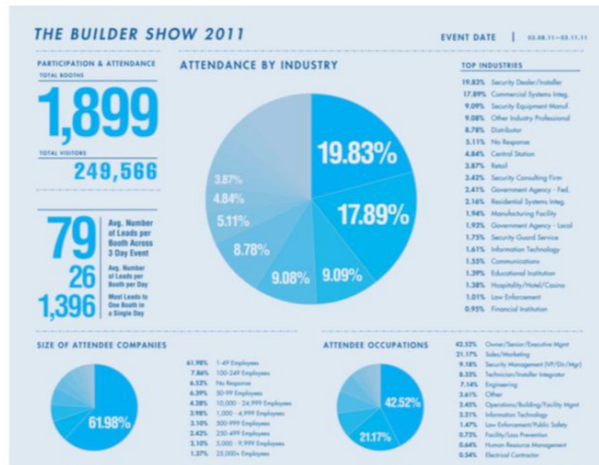
(a) Original website



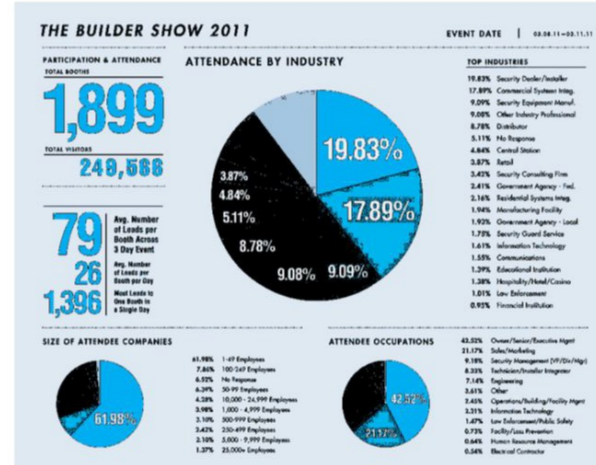
(b) Colors pairs that are not differentiable by 20% of the population have been set to black.



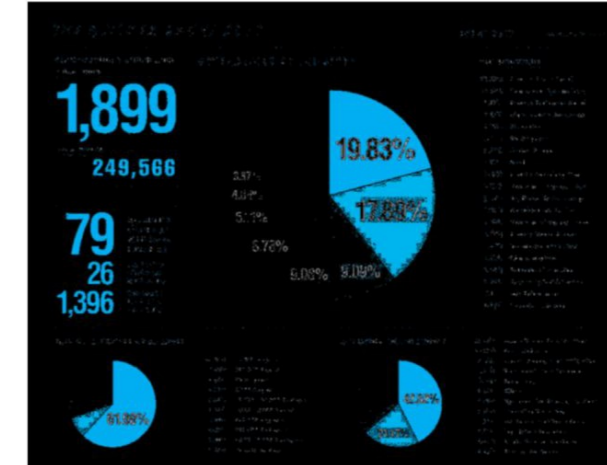
(c) Colors pairs that are not differentiable by 10% of the population have been set to black.



(d) Original infographic

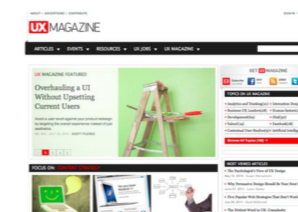


(e) Colors pairs that are not differentiable by 20% of the population have been set to black.



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

That means....



(a) Original website



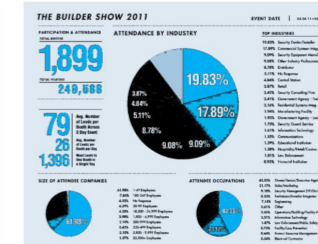
(b) Colors pairs that are not differentiable by 20% of the population have been set to black.



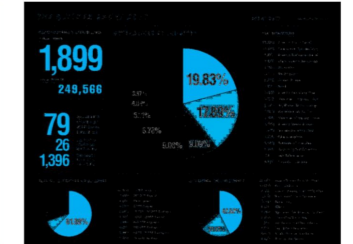
(c) Colors pairs that are not differentiable by 10% of the population have been set to black.



(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.

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

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**.

[HELP](#) for questions about shipping.

NICKNAME:	<input type="text" value="MYSELF"/>	
	Please assign a "nickname" for the person you're shipping to. You may change or delete this information at any time.	
FIRST NAME:	<input type="text" value="DOUGLAS"/>	MIDDLE INITIAL: <input type="text"/>
LAST NAME:	<input type="text"/>	
ADDRESS:	<input type="text" value="245 SAN JOSE RD"/>	
	<input type="text"/>	
	<input type="text"/>	(International use only)
CITY:	<input type="text" value="LOS GATOS"/>	
STATE/PROVINCE:	<input type="text" value="California"/>	
	Includes APO and FPO. Use "Other" if country is not USA or Canada.	
ZIP/POSTAL CODE:	<input type="text" value="95333"/>	
COUNTRY:	<input type="text" value="Select a country"/>	
SHIPPING METHOD:	In the U.S.: HELP <input checked="" type="radio"/> Standard UPS (2 business days plus) International: HELP <input type="radio"/> Canada Canada Post (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

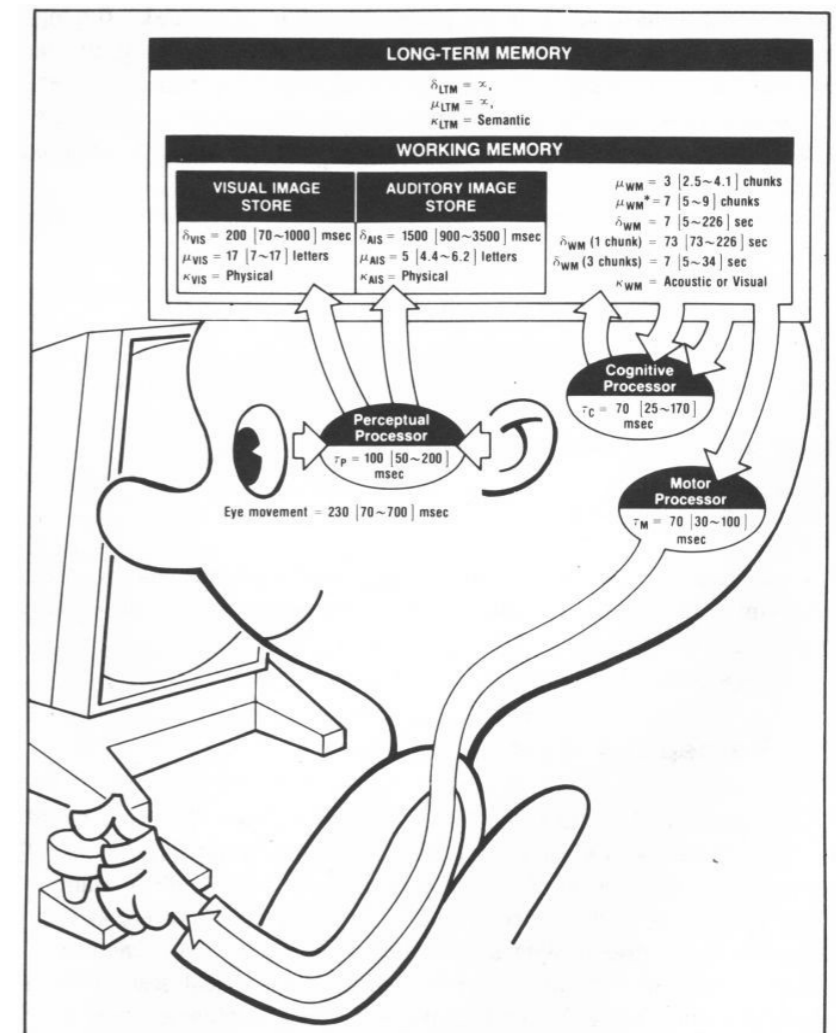
The Model Human Processor

Developed by Card, Moran & Newell (1983)

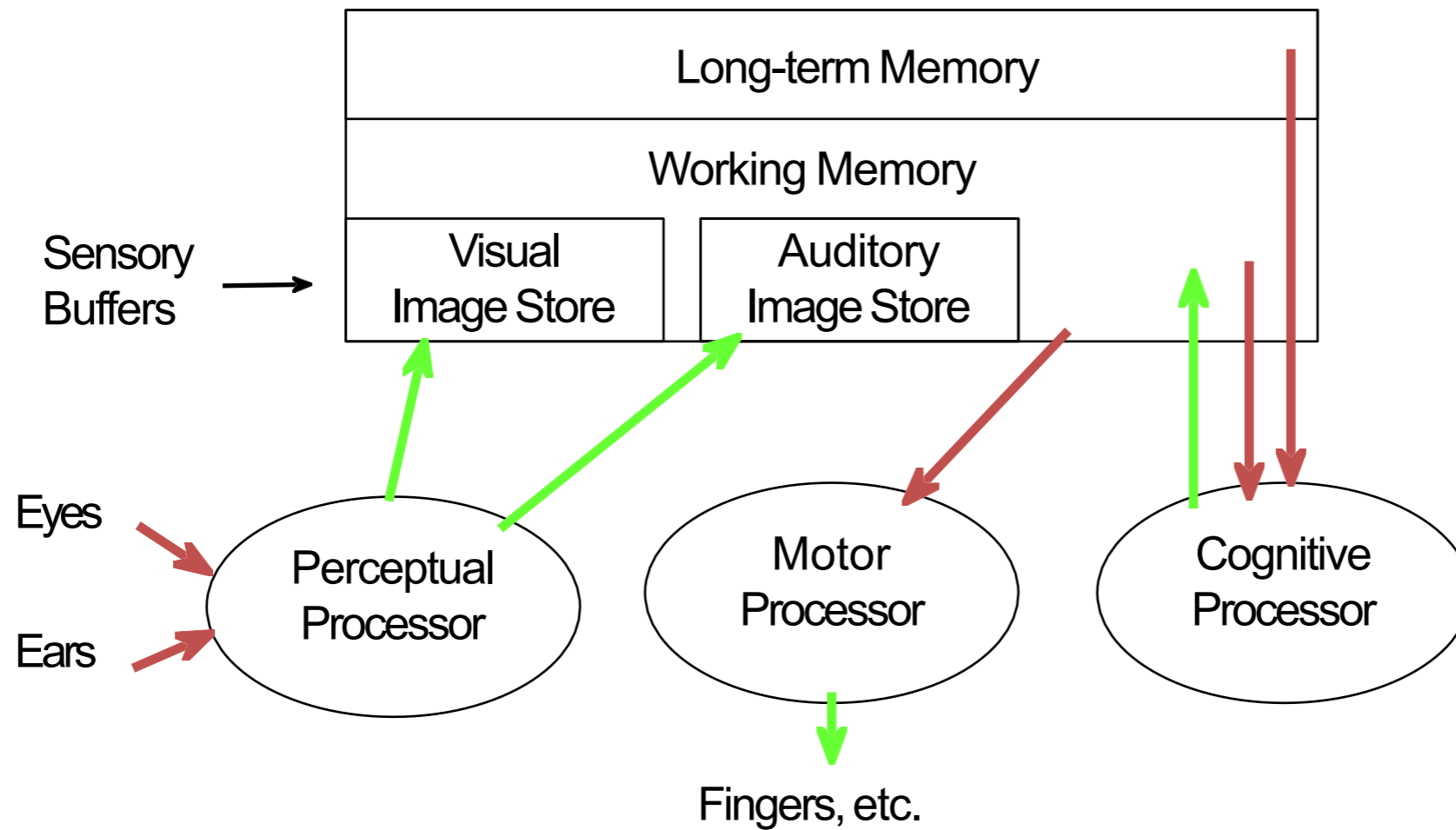
Based on empirical data

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

Same book that named human computer
interaction!



The Model Human Processor



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

BECMSIACI

BEC MSI ACI

IBM CIA CSE

Memory

Working memory (also known as short-term)

Small capacity (7 ± 2 “chunks”)

6174591765 vs. (617) 459-1765

BECMSIACI vs. IBM CIA CSE

Rapid access (~ 70 ms) 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...

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

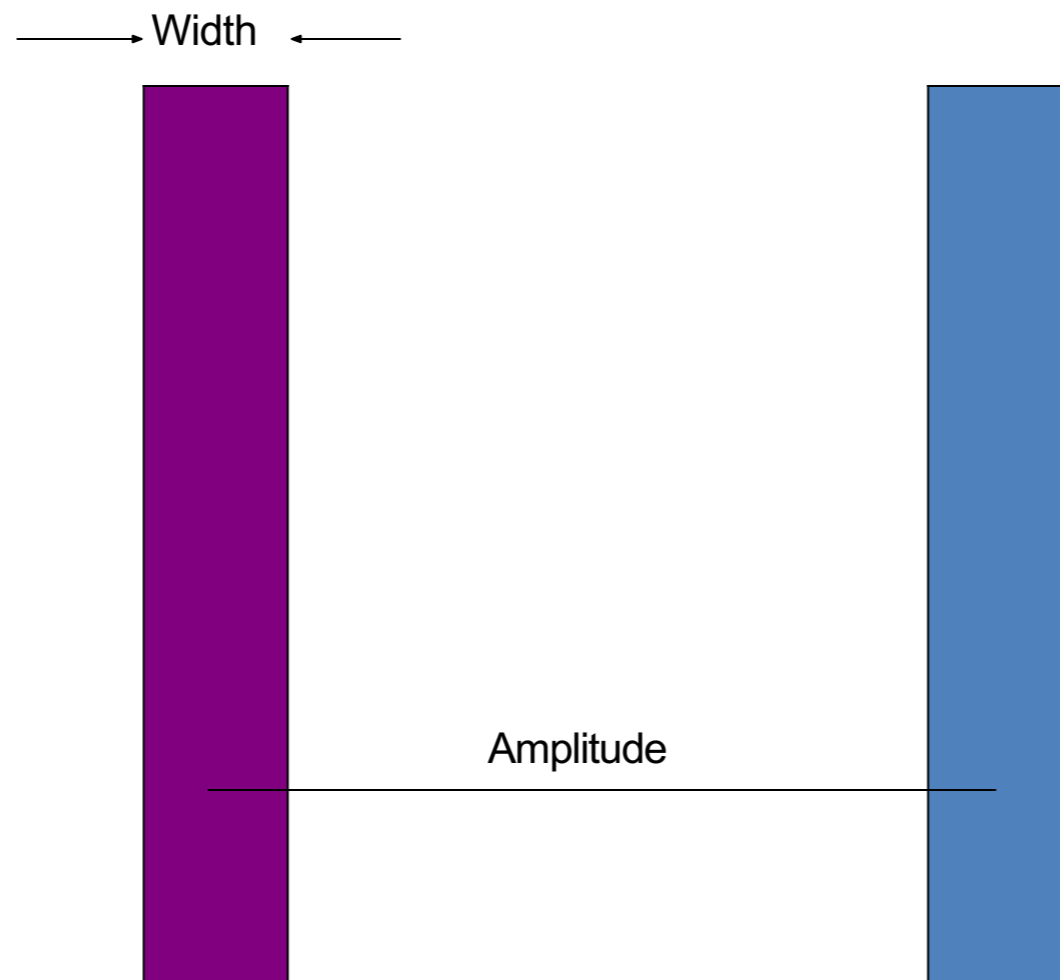
Very powerful, widely used

Holds for many circumstances (e.g., under water)

Allows for comparison among different experiments

Used both to measure and to predict

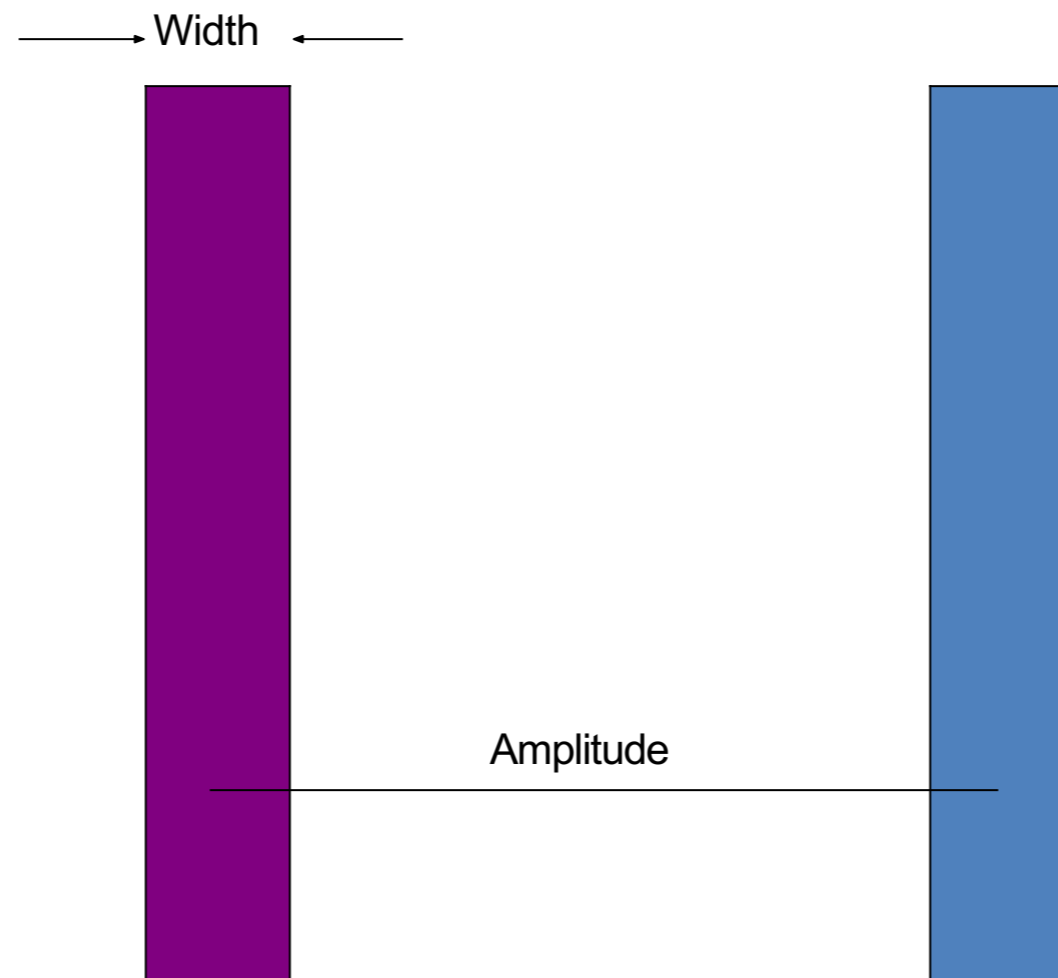
Reciprocal Point-Select Task



Fitts's Law: Index of Difficulty (ID)

$$ID = \log_2(A / W + 1)$$

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)

$$ID = \log_2(A / W + 1)$$

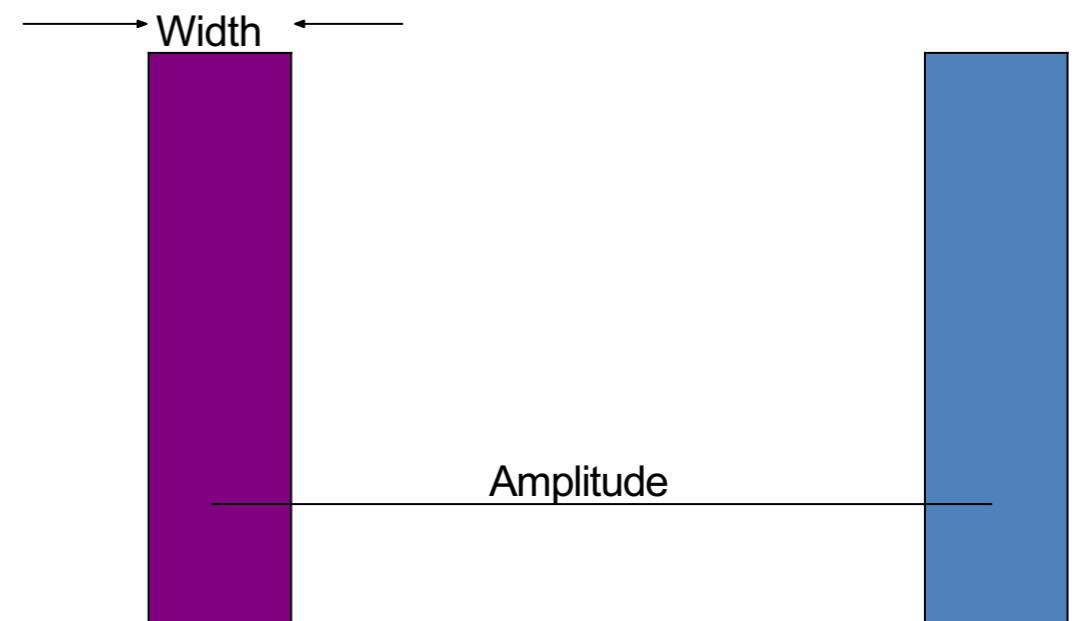
The difficulty to hit a target varies with the log of the **ratio** of the movement distance (A) to target width (W)

Why is it significant that it is a ratio?

Units of A and W don't matter

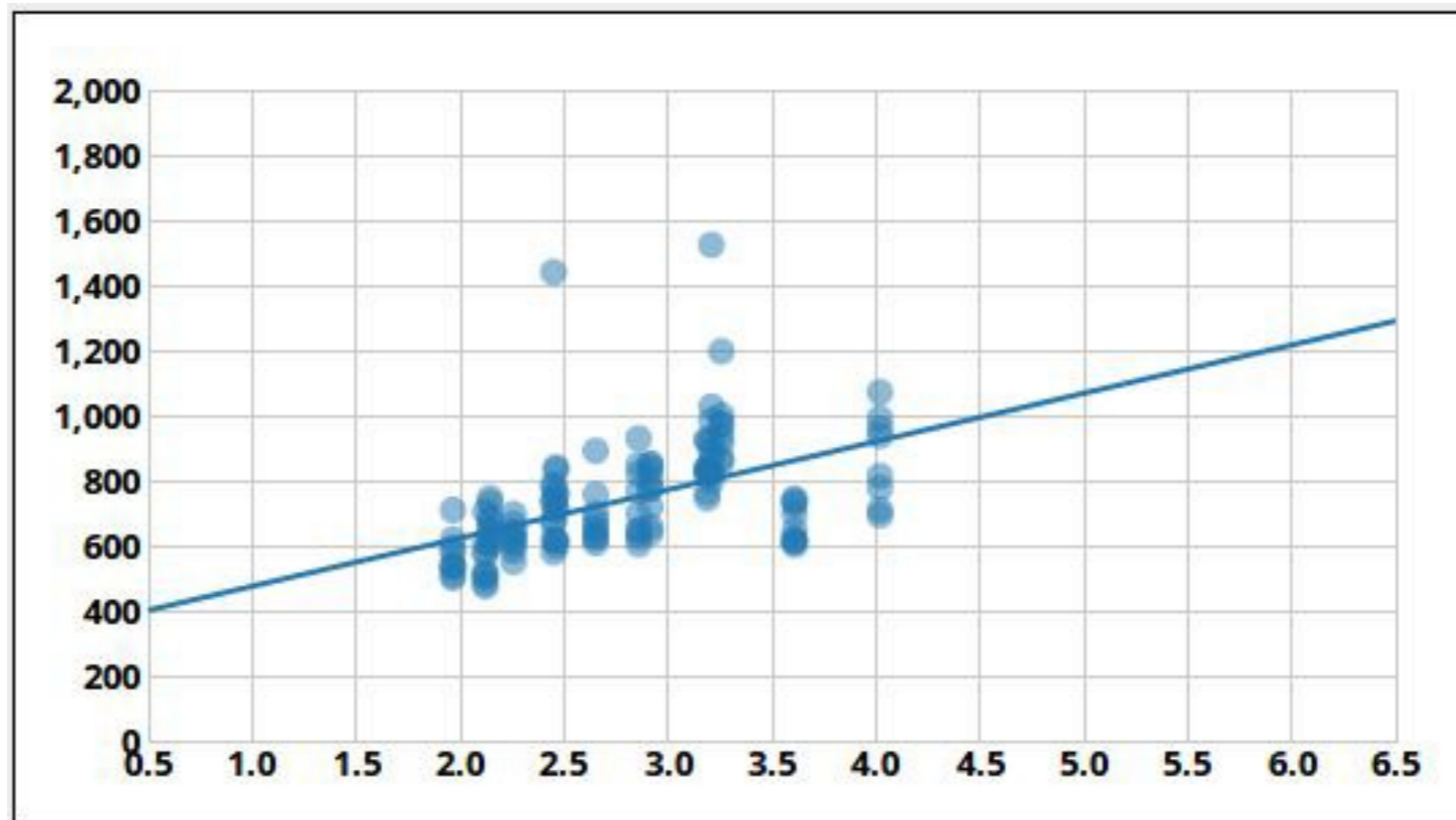
Allows comparison across experiments

(Typically reported in "bits")

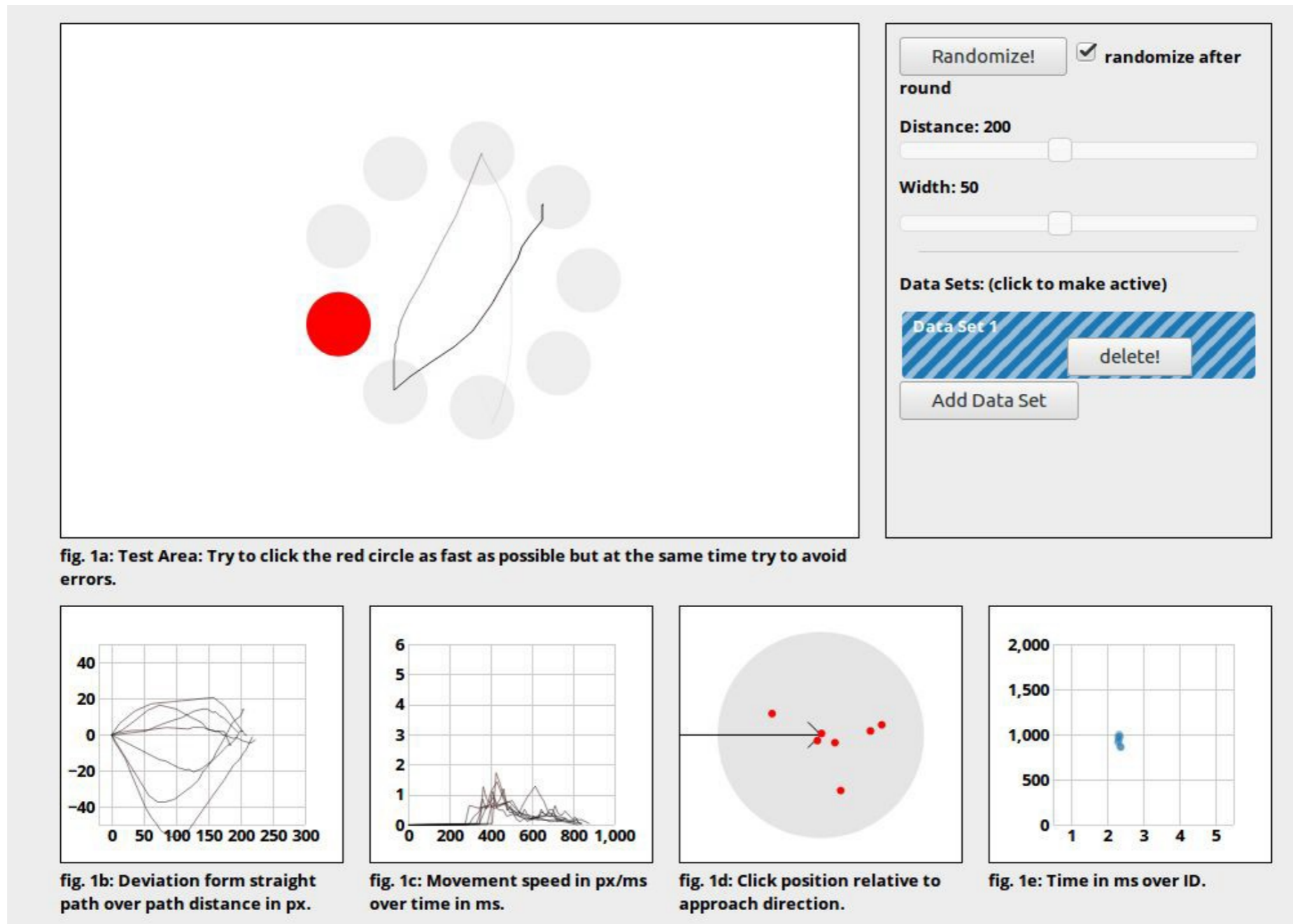


Fitts's Law: Linear variation

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



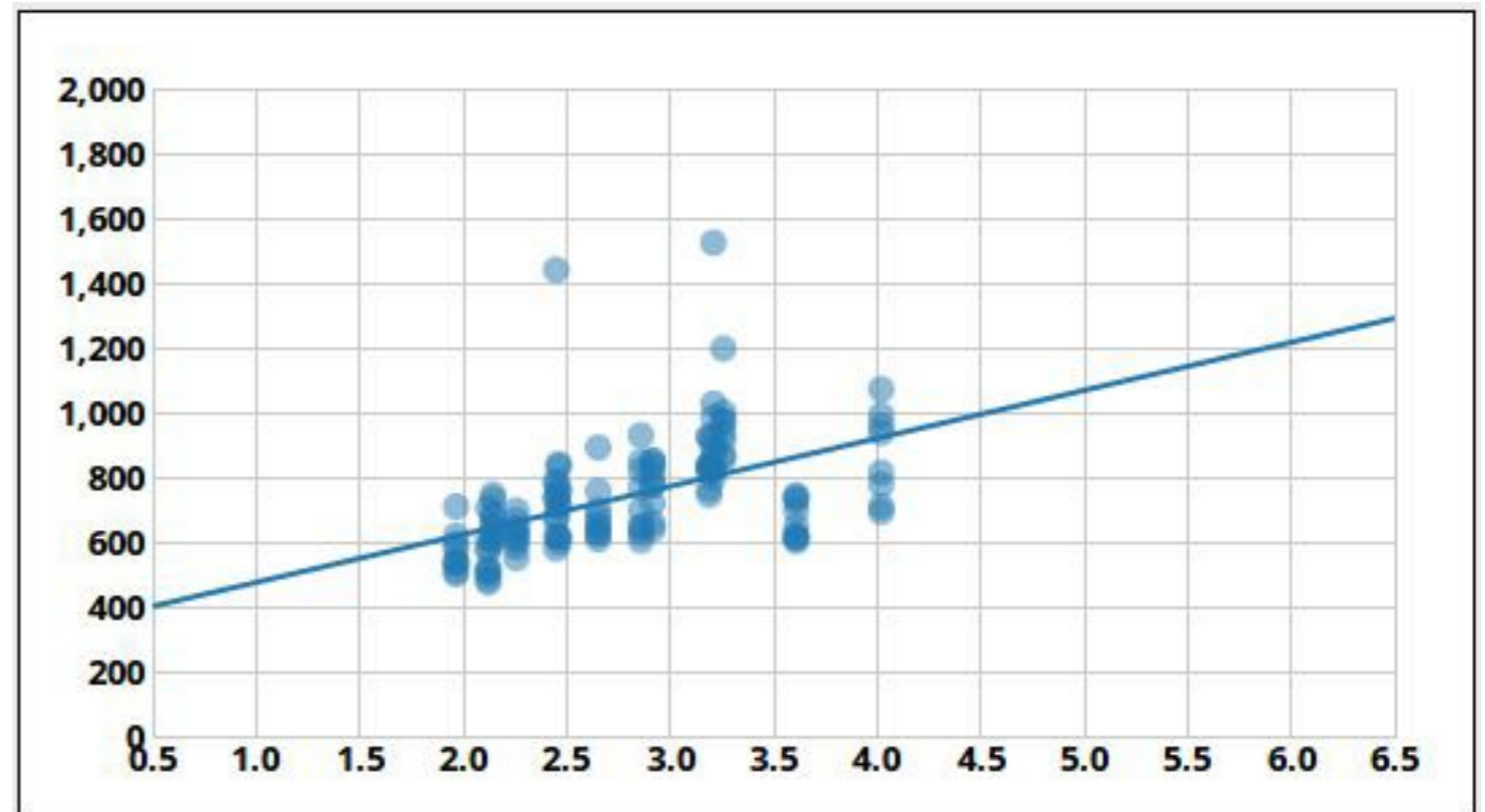
A Fitts's Law Experiment



“Beating” Fitts’s Law

It is the law, right?

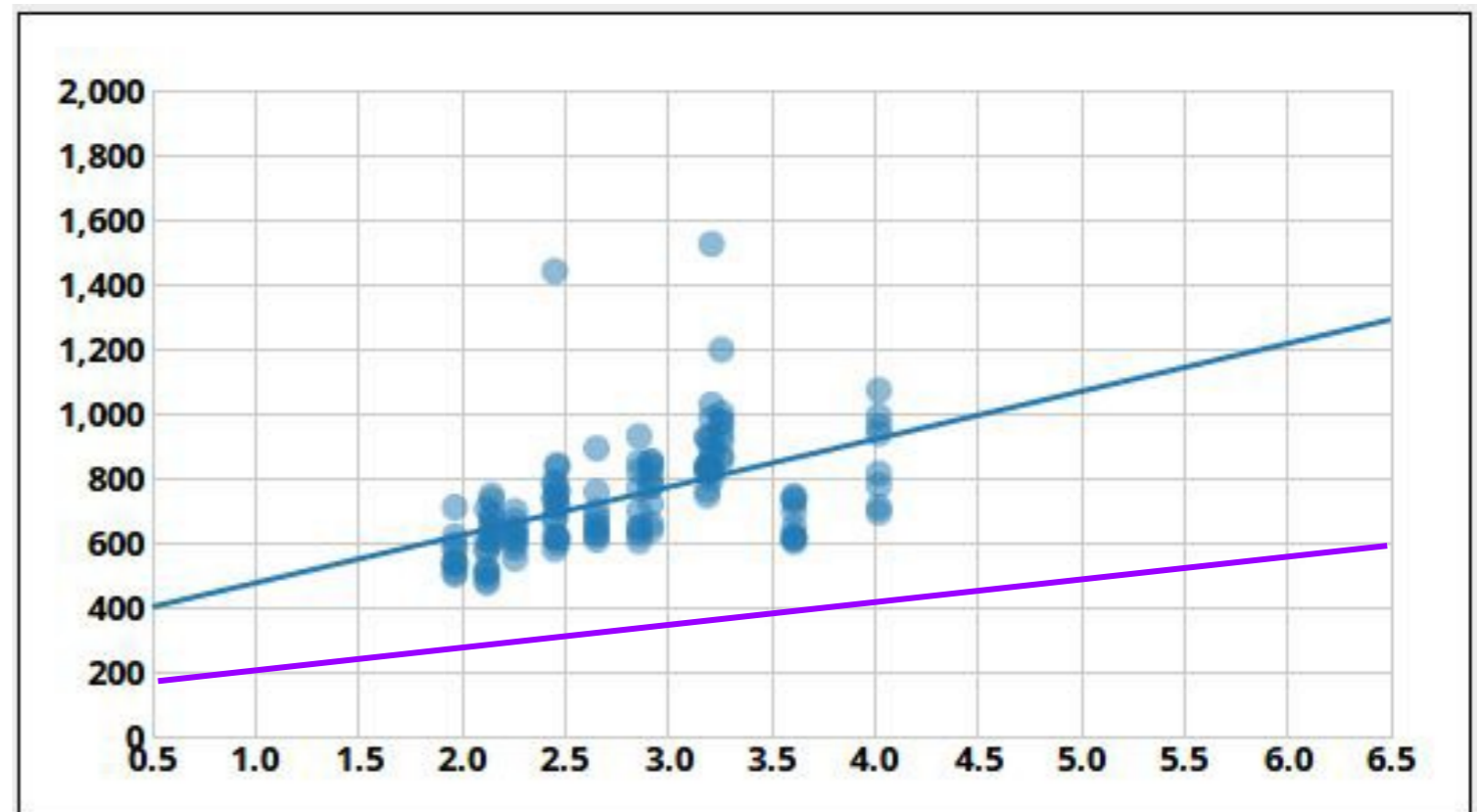
$$MT = a + b \log_2(A / W + 1)$$



“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?

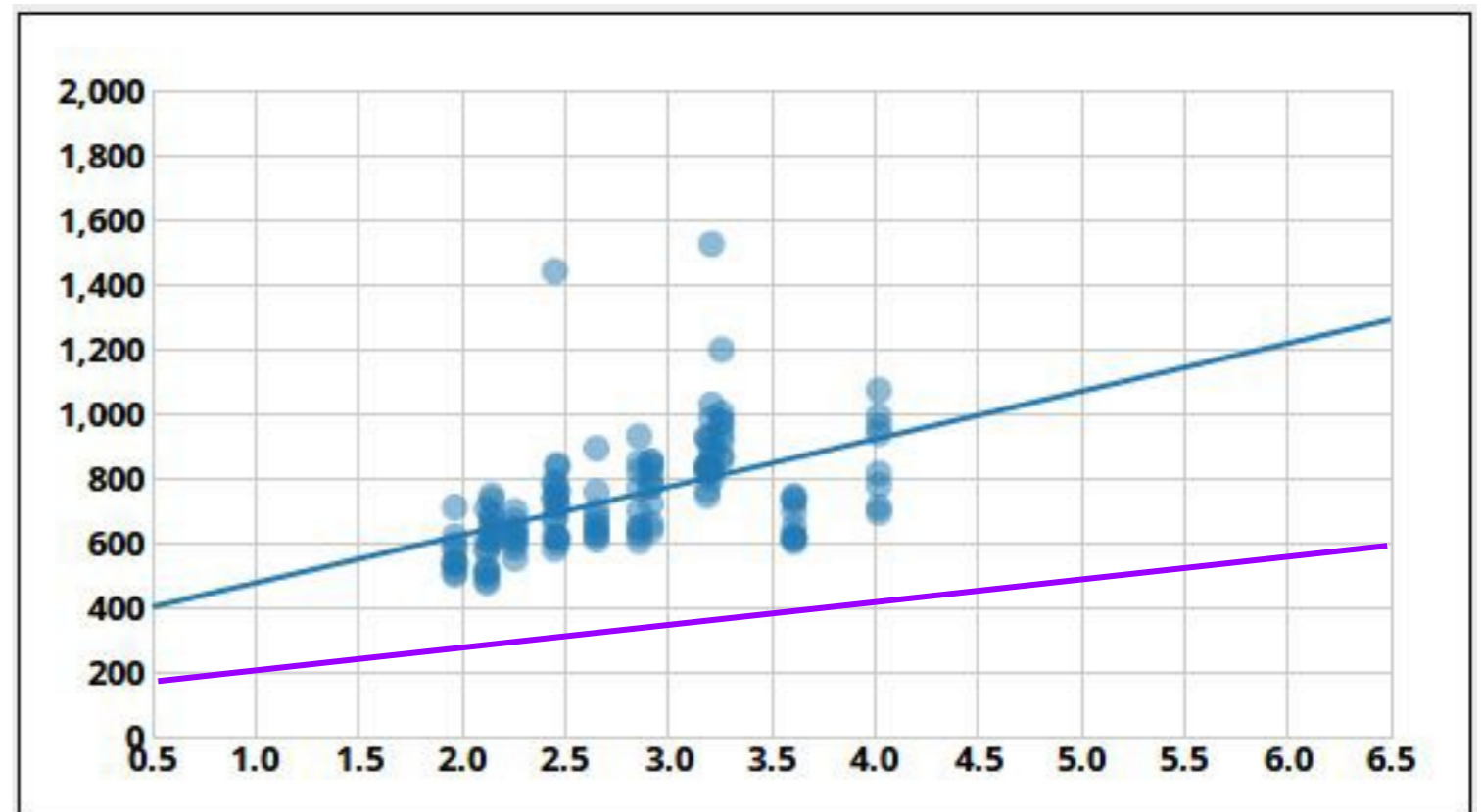
$$MT = a + b \log_2(A / W + 1)$$

So how can we reduce movement time?

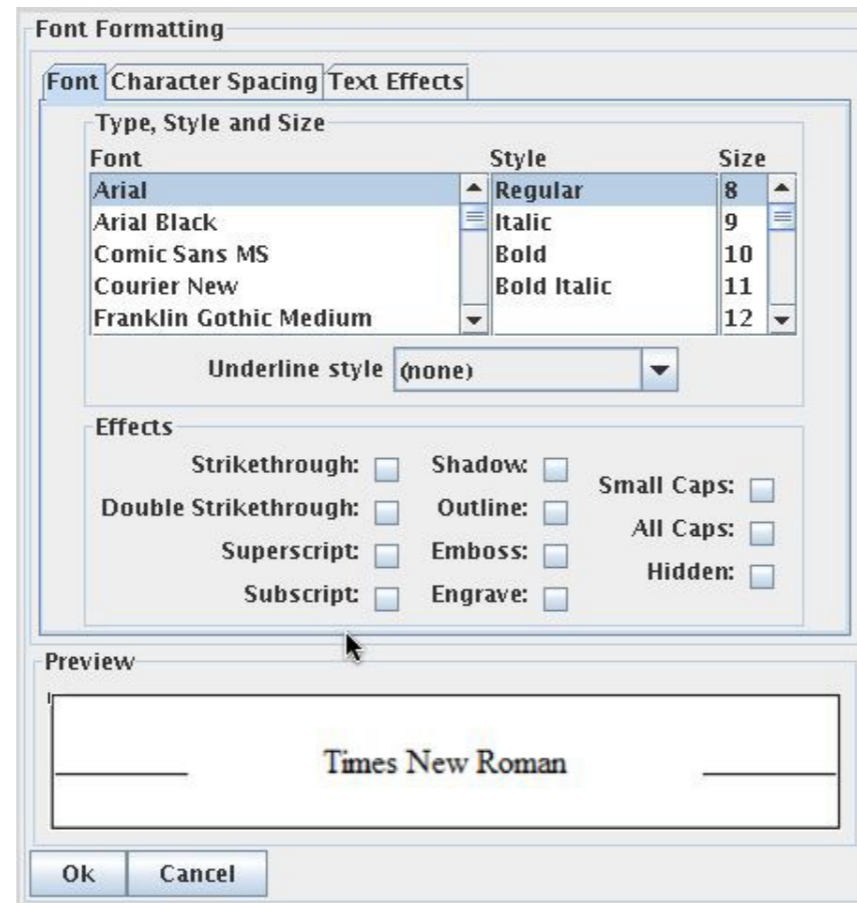
Reduce A?

Increase W?

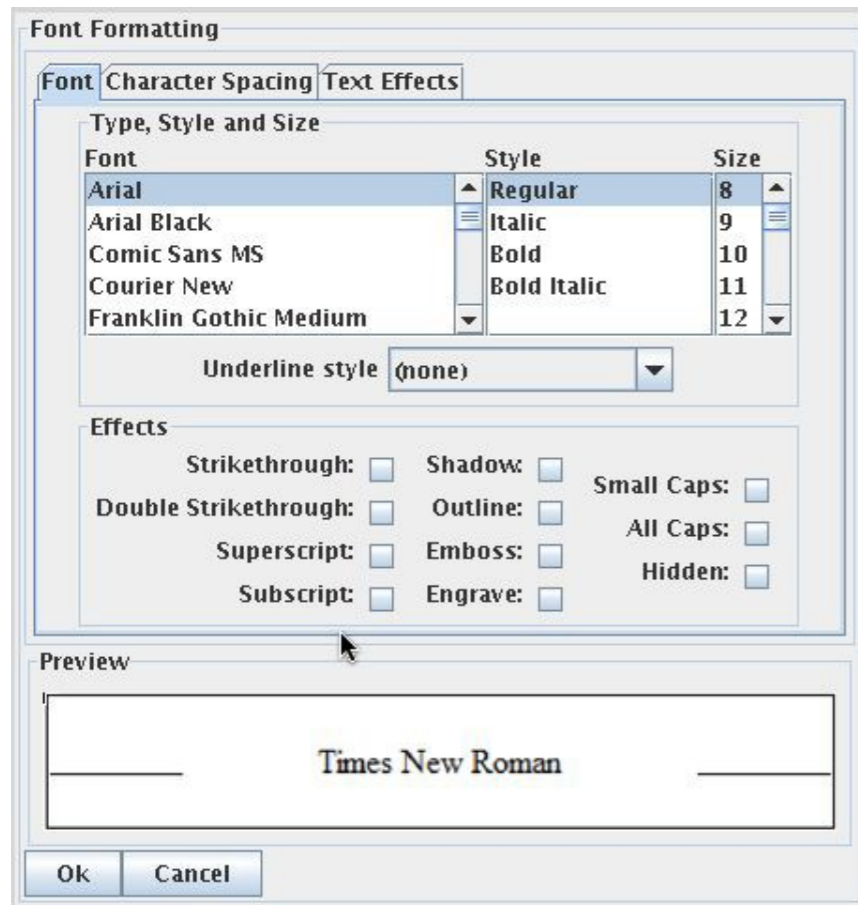
Considering specific
(a) and (b)'s ?



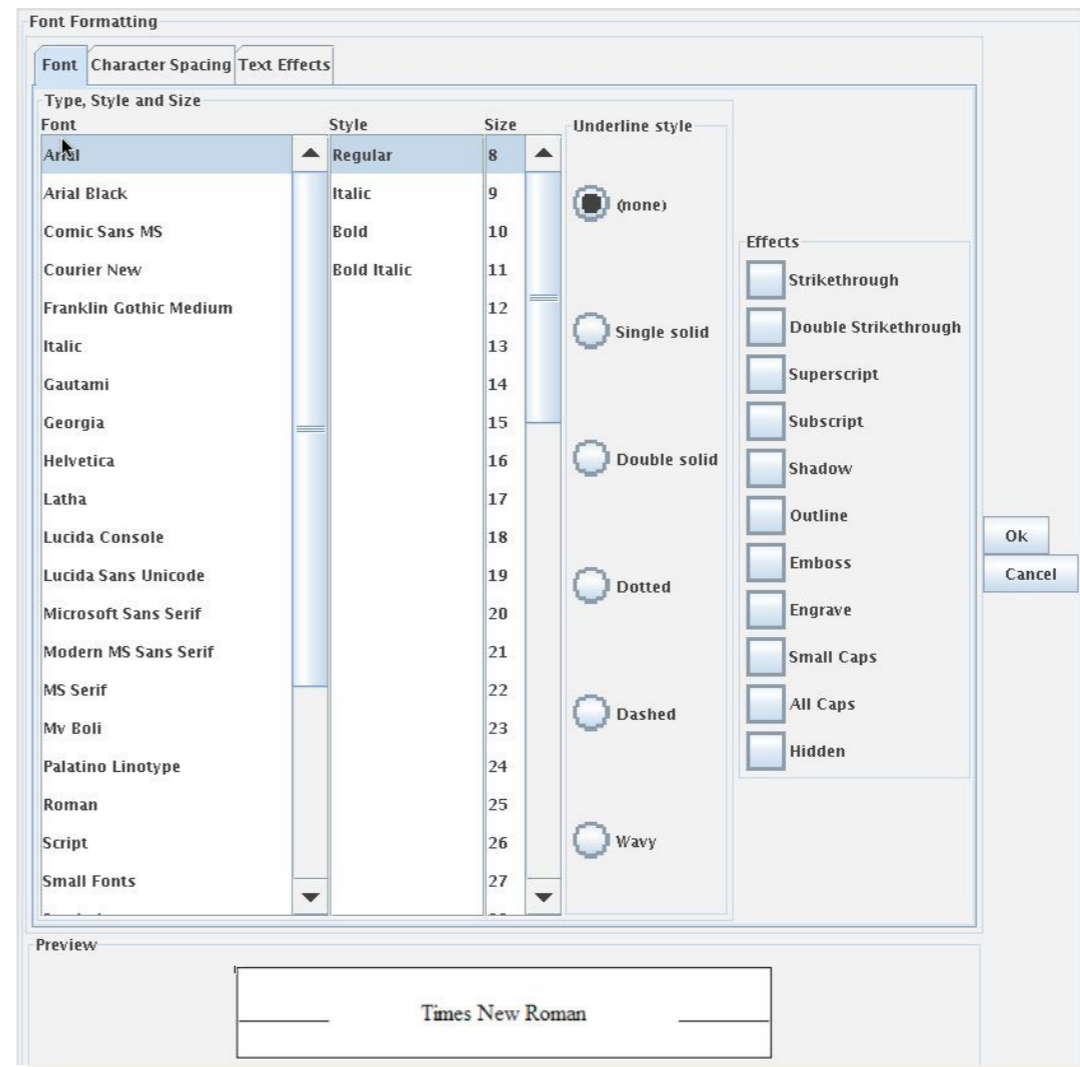
Manufacturer Interface



Manufacturer Interface

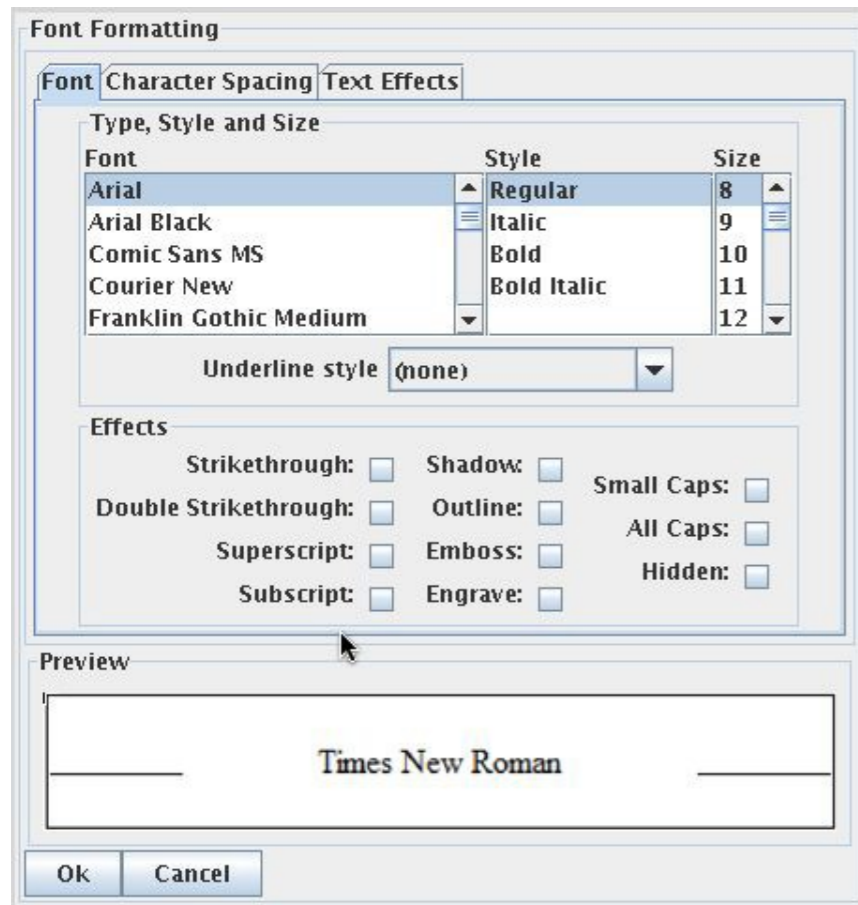


Person with Cerebral Palsy*

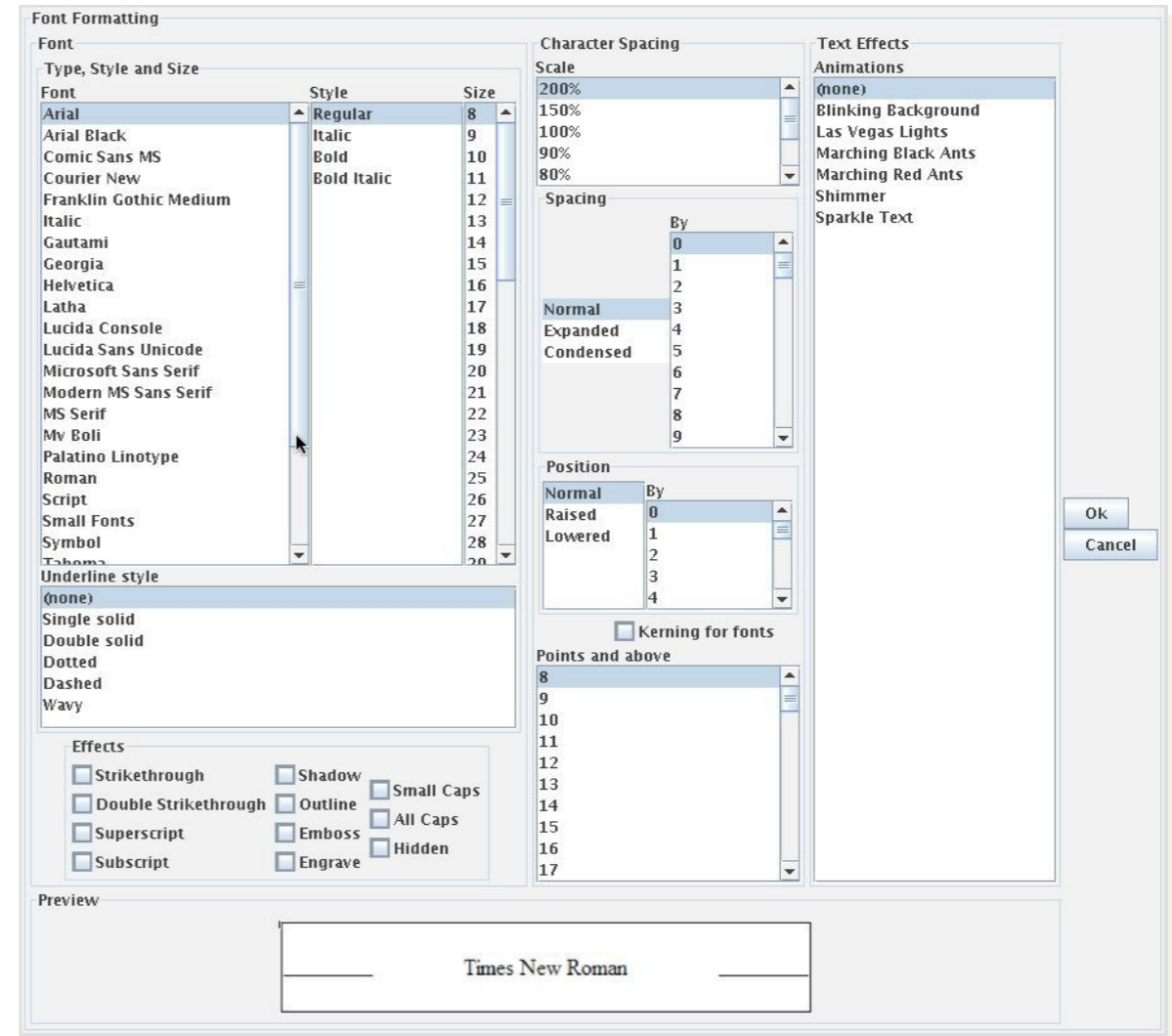


(* fast, spastic (i.e., highly imprecise) movements

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

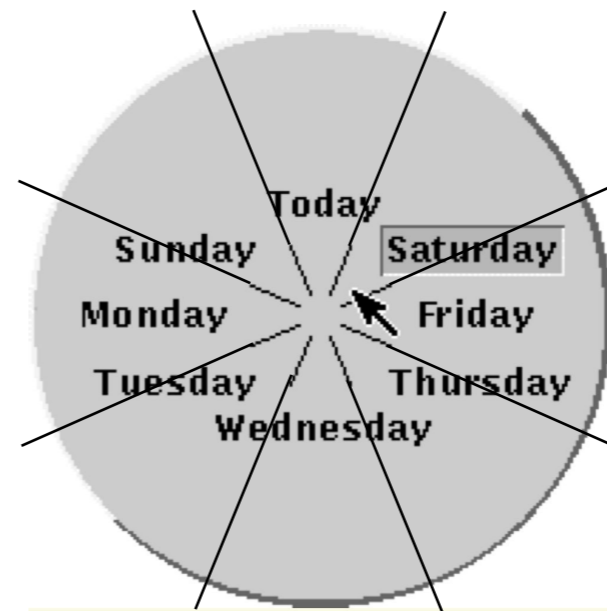
Fitts's Law Examples

Which will be faster on average?

Pop-up Linear Menu



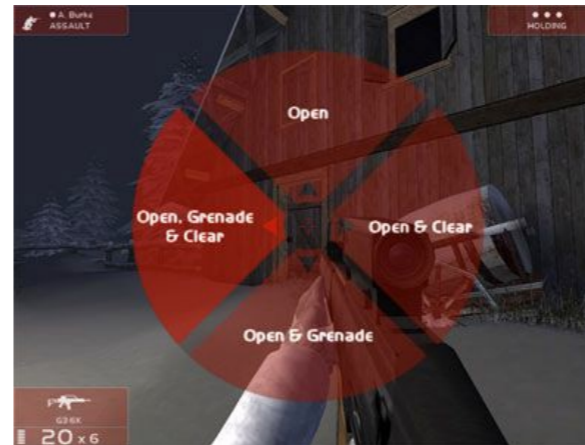
Pop-up Pie Menu



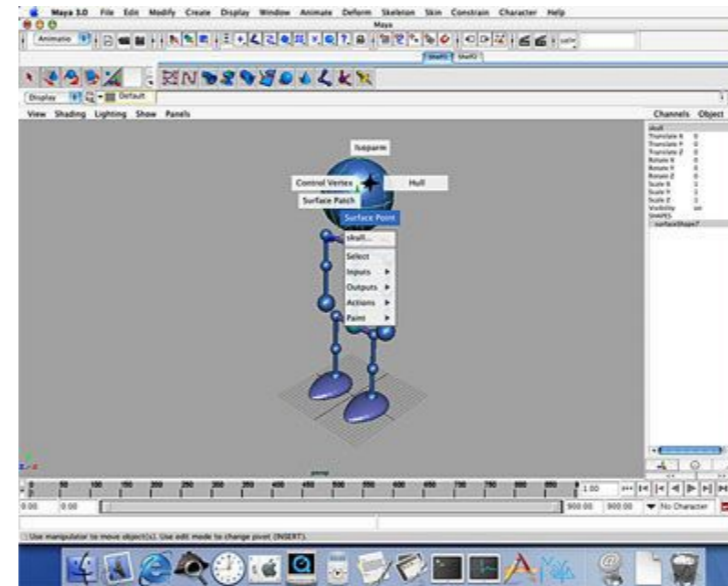
Pie Menus in Use



The Sims



Rainbow 6

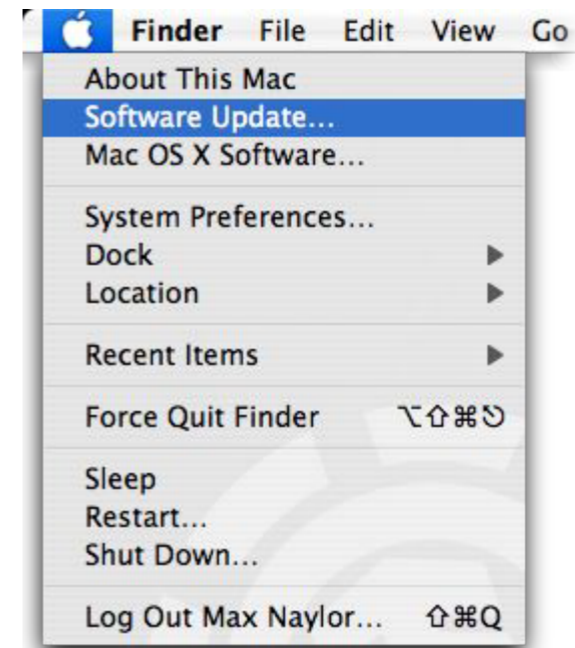


Maya

Fitts's Law in Windowing

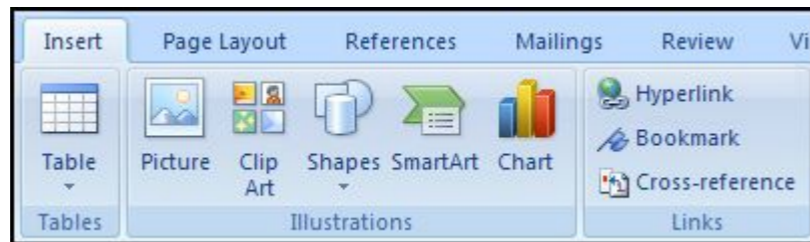


Windows 95: Missed by a pixel
Windows XP: Good to the last drop

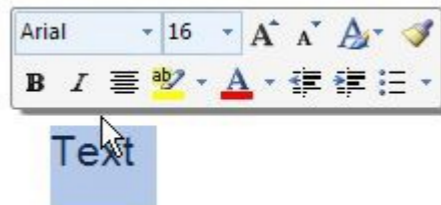


Macintosh Menu

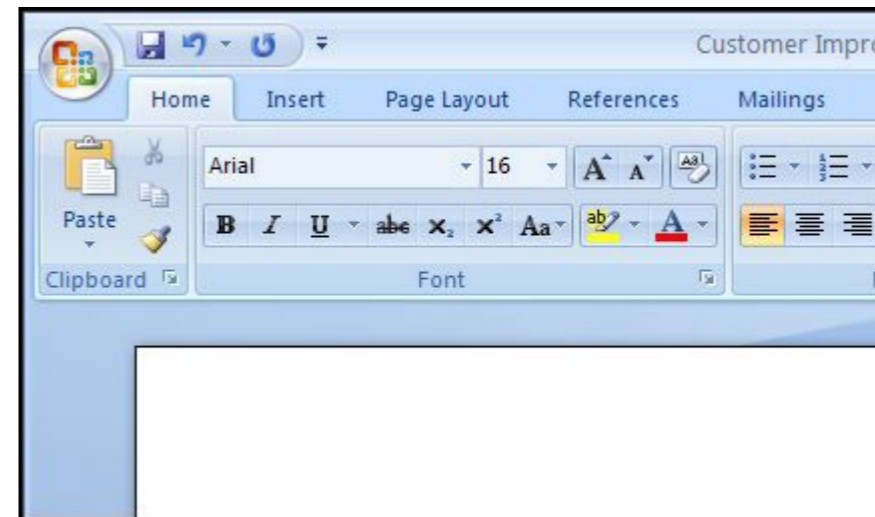
Fitts's Law in MS Office



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



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

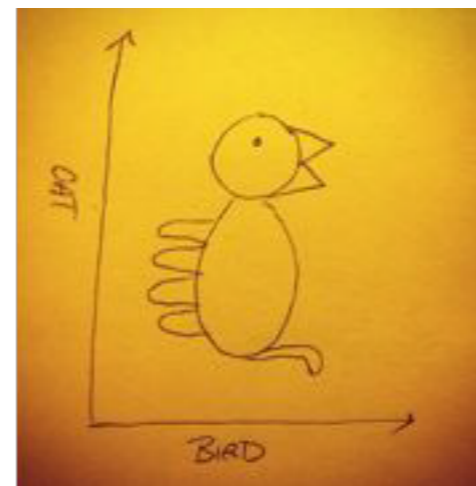
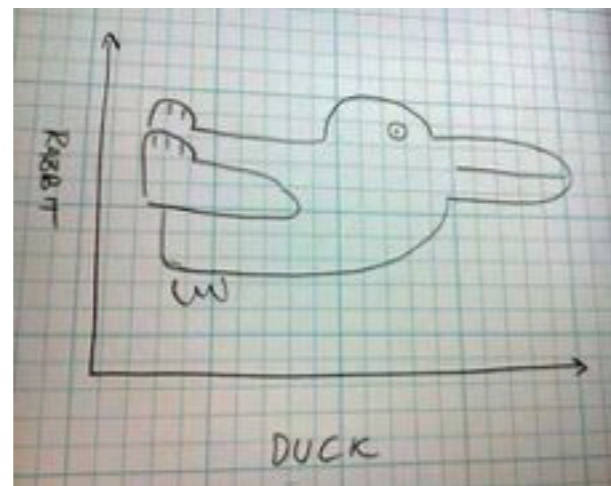
Gestalt Principles

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

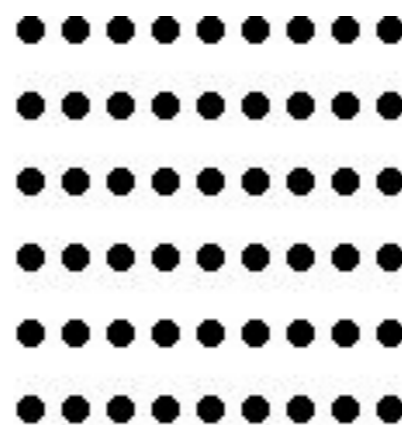
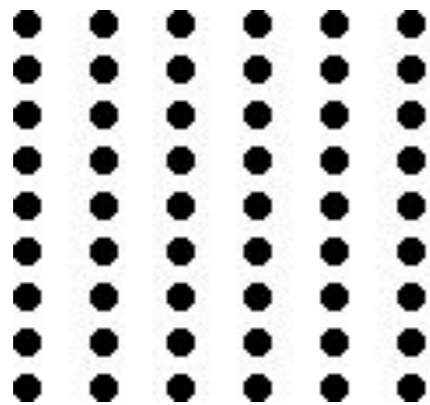


Gestalt Psychology



Principle: Proximity

Objects close to each other form a group



Principle: Proximity

Using Lies in Research

By Nate Bolt • March 8, 2011

While it might be an uncomfortable topic, uncovering the lies behind a product or interface can be one of the most effective ways to turn ailing projects around.

[Read More](#)

Considerations for Mobile Design (Part 2): Dimensions

By David Leggett • March 1, 2011

In part two of this series, David helps readers adapt their design regimes to the (typically) small screens of mobile devices. Using responsive design, our experiences adapt to a variety of conditions.

[Read More](#)

A Simple, Usable Review

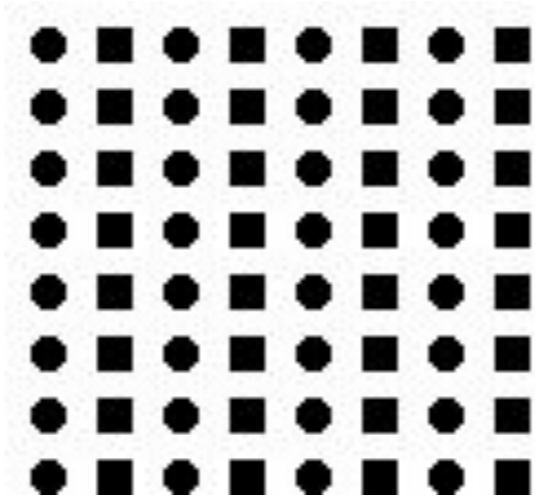
By Paul Seys • February 24, 2011

In this detailed review, Paul Seys describes an up-and-coming UX title that's jam-packed with lessons for designers both new and established. Follow along to learn how author Giles Colborne's teaches his readers the essence of great design.

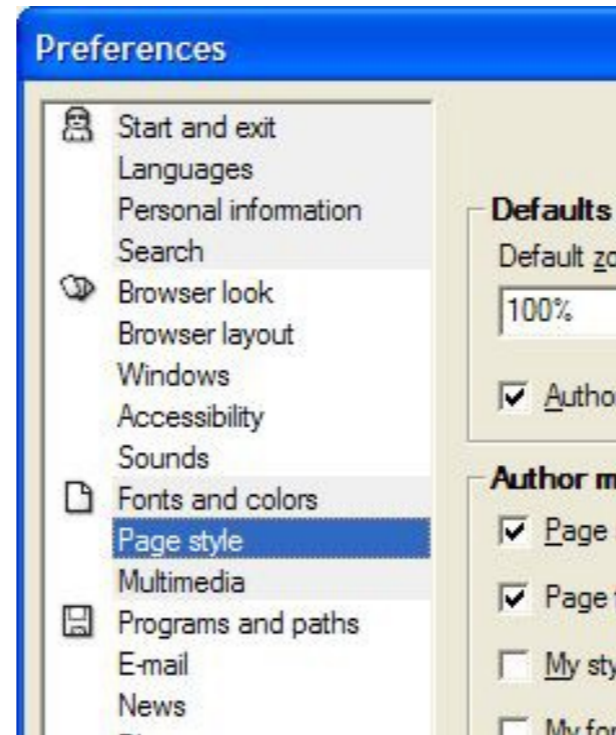
[Read More](#)

Principle: Similarity

Objects that are similar form a group



Principle: Similarity



Principle: Closure

Even incomplete objects are perceived as whole

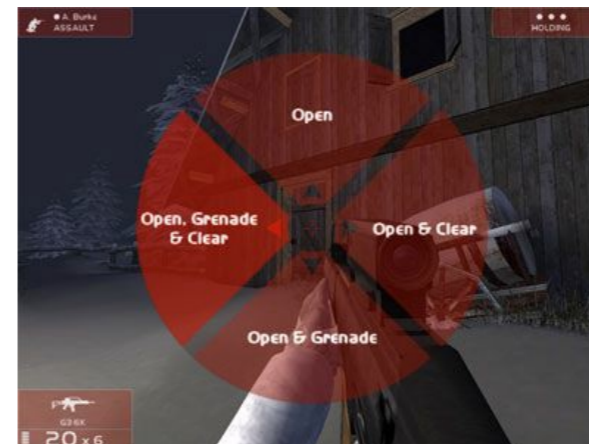
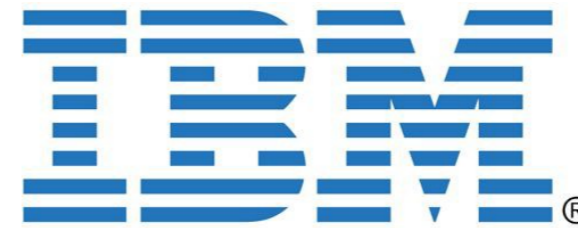
Increases regularity of stimuli



Principle: Closure



The Sims



Rainbow 6

Principle: Symmetry

Objects are perceived as symmetrical and forming around a center point

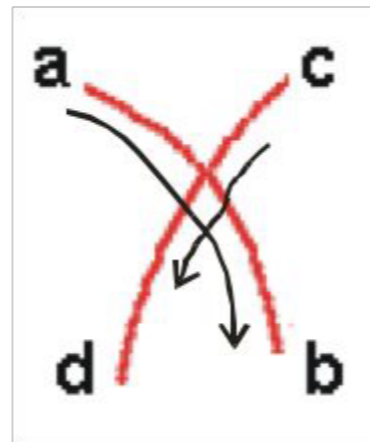
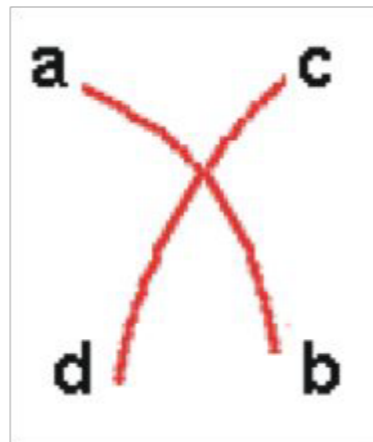


Continuity

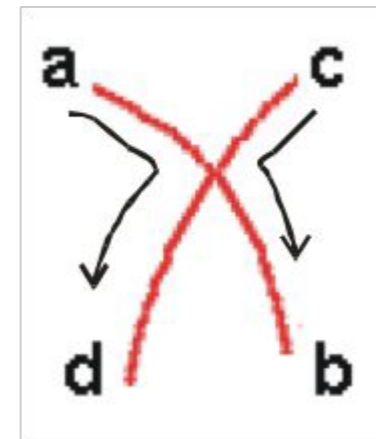
Objects are perceived as grouped when they align

Remain distinct even with overlap

Preferred over abrupt directional changes



what most
people see



not this

Models from Different Perspectives

Visual System

Model Human Processor

Fitts's Law

Gestalt Principles

Biological Model

Higher-Level Model

Model by Analogy

Predict Interpretation

Ask me something!