CSE 440: Introduction to HCI

User Interface Design, Prototyping, and Evaluation

Lecture 07:
Human Performance

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Tuesday/Thursday
12:00 to 1:20

design:
use:
build:

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Some Reminders

Task Analysis Critique Tomorrow

- do tasks reveal insight into the underlying problem
- do tasks expose an interesting design space

Keep your design options open

Our critique is not your answer

- we cannot pave a path to insight
- we will not always be consistent in our response

Today

Human Performance

- Visual System
- Model Human Processor
- Fitts's Law
- Gestalt Principles

These are Examples of What?

Popsicle-stick bridge

$x = x0 + v0t + \frac{1}{2} at2$

ACT-R

Goffman’s Negotiated Approach

Norman’s Execution-Evaluation Cycle

Models

We have said models describe phenomena, isolating components and allowing a closer look

Today is a closer look at modeling humans

- 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 a Model

How would you go about creating a model?

Creating a Model

How would you go about creating a model?

One approach:

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

Fundamentally an inductive process

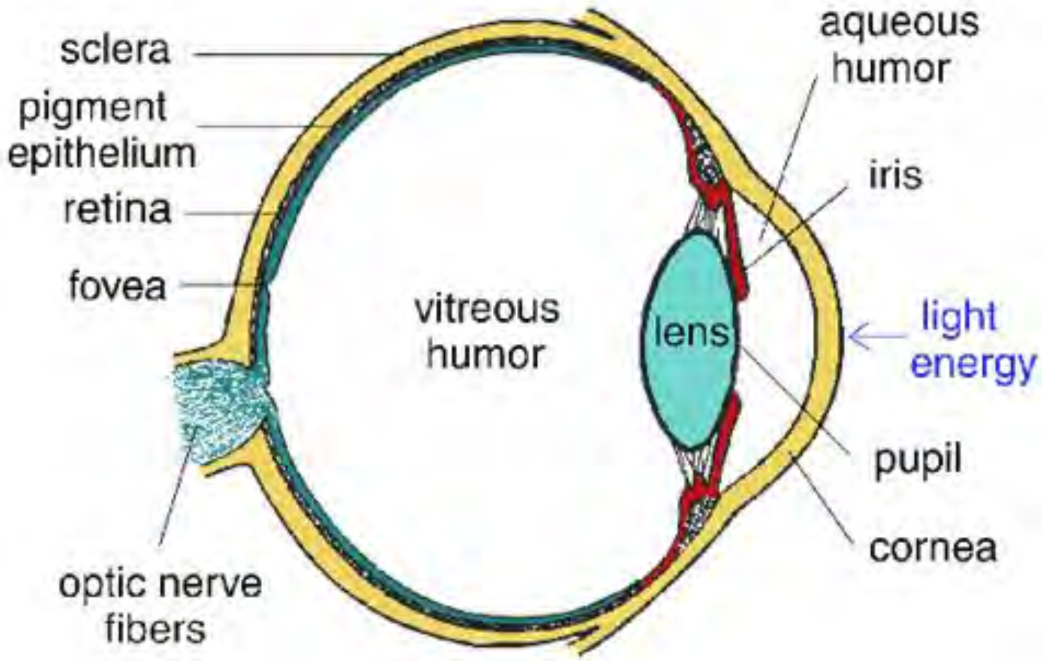
- From specific observations to broader generalization

Today

Some example models of human performance

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

Human Visual System



Light passes through lens, focused on retina

Blind Spot?

Blind Spot

a	b	c	d	e	f	g	h
i	j	k	l	m	n	o	p
q	r	s	t	u	v	w	x

Use right eye, look at letters

Blind Spot

Use left eye, look at cross

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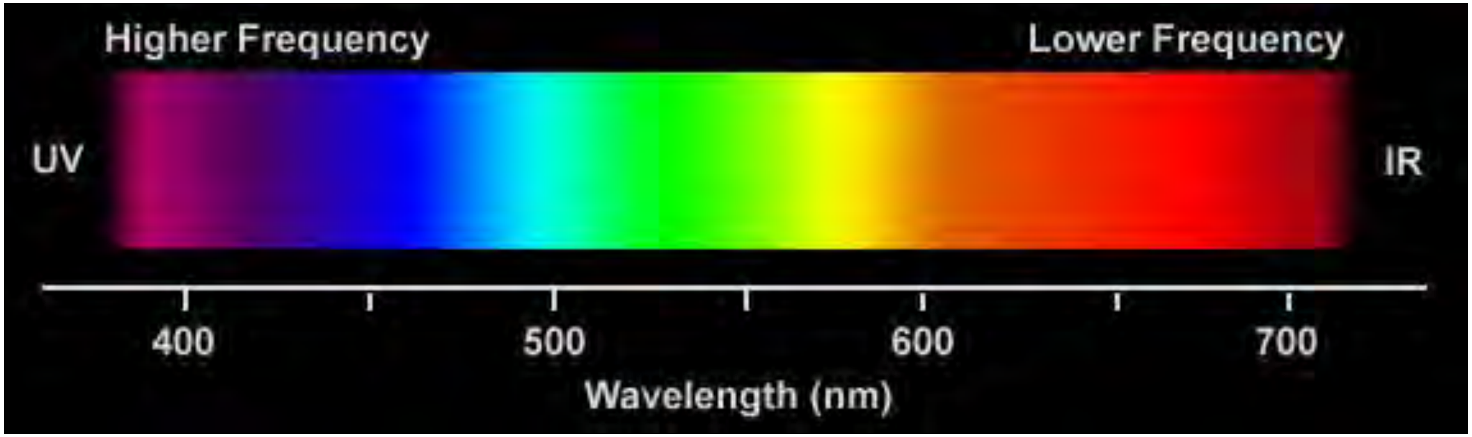
Visible Spectrum



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 …

Retina

Center of retina has most of the cones

- Allows for high acuity of objects focused at center

Retina

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Edge of retina is dominated by …

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Edge of retina is dominated by rods

- Allows detecting motion of threats in periphery

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What does that mean for you?

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What does that mean for you?

- Peripheral movement is easily distracting

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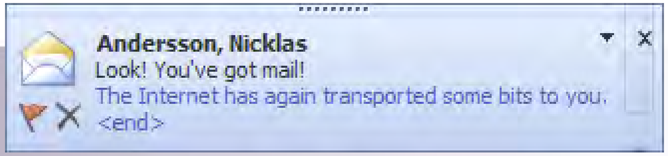


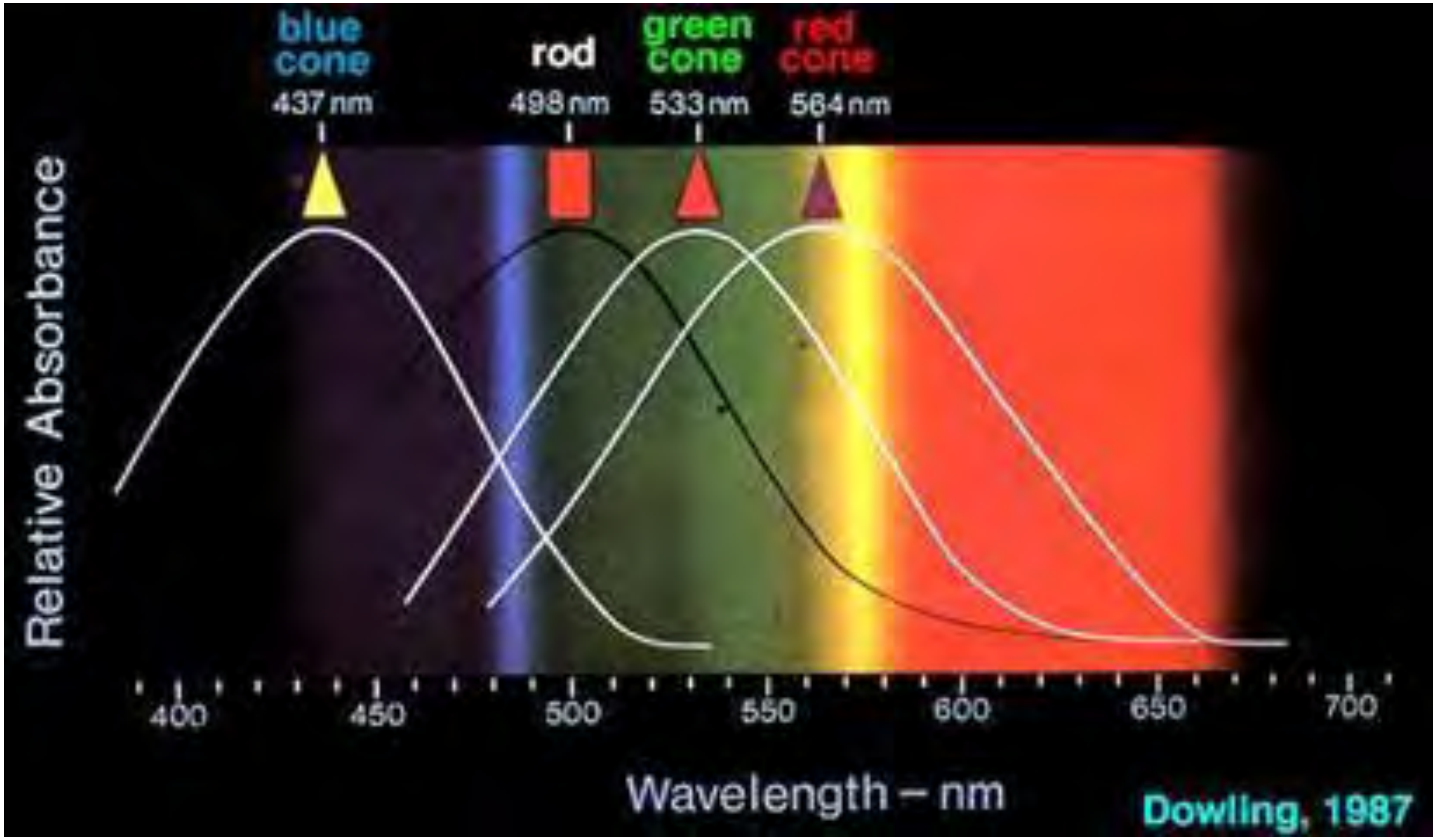
Color Perception via Cones

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 of gives us a continuous perception of color

Color Sensitivity



Distribution of Photopigments

Not distributed evenly

- Mainly reds (64%), Very few blues (4%)
- Insensitivity to short wavelengths (i.e., blue)

No blue cones in retina center

- Fixation on small blue object yields "disappearance"

Lens yellows with age, absorbs short wavelengths

- Sensitivity to blue is reduced even further

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 Red + 0.59 Green + 0.11 Blue

Shapes detected by finding edges

- We use brightness and color difference

Implication

- Blue edges and shapes are hard

Color Sensitivity & Image Detection

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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

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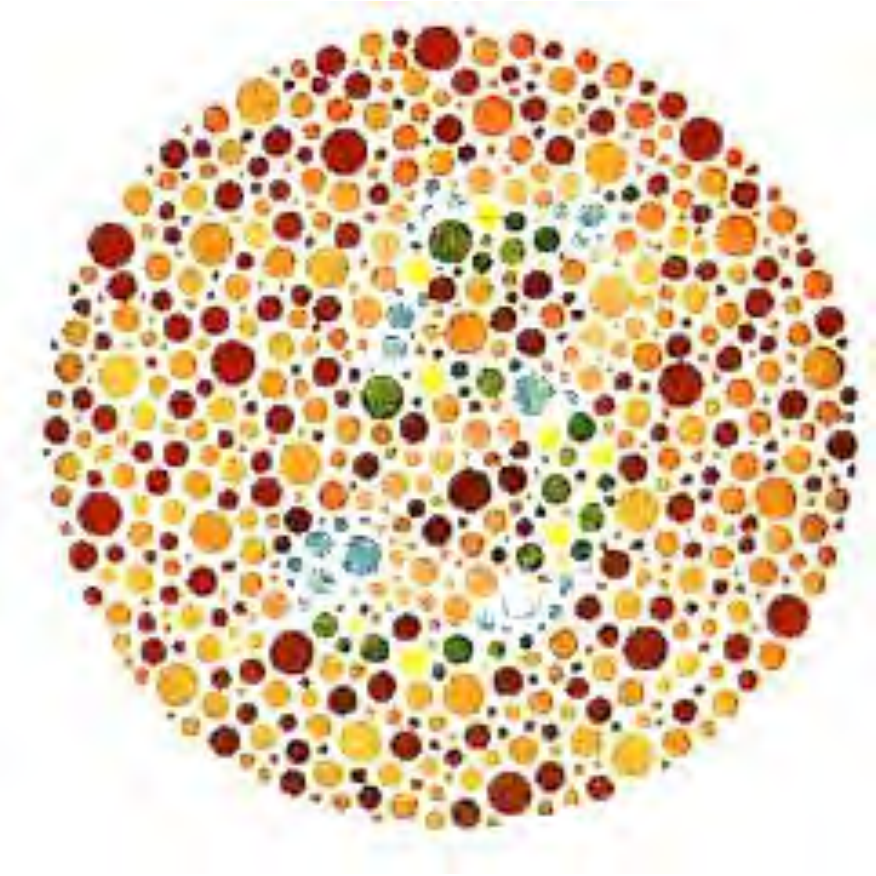
Saturated colors (i.e., pure colors) require more focusing than desaturated (i.e., pastels)

This hurts, why?

Color 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
    - Lack of either green or red photopigment, cannot discriminate colors dependent on red and green
- Also known as color blindness

Red-Green Deficiency Test



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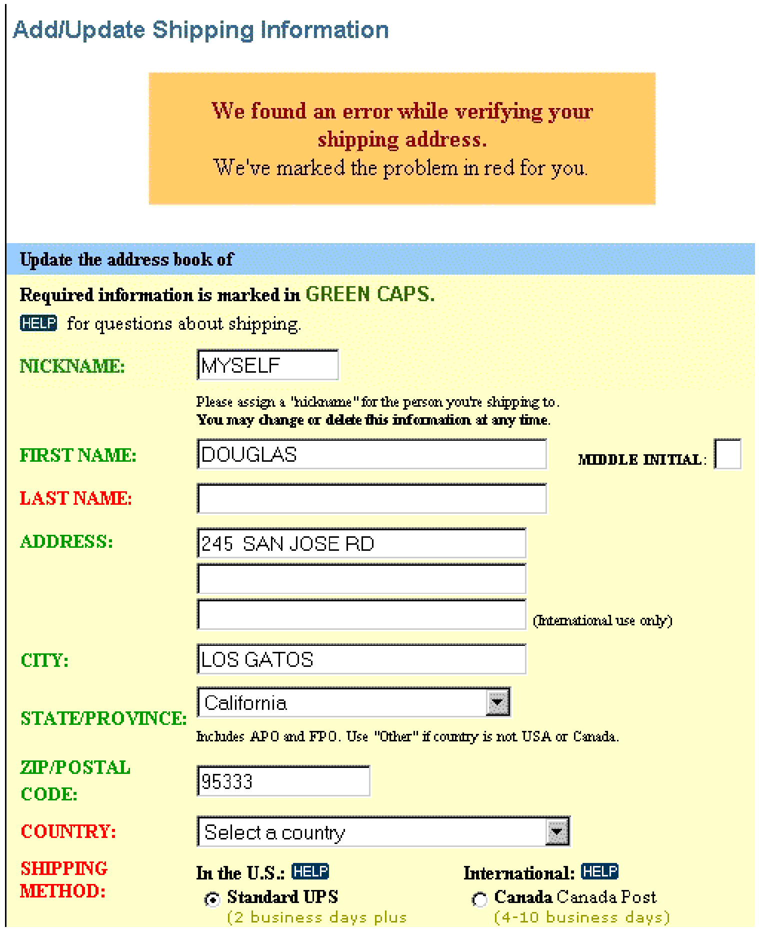
Dual / Redundant Encoding

Apples to Apples

Pandemic

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

Dual / Redundant Encoding



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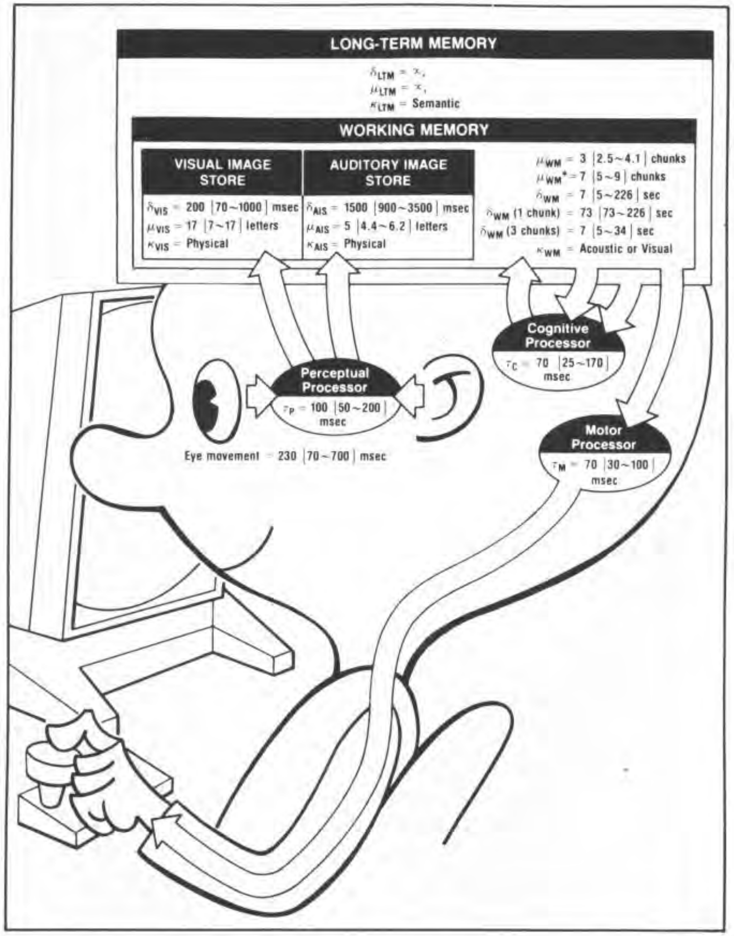
The Model Human Processor



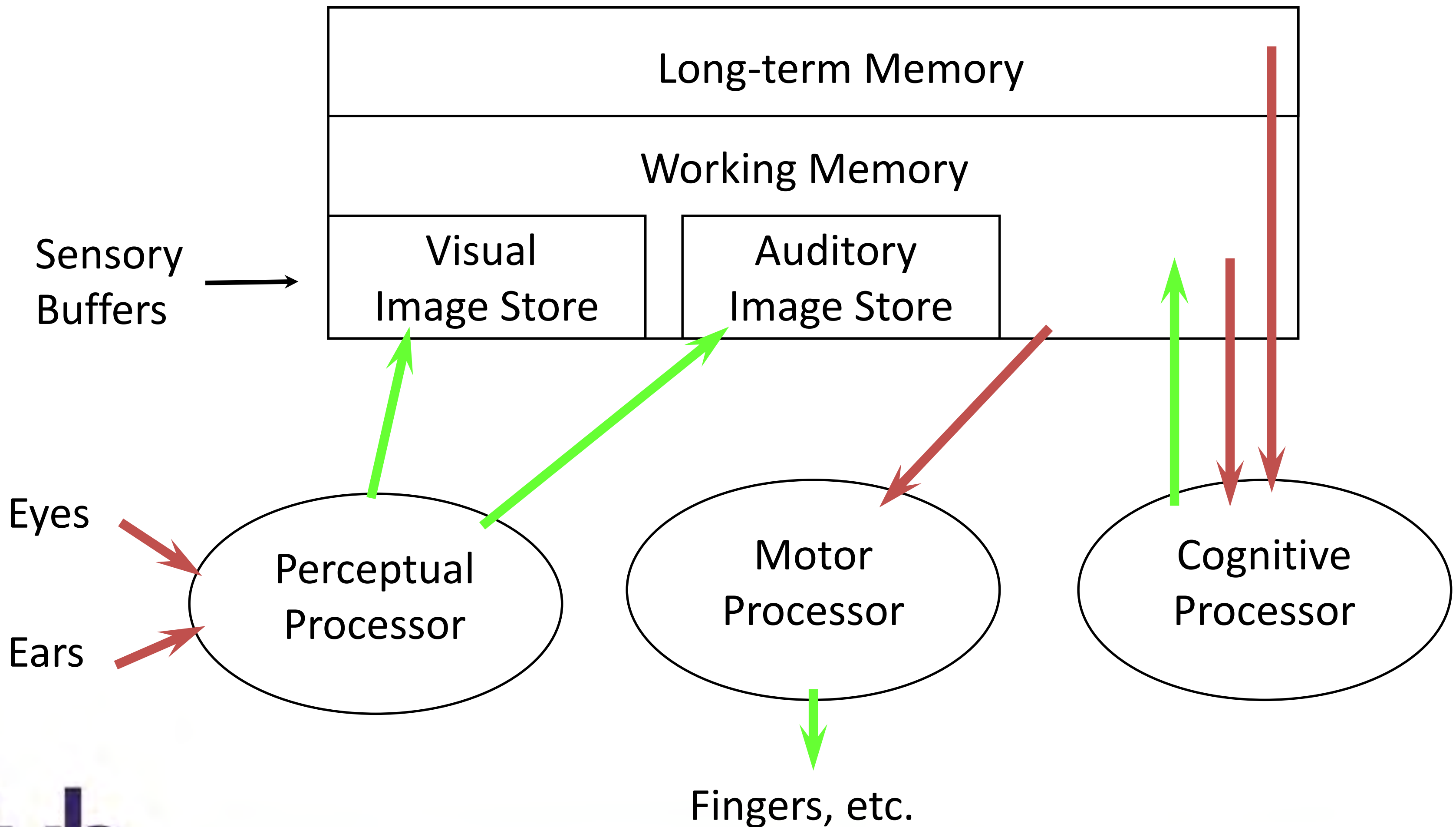
Developed by Card, Moran, & Newell (1983)

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

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BM CIA CSE I

University of
Washington

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

Volunteer

Activation Experiment

Volunteer

Start saying colors you see in list of words

- When slide comes up, as fast as you can
- There will be three columns of words

Say “done” when finished

- Everyone else time how long it takes

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

Activation Experiment

Do it again

Say “done” when finished

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

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Activation Experiment

Do it again

Say “done” when finished

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

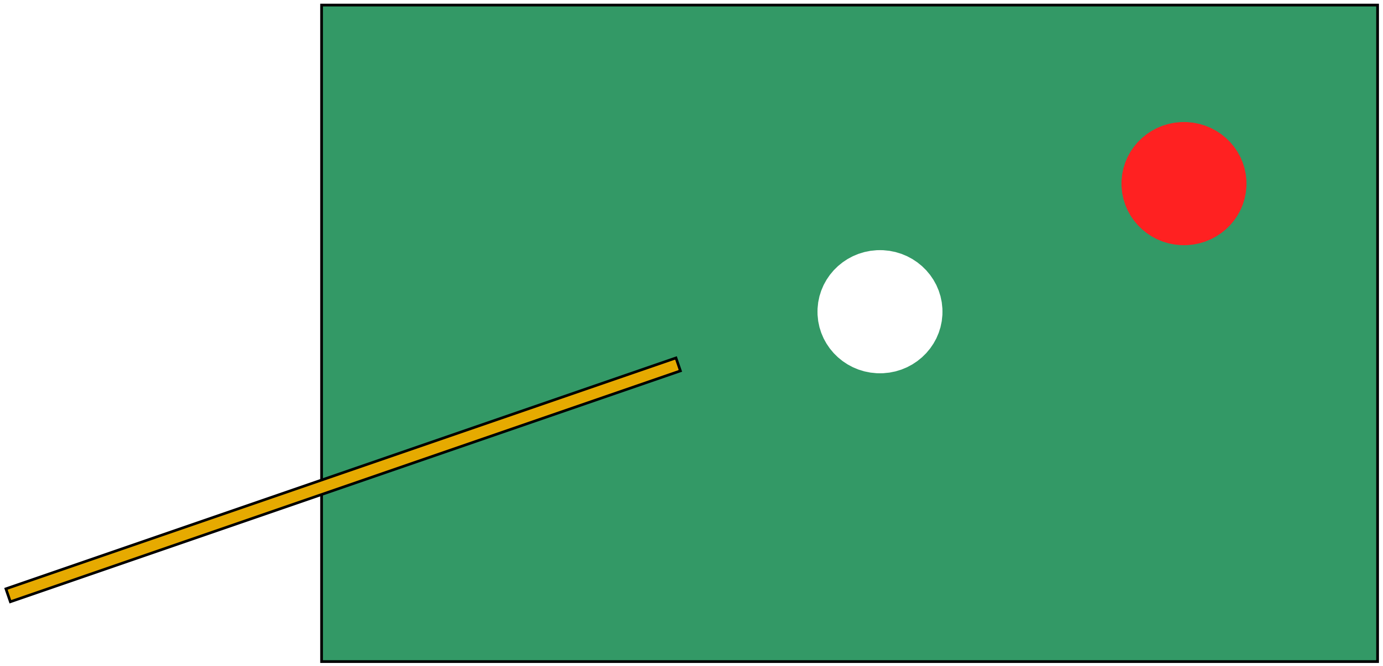
- On each cycle, contents in working memory initiate actions associatively linked in long-term memory
- Actions modify the contents of working memory

Discrimination Principle

- Retrieval is determined by candidates that exist in memory relative to retrieval cues
- Interference created by strongly activated chunks

See also Freudian slips

Perceptual Causality



How soon must the red ball move after cue ball collides with it?

Perceptual Causality

Stimuli that occur within one cycle of the perceptual processor fuse into a single concept

Requirement

- If you want to create the perception of causality, then you need to be sufficiently responsive

Caution

- Two stimuli intended to be distinct can fuse if the first event appears to cause the other

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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

Fitts's Law (1954)

James's use of 's is correct, but others may say Fitts' Law

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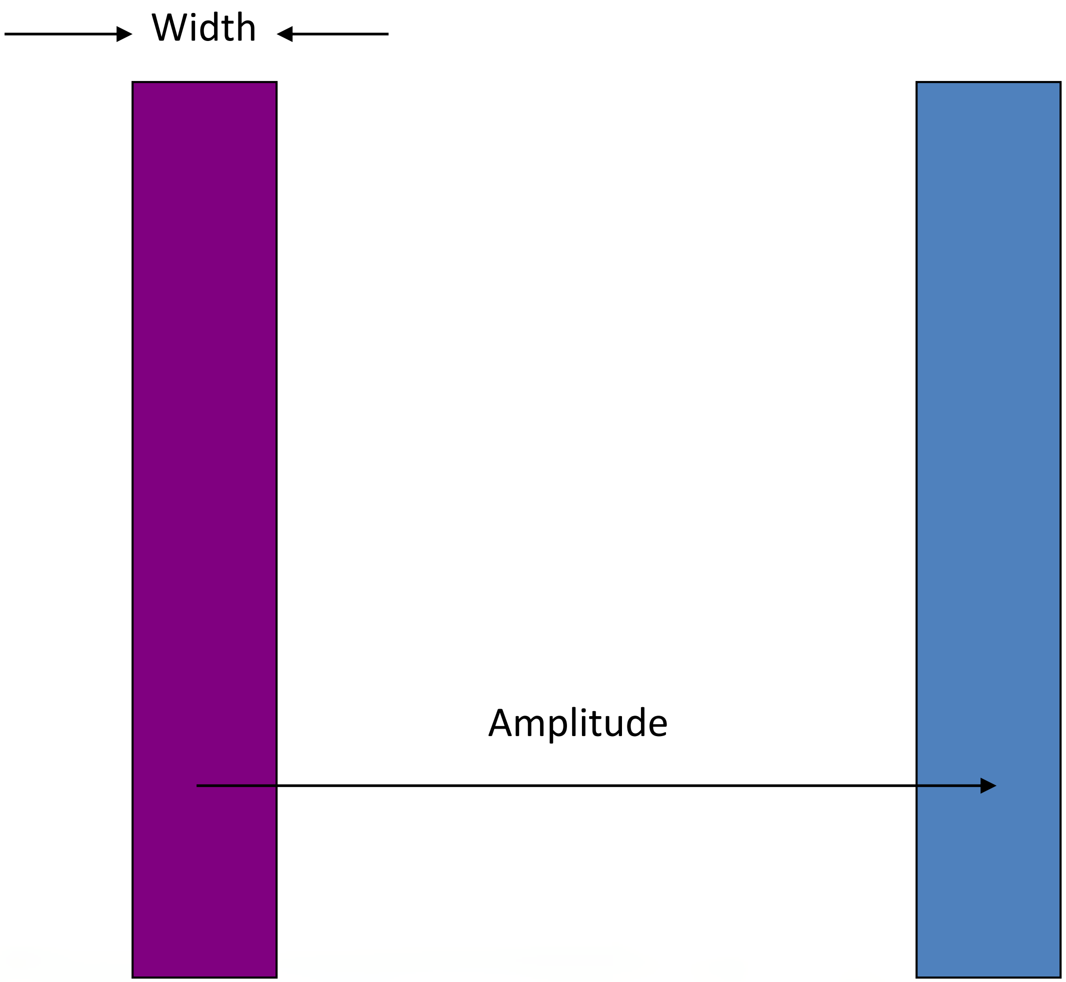
Reciprocal Point-Select Task



Closed Loop versus Open Loop

What is closed loop motion?

What is open loop motion?

Closed Loop versus Open Loop

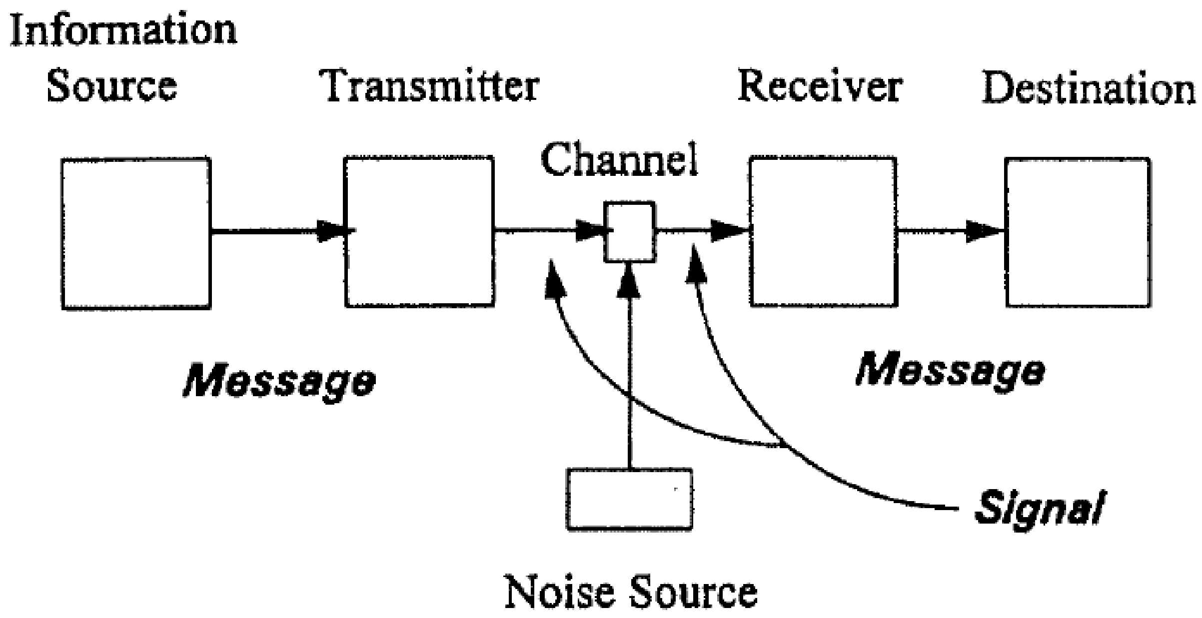
What is closed loop motion?

- Rapid aimed movements with feedback correction
- Fitts's law models this

What is open loop motion?

- Ballistic movements without feedback correction
- Example: Throwing a dart
- See Schmidt's Law (1979)

Model by Analogy



Analogy to Information Transmission
Shannon and Weaver, 1959

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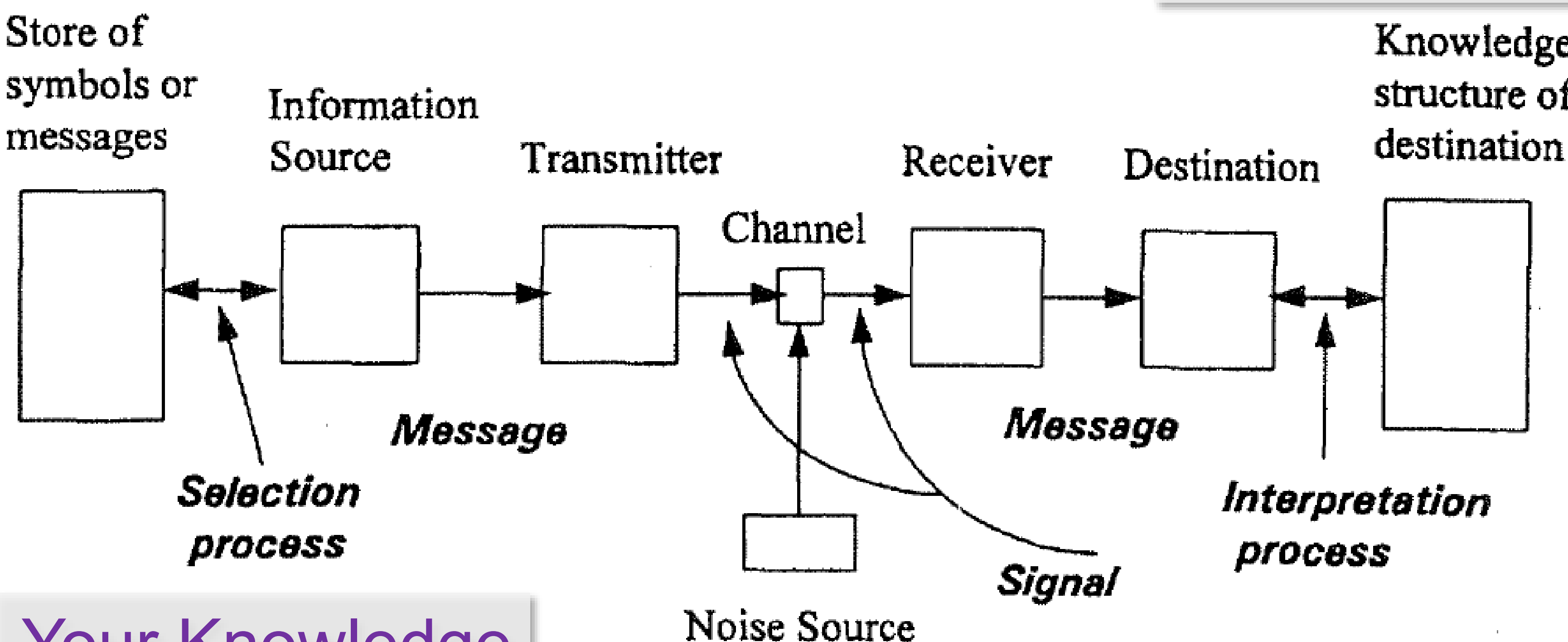
Model by Analogy

The Interface



Your Knowledge

Analogy to Information Transmission
Shannon and Weaver, 1959

Fitts's Law

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

What kind of equation does this remind you of?

Fitts's Law

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

What kind of equation does this remind you of?

$y = mx + b$

$MT = a + bx$, where $x = \log_2(A / W + 1)$

x is called the Index of Difficulty (ID)

As "A" goes up, ID goes up

As "W" goes up, ID goes down

Index of Difficulty (ID)

log2(A / W + 1)

- Fitts's Law claims that the time to acquire a target increases linearly with the log of the ratio of the movement distance (A) to target width (W)

Why is it significant that it is a ratio?

Index of Difficulty (ID)

log2(A / W + 1)

- Fitts's Law claims that the time to acquire a target increases linearly 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

Index of Difficulty (ID)

log2(A / W + 1)

- Fitts's Law claims that the time to acquire a target increases linearly with the log of the ratio of the movement distance (A) to target width (W)

ID units typically in "bits"

- Because of association with information capacity and somewhat arbitrary use of base-2 logarithm

Index of Performance (IP)

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

- b is slope

1/b is called Index of Performance (IP)

- If MT is in seconds, IP is in bits/second

Also called “throughput” or “bandwidth”

- Consistent with analogy of the interaction as an information channel from human to target

A Fitts's Law Experiment

Experimental Design and Analysis

Factorial Design

Experiment with more than one manipulation

Within vs. Between Participant Design

Statistical power versus potential confounds

Carryover Effects and Counterbalanced Designs

A	B	C	D
C	D	A	B
D	C	B	A
B	A	D	C

Latin Square Design

“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

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?

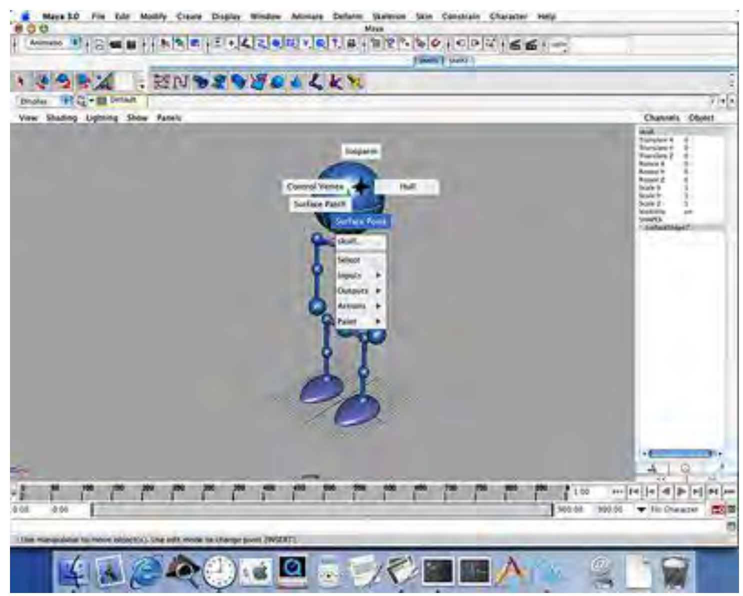
Pop-up Linear Menu

Pop-up Pie Menu

Pie Menus in Use

The Sims

Rainbow 6



Maya

Fitts's Law Examples

Which will be faster on average?

Pop-up Linear Menu

Pop-up Pie Menu

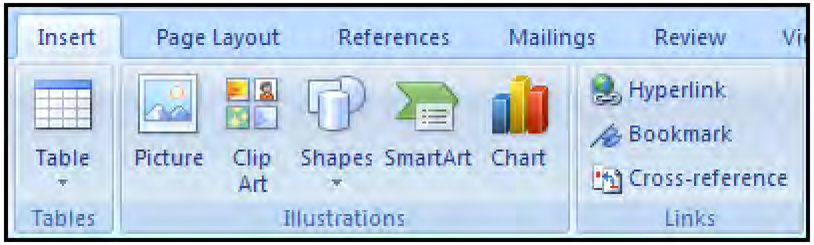
What about adaptive menus?

Fitts's Law in Windowing

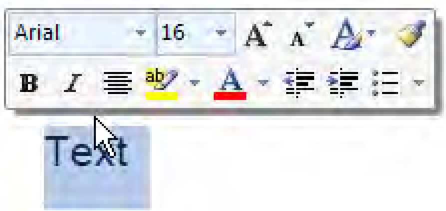
Windows 95: Missed by a pixel
Windows XP: Good to the last drop

Macintosh Menu

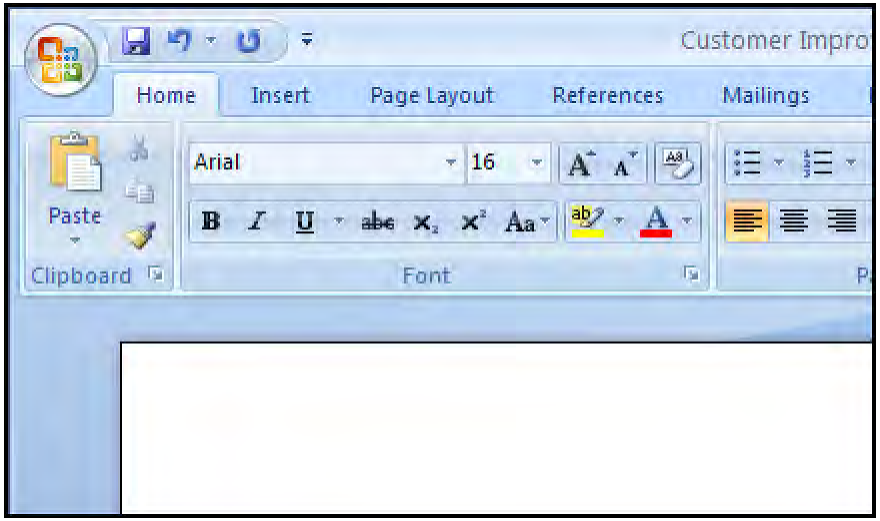
Fitts's Law in MS Office 2007



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

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Bubble Cursor

Grossman and Balakrishnan, 2005

Bubble Cursor with Prefab

Dixon et al, 2012

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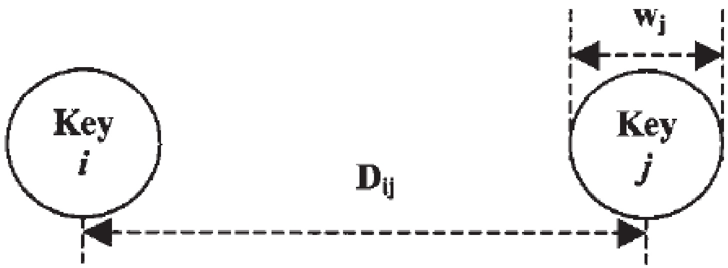
Bubble Cursor with Prefab

Dixon et al, 2012

Fitts's Law and Keyboard Layout



$$MT = a + b \log_2 \left(\frac{D_{ij}}{W_j} + 1 \right),$$

$$t = \sum_{i=1}^{27} \sum_{j=1}^{27} \frac{P_{ij}}{IP} \left[log_2 \left(\frac{D_{ij}}{W_j} + 1 \right) \right],$$

Zhai et. al (2002) pose stylus keyboard layout as an optimization of all key pairs, weighted by language frequency

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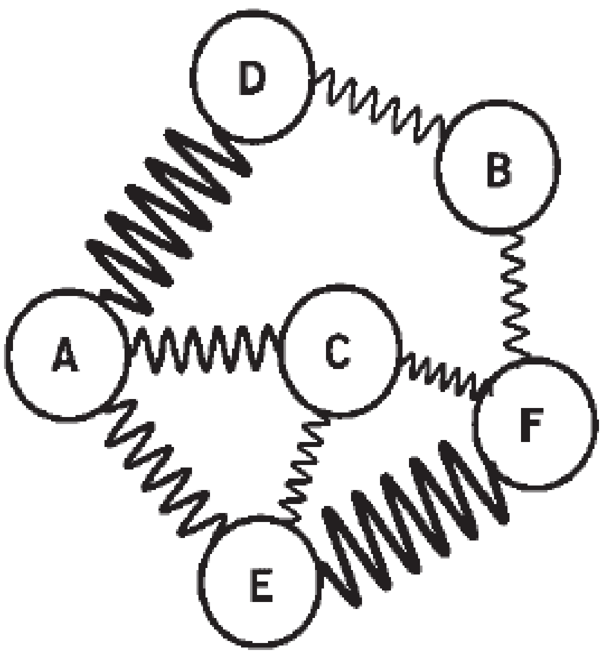
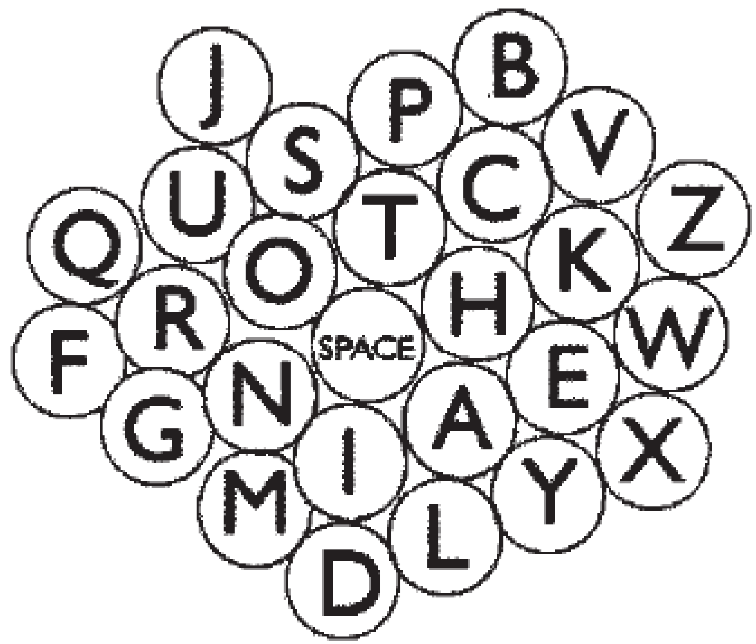
Hooke's Keyboard

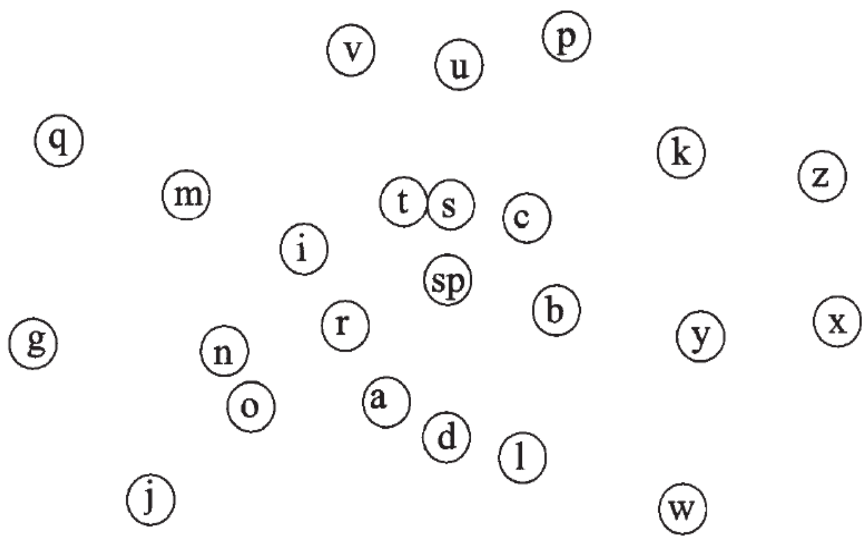
Optimizes a system of springs

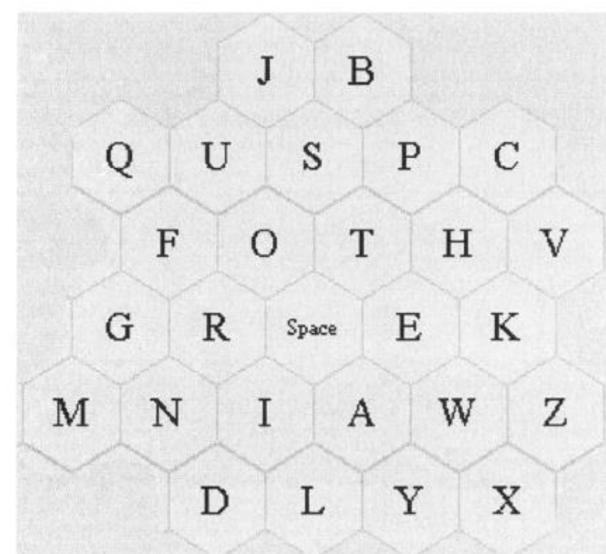




Metropolis Keyboard

Random walk minimizing scoring function

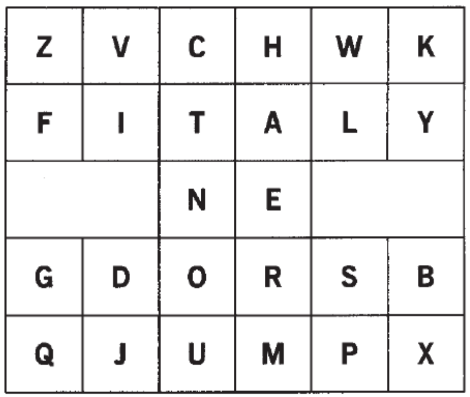




Considering Multiple Space Keys

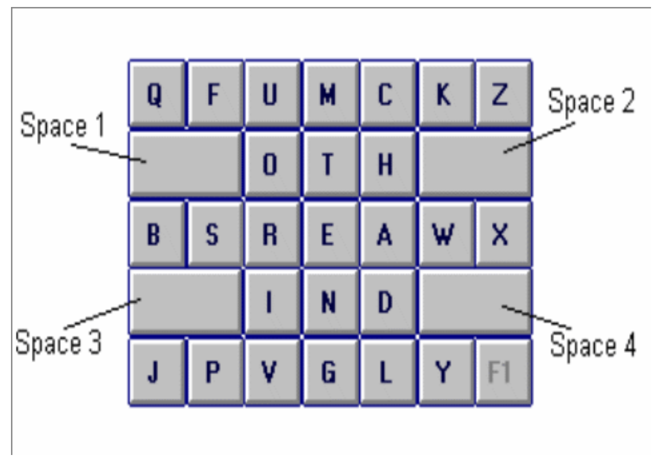
FITALY Keyboard

Textware Solutions



OPTI Keyboard

MacKenzie and Zhang 1999



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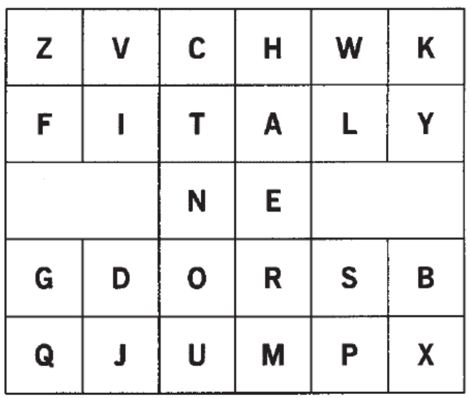

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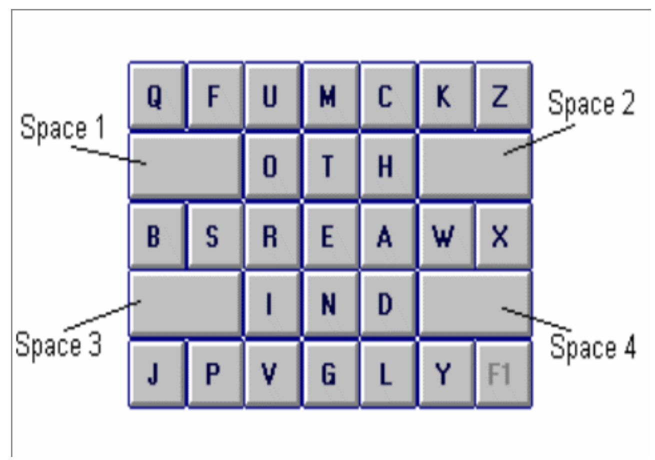
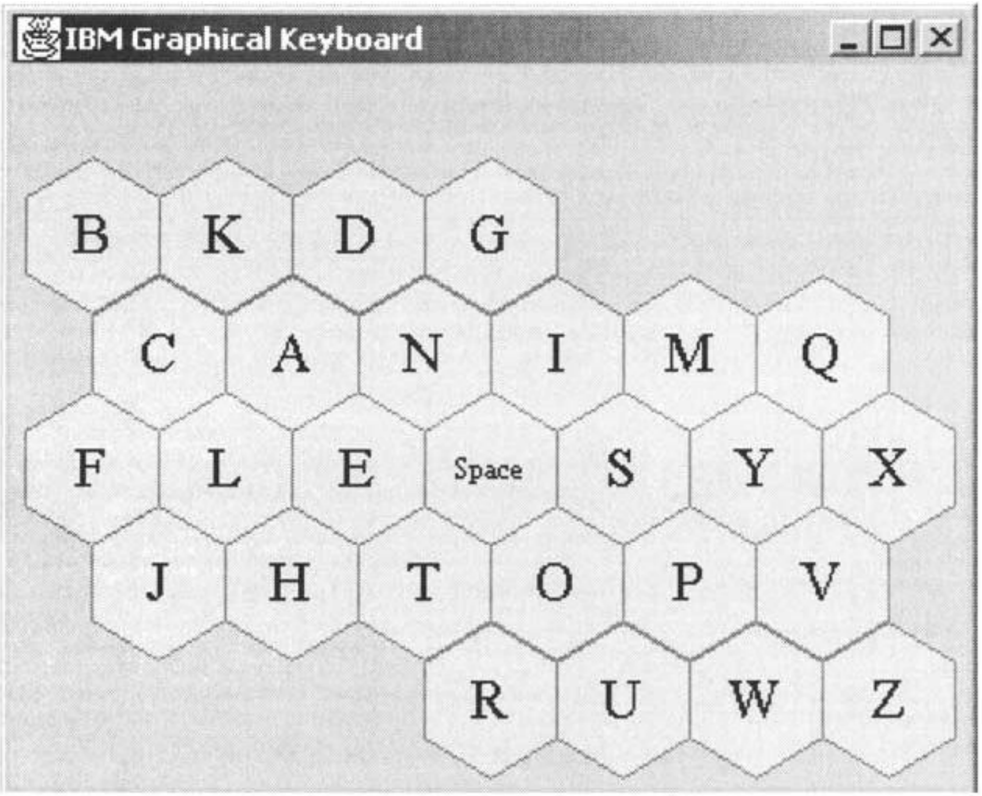


Correct choice of space key becomes important

Requires planning head to be optimal

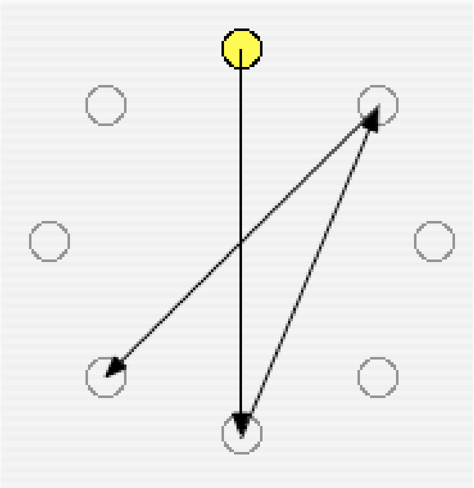
ATOMIK Keyboard

Optimized keyboard, adjusted for early letters in upper left and later letters in lower right

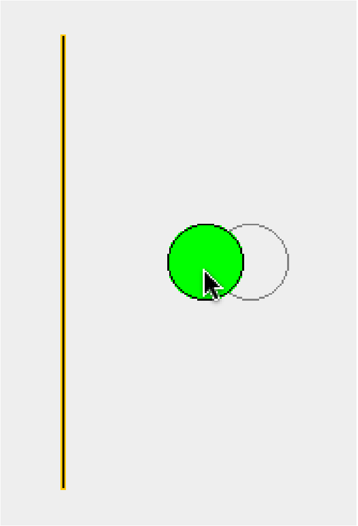


Using Motor Ability in Design

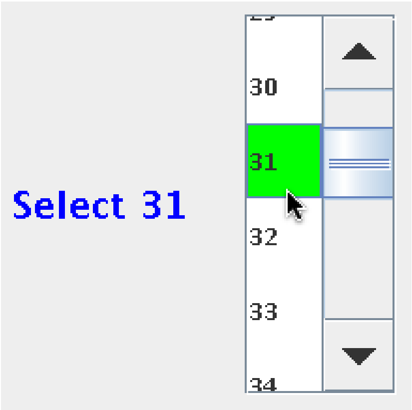
Pointing



Dragging



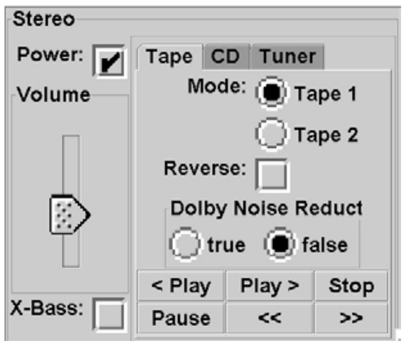
List Selection



Gajos et al 2007

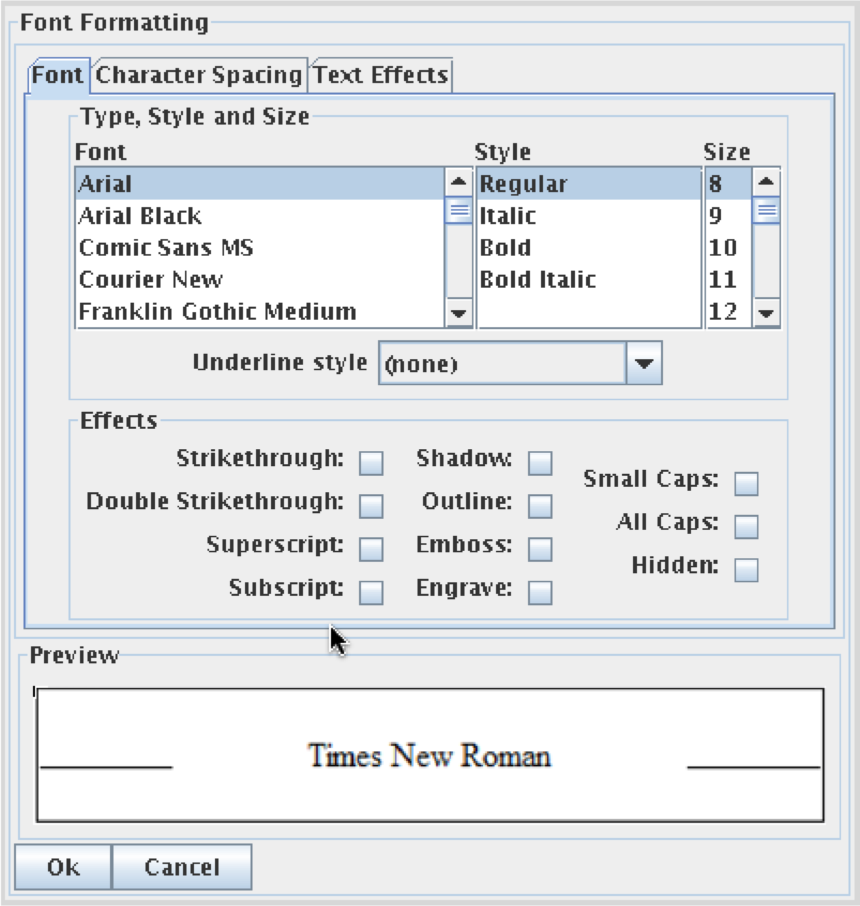
Interface Generation As Optimization

$(

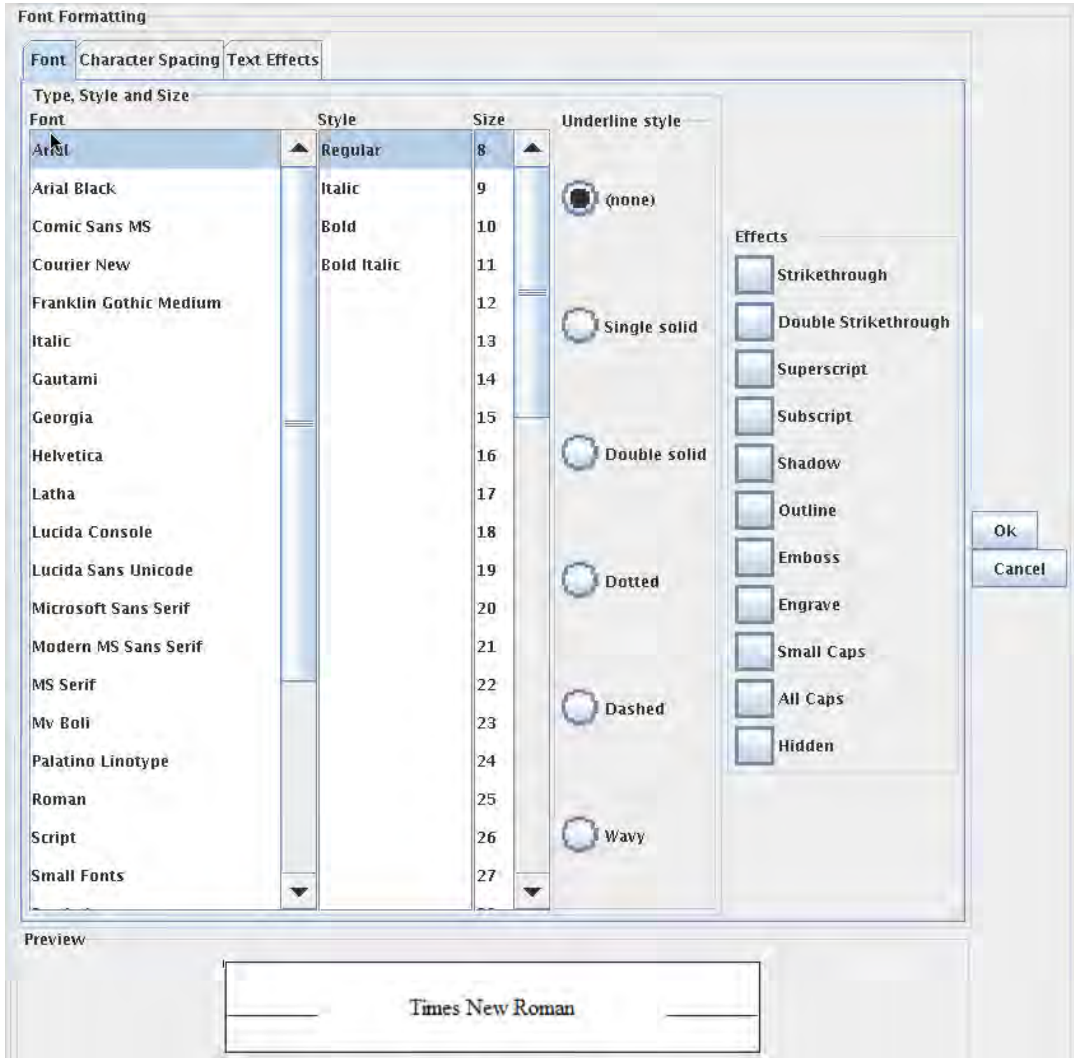


) = Estimated task completion time

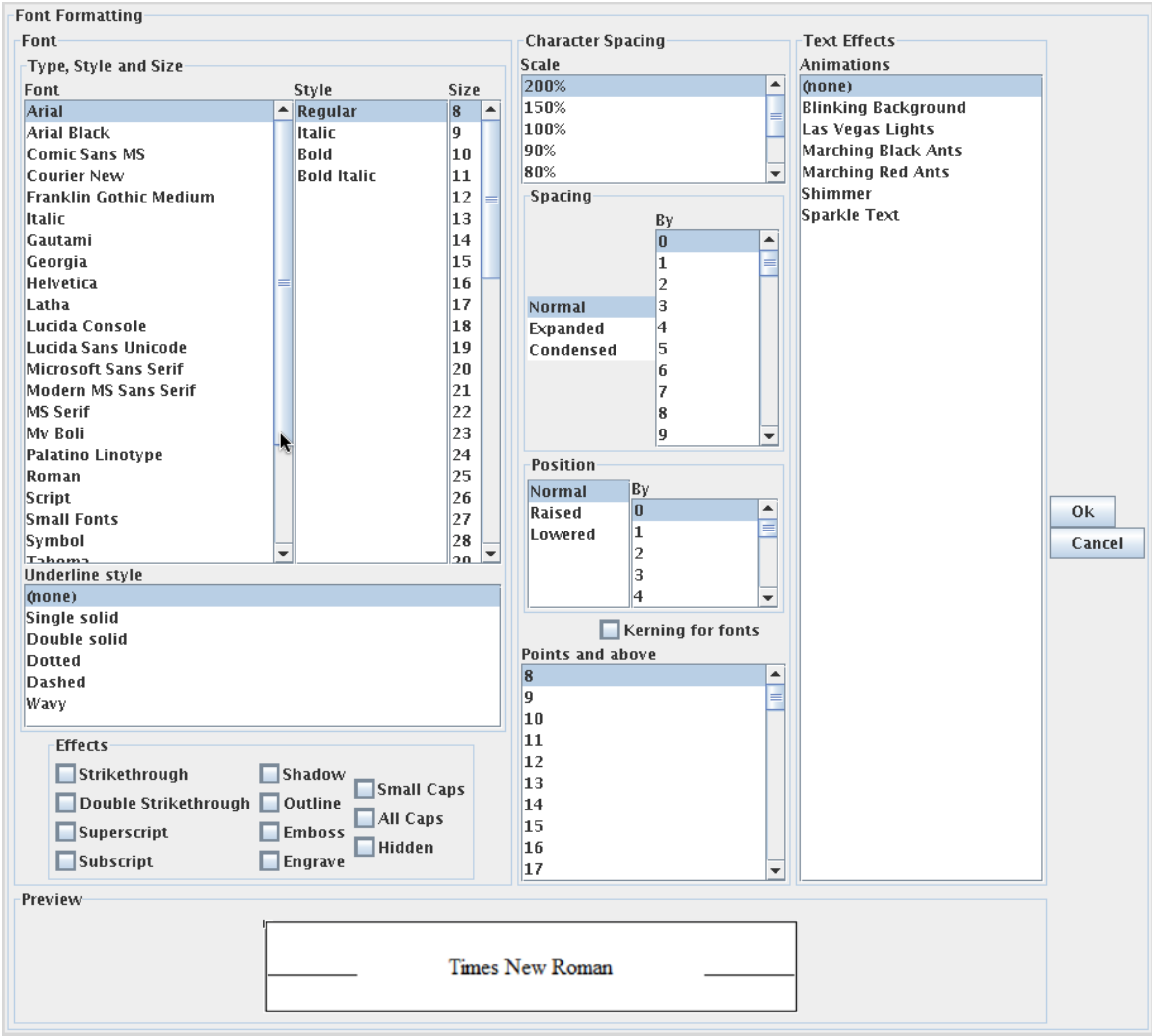
Manufacturer Interface



Person with Cerebral Palsy



Person with Muscular Dystrophy



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

Gravity Fields

- Pointer gets close, gets "sucked in" to target

Sticky Icons

- When within target, pointer "sticks"

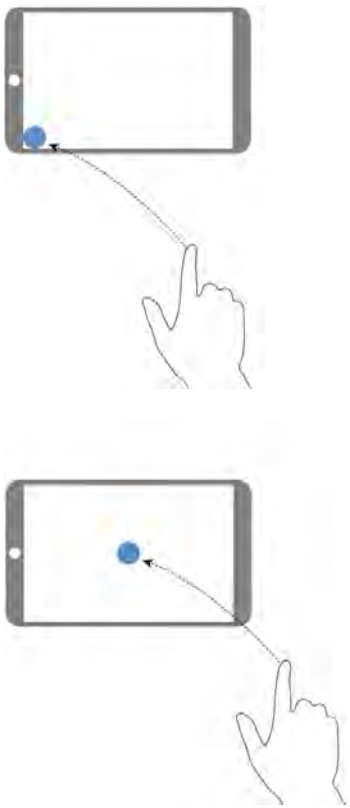
Constrained Motion

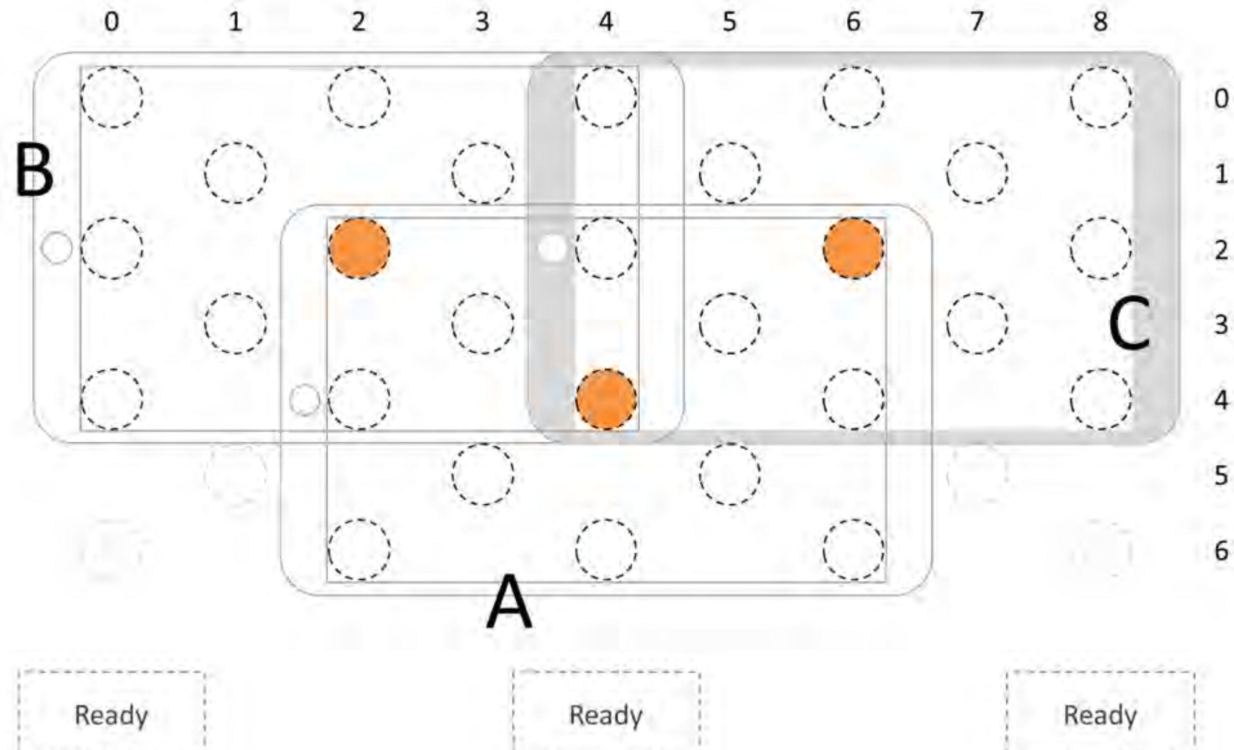
- Snapping, holding Shift to limit degrees of movement

Target Prediction

- Determine likely target, move it nearer or expand it

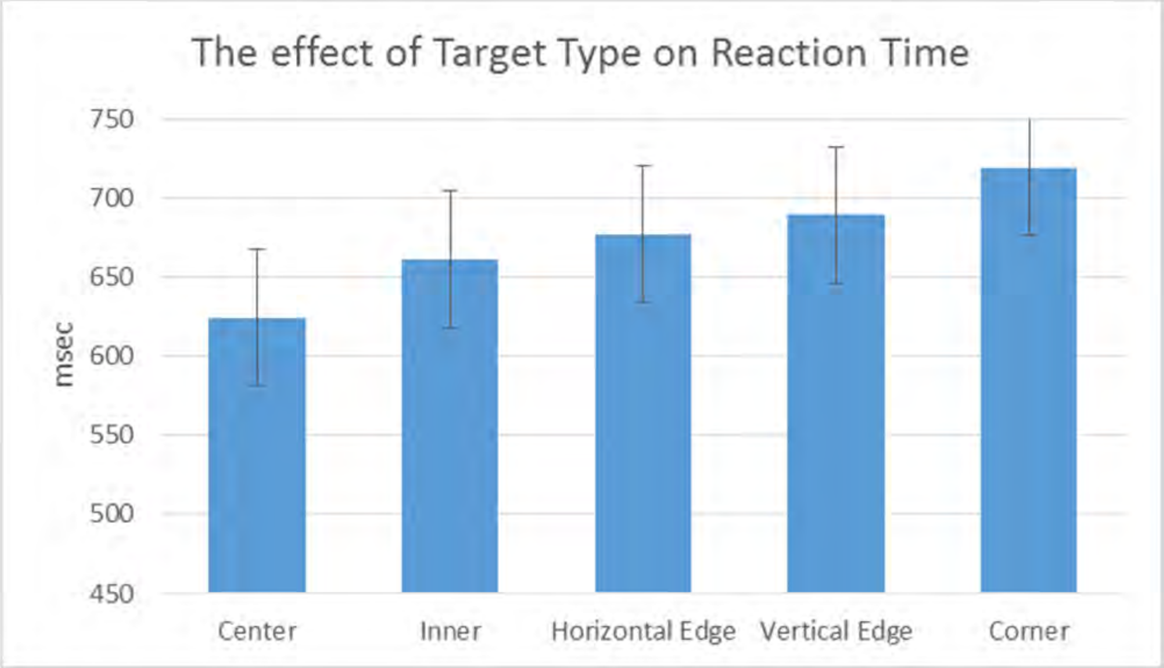
Fitts's Law, Edge Targets, and Touch





Fitts's Law, Edge Targets, and Touch

Avrahami finds edge targets are actually slower with touch devices, at same physical location



Are people border cautious?

Today

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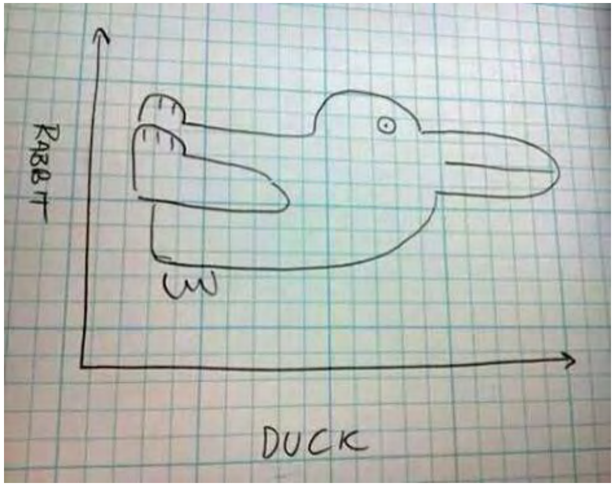
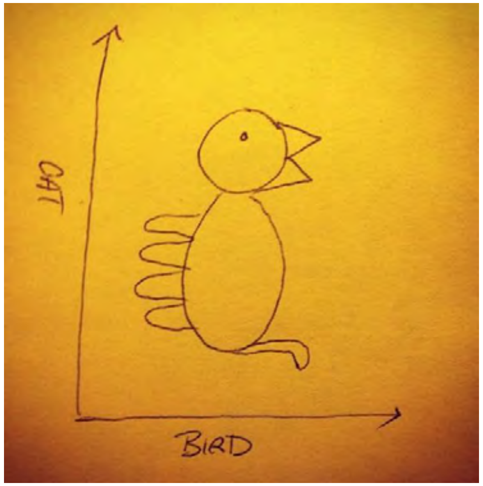
Gestalt Principles	Predict Interpretation

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





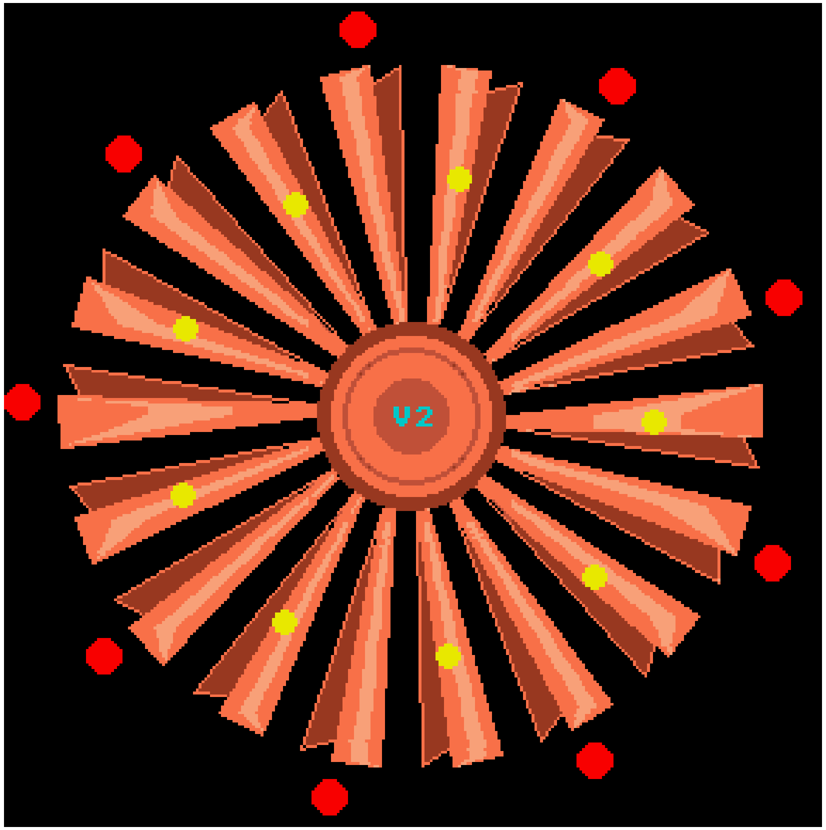
Gestalt Psychology

You can still see the dog…

Gestalt Psychology

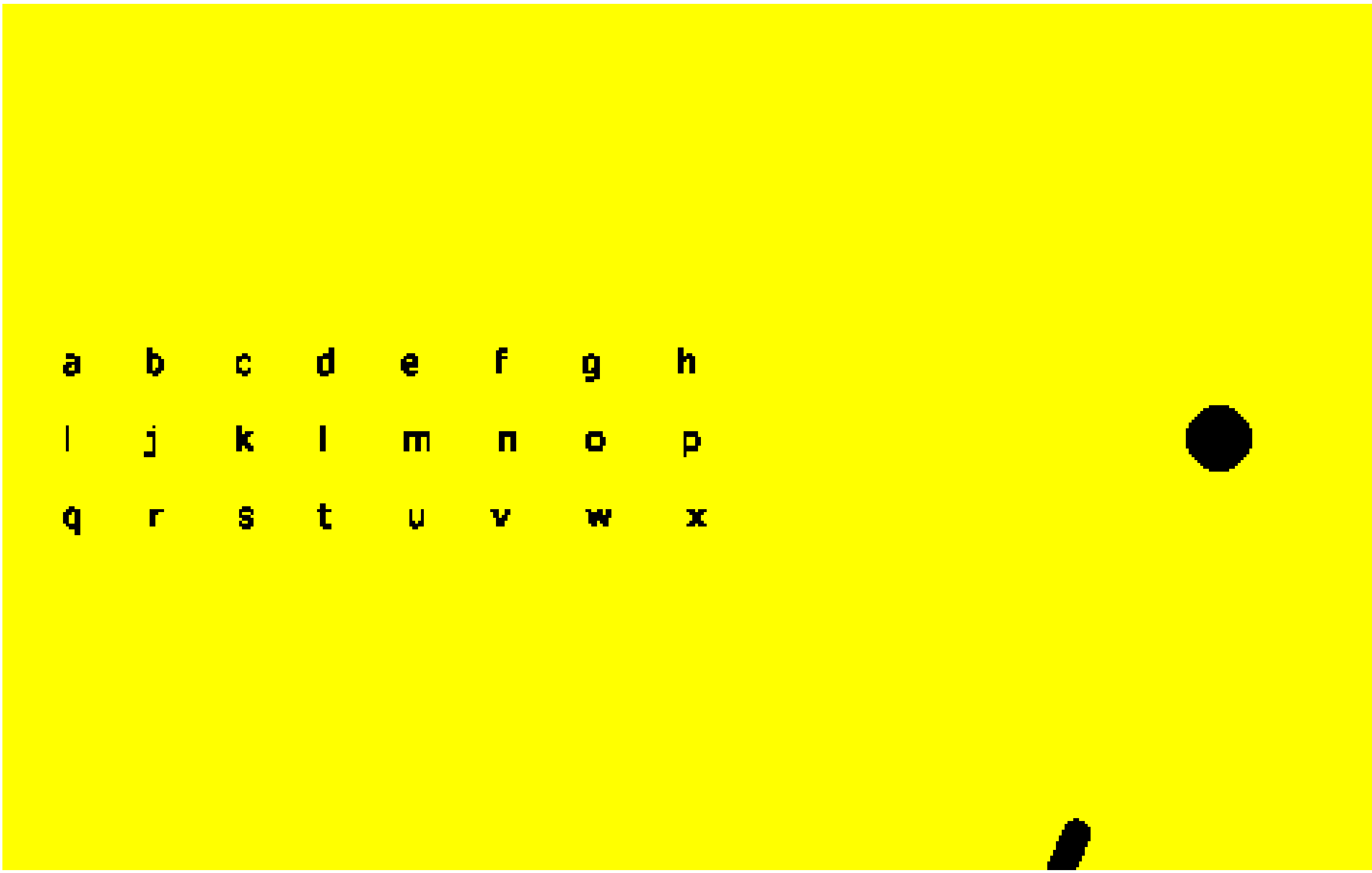
You can still see the dog…

Spinning Wheel



Follow the red dots vs follow the yellow dots

Blind Spot Interpolation



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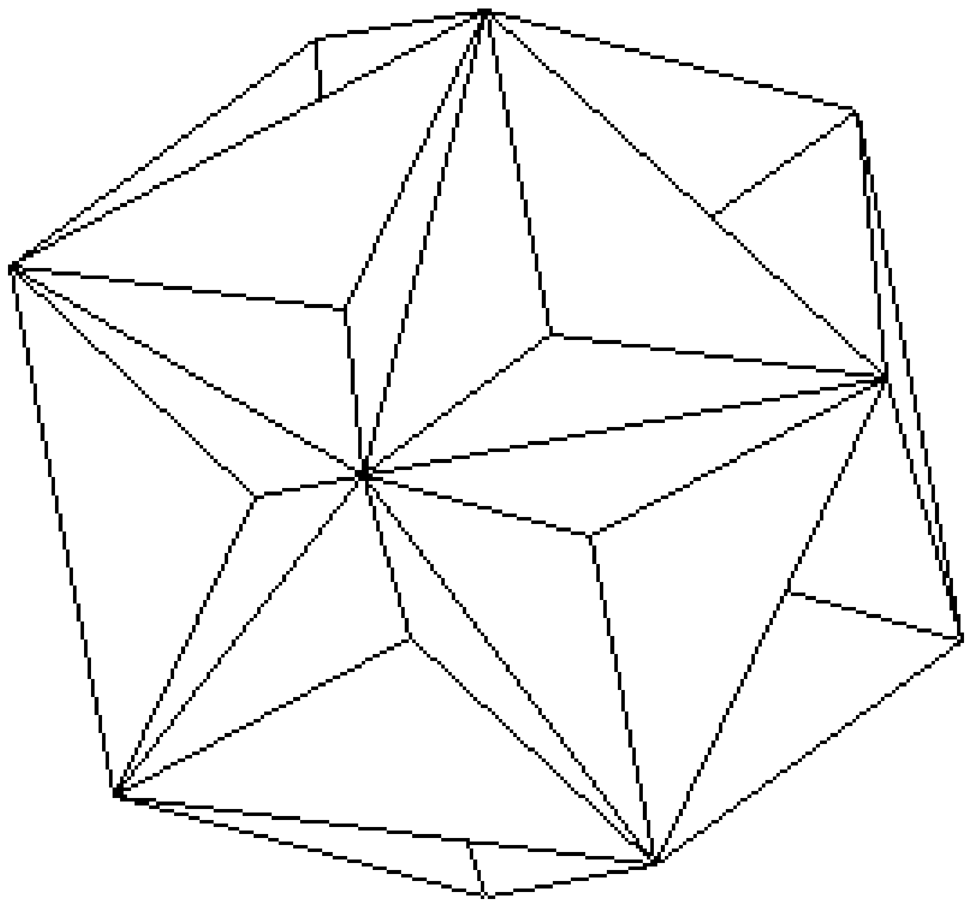
Use right eye, look at letters

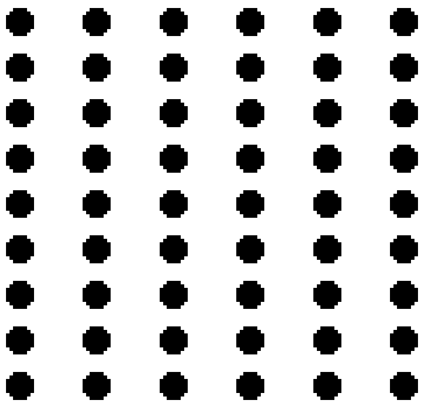
Painful Image Warning

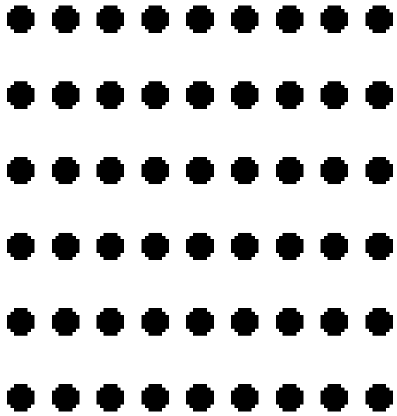
Difficult to Reconcile



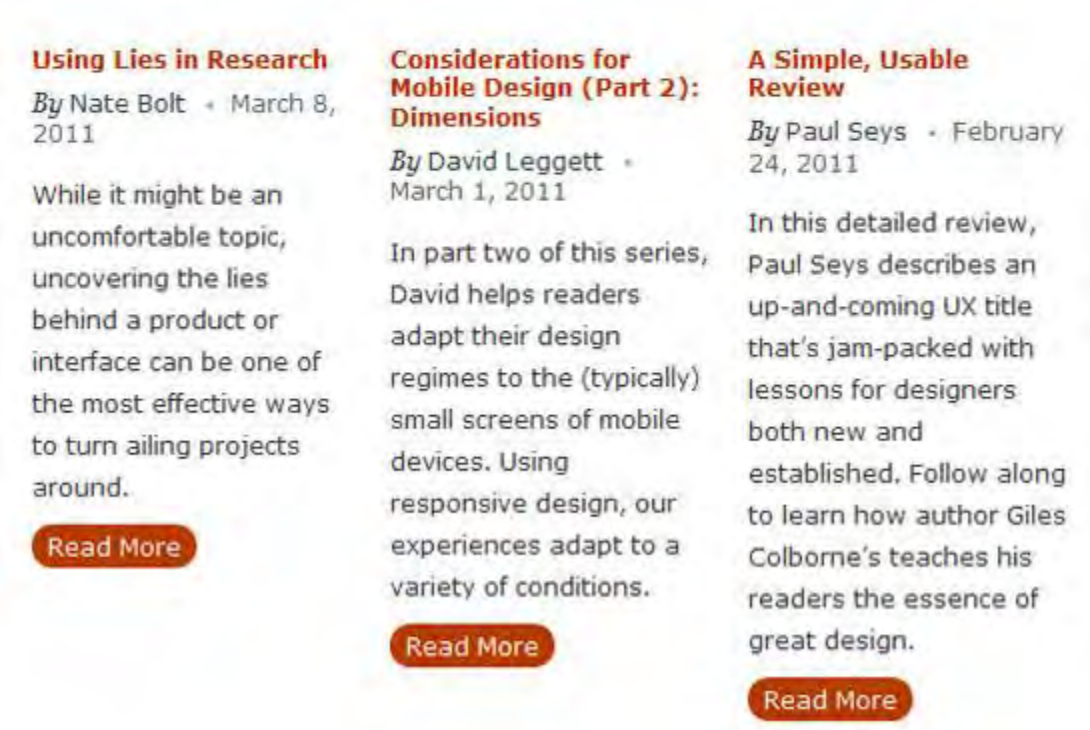
Proximity

Objects close to each other form a group





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.

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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

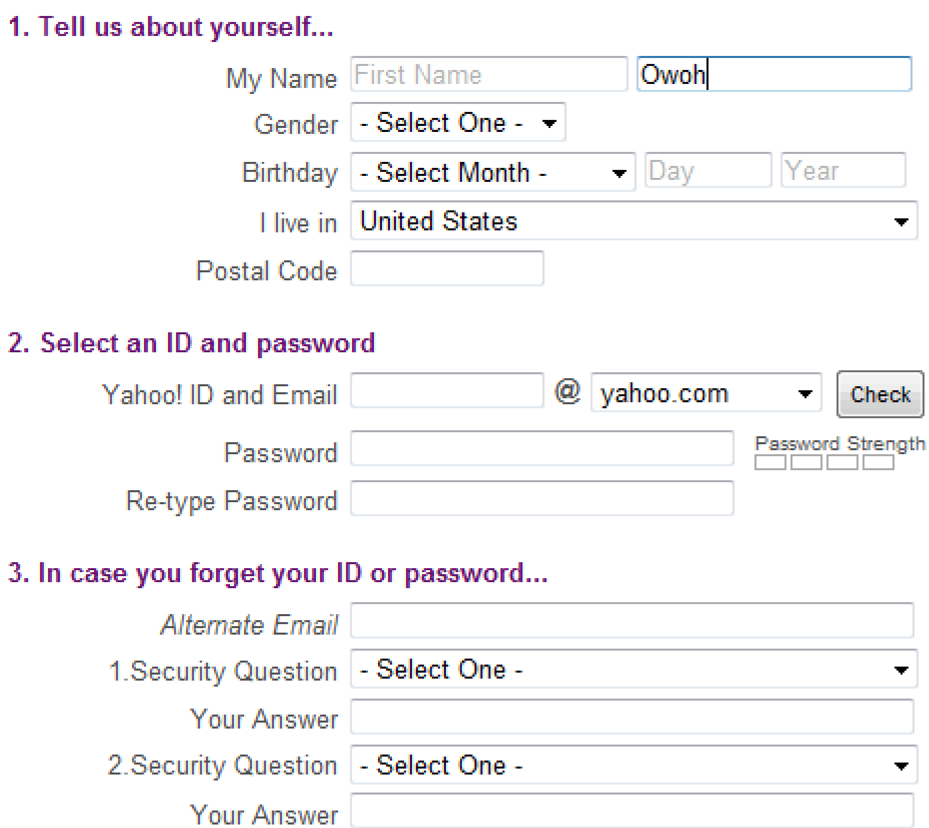
A Simple, Usable Review

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.

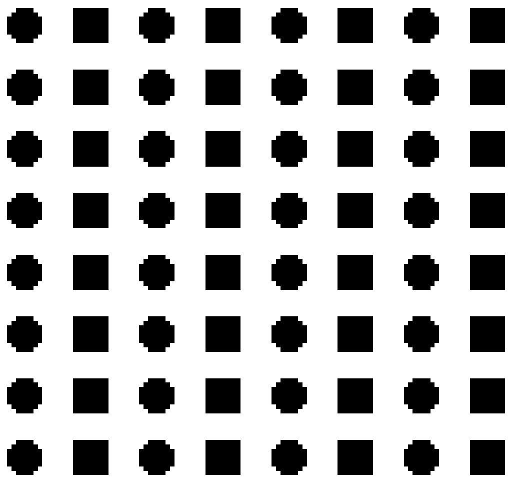
Read More

Proximity

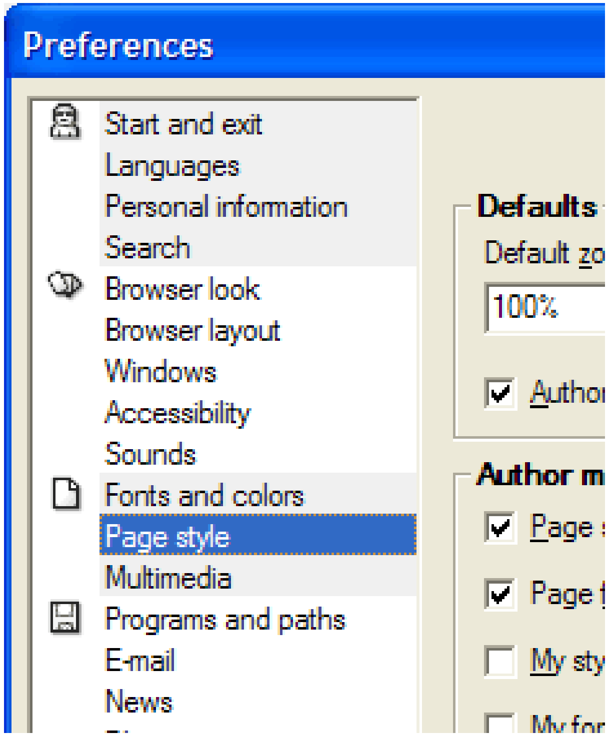

1. Tell us about yourself...
My Name
First Name
Owoh
Gender
- Select One -
Birthday
- Select Month -
Day
Year
I live in
United States
Postal Code
2. Select an ID and password
Yahoo! ID and Email
@
yahoo.com
Check
Password
Password Strength
Re-type Password
3. In case you forget your ID or password...
Alternate Email
1.Security Question
- Select One -
Your Answer
2.Security Question
- Select One -
Your Answer

Similarity

Objects that are similar form a group



Similarity


Preferences
Start and exit
Languages
Personal information
Search
Browser look
Browser layout
Windows
Accessibility
Sounds
Fonts and colors
Page style
Multimedia
Programs and paths
E-mail
News
Defaults
Default zo
100%
Author
Author m
Page
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My sty

Proximity and Similarity

Proximity and Similarity

After discovering that one of these accesses a menu, people will expect they all access a menu. They are the same.

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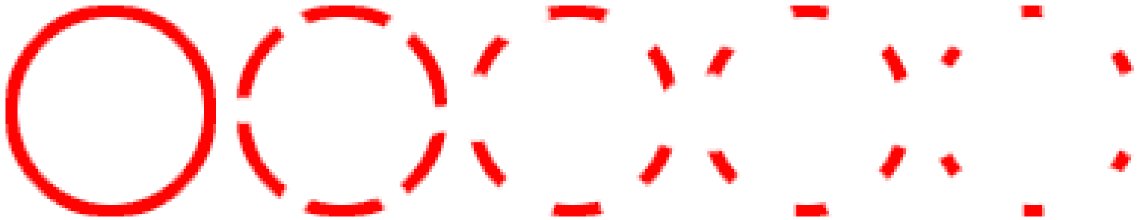
Closure

Even incomplete objects are perceived as whole

- Increases regularity of stimuli



Closure

The Sims

Rainbow 6

Symmetry

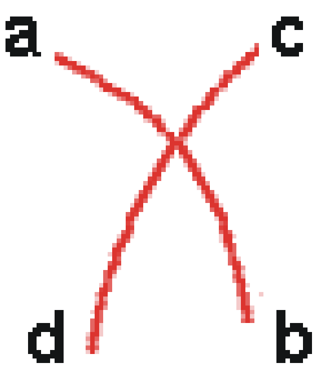
Objects are perceived as symmetrical and forming around a center point

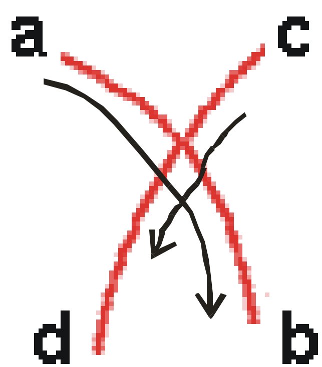
If you fight symmetry, be sure you have a reason

Continuity

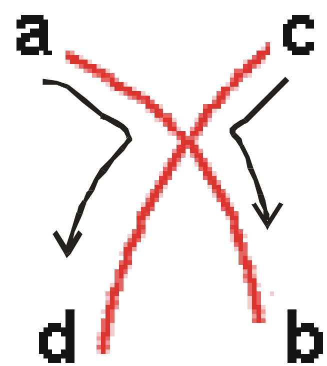
Objects are perceived as grouped when they align

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





what most people see



not this

Continuity

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Models from Different Perspectives

Some example models of human performance

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

CSE 440: Introduction to HCI

User Interface Design, Prototyping, and Evaluation

Lecture 07:
Human Performance

James Fogarty
Alex Fiannaca
Lauren Milne
Saba Kawas
Kelsey Munsell

Tuesday/Thursday
12:00 to 1:20

design:
use:
build:

University of Washington