

Perception & Design

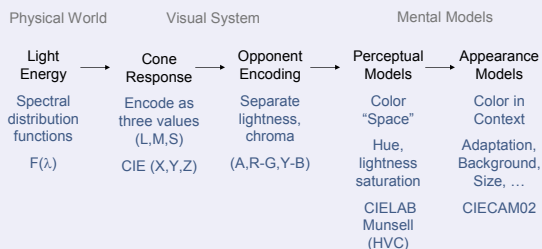
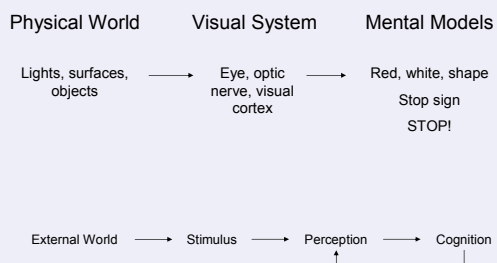
Show Me the Numbers (ch 7&9)
The Visual Display of Quantitative Information (ch 2)

Sit near the front: some demos are small

Today's lecture

- Color (briefly)
- Preattentive Processing
- Gestalt Principles
- Bertin's semiotics
- Memory
- Design for Communication
- Discussion
 - Data Gathering
 - Vis Critiques

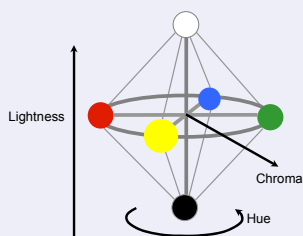
Next Lecture: Bring your Tufte book



FYI: Don't try to memorize

"Perceptual" Color Spaces

- Hue
- Color's "name"
 - Angular scale
- Lightness (brightness)
- Linear scale
 - Black to white
- Chroma (saturation)
- Intensity or purity
 - Radial scale



Munsell Atlas



Courtesy Gretag-Macbeth

Art & Design

Hue (color wheel)

- Opposites complement (contrast)
- Adjacent are analogous
- Many different color wheels*

*See www.handprint.com for examples

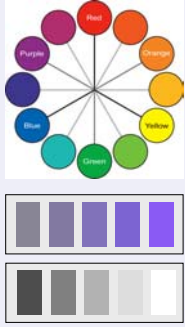
Chroma (saturation)

- Intensity or purity
- Distance from gray

Value (lightness)

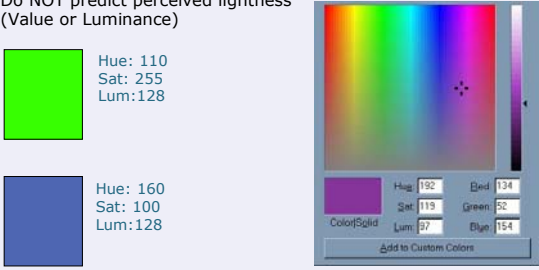
- Dark to light
- Applies to all colors, not just gray

Wucius Wong, Principles of Color Design



RGB: Pseudo-Perceptual Models

HLS, HSV (HSB)
NOT perceptually accurate
Do NOT predict perceived lightness (Value or Luminance)



Hue: 110
Sat: 255
Lum: 128

Hue: 160
Sat: 100
Lum: 128

Color Names

Basic names (Berlin & Kay)

- Linguistic study of names
- Similar names
- Similar evolution
- Many different languages
- Somewhat controversial

Perceptual primaries

- black
- white
- gray
- red
- green
- blue
- yellow
- orange
- purple
- brown
- pink

Preattentive Effects

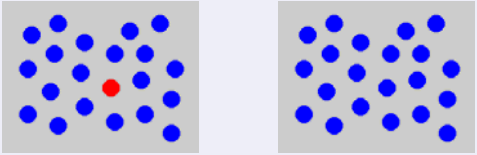
A limited set of visual properties processed preattentively (without need for focusing attention)

Much studied for visualization

- What can be perceived immediately
- What properties are good discriminators
- What can mislead viewers

From Marti Hearst, UC Berkeley

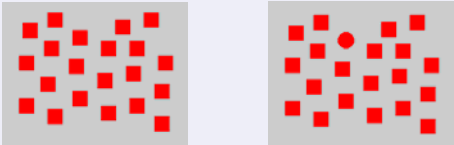
Example: Color Selection



Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in color.

From Marti Hearst, UC Berkeley

Example: Shape Selection



Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in form (curvature)

From Marti Hearst, UC Berkeley

Pre-attentive Processing

< 200 - 250ms qualifies as pre-attentive

- eye movements take at least 200ms
- yet certain processing can be done very quickly, implying low-level processing in parallel

If a decision takes a fixed amount of time regardless of the number of distractors, it is considered to be preattentive.

From Marti Hearst, UC Berkeley

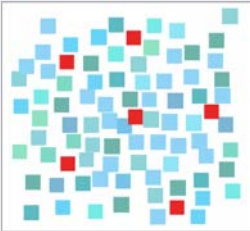
Demonstration

Count the 7's

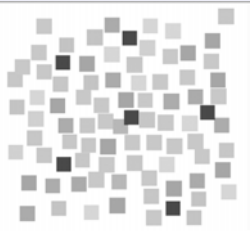
13579345978274055 24937916478254137 23876597277103866 19874367259047362 95637283649105676 32543787954836754 56840378465485690	13579345978274055 24937916478254137 23876597277103866 19874367259047362 95637283649105676 32543787954836754 56840378465785690	13579345978274055 24937916478254137 23876597277103866 19874367259047362 95637283649105676 32543787954836754 56840378465785690
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Time proportional to the number of digits Time proportional to the number of 7's Both 3's and 7's seen preattentively

Contrast Creates Pop-out



Hue and lightness



Lightness only

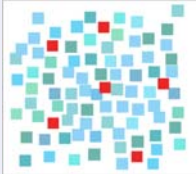
Pop-out vs. Distinguishable

Pop-out

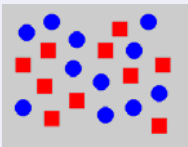
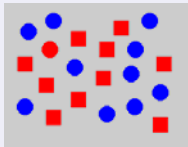
- Typically, 5-6 distinct values simultaneously
- Up to 9 under controlled conditions

Distinguishable

- 20 easily for reasonable sized stimuli
- More if in a controlled context
- Usually need a legend



Conjunction of Features

Viewer *cannot* rapidly and accurately determine whether the target (red circle) is present or absent when target has two or more features, each of which are present in the distractors. Viewer must search sequentially.

From Marti Hearst, UC Berkeley

Demonstration

<http://www.csc.ncsu.edu/faculty/healey/PP/>

Chris Healey, North Carolina State University

Preattentive Visual Properties (Healey 97)

length	Triesman & Gormican [1988]
width	Julesz [1985]
size	Triesman & Gelade [1980]
curvature	Triesman & Gormican [1988]
number	Julesz [1985]; Trick & Pylyshyn [1994]
terminators	Julesz & Bergen [1983]
intersection	Julesz & Bergen [1983]
closure	Enns [1986]; Triesman & Souther [1985]
colour (hue)	Nagy & Sanchez [1990, 1992]; D'Zmura [1991] Kawai et al. [1995]; Bauer et al. [1996]
intensity	Beck et al. [1983]; Triesman & Gormican [1988]
flicker	Julesz [1971]
direction of motion	Nakayama & Silverman [1986]; Driver & McLeod [1992]
binocular lustre	Wolfe & Franzel [1988]
stereoscopic depth	Nakayama & Silverman [1986]
3-D depth cues	Enns [1990]
lighting direction	Enns [1990]

Depth of Field

Sharp foreground, blurred background, preattentive focus



Photography



Semantic Depth of Field

<http://kosara.net/research/index.html>

Slide adapted from Robert Kosara

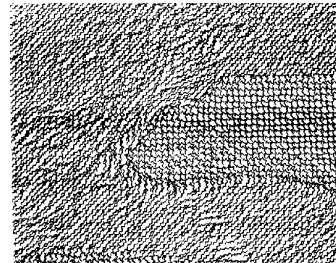
Emergence

Holistic perception of image



Slide adapted from Robert Kosara

Use Grouping of Well-Chosen Shapes for Displaying Multivariate Data



From Marti Hearst, UC Berkeley

Gestalt Principles

Idea: forms or patterns transcend the stimuli used to create them.

- Why do patterns emerge?
- Under what circumstances?

Principles of pattern recognition

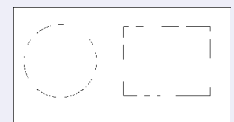
- "Gestalt" German for "pattern" or "form, configuration"
- Original proposed mechanisms turned out to be wrong
- Rules themselves are still useful

Slide adapted from Tamara Munzner

Gestalt Laws

Relationship between objects

- Closure
- Proximity
- Similarity
- Continuity
- Connectedness
- Symmetry
- and more ...



Slide adapted from Robert Kosara

Similarity

Slide adapted from Tamara Munzner

Continuity

smooth not abrupt change
overrules proximity

Slide adapted from Tamara Munzner

Connectedness

can overrule size, shape

Slide adapted from Tamara Munzner

Symmetry

emphasizes relationships

Slide adapted from Tamara Munzner

Figure and Ground

Multistable, Illusion

False contours (or 1+1 = 3)

Slide adapted from Robert Kosara

Unexpected Effects

Influence on Visualization

Why we care

- Exploit strengths, avoid weaknesses
- Optimize, not interfere

Design criteria

- Effectiveness
- Expressiveness
- No false messages

Design criteria: Effectiveness

Faster to interpret
More distinctions
Fewer errors

This?

Or this?

Design criteria: Expressiveness

Show all the data
Show only the data
Show only valid relationships

Ordering?

Drama
Mystery
Comedy
Music
Action
War
SF
Western
Horror

Bertin's Graphical Vocabulary

Position

Marks

Points:

Lines:

Areas:

Retinal variables

Color:

Size:

Shape:

Grayscale:

Orientation:

Texture:

Bertin's Expressiveness Rankings

Association: The marks can be perceived as similar

Selection: The marks are perceived as different, forming families

Order: The marks are perceived as ordered

Quantity: The marks are perceived as proportional to each other

Size	
Value	
Texture	
Colour	
Orientation	
Shape	

adapted from Spence 2006

Rankings: Encoding quantitative data

Most accurate

Least accurate

Position:

Length:

Angle/Slope:

Area:

Volume:

Colour/Density:

Cleveland & McGill 1984, adapted from Spence 2006

jdm1 Retinal is an adjective. Add "variables", "information"?

Color column is a different font than Gray column

Gray => Grayscale if it fits

Jock Mackinlay, 1/10/2006


Rankings: Data relationships


	Spatial			Object		
	Q	O	N	Q	O	N
Extent	Position	●	●	●	○	○
	Size	●	●	●	○	○
Distinguish	Orientation	◐	◑	●	○	○
	Color	◐	◑	●	○	○
	Texture	◐	◑	●	○	○
				Shape	○	○


Q: Quantitative
O: Ordinal
N: Nominal

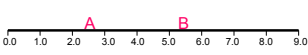
● Good ◐ Fair ○ Poor

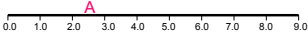
Space and Relationships

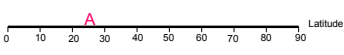
Nominal Presence: 

Nominal Grid: 


Ordinal Grid: 


Quantitative Scale: 


Spatial Coordinates: 


Geographical Scale: 


Composition of space


1D axis: 


2D axis: 

3D axis: 

Single axis: 

Double axis: 

Triple axis: 

Mark composition: 

Application

Jock Mackinlay (1986), Automating the design of graphical presentations of relational information

Chris Stolte (2002), Polaris: A System for Query, Analysis, and Visualization of Multidimensional Relational Databases

VizQL: a language for query, analysis and visualization

Tableau Software

[Jump ahead](#)

Examples

From Jock's Thesis

Automobile Relations

Price: cars → [12000, 60000]

Mileage: cars → [10, 40]

Weight: cars → [1500, 5000]

Repair: cars → [Great, Good, OK, Poor, Bad]

Nation: cars → [USA, Germany, France, ...]

Cars = {Accord, Audi, BMW, ...}

Key Idea

How should data of various types be encoded into visual features?

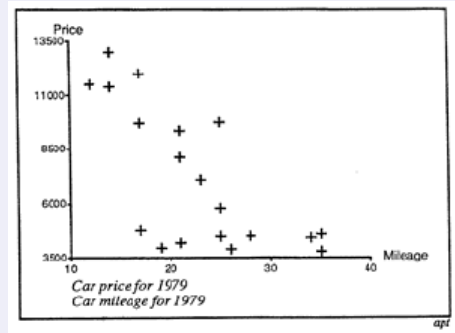
Mapping quantities into shapes does not work!

- 10 100
- ■

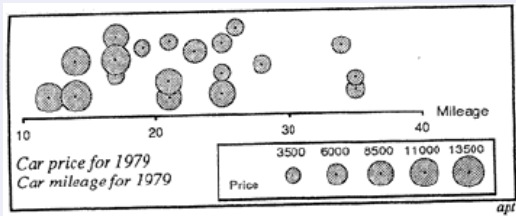
But using extent works well



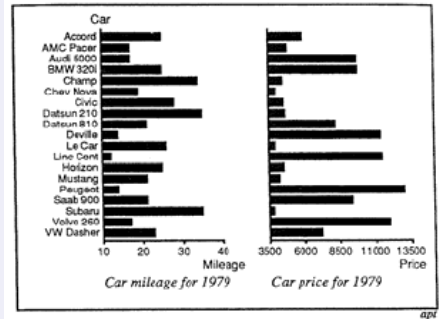
Mileage vs Price



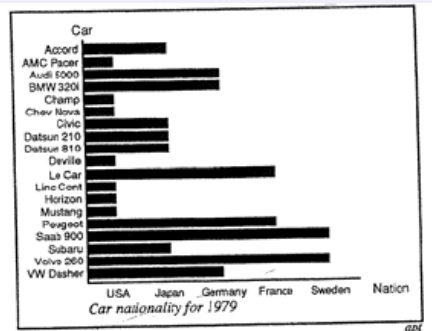
An Alternate View of Mileage and Price



Make, Mileage, Price



Does This Work?



Memory

Iconic memory

- Preattentive
- "Snapshot"

Working memory

- Short-term
- Limited (5-7 "chunks")
- Different forms

Long-term memory

Colin Ware, *Information Visualization: Perception for Design*

Design for Communication

Organize your data

- Group, prioritize, sequence
- Define your message(s)

Show only the data

- Data/ink ratio
- Focus your message

Highlight what's important

- Visual attributes
- Analogy and contrast
- Prioritize your message

Layout for readability

Few and Tufte

Few: General graph design

- Accurately map quantity
 - Consistent scales
 - Start at zeros
- Avoid 3D display

Tufte: Graphical Integrity

- Present value relationships accurately
 - Representation of numbers precisely matches data
 - Avoid area and volume encodings
 - Adjust currency values for inflation or other correlated changes (such as population changes)
- Label carefully and clearly
- Present data in context

Data Gathering

<http://courses.washington.edu/info424/DataSources.htm>

Vis Critiques

Look at the images, discuss

- What type of graph is it?
- Why is it good?
- How many dimensions?
- Data-Ink ratio
- How could it be improved?

Relationship to grade

- Don't worry
- Grade reflects effort
- Context of second week

[VisCritiques Overview](#)

Next class

Tufte, *Envisioning Information*, Escaping Flatland
 Few ch 11, Design Solutions for Multiple Variables
 Project Questions
 Hand out Few test

Bring your Tufte book