Perception

Maneesh Agrawala

CS 448B: Visualization
Fall 2020

1

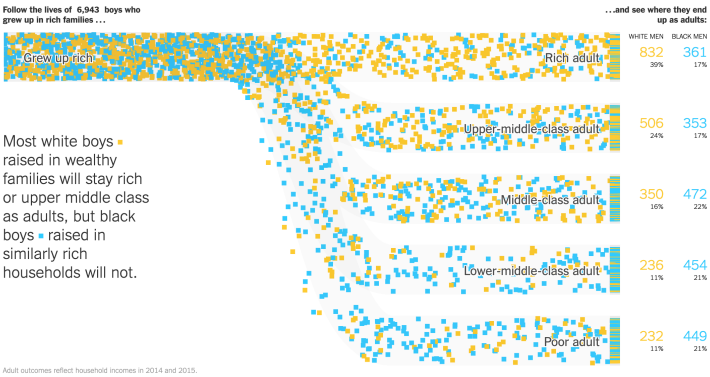
SHARE

Extensive Data Shows Punishing Reach of Racism for Black Boys

By **EMILY BADGER, CLAIRE CAIN MILLER, ADAM PEARCE** and **KEVIN QUEALY** MARCH 19, 2018

Black boys raised in America, even in the wealthiest families and living in some of the most well-to-do neighborhoods, still earn less in adulthood than white boys with similar backgrounds, according to a sweeping new study that traced the lives of millions of children.

White boys who grow up rich are likely to remain that way. Black boys raised at the top, however, are more likely to become poor than to stay wealthy in their own adult households.



2

Perception

3

Mackinlay's effectiveness criteria

Effectiveness

A visualization is more effective than another visualization if the information conveyed by one visualization is more readily *perceived* than the information in the other visualization.

4

Mackinlay's ranking of encodings

QUANTITATIVE	ORDINAL	NOMINAL
Position	Position	Position
Length	Density (Val)	Color Hue
Angle	Color Sat	Texture
Slope	Color Hue	Connection
Area (Size)	Texture	Containment
Volume	Connection	Density (Val)
Density (Val)	Containment	Color Sat
Color Sat	Length	Shape
Color Hue	Angle	Length
Texture	Slope	Angle
Connection	Area (Size)	Slope
Containment	Volume	Area
Shape	Shape	Volume

5

Topics

Signal Detection
Magnitude Estimation
Pre-Attentive Visual Processing
Using Multiple Visual Encodings
Gestalt Grouping
Change Blindness

6

Detection

7

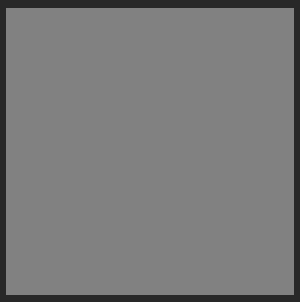
Detecting brightness

Which is brighter?

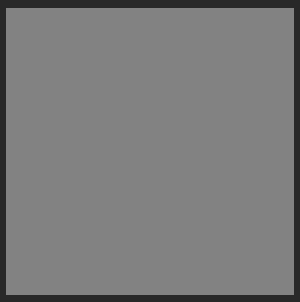
8

Detecting brightness

(128, 128, 128)



(130, 130, 130)



Which is brighter?

9

Just noticeable difference

JND (Weber's Law)

$$\Delta S = k\frac{\Delta I}{I}$$

- Ratios more important than magnitude
- Most continuous variations in stimuli are perceived in discrete steps

10

Information in color and value

Value is perceived as ordered

∴ Encode ordinal variables (O)

∴ Encode continuous variables (Q) [not as well]

Hue is normally perceived as unordered

∴ Encode nominal variables (N) using color

11

Steps in font size

Sizes standardized in 16th century

12

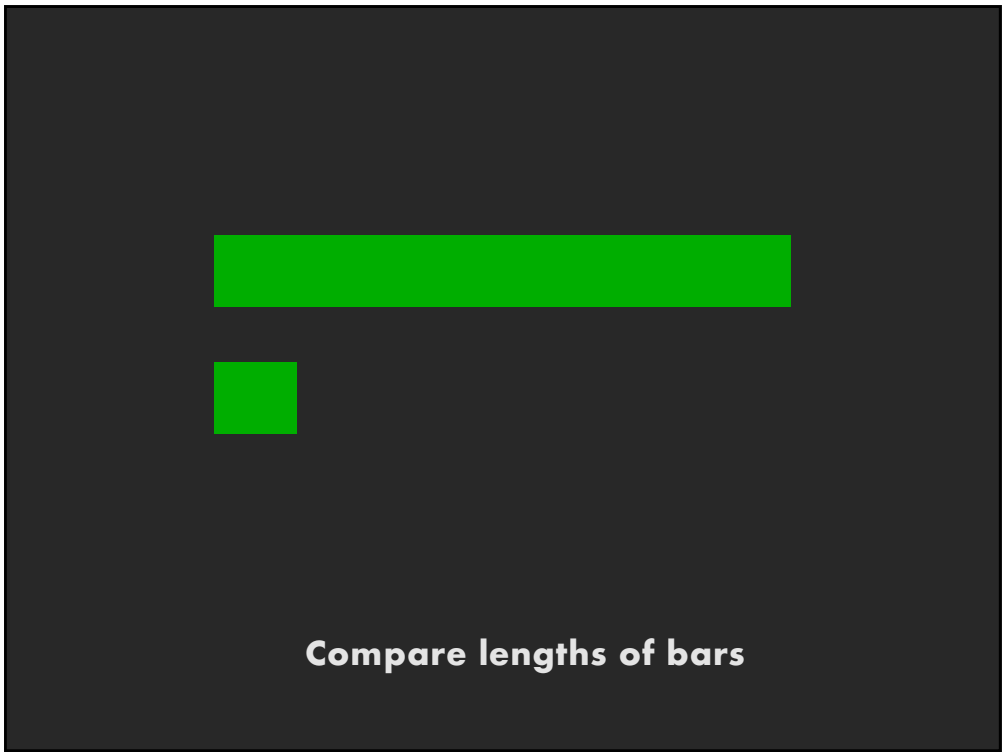
Estimating Magnitude

14

16

17

18



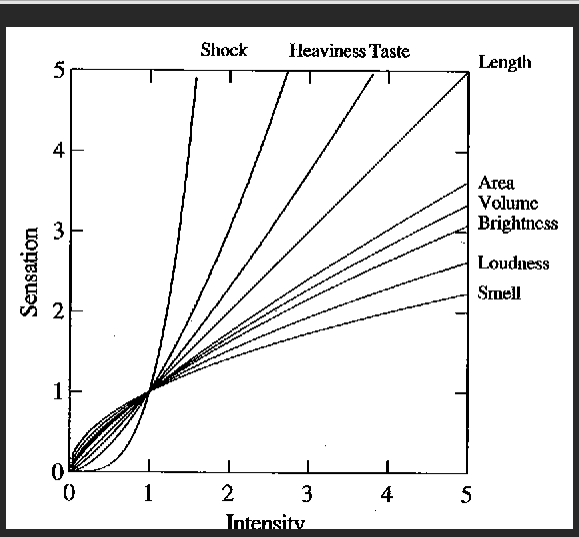
19

20

Steven's power law

$$S = I^p$$

p < 1 : underestimate
p > 1 : overestimate



[graph from Wilkinson 99, based on Stevens 61]

21

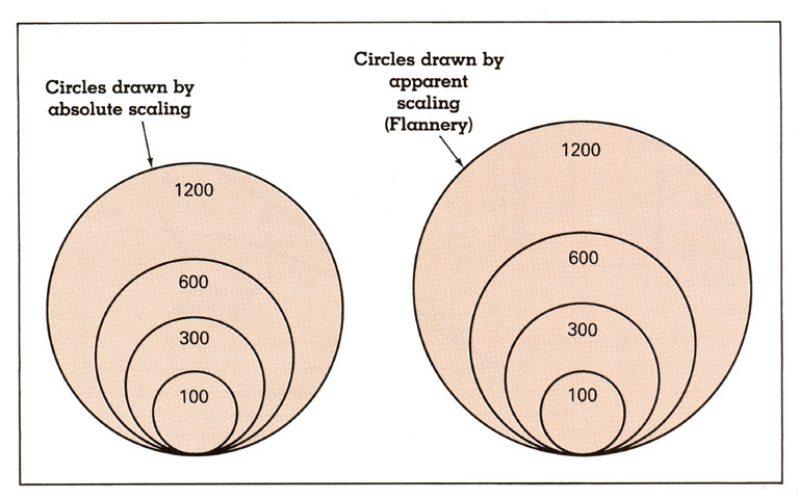
Exponents of power law

Sensation	Exponent
Loudness	0.6
Brightness	0.33
Smell	0.55 (Coffee) - 0.6 (Heptane)
Taste	0.6 (Saccharine) -1.3 (Salt)
Temperature	1.0 (Cold) – 1.6 (Warm)
Vibration	0.6 (250 Hz) – 0.95 (60 Hz)
Duration	1.1
Pressure	1.1
Heaviness	1.45
Electic Shock	3.5

[Psychophysics of Sensory Function, Stevens 61]

22

Apparent magnitude scaling



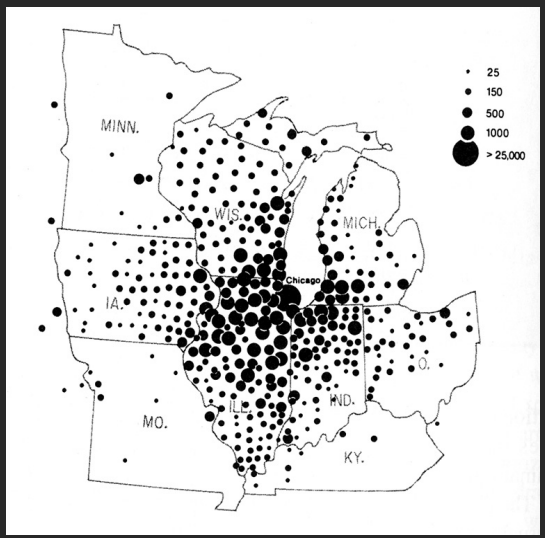
[Cartography: Thematic Map Design, Figure 8.6, p. 170, Dent, 96]

$S = 0.98A^{0.87}$ [from Flannery 71]

23

Proportional symbol map

Newspaper Circulation



[Cartography: Thematic Map Design, Figure 8.8, p. 172, Dent, 96]

24

Graduated sphere map

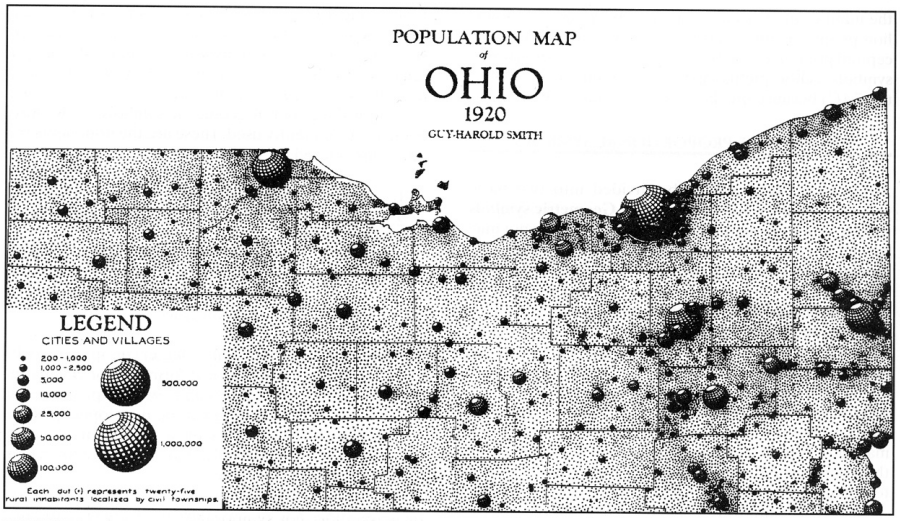


FIGURE 7.4. An eye-catching map created using three-dimensional geometric symbols. (After Smith, 1928. First published in *The Geographical Review,* 18(3), plate 4. Reprinted with permission of the American Geographical Society.)

25

Cleveland and McGill

27

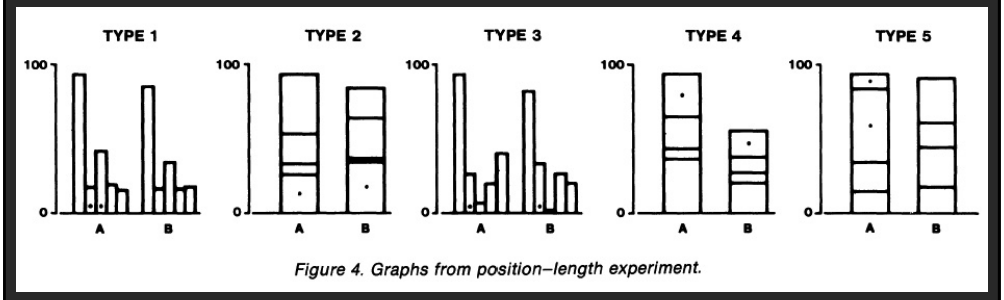


Figure 4. Graphs from position–length experiment.

[Cleveland and McGill 84]

28

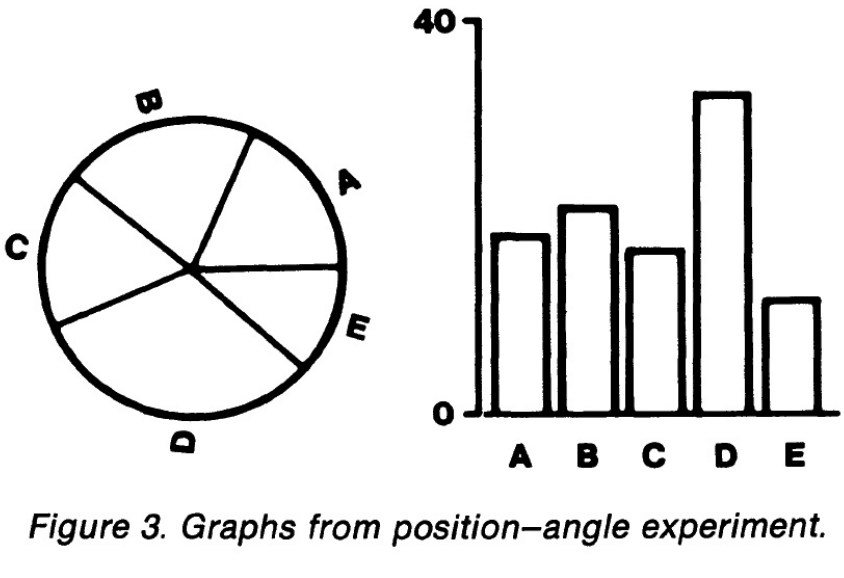


Figure 3. Graphs from position–angle experiment.

[Cleveland and McGill 84]

29

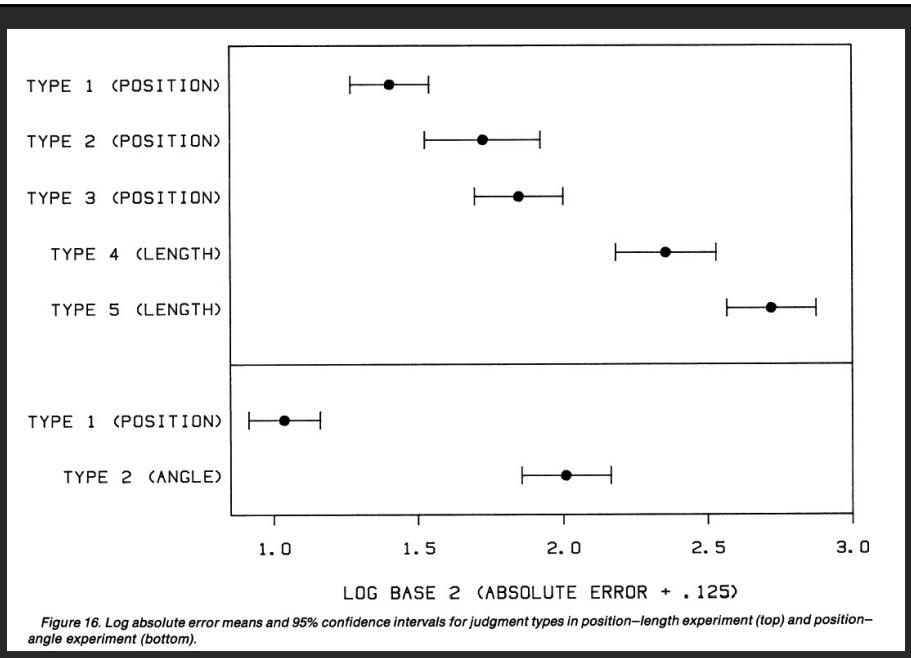


Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

[Cleveland and McGill 84]

30

Relative magnitude estimation

Most accurate

Least accurate

Position (common) scale
Position (non-aligned) scale
Length
Slope
Angle
Area
Volume
Color hue-saturation-density

31

Mackinlay's ranking of encodings

QUANTITATIVE	ORDINAL	NOMINAL
Position	Position	Position
Length	Density (Val)	Color Hue
Angle	Color Sat	Texture
Slope	Color Hue	Connection
Area (Size)	Texture	Containment
Volume	Connection	Density (Val)
Density (Val)	Containment	Color Sat
Color Sat	Length	Shape
Color Hue	Angle	Length
Texture	Slope	Angle
Connection	Area (Size)	Slope
Containment	Volume	Area
Shape	Shape	Volume

32

Preattentive vs. Attentive

33

How many 3's

12817687561389765469845069856049828267629809858458224509856458945098450980943585909103020990595959577256467505067890456788457898098216776548763649085609129496869

[based on slide from Stasko]

34

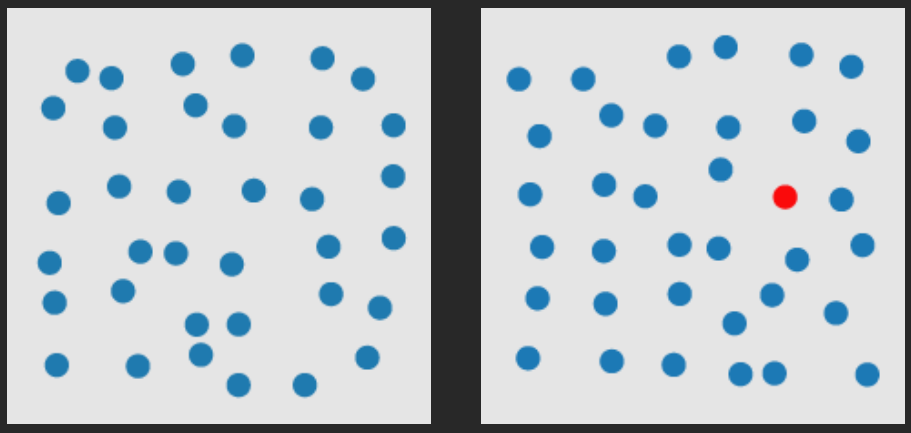
How many 3's

12817687561389765469845069856049828267629809858458224509856458945098450980943585909103020990595959577256467505067890456788457898098216776548763649085609129496869

[based on slide from Stasko]

35

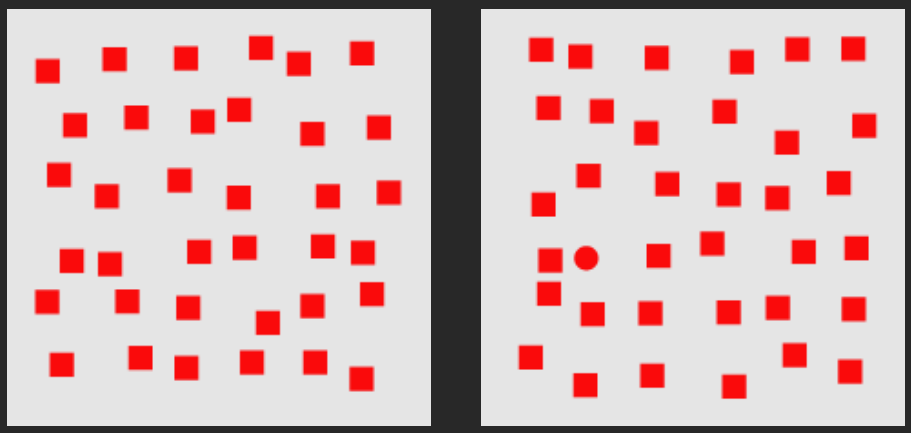
Visual pop-out: Color



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

36

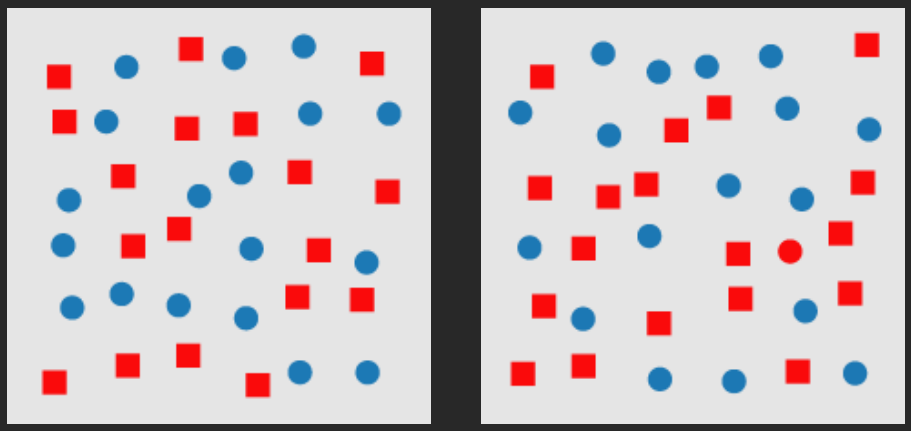
Visual pop-out: Shape



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

37

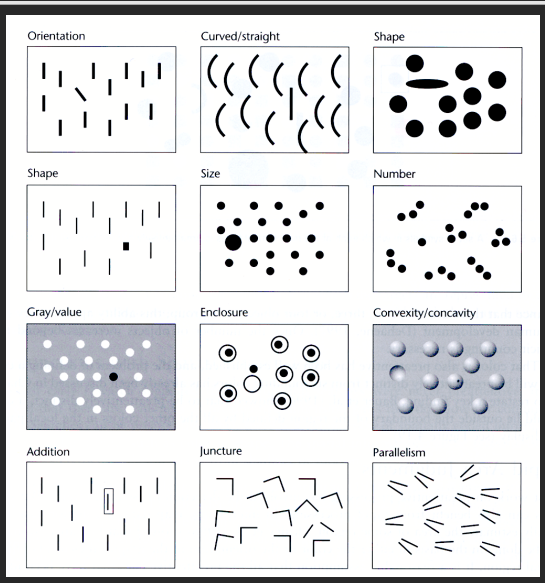
Feature conjunctions



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

38

Preattentive features



[Information Visualization. Figure 5. 5 Ware 04]

39

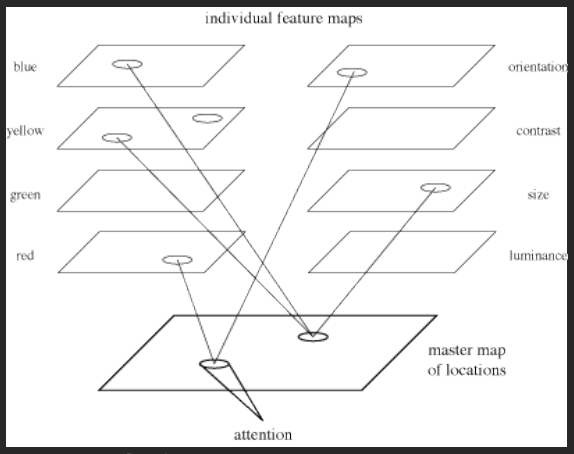
More preattentive features

Line (blob) orientation	Julesz & Bergen [1983]; Wolfe et al. [1992]
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]

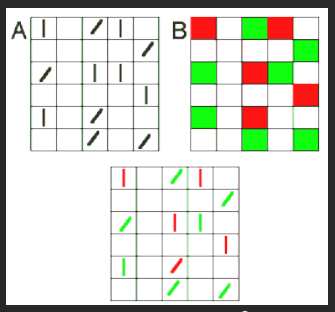
http://www.csc.ncsu.edu/faculty/healey/PP/index.html

40

Feature-integration theory



Treisman's feature integration model [Healey04]



Feature maps for orientation & color [Green]

42

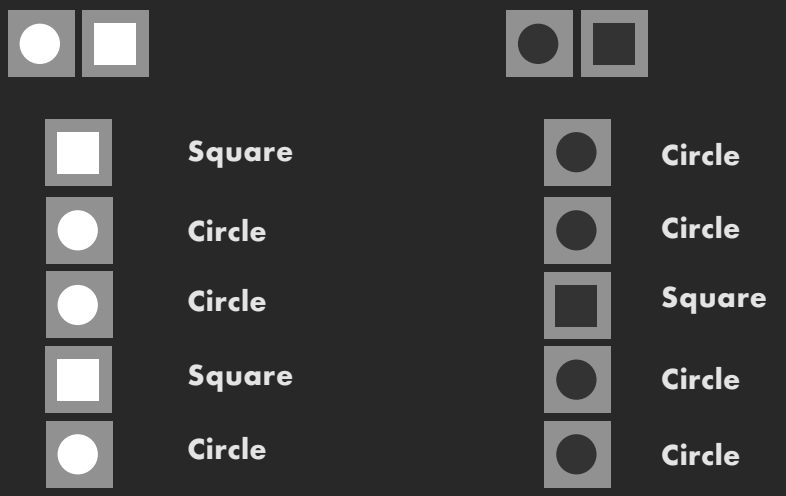
Multiple Attributes

43

One-dimensional: Lightness

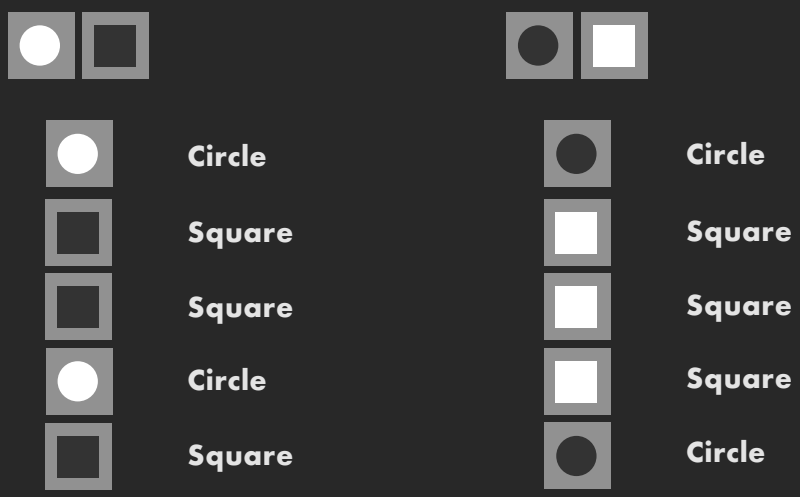
44

One-dimensional: Shape



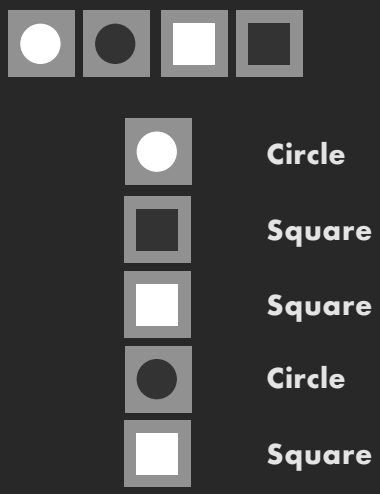
45

Correlated dims: Shape or lightness



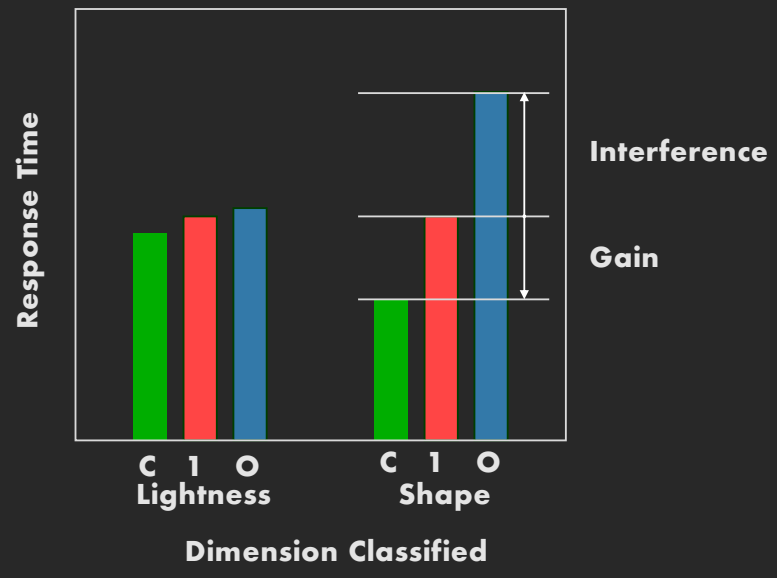
46

Orthogonal dims: Shape & lightness



47

Speeded classification



48

Speeded classification

Redundancy gain

Facilitation in reading one dimension when the other provides redundant information

Filtering interference

Difficulty in ignoring one dimension while attending to the other

49

Types of dimensions

Integral

Filtering interference and redundancy gain

Separable

No interference or gain

Configural

Only interference, but no redundancy gain

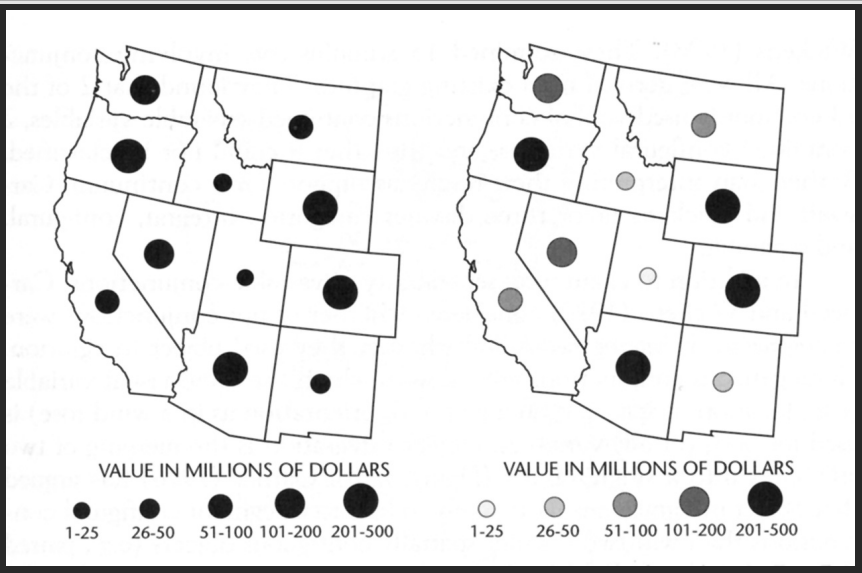
Asymmetrical

One dimension separable from other, not vice versa

Stroop effect – Color naming influenced by word identity, but word naming not influenced by color

50

Correlated dims: Size and value



W. S. Dobson, Visual information processing and cartographic communication: The role of redundant stimulus dimensions, 1983 (reprinted in MacEachren, 1995)

51

Othogonal dims: Aspect ratio

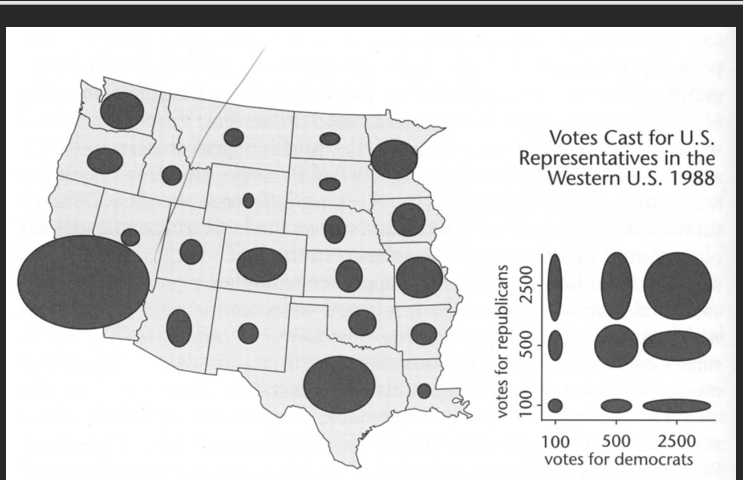


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

[MacEachren 95]

52

Orientation and Size (Single Mark)

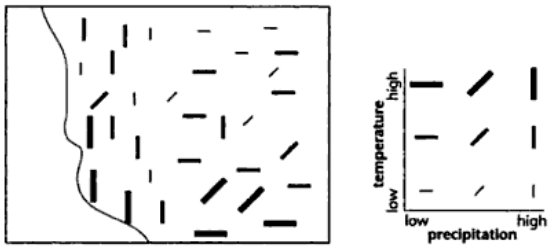


FIGURE 3.36. A map of temperature and precipitation using symbol size and orientation to represent data values on the two variables.

How well can you see temperature or precipitation? Is there a correlation between the two?

[MacEachren 95]

53

Shape and Size

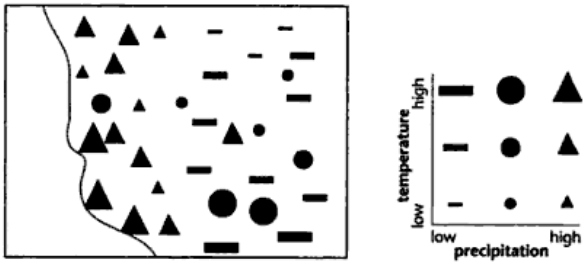


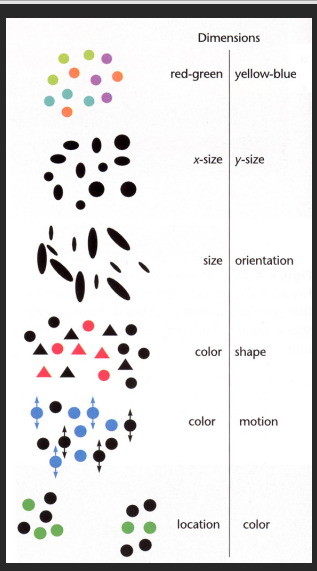
FIGURE 3.40. The bivariate temperature–precipitation map of Figure 3.36, this time using point symbols that vary in shape and size to represent the two quantities.

Easier to see one shape across multiple sizes than one size of across multiple shapes?

[MacEachren 95]

54

Summary of Integral-Separable



Integral

Separable

[Figure 5.25, Color Plate 10, Ware 00]

56

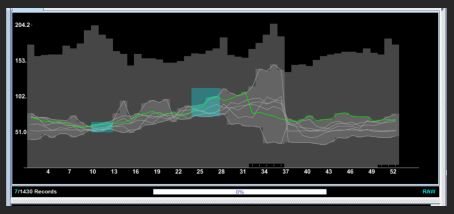
Announcements

58

Assignment 3: Dynamic Queries

Create a **small** interactive dynamic query application similar to TimeSearcher, but for top 100 personalities on Cable TV News.

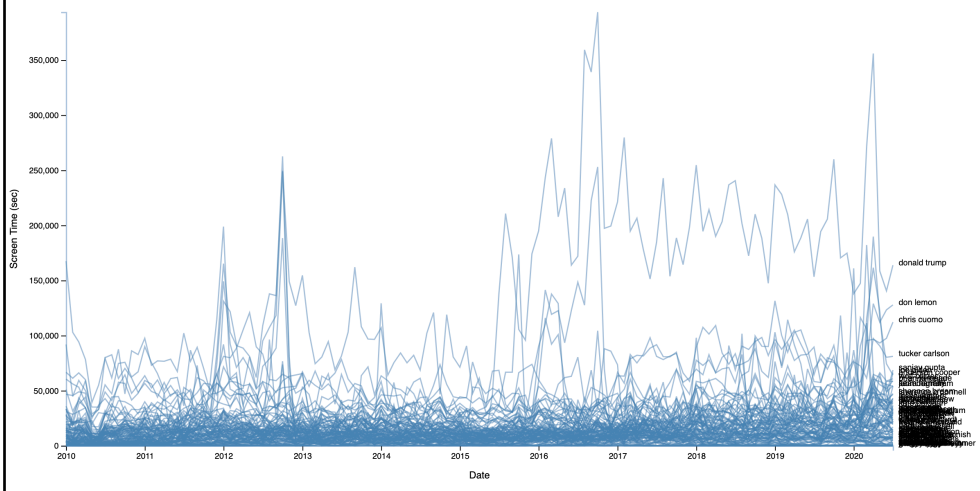
1. Implement timeboxes interface
2. Submit the application and a short write-up on canvas



Can work alone or in pairs

Due before class on **Oct 20, 2020**

59



60

Discussing notebooks

We are happy to discuss your code

- But, do not publish your notebook
- Instead enable link sharing and share the link with us privately through Piazza

61

Class Schedule Updates

No class Tu Nov 3rd – VOTE!

Guest Lecture Th Nov 12

Jessica Hullman on
Visualizing Uncertainty

62