Perception

Maneesh Agrawala

CS 448B: Visualization
Fall 2021

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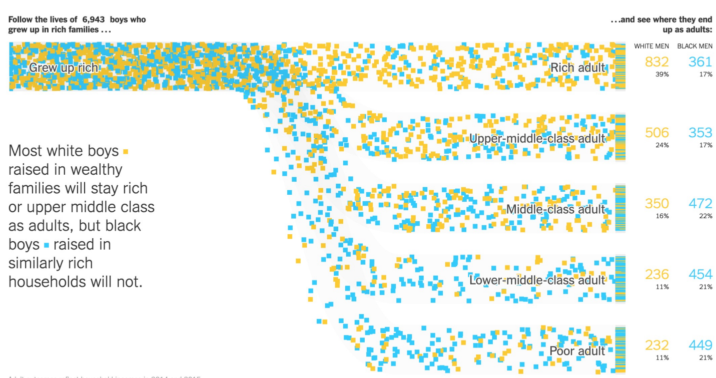
SHARE

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.



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Reading Response Questions/Thoughts

Can D3 verify data and check errors, or should all the data wrangling occur before using it?

I'm still really confused about the use of the enter, update, and exit data fields. Why would a programmer need to have access to data that has already exited?

When would you recommend someone to use D3 over tools such as Tableau, particularly in a workplace / professional setting?

For D3, did Mike Bostock and team have to choose between doing their PhD research and building out their project for general programmer consumption?

It was mentioned that D3 is the standard in industry for making these dynamic and interactive visuals, but is that still the case with static visuals?

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Perception

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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.

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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

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Detection

8

Detecting brightness

Which is brighter?

9

Detecting brightness

(128, 128, 128) (130, 130, 130)

Which is brighter?

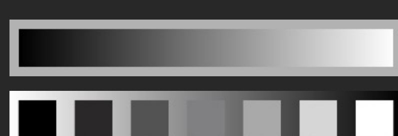
10

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



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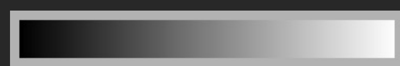
Information in color and value

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

12

Steps in font size

Sizes standardized in 16th century

a a a a a a a a a a a a a a a a

6 7 8 9 10 11 12 14 16 18 21 24 36 48 60 72

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Estimating Magnitude

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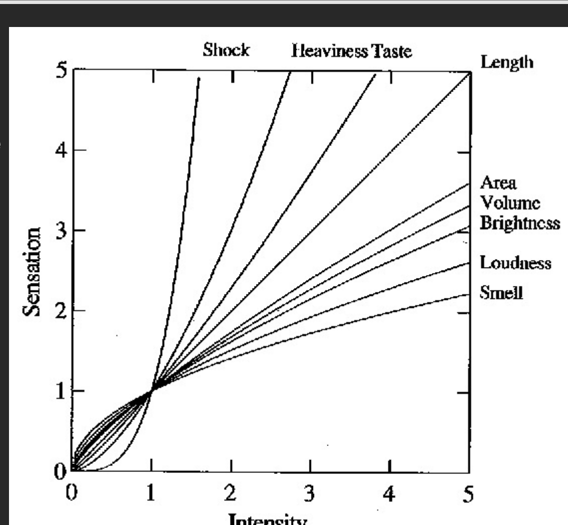
Steven's power law

$$S = I^p$$

p < 1 : underestimate
p > 1 : overestimate



[graph from Wilkinson 99, based on Stevens 61]

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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]

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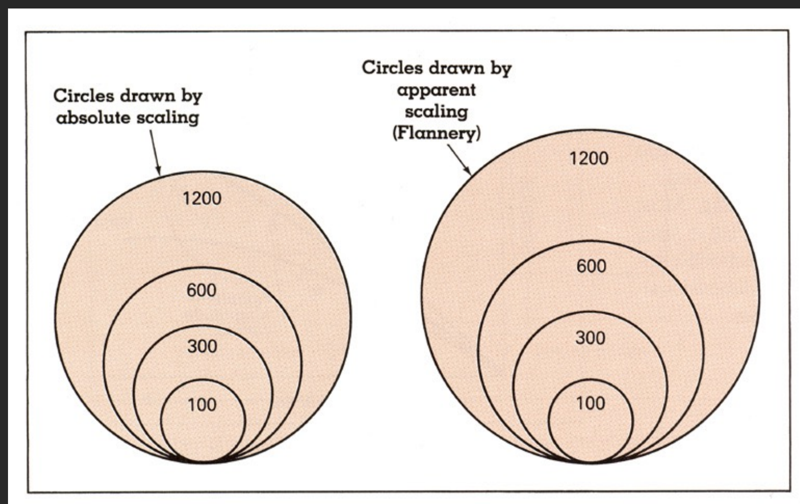
Apparent magnitude scaling



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

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

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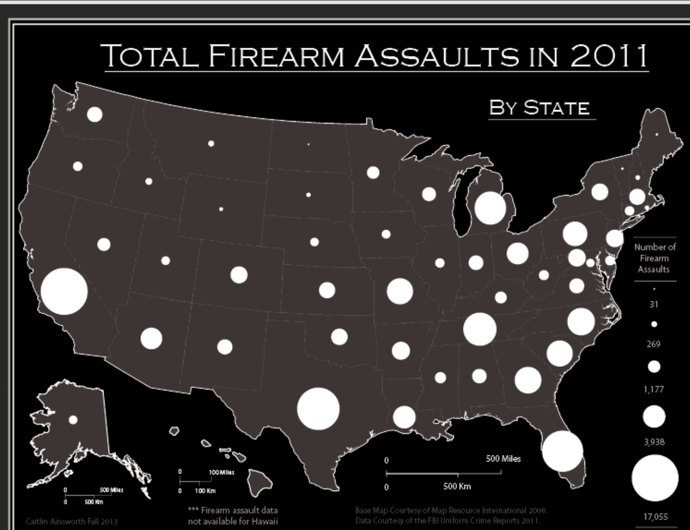
Absolute Symbol Scaling



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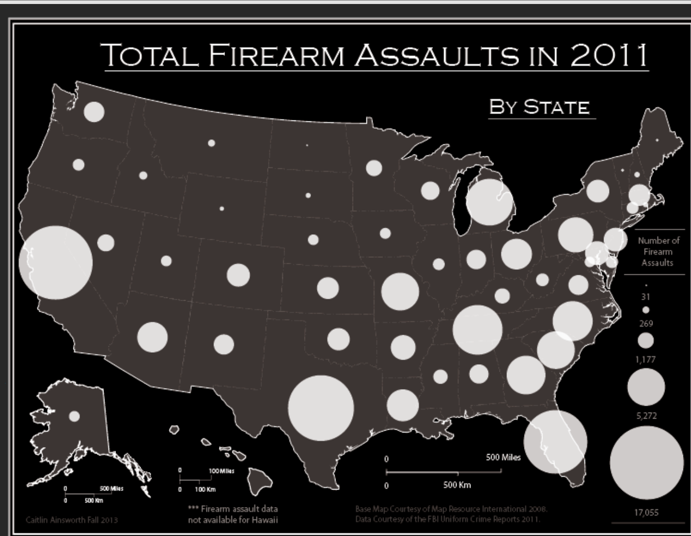
Flannery Scaling



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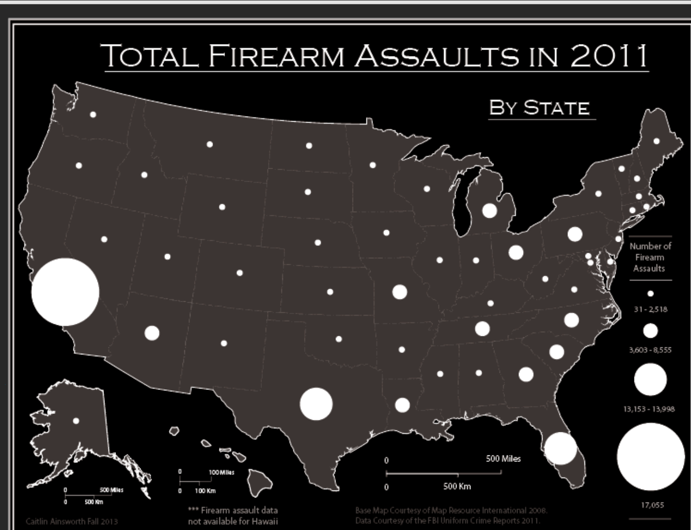
Graduated Symbols



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Graduated sphere map

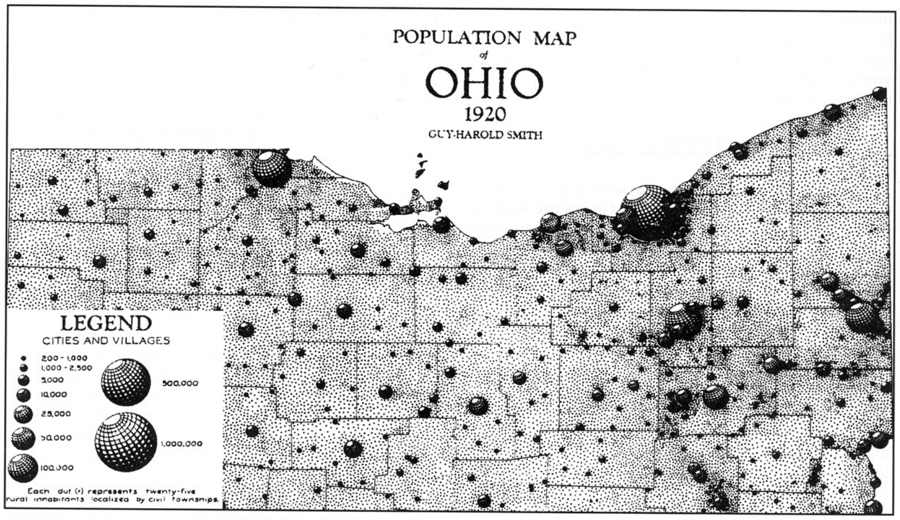

FIGURE 7.4. An eye-catching map created using three-dimensional geometric symbols. (After Smith, 1928. First published in *The Geographical Review,* 18(3), plate 4. Reprinted with permission of the American Geographical Society.)

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Cleveland and McGill

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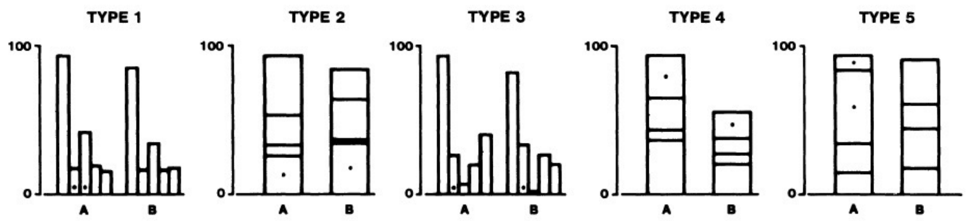

Figure 4. Graphs from position–length experiment.

[Cleveland and McGill 84]

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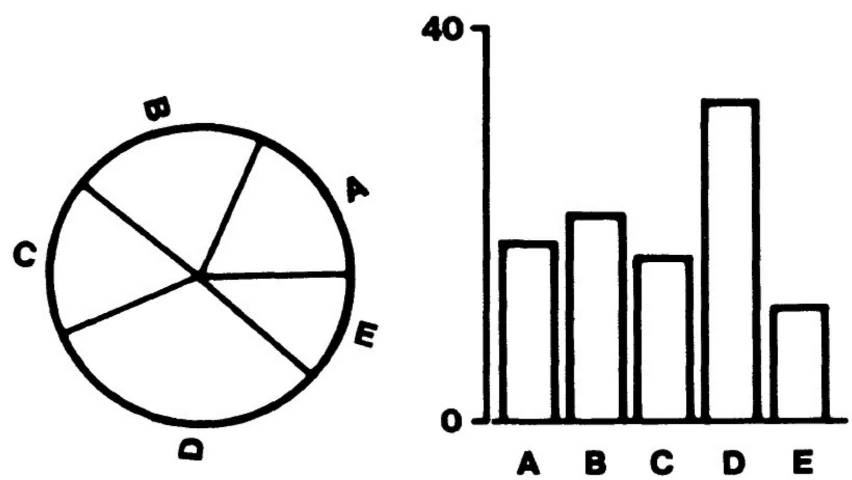

Figure 3. Graphs from position–angle experiment.

[Cleveland and McGill 84]

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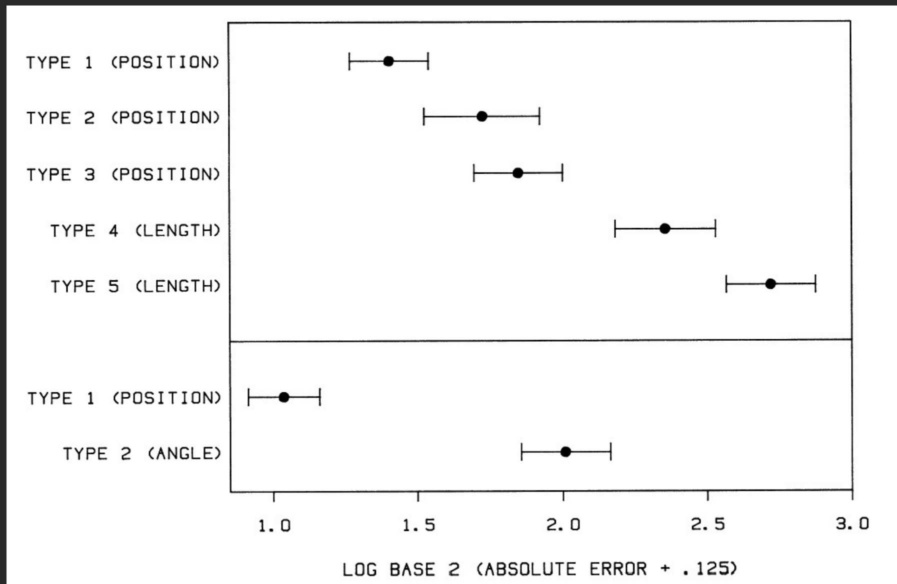

Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

[Cleveland and McGill 84]

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Relative magnitude estimation

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

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Mackinlay's ranking of encodings

QUANTITATIVE	ORDINAL	NOMINAL
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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

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Preattentive vs. Attentive

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How many 3’s

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

[based on slide from Stasko]

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How many 3’s

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

[based on slide from Stasko]

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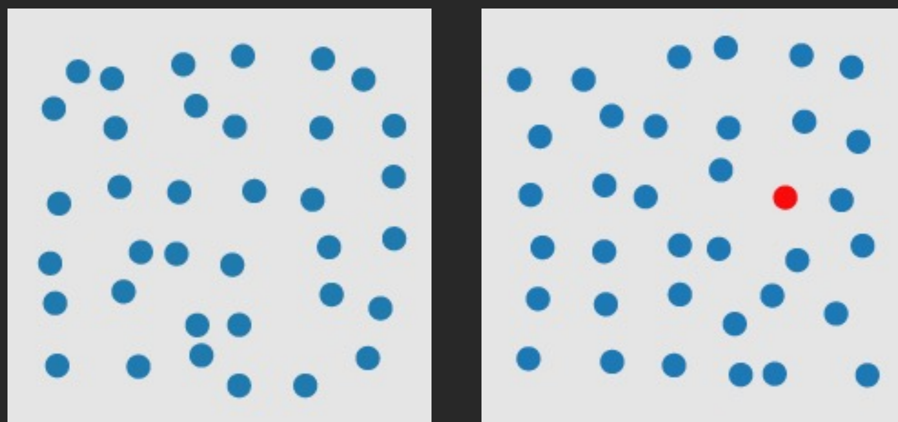
Visual pop-out: Color



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

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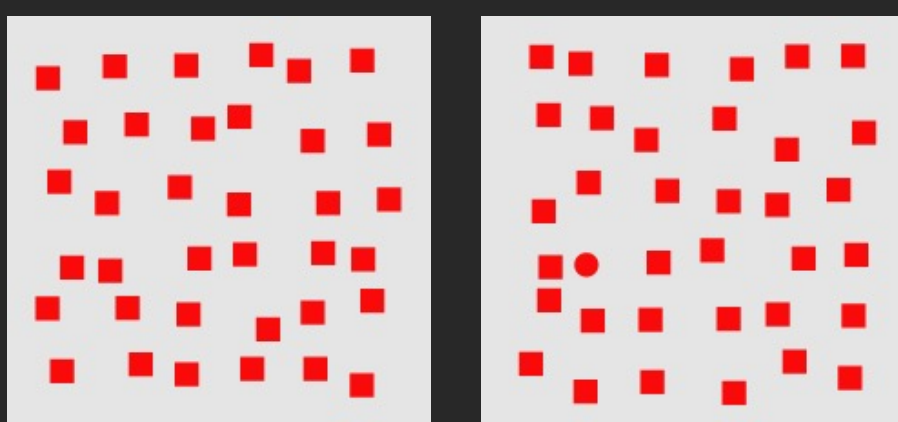
Visual pop-out: Shape



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

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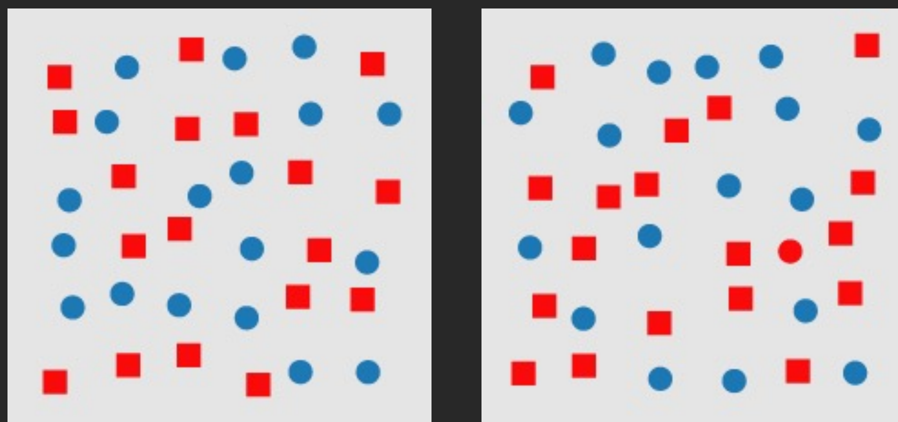
Feature conjunctions



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

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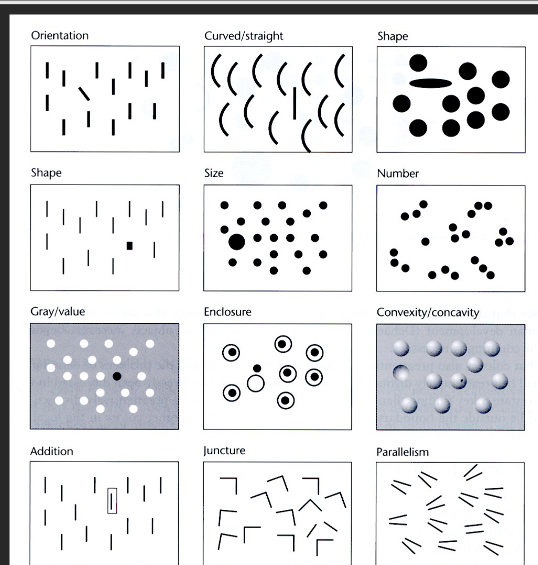
Preattentive features



[Information Visualization. Figure 5. 5 Ware 04]

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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

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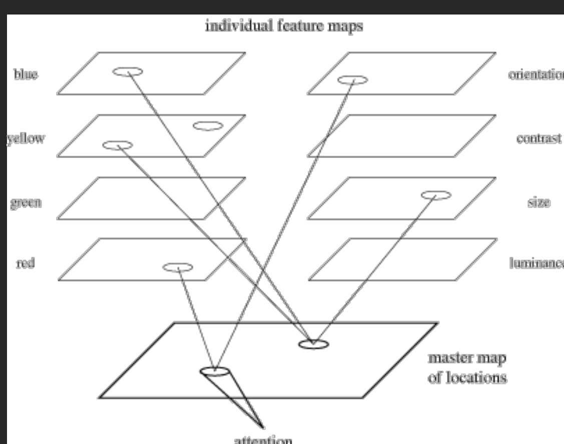
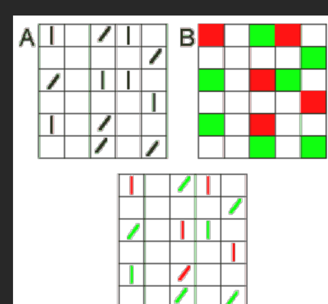
Feature-integration theory



Treisman' s feature integration model [Healey04]



Feature maps for orientation & color [Green]

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Multiple Attributes

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One-dimensional: Lightness

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One-dimensional: Shape

Square	Circle
Circle	Circle
Circle	Square
Square	Circle
Circle	Circle

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Correlated dims: Shape or lightness

Circle	Circle
Square	Square
Square	Square
Circle	Square
Square	Circle

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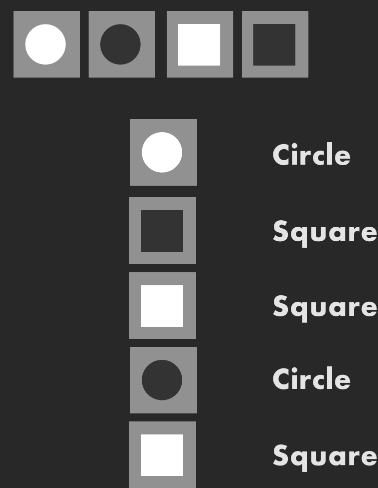
Orthogonal dims: Shape & lightness



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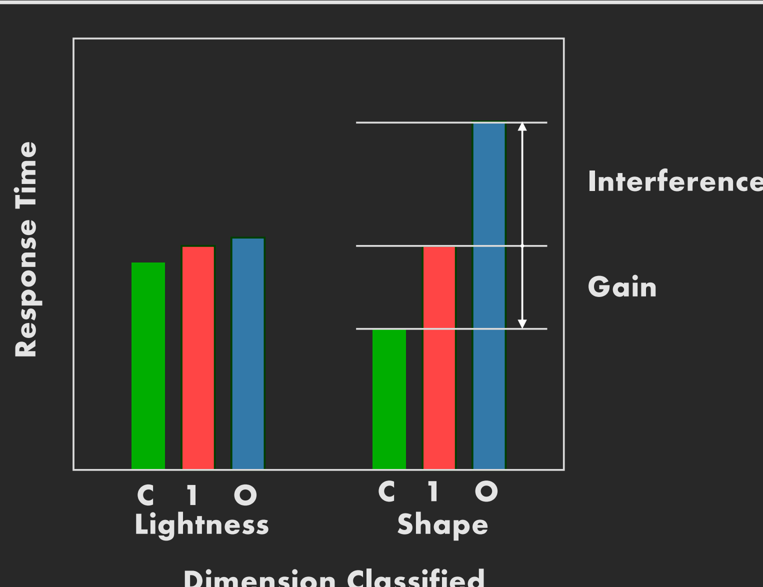
Speeded classification



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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

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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

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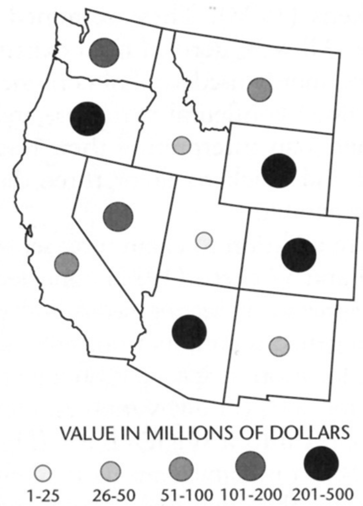
Correlated dims: Size and value



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

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Othogonal dims: Height, Width

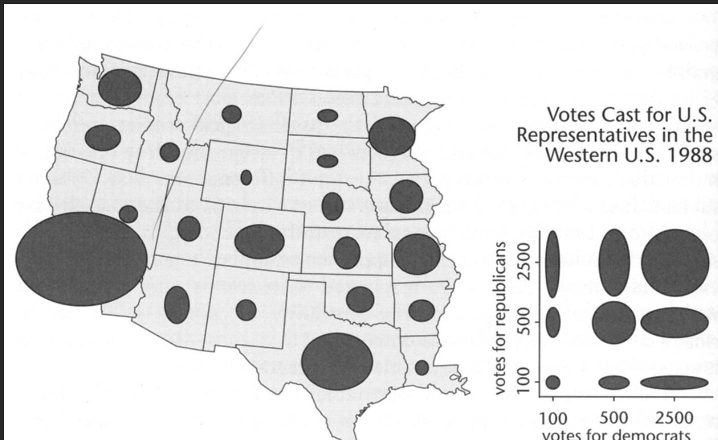

FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

[MacEachren 95]

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Orientation and Size (Single Mark)

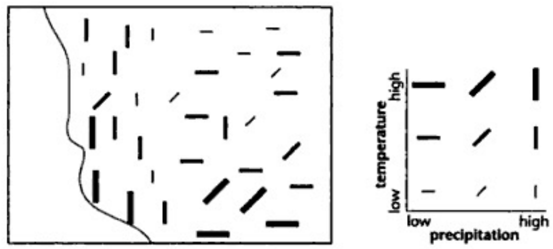

FIGURE 3.36. A map of temperature and precipitation using symbol size and orientation to represent data values on the two variables.

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

[MacEachren 95]

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Shape and Size

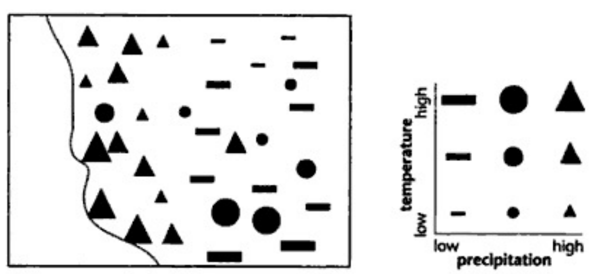

FIGURE 3.40. The bivariate temperature–precipitation map of Figure 3.36, this time using point symbols that vary in shape and size to represent the two quantities.

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

[MacEachren 95]

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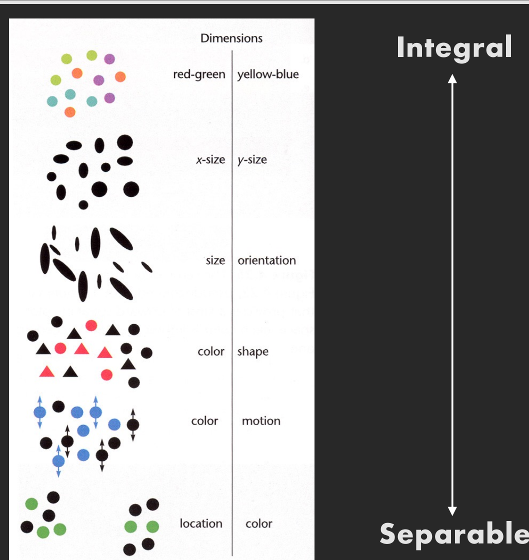
Summary of Integral-Separable



[Figure 5.25, Color Plate 10, Ware 00]

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Announcements

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Assignment 3: Dynamic Queries

Create a **small** interactive dynamic query application similar to HomeFiner, but for restaurants data.

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

Can work alone or in pairs

Due before class on **Oct 25, 2021**

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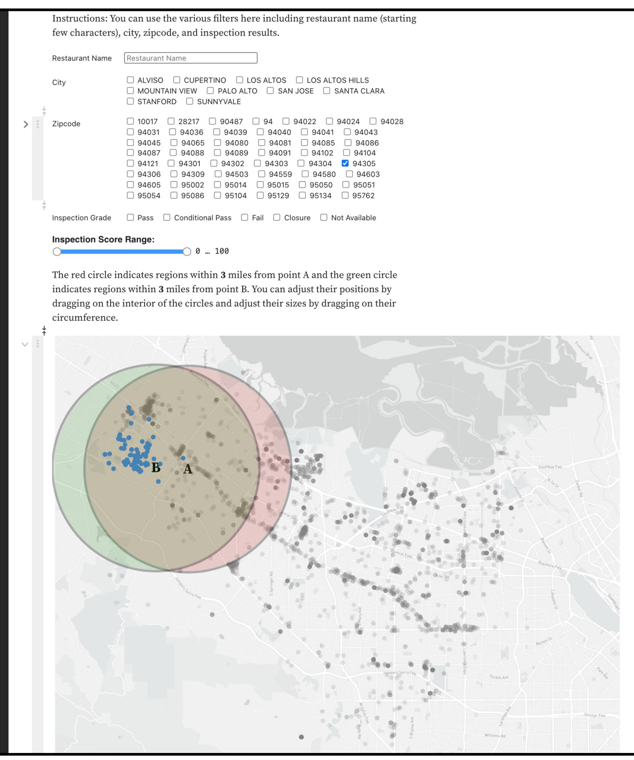

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Discussing notebooks

Stay tuned for extra office hours

We are happy to discuss your code

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

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Gestalt

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Principles

- figure/ground
- proximity
- similarity
- symmetry
- connectedness
- continuity
- closure
- common fate
- transparency

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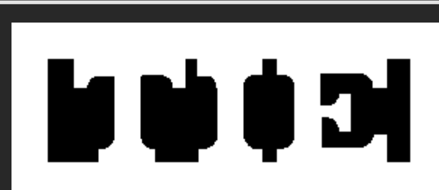
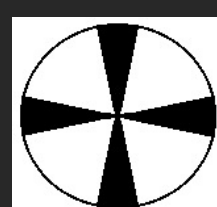
Figure/Ground

Ambiguous



Principle of surroundedness



Principle of relative size

http://www.aber.ac.uk/media/Modules/MC10220/visper06.html

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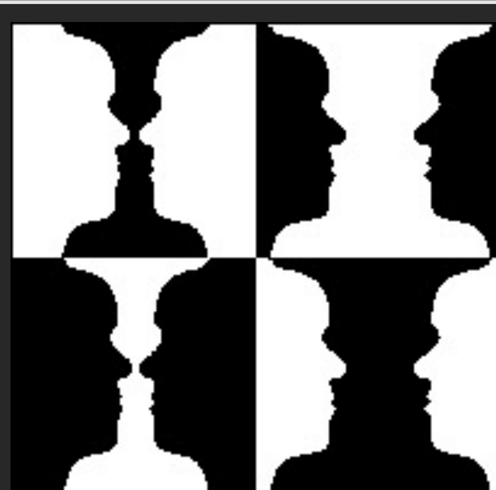
Figure/Ground

Ambiguous



Unambiguous

http://www.aber.ac.uk/media/Modules/MC10220/visper06.html

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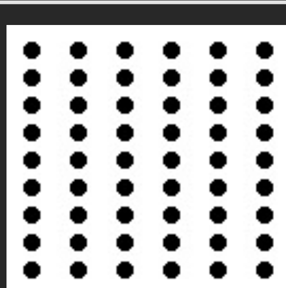
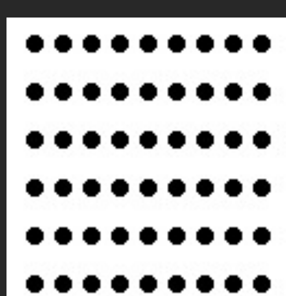
Proximity





[Ware 00]

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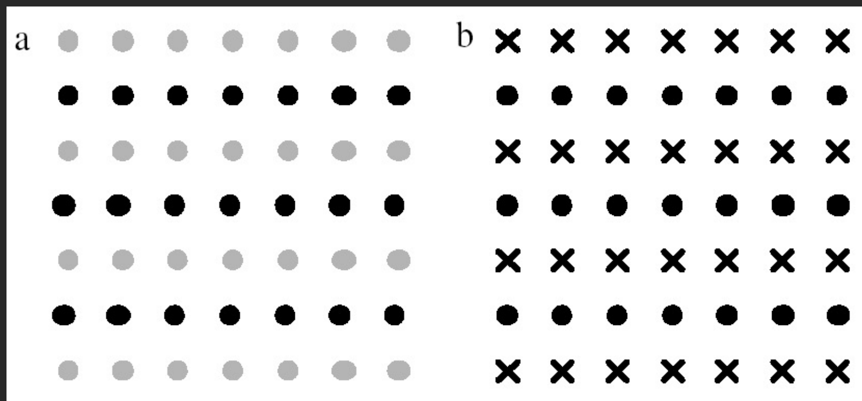
Similarity



Rows dominate due to similarity [from Ware 04]

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