

Lecture 5

9/22/2020

Visual Encoding

- ▶ How do we encode data visually?
 - ▶ Marks - basic graphical elements in a visualization
 - ▶ Channels - ways to control the appearance of the marks

Marks

- ▶ Classified by dimensionality
- ▶ Classified according to number of spatial dimensions required

➞ Points



➞ Lines



➞ Areas



Channels

- Parameters that control the appearance of marks

➔ Position

➔ Horizontal



➔ Vertical



➔ Both



➔ Color



➔ Shape



➔ Tilt



➔ Size

➔ Length



➔ Area



➔ Volume



Channels

- ▶ Usually map an attribute to a single channel
 - ▶ Could use multiple channels, but...
 - ▶ Limited number of channels
- ▶ Restrictions on size and shape
 - ▶ Points are nothing but location so size and shape are ok
 - ▶ Lines have a length, cannot easily encode attribute as length
 - ▶ Maps with boundaries have area, changing size can be problematic

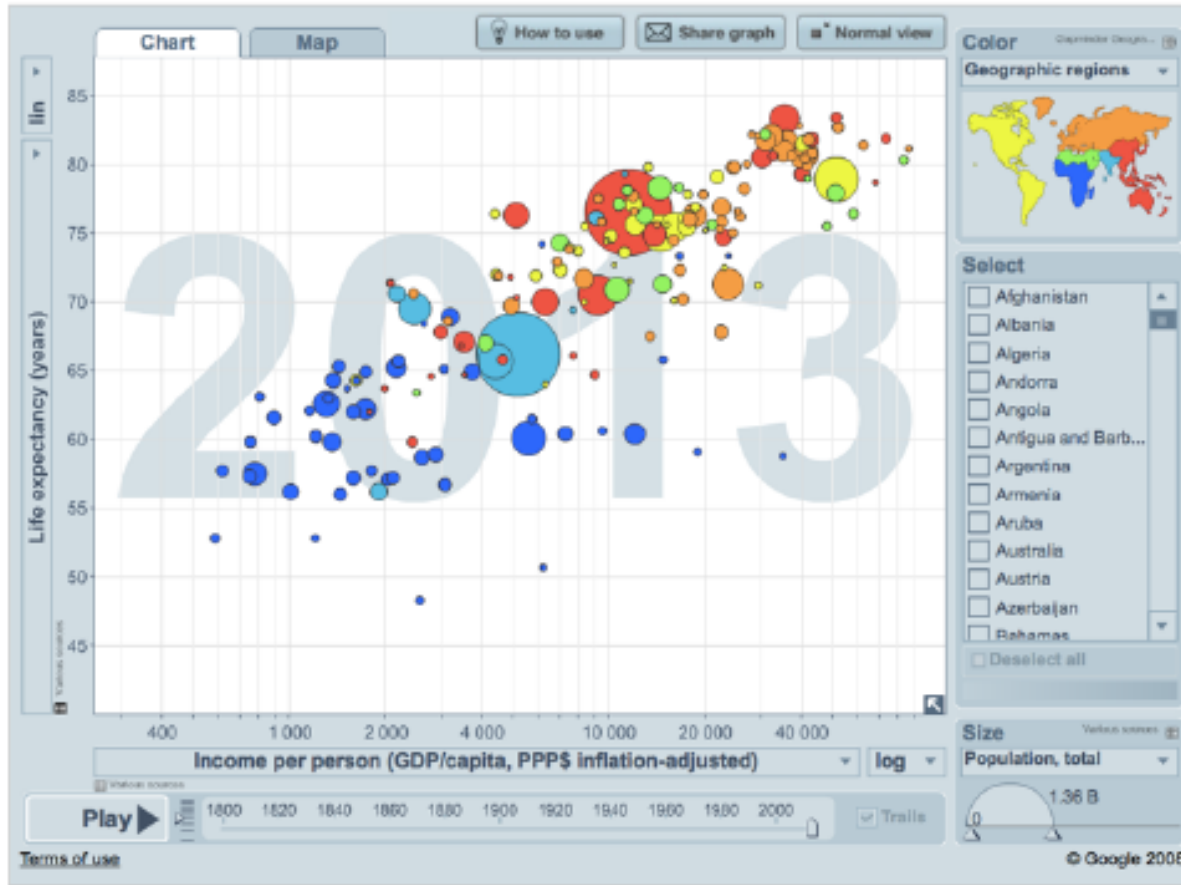


Channels: Visual Appearance

- How should we encode this data?

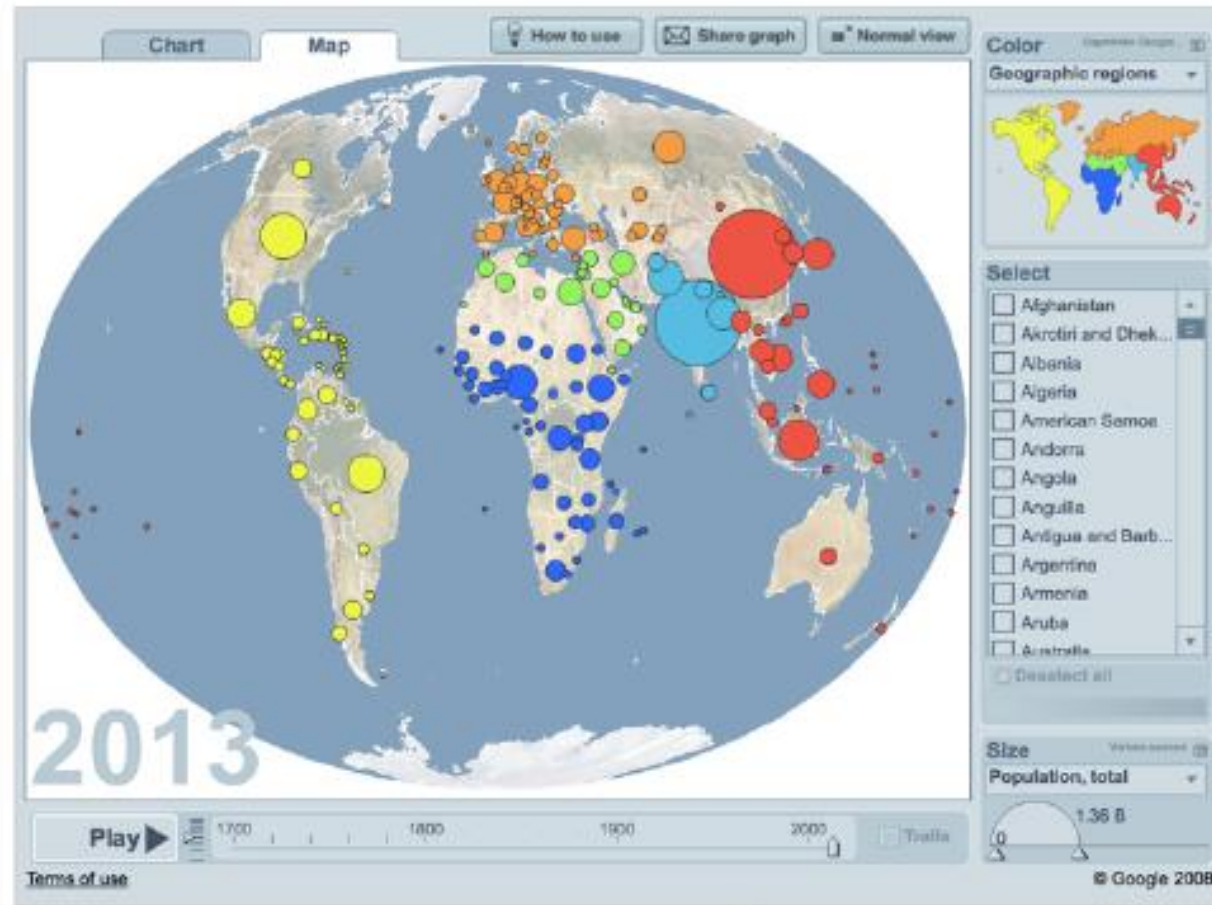
Name	Region	Population	Life Expectancy	Income
China	East Asia & Pacific	1335029250	73.28	7226.07
India	South Asia	1140340245	64.01	2731
United States	America	306509345	79.43	41256.08
Indonesia	East Asia & Pacific	228721000	71.17	3818.08
Brazil	America	193806549	72.68	9569.78
Pakistan	South Asia	176191165	66.84	2603
Bangladesh	South Asia	156645463	66.56	1492
Nigeria	Sub-Saharan Africa	141535316	48.17	2158.98
Japan	East Asia & Pacific	127383472	82.98	29680.68
Mexico	America	111209909	76.47	11250.37
Philippines	East Asia & Pacific	94285619	72.1	3203.97
Vietnam	East Asia & Pacific	86970762	74.7	2679.34
Germany	Europe & Central Asia	82338100	80.08	31191.15
Ethiopia	Sub-Saharan Africa	79996293	55.69	812.16
Turkey	Europe & Central Asia	72626967	72.06	8040.78

Potential Solution



[Gapminder, Wealth & Health of Nations]

Another Solution



[Gapminder, Wealth & Health of Nations]

Mark Types

- ▶ Can have marks for items/nodes and links
- ▶ Link marks
 - ▶ Connection -> pairwise relationship
 - ▶ Containment -> hierarchical relationship using areas; connection marks can be nested within each other at multiple levels

Marks as Items/Nodes

➞ Points



➞ Lines



➞ Areas



Marks as Links

➞ Containment



➞ Connection



Channel Types

➔ Position

➔ Horizontal



➔ Vertical



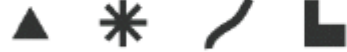
➔ Both



➔ Color



➔ Shape



➔ Tilt



➔ Size

➔ Length



➔ Area



➔ Volume




Channel Types

identity (what or where) *magnitude (how much)*

➞ Position

➞ Horizontal ➞ Vertical ➞ Both



➞ Color



➞ Shape




➞ Tilt



➞ Size

➞ Length ➞ Area

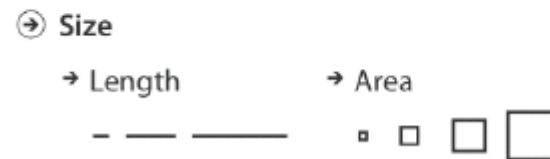
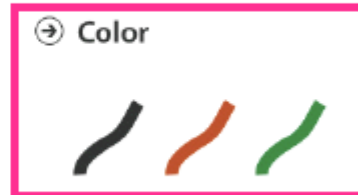
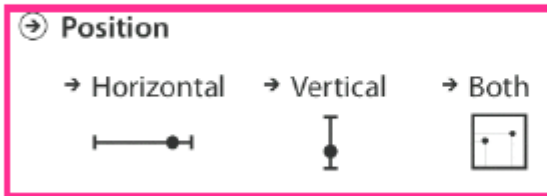


➞ Volume



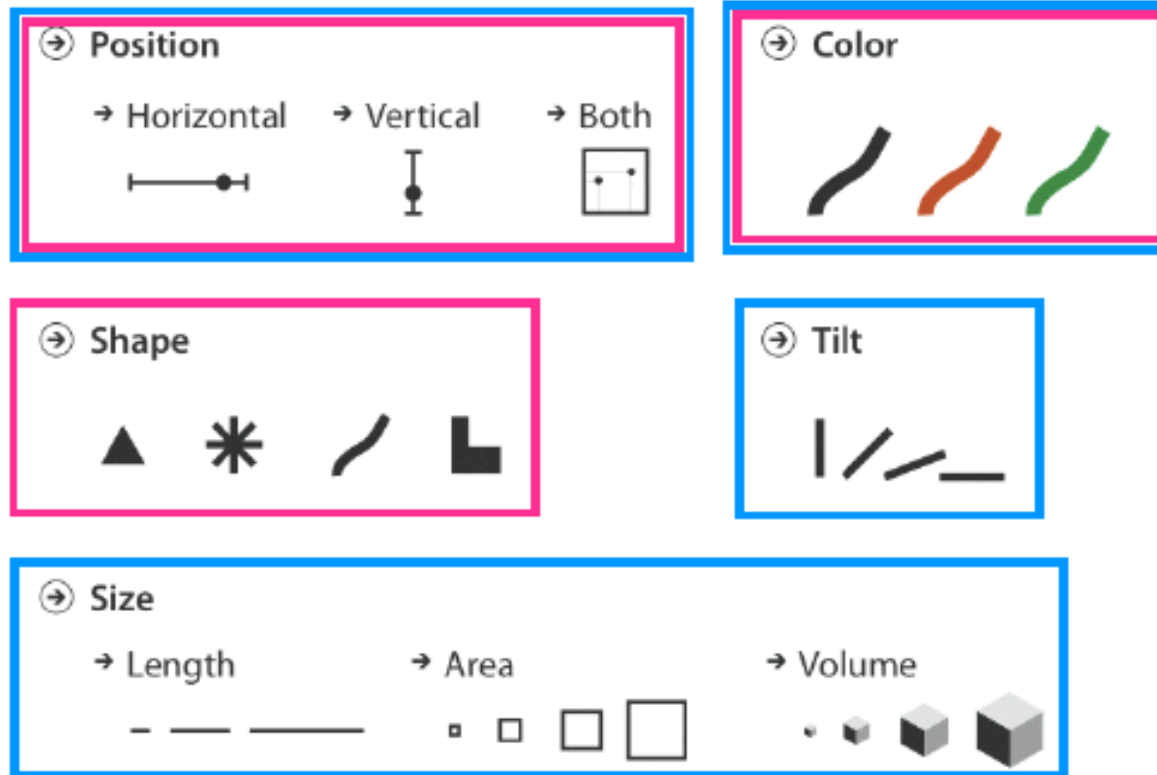
Channel Types

identity (what or where) *magnitude (how much)*



Channel Types











identity (what or where) *magnitude (how much)*







Expressiveness & Effectiveness

- ▶ Expressiveness Principle: all data from the dataset and nothing more should be shown
 - ▶ Do encode ordered data in an ordered fashion
 - ▶ Don't encode categorical data in a way that implies an ordering
- ▶ Effectiveness Principle: the most important attributes should be the most salient
 - ▶ Saliency: how noticeable something is
 - ▶ How do the channels we have discussed measure up?
 - ▶ How was this determined?

(how much)

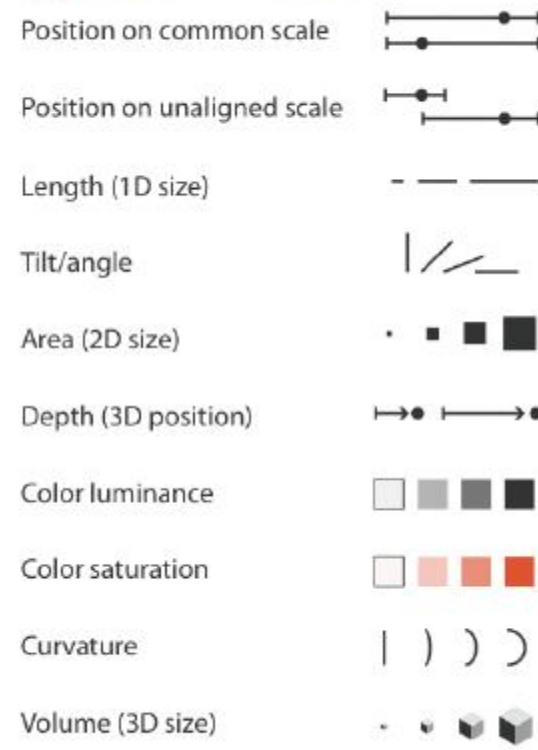
➔ Magnitude Channels: Ordered Attributes	
Position on common scale	
Position on unaligned scale	
Length (1D size)	
Tilt/angle	
Area (2D size)	
Depth (3D position)	
Color luminance	
Color saturation	
Curvature	
Volume (3D size)	

(what or where)

➔ Identity Channels: Categorical Attributes	
Spatial region	
Color hue	
Motion	
Shape	

expressiveness

➔ Magnitude Channels: **Ordered** Attributes



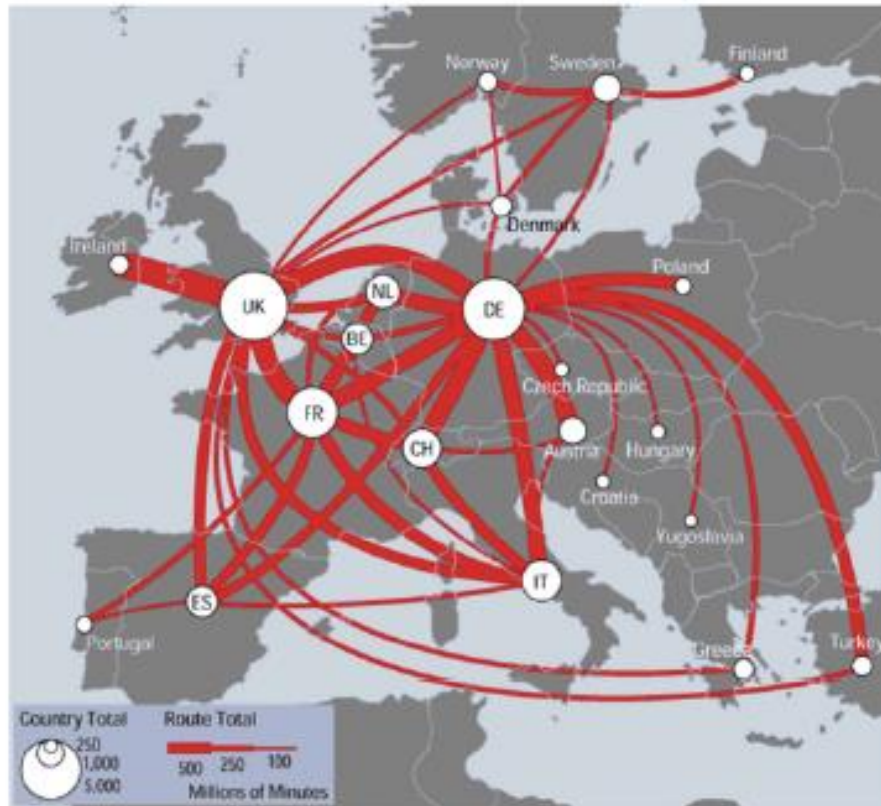
➔ Identity Channels: **Categorical** Attributes



effectiveness

Discriminability

- Can you discern channel differences?

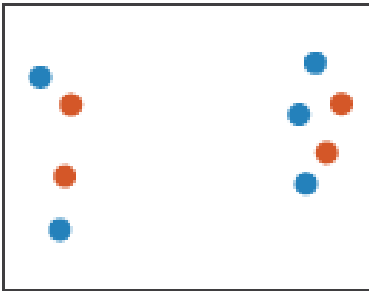


- Bins
 - # of different values that need to be shown for the attribute being encoded must not be greater than the number of bins available for the visual channel used to encode it.

Separability

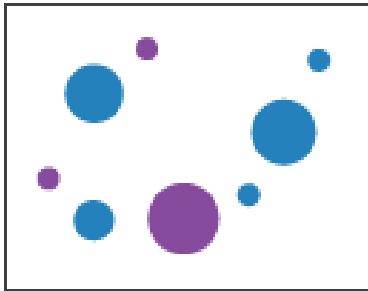
- ▶ Cannot treat all channels as independent!
- ▶ Separable: each individual channel can be distinguished
- ▶ Integral: the channels are perceived together
 - ▶ Attempts to encode different information in integral channels will fail

Position
+ Hue (Color)



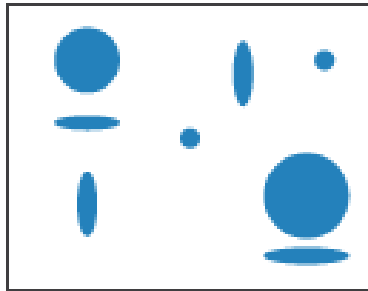
Fully separable

Size
+ Hue (Color)



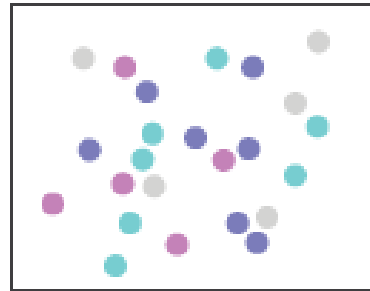
Some Interference

Width
+ Height



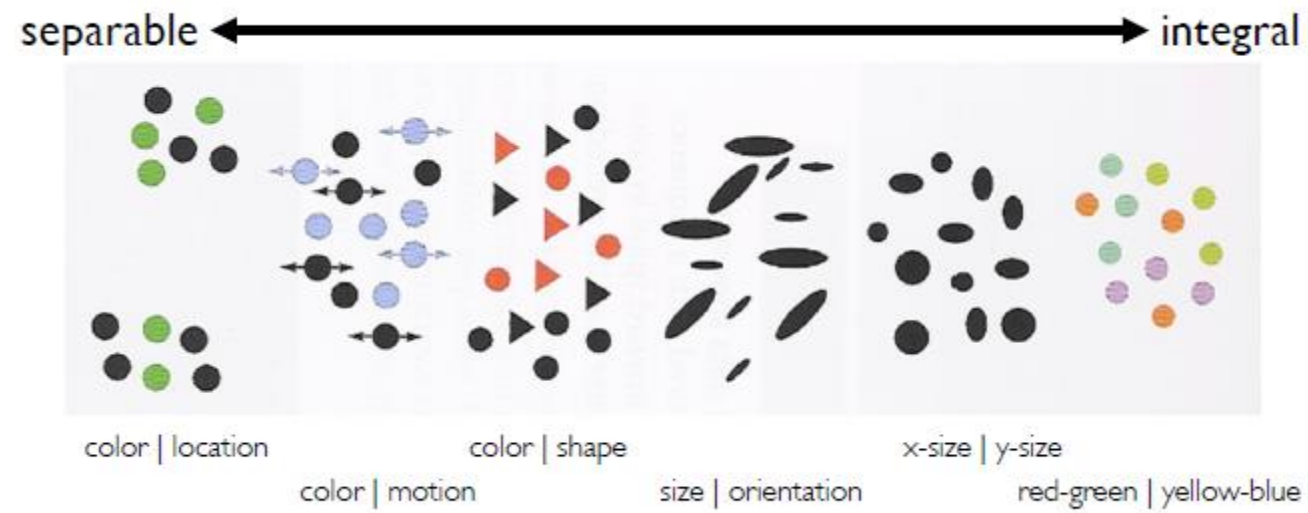
Some/significant
Interference

Red
+ Green

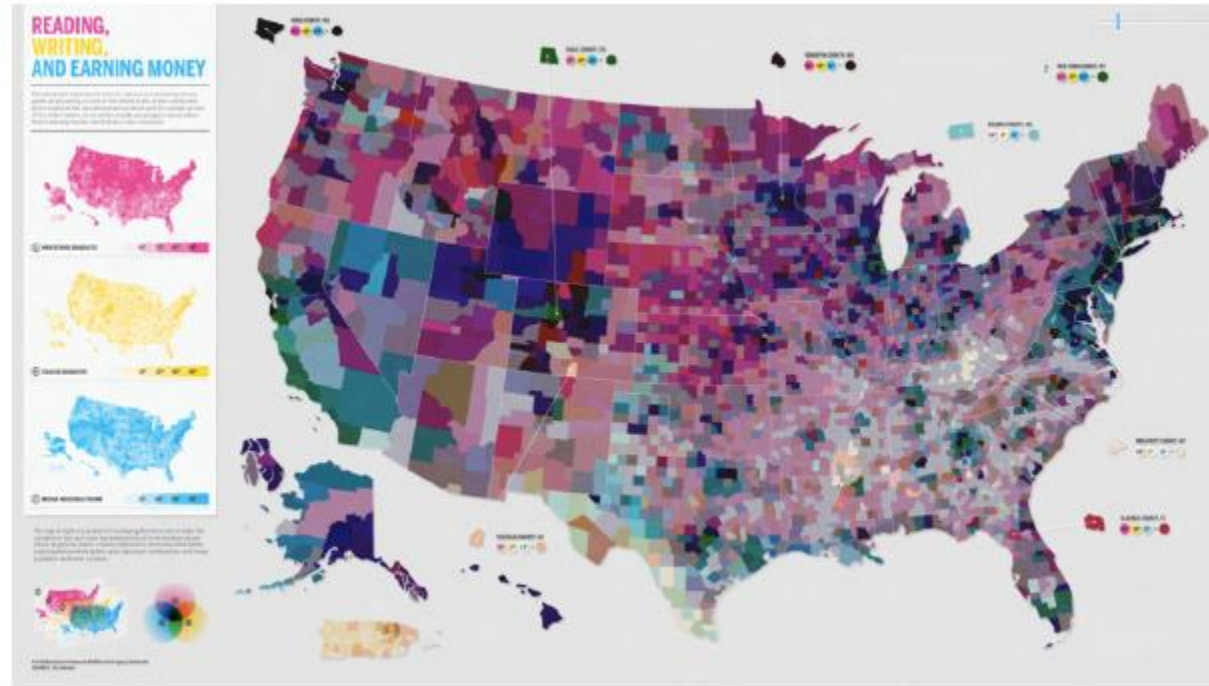


Major Interference

Separable vs Integral



Integral Channels



[<http://magazine.good.is/infographics/america-s-richest-counties-and-best-educated-counties>]

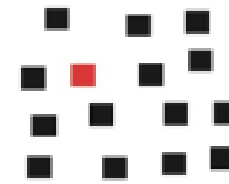
Perceptual Effects

- ▶ Pop-out
- ▶ Steven's Power Law
- ▶ Weber's Law
- ▶ Gestalt principles

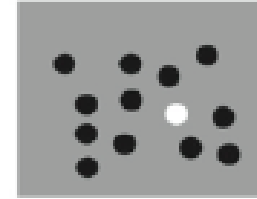
Basic Popout Channels

Color

hue

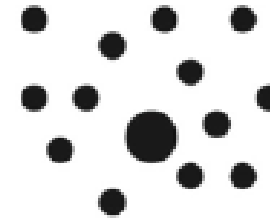


lightness

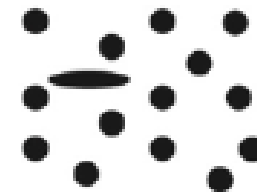


Elementary shape

size



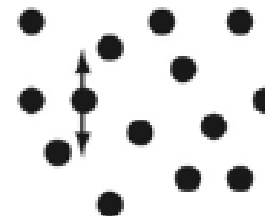
elongation



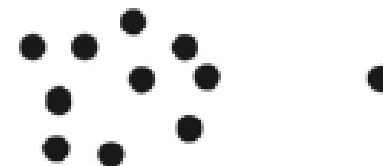
orientation



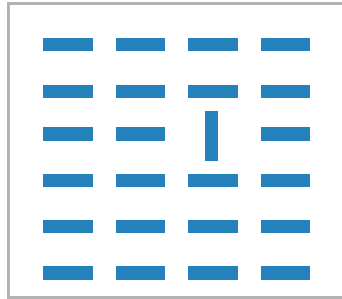
Motion



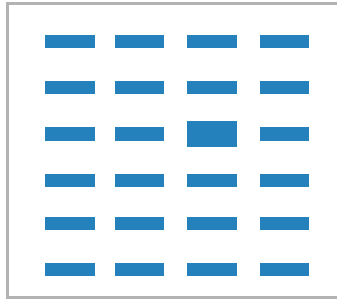
Spatial grouping



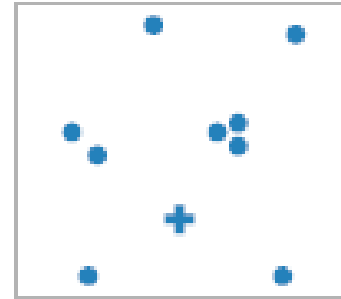
Visual Popout



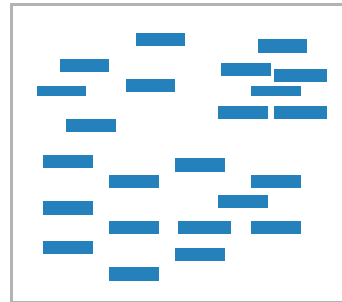
(a)



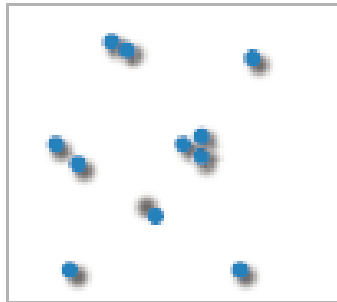
(b)



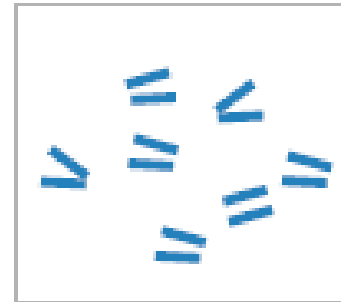
(c)



(d)

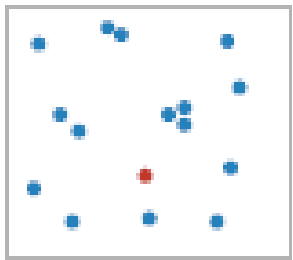


(e)

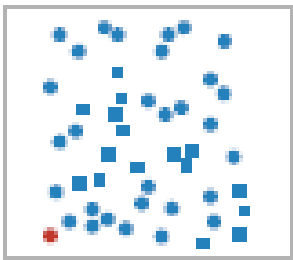


(f)

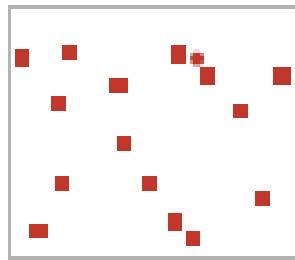
Visual Popout



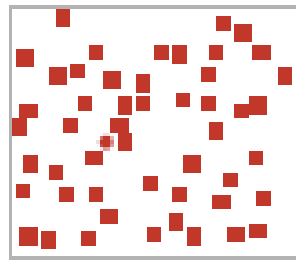
(a)



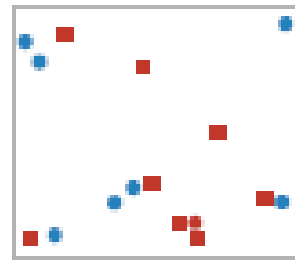
(b)



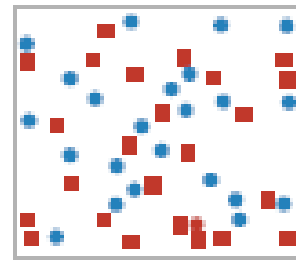
(c)



(d)



(e)



(f)

Takeaway

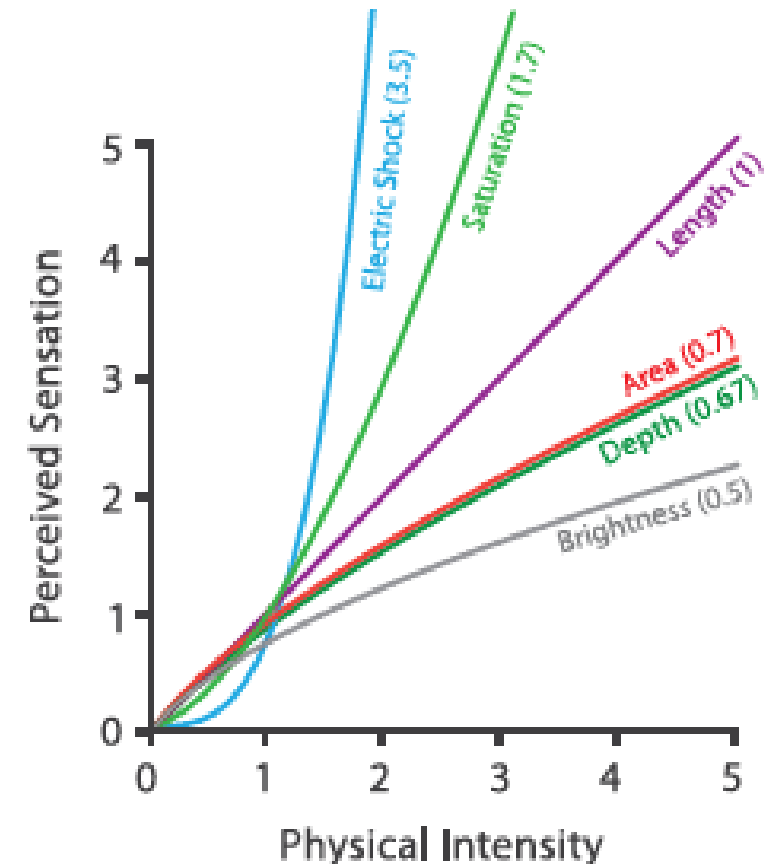
We can easily see object that are different in color and shape, or that are in motion.

Use color and shape sparingly to make the important information pop out.

Psychophysics

- ▶ Way to quantify effectiveness: accuracy
- ▶ How do we perceive changes in stimuli
- ▶ The Psychophysical Power Law [Stevens, 1975]: All sensory channels follow a power function based on stimulus intensity ($S = I^n$)
- ▶ Length is fairly accurate
- ▶ Magnified vs. compressed sensations

Steven's Psychophysical Power Law: $S = I^n$



Our visual system sees differences, not absolute values, and is attracted to edges

Maximize the contrast with the background if the outlines of shapes are important.

Relative vs Absolute Judgement

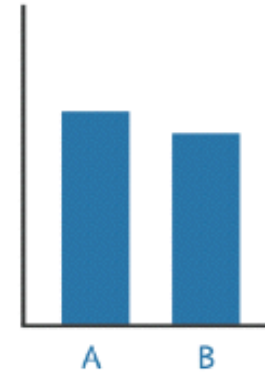
- ▶ Weber's Law
 - ▶ We judge based on relative, not absolute, differences
 - ▶ The amount of perceived difference depends is relative to the object's magnitude!



Unframed
Unaligned



Framed
Unaligned

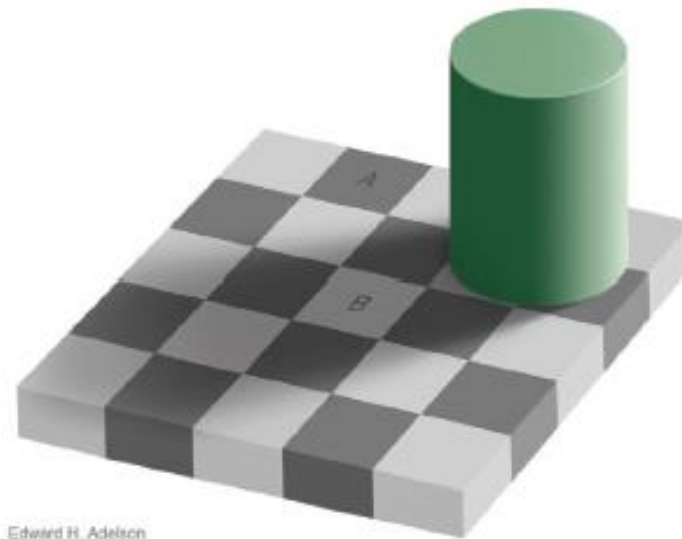


Unframed
Aligned

Gestalt Principles

- ▶ Similarity: things that look like each other (size, color, shape) are related
- ▶ Proximity: things that are visually close to each other are related
- ▶ Connection: things that are visually connected are related
- ▶ Continuity: We complete hidden object into simple, familiar shapes
- ▶ Closure: we see incomplete shapes as complete
- ▶ Figure/Ground: elements are perceived as either figures or background
- ▶ Common fate: elements with the same moving direction are perceived as a unit

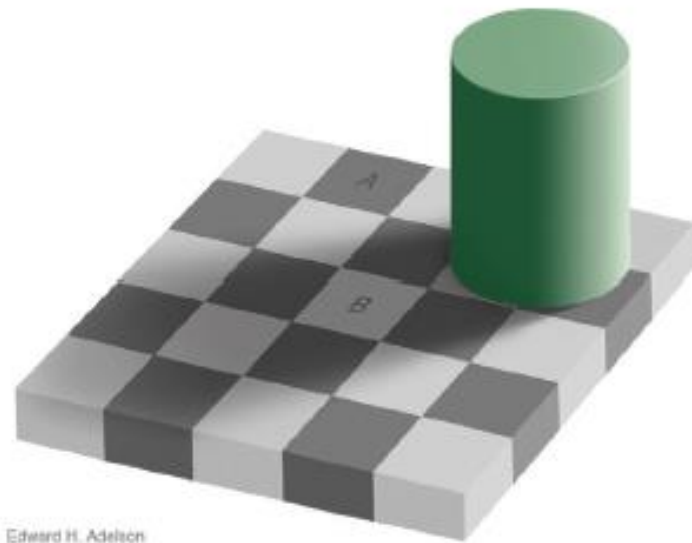
Luminance Perception



Edward H. Adelson

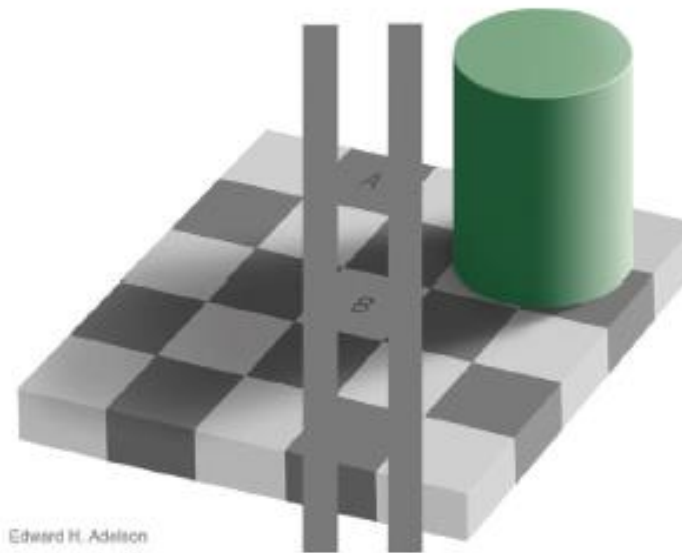
(a)

Luminance Perception



Edward H. Adelson

(a)



Edward H. Adelson

(b)

Interaction of Color



Hue, Saturation, Luminance

Green Hue at 0 Value



Green Hue at -100 Value



An example of the hue slider's ability to replace and alter colour tones.

Red Saturation at 0 Value



Red Saturation at -82 Value



Decreasing the saturation of individual colours is good for removing 'offensive' colours.

Green Luminance at 0 Value



Green Luminance at +64 Value



Adjusting the luminance slider changes the brightness of a colour.

ted.com/talks/hans_rosling_the_best_stats_you_ve_ever_seen

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Hans Rosling | TED2006
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HANSROSLING


19:16

Details About the talk
Transcript 49 languages
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You've never seen data presented like this. With the drama and urgency of a sportscaster, statistics guru Hans Rosling debunks myths about the so-called "developing world."

This talk was presented at an official TED conference, and was featured by our editors on the home page.

ABOUT THE SPEAKER

 **Hans Rosling** · Global health expert; data visionary
In Hans Rosling's hands, data sings. Global trends in health and economics come to vivid life. And the big picture of global development -- with some surprisingly good news -- snaps into sharp focus.

14,719,005 views

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https://www.ted.com/talks/hans_rosling_the_best_stats_you_ve_ever_seen

Sources/Credits

- ▶ Tamara Munzner, Visualization Analysis & Design, A K Peters Visualization Series, CRC Press, 2014.
- ▶ Utah, Miriah Meyer, Visualization (2014).
- ▶ UMass Dartmouth, David Koop, Data Visualization (2015).