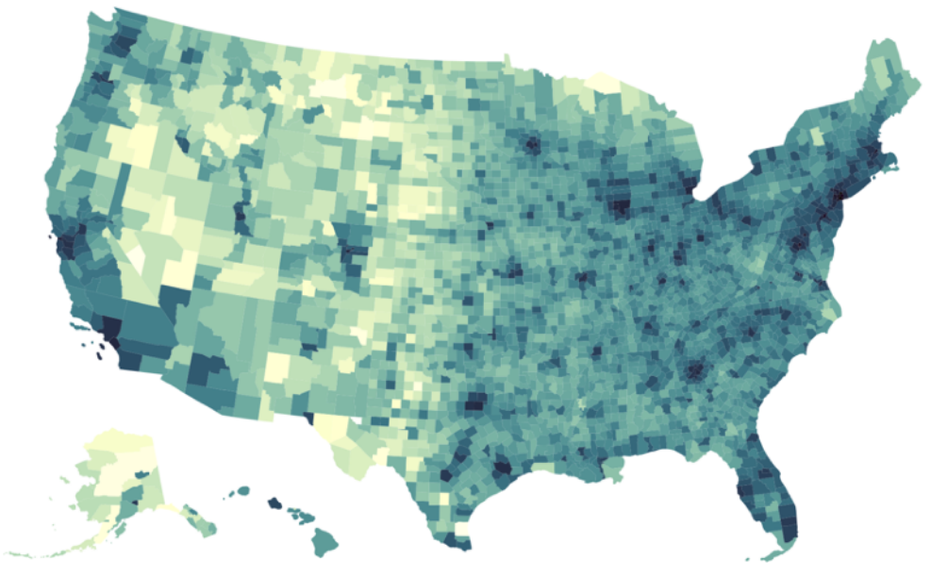
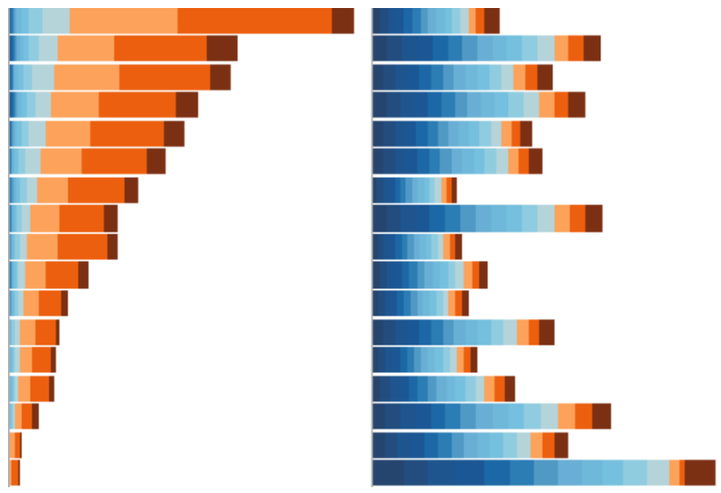
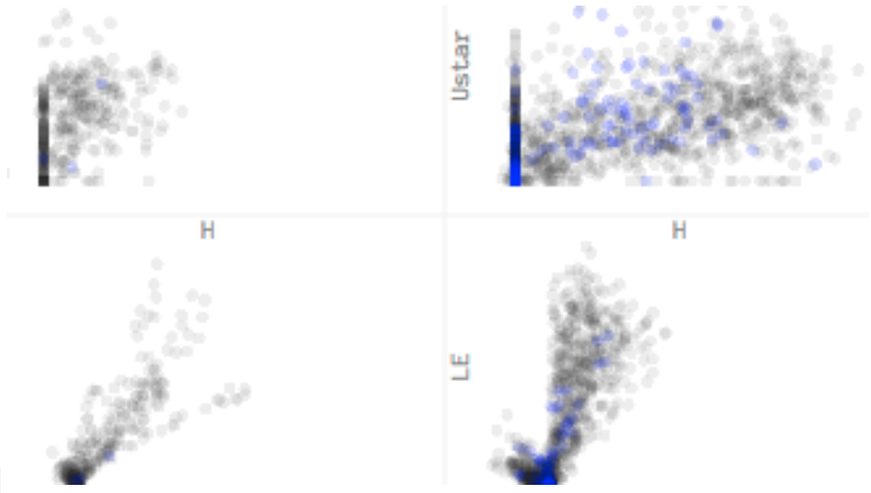




CS 526 Computer Graphics II

Marks & Channels

Khairi Reda | redak@uic.edu
UIC CS

D3 exercises

go.uic.edu/d3

Web server instructions

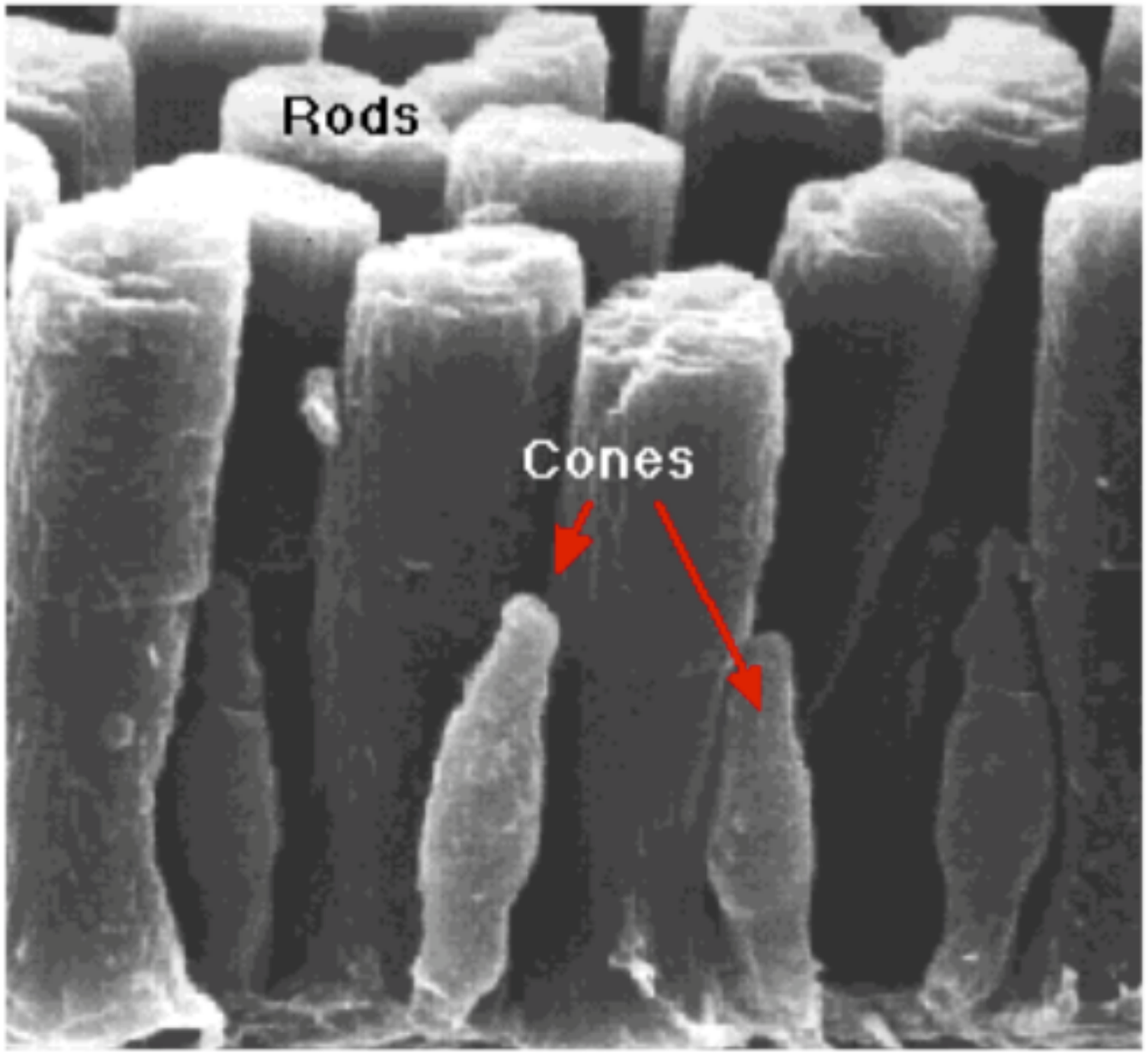
go.uic.edu/webserver

Running Python web server

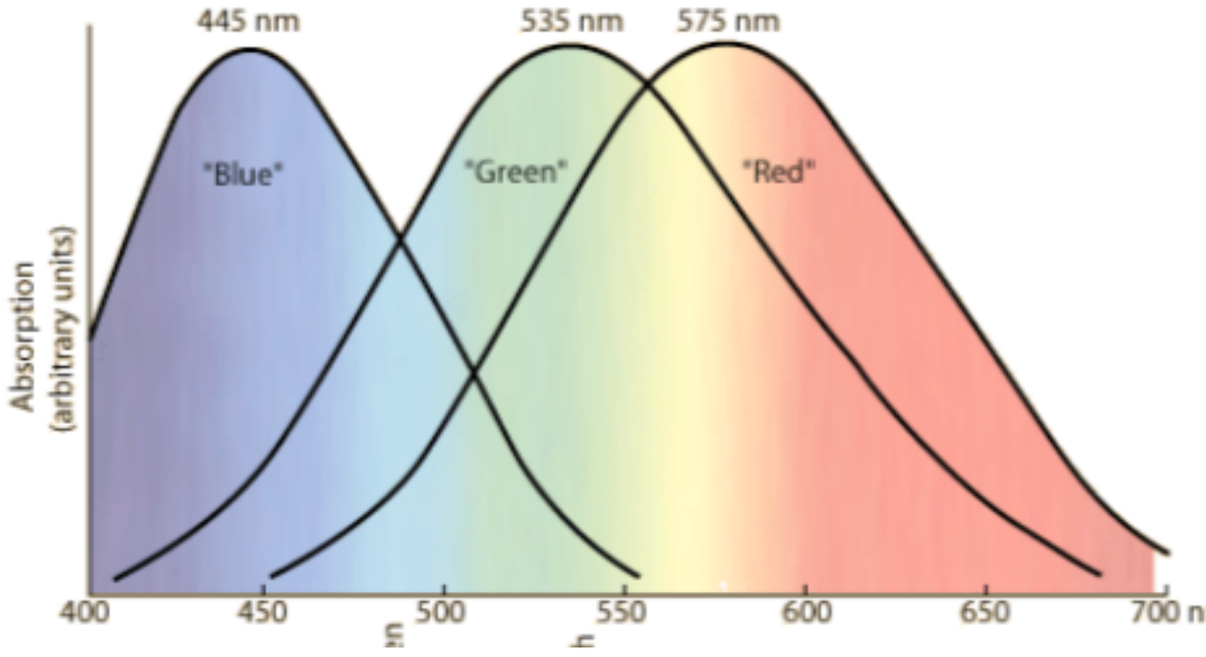
```
[ redak khairis-mbp Desktop ] cd webserver
[ redak khairis-mbp webserver ] ls
cat.jpg
[ redak khairis-mbp webserver ] python3 -m http.server
```

Last weeks...

Cones, Rods, Color vision

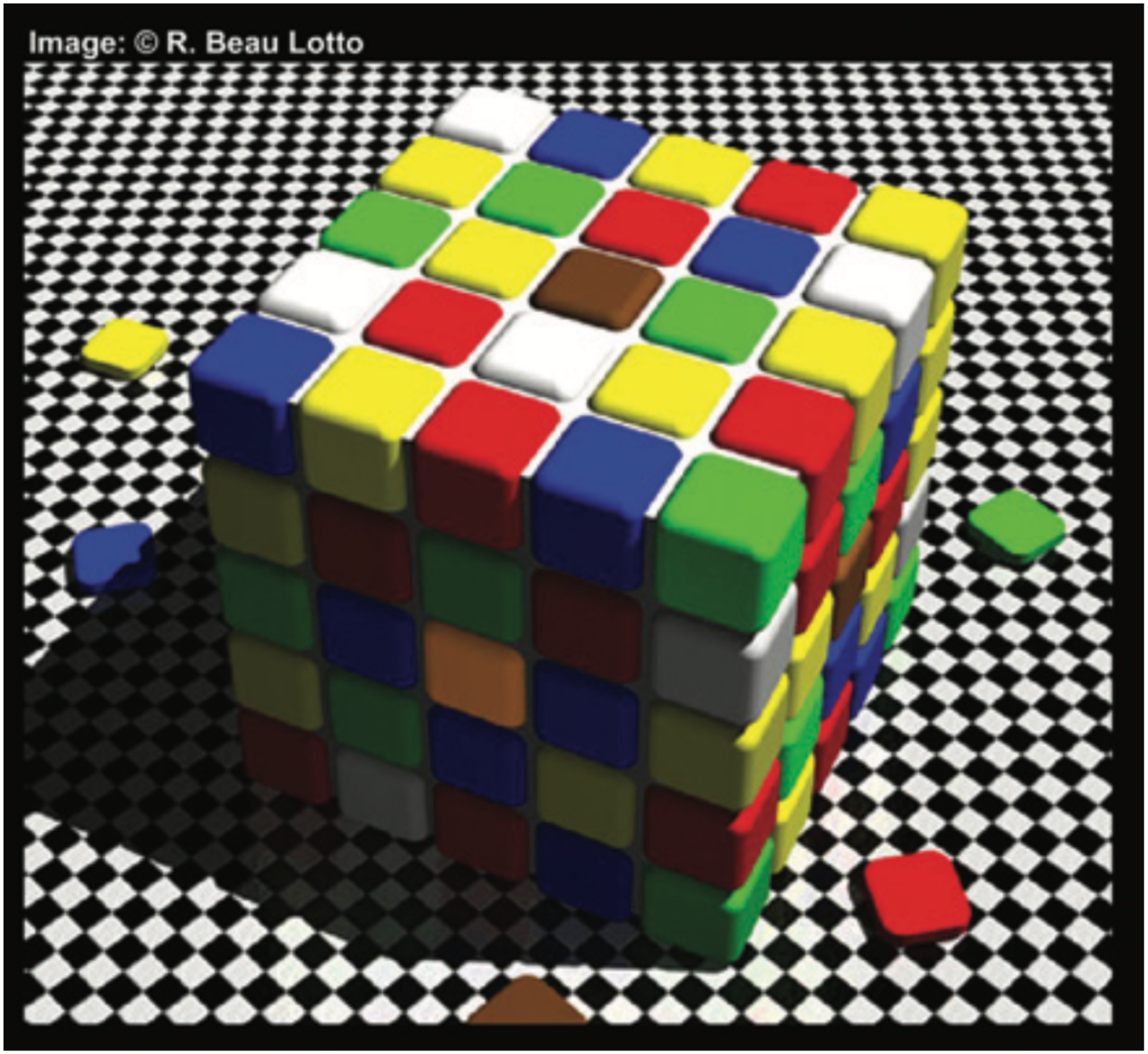


Wandell, “Foundations of Vision”



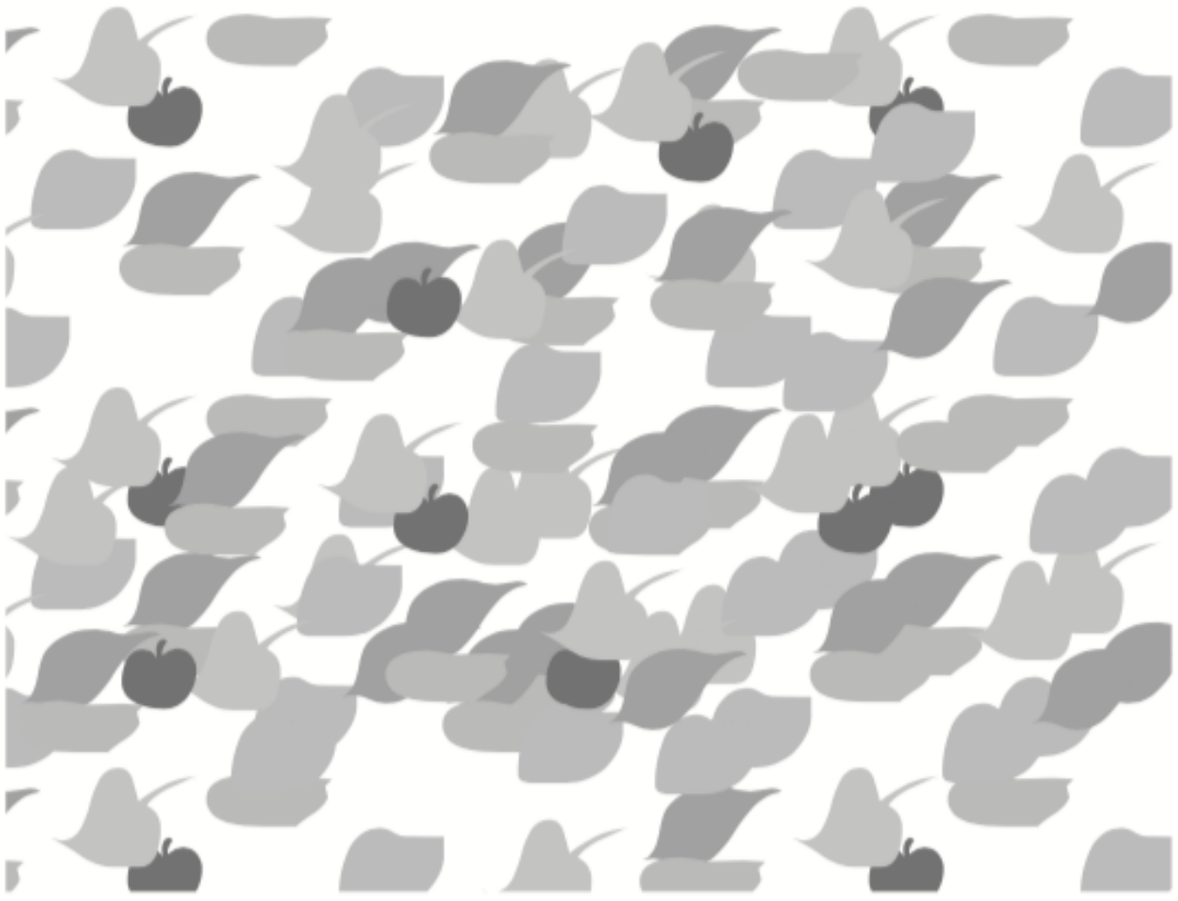
HyperPhysics, Georgia State University

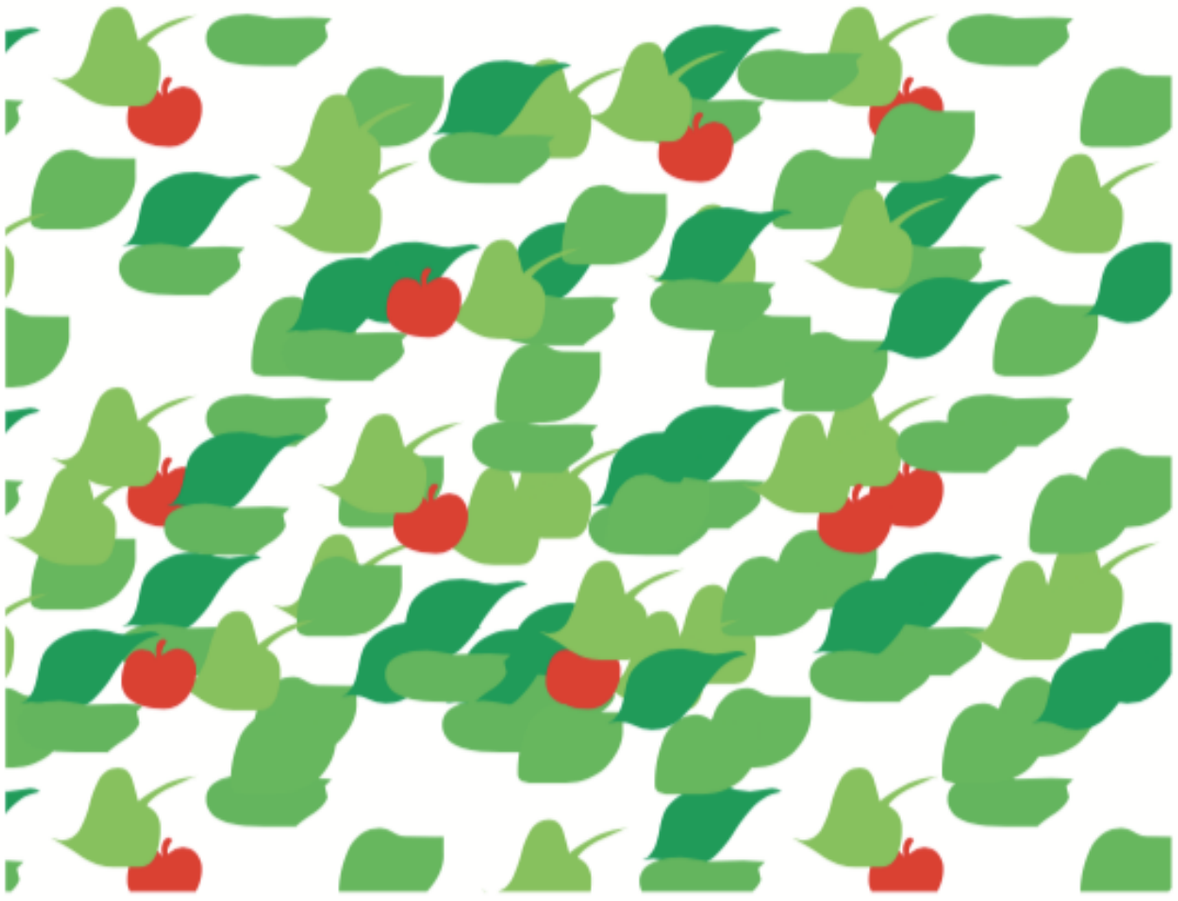
Simultaneous contrast



Simultaneous contrast

POPOUT





Last week…

Our visual system sees differences, not absolute values

We can easily see objects that are different in color and shape, or that are in motion (popouts)

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

This week

- **Visual encoding**
- Marks and channels
- Perceptual accuracy of channels

Terminology

- **Items:** are individual units of data. For example: rows in a table, points on a timeline, nodes, …
- **Attribute (or variable):** a property relating to items

Tables

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box		7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	[illegible]	5-Low	Wrap Bag	0.56	1/20/05
69	[illegible]5	4-Not Specified	Small Pack	0.44	6/6/05
69	[illegible]5	4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

attribute

item

cell

Attribute/Variable Types

✦Categorical (Nominal, Qualitative)

A finite set of categories

No implicit ordering between categories

✦Ordered

- **Ordinal**

  Implicit ordering between categories/levels,
  but no clear magnitude difference.

  Can compare and determine greater/less than

- **Quantitative**

  Meaningful magnitude

  Can do arithmetic

Quantitative Data

Interval vs. Ratio

✦ **Interval**

- Zero does not indicate an absence of detectable measurement
- We can determine distance between measurement, but not proportions
- Example: temperature (Celsius or Fahrenheit), date

✦ **Ratio**

- The position of zero indicates there is nothing of the measured entity
- Can determine ratio and proportions
- Example: weight, age

Quick check

What attribute/variable type (Categorical, Ordinal, Quantitative) best fit the following measurements?

- Speed
- Facebook reactions (Like, Angry, Sad, etc…)
- Car configurations (Compact, Mid-Sedan, SUV)
- Product Name
- IQ scores
- College Majors
- 50-meter race time

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
32	7/16/07	2-High	Medium Box	0.6	7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
69	6/4/05	4-Not Spec		0.6	6/6/05
70	12/18/06	5-Low		0.59	12/23/06
70	12/18/06	5-Low		0.82	12/23/06
96	4/17/05	2-High		0.55	4/19/05
97	1/29/06	3-Medium		0.38	1/30/06
129	11/19/08	5-Low		0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

quantitative
ordinal
categorical

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
32	7/16/07	2-High	Medium Box	0.6	7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
69	6/4/05	4-Not Spec		0.6	6/6/05
70	12/18/06	5-Low		0.59	12/23/06
70	12/18/06	5-Low		0.82	12/23/06
96	4/17/05	2-High		0.55	4/19/05
97	1/29/06	3-Medium		0.38	1/30/06
129	11/19/08	5-Low		0.37	11/28/08
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130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

quantitative
ordinal
categorical

Marks & Channels

The visualization alphabet

How can we represent two numbers: 5, 10?

Marks

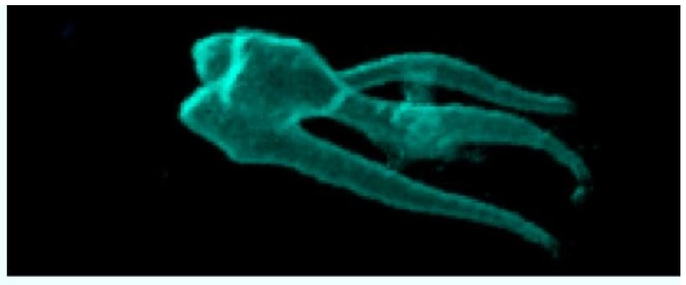
Graphical elements in an image

points (0D)

lines (1D)

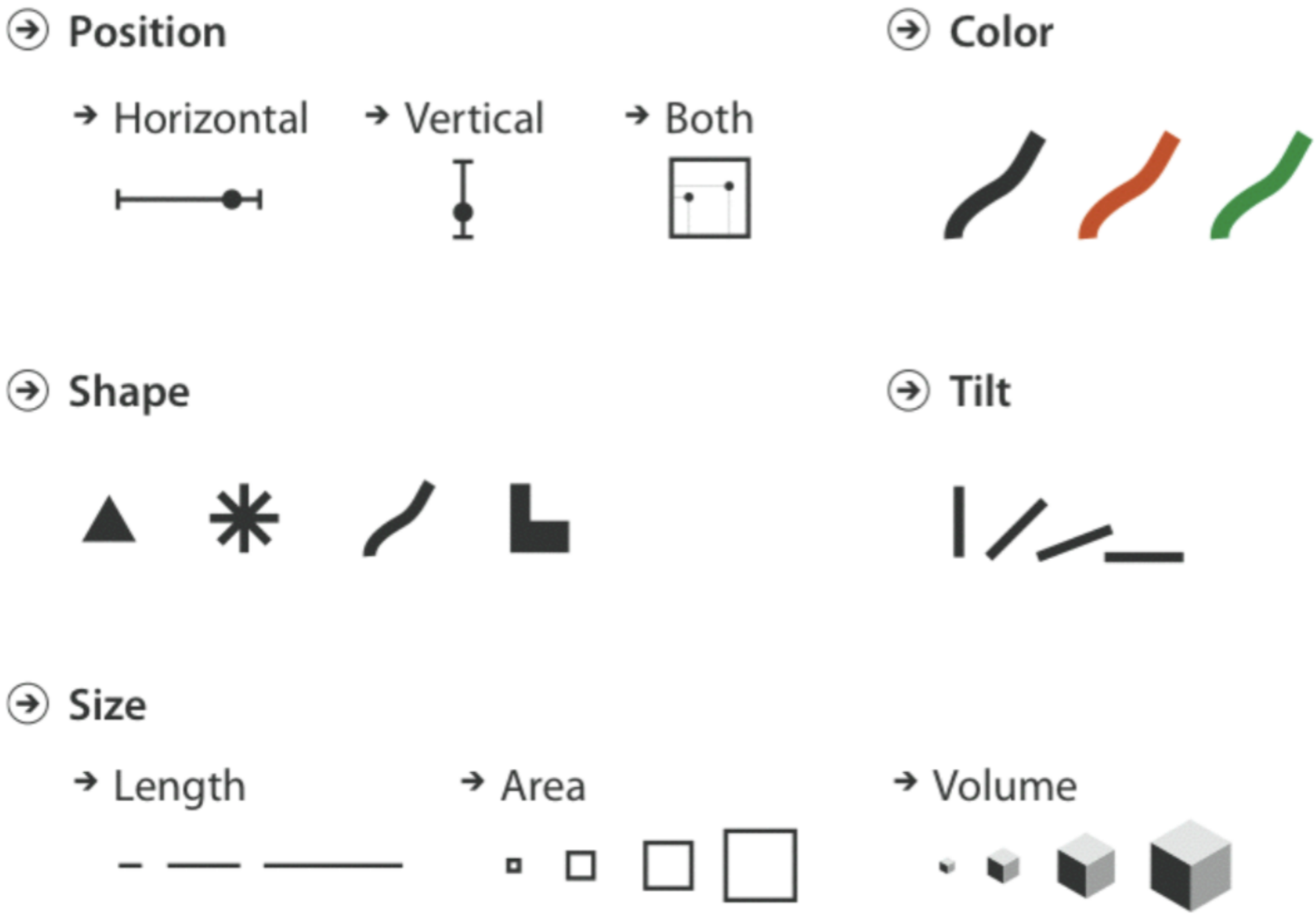
rectangles (2D)

volume clouds (3D)

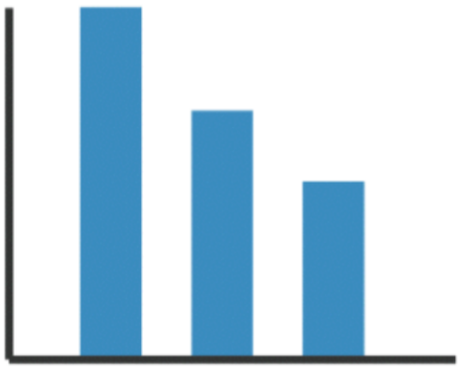


Channels (aka Visual Variables)

Parameters that control the appearance of marks based on **attributes**



Name the mark & channel



Mark: Bar

Channels:

Length mapped to quantitative attribute

Position mapped to categorical attribute

Mark: Point

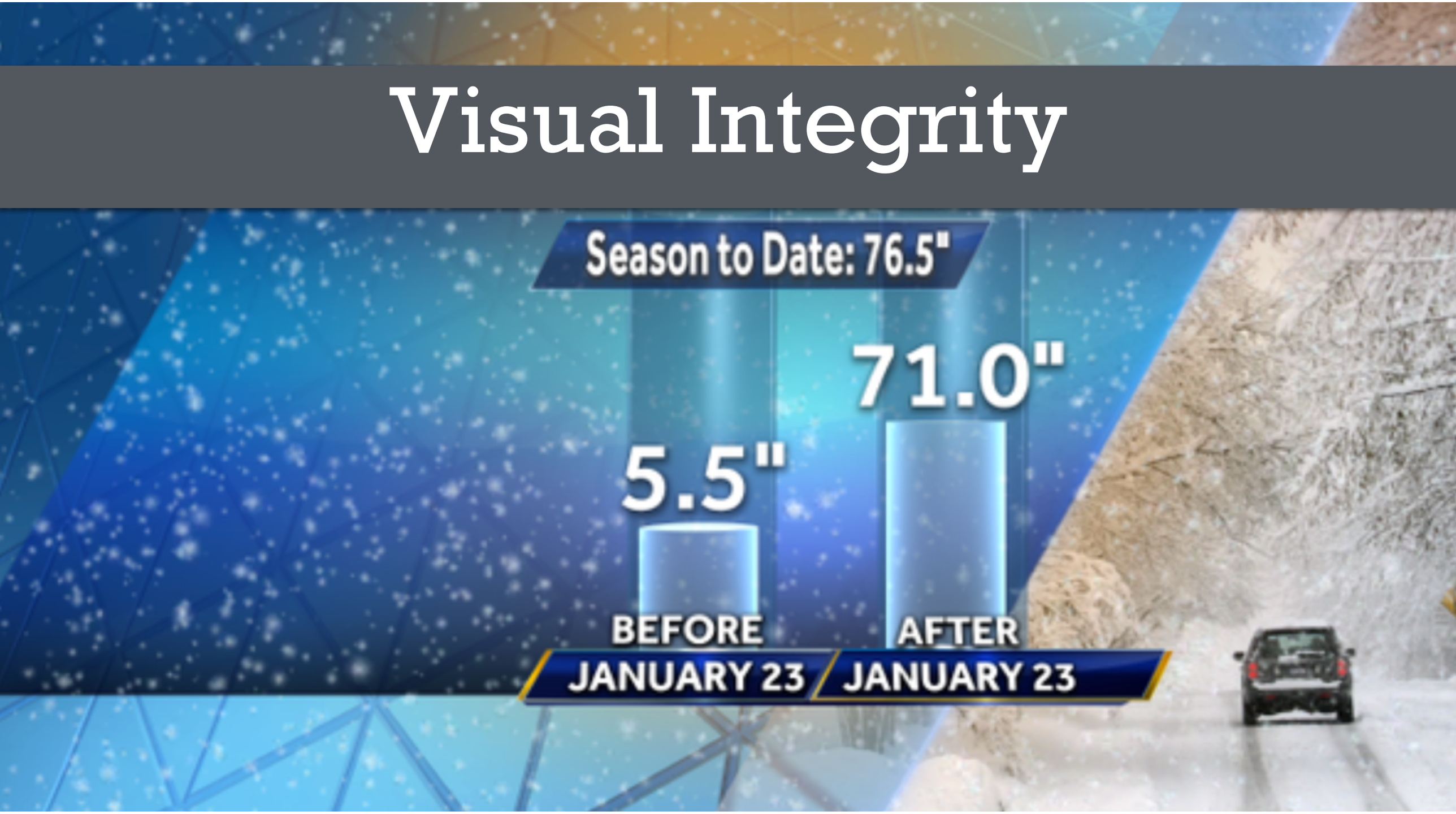
Channels:

Position (x,y) mapped
2 quantitative attributes

+Hue channel
mapped to 1 categorical attribute

+Size channel
mapped to 1 quantitative attribute

What's wrong here?

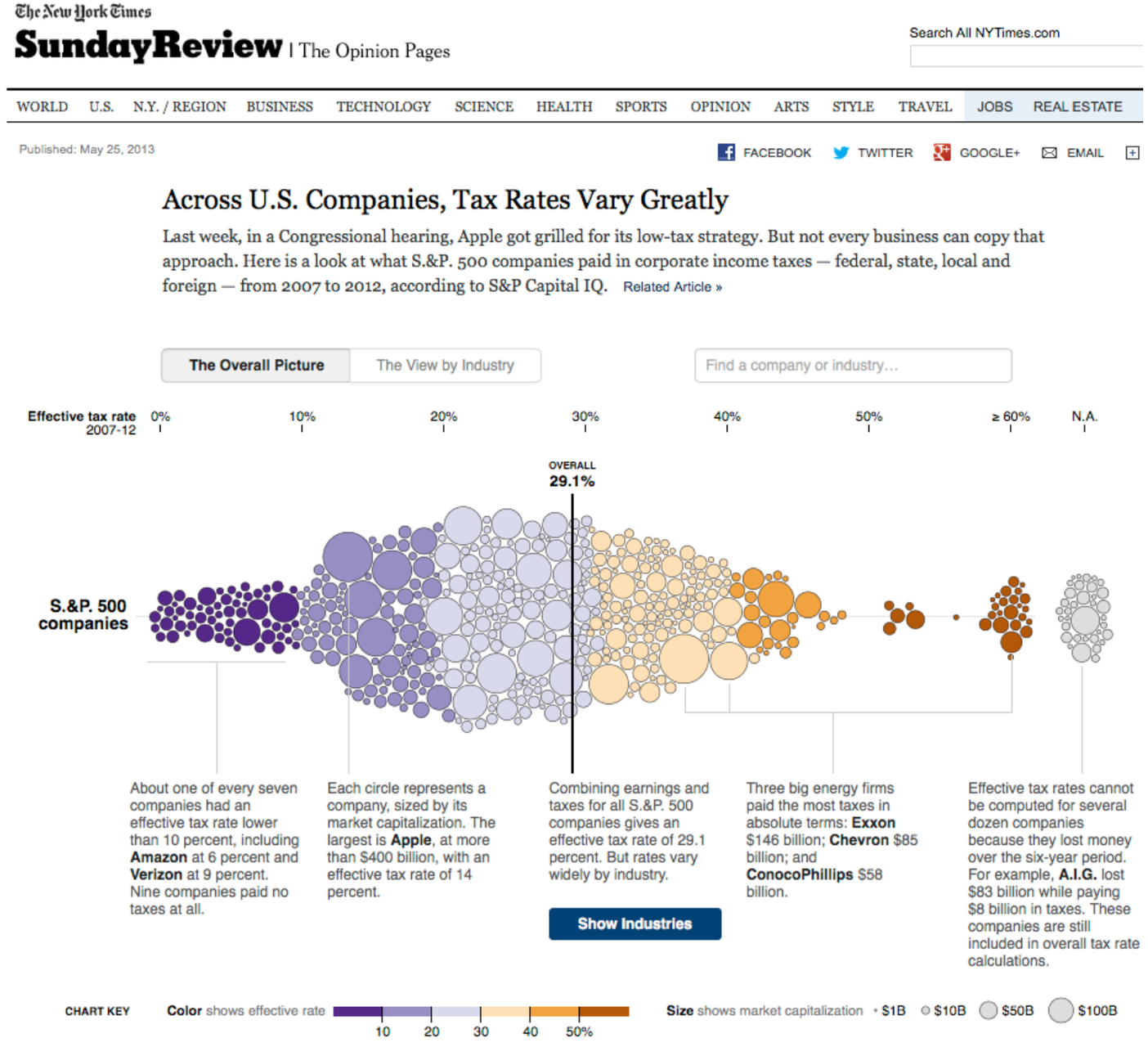


The magnitude of a channel (length in this case) should be proportional to the attribute (snowfall)

Alex Lex

Name the channel

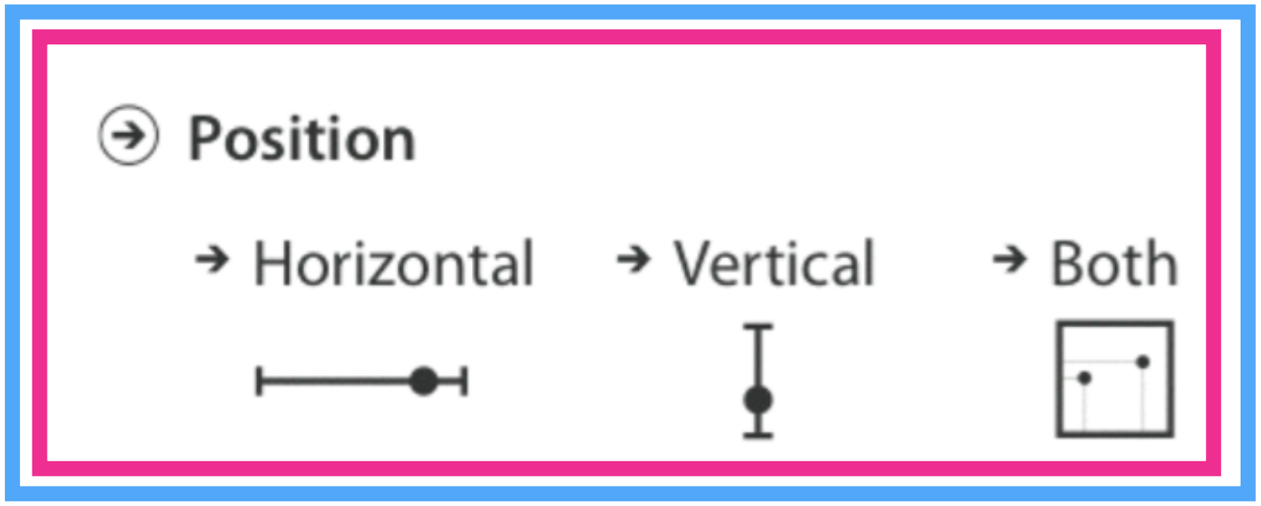
https://tinyurl.com/ybjznp92

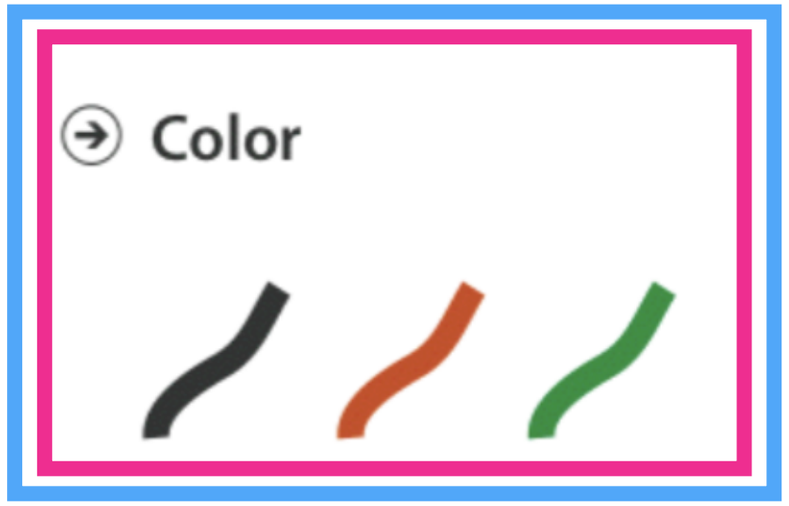


Channel Types

identity (what or where)

magnitude (how much)





Tamara Munzner
Via Miriah Meyer

magnitude channels

good for **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)

identity channels

good for **categorical** attributes

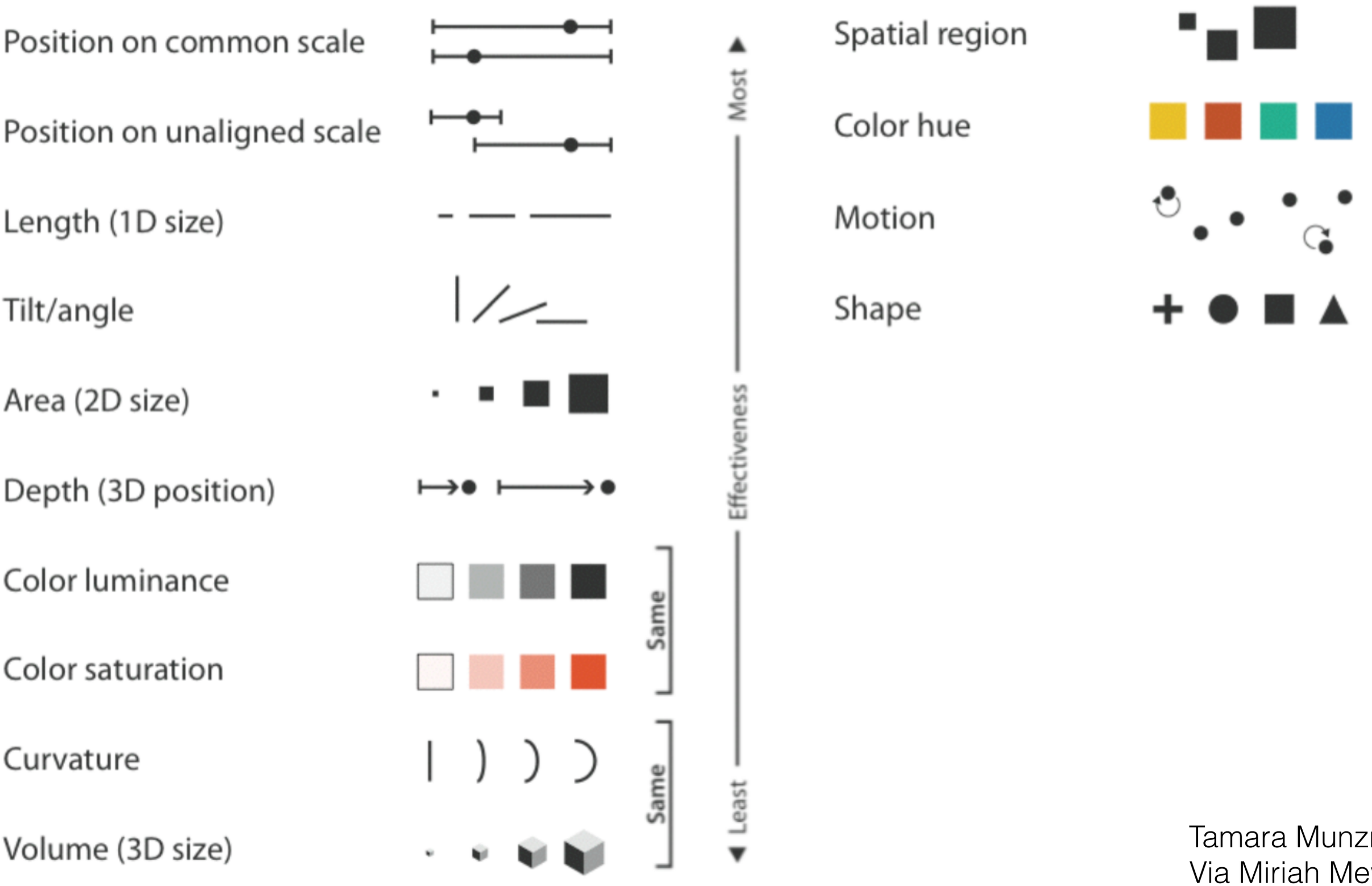
Spatial region

Color hue

Motion

Shape

Tamara Munzner
Via Miriah Meyer

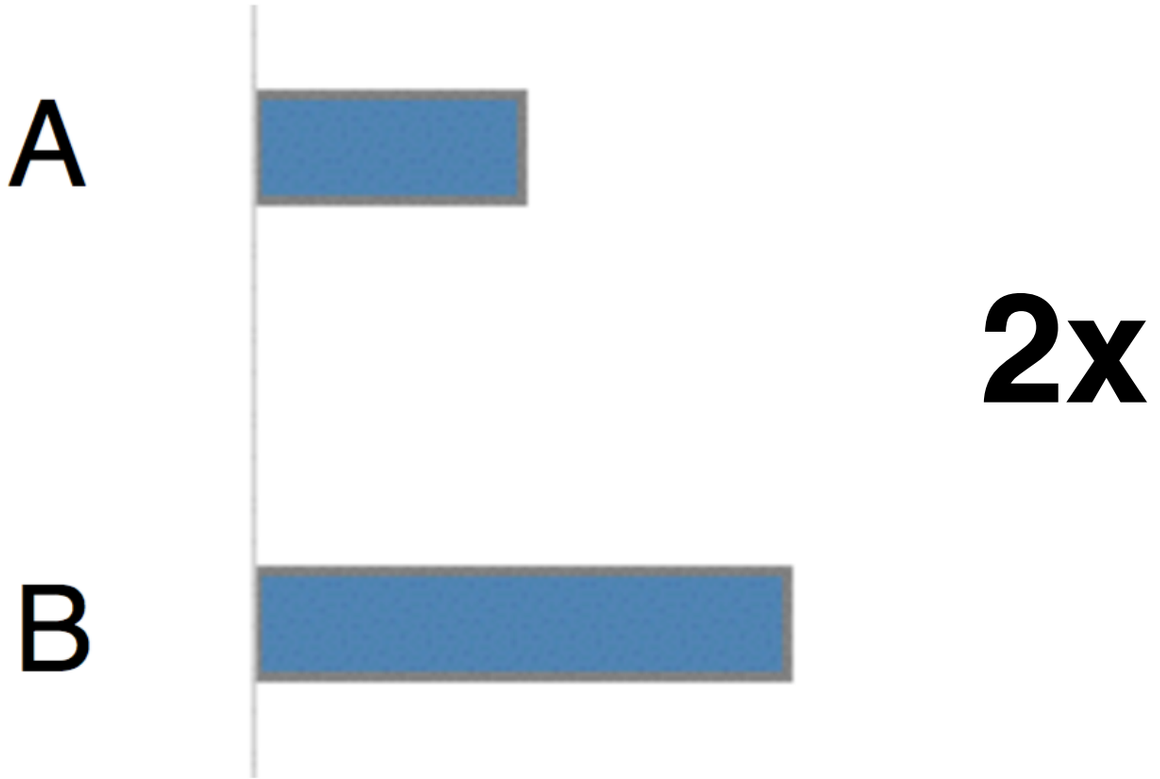


Tamara Munzner
Via Miriah Meyer

How do we know the relative accuracy of the visual channels?

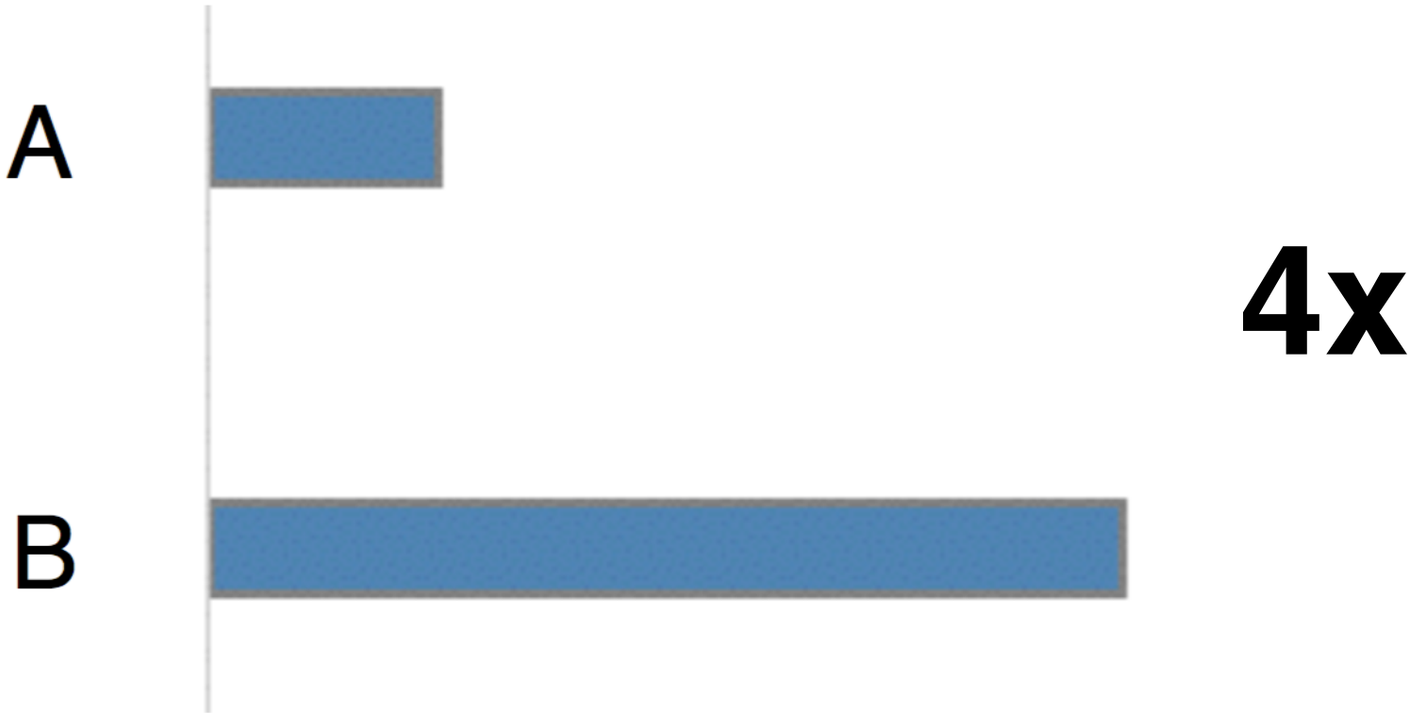
Let’s play a game…

How much longer?



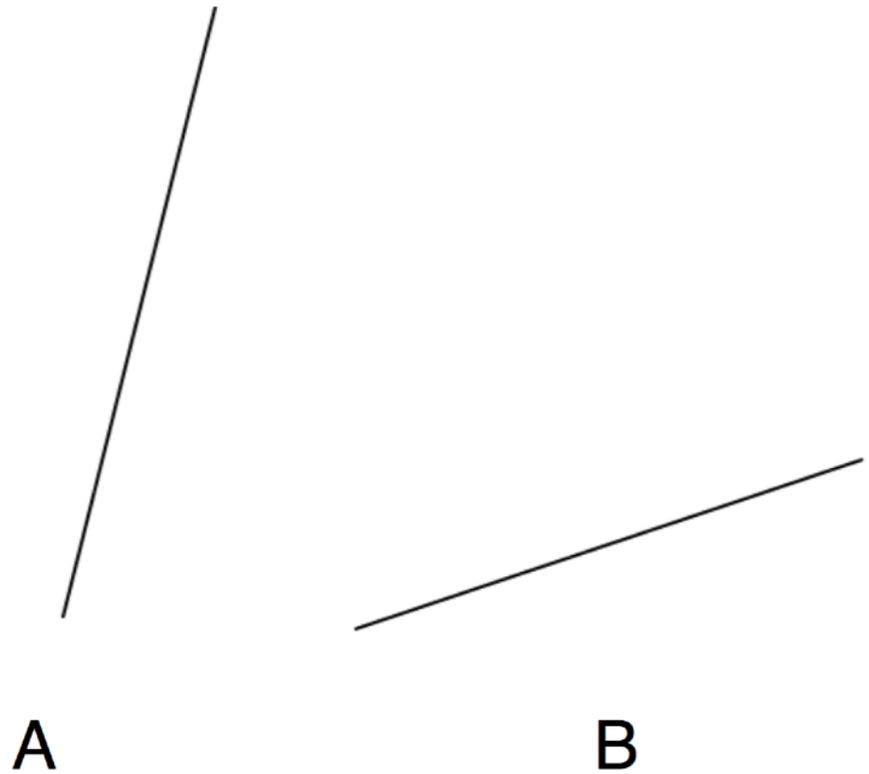
Alex Lex

How much longer?



Alex Lex

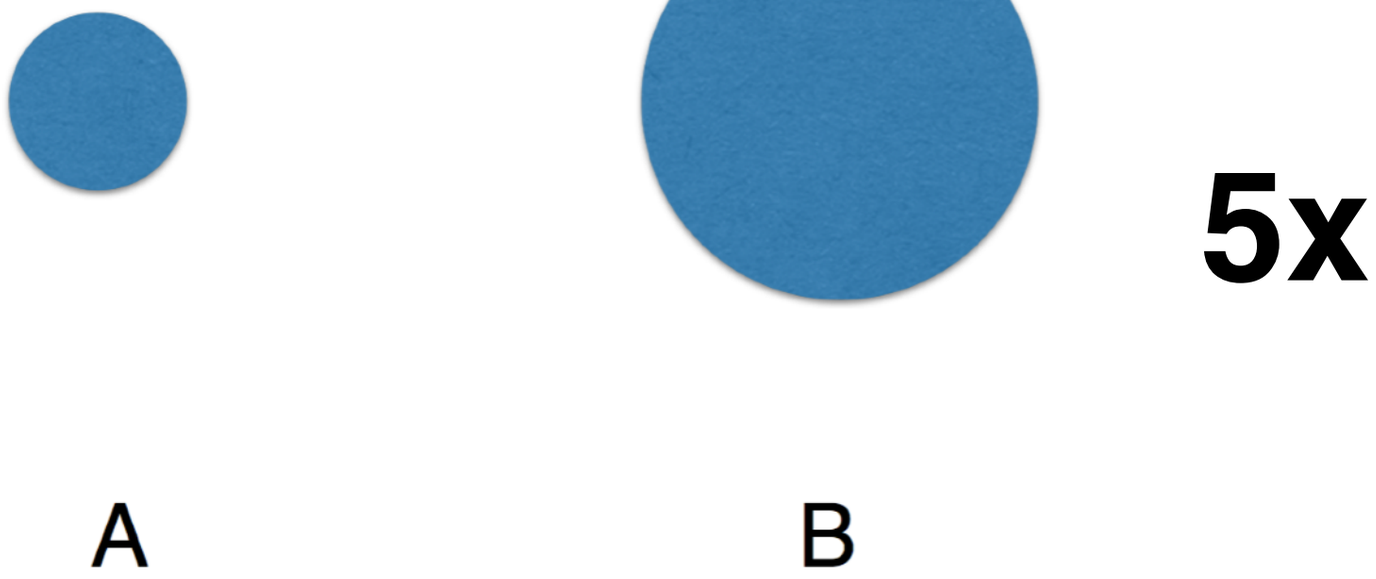
How much tilt?



4x

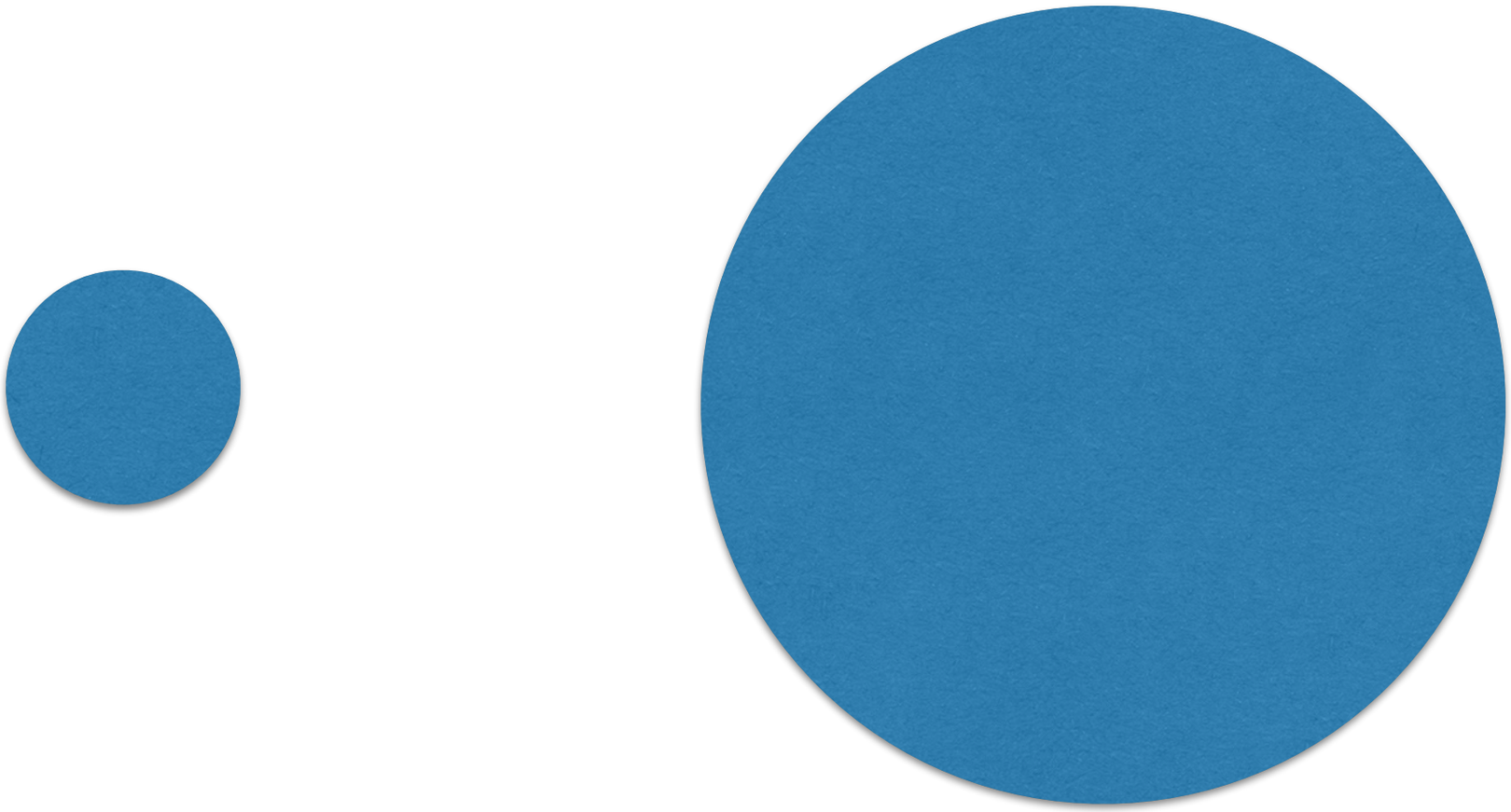
Alex Lex

How much larger (area)?



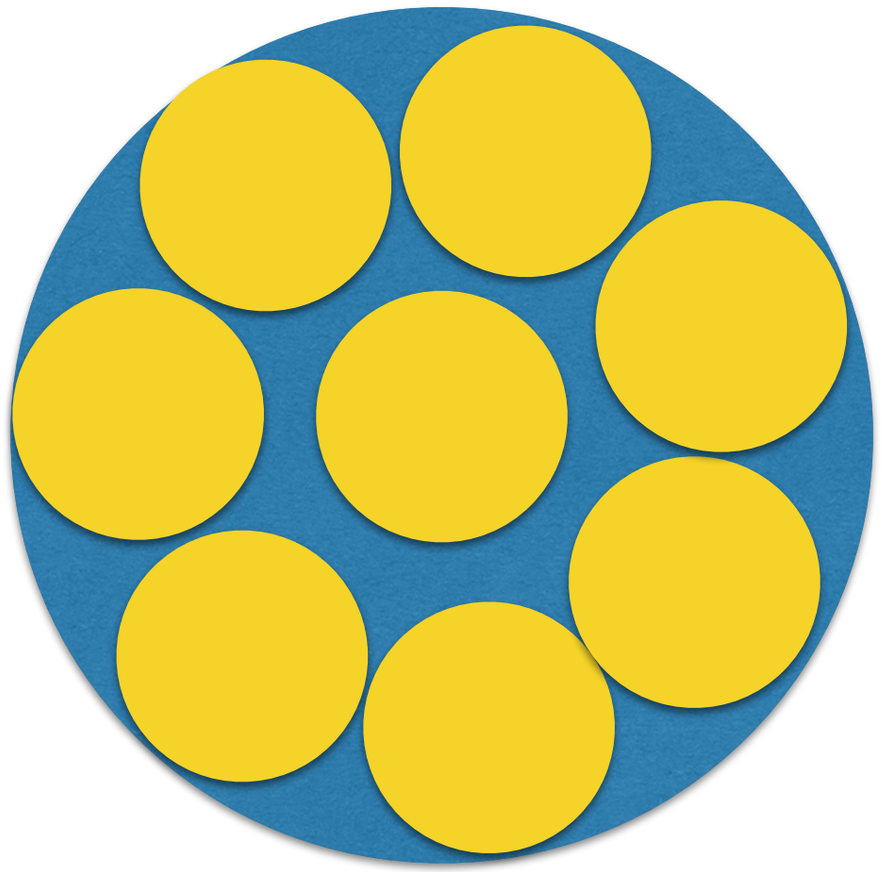
Alex Lex

How much larger (area)?



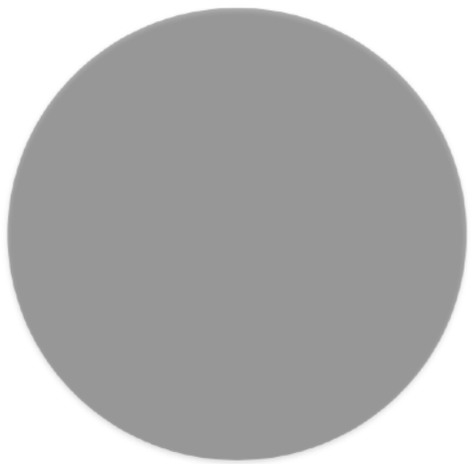
11x

How much larger (area)?

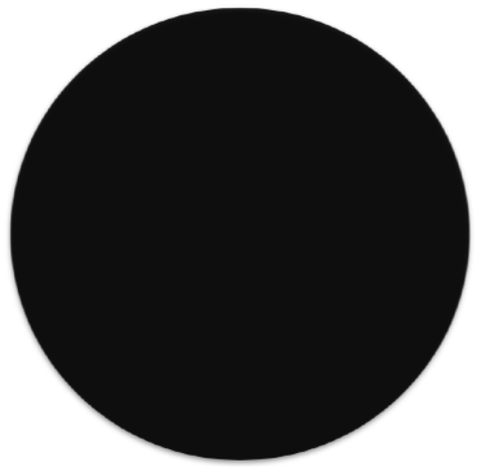


11x

How much darker?



A



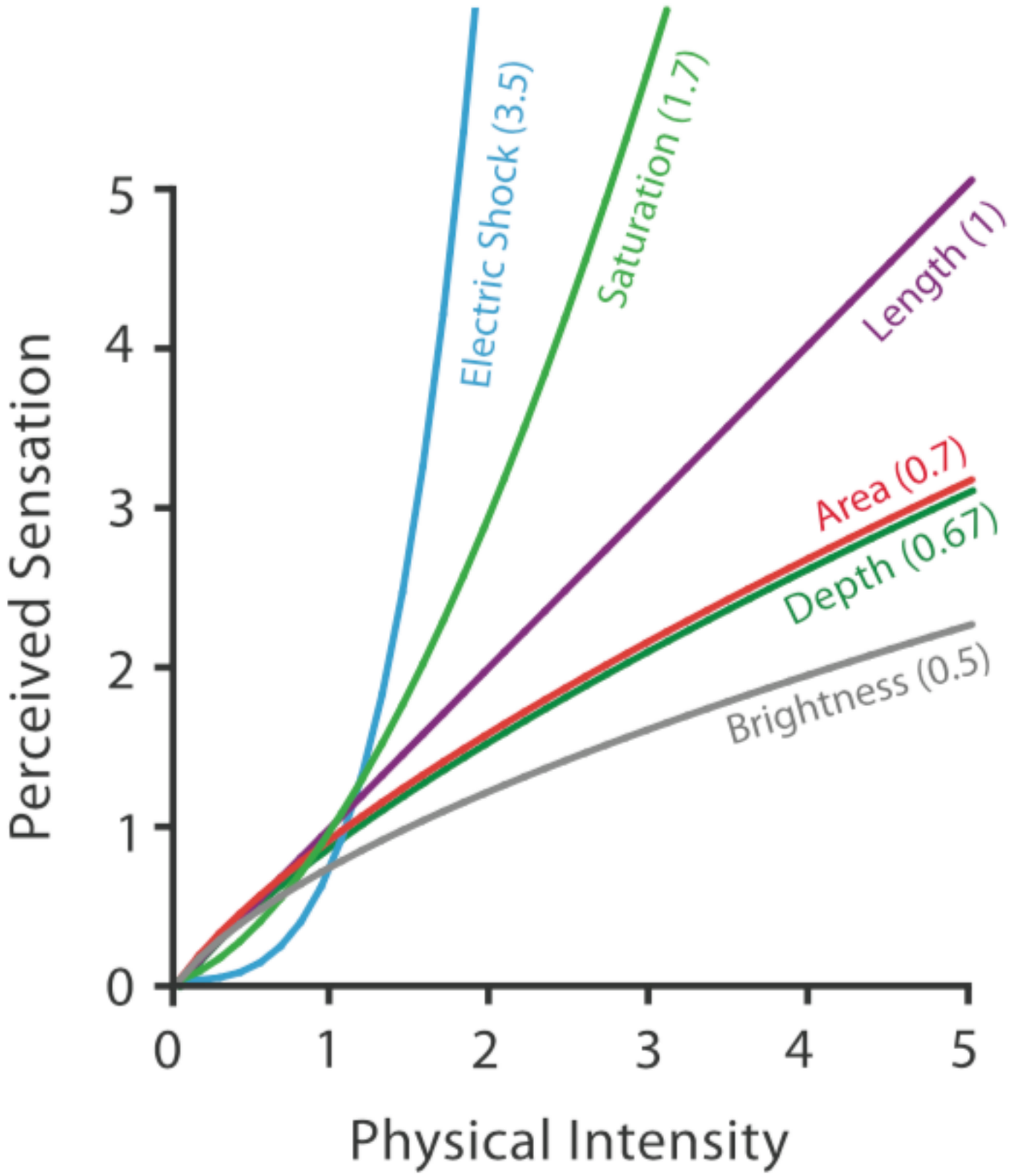
B

3x

Alex Lex

Psychophysics

Steven's Psychological power law



perceived
sensation

$$S = I^n$$

physical
intensity

Cleveland & McGill, 1984

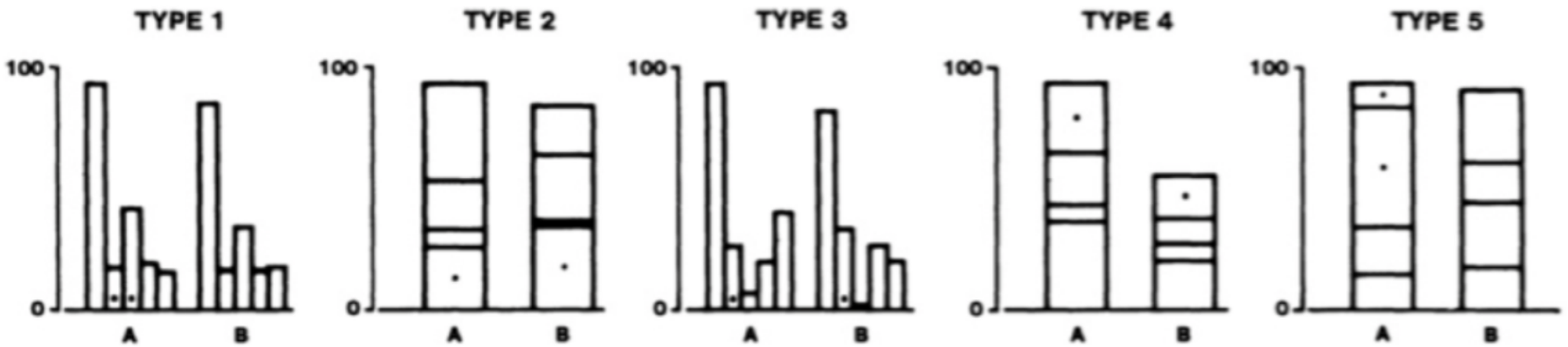


Figure 4. Graphs from position–length experiment.

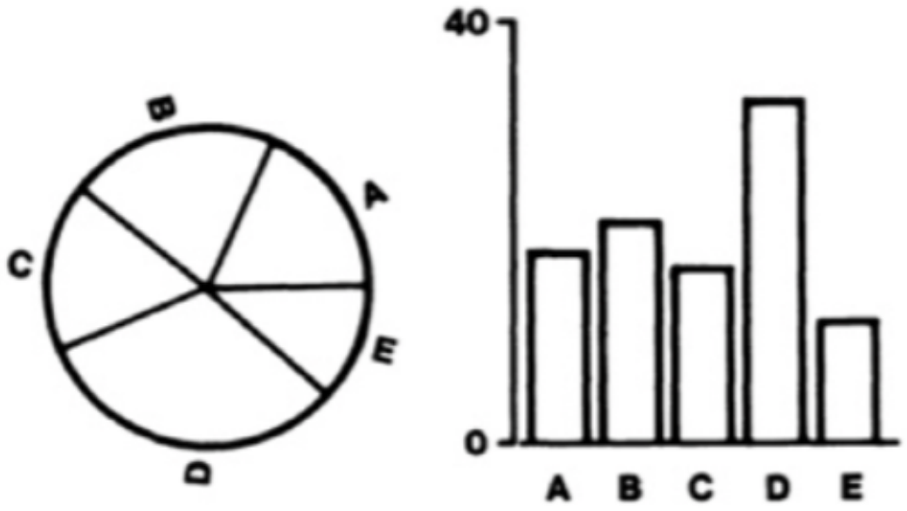
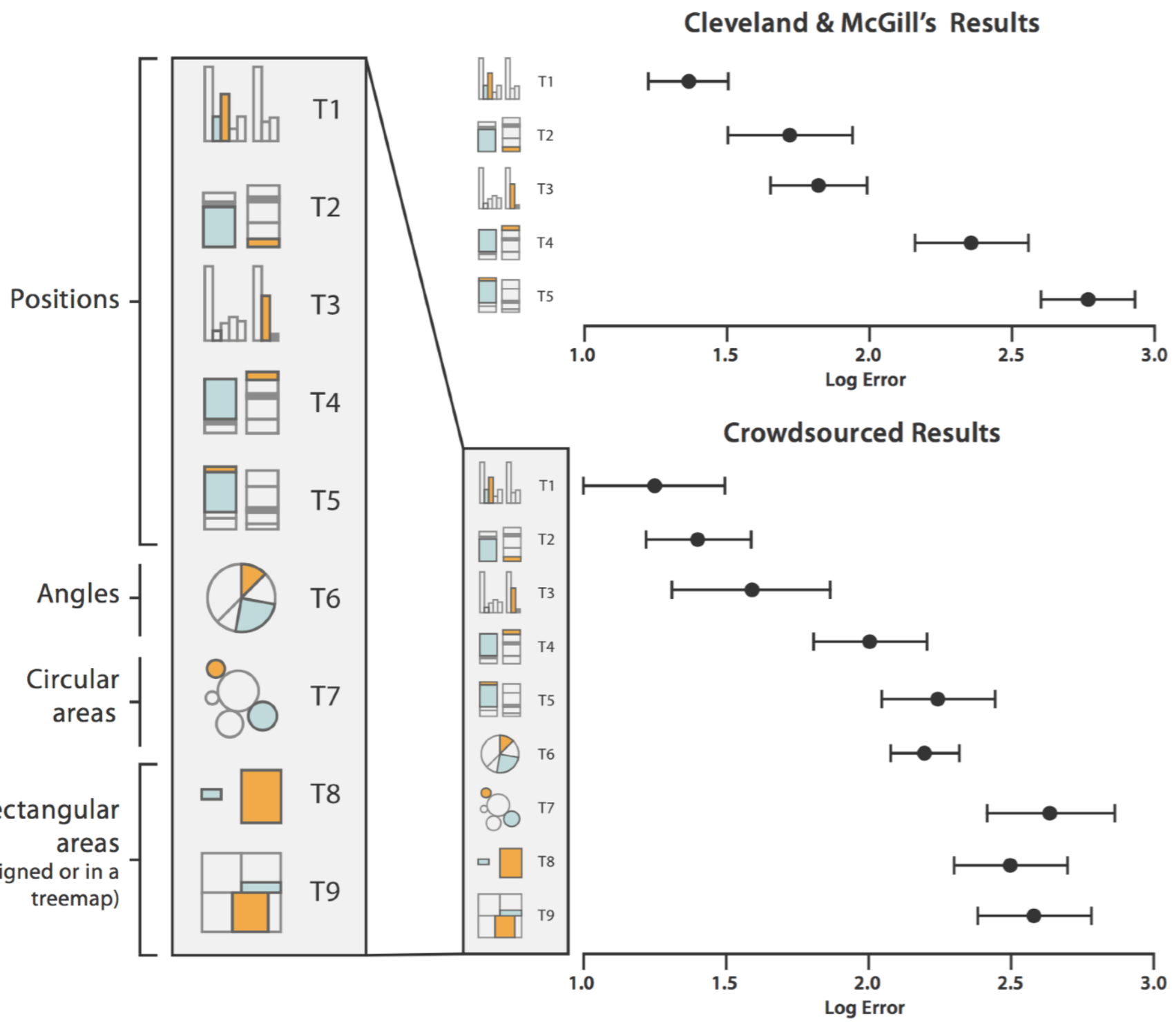


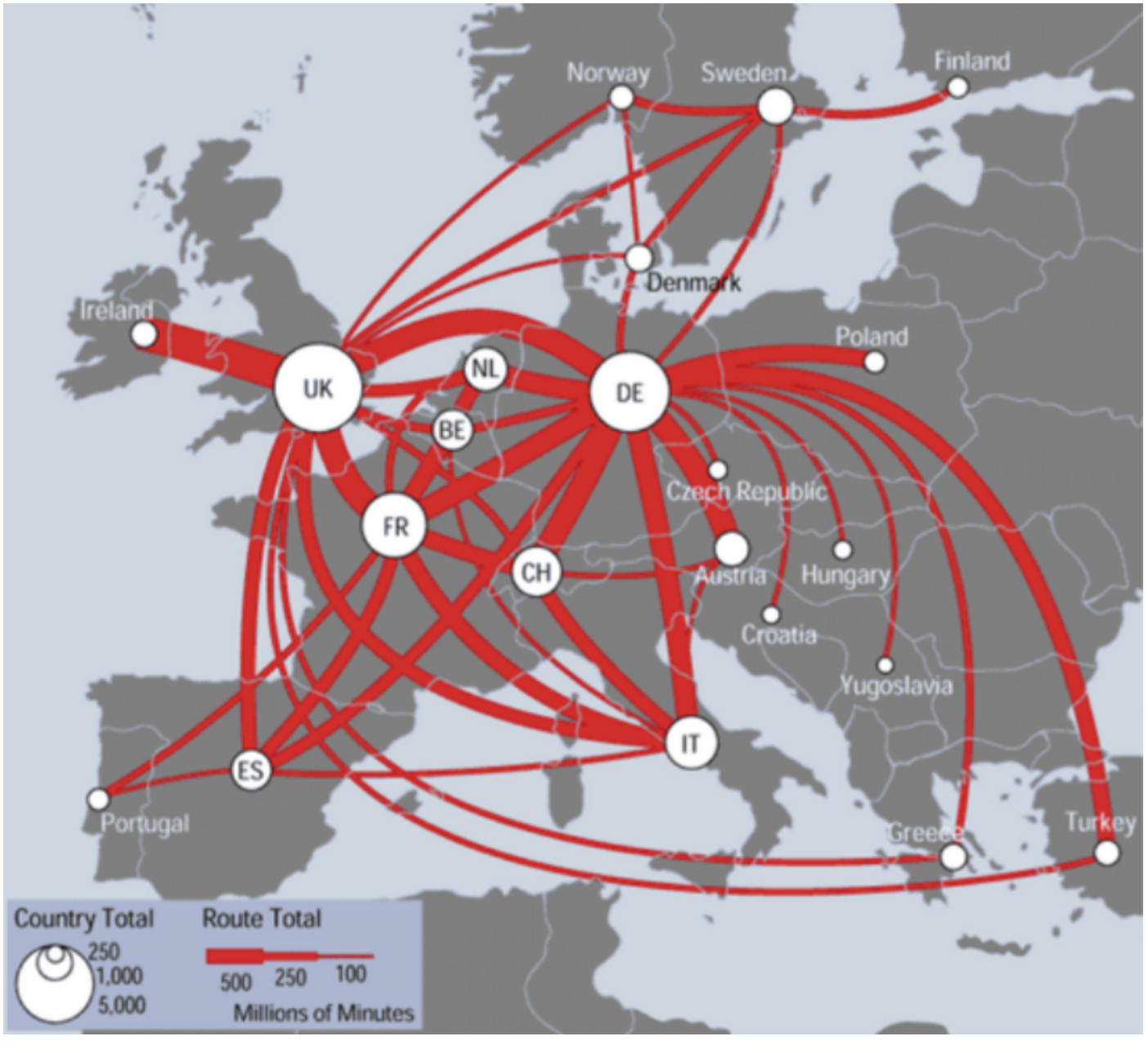
Figure 3. Graphs from position–angle experiment.

Heer & Bostock, 2010



Discriminability

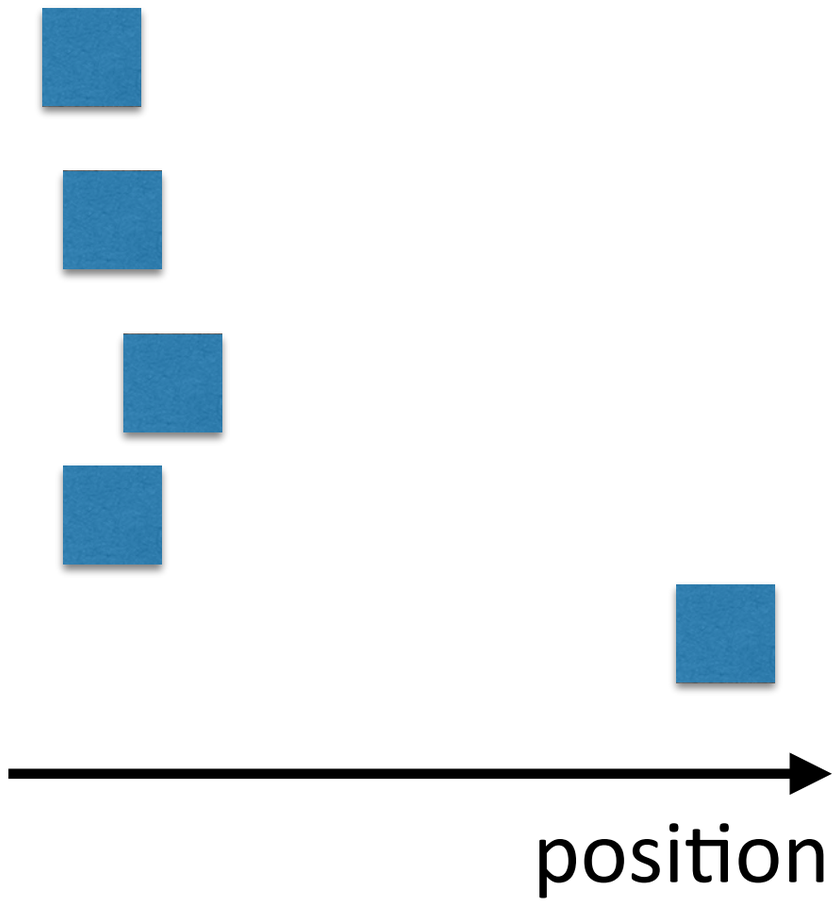
can channel differences be discerned?



Via Miriah Meyer

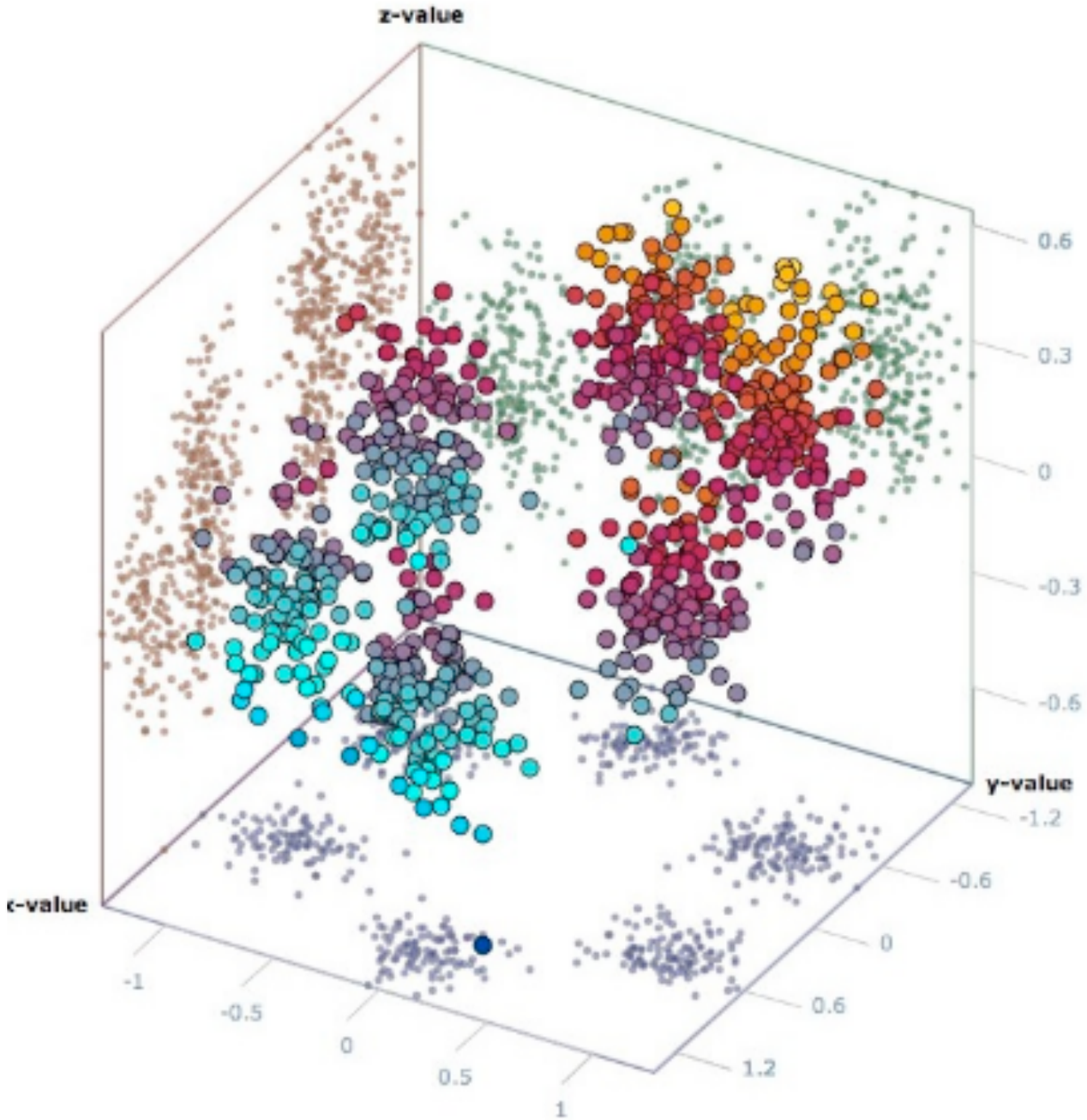
Position

Offers very good discriminability



Position

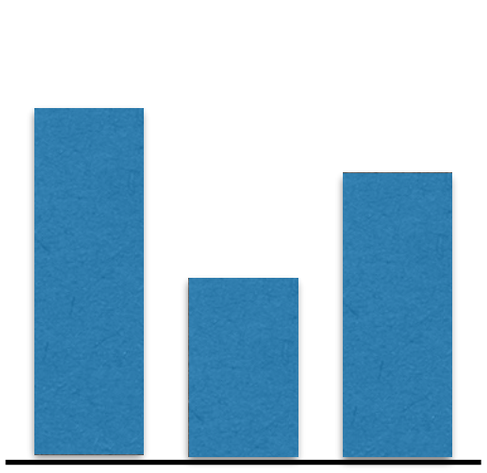
But this doesn’t extend to 3D!



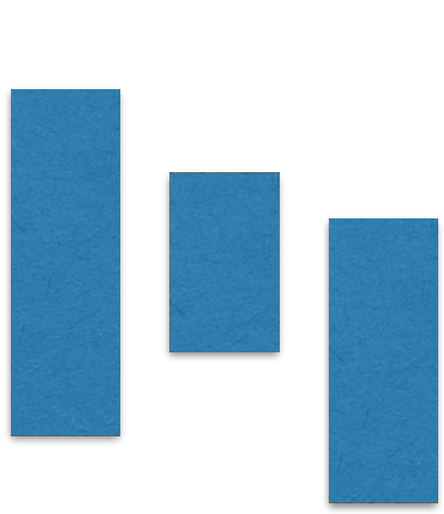
Perspective distortion

Occlusions

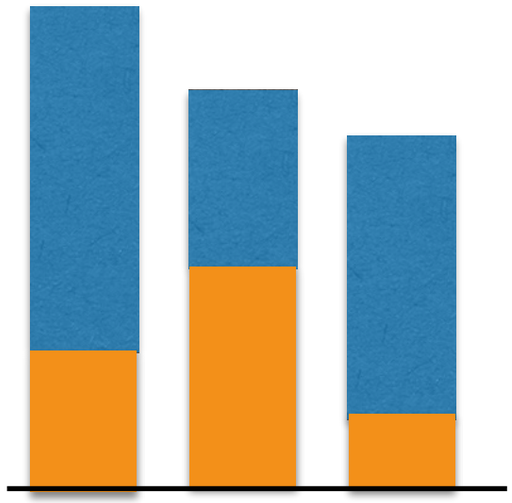
Factors affecting accuracy of Length/Position judgement



aligned



unaligned



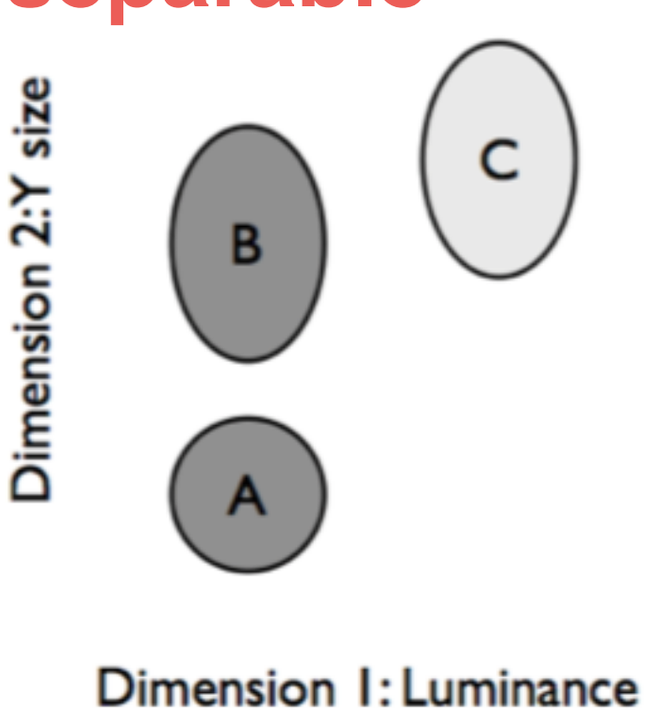
stacked bar chart (unaligned)

Separable vs Integral channels

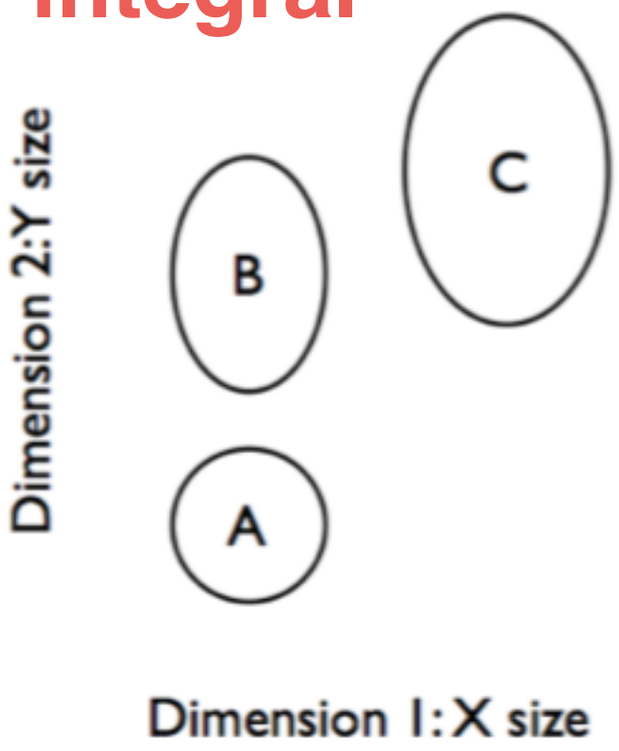
separable channels: can be judged individually

integral channels: are viewed holistically

separable



integral



Ware 2004
Based on a slide by Miriah Meyer

Separable vs Integral channels

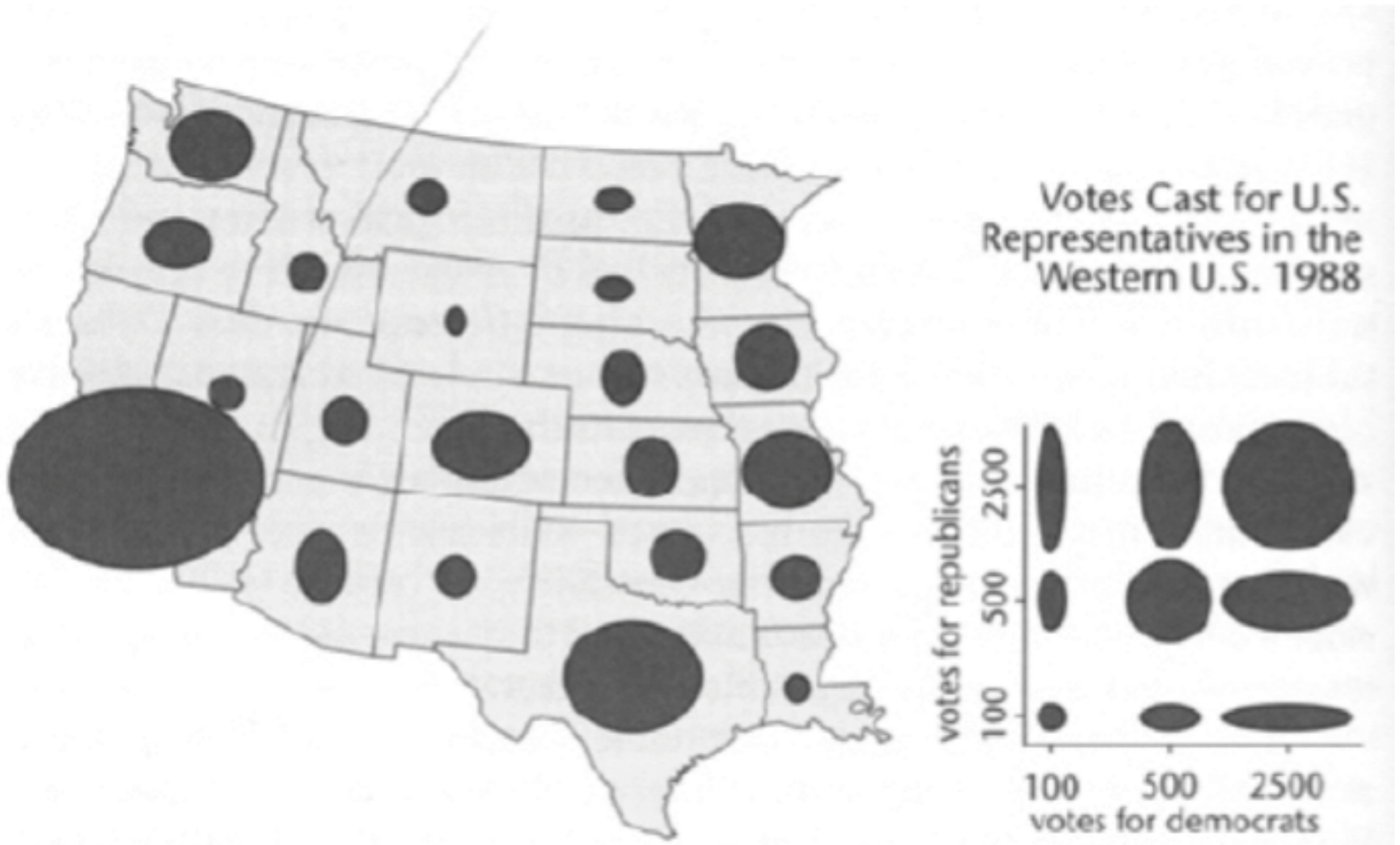
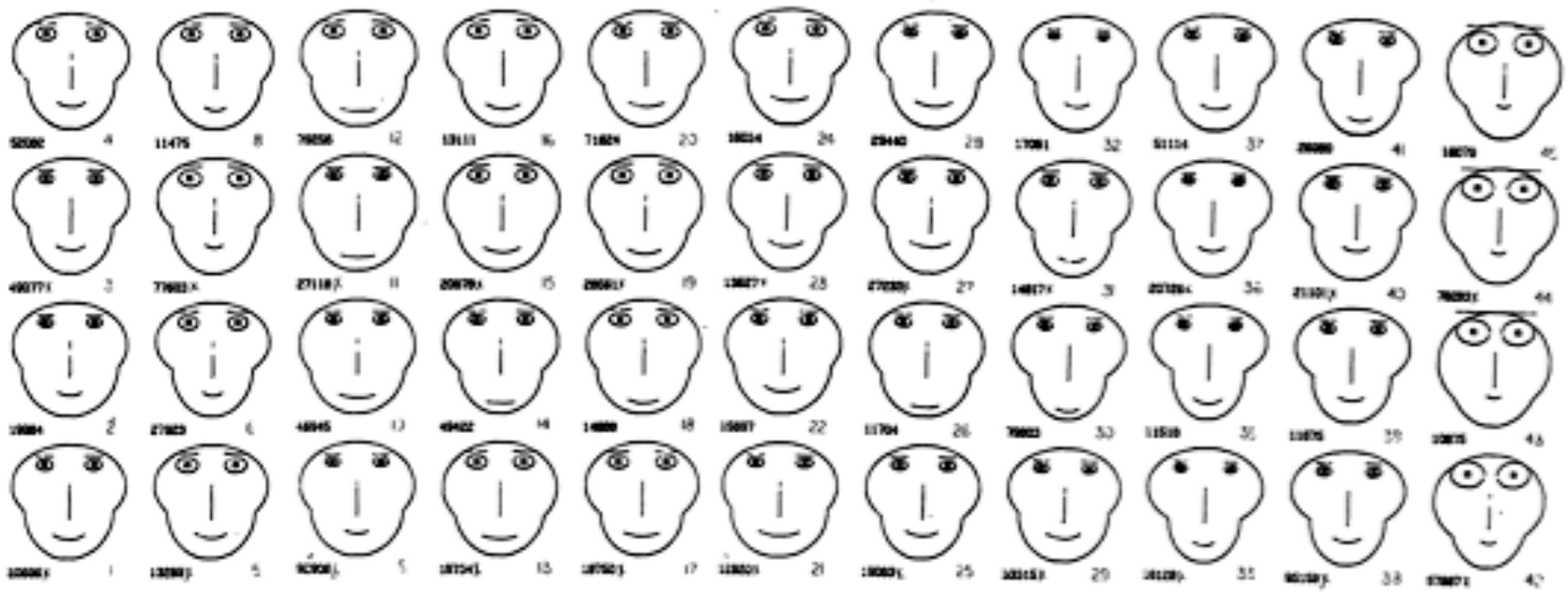
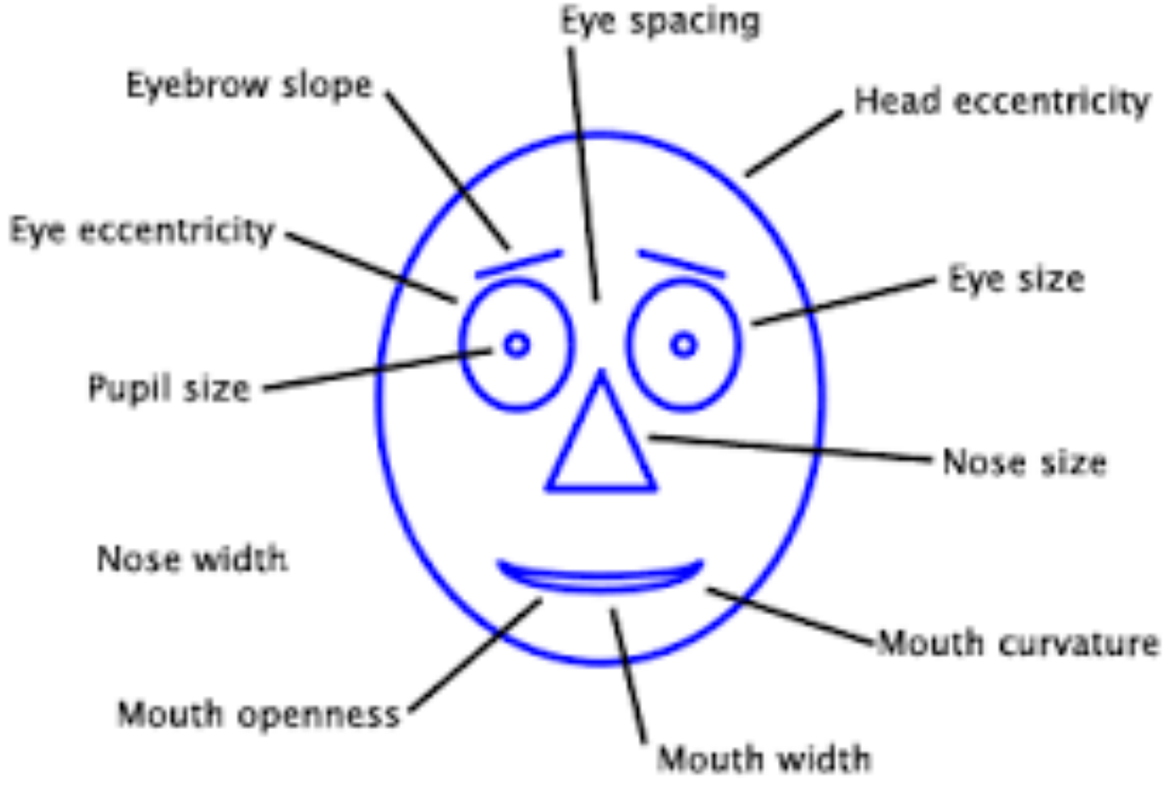


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

MacEachren 1995
Via Miriah Meyer

Chernoff faces





Chernoff faces