

Lecture 4

Visual Encoding: Marks and Channels

DTS204TC Data Visualisation

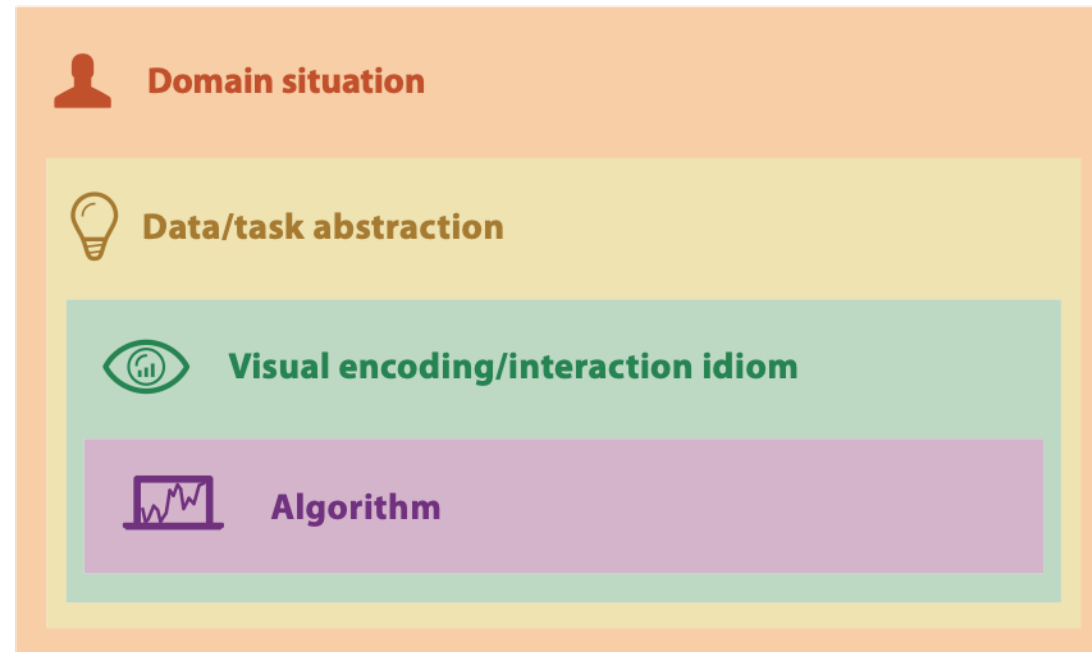


Outline

- General Introduction
- Marks
- Channels
- Channels Effectiveness
- Visual Encoding (for marks and channels)

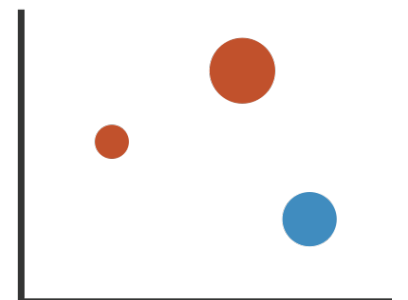
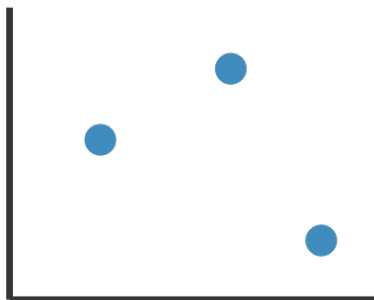
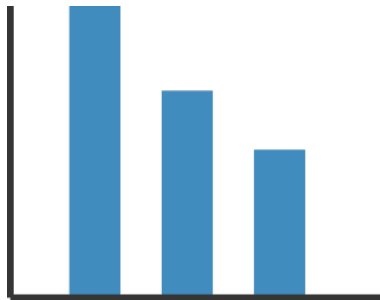
General Introduction

- how to systematically analyse idiom structure?



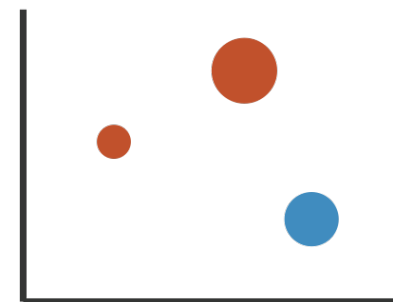
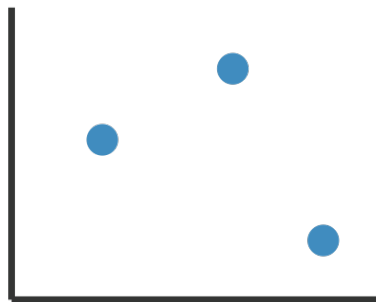
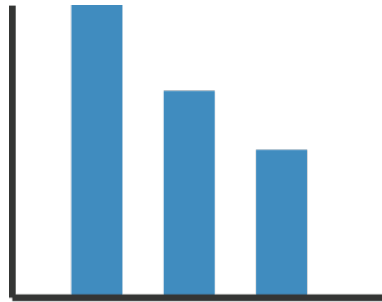
General Introduction

- how to systematically analyse idiom structure?



General Introduction

- how to systematically analyse idiom structure?

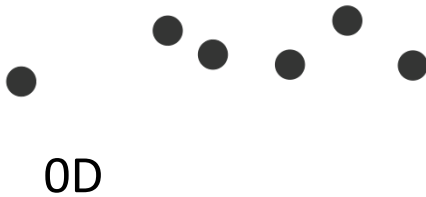


- marks & channels
 - marks: represent **items** or **links**
 - channels: change appearance of marks based on **attributes**

Marks

- Marks for items
 - basic geometric elements

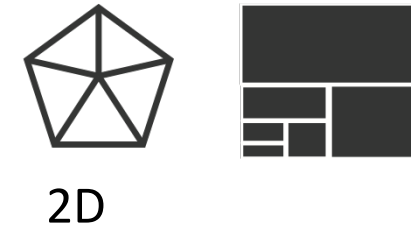
➞ Points



➞ Lines



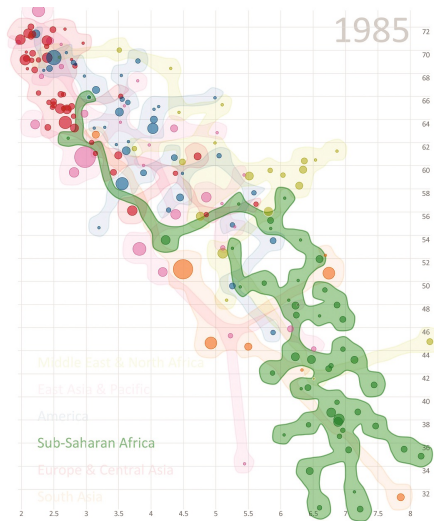
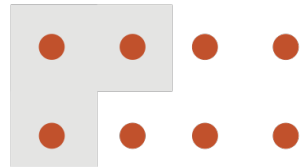
➞ Areas



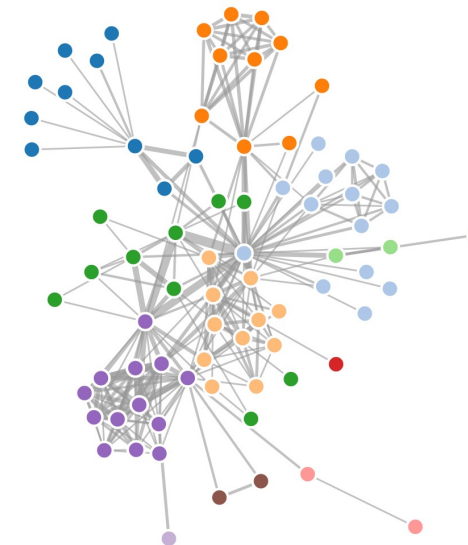
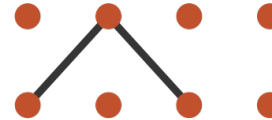
Marks

- Marks for links

➞ **Containment**



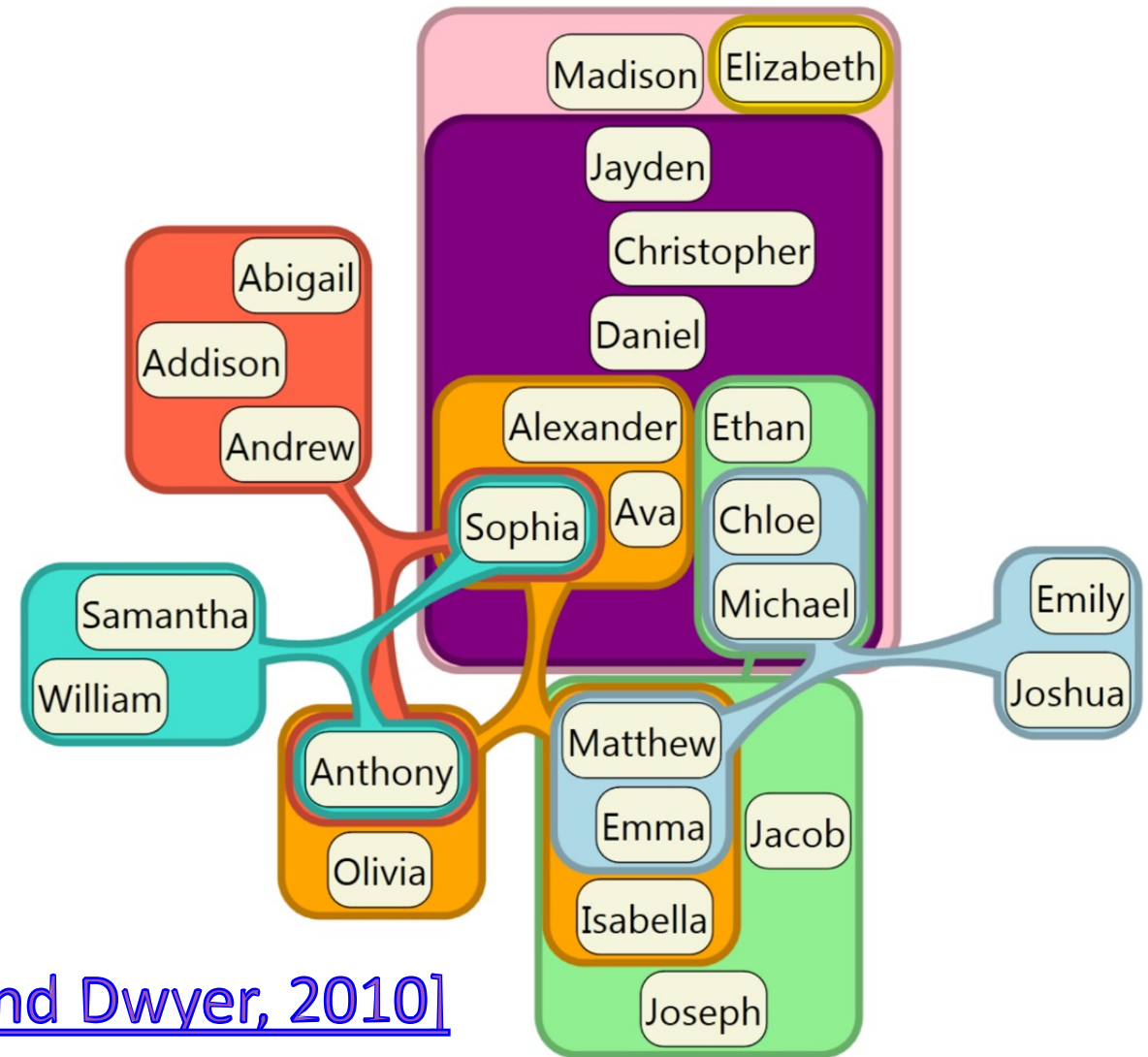
➞ **Connection**



vialab.science.uoit.ca/portfolio/bubblesets <https://observablehq.com/@d3/force-directed-graph>

Marks

- Marks of links
 - containment can be nested



[\[Untangling Euler Diagrams, Riche and Dwyer, 2010\]](#)

Channels

- control appearance of marks
 - proportional to or based on **attributes**
- Visual channels
 - visual variables
 - retinal channels
 - visual dimensions

➞ Position

➞ Horizontal



➞ Vertical



➞ Both



➞ Color



➞ Shape



➞ Tilt



➞ Size

➞ Length



➞ Area



➞ Volume



Channels

- expressiveness

- Attribute Types

- Categorical

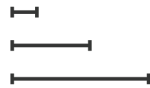


- Ordered

- Ordinal



- Quantitative



- Position

- Horizontal



- Vertical



- Both



- Color



- Shape



- Tilt



- Size

- Length



- Area



- Volume




Channels

- expressiveness

- Magnitude Channels
 - Ordered Attributes
- Identity Channels
 - Categorical Attributes

➔ 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) 

➔ Identity Channels: **Categorical** Attributes

Spatial region 

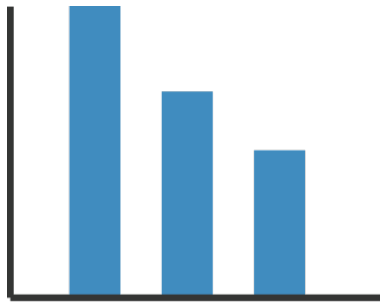
Color hue 

Motion 

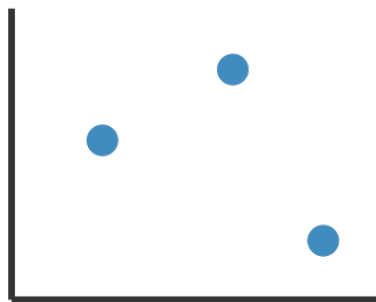
Shape 

Channels

- Types



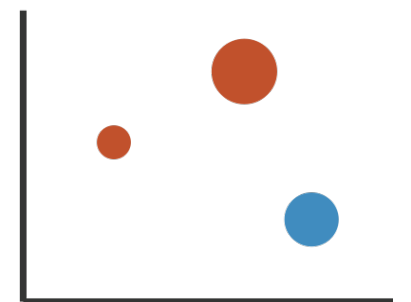
Vertical Position
Length



Vertical Position
Horizontal Position



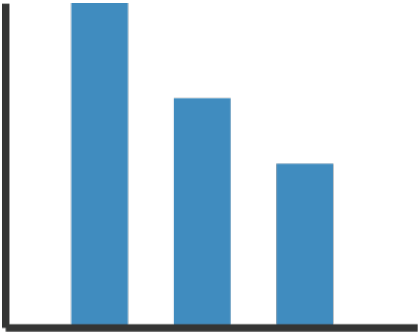
Vertical Position
Horizontal Position
Color



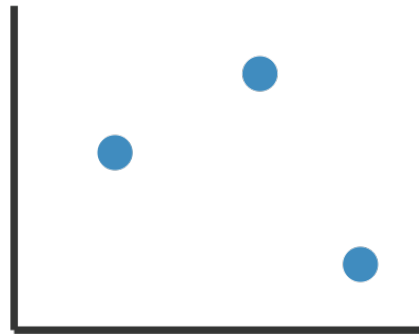
Vertical Position
Horizontal Position
Color
Size (area)

Channels

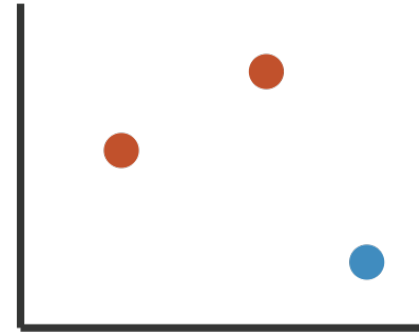
- Types



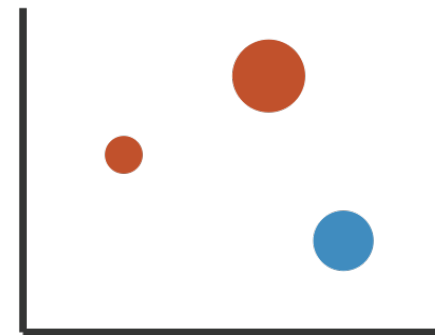
Vertical Position (**identity**)
Length (**magnitude**)



Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)



Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)
Color (**identity**)



Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)
Color (**identity**)
Size (**magnitude**)

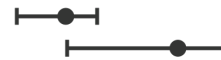
Channels

- Rankings

Position on common scale



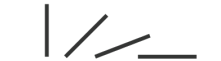
Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



Spatial region



Color hue



Motion



Shape

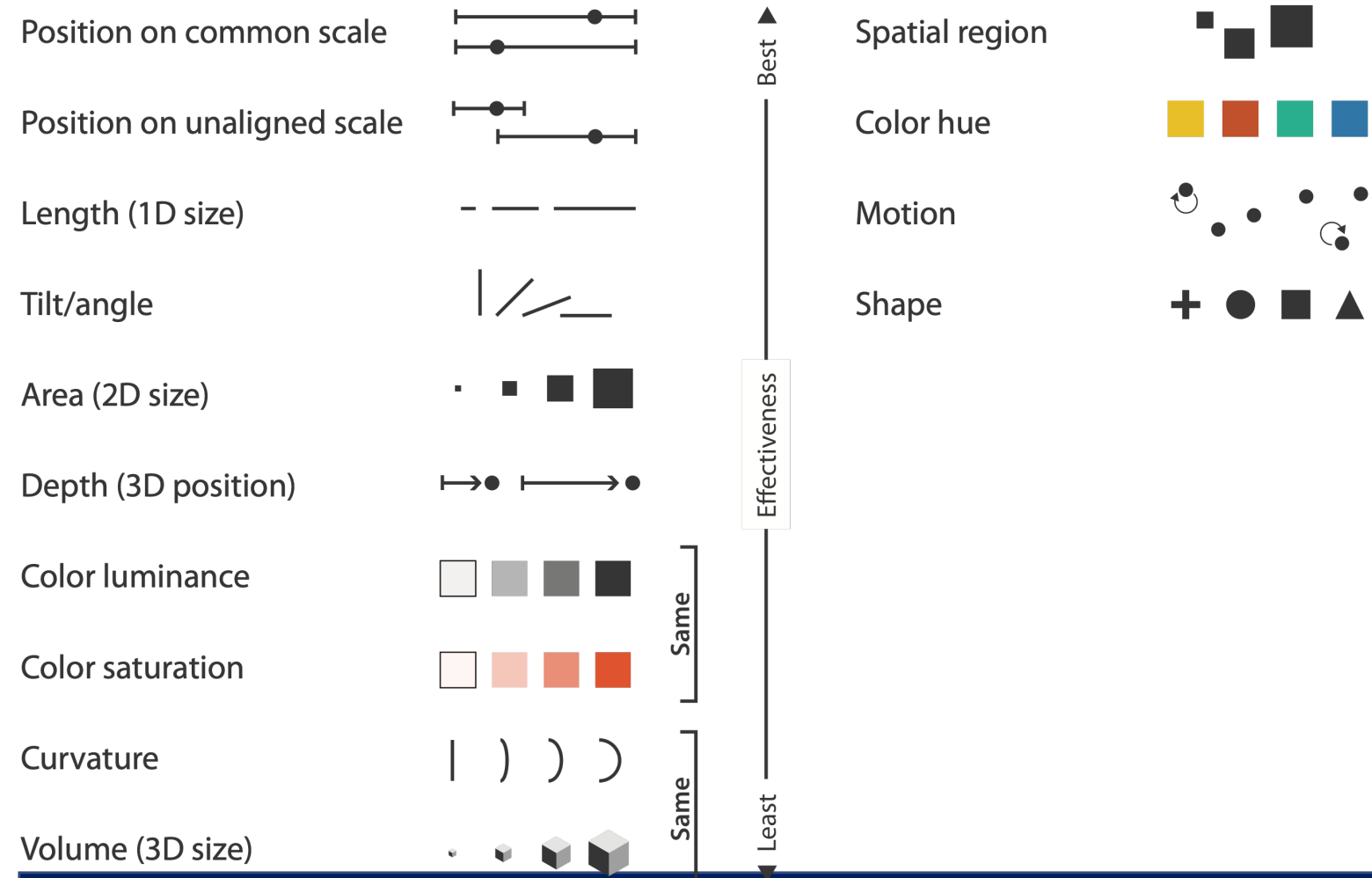


Channels

- Rankings
 - **Expressiveness**
 - Visual encoding should express all of—and only—the information in the dataset
 - Ordered data should be shown in a way we perceive as ordered
 - match channel and data characteristics
 - **Effectiveness**
 - channels differ in accuracy of perception
 - spatial position ranks high for both

Channels

- Rankings



Channel Effectiveness

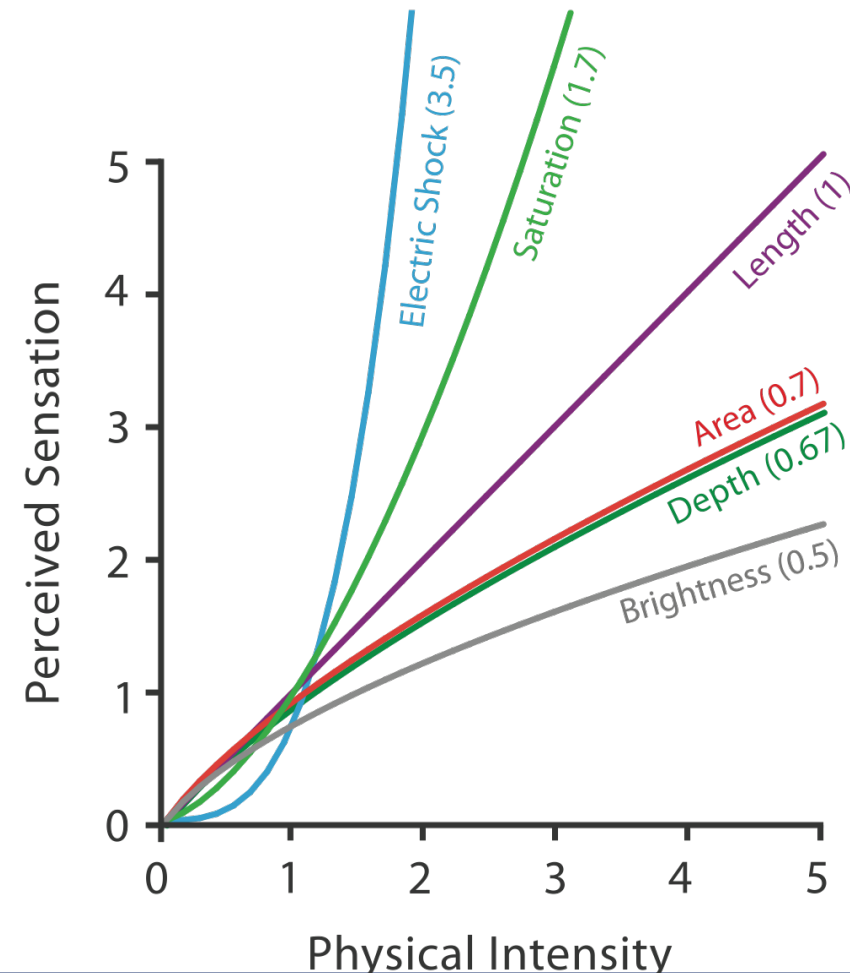
- Where does the ranking come from?
 - **accuracy**: how precisely can we tell the difference between encoded items?
 - **discriminability**: how many unique steps can we perceive?
 - **separability**: is our ability to use this channel affected by another one?
 - **popout**: can things jump out using this channel?

Channel Effectiveness

- accuracy:
 - Length is accurate: Linear

<https://woodgears.ca/eyeball/index.html>

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



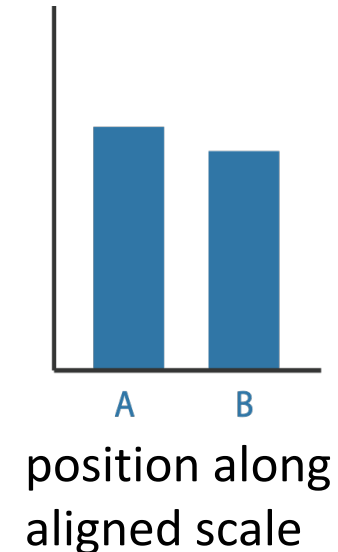
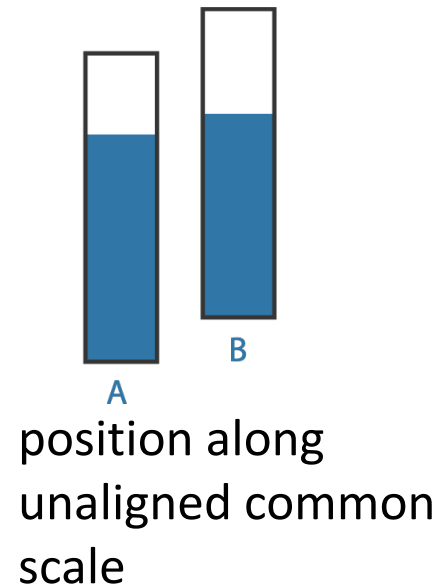
Channel Effectiveness

- Accuracy:
 - Factors: alignment; distractors; distance; common scale



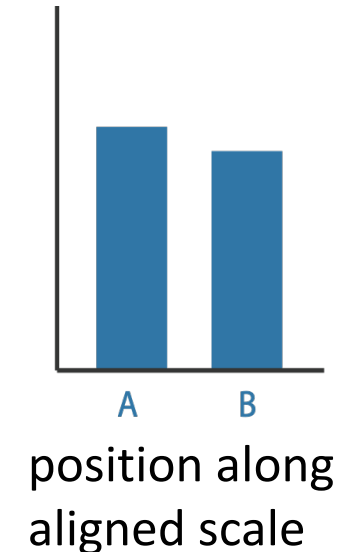
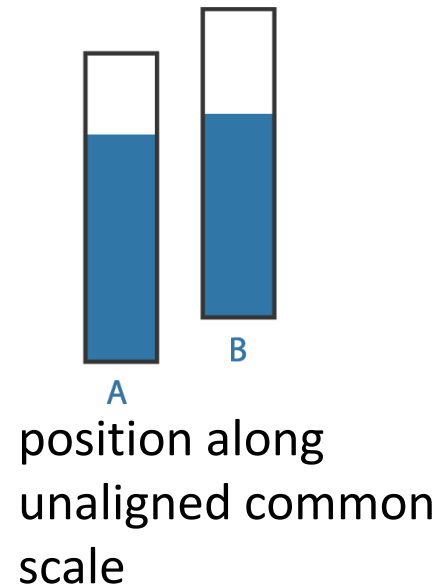
Channel Effectiveness

- Accuracy:
 - Relative vs. absolute judgement
 - perceptual system mostly operates with relative judgements, not absolute judgement
 - that's why accuracy increases with common frame/scale and alignment



Channel Effectiveness

- Accuracy:
 - Relative vs. absolute judgement
 - perceptual system mostly operates with relative judgements, not absolute judgement
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 - Weber's Law: ratio of increment to background is constant

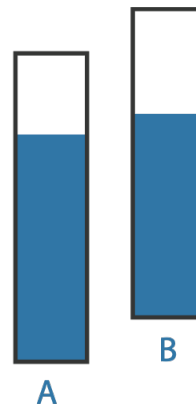


Channel Effectiveness

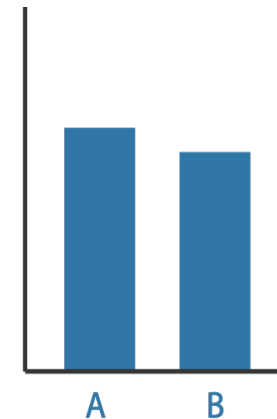
- Accuracy:
 - Relative vs. absolute judgement
 - perceptual system mostly operates with relative judgements, not absolute judgement
 - that's why accuracy increases with common frame/scale and alignment
 - Weber's Law: ratio of increment to background is constant
 - filled rectangles differ in length by 1:9, difficult judgement
 - white rectangles differ in length by 1:2, easy judgement



length



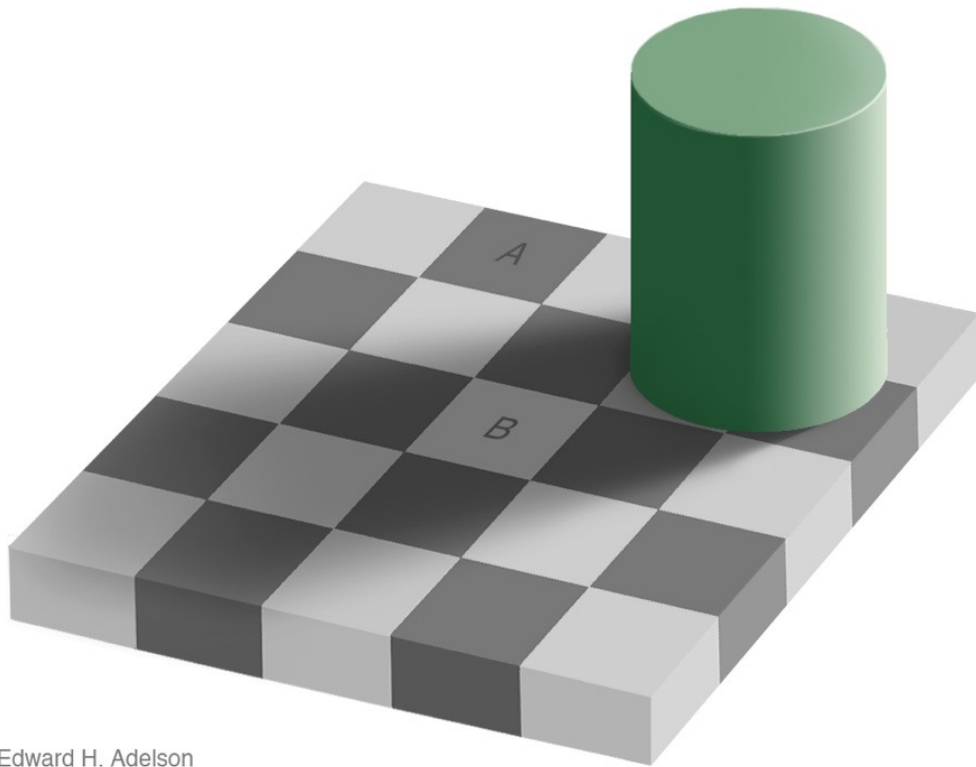
position along
unaligned common
scale



position along
aligned scale

Channel Effectiveness

- Accuracy:
 - Relative Luminance Judgement
 - perception of luminance is contextual based on contrast with surroundings

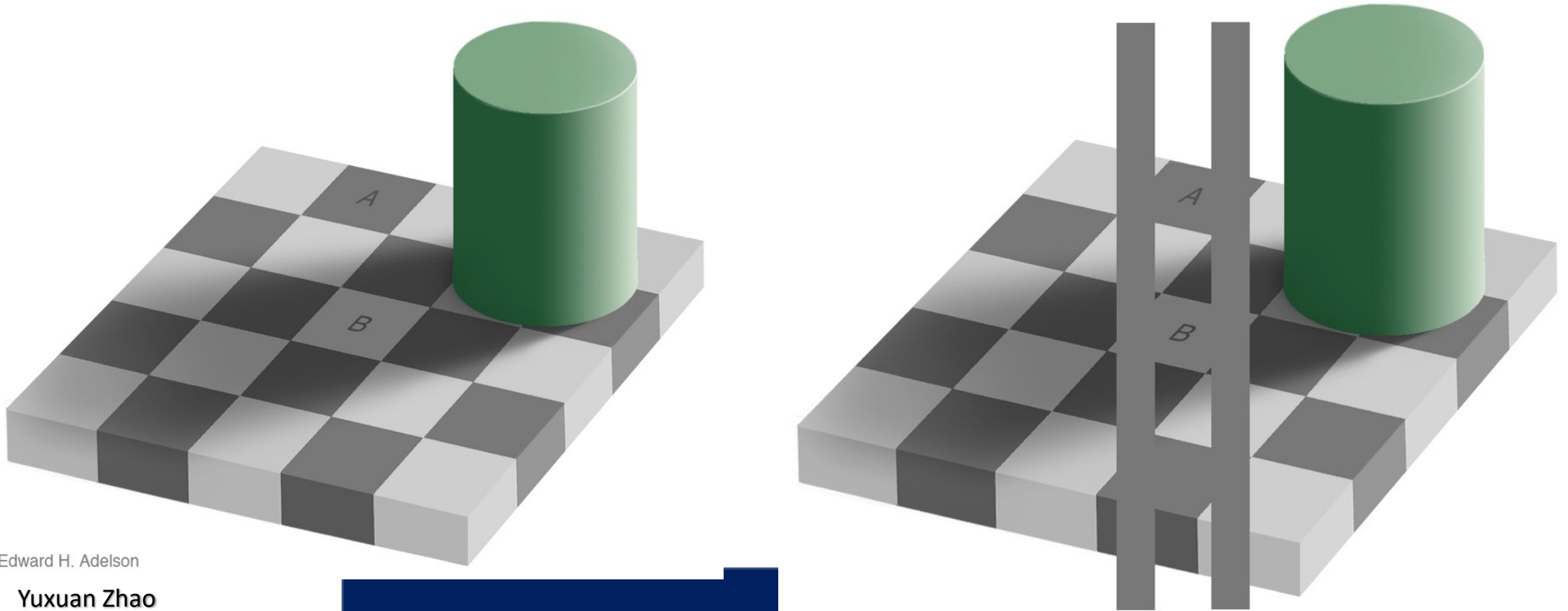


Edward H. Adelson

Yuxuan Zhao

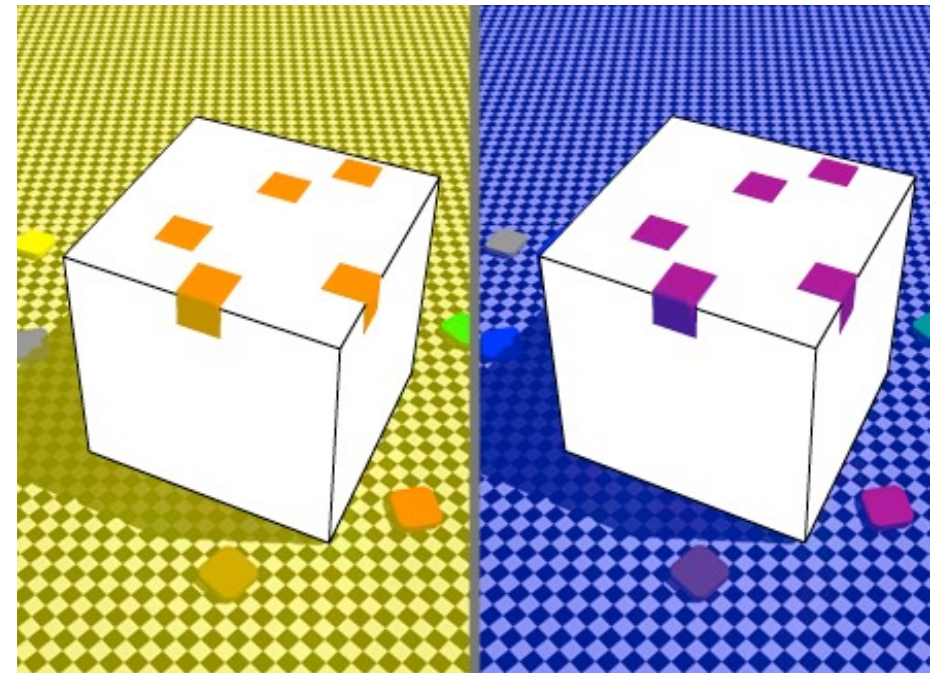
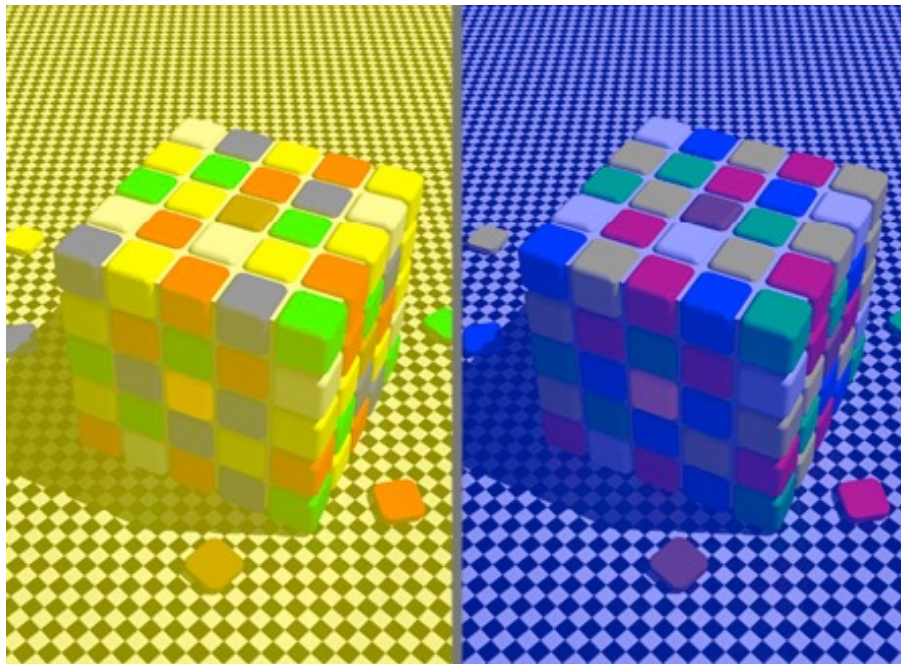
Channel Effectiveness

- Accuracy:
 - Relative Luminance Judgement
 - perception of luminance is contextual based on contrast with surroundings



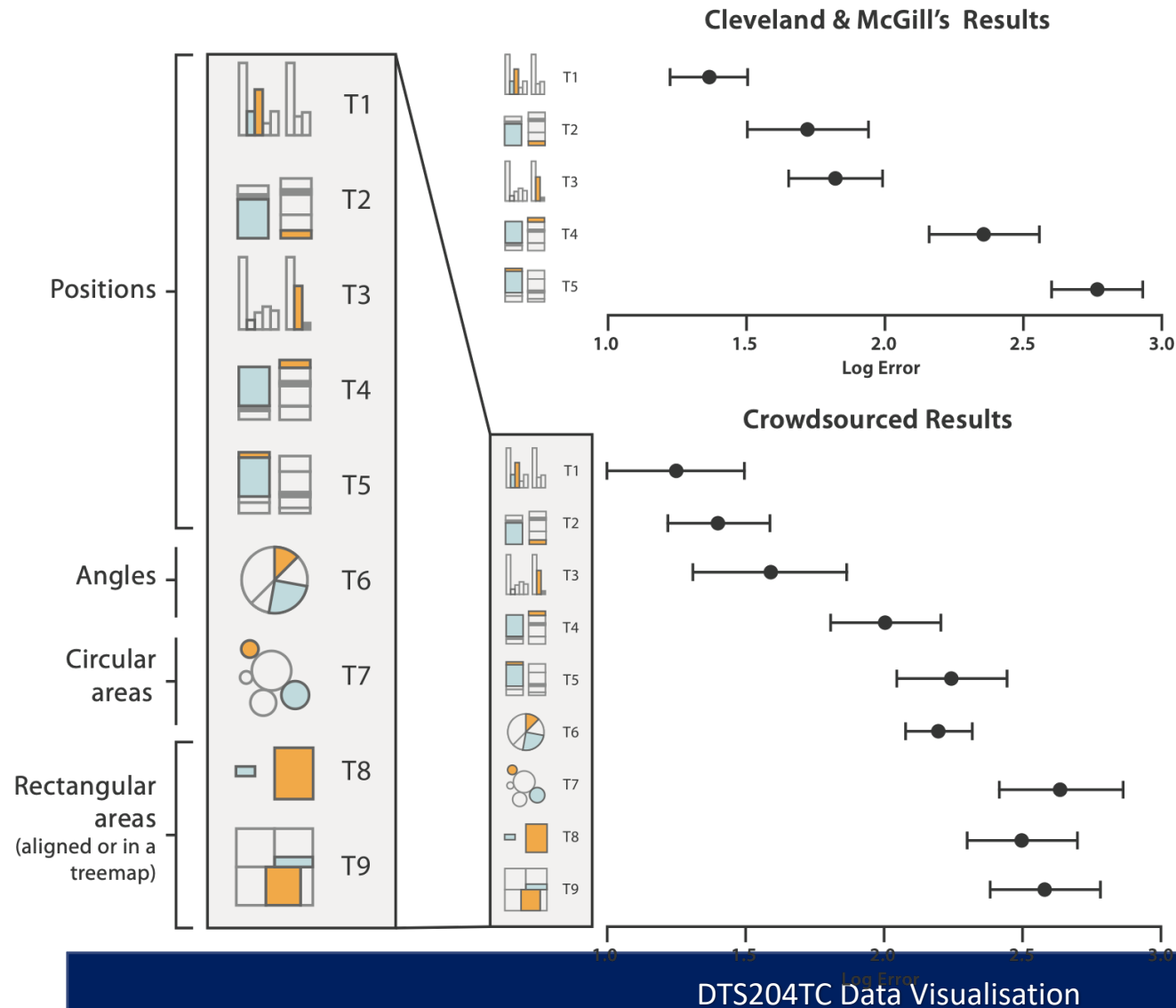
Channel Effectiveness

- Accuracy:
 - Relative Color Judgement
 - color constancy across broad range of illumination condition



Channel Effectiveness

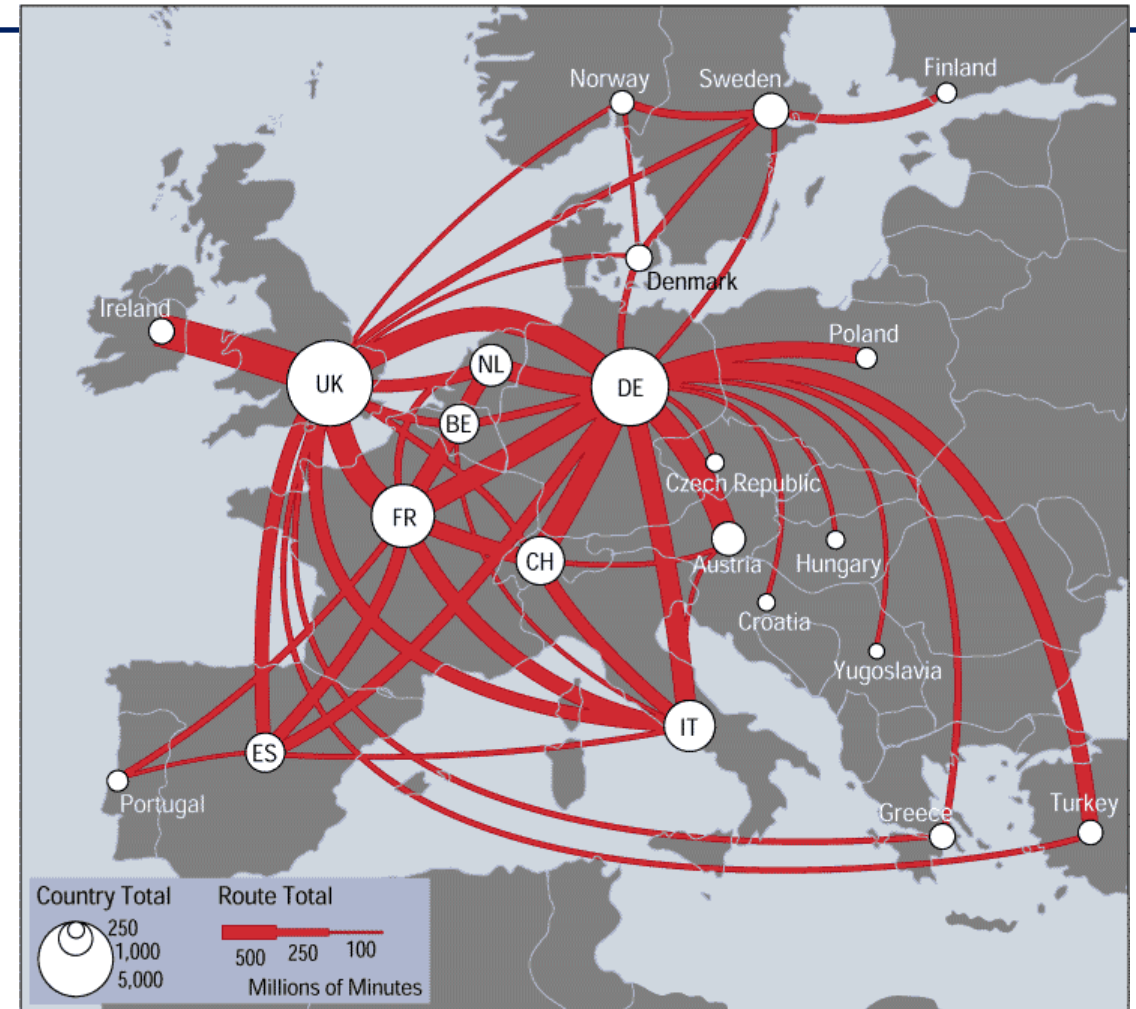
- accuracy: Vis experiments



[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

Channel Effectiveness

- Discriminability : How many usable steps?
 - must be sufficient for number of attribute levels to show
 - example: linewidth: few bins



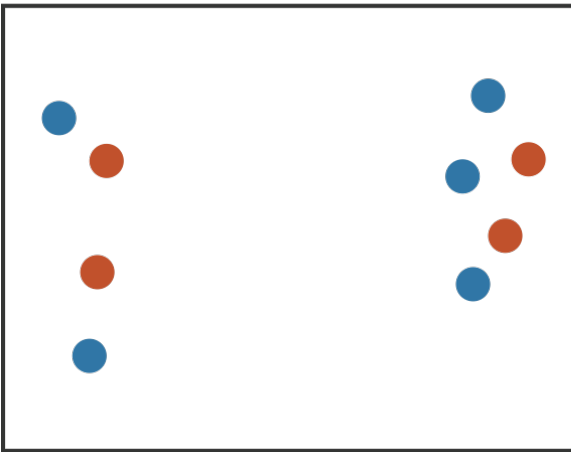
[\[mappa.mundi.net/maps/maps_014/telegeography.html\]](http://mappa.mundi.net/maps/maps_014/telegeography.html)

Channel Effectiveness

- Separability

Position

+ Hue (Color)

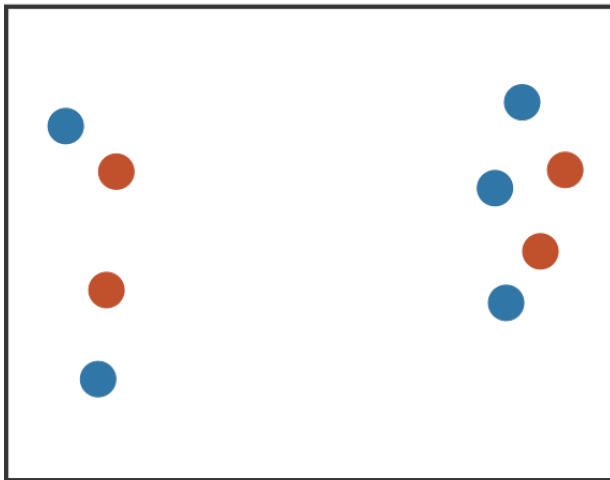


Fully separable

2 groups each

Channel Effectiveness

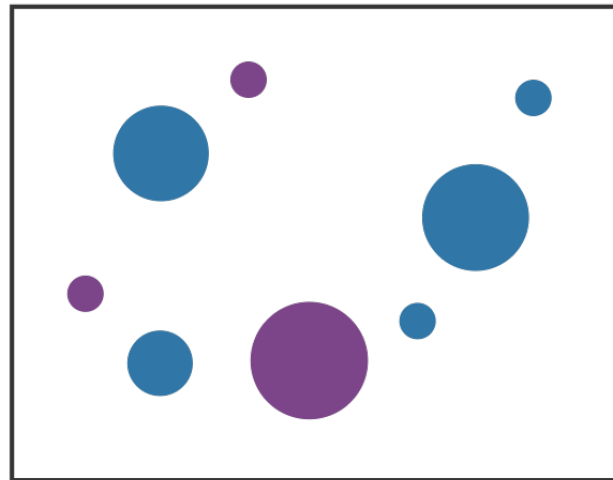
- Separability
Position
+ Hue (Color)



Fully separable

2 groups each

- Size
+ Hue (Color)



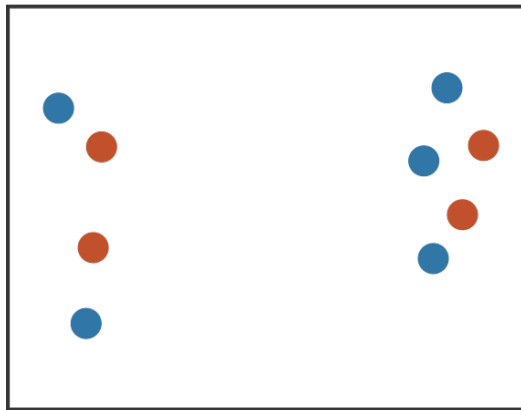
Some interference

2 groups each

Channel Effectiveness

- Separability

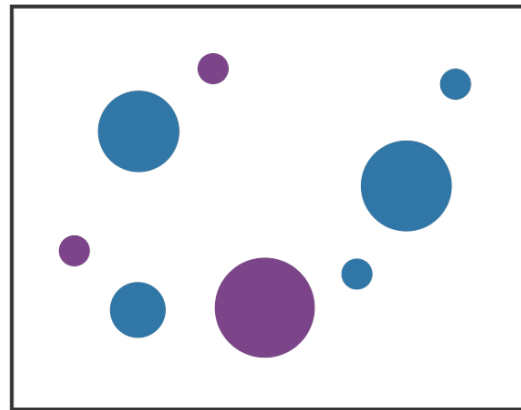
Position
+ Hue (Color)



Fully separable

2 groups each

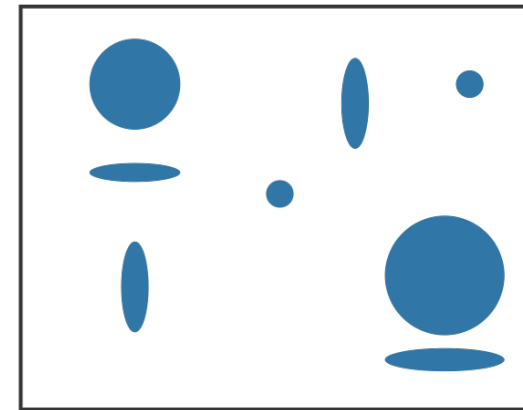
Size
+ Hue (Color)



Some interference

2 groups each

Width
+ Height



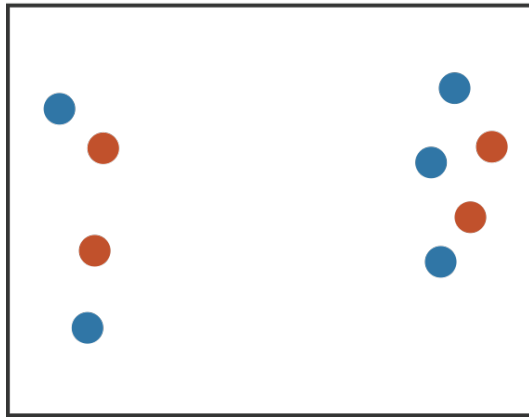
Some/significant
interference

2 groups total: area

Channel Effectiveness

- Separability

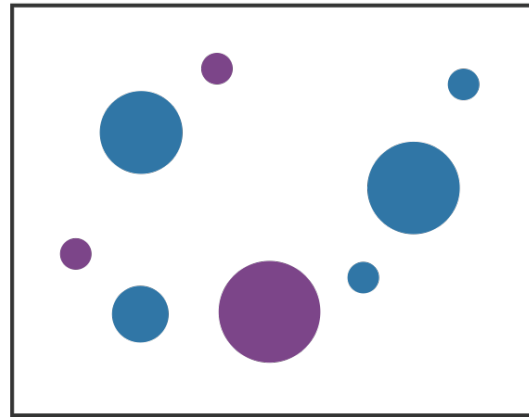
Position
+ Hue (Color)



Fully separable

2 groups each

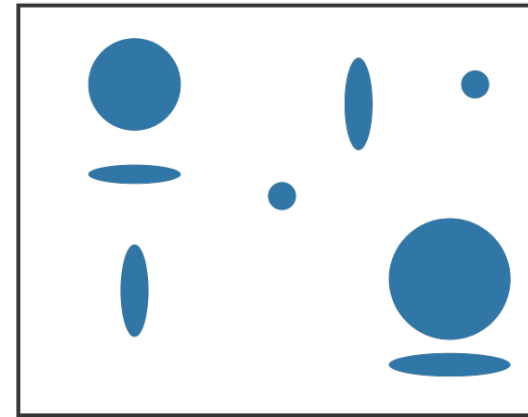
Size
+ Hue (Color)



Some interference

2 groups each

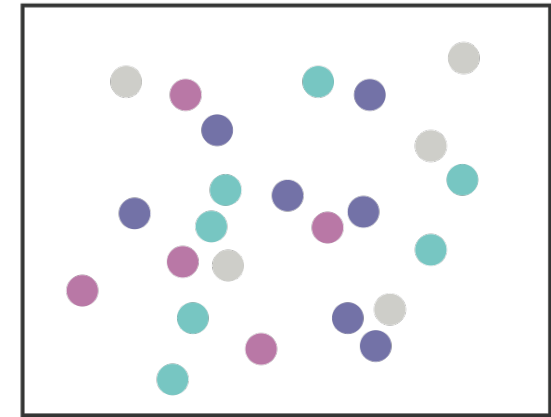
Width
+ Height



Some/significant
interference

3 groups total: area

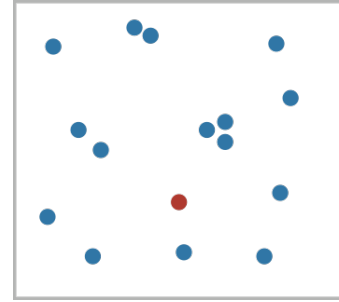
Red
+ Green



Major interference

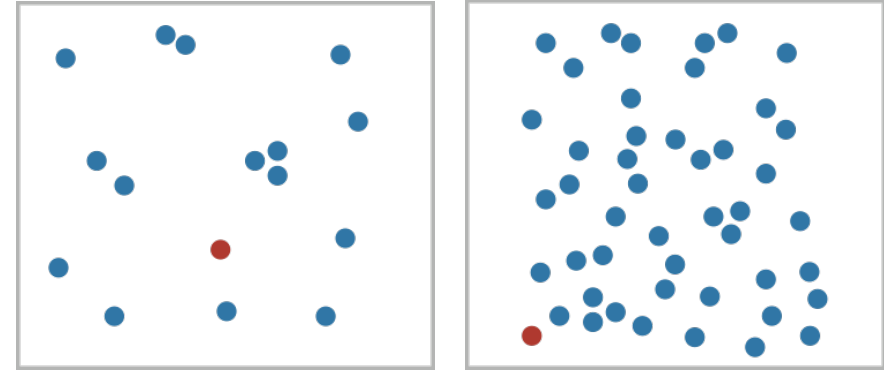
4 groups total: integral hue

Channel Effectiveness



- Popout
 - Find the red bot
 - how long does it take

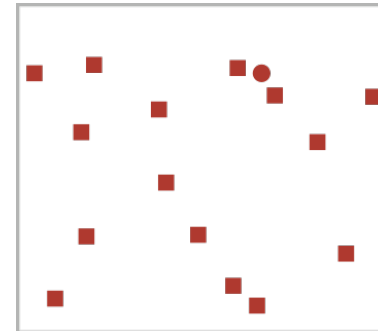
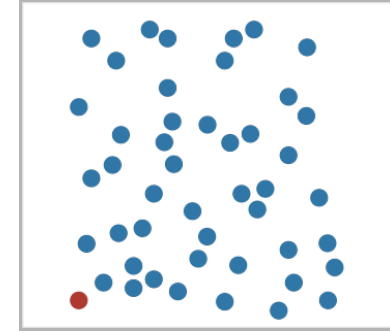
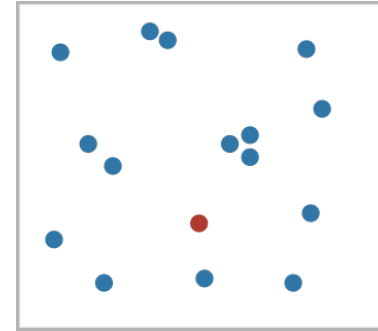
Channel Effectiveness



- Popout
 - Find the red bot
 - how long does it take

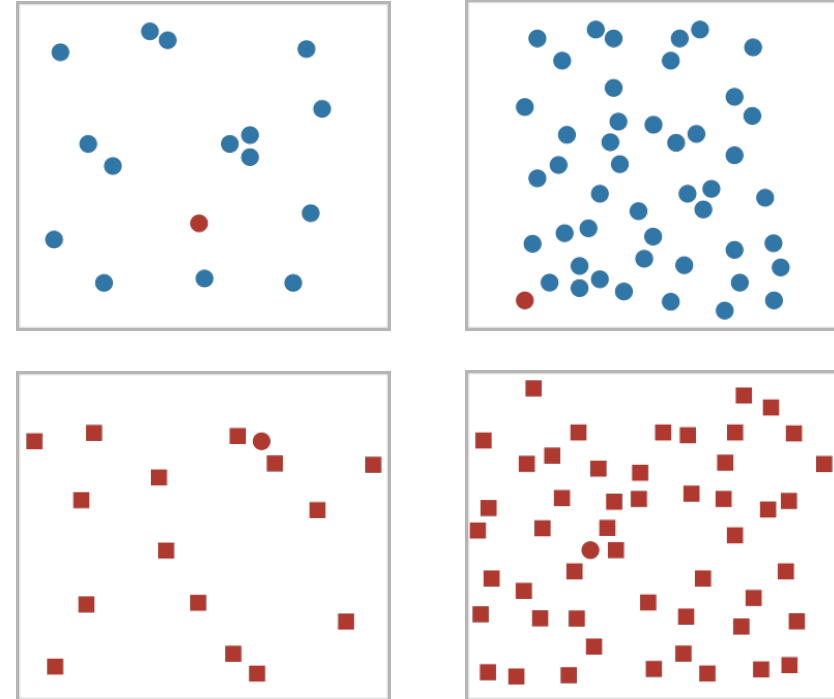
Channel Effectiveness

- Popout
 - Find the red bot
 - how long does it take



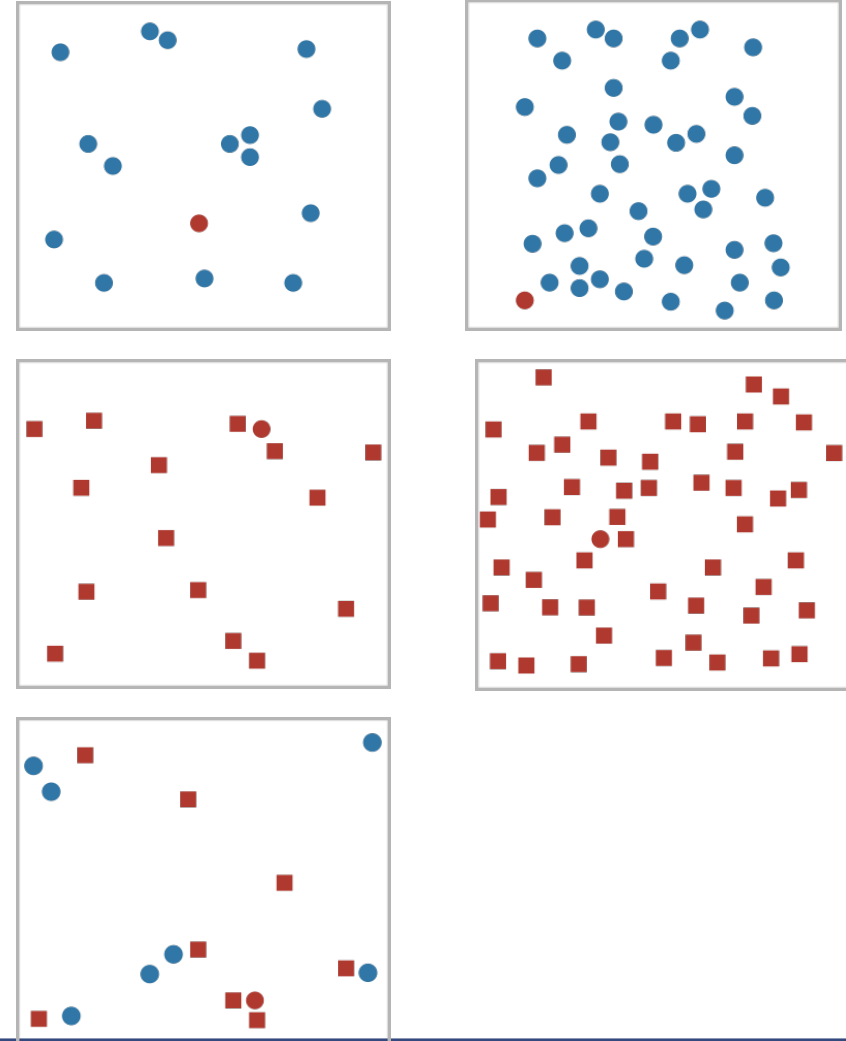
Channel Effectiveness

- Popout
 - Find the red bot
 - how long does it take



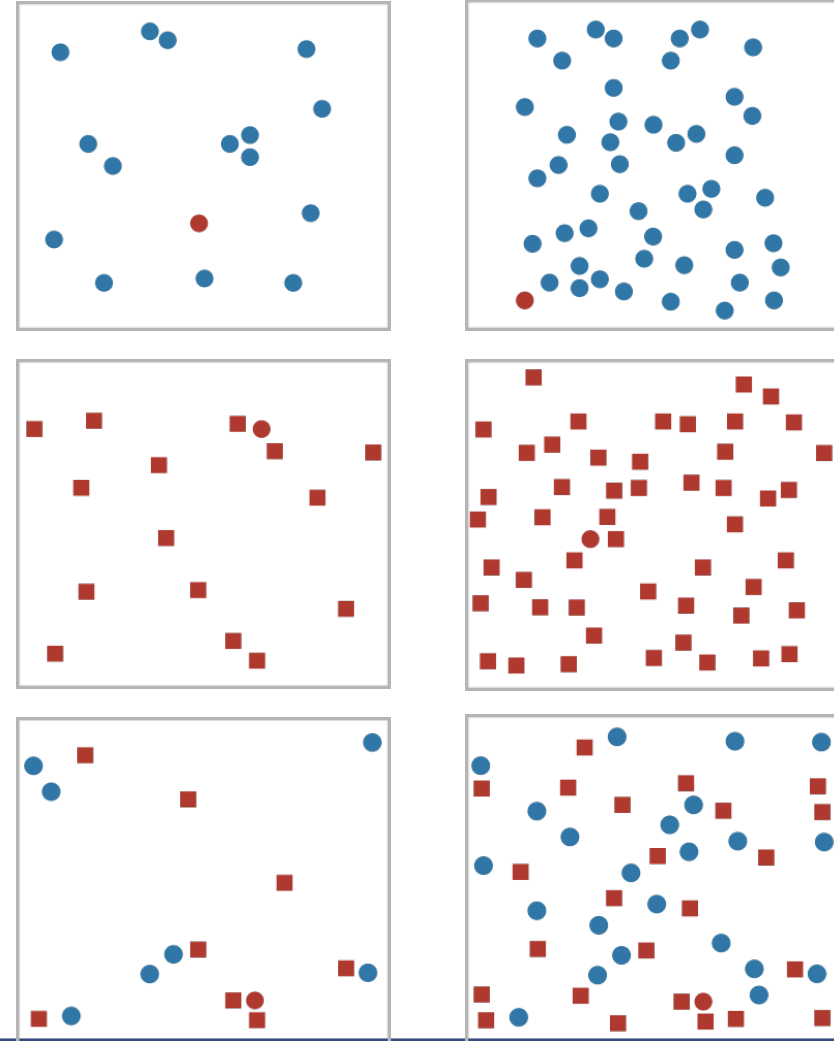
Channel Effectiveness

- Popout
 - Find the red bot
 - how long does it take



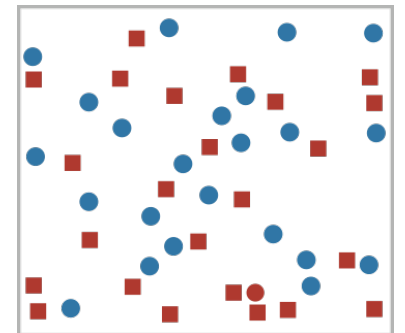
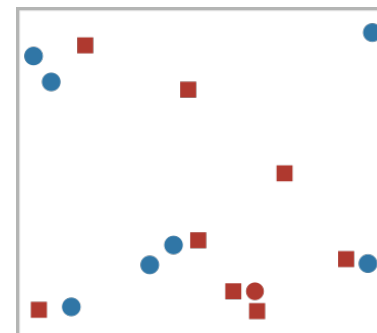
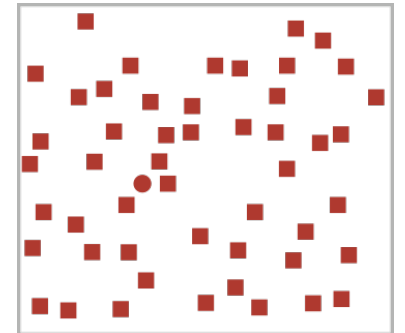
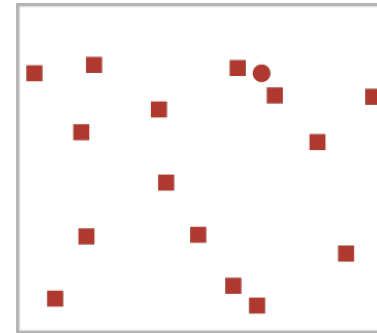
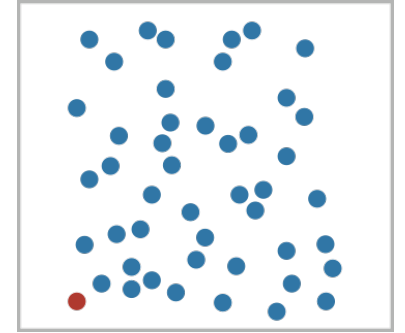
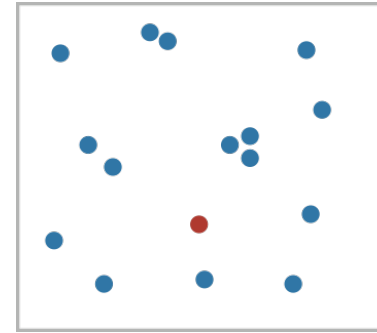
Channel Effectiveness

- Popout
 - Find the red bot
 - how long does it take



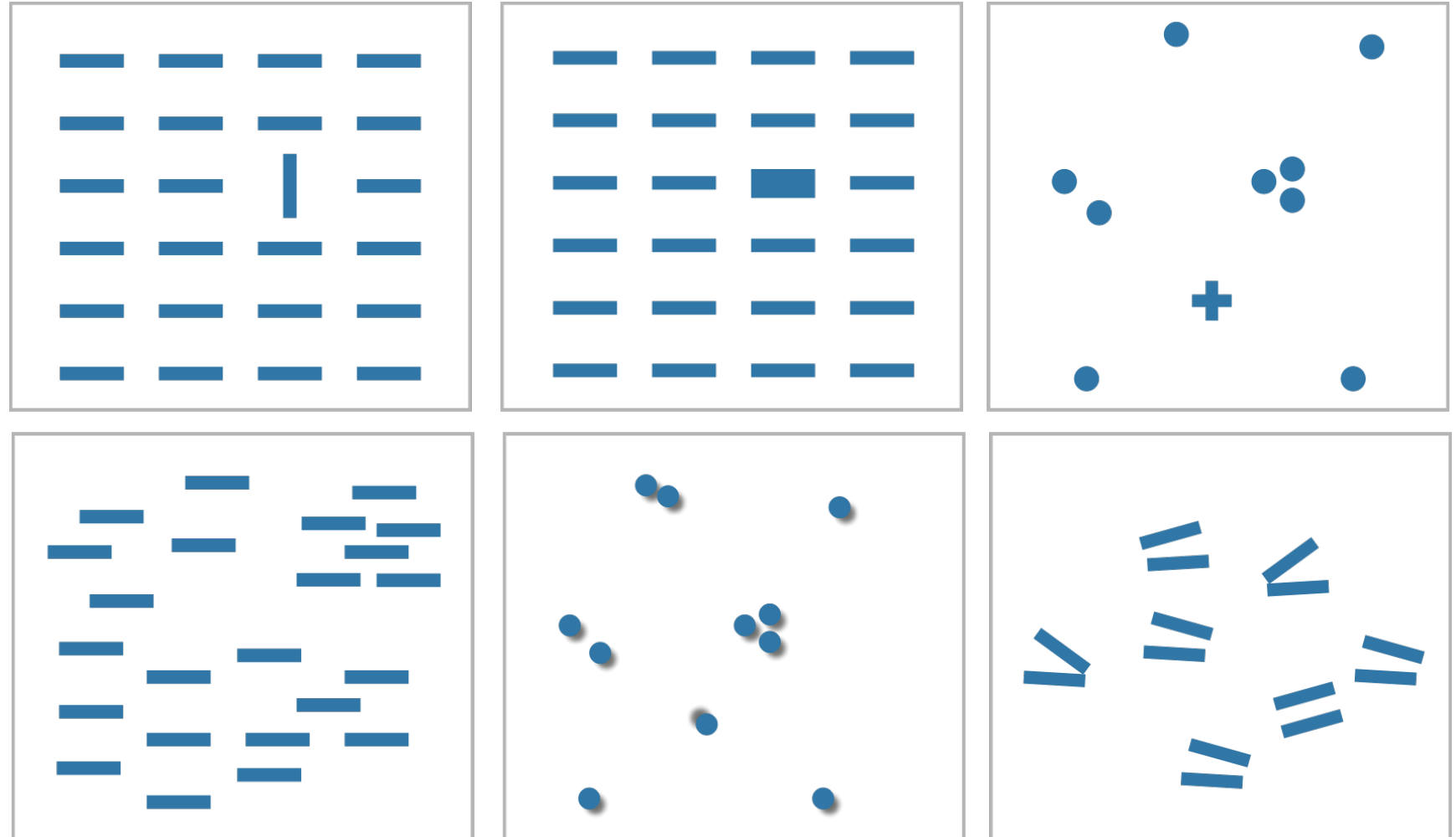
Channel Effectiveness

- Popout
 - Find the red bot
 - how long does it take
- Individual channel
 - speed independent of distractor count
 - speed depends on channel and amount of difference from distractors
- combination
 - speed depends on number of distractors



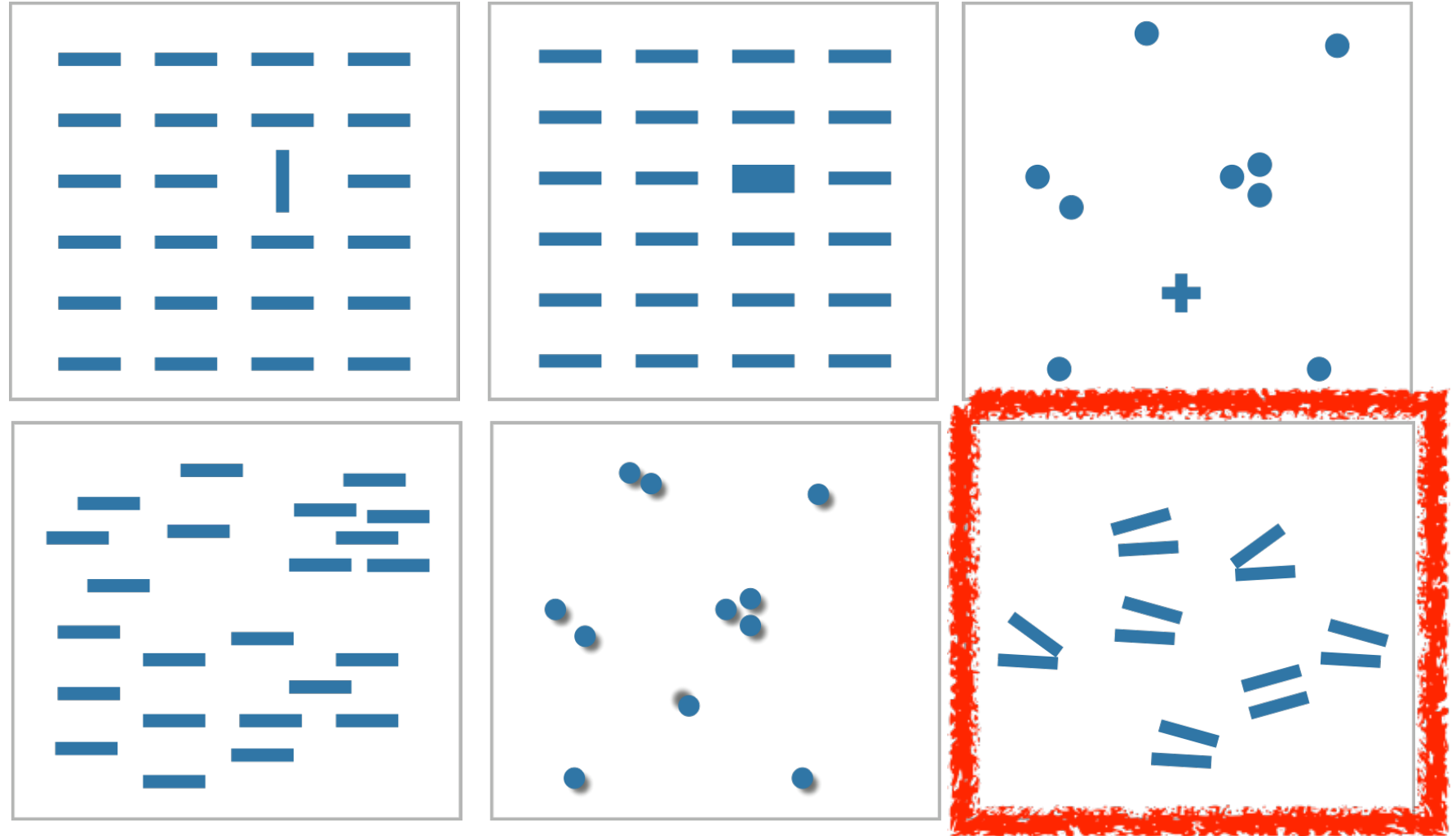
Channel Effectiveness

- Popout
- Many channels
 - tilt, size, shape, proximity, shadow direction, ...



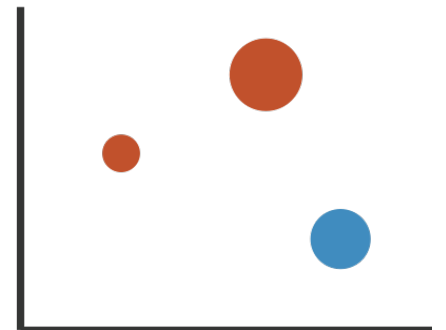
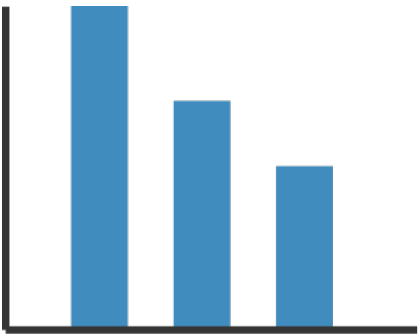
Channel Effectiveness

- Popout
- Many channels
 - tilt, size, shape, proximity, shadow direction, ...
- **but** not all!
 - parallel line pairs do not pop out from tilted pairs



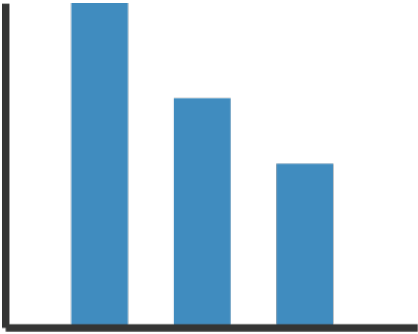
Visual Encoding

- analyze idiom structure as combination of marks and channels



Visual Encoding

- analyze idiom structure as combination of marks and channels



Vertical Position (**identity**)
Length (**magnitude**)

Marks: line



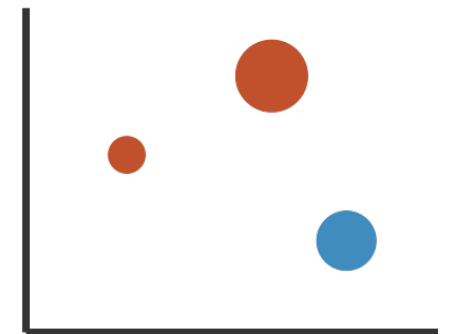
Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)

Marks: point



Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)
Color (**identity**)

Marks: point

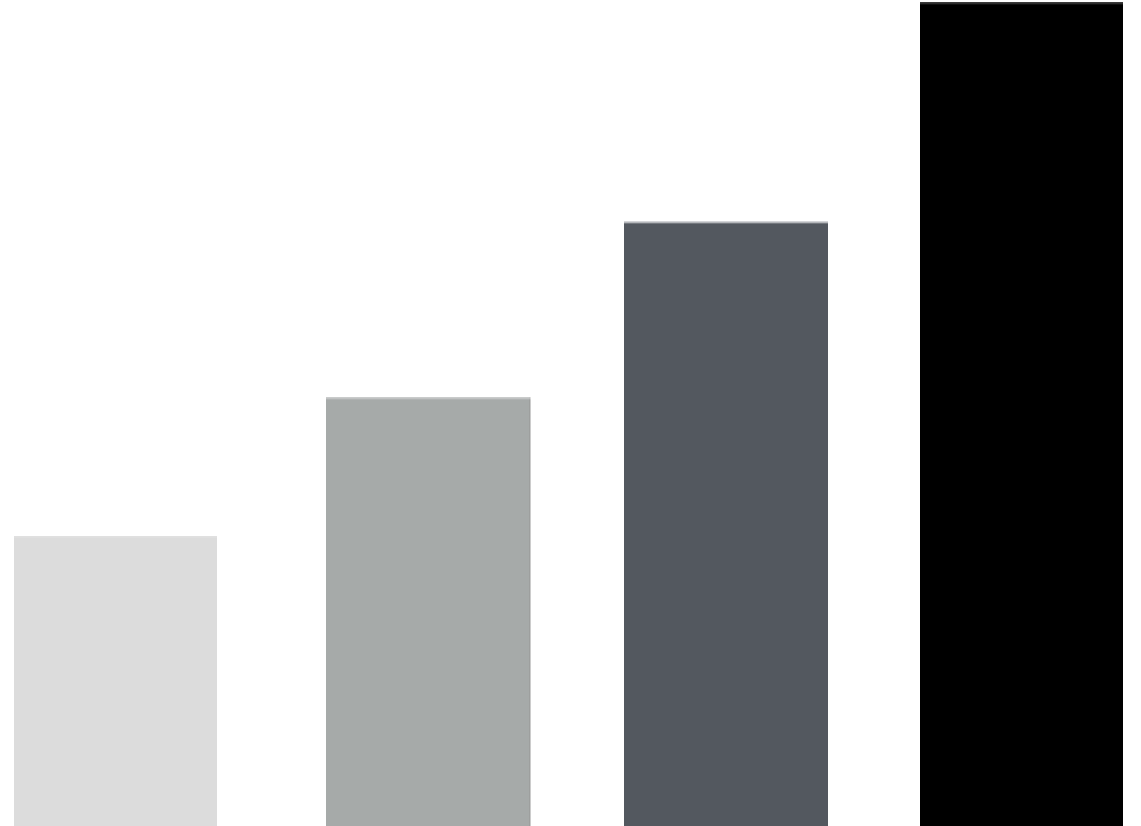


Vertical Position (**magnitude**)
Horizontal Position (**magnitude**)
Color (**identity**)
Size (**magnitude**)

Marks: point

Visual Encoding

- Redundant encoding
 - multiple channels
 - sends stronger message
 - but uses up channels
 - eg length and luminance



Summary

- General Introduction
- Marks
 - items
 - links
- Channels
 - expressiveness
 - effectiveness
- Channels Effective
 - accuracy; discriminability; separability; popup
 - factors
- Visual Encoding