Data Visualisation
Marks and Channels

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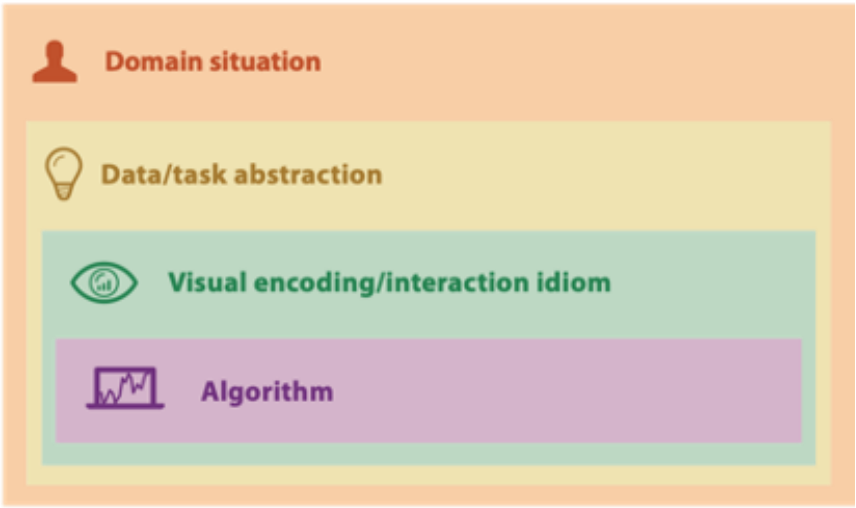
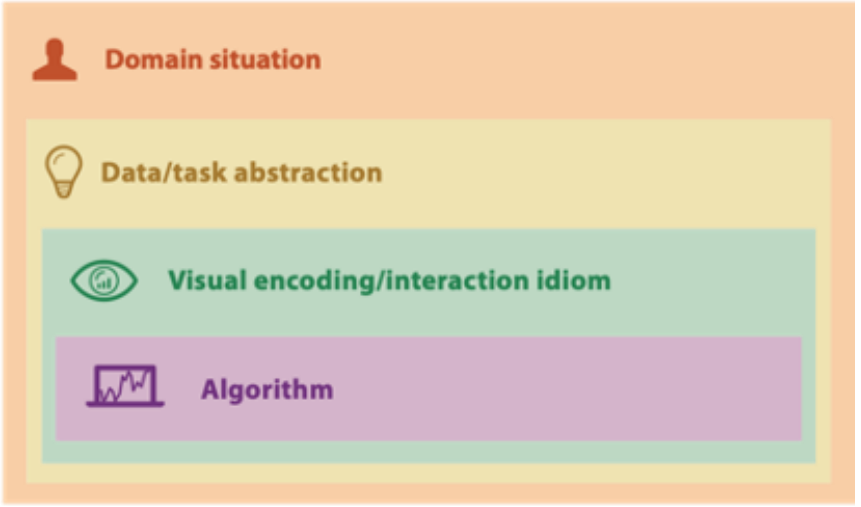
Slides taken, reformatted and used from Tamara Munzner (UBC, Canada)

Visual encoding

- How to systematically analyze idiom structure?



Visual encoding

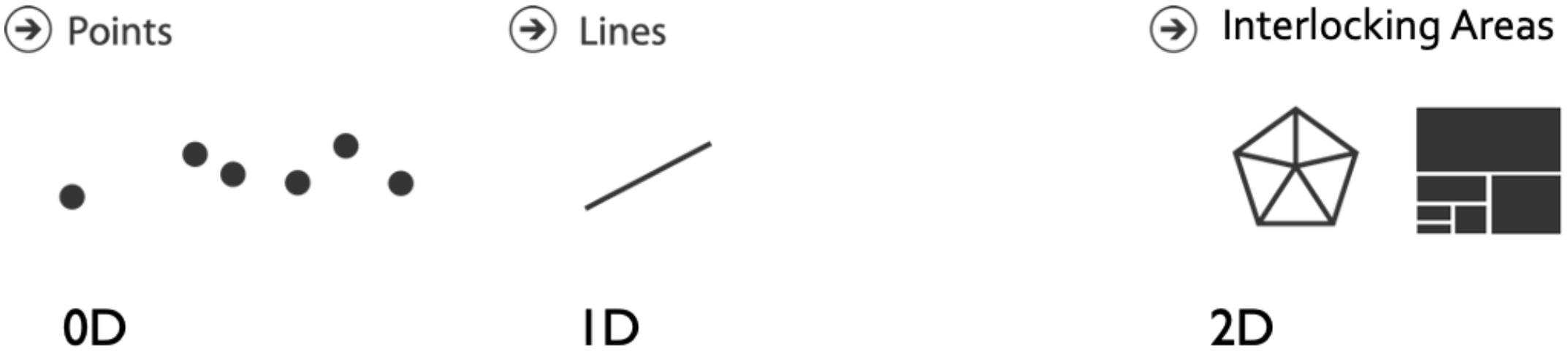


- How to systematically analyze idiom structure?

- Marks and channels
  - Marks: represent items or links
  - Channels: change appearance of marks based on attributes

Marks for items (rows of table)

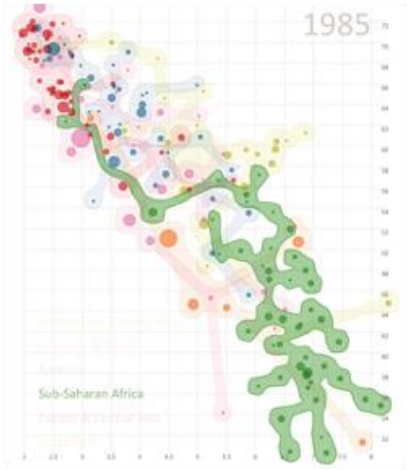
- Basic geometric elements



- 3D mark: volume, rarely used

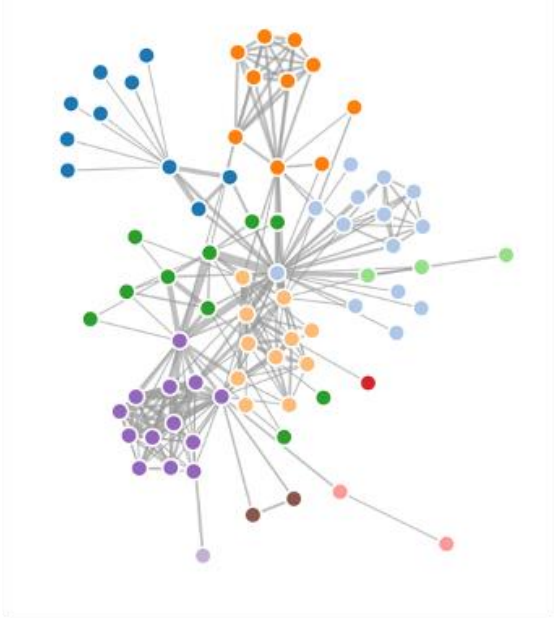
Marks for links

Containment



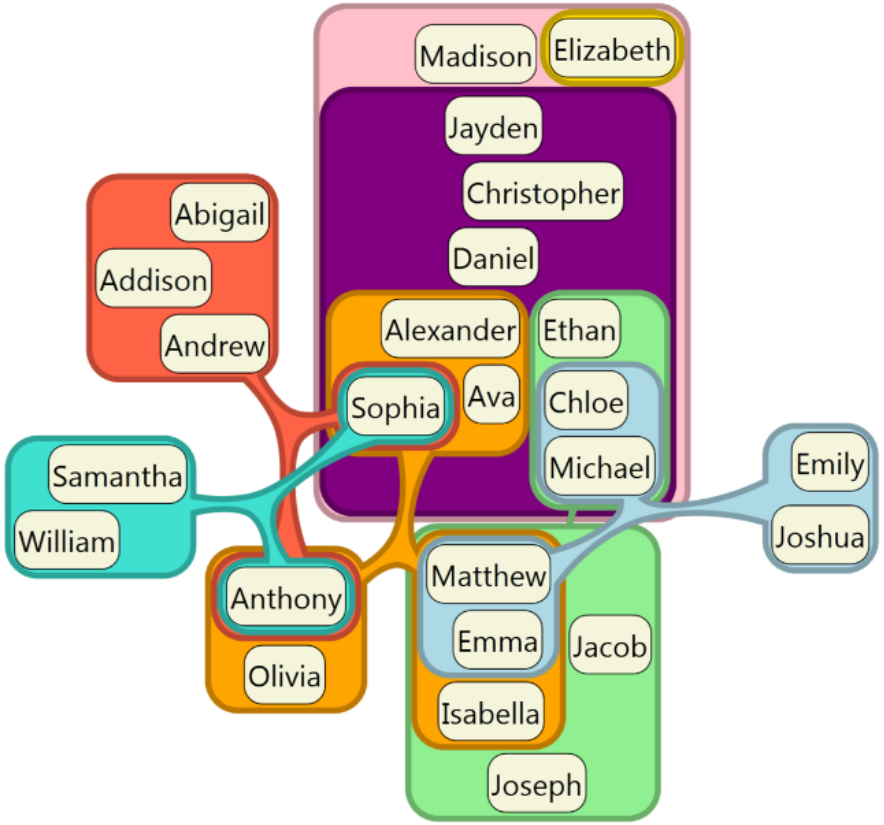
vialab.science.uoit.ca/portfolio/bubblesets

Connection



https://observablehq.com/@d3/force-directed-graph

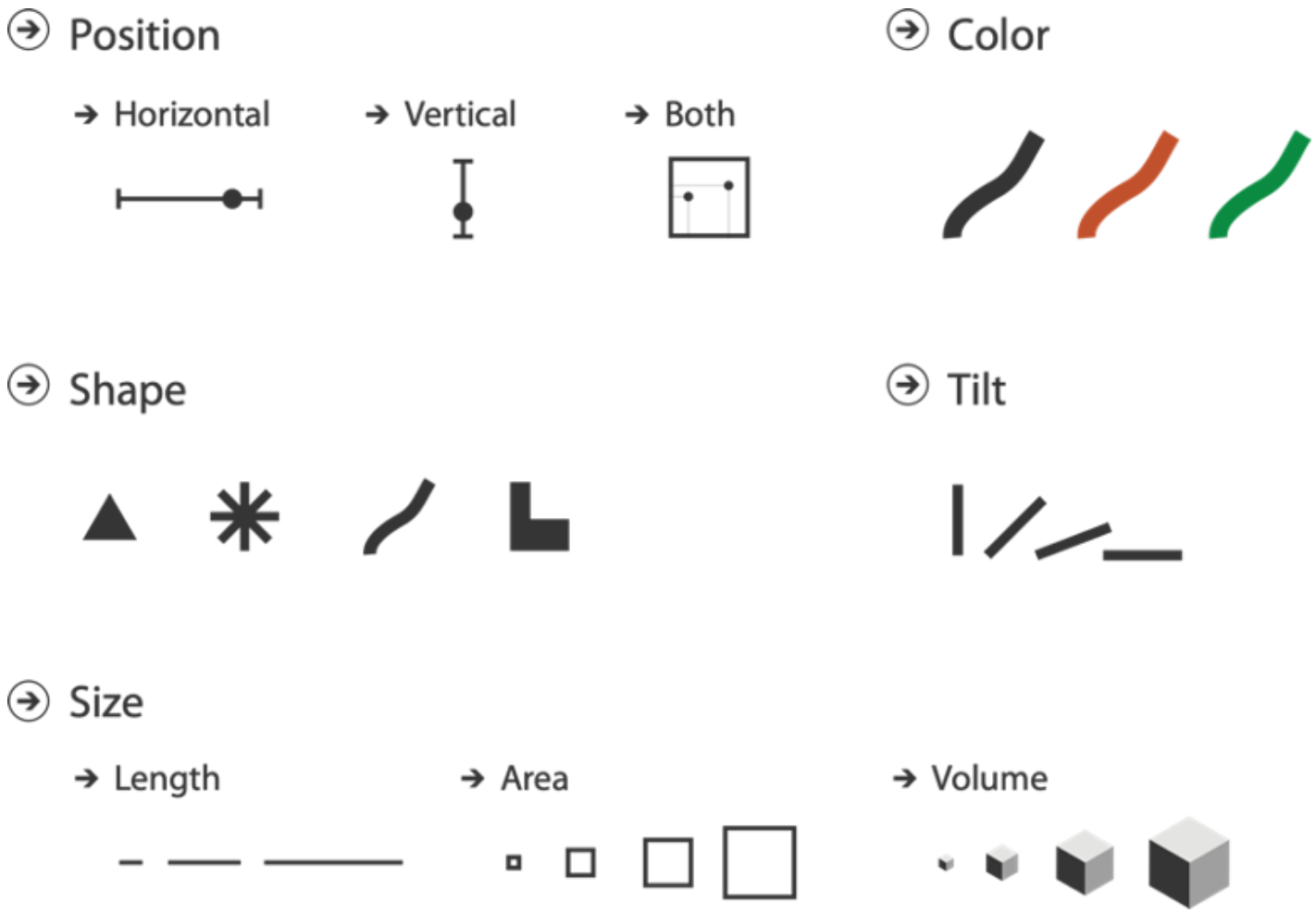
Containment can be nested



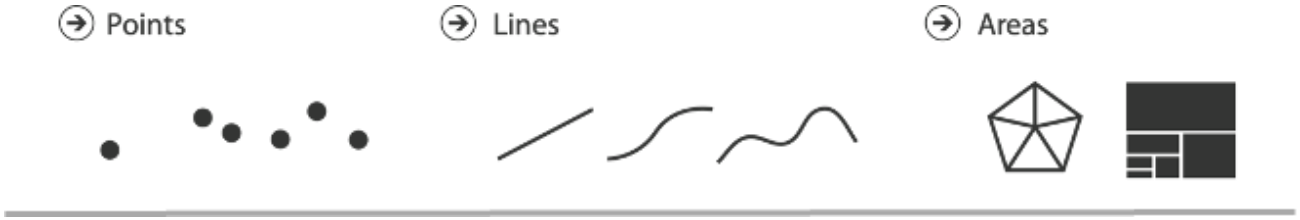
[Untangling Euler Diagrams, Riche and Dwyer, 2010]

Channels

- Control appearance of marks
  - Proportional to or based on attributes
- Many names
  - Visual channels
  - Visual variables
  - Retinal channels
  - Visual dimensions
  - …



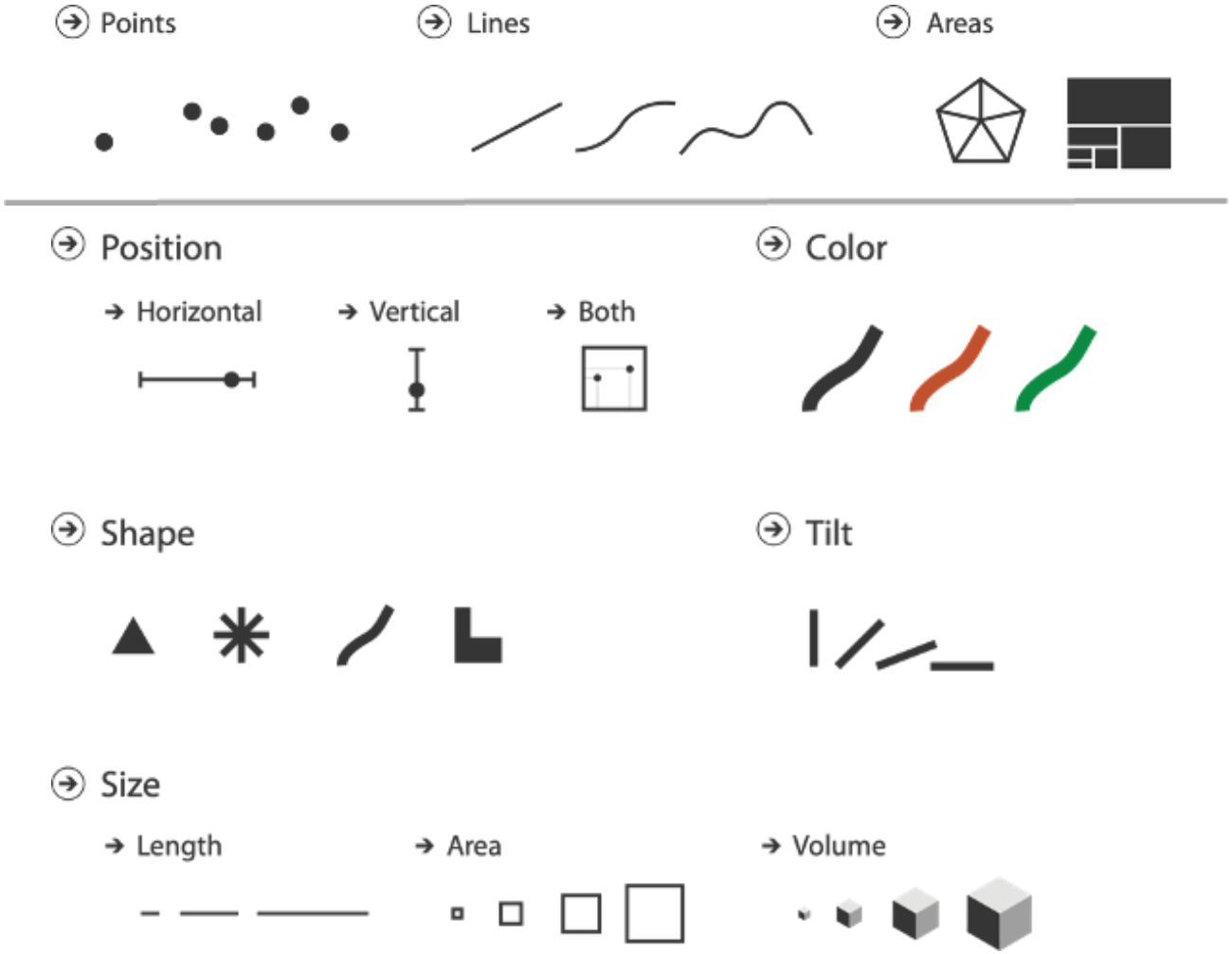
Definitions: Marks and channels



- Marks
  - Geometric primitives

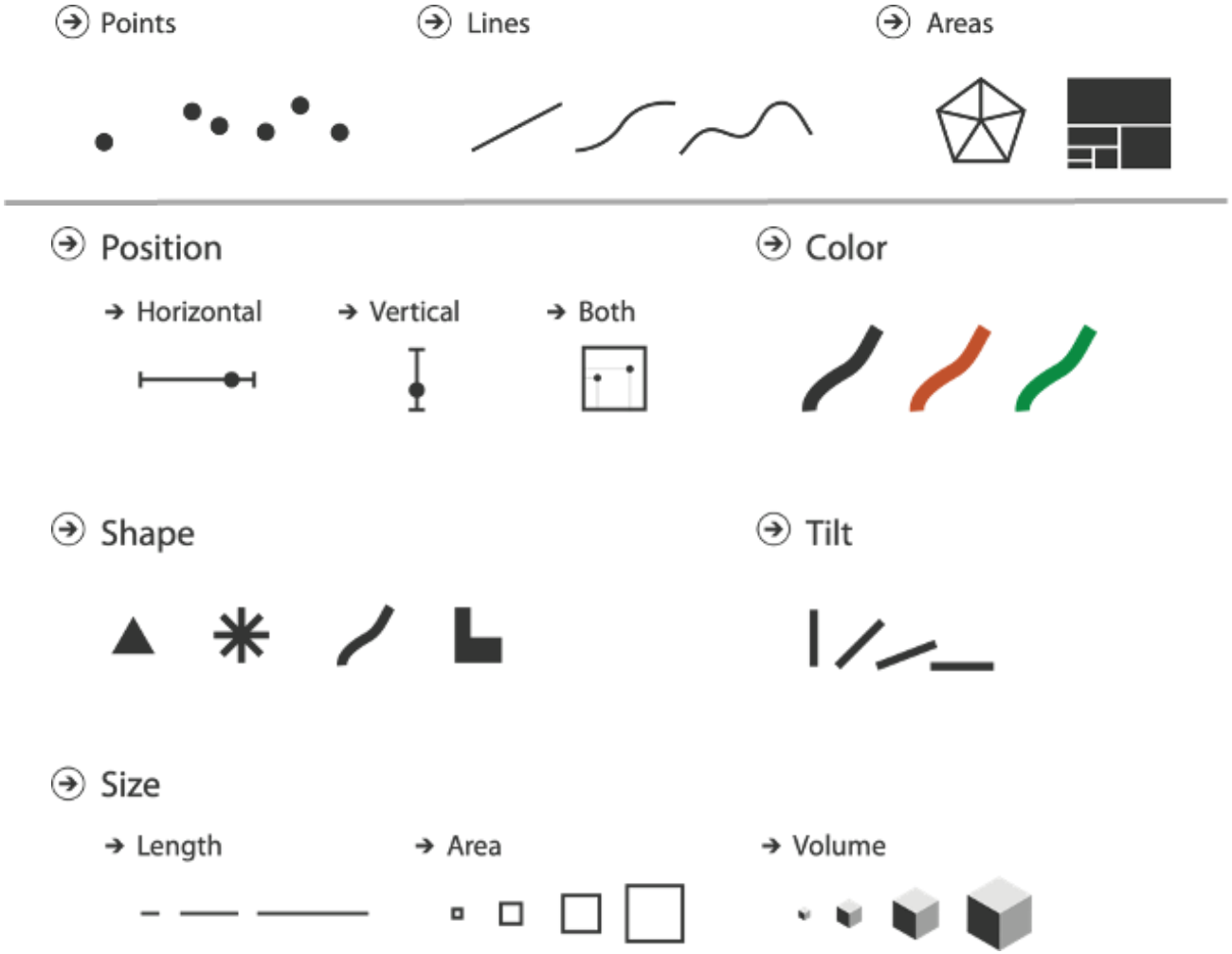
Definitions: Marks and channels

- Marks
  - Geometric primitives
- Channels
  - Control appearance of marks



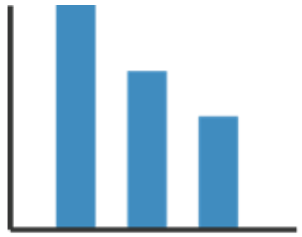
Definitions: Marks and channels

- Marks
  - Geometric primitives
- Channels
  - Control appearance of marks
- Channel properties differ
  - Type and amount of information that can be conveyed to human perceptual system



Visual encoding

- Analyze idiom structure as combination of marks and channels



1:
vertical position

mark: line

2:
vertical position
horizontal position

mark: point

3:
vertical position
horizontal position
color hue

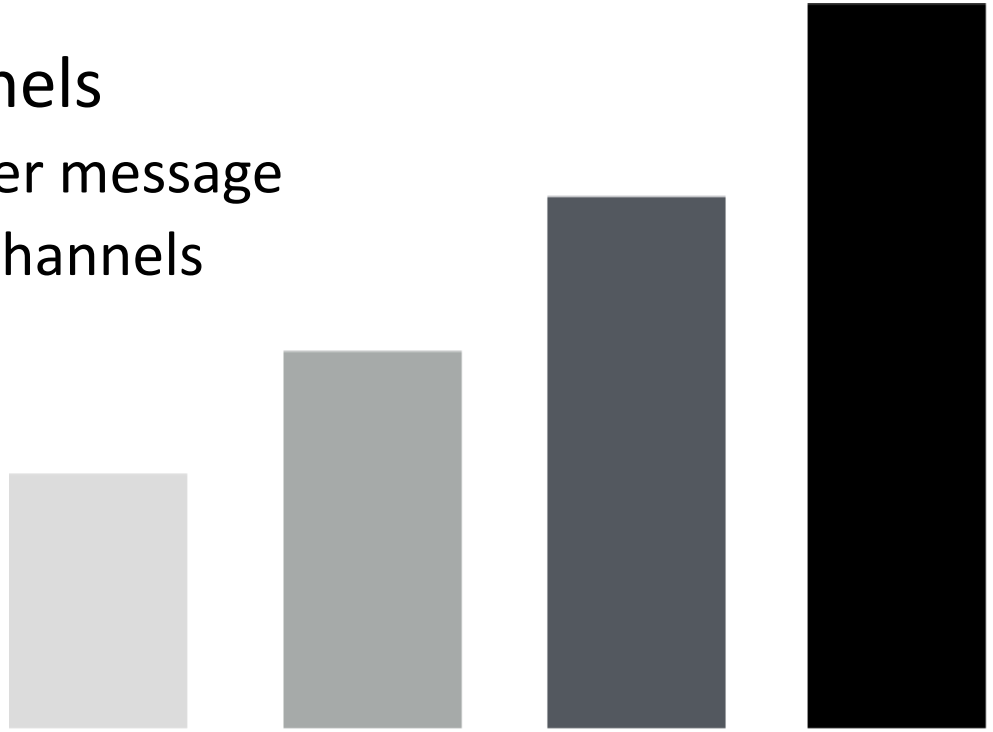
mark: point

4:
vertical position
horizontal position
color hue
size (area)

mark: point

Redundant encoding

- Multiple channels
  - Sends stronger message
  - But uses up channels



Length and Luminance

Marks as constraints

- Math view: geometric primitives have dimensions

- Constraint view: mark type constrains what else can be encoded
  - Points: 0 constraints on size, can encode more attributes with size and shape
  - Lines 1 constraint on size (length), can still size code other way (width)
  - Interlocking areas: 2 constraints on size (length/width), cannot zsize or shape code
    - Interlocking: size, shape, position

Scope of analysis

- Simplifying assumptions: one mark per item (row), single view

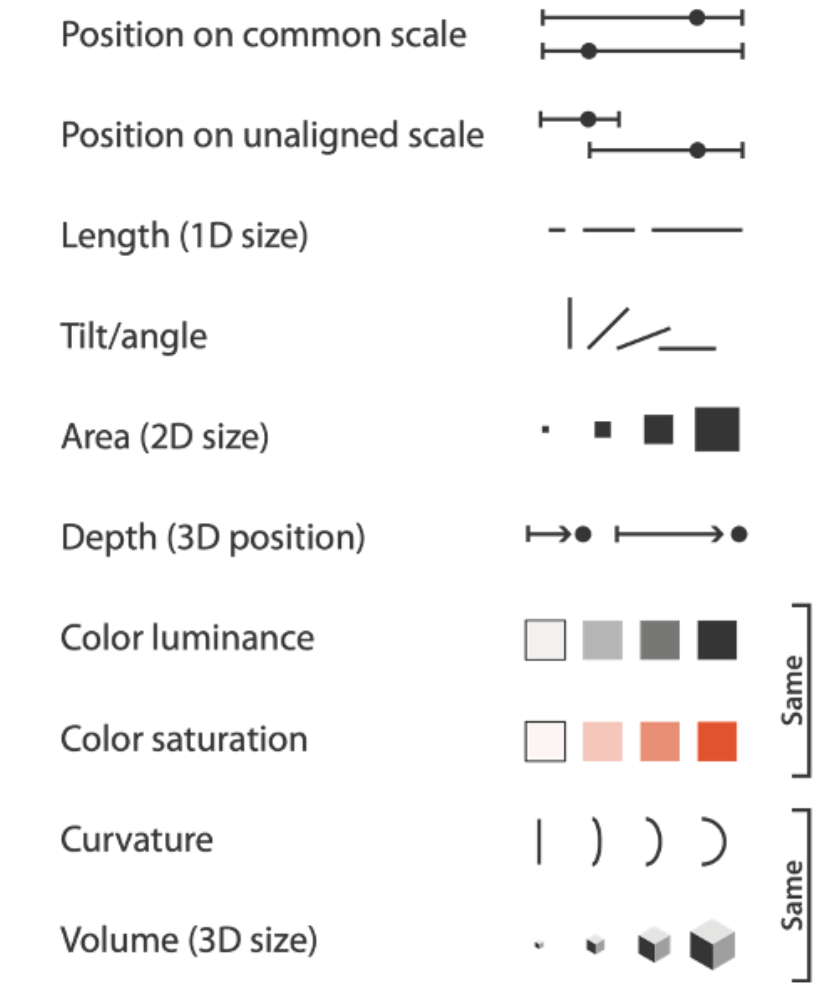
- Later on
  - Multiple views
  - Multiple marks in a region (glyph)
  - Some items not represented by marks (aggregation and filtering)

When to use which channel

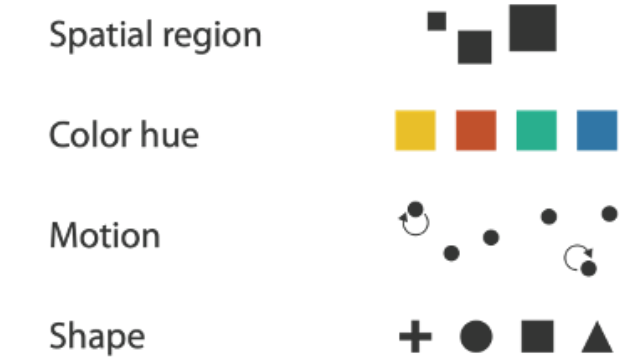
- Expressiveness
  - Match channel type to data type
- Effectiveness
  - Some channels are better than others

Channel: Rankings – how attributes are shown

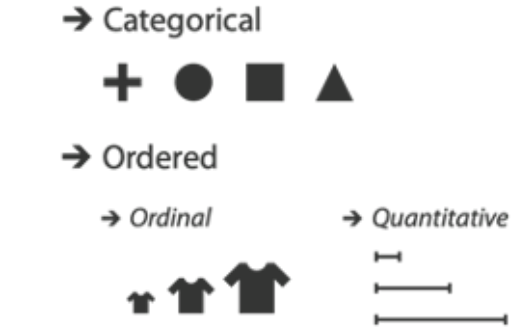
Magnitude Channels: Ordered Attributes



Identity Channels: Categorical Attributes



Attribute Types

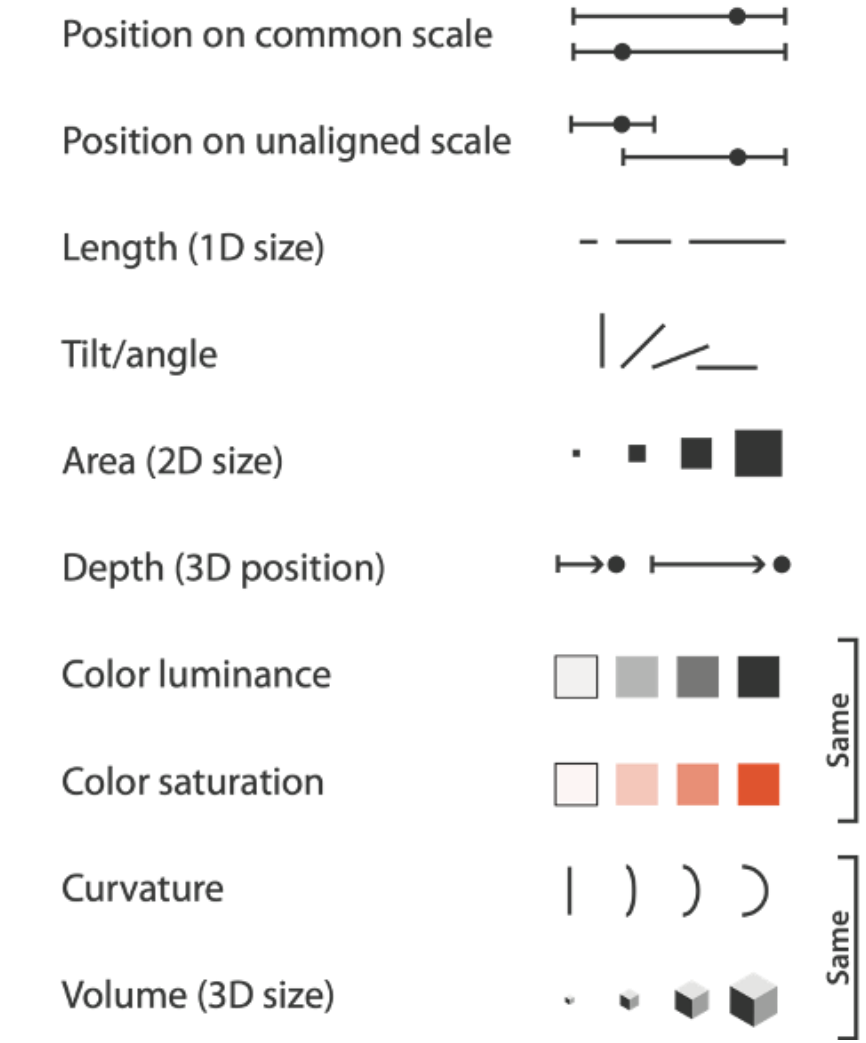


Expressiveness
- match channel and data characteristics
- magnitude for ordered
- how much? Which rank?

Identity for categorical
- what

Channel: Rankings – how attributes are shown

Magnitude Channels: Ordered Attributes



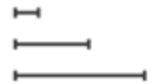
Identity Channels: Categorical Attributes

Attribute Types

- Categorical

- Ordered
  - *Ordinal*

  - *Quantitative*



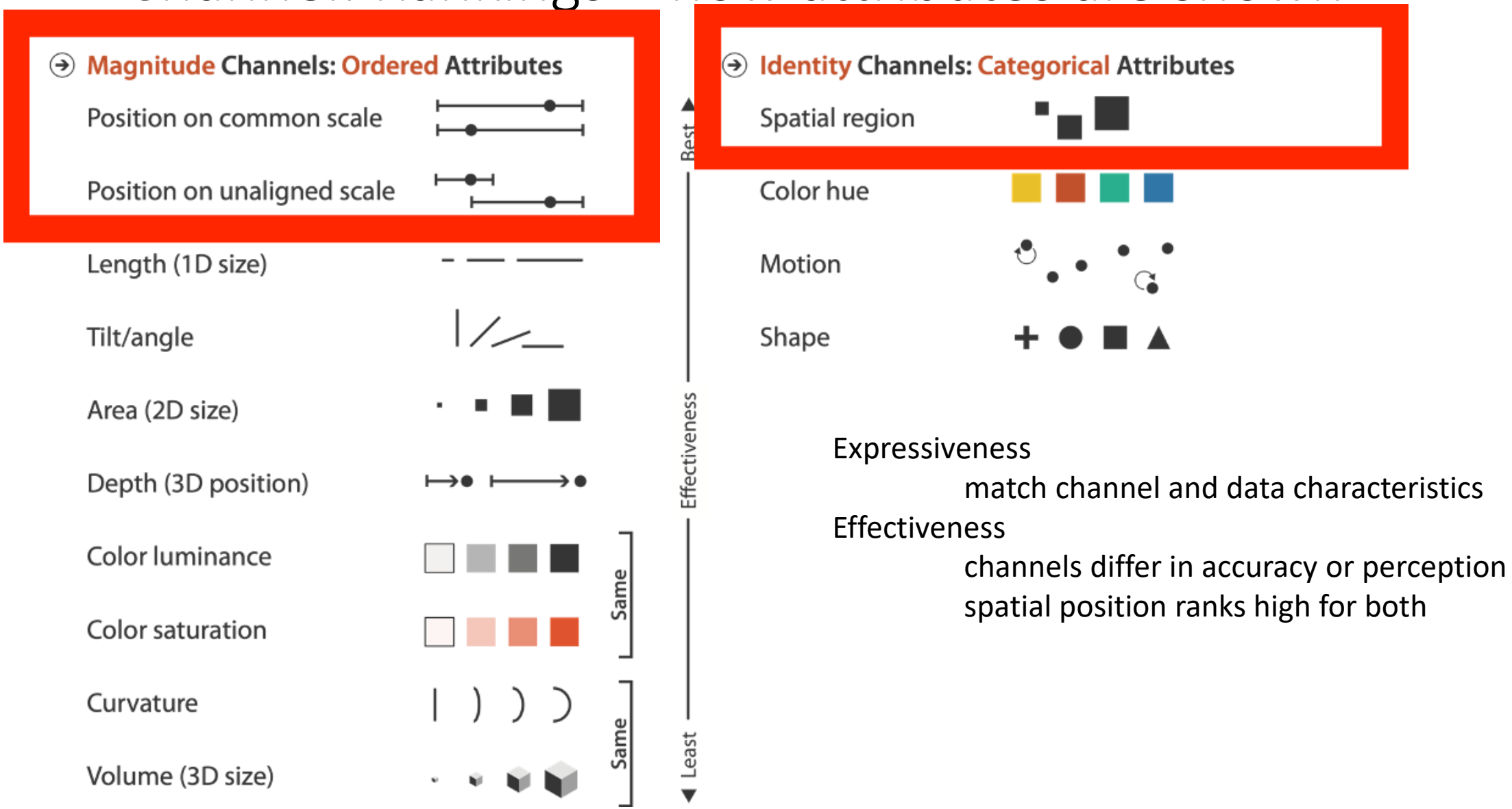
Expressiveness

match channel and data characteristics

Effectiveness

channels differ in accuracy or perception

Channel: Rankings – how attributes are shown



Expressiveness

match channel and data characteristics

Effectiveness

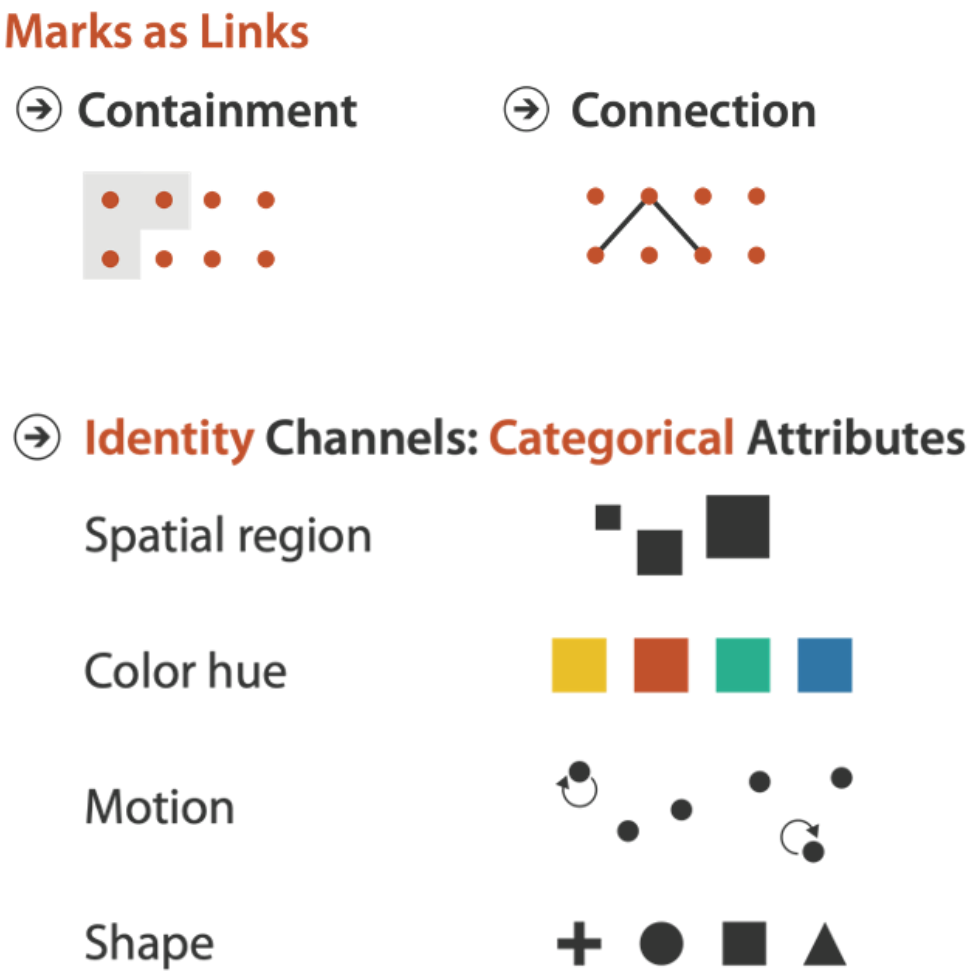
channels differ in accuracy or perception

spatial position ranks high for both

Grouping

- Containment
- Connection

- Proximity
  - Same spatial region
- Similarity
  - Same values as other categorical channels

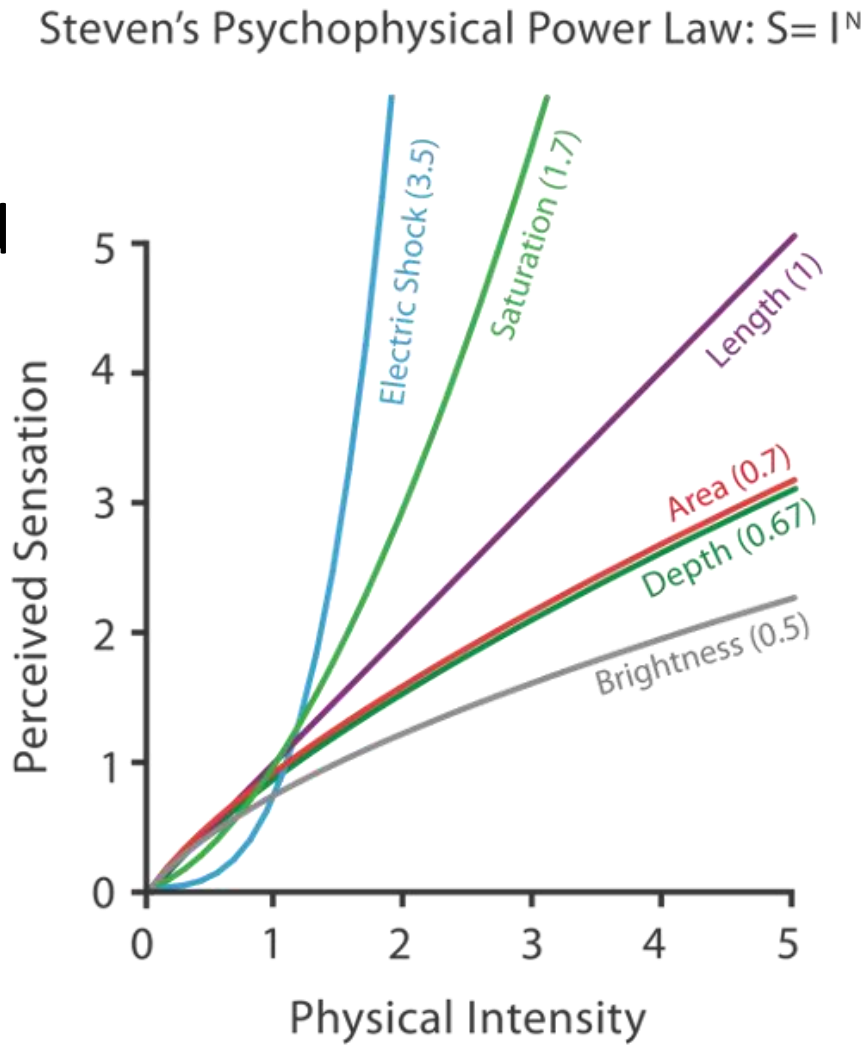


Channel effectiveness

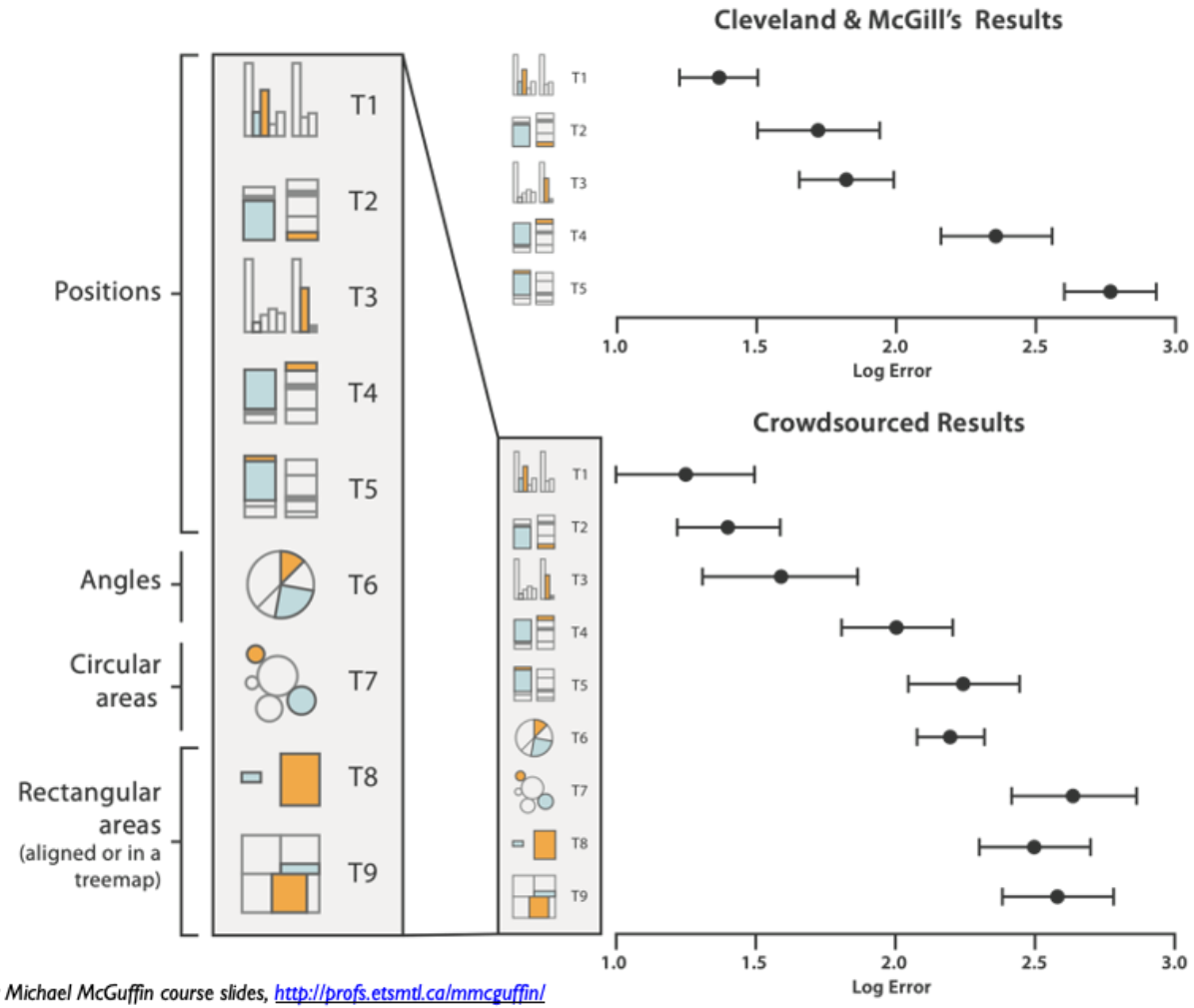
- Accuracy: how precisely can we tell the difference between encoded items?
- Discriminability: how many unique steps can we perceive?
- Separability: is our ability to use this channel affected by another one?
- Popout: can things jump out using this channel?

Accuracy: fundamental theory

- Length is accurate: linear
- Others magnified or compressed
  - Exponent characterizes



Accuracy: Visualization Experiments

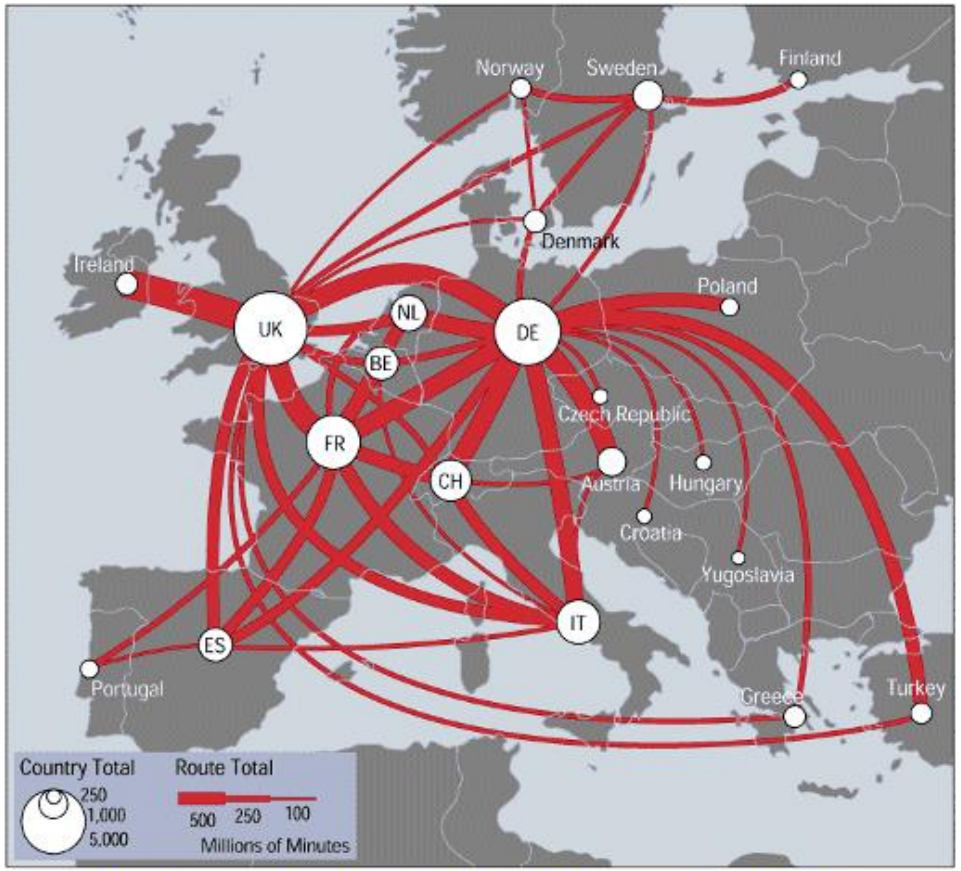


after Michael McGuffin course slides, http://profs.etsmtl.ca/mmcguffin/

[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.]

Discriminability: How many usable steps?

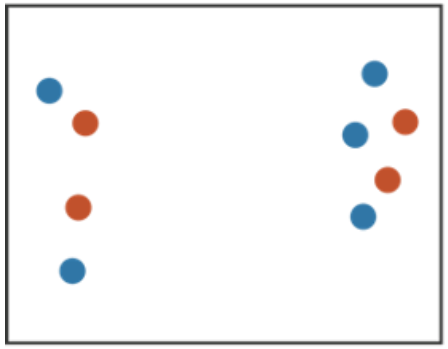
- Must be sufficient for number of attribute levels to show
  - Linewidth: few bins



[mappa.mundi.net/maps/maps_014/telegeography.html]

Separability vs. integrality

Position
+ Hue (Color)



Fully separable

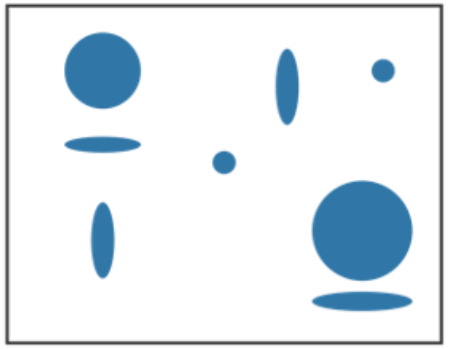
2 groups each

Size
+ Hue (Color)

Some interference

2 groups each

Width
+ Height



Some/significant interference

3 groups total: integral area

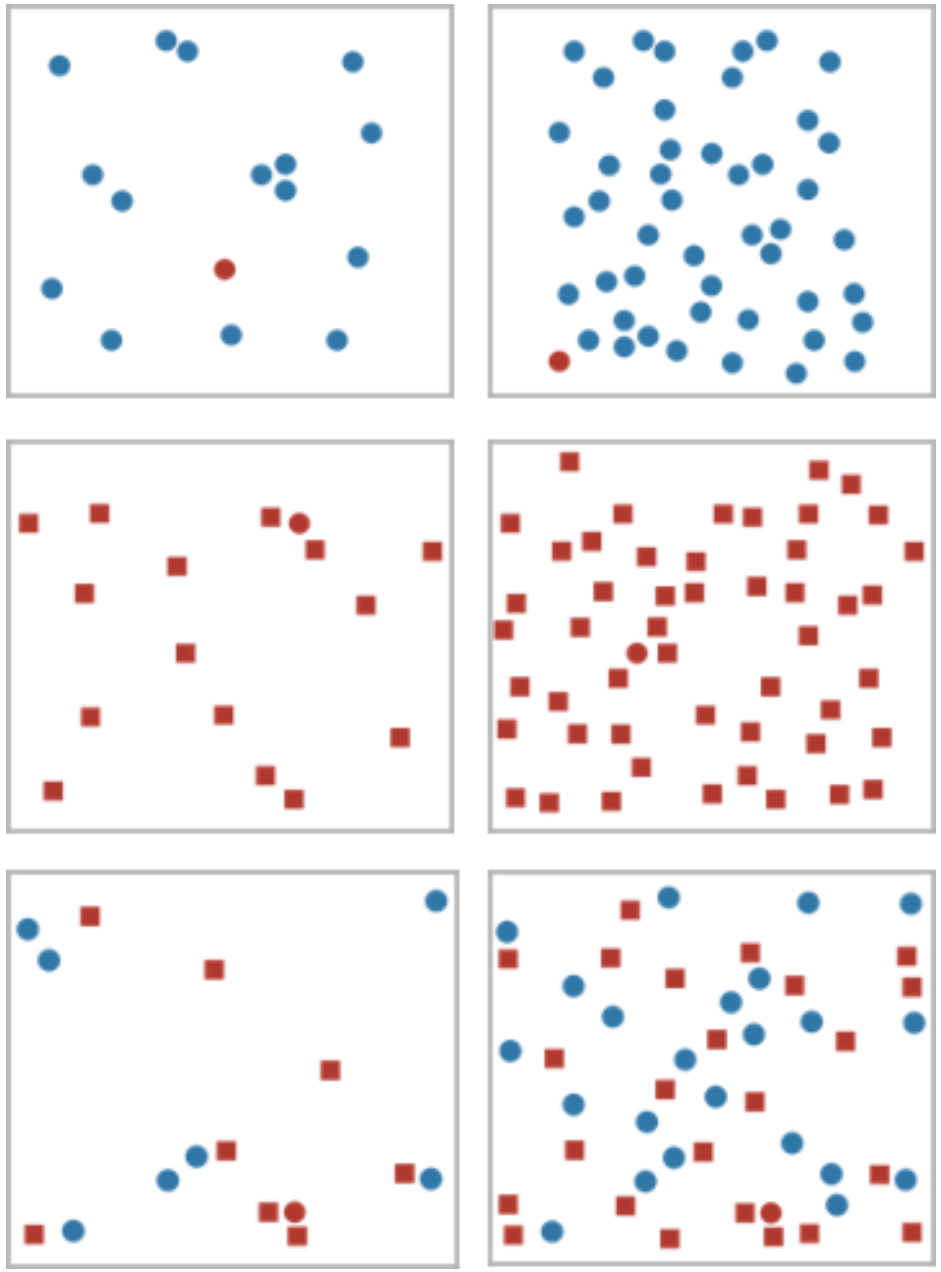
Red
+ Green

Major interference

4 groups total: integral hue

Popout

- Find the red dot
- Parallel processing on many individual channels
  - Speed independent of distractor count
  - Speed depends on channel and amount of difference from distractors
- Serial search (almost all) combinations
  - Speed depends on number of distractors (tempting)



Popout

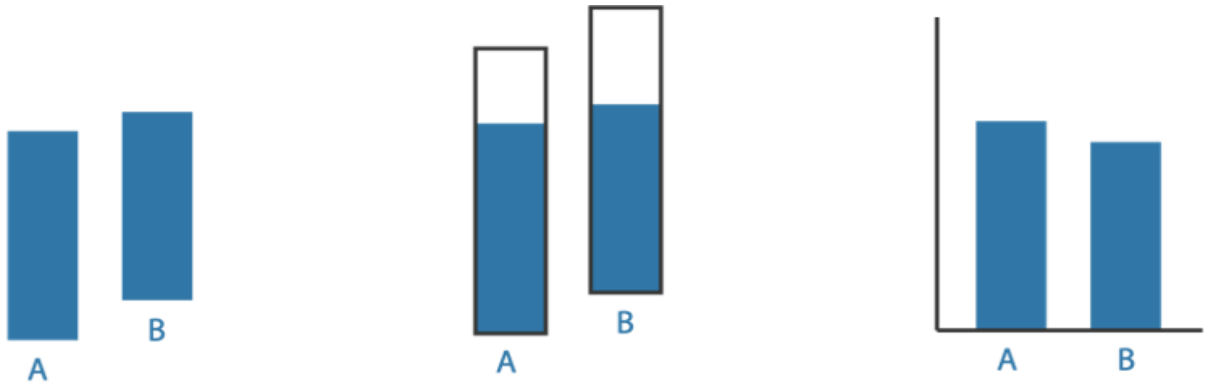
- Many channels
  - Tilt, size, shape, proximity, shadow direction
- But not all
  - Parallel line pairs do not pop out from tilted pairs

Factors affecting accuracy

- Alignment
- Distractors
- Distance
- Common scale / alignment

Relative vs. absolute judgements

- Perceptual system mostly operates with relative judgements, not absolute
  - 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 judgment



after [Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.]