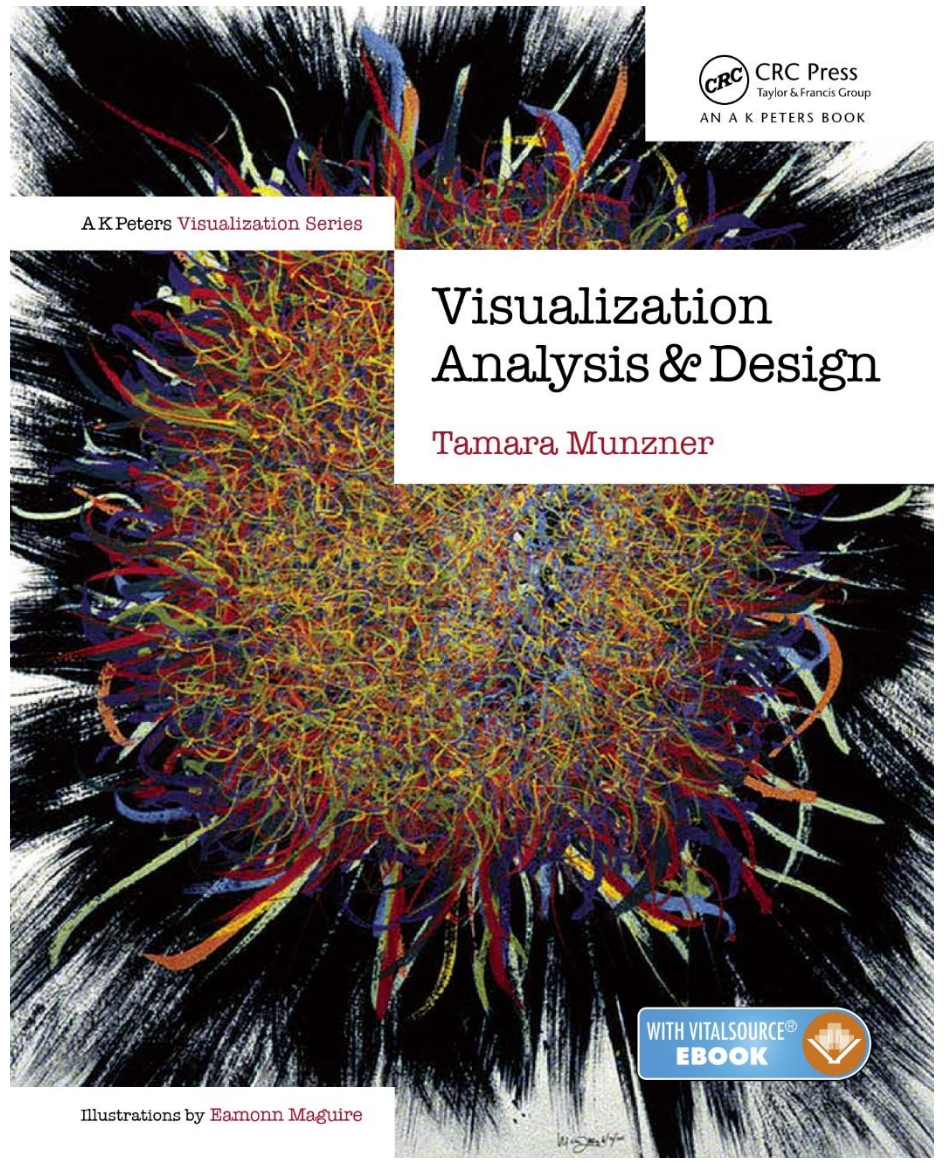
Cody Dunne

Northeastern University

Marks and Channels

CHECKING IN

The Nested Model for Visualization Development



"Nested Model"

Domain situation
Observe target users using existing tools

Data/task abstraction

Visual encoding/interaction idiom
Justify design with respect to alternatives

Algorithm
Measure system time/memory
Analyze computational complexity

Analyze results qualitatively

Measure human time with lab experiment (*lab study*)

Observe target users after deployment (*field study*)

Measure adoption

Example

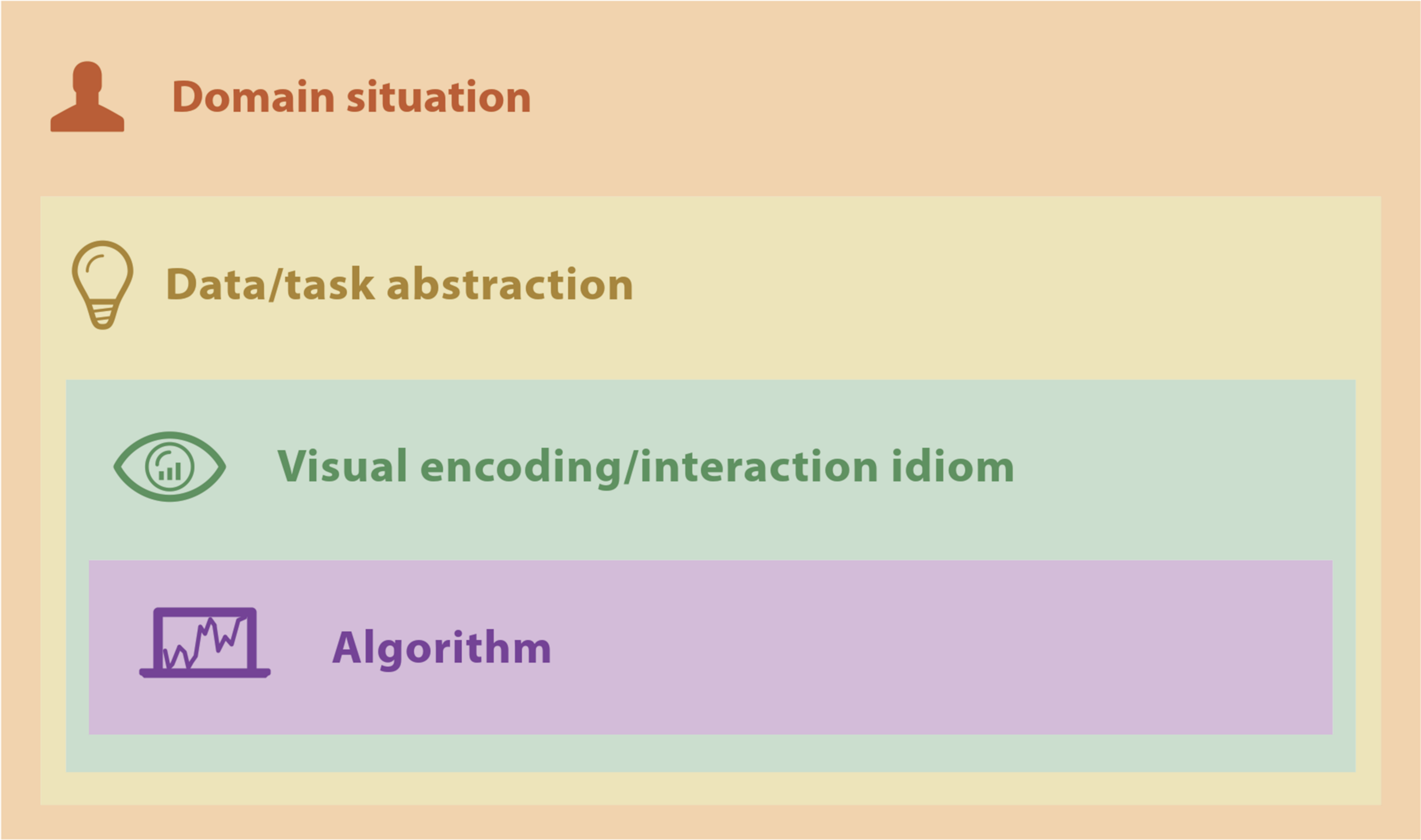
FAA (aviation)

What is the busiest time of day at Logan Airport?

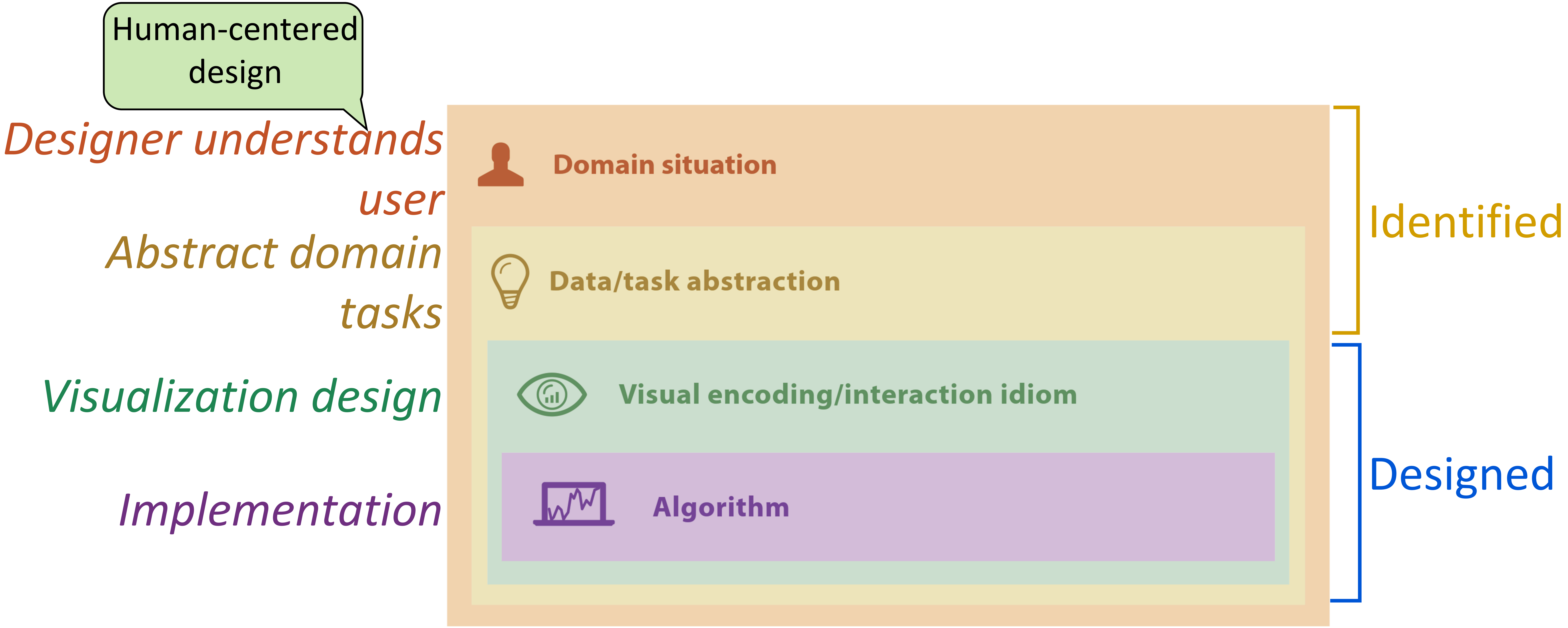
Map vs. Scatter Plot vs. Bar


Tamara Munzner

Nested Model



Nested Model



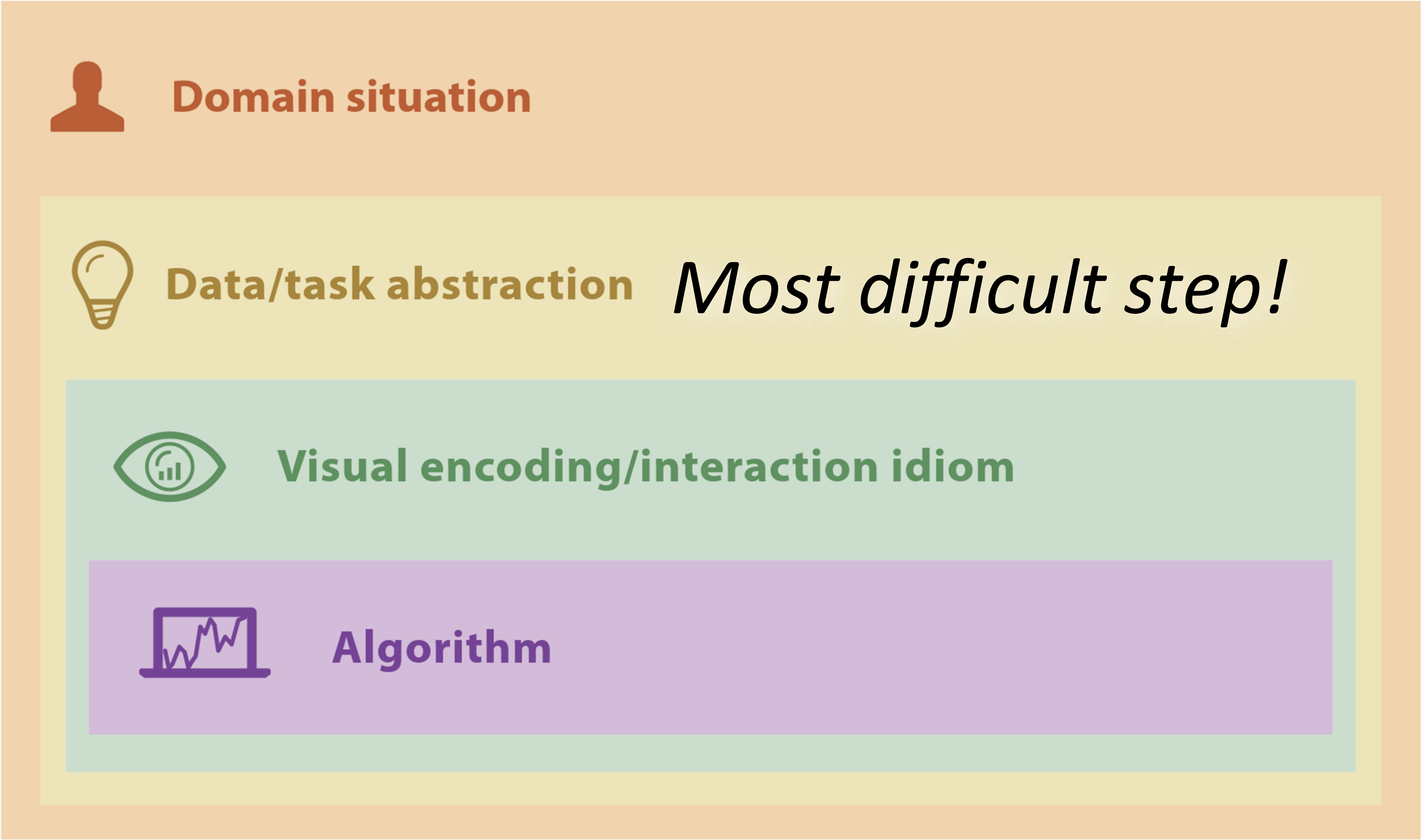
Nested Model

Design Study

TOP-DOWN
“problem-driven”

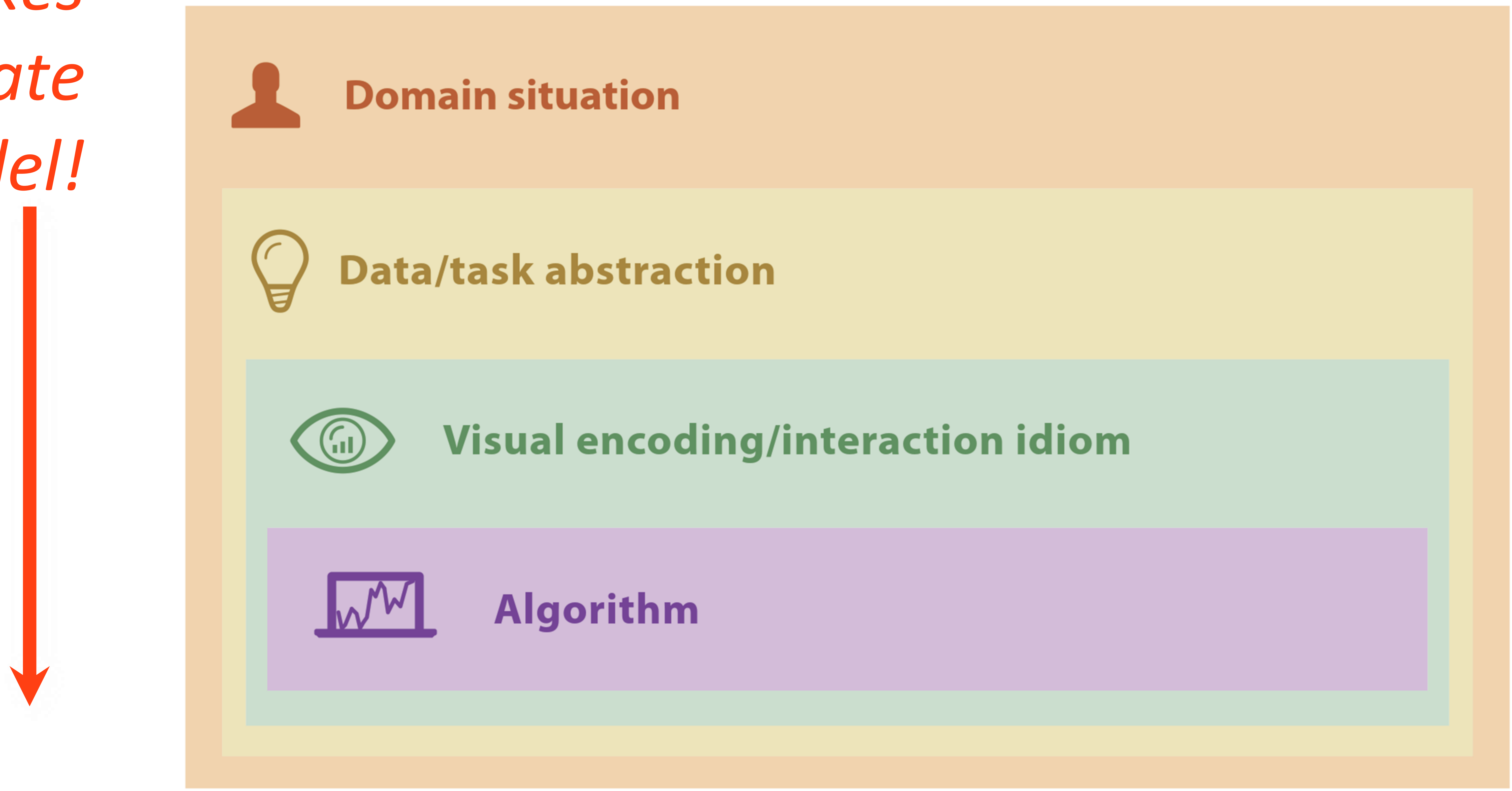
Technique

BOTTOM-UP
“technique-driven”

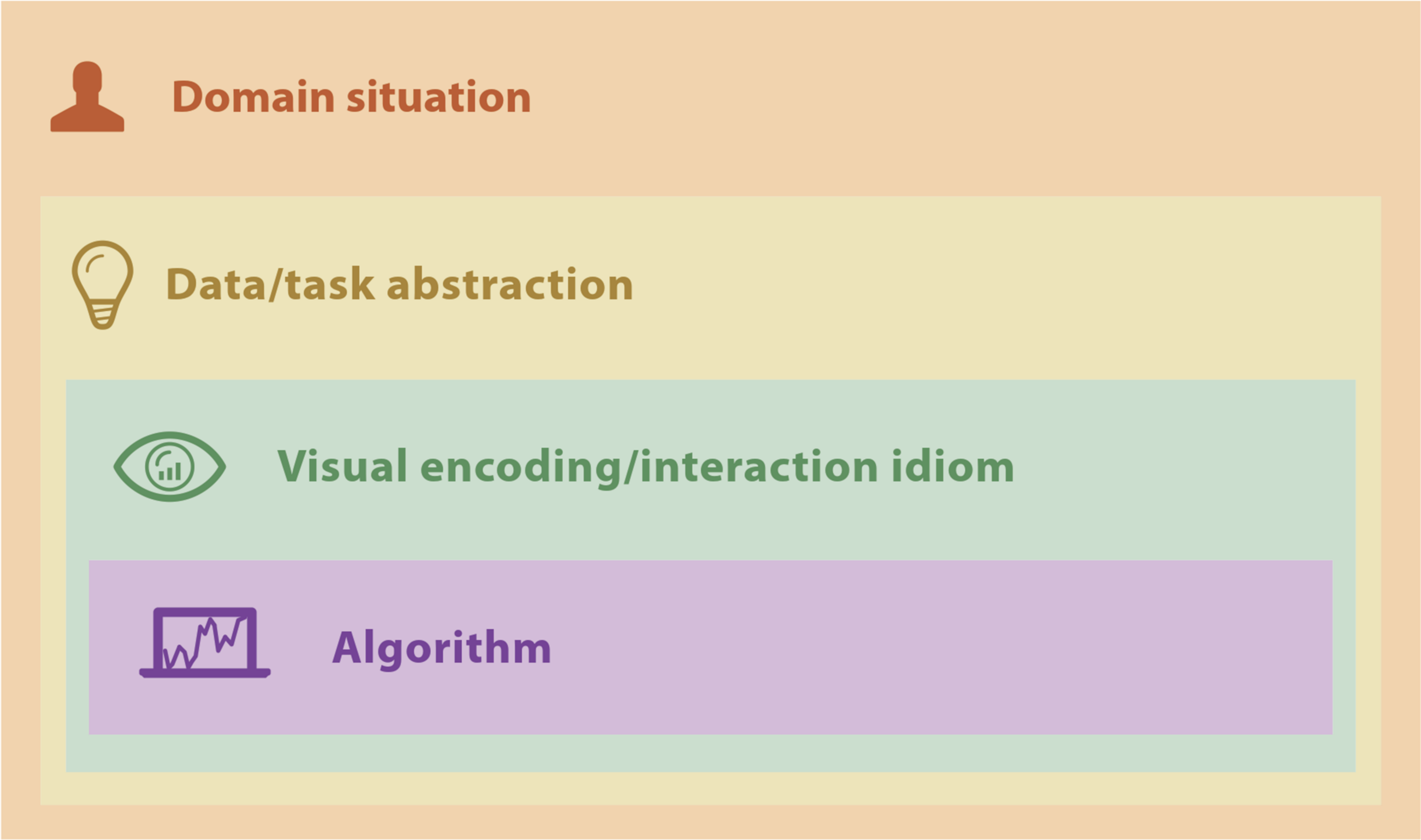


Nested Model

Mistakes propagate through model!



Threats to Validity

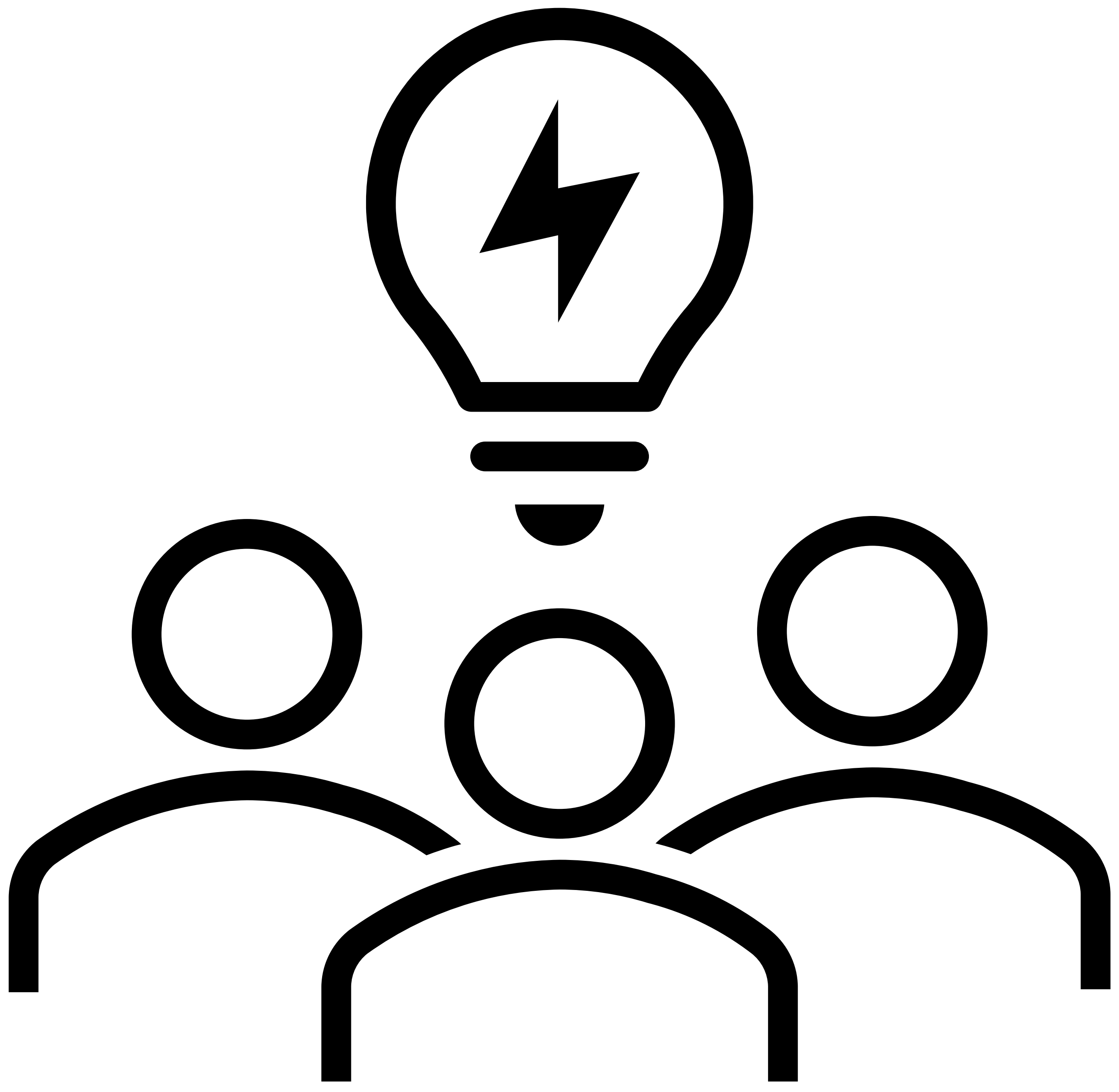


Threats to Validity

- Domain situation
- Data/task abstraction
- Visual encoding/interaction idiom
- Algorithm

Marks and Channels

In-Class Exercise



In-class brainstorming: building blocks

9m

1. Take 5 minutes to talk in groups of 4–5 and brainstorm what you think the building blocks to a visualization are.

2. Be prepared to share with the class.

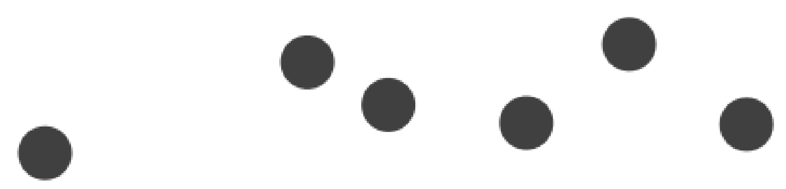
Goals for Today

- Learn the basic visual primitives of visualizations (marks and channels)
- Understand how marks and channels are assembled to make visualizations
- Learn which marks and channels are most effective for a given task ("perceptual ordering")

Visualization Building Blocks

MARK = basic graphical element in an image

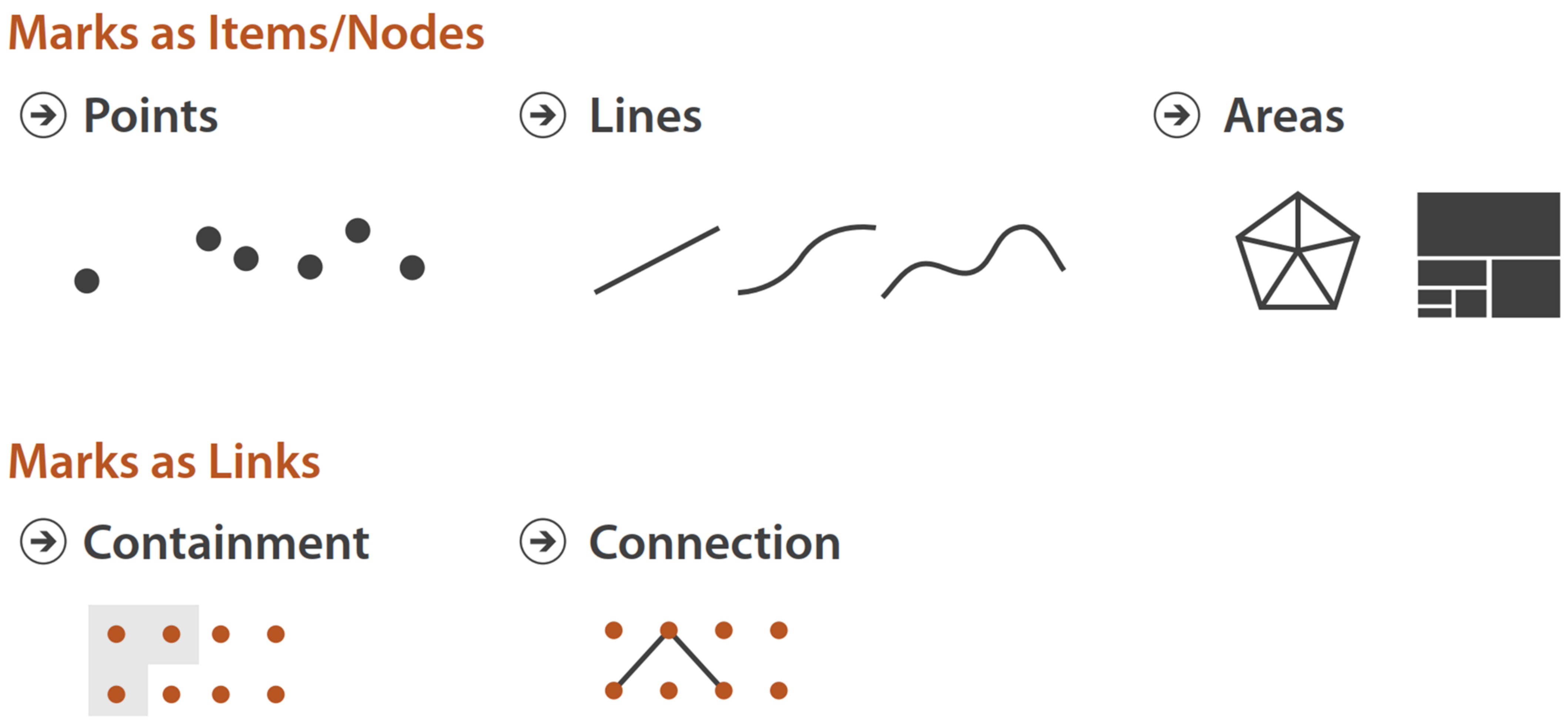
➔ **Points**



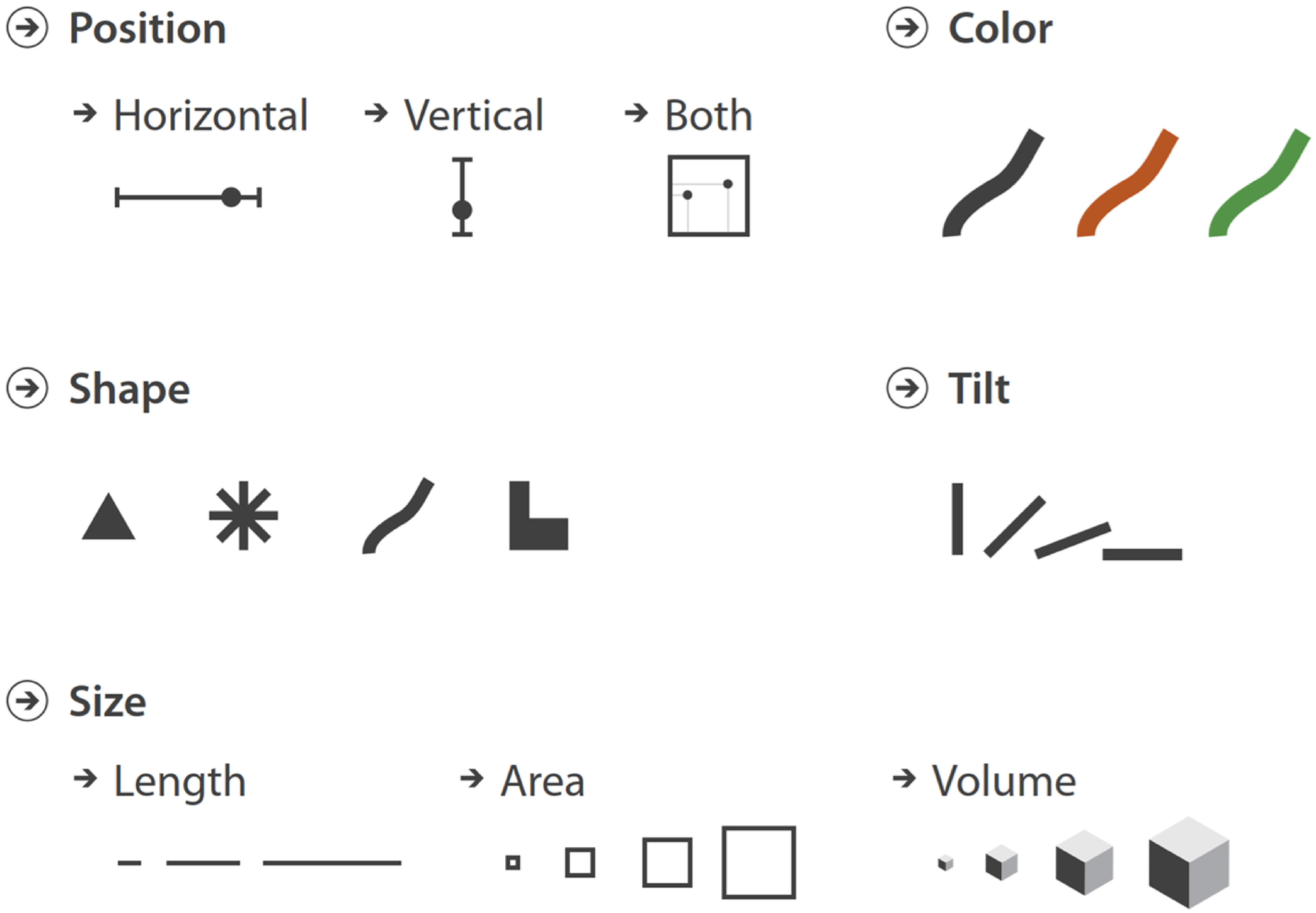
Visualization Building Blocks

CHANNEL = way to control the appearance of marks, independent of the dimensionality of the geometric primitive

Visualization Building Blocks



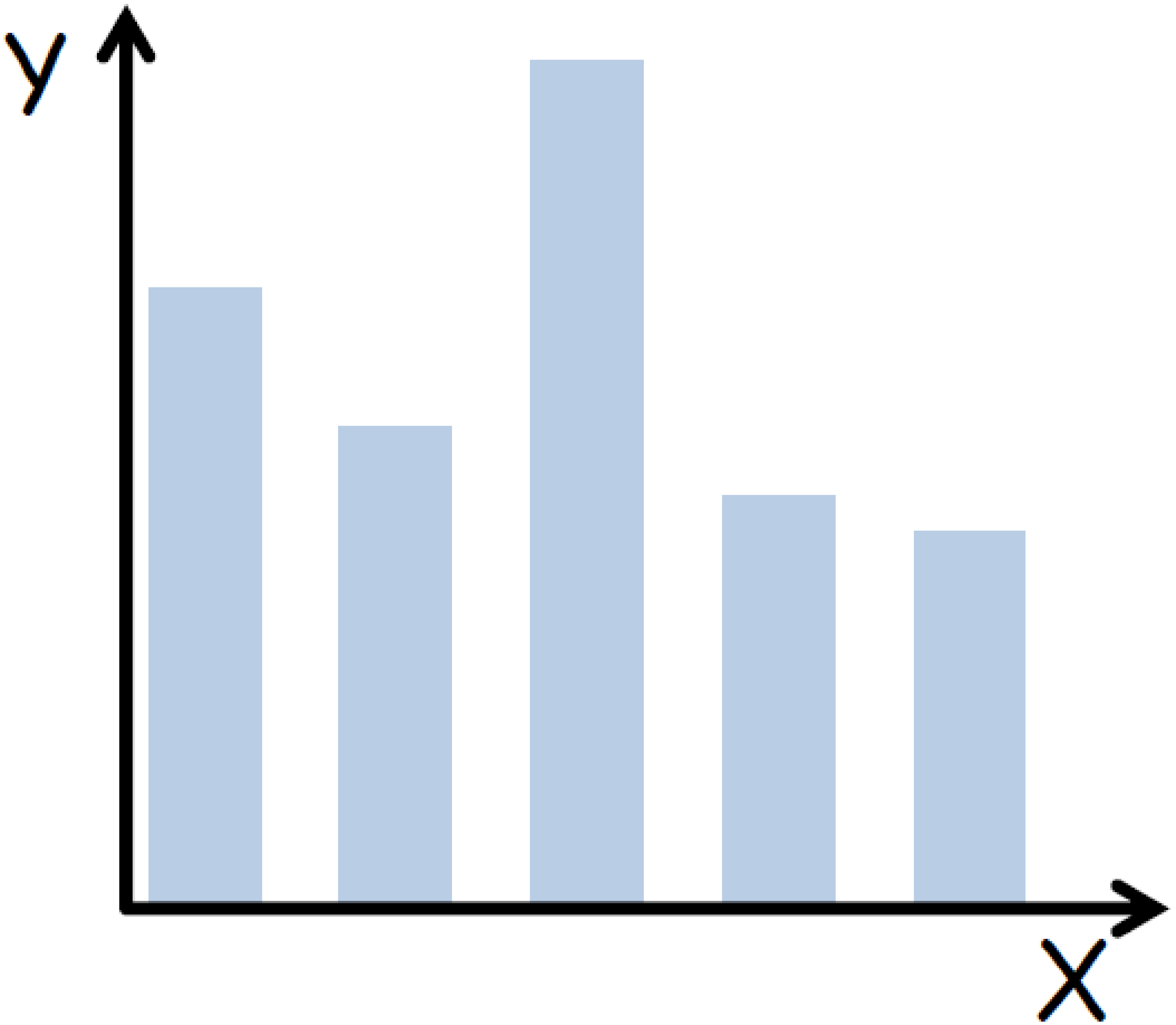
Channels :

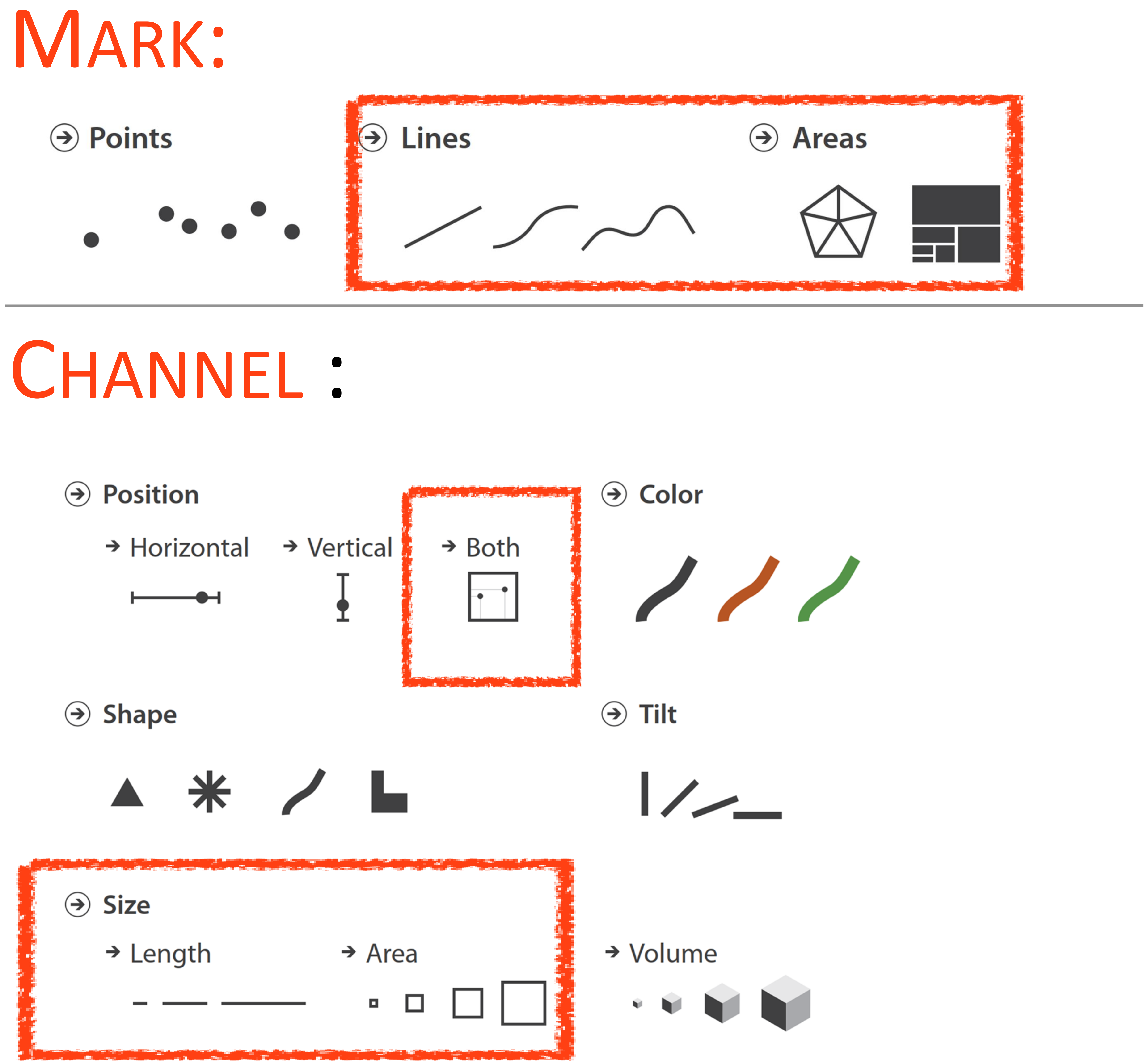


Note: these are all really important concepts when it comes time to coding your visualizations…!

Visualization Building Blocks

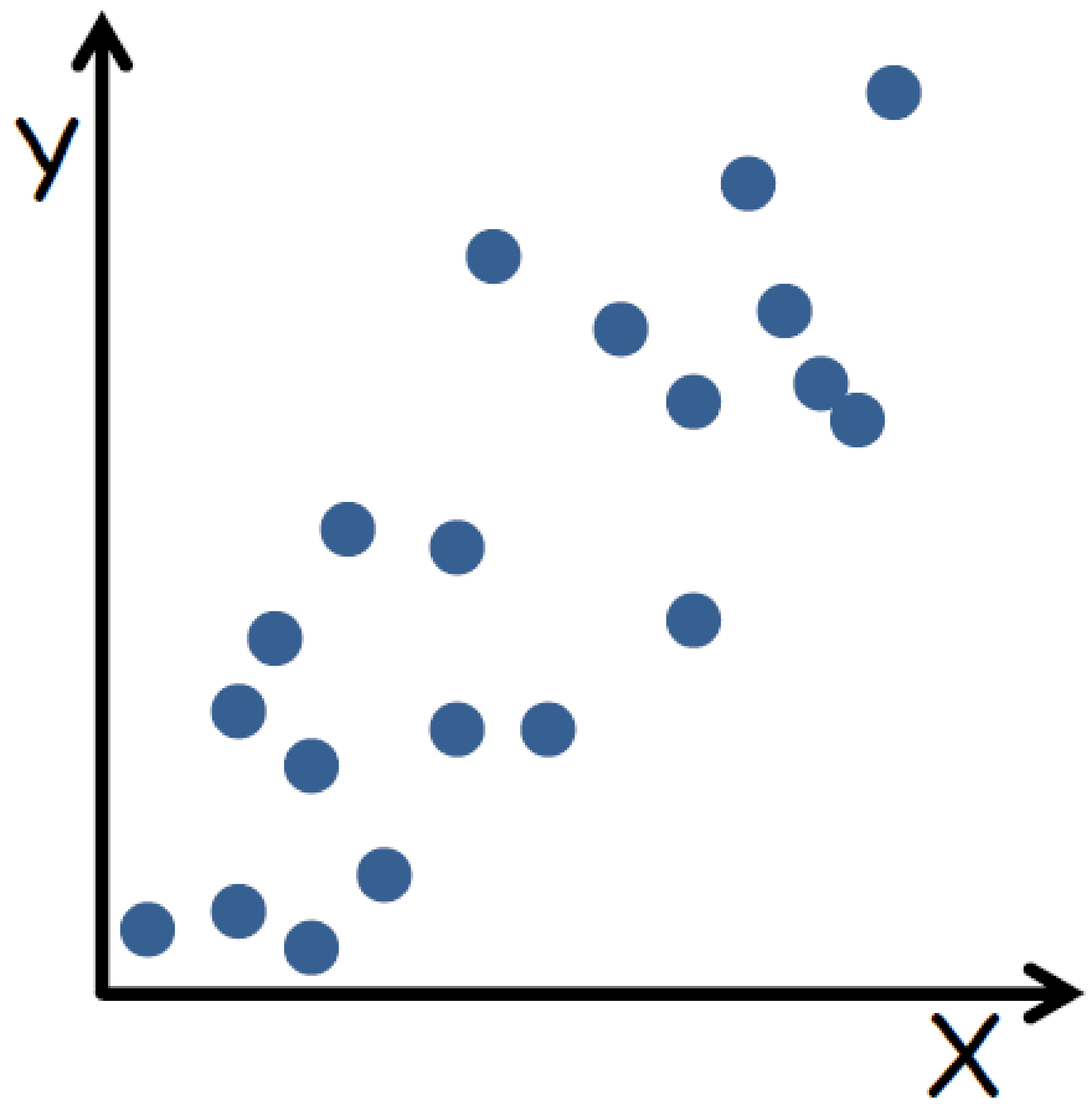
of attributes encoded: 2

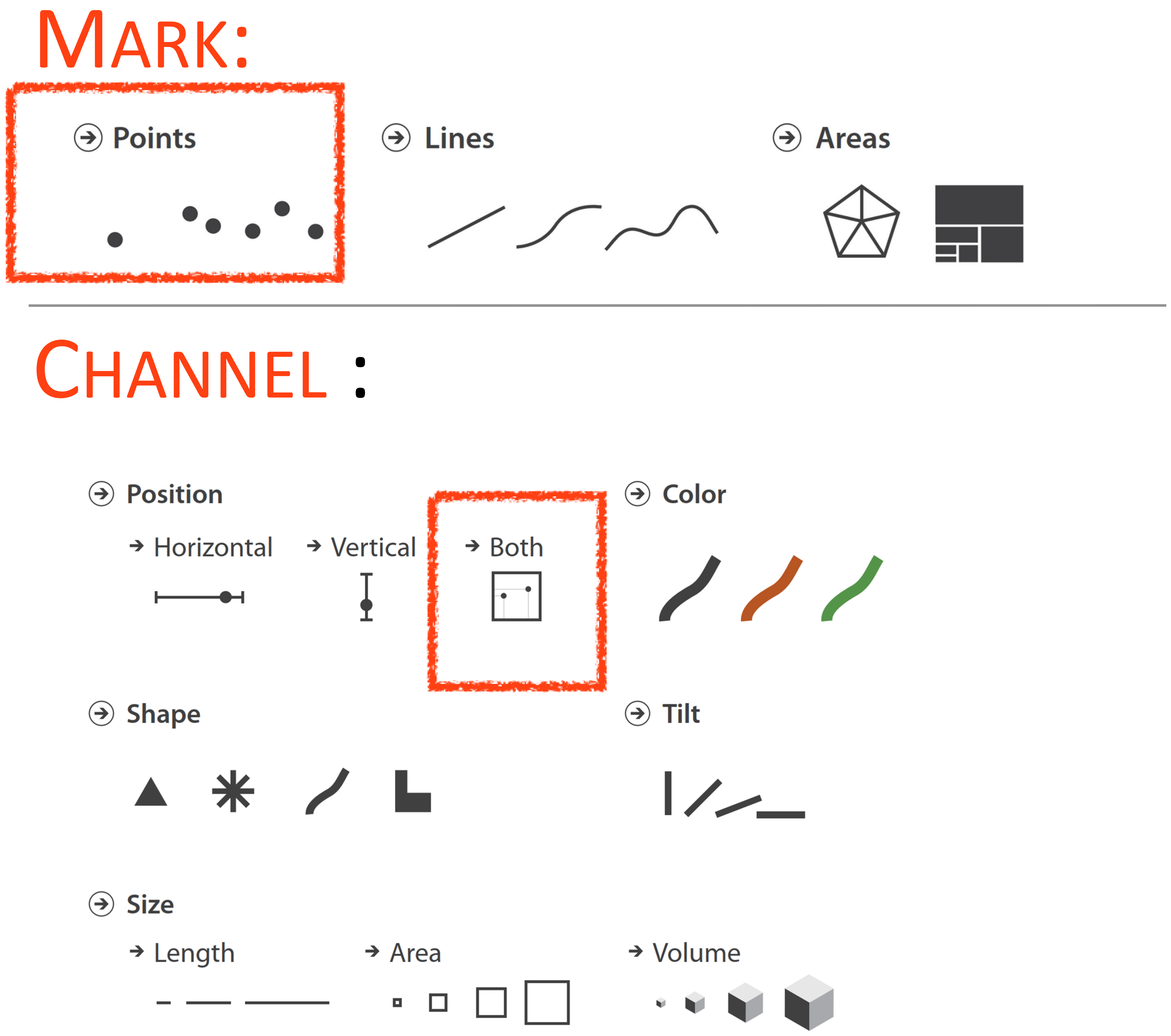




Visualization Building Blocks

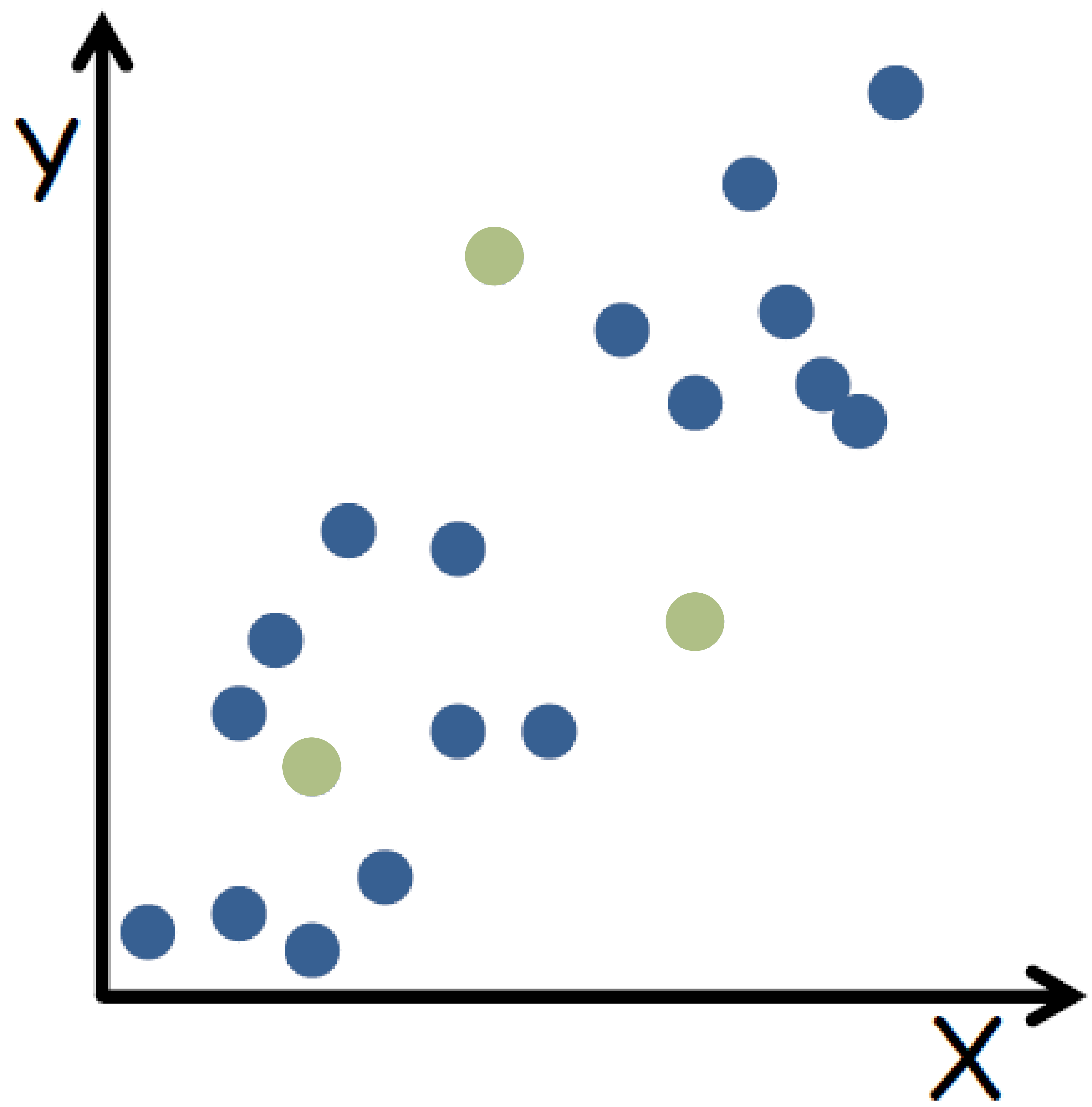
of attributes encoded: 2

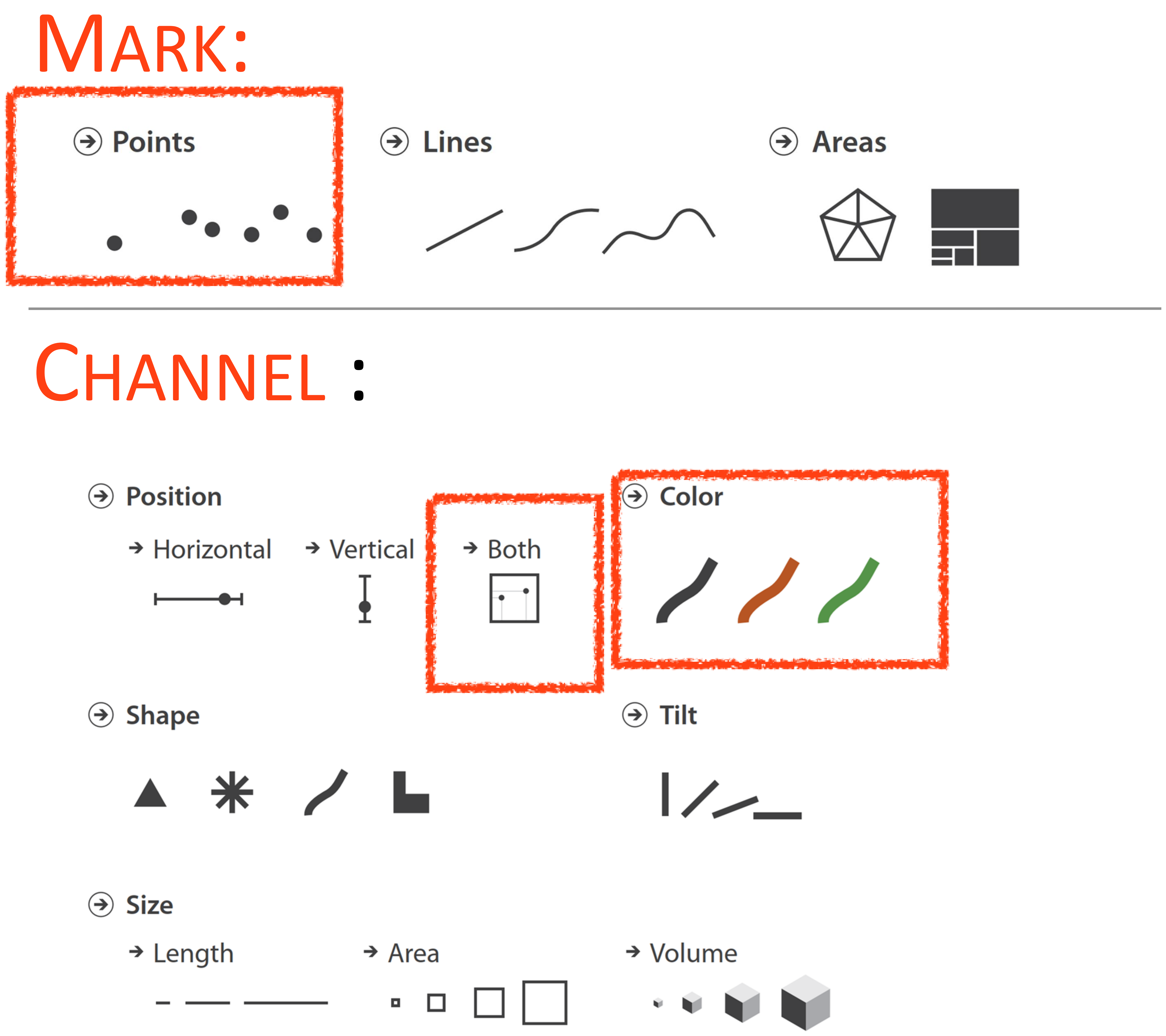




Visualization Building Blocks

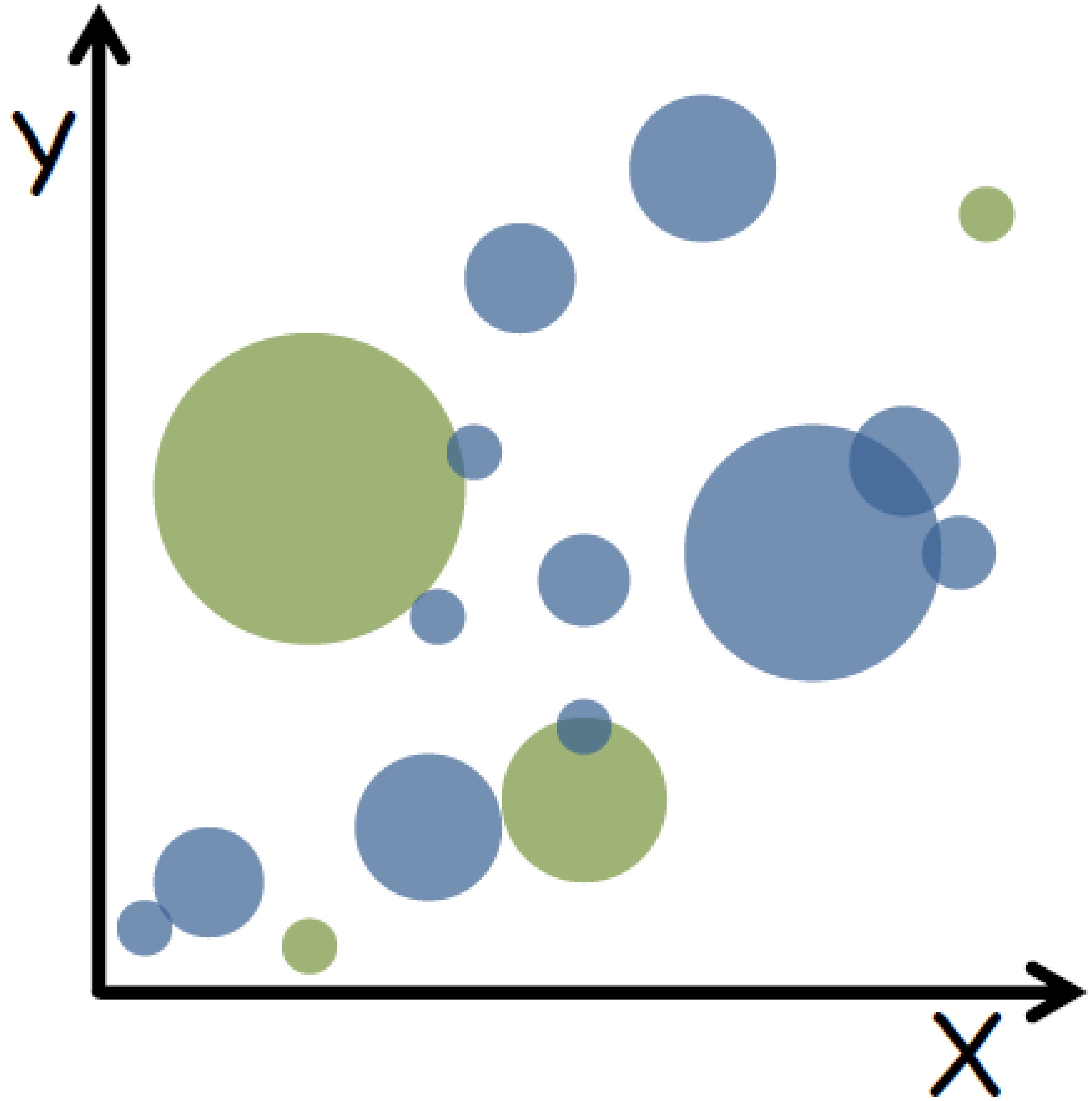
of attributes encoded: 3



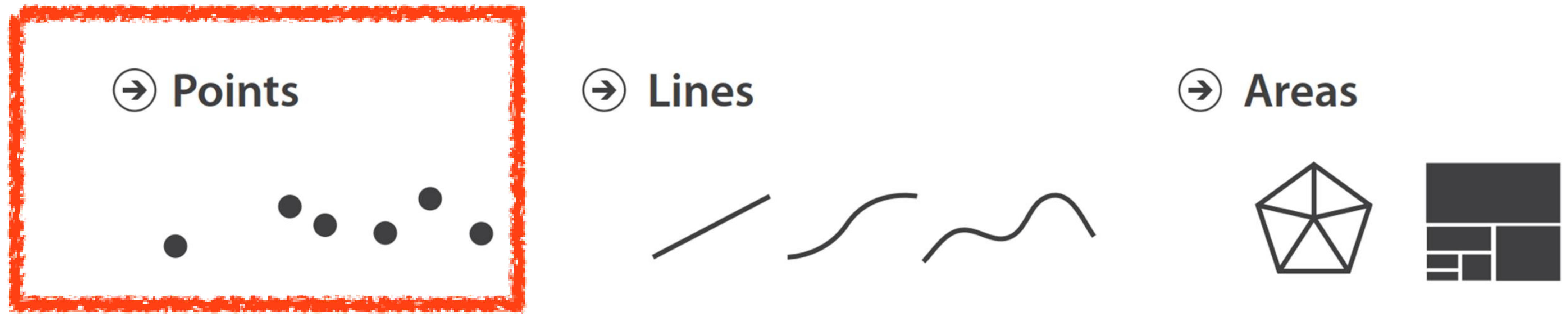


Visualization Building Blocks

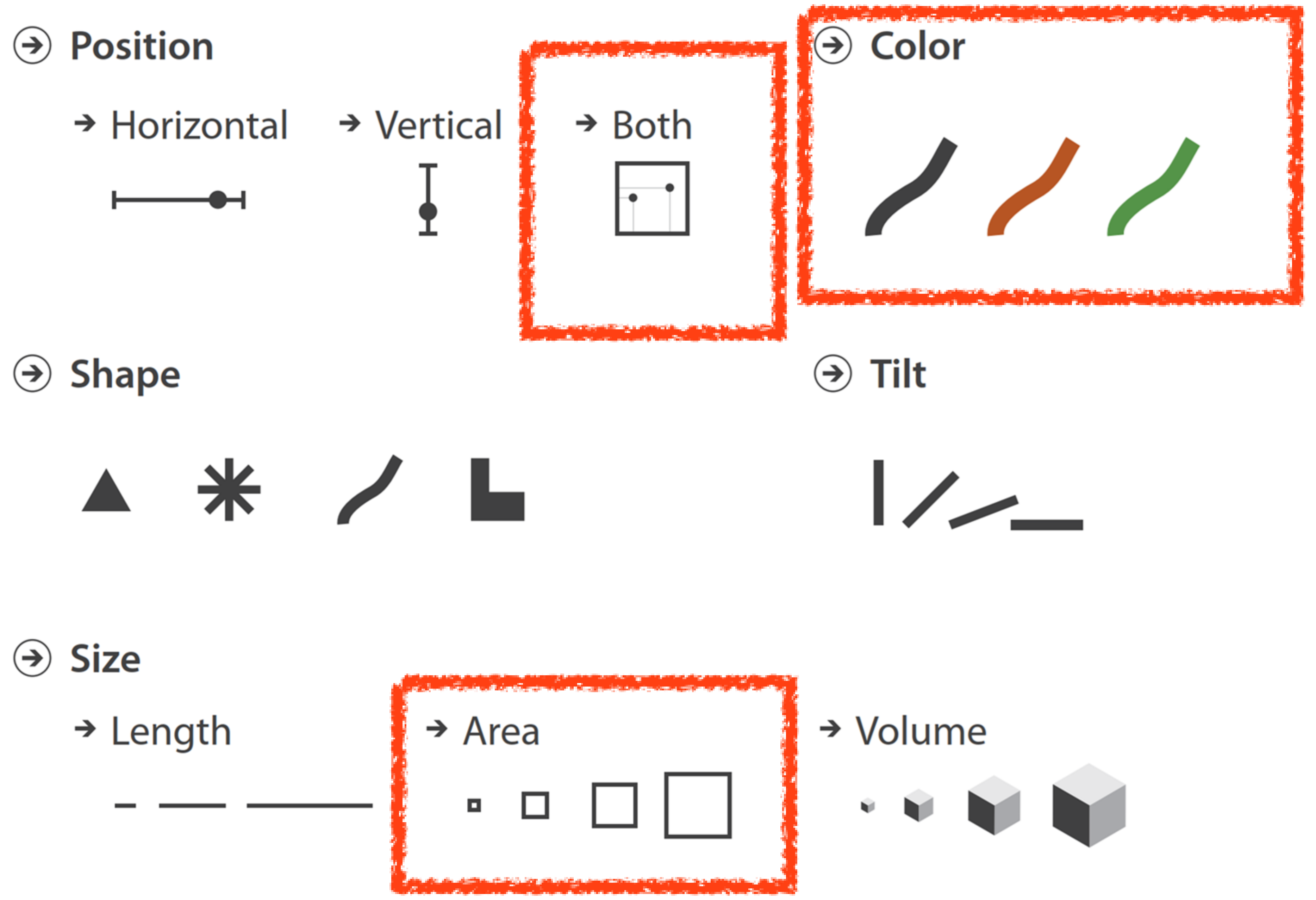
of attributes encoded: 4



MARK:

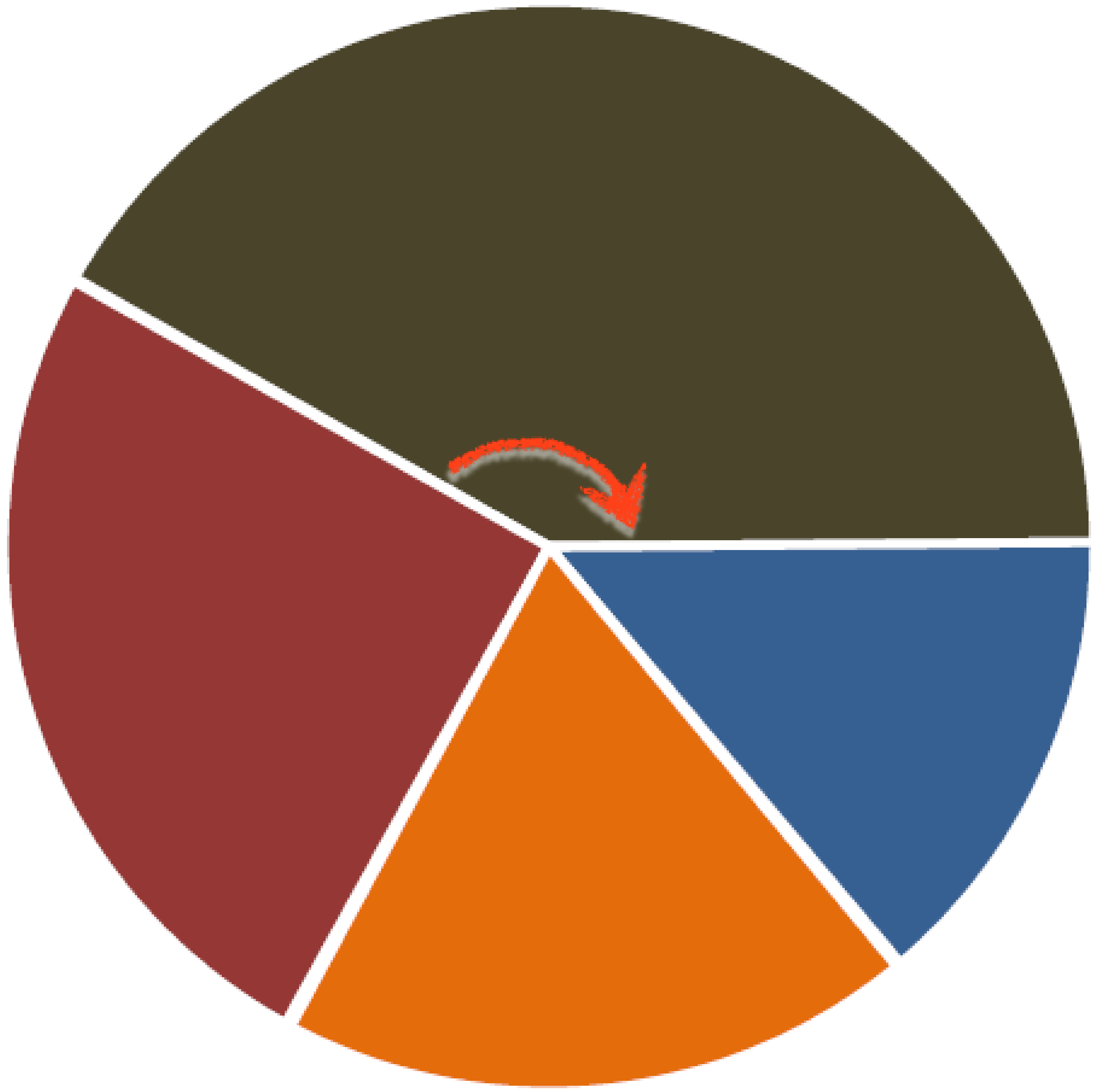


CHANNEL :

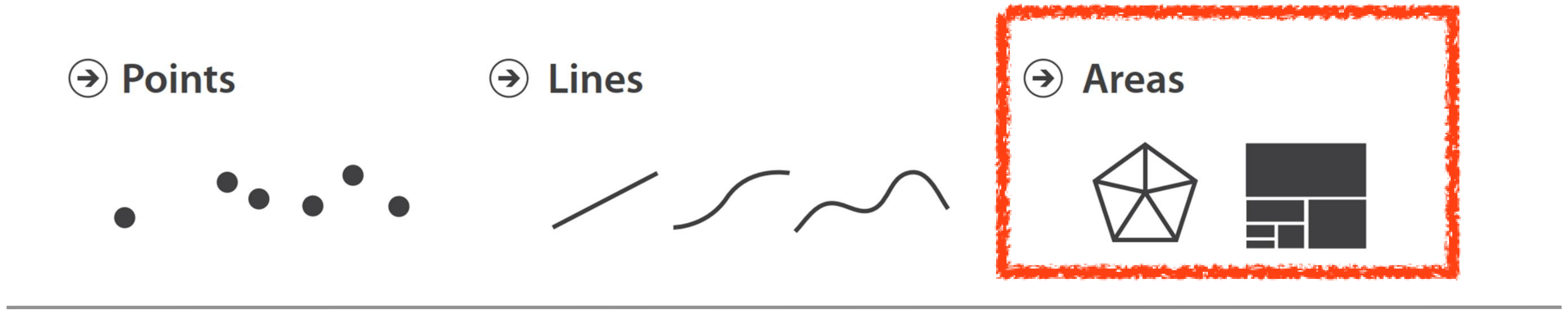


Visualization Building Blocks

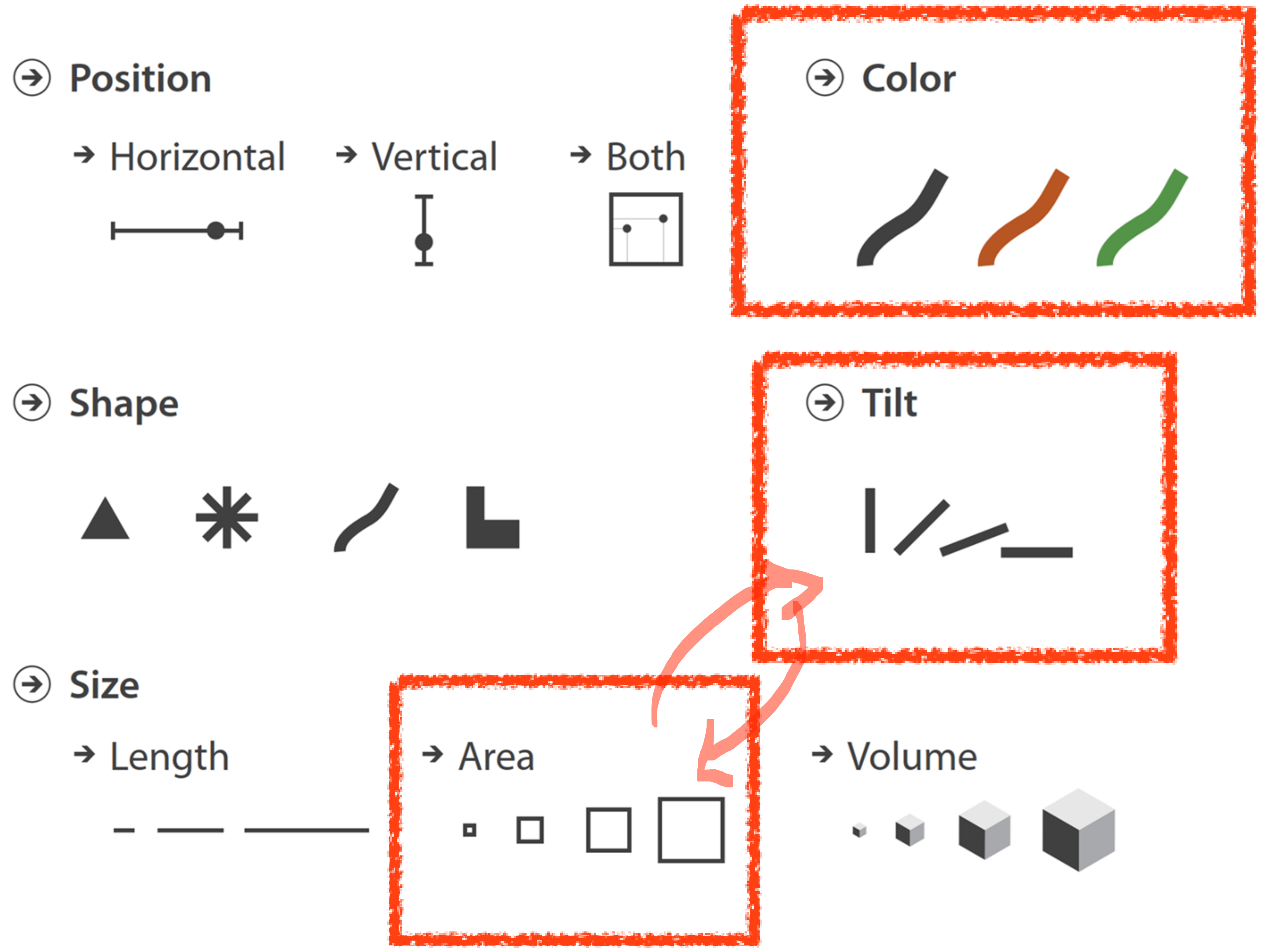
of attributes encoded: 2



MARK:



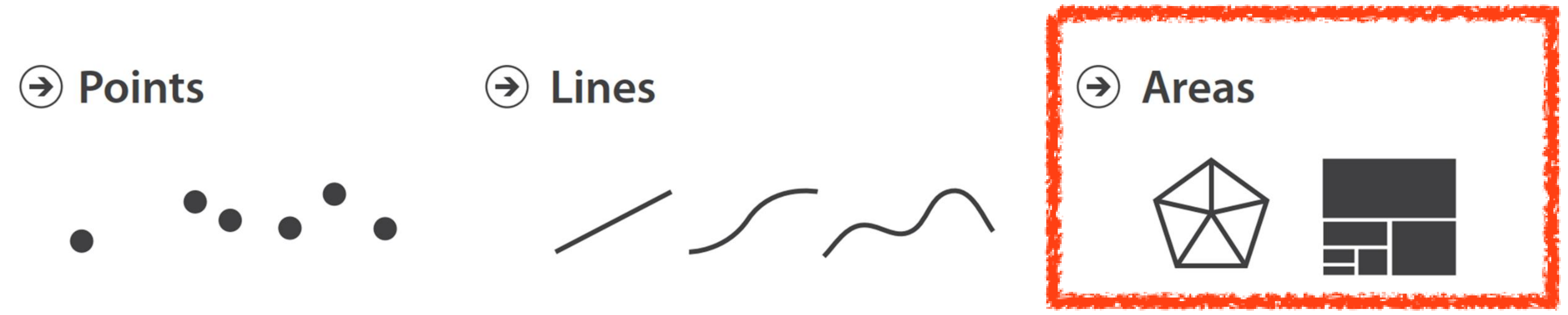
CHANNEL :



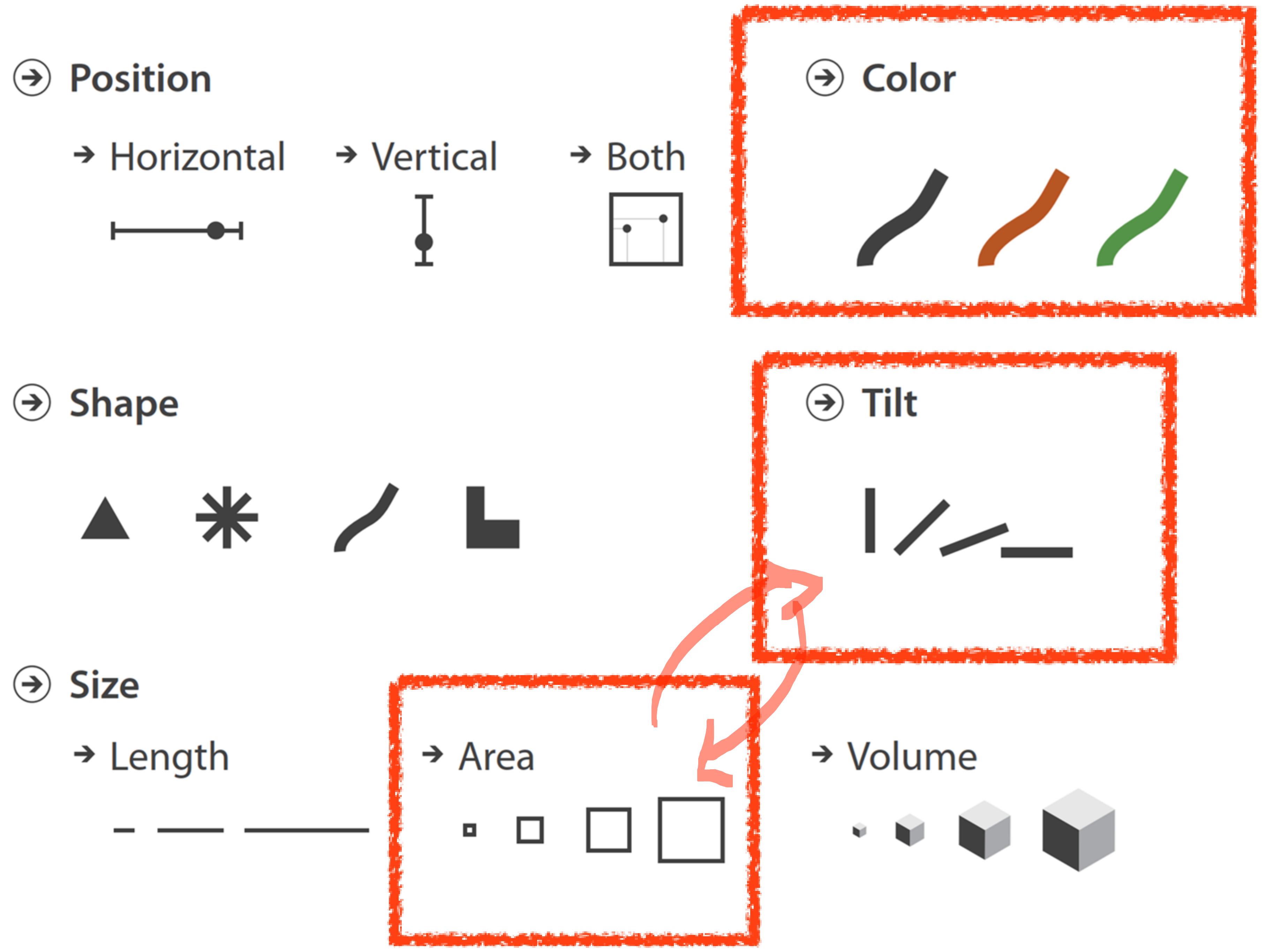
Visualization Building Blocks

of attributes encoded: 2

MARK:

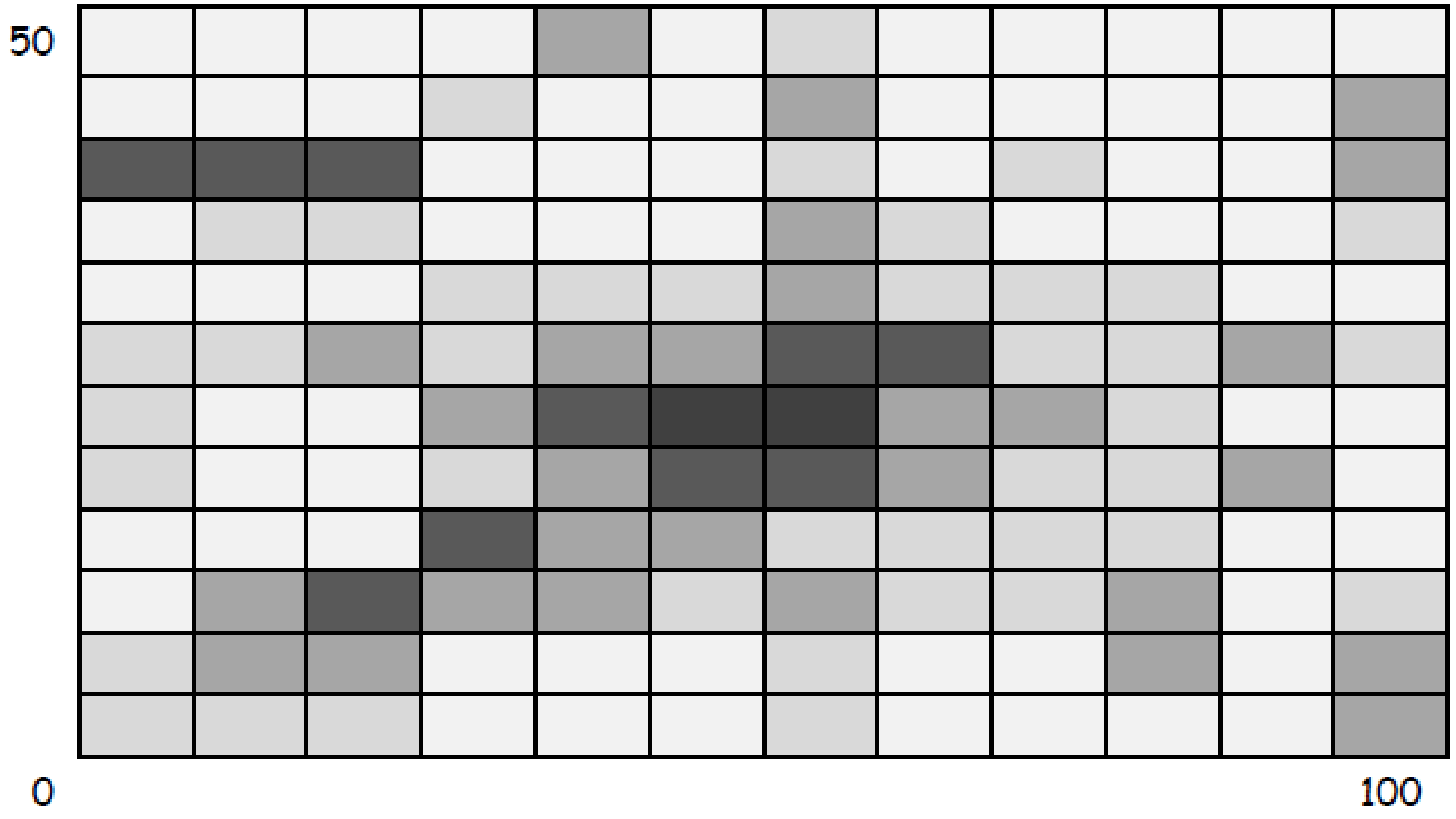


CHANNEL :



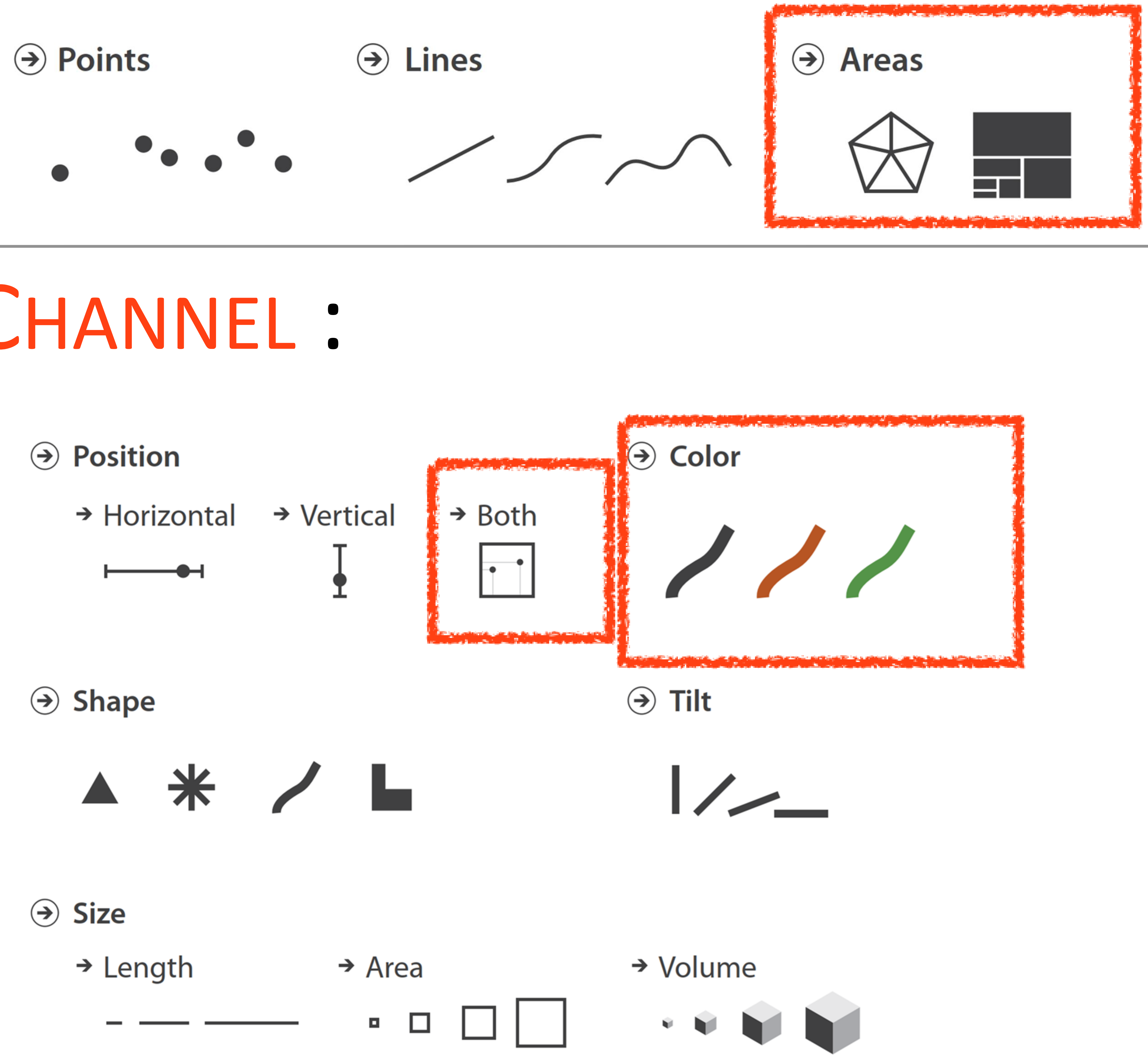
Visualization Building Blocks

of attributes encoded:



MARK:

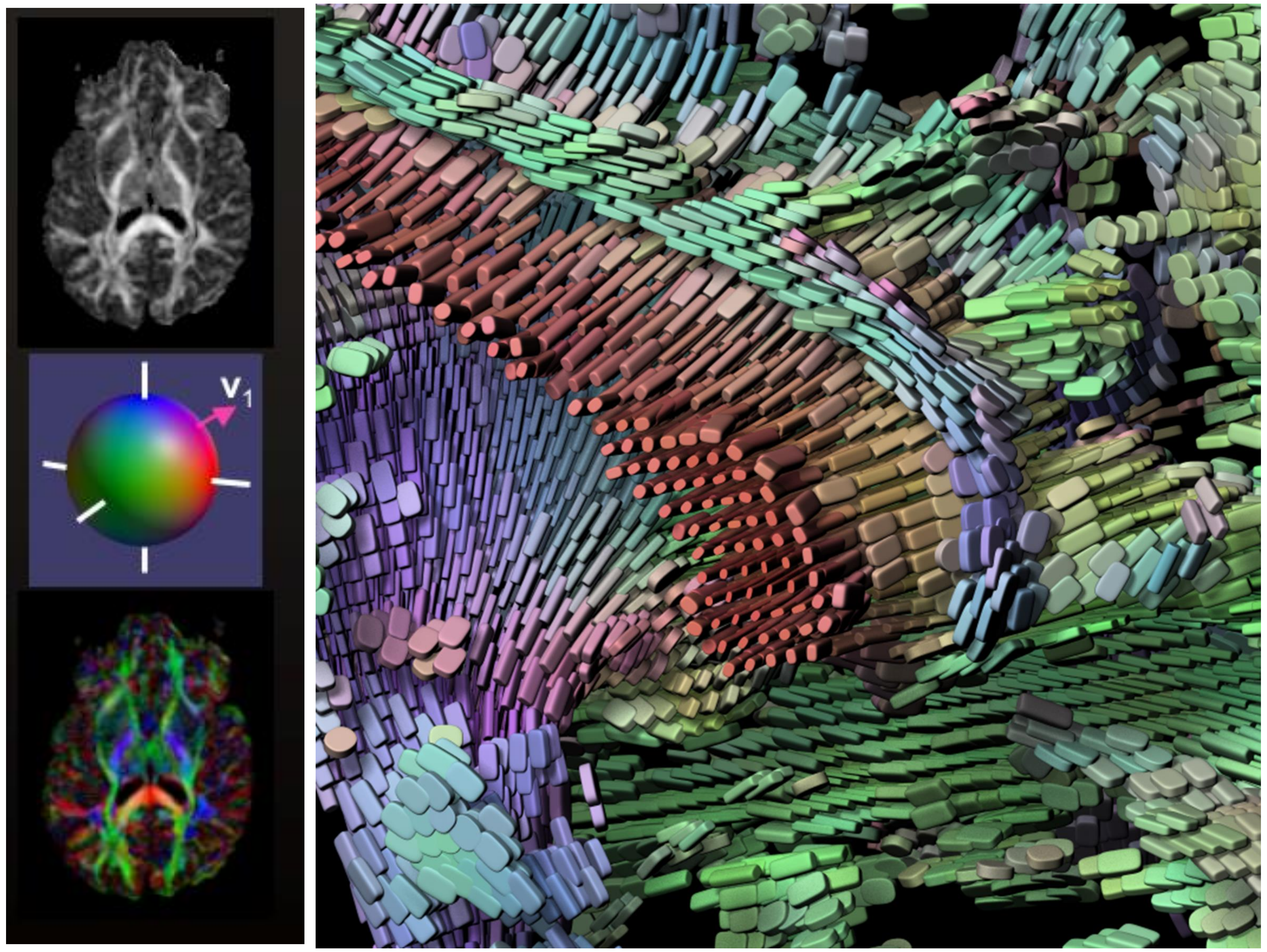
CHANNEL :



Visualization Building Blocks

Don't overload the user with encodings!

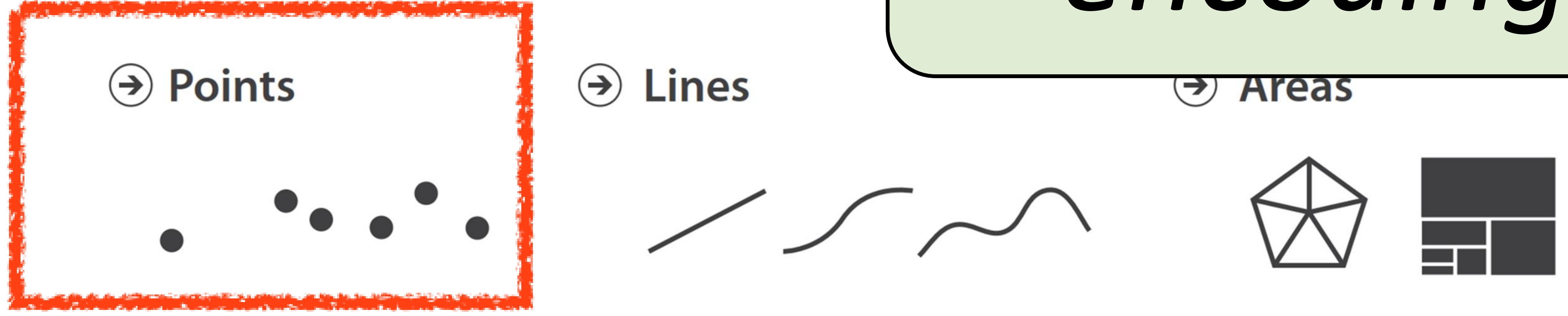
# of attributes encoded: ?



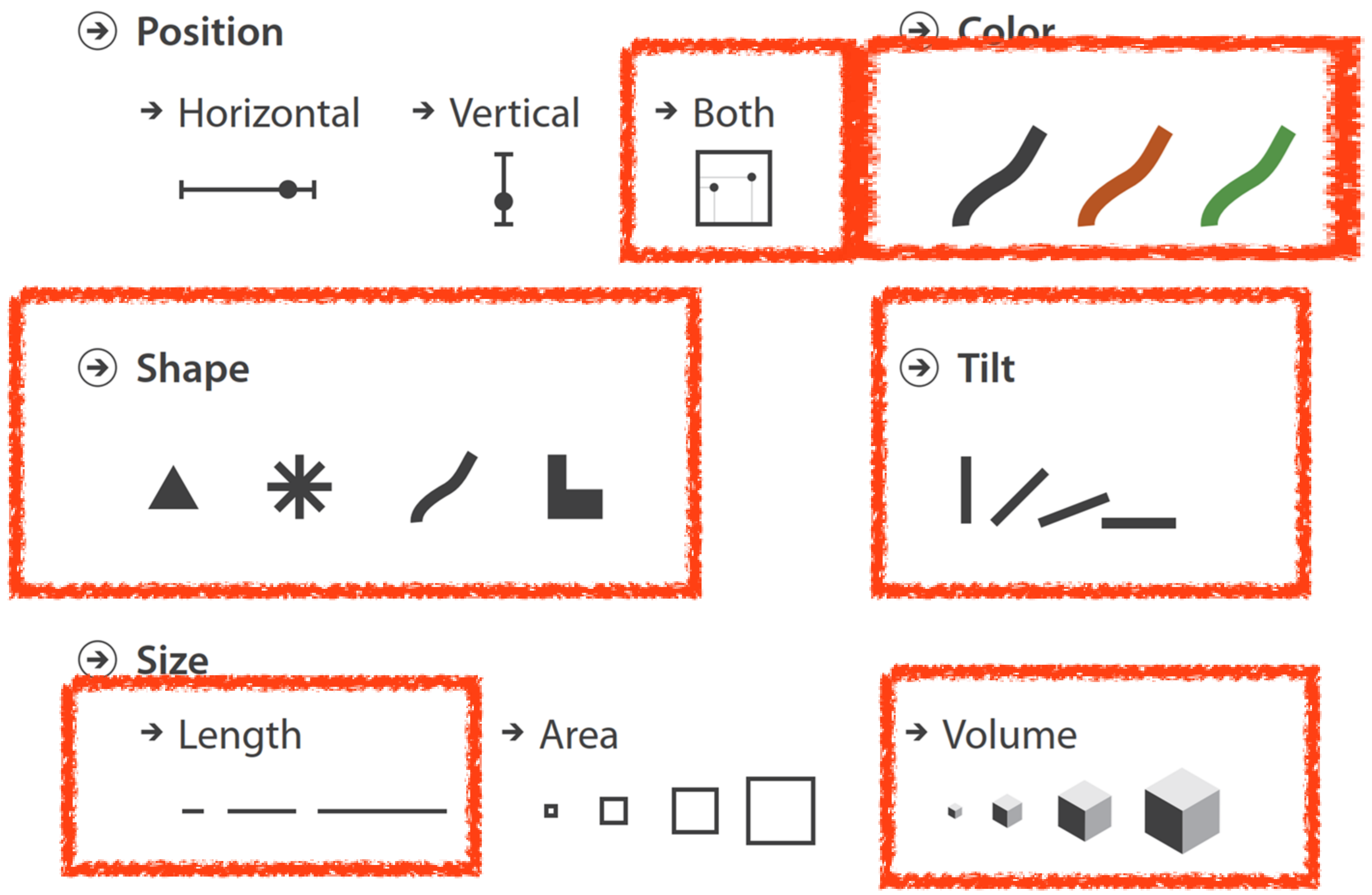
[Kindlmann (2004)](#)

+ position in 3D space

MARK:



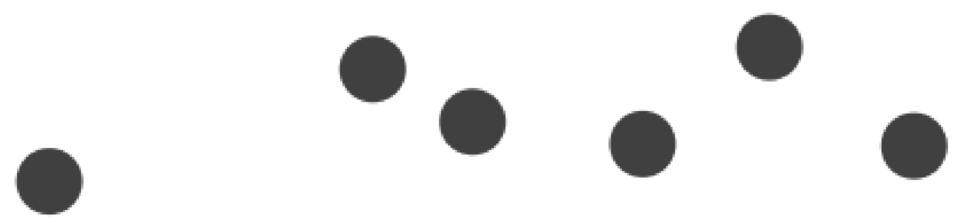
CHANNEL :



Visualization Building Blocks

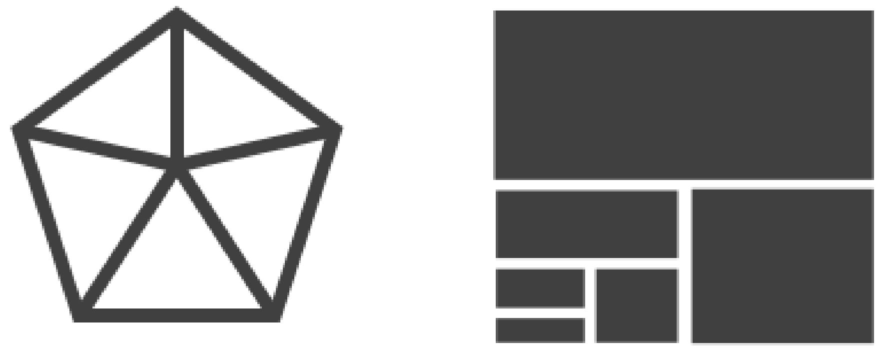
Marks as Items/Nodes

➔ Points



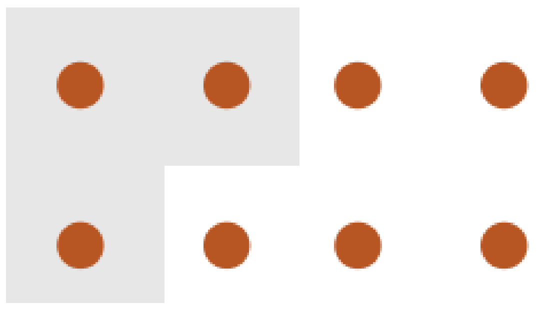
➔ Lines

➔ Areas

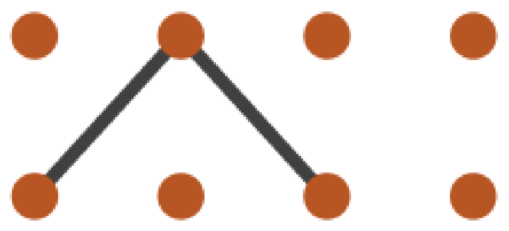


Marks as Links

➔ Containment



➔ Connection

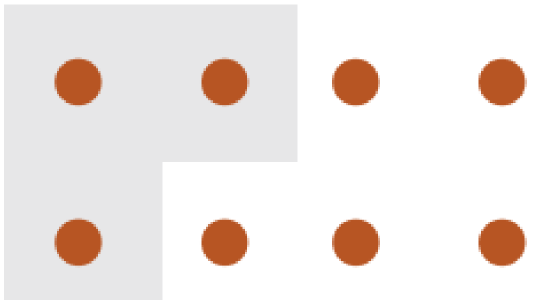


Munzner, "Visualization Analysis and Design" (2014)

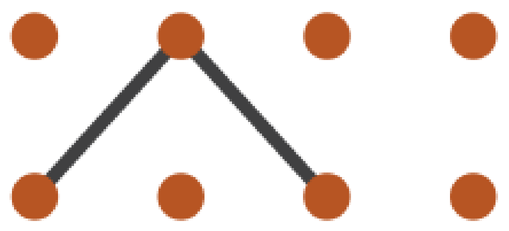
Visualization Building Blocks

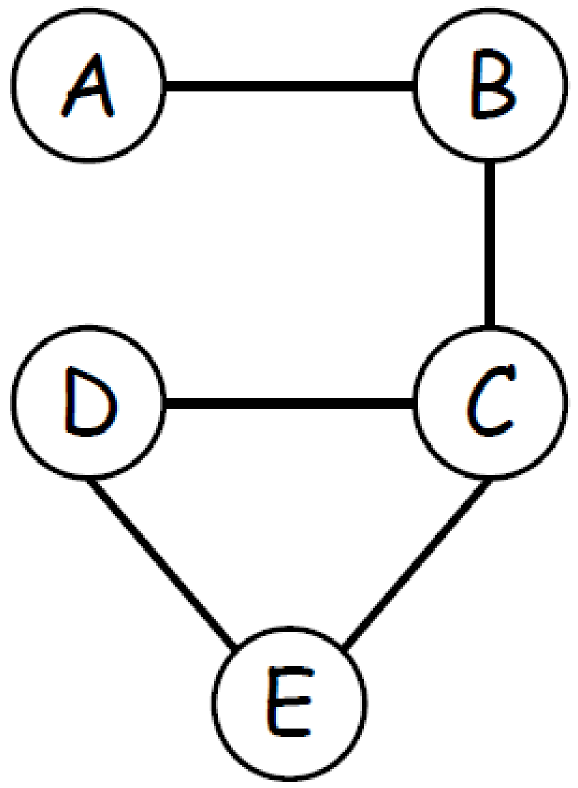
Marks as Links

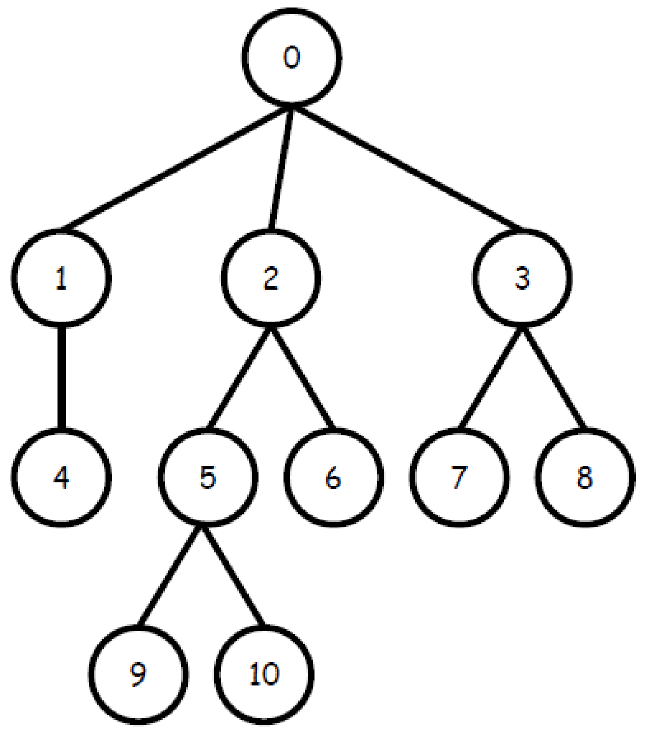
➔ Containment

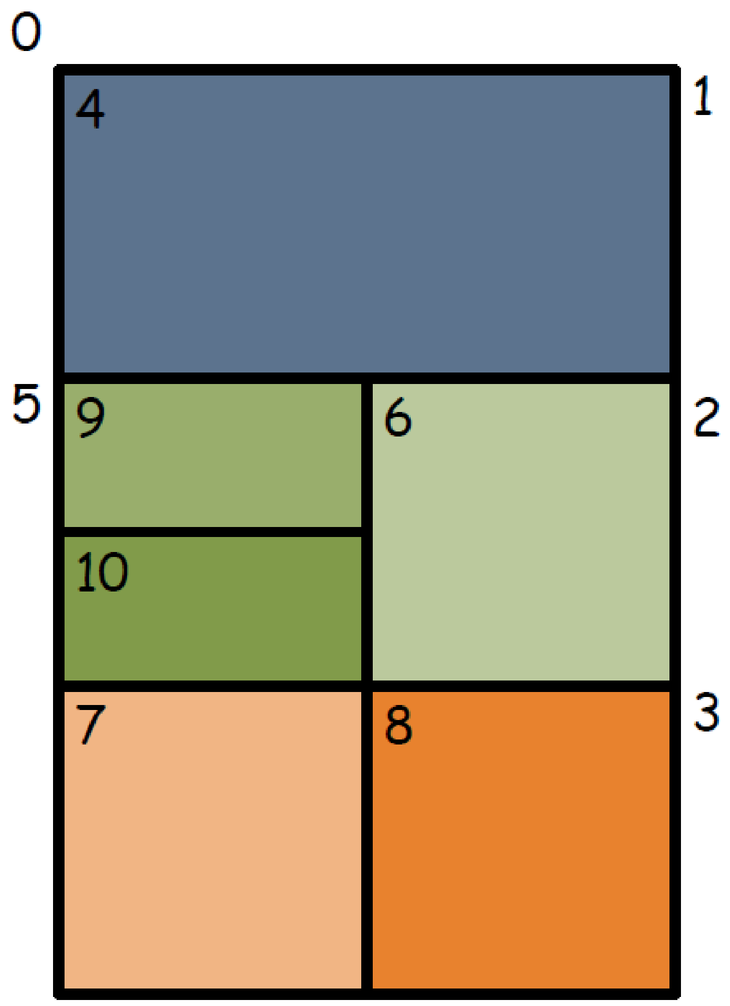


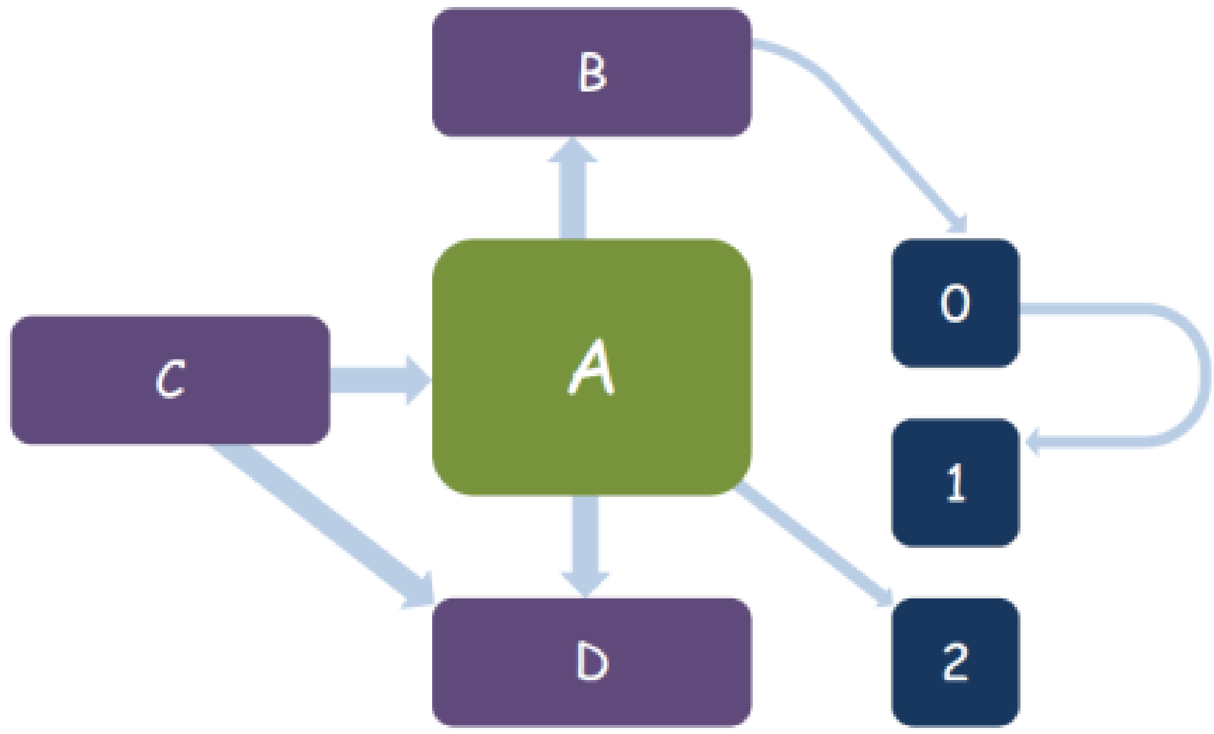
➔ Connection

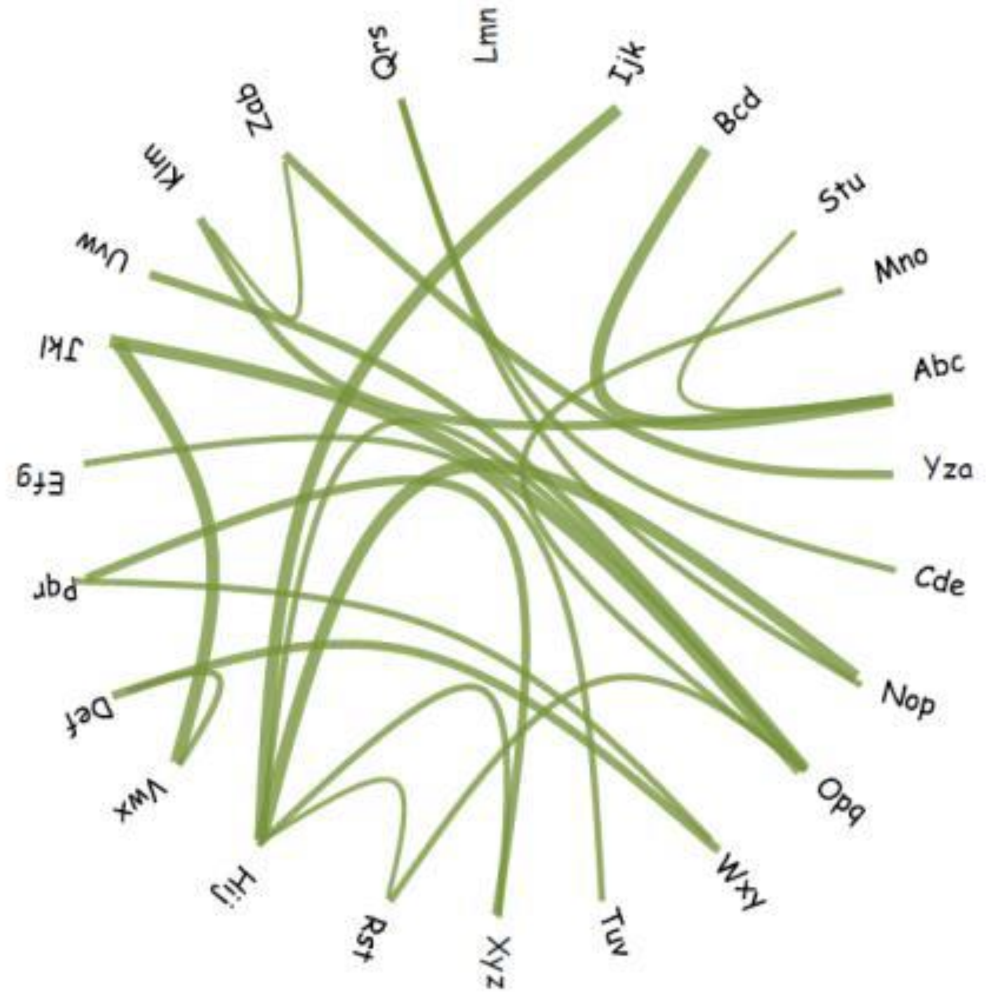




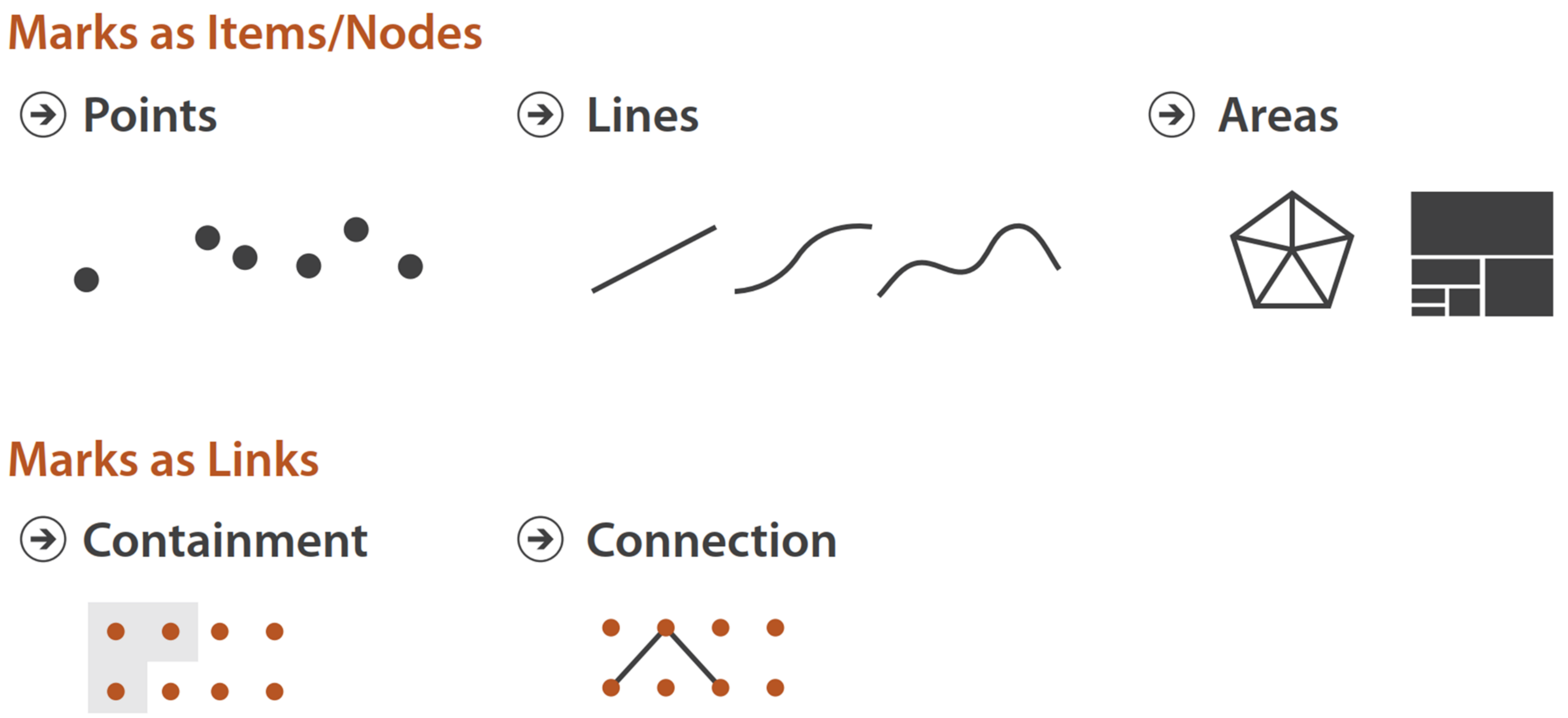


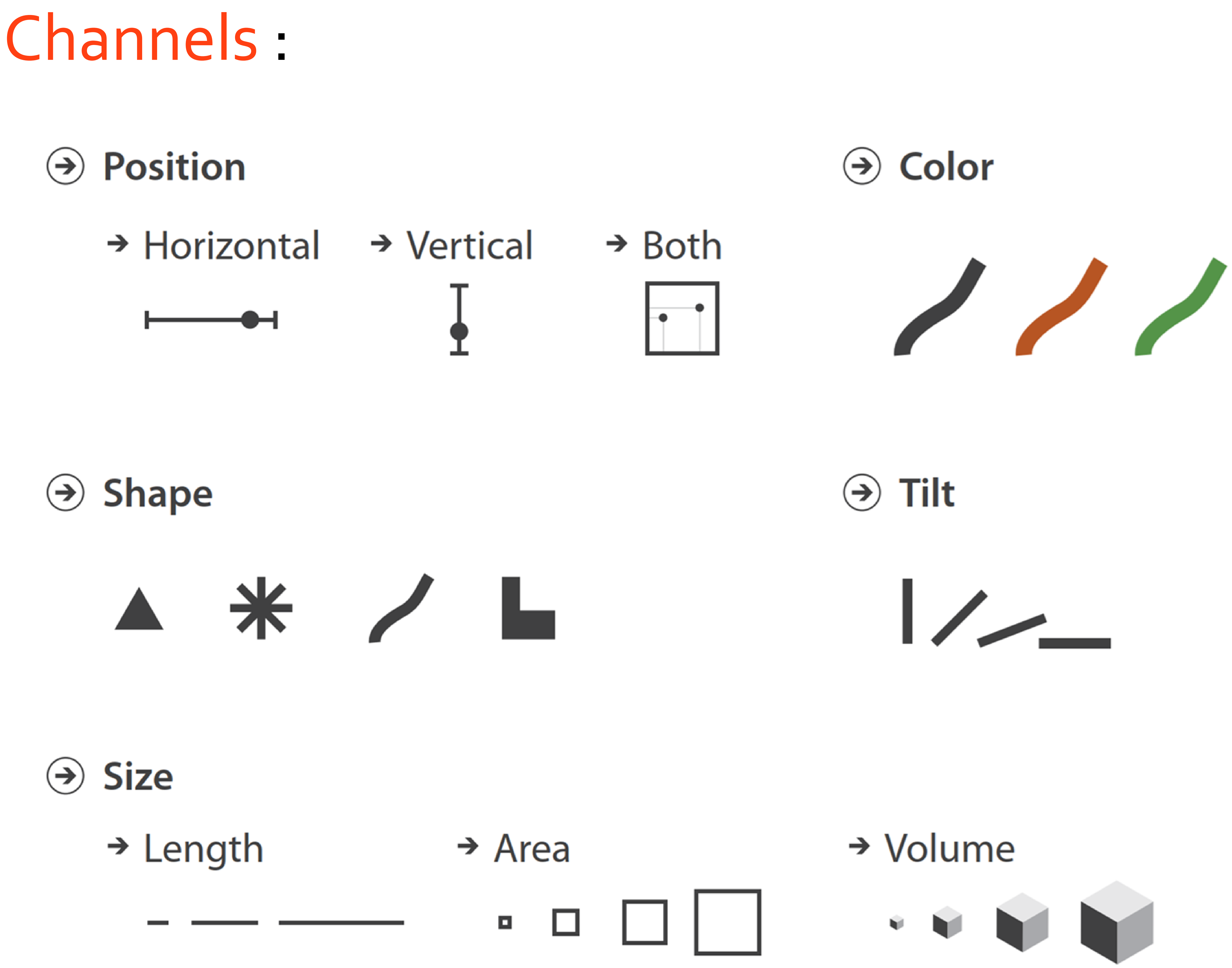






Visualization Building Blocks

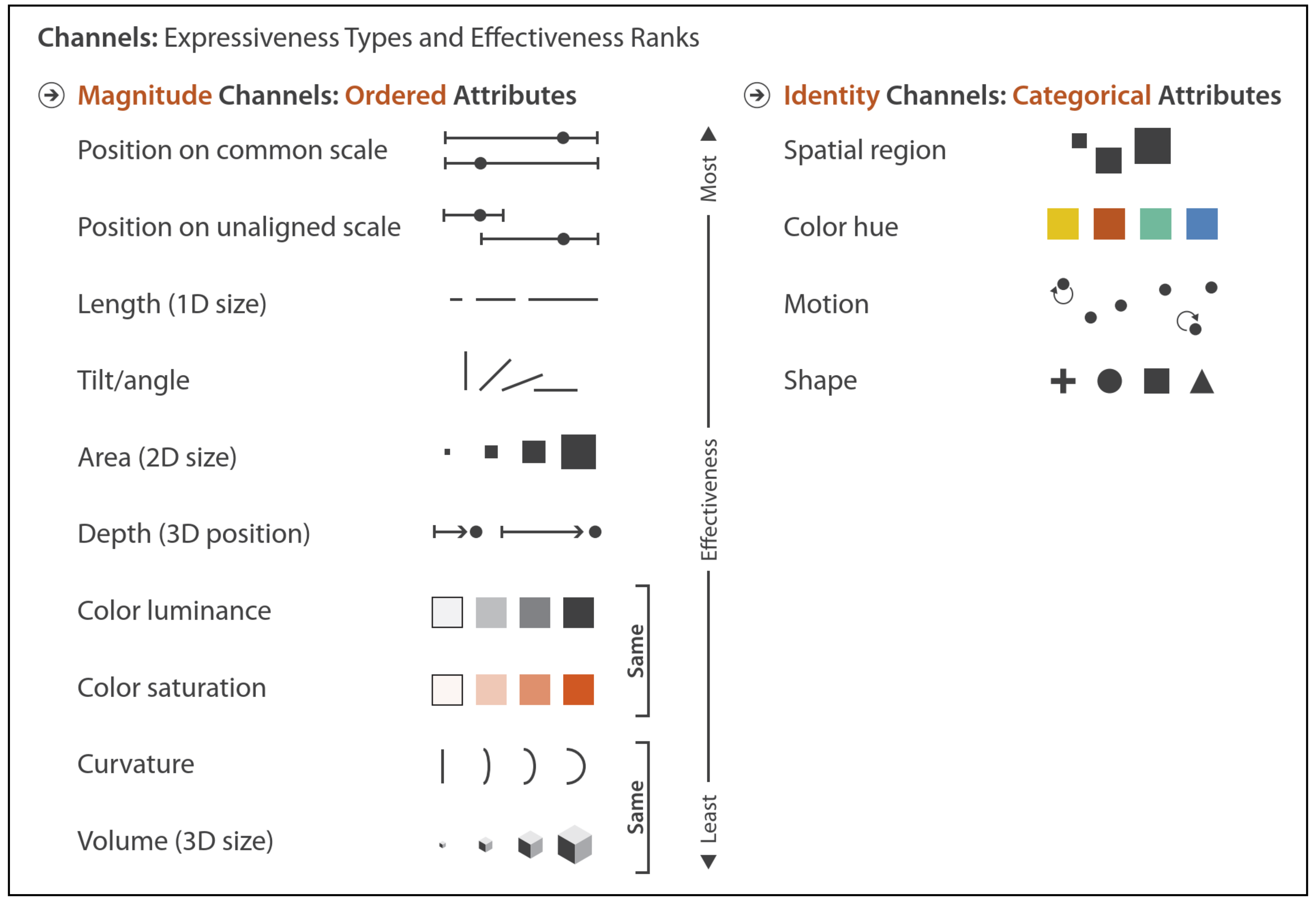




Note: these are all really important concepts when it comes time to coding your visualizations...!

How do I pick *which* marks or channels to use?

How to pick? User study results!



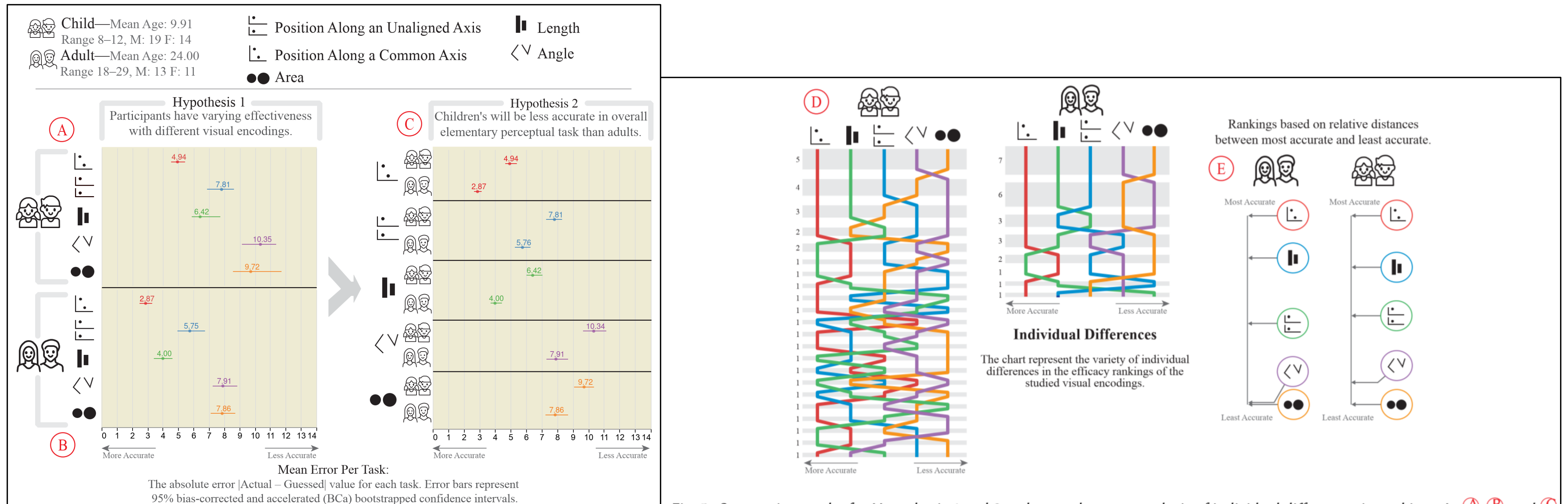


Fig. 5. Summative results for Hypothesis 1 and 2 and an exploratory analysis of individual differences in rankings. In Ⓐ, Ⓑ, and Ⓒ the error bars show 95% bias-corrected and accelerated (BCa) bootstrapped confidence intervals [23]. (A *rough* rule of thumb for reading 95% CIs is that if two intervals overlap by less than 1/4 of their average length, then the comparison will have p < .05 [22].) The mean absolute error for each encoding is shown in Ⓐ for children and Ⓑ for adults. In Ⓒ, the previous two charts are rearranged to compare children with adults. Children are clearly less accurate when using each of the encodings. The exploratory analysis included, Ⓓ, shows the variation in encoding rankings among individual children (left) and adults (right). Each line represents an encoding, ranked left-to-right in increasing mean absolute error for each task. The grey rows are sized to represent the count of individuals with a shared ranking. E.g., the top row shows that 5 children ranked Position Along a Common Axis as most accurate, followed by Length, Position Along an Unaligned Axis, Angle, and lastly Area. The line-row intersections show the encoding ranking for that row. Children displayed a larger variety of individual differences in encoding rankings than adults. Finally, Ⓔ shows more simply the *overall* rankings we found for adults and children.

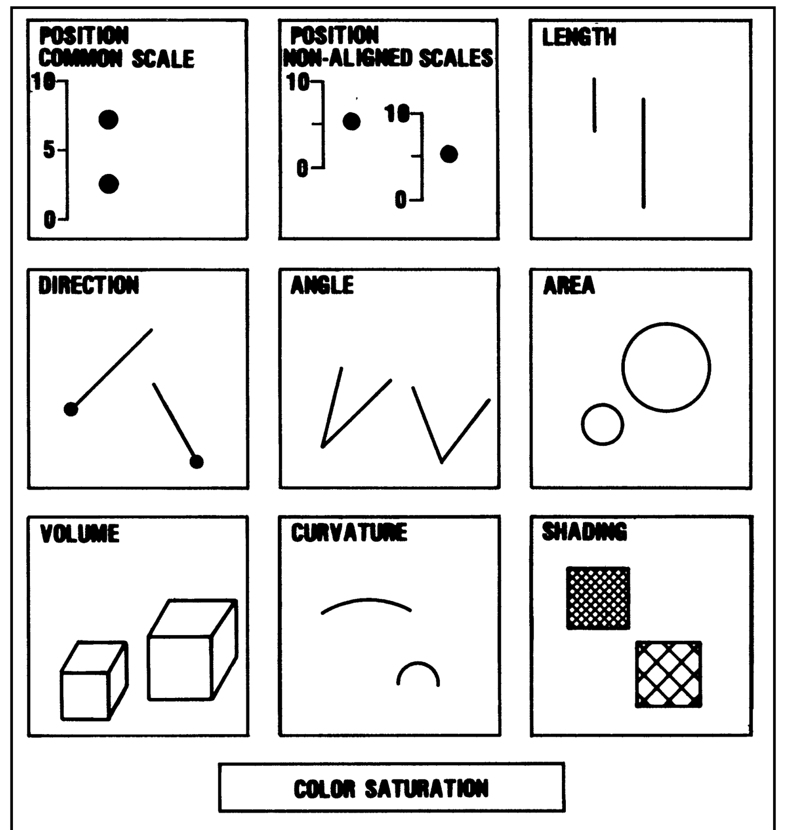


Figure 1. Elementary perceptual tasks.

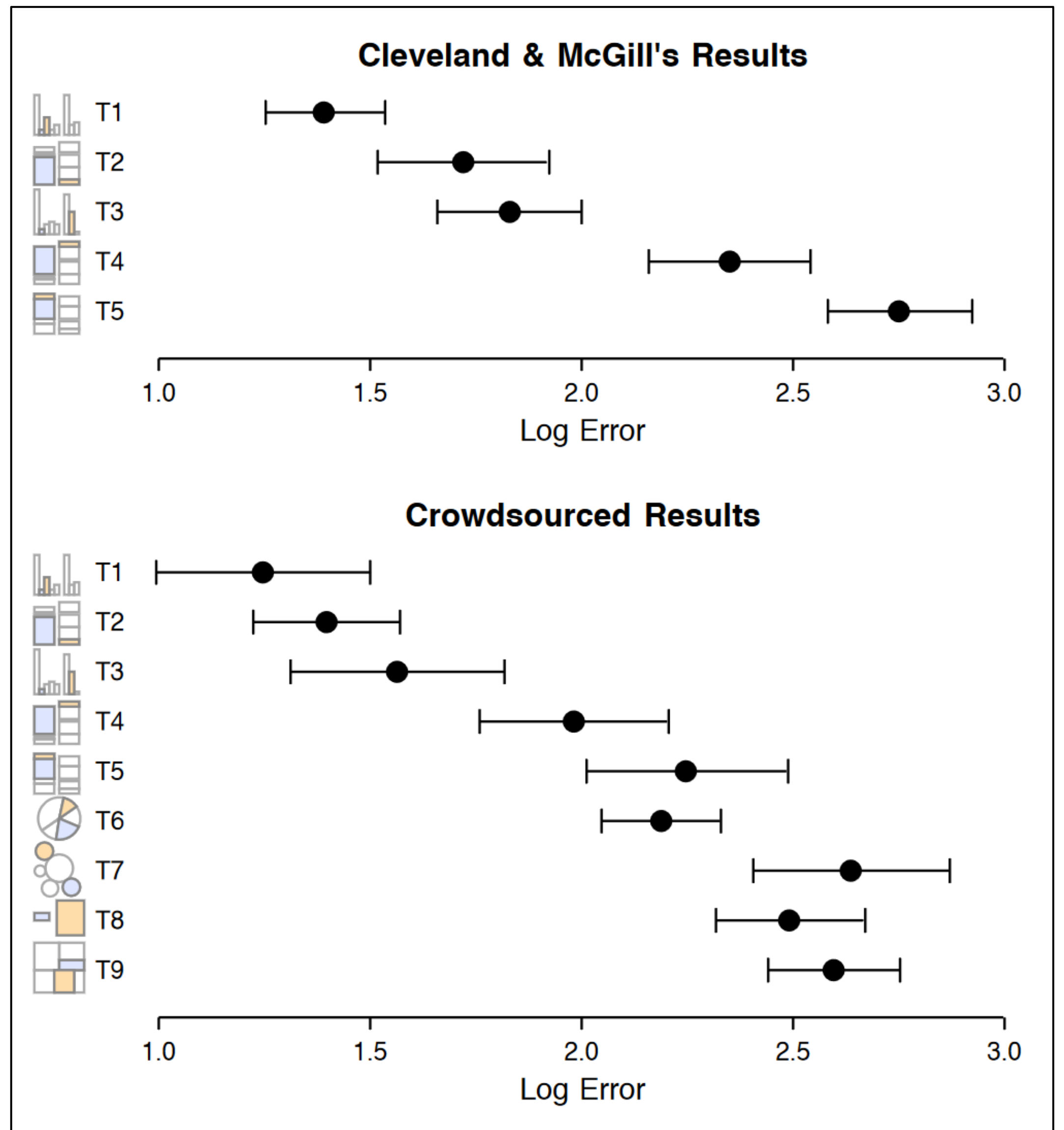


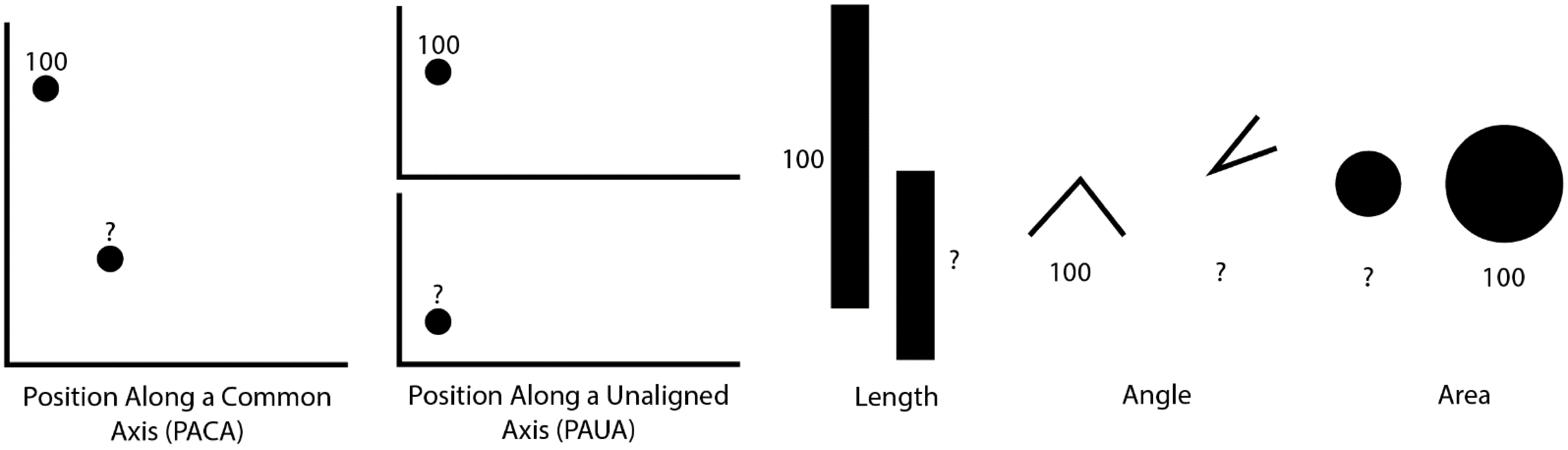
Figure 4: Proportional judgment results (Exp. 1A & B). Top: Cleveland & McGill's [7] lab study. Bottom: MTurk studies. Error bars indicate 95% confidence intervals.

Munzer, 2014
Cleveland & McGill, 1984
Heer & Bostock, 2010
Mackinlay, 1986
Panavas et al., 2022

In-class study—graphical perception

16 min

https://neu-ds-4200-f23.github.io/in-class/graphical-perception



“Ordering of Elemental Perceptual Tasks”

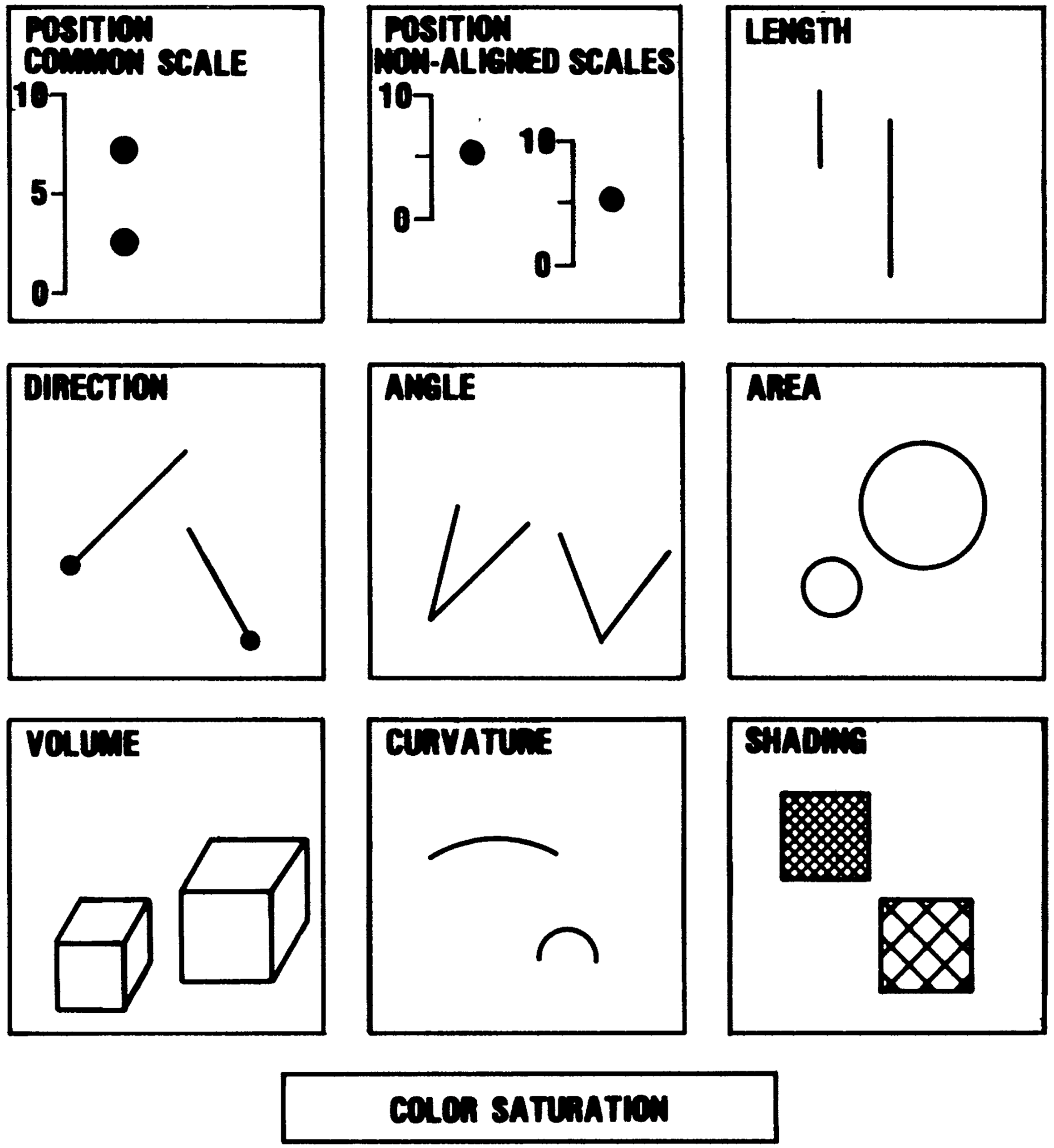


Figure 1. Elementary perceptual tasks.

Cleveland & McGill (1984)

“Ordering of Elemental Perceptual Tasks”

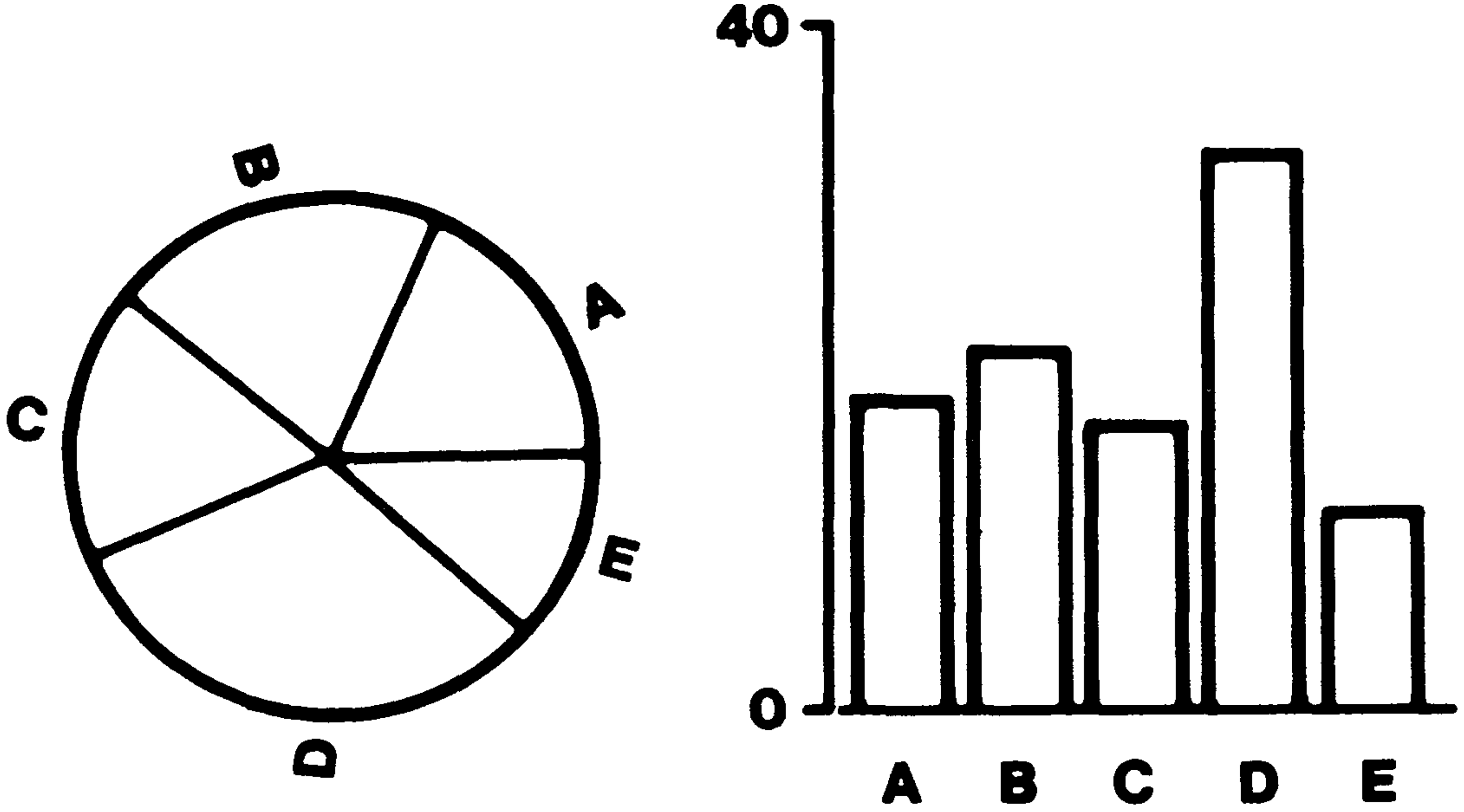
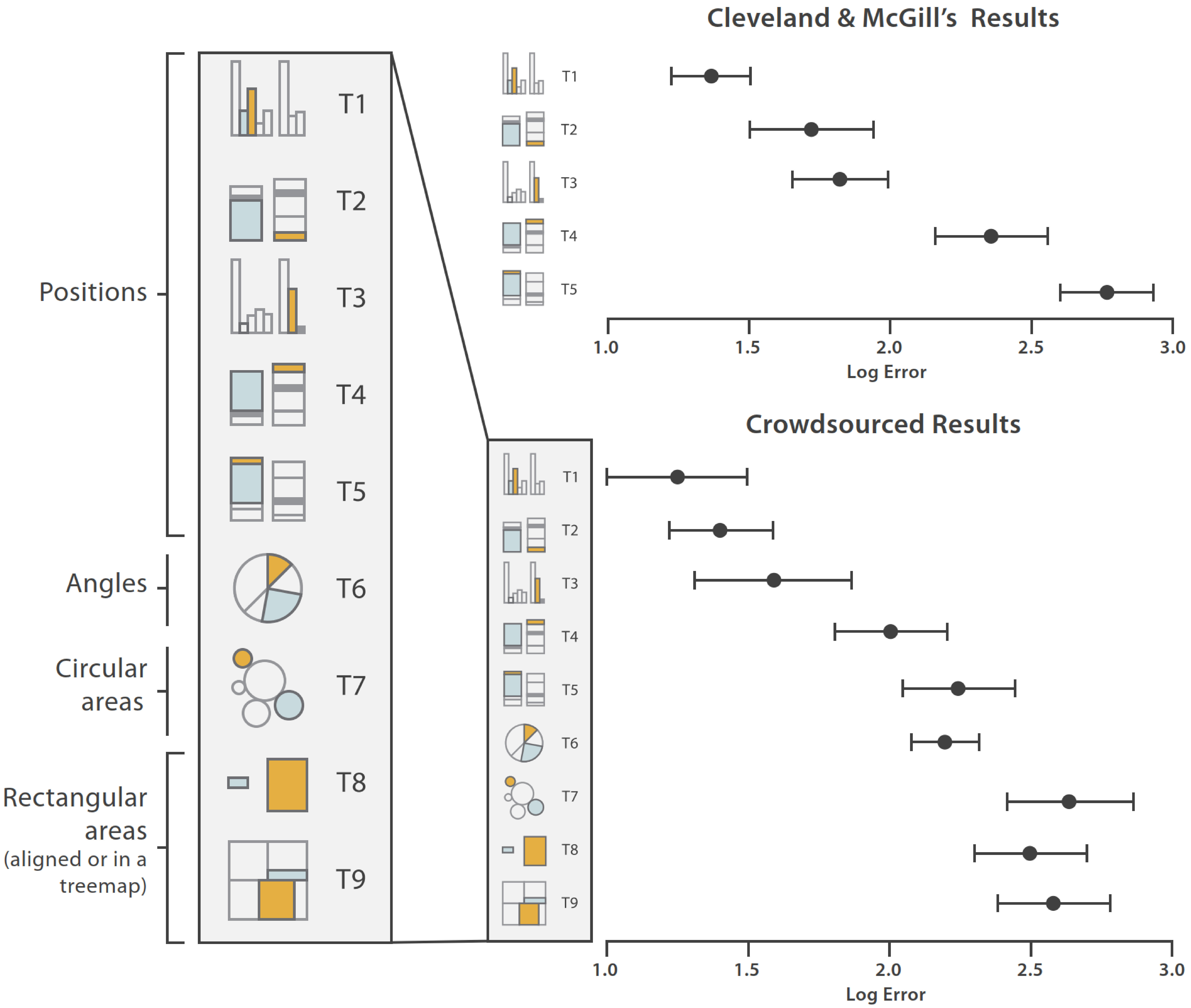


Figure 3. Graphs from position–angle experiment.

TASK: Which segment/bar is the maximum, and what is its percentage/value?

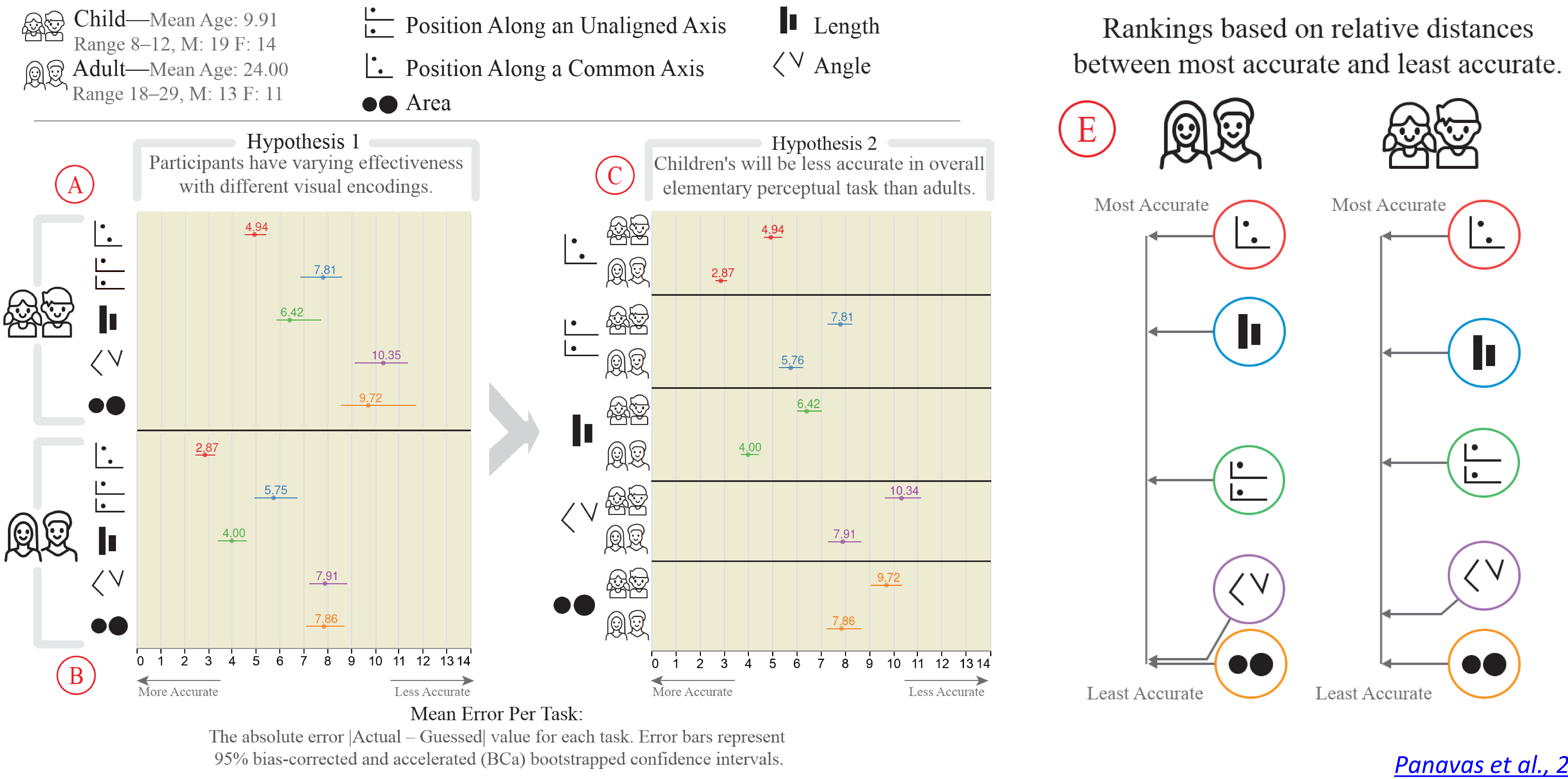
Cleveland & McGill (1984),
larger replication on AMT by Heer & Bostock (2010)



[Heer & Bostock (2010)]

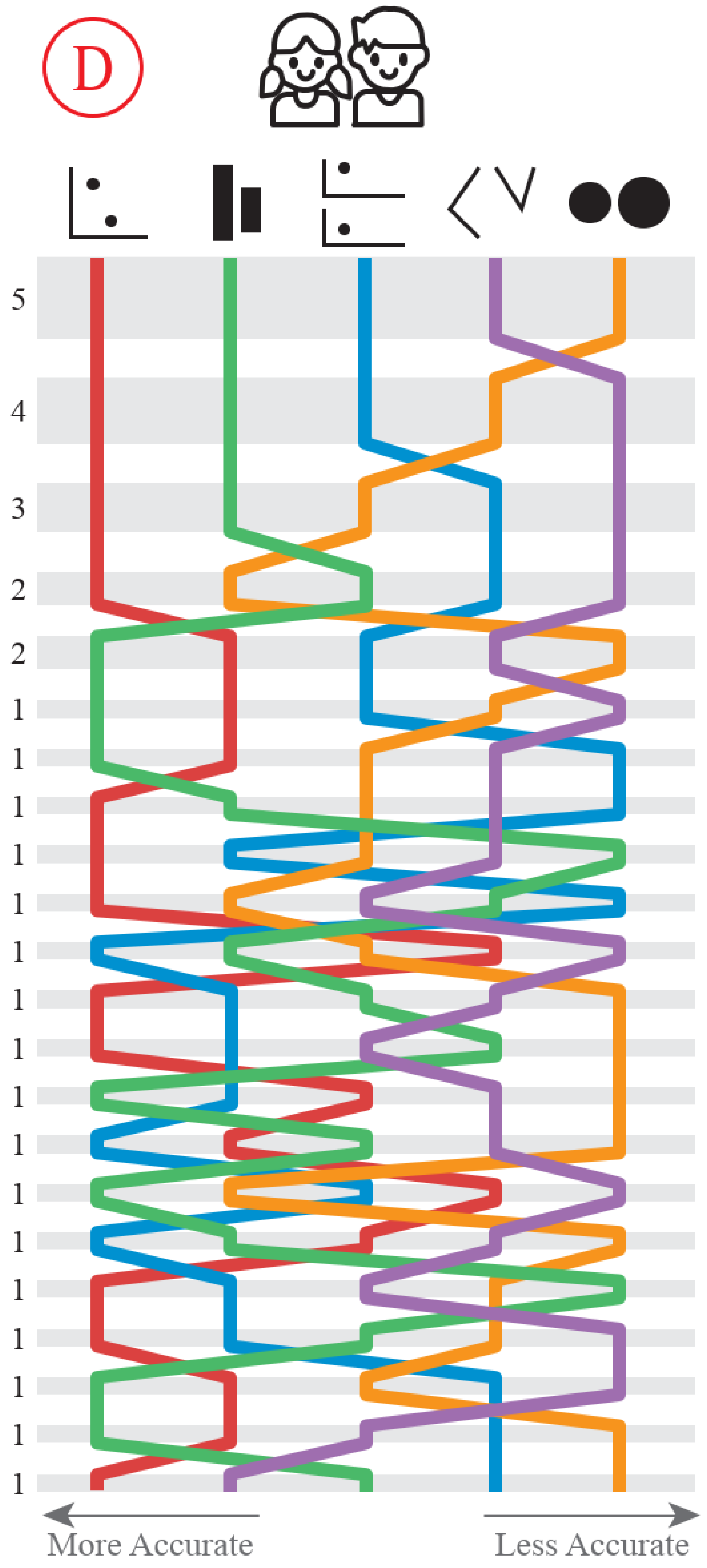
➔ Magnitude Channels: Ordered Attributes

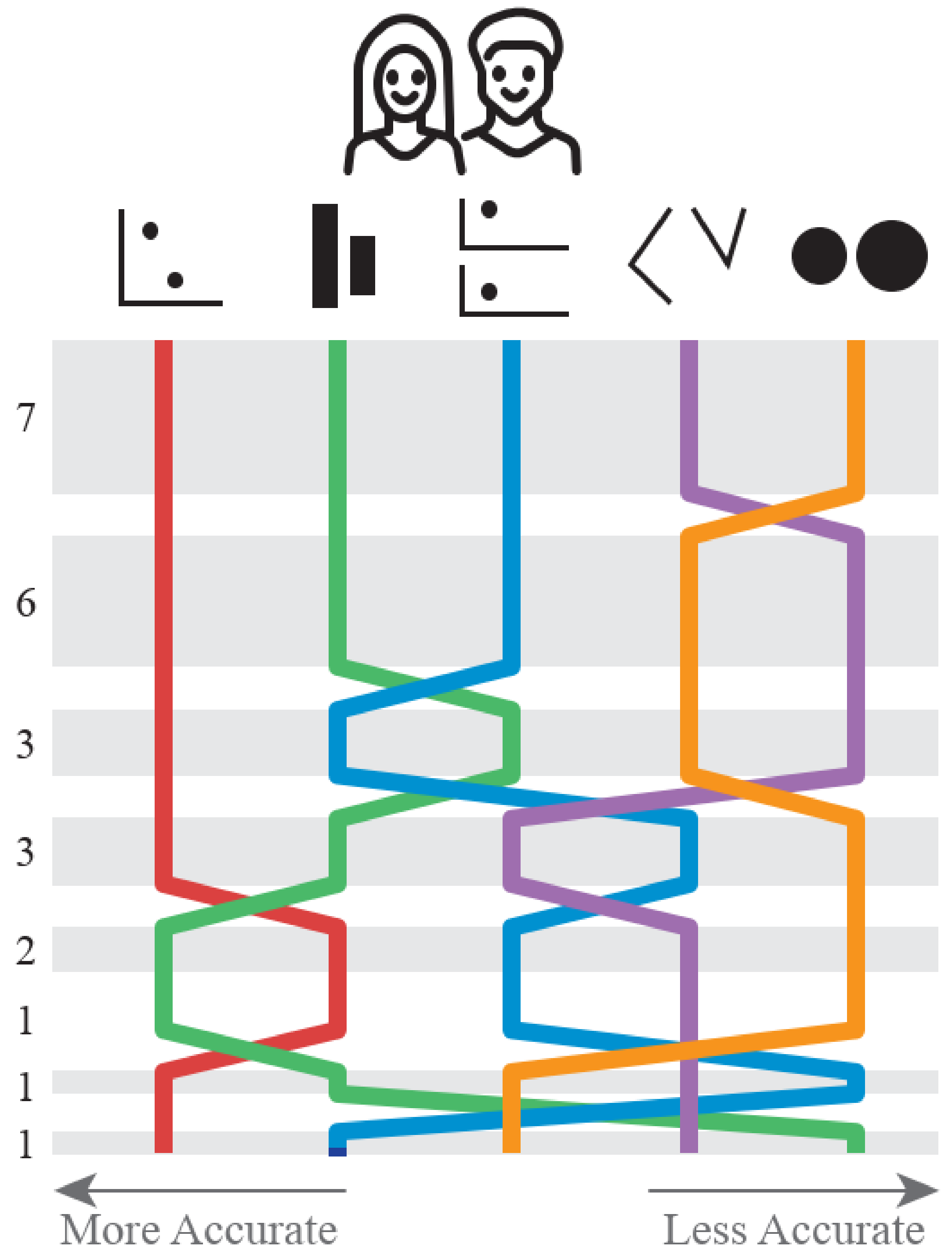
More recent replications



[Panavas et al., 2022](#)

Caveats





Individual Differences

The chart represent the variety of individual differences in the efficacy rankings of the studied visual encodings.

Panavas et al., 2022

Expressiveness and Effectiveness

Effectiveness principle: the importance of the attribute should match the salience of the channel; that is, its noticeability.
(i.e., encode most important attributes with highest ranked channels)

Expressiveness principle: the visual encoding should express all of, and only, the information in the dataset attributes.
(i.e., data characteristics should match the channel)

Mackinlay (1986)

My Summary: Prioritize choosing the most appropriate channel for each attribute

Expressiveness and Effectiveness

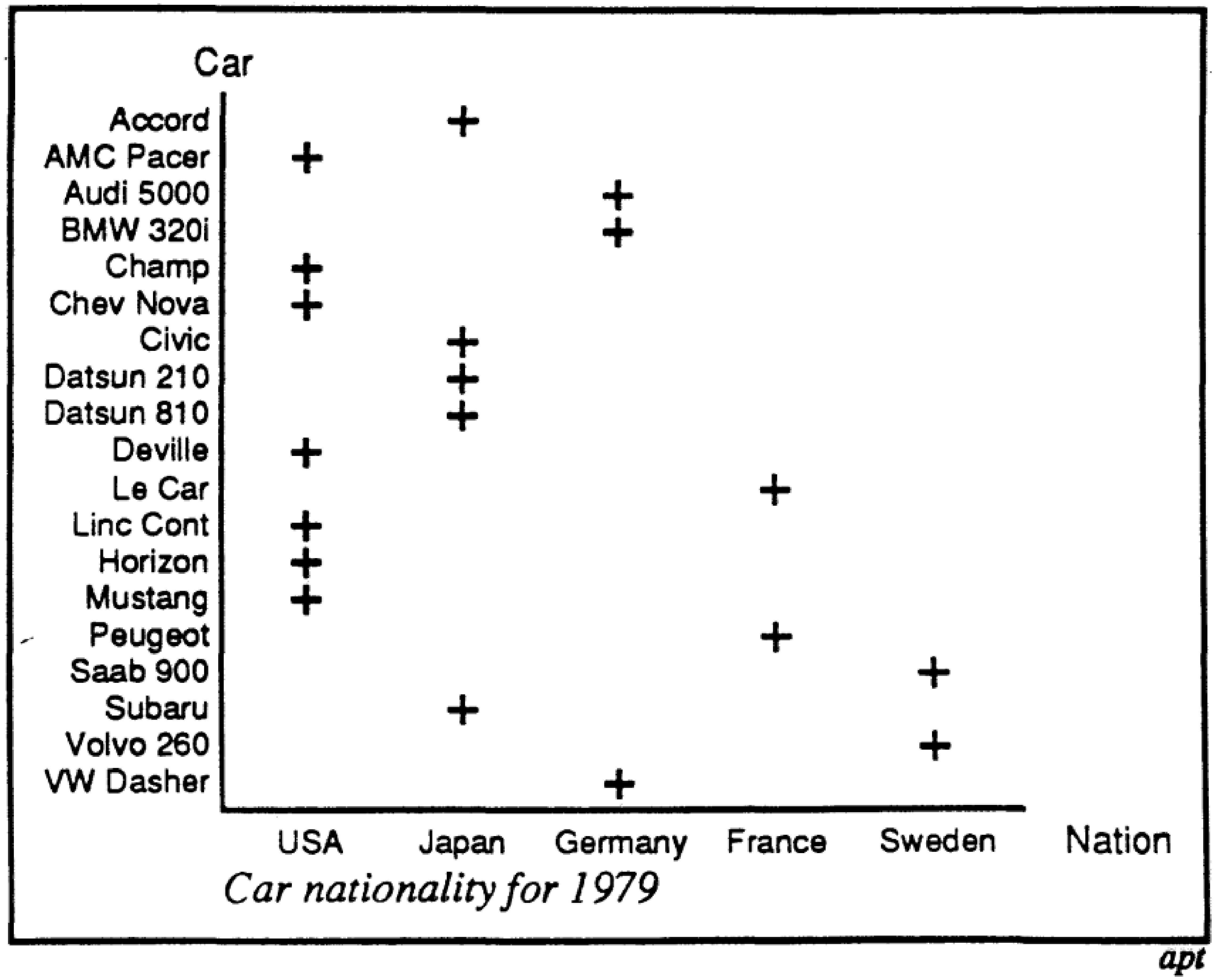
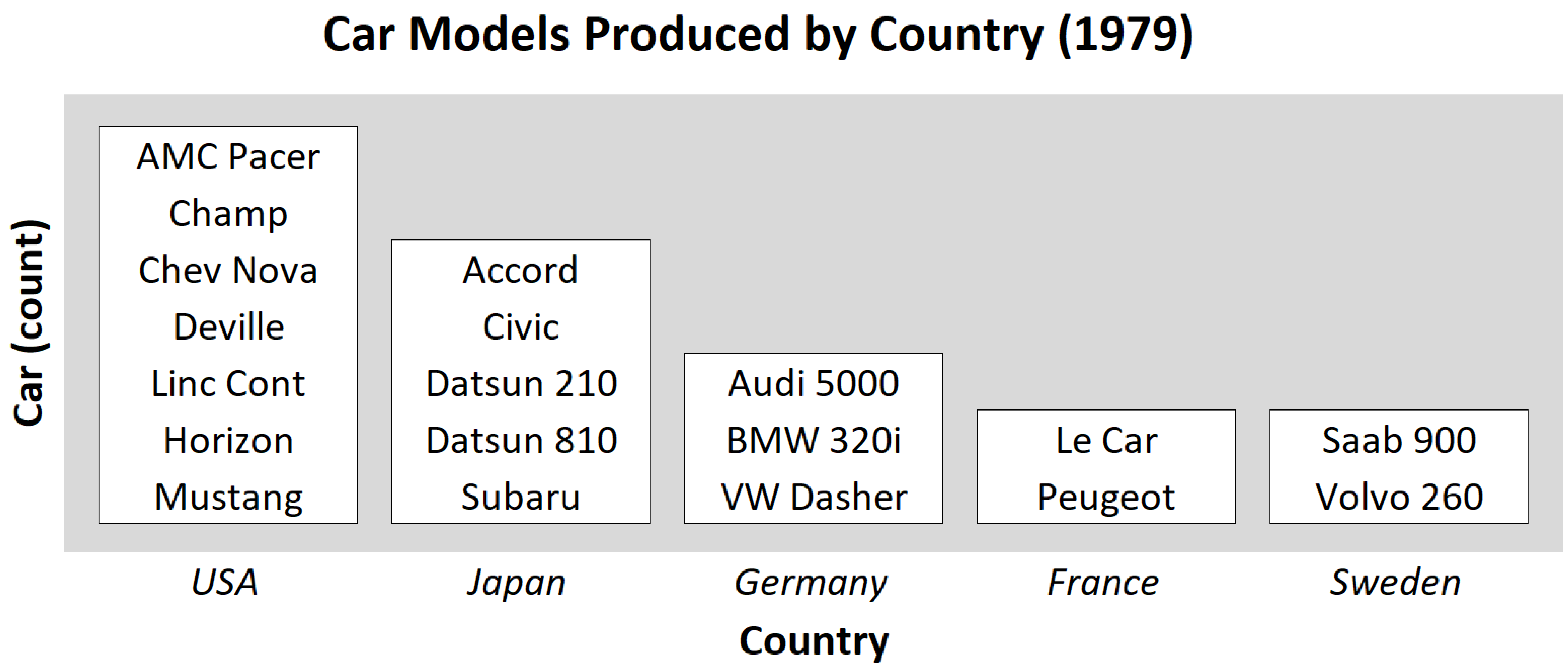


Figure 12: Correct Use of a Plot Chart for the Nation Relation. *Since bar charts encode ordered domain sets, plot charts are conventionally used to encode nominal domain sets. The ordering of the labels on the axes is ignored.*

Mackinlay (1986)

Expressiveness and Effectiveness



In-Class Exercise

3, 12, 42

3, 12, 42

In-class Sketching: “Three numbers”

20m

1. **Individually** *(15m) u*se pens & post-it notes to sketch as many possible visualizations as you can of these three numbers.
2. No upload required
3. **As a class** *(5m)* I will call on some of you to show your designs and discuss common themes.

Jonathan Schwabish

For Next Time

neu-ds-4200-f23.github.io/schedule/

Look at the upcoming assignments and deadlines

- Textbook, Readings, & Reading Quizzes—Variable days
- In-Class Activities—If due, they are due 11:59pm the same day as class

Everyday Required Supplies:
- 5+ colors of pen or marker
- White paper
- Laptop and charger

Use Slack for general questions, email codydunne-and-tas@ccs.neu.edu for questions specific to you.

Week 3: Data, Tasks, Tables, and Gestalt	
Tue, Sep 19 *Data types and tasks* Required Readings: 1 VAD Chapter 2—What: Data Abstraction 2 VAD Chapter 3—Why: Task Abstraction	**Fri, Sep 22** *Arrange tables* Required Readings: 1 VAD Chapter 7—Arrange Tables 2 Gestalt Principles (Part 1) by Bang Wong (2010) 3 Gestalt Principles (Part 2) by Bang Wong (2010) A2—Encodings & xenographics Due at 11:59pm
Week 4: Color, Pop-out, Illusions, Interaction, and Animation	
Tue, Sep 26 *Color, Pop-out, illusions* Required Readings: 1 VAD Chapter 10—Map Color and Other Channels	**Fri, Sep 29** *Interaction and Animation* Required Readings: 1 VAD Chapter 11—Manipulate View 2 VAD Chapter 12—Facet into Multiple Views

A3