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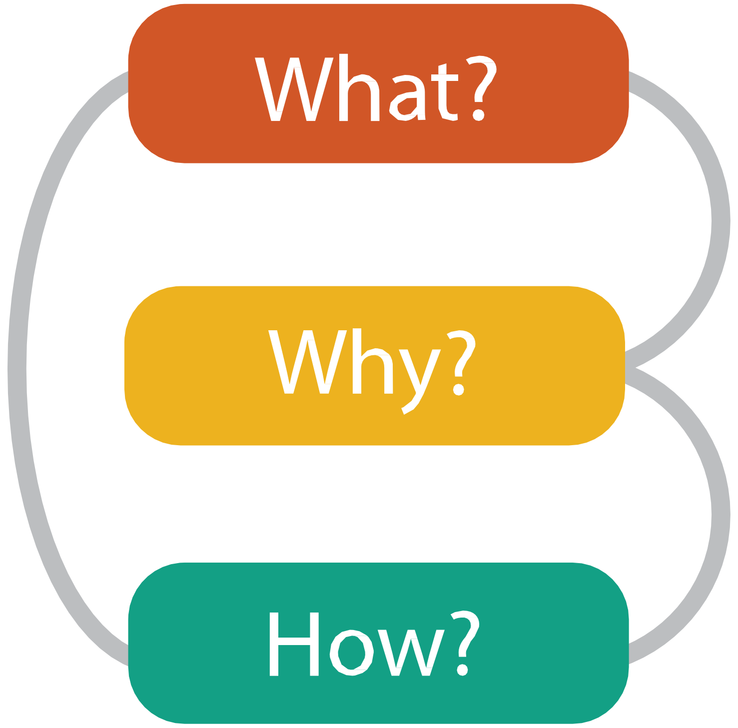
Visualization for Data Science
DS-4630 / CS-5630

VISUAL ENCODING

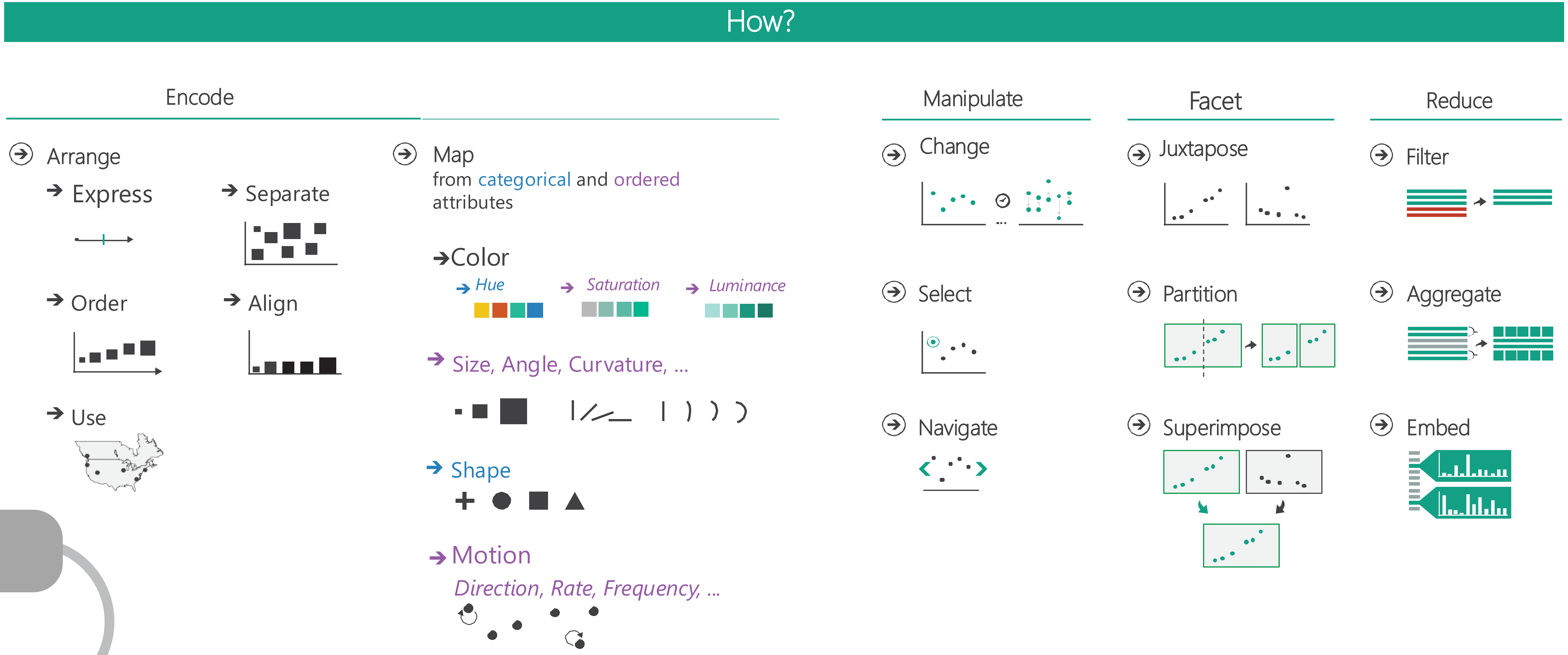
analysis: what, why, and how

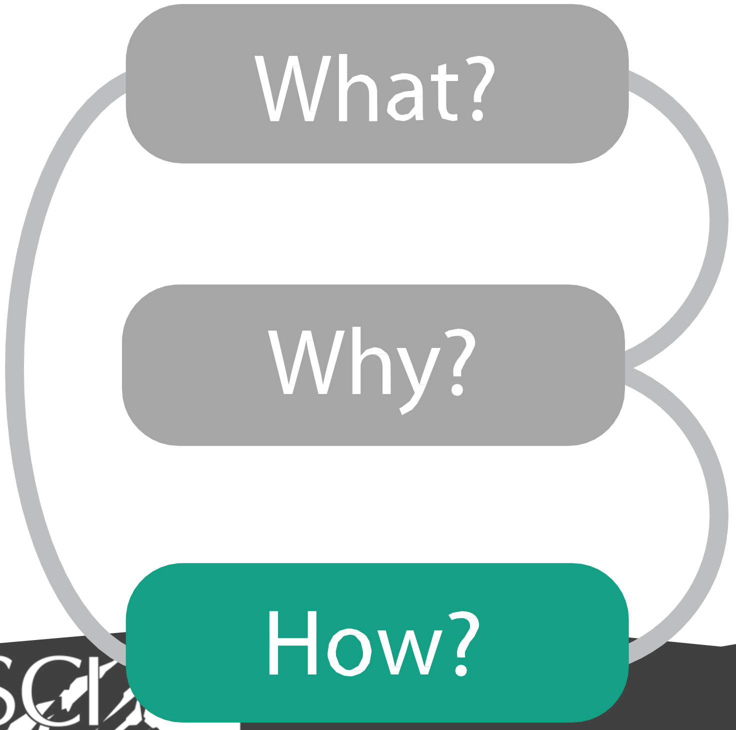
- what is shown?
- why is the user looking at it?
- how is it shown?



- abstract vocabulary avoids domain-specific terms
- what-why-how analysis framework as scaffold to think systematically about design space

visual encoding



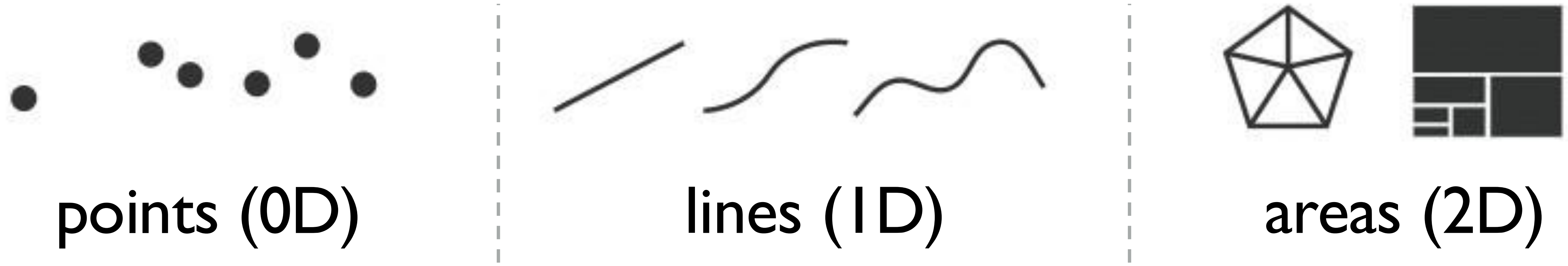


Visual Encoding

- marks and channels
- planar position
- time

MARKS

- graphical element in an image
- classified according to number of spatial dimensions required



marks

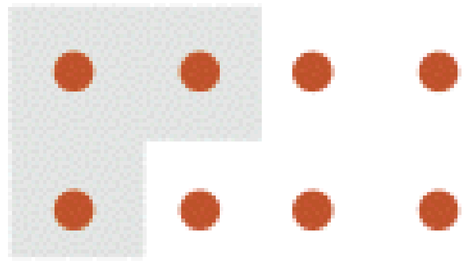
marks as nodes (items)

points (0D)

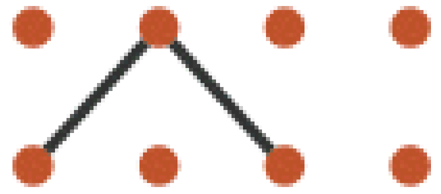
lines (1D)

areas (2D)

marks as links



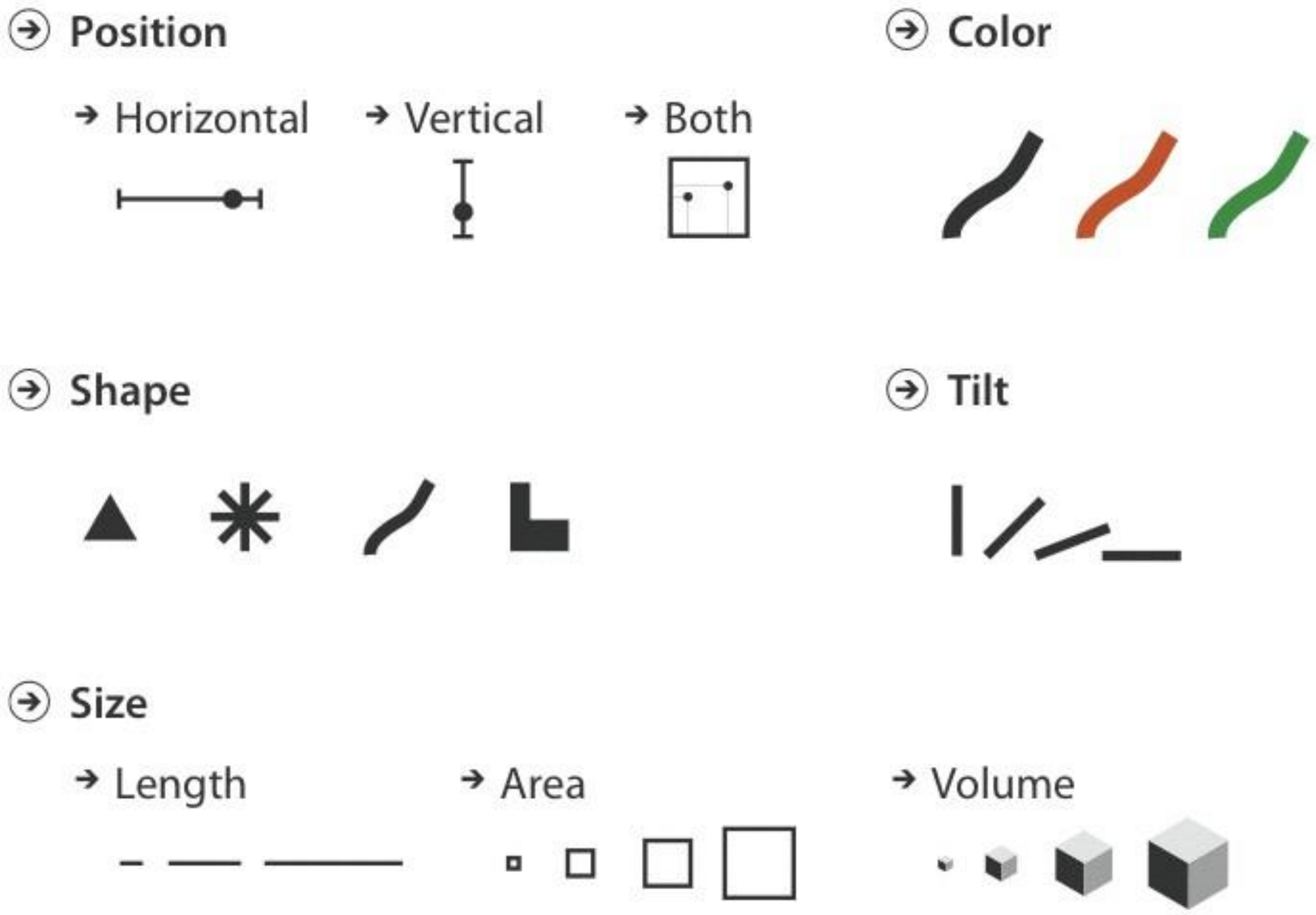
containment



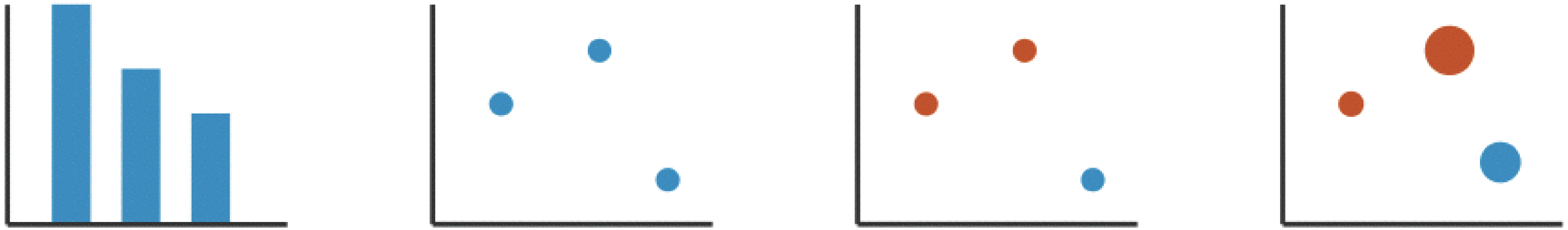
connection

CHANNELS

- parameters that control the appearance of marks

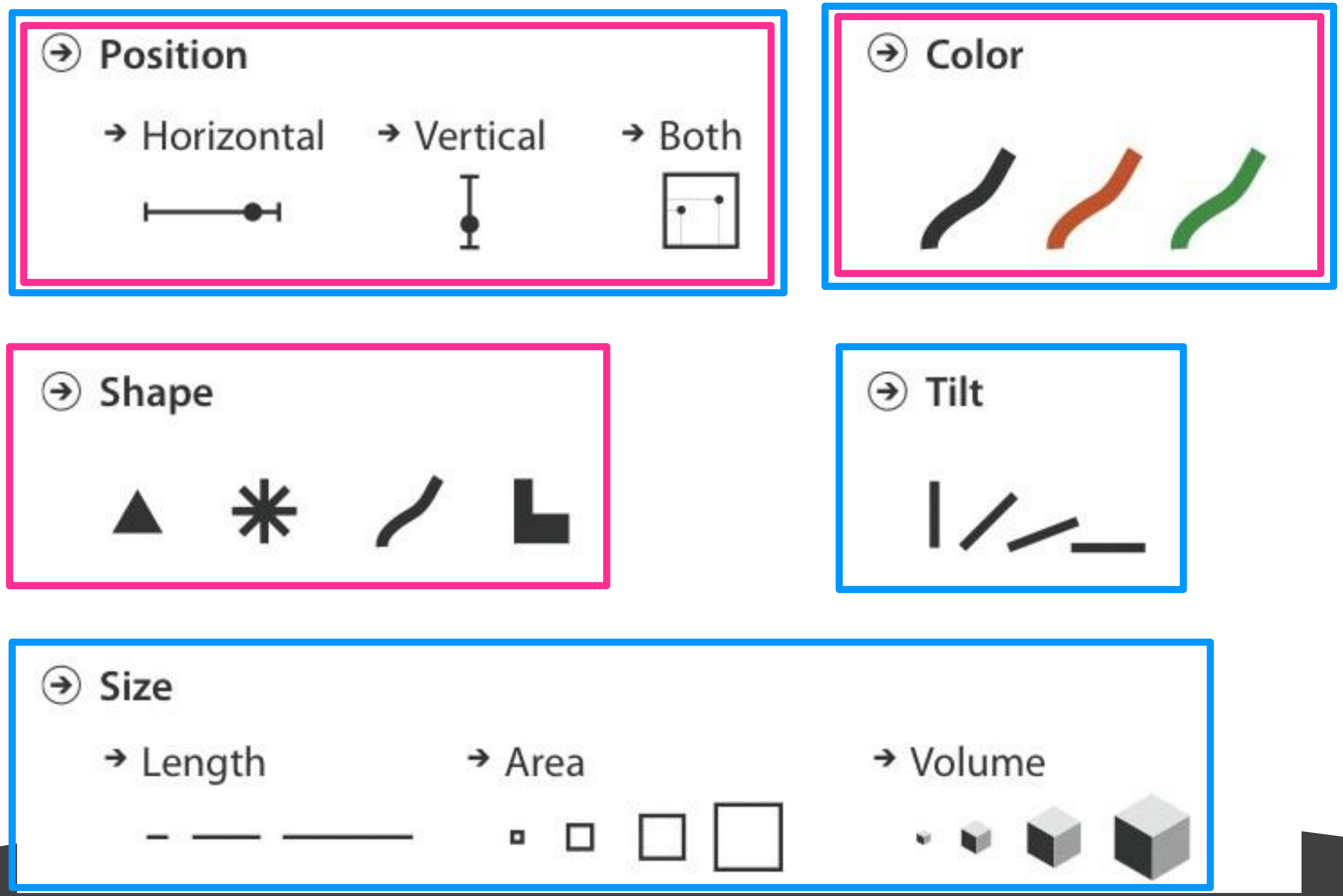


name that mark and channel

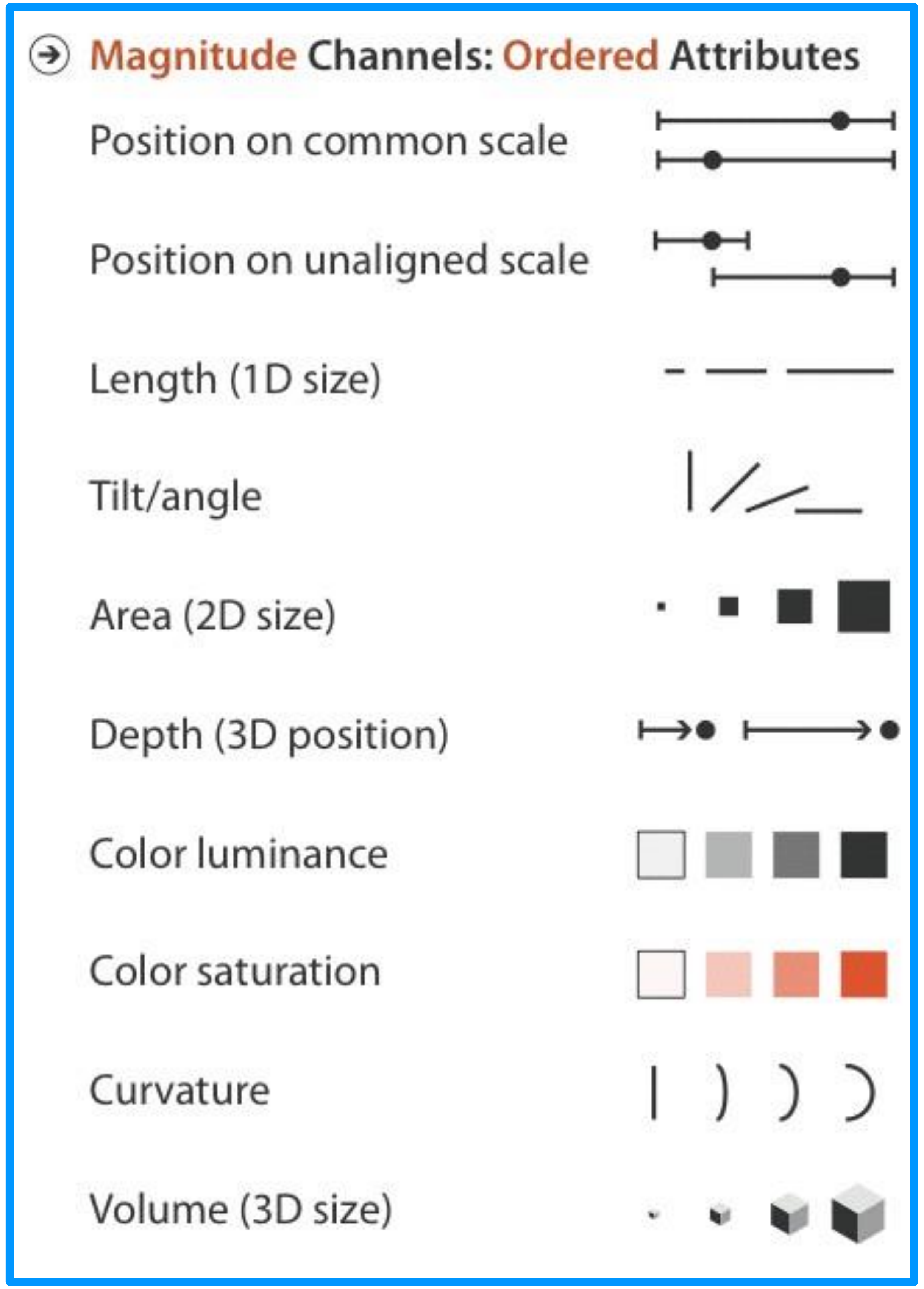


CHANNEL TYPES

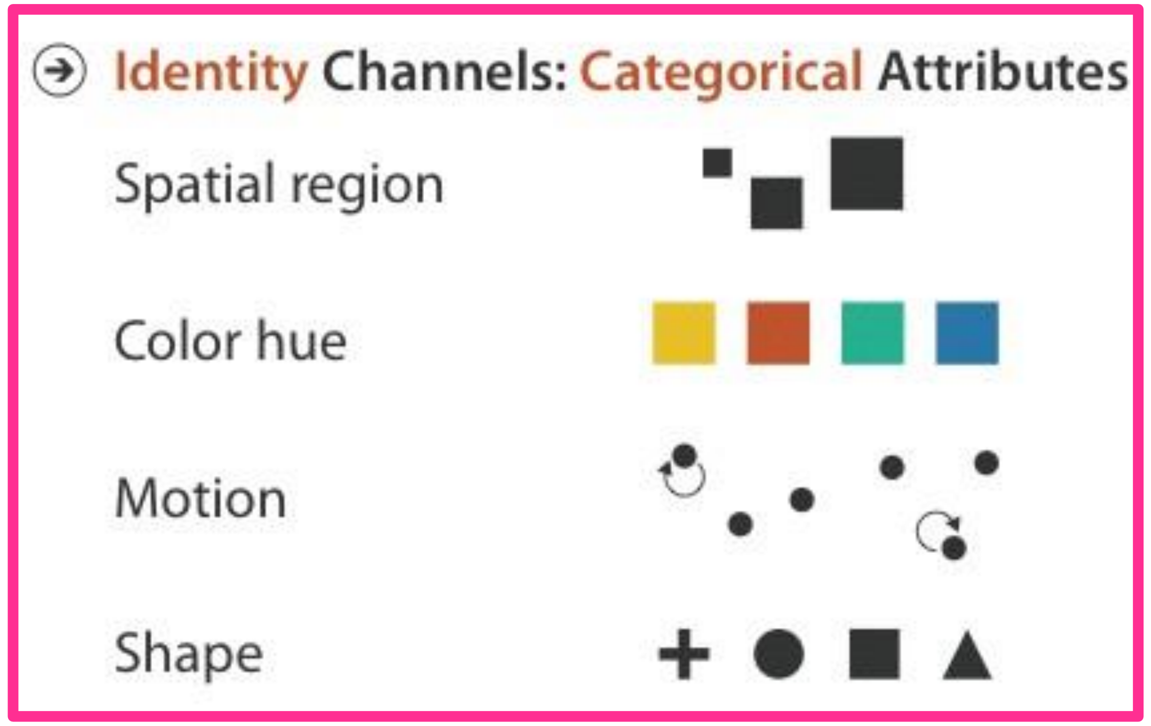
identity (what or where)
magnitude (how much)



expressiveness & effectiveness

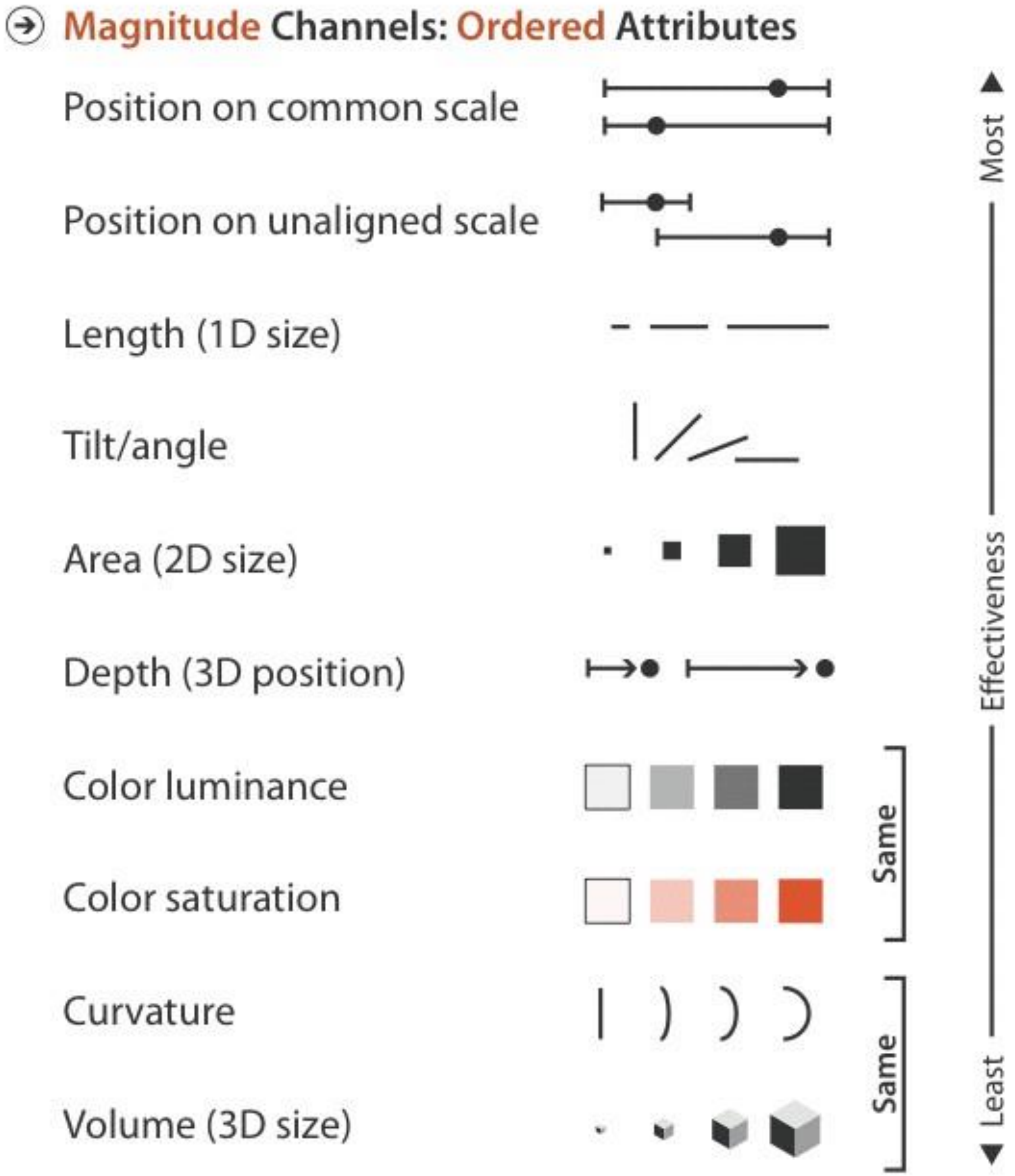


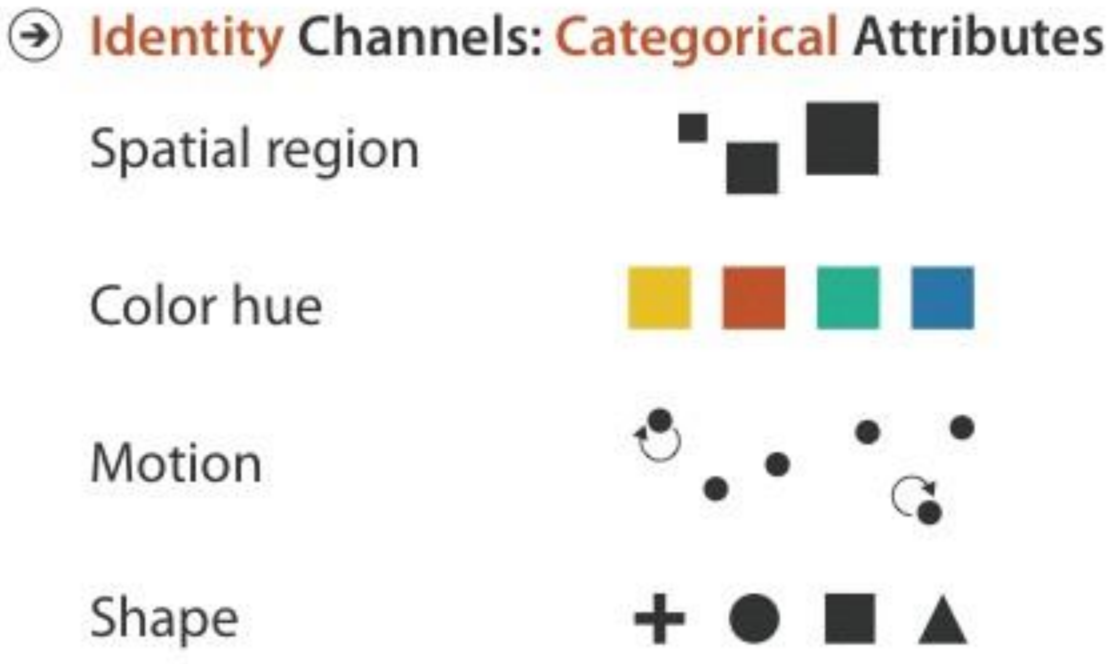
(how much)



(what or where)

expressiveness

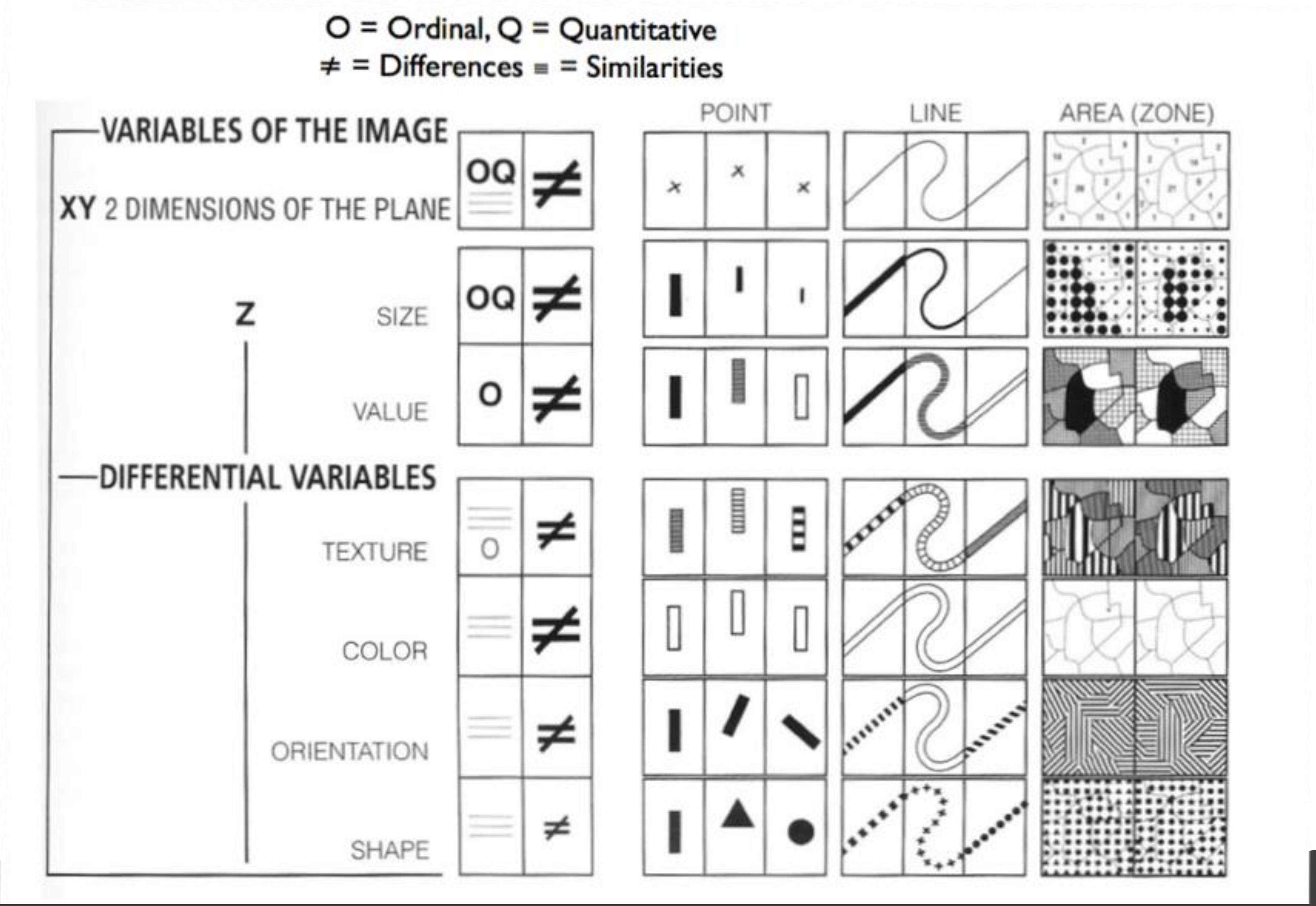




effectiveness

WHERE DO RANKINGS COME FROM?

Bertin, “Semiology of Graphics”, 1967



Cleveland & McGill, “Graphical Perception and Graphical Methods for Analyzing Scientific Data”, 1985

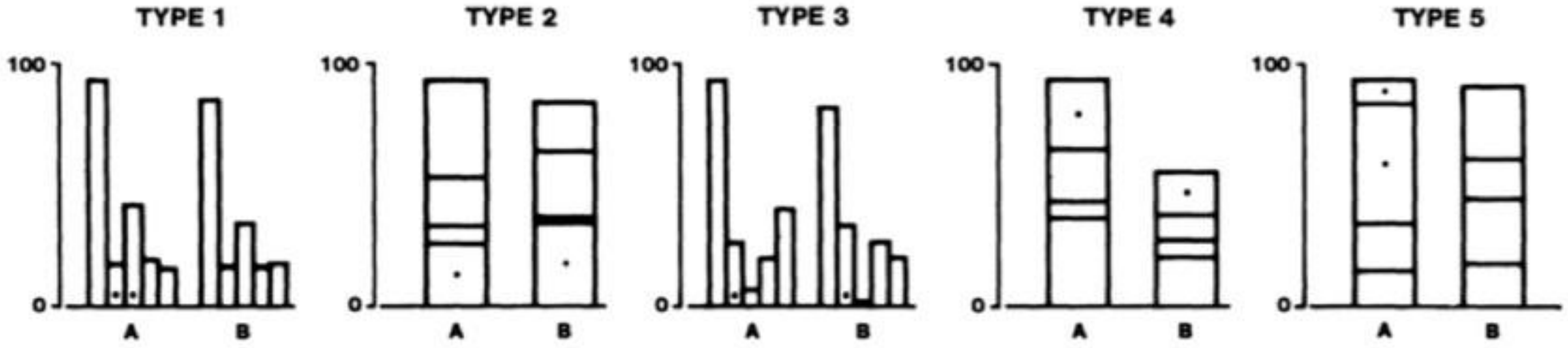


Figure 4. Graphs from position–length experiment.

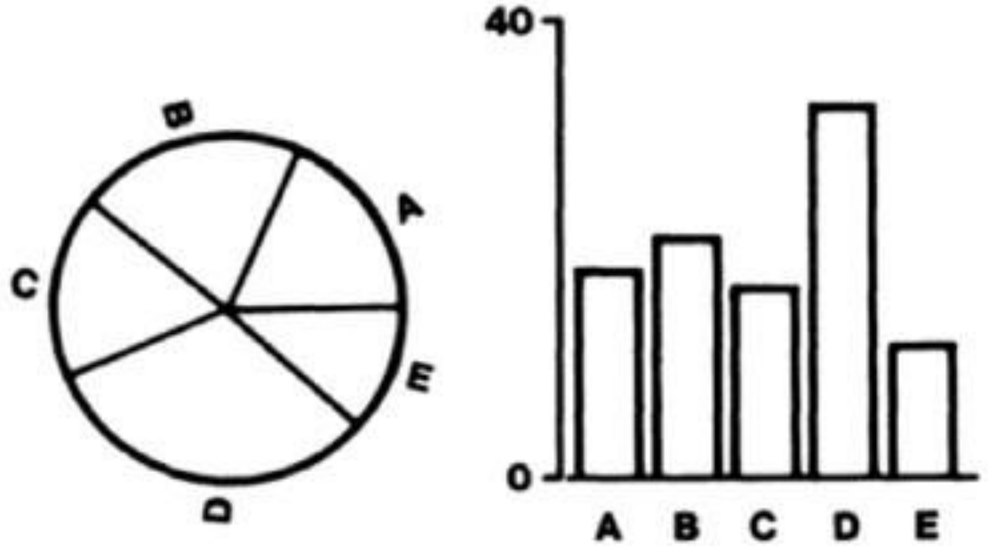
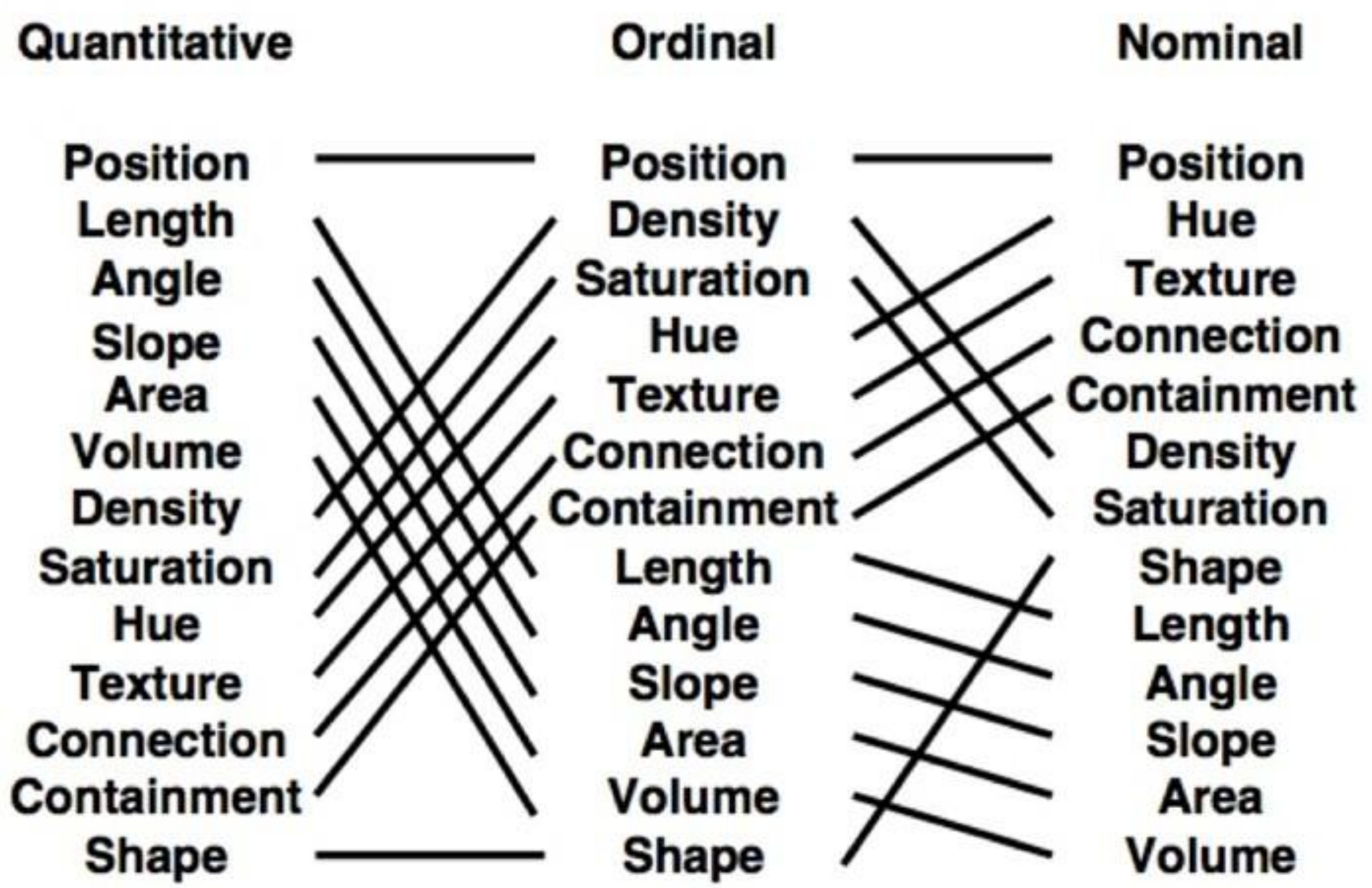


Figure 3. Graphs from position–angle experiment.

Mackinlay, “Automating the Design of Graphical Presentations of Relational Information”, 1986



Heer & Bostock, “Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design”, 2010

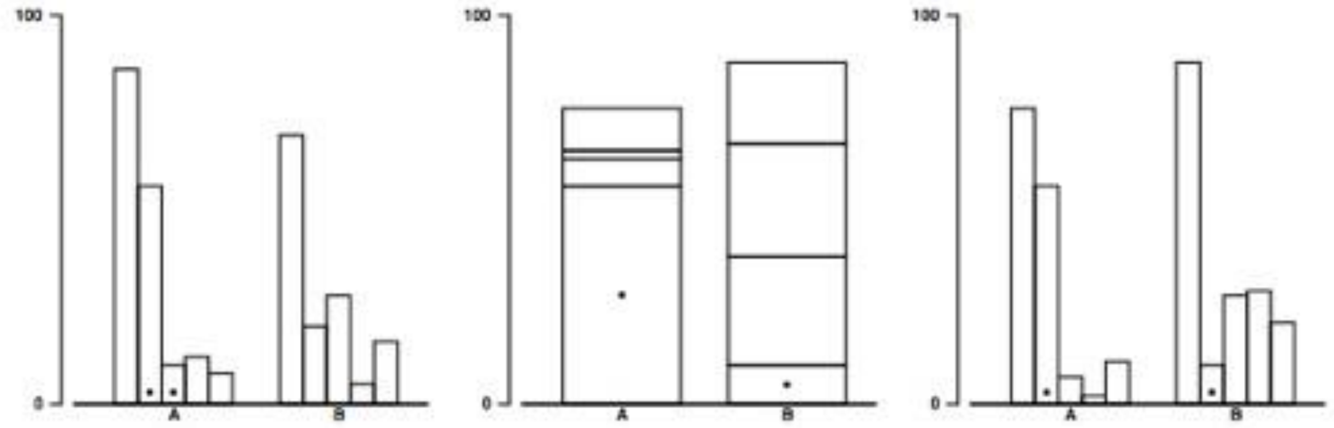


Figure 1: Stimuli for judgment tasks T1, T2 & T3. Subjects estimated percent differences between elements.

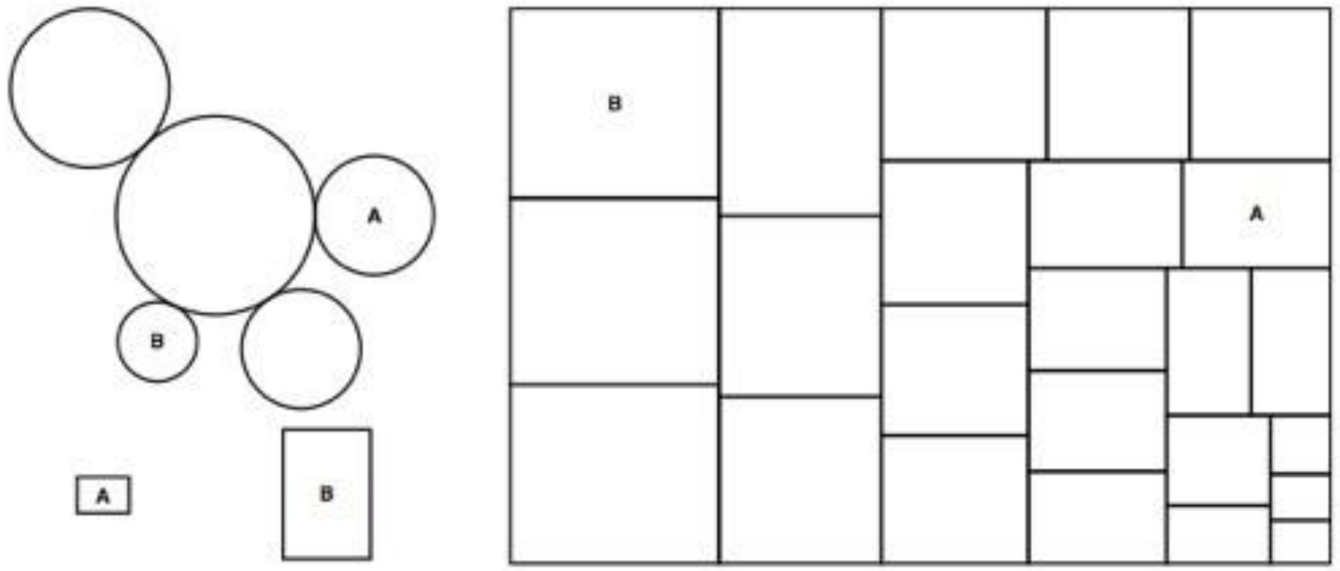
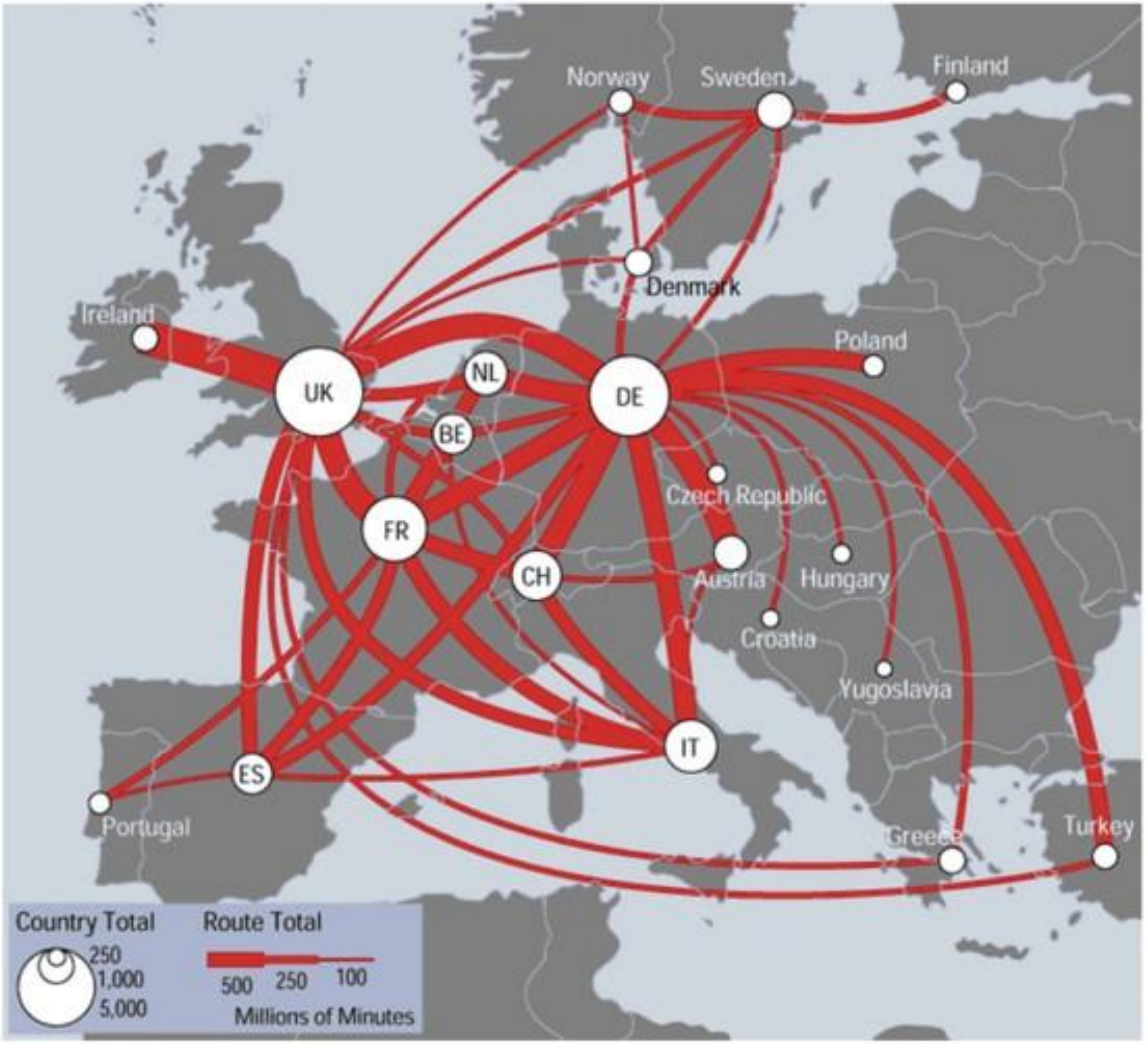


Figure 2: Area judgment stimuli. Top left: Bubble chart (T7), Bottom left: Center-aligned rectangles (T8), Right: Treemap (T9).

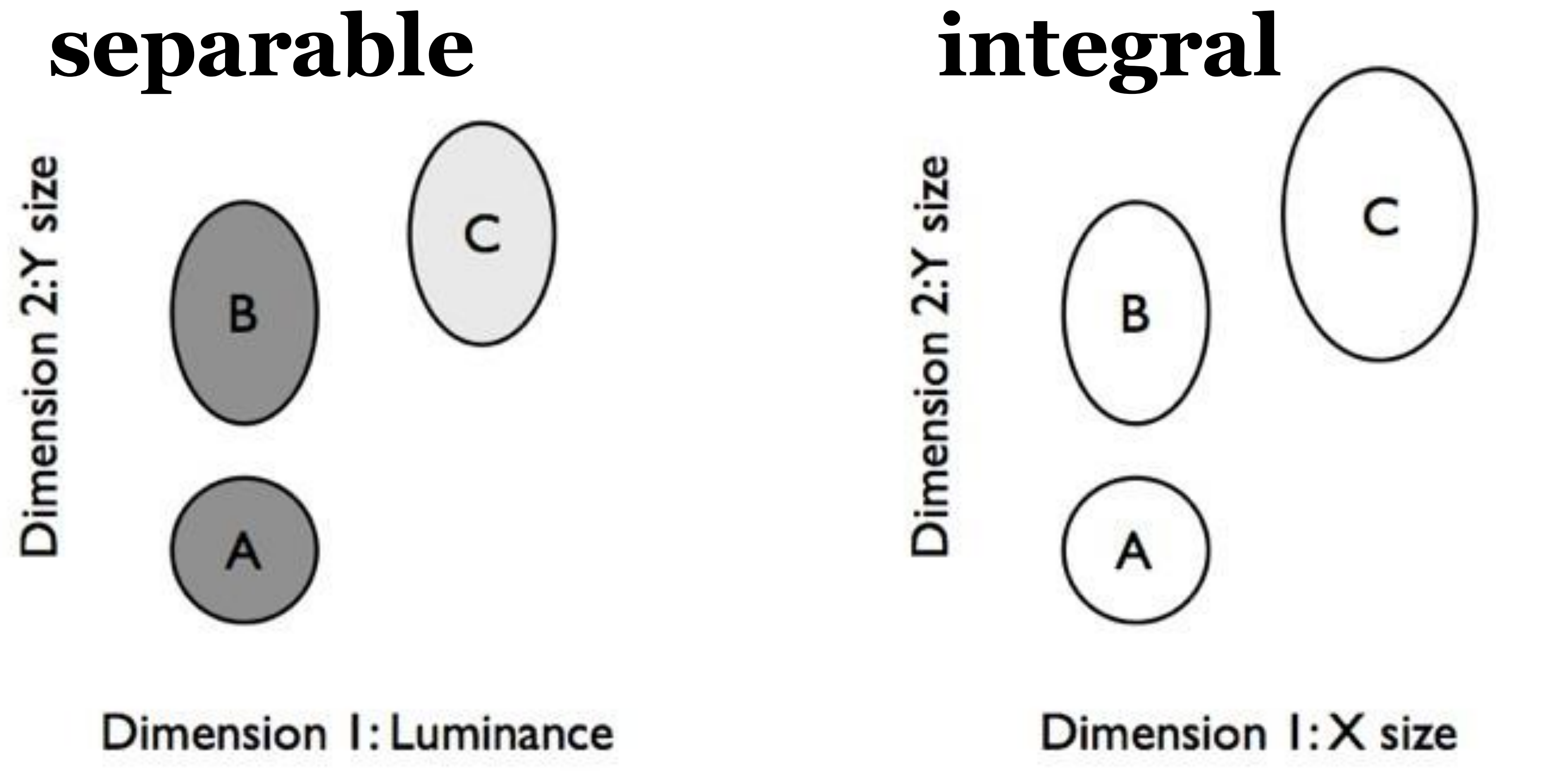
DISCRIMINABILITY

- can channel differences be discerned?



SEPARABLE vs INTEGRAL

- separable: can judge each channel individually
- integral: two channels are viewed holistically



- Ware 2004

SEPARABLE vs INTEGRAL

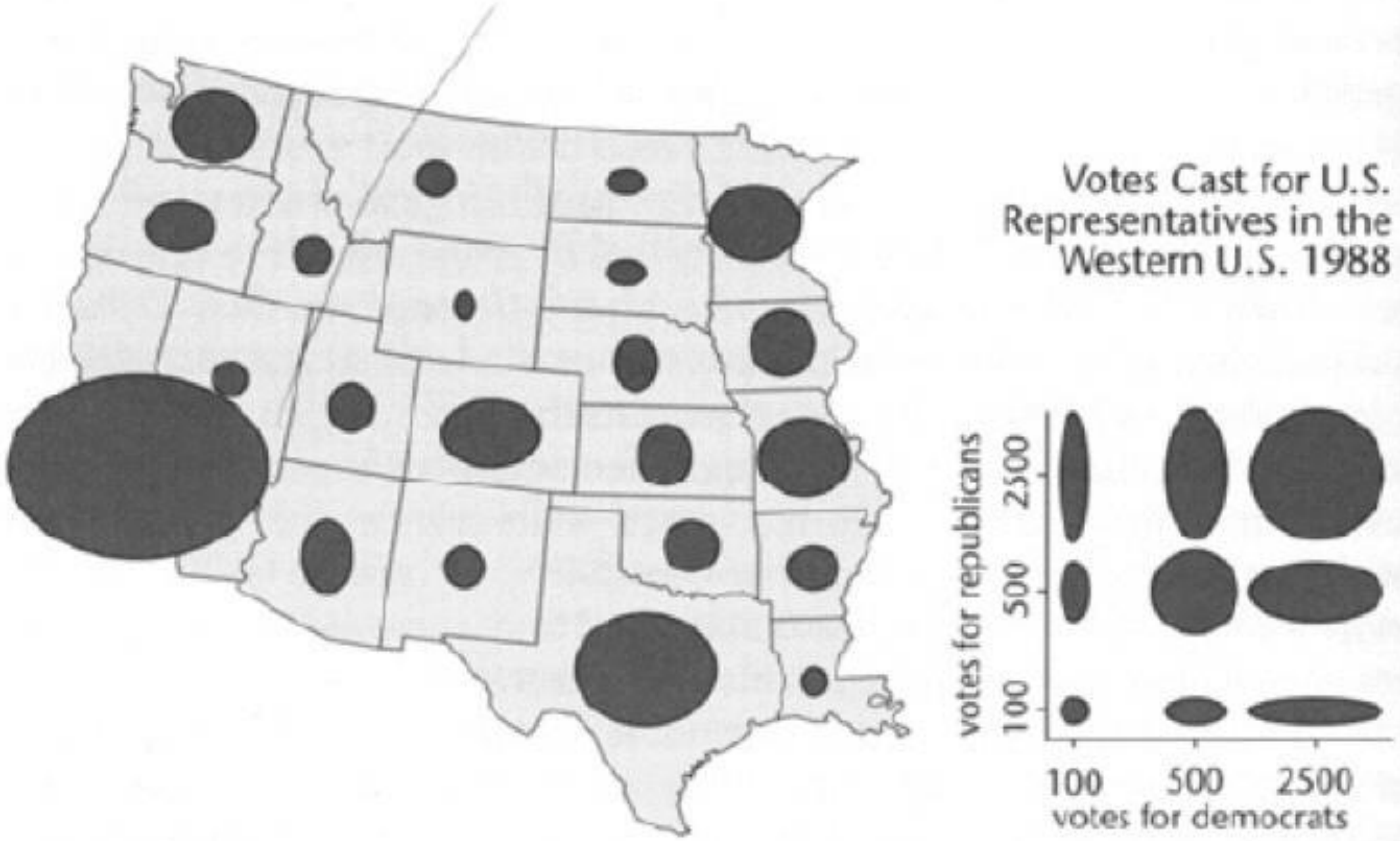
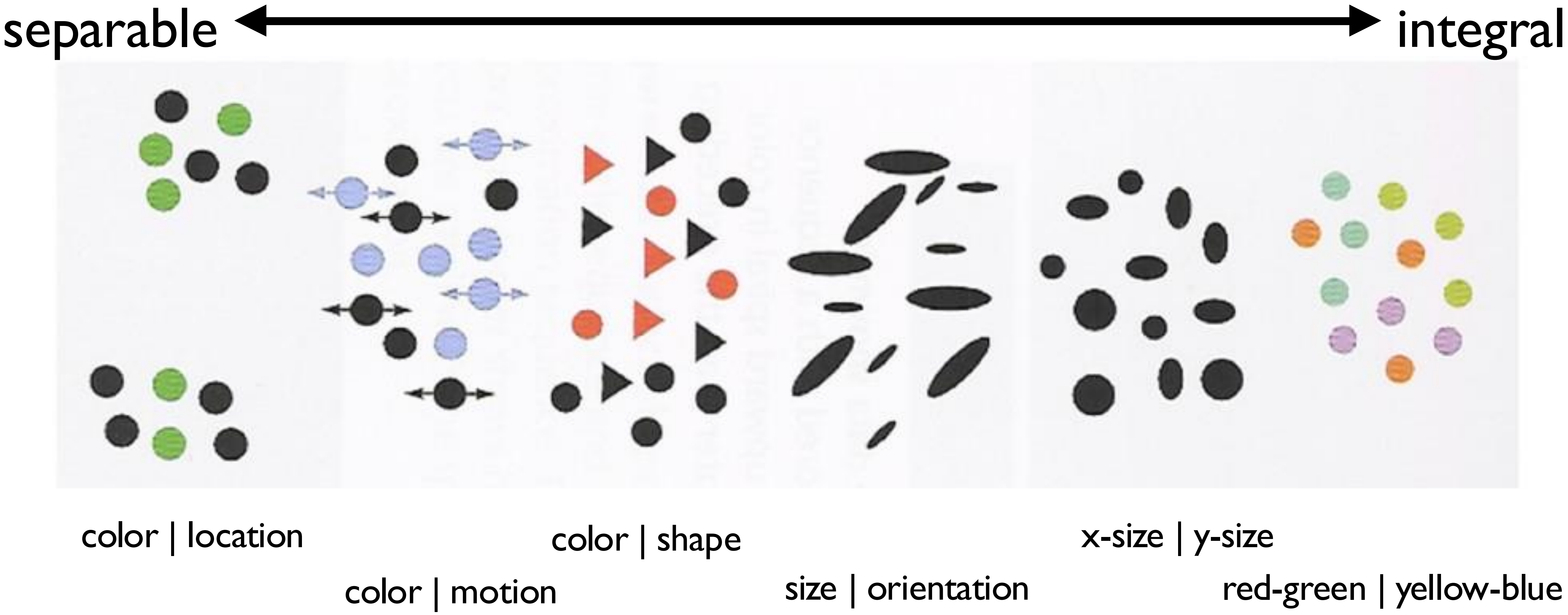
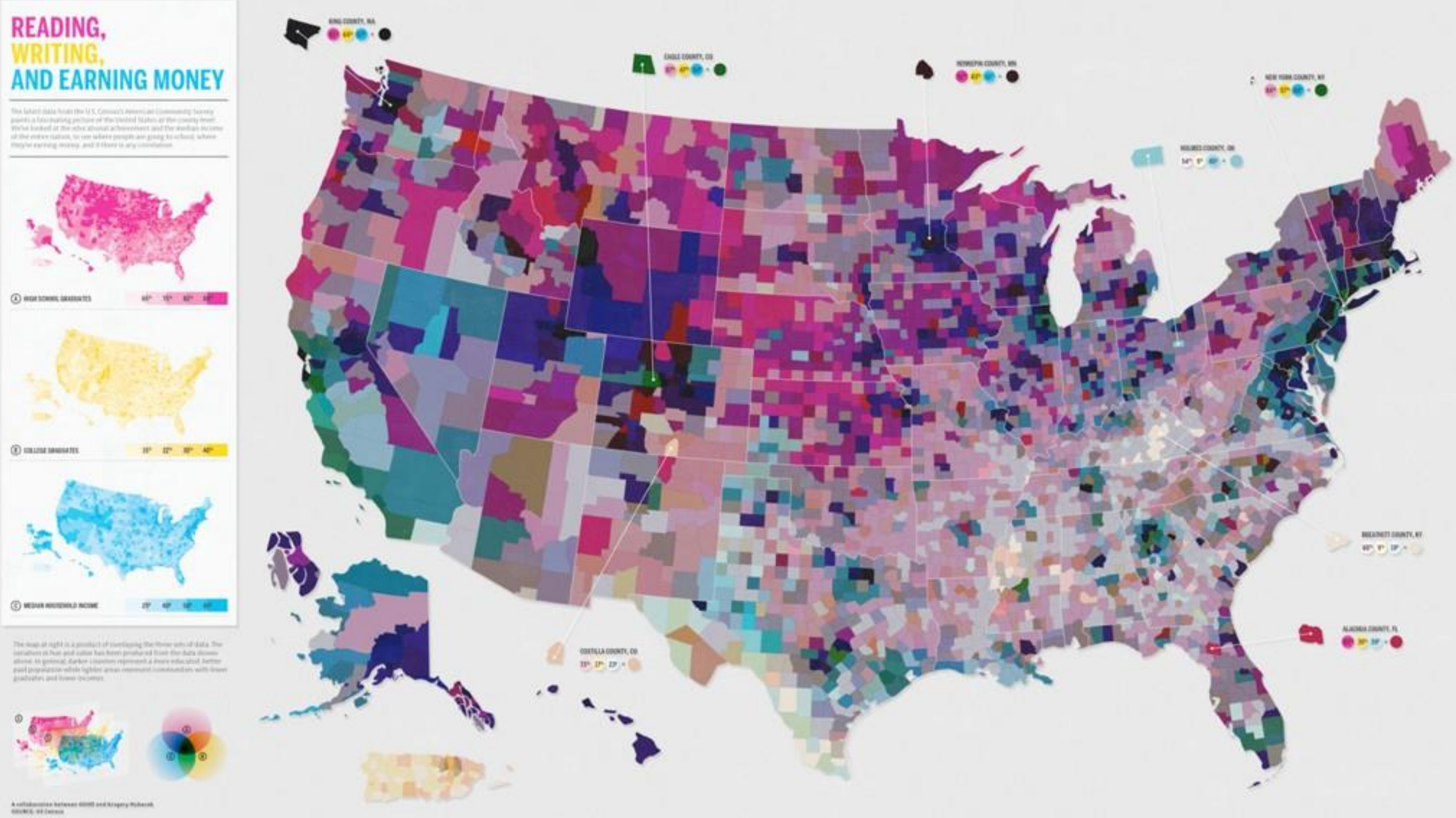


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

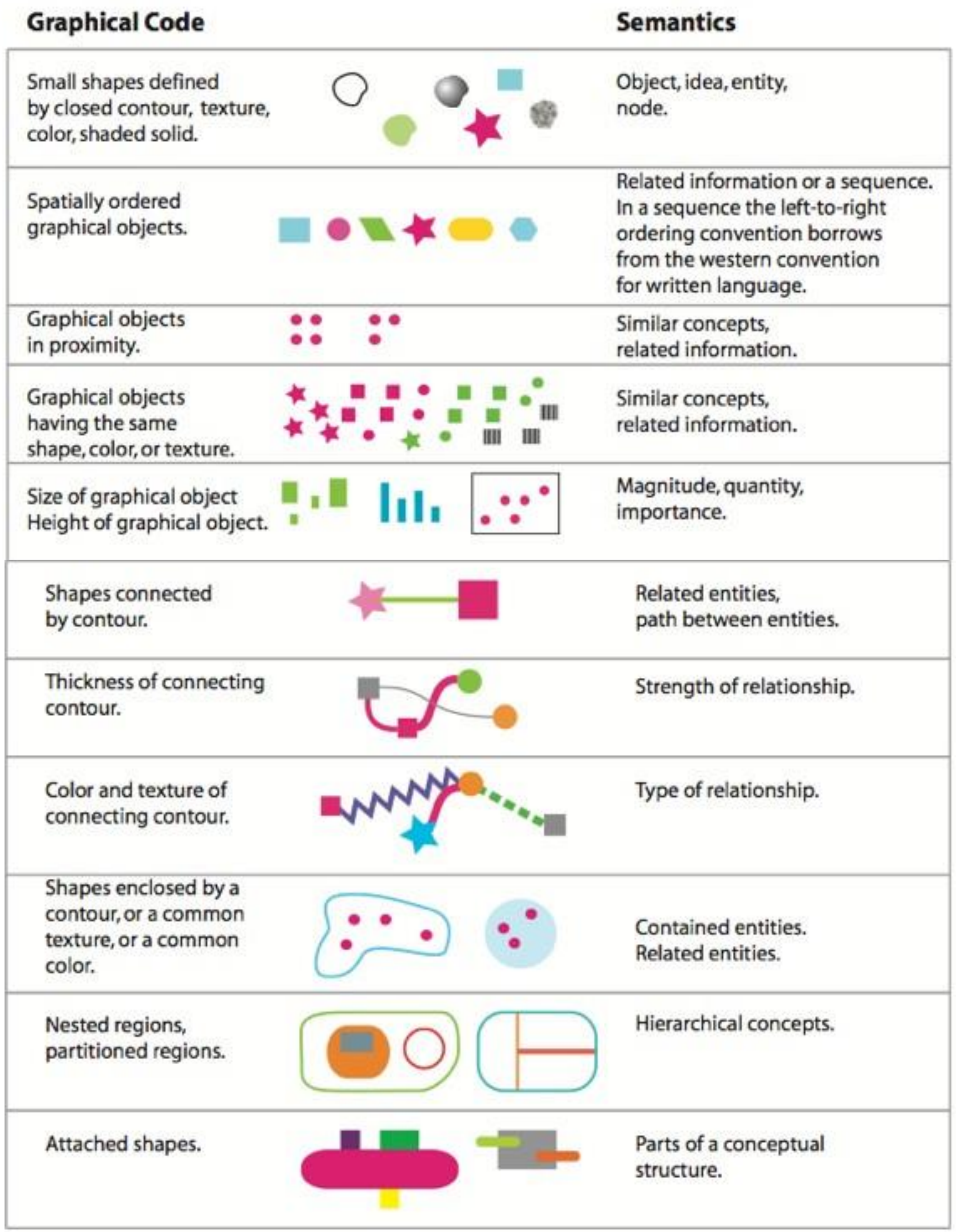
SEPARABLE vs INTEGRAL





http://www.good.is/post/america-s-richest-counties-and-best-educated-counties/

Encoding semantics



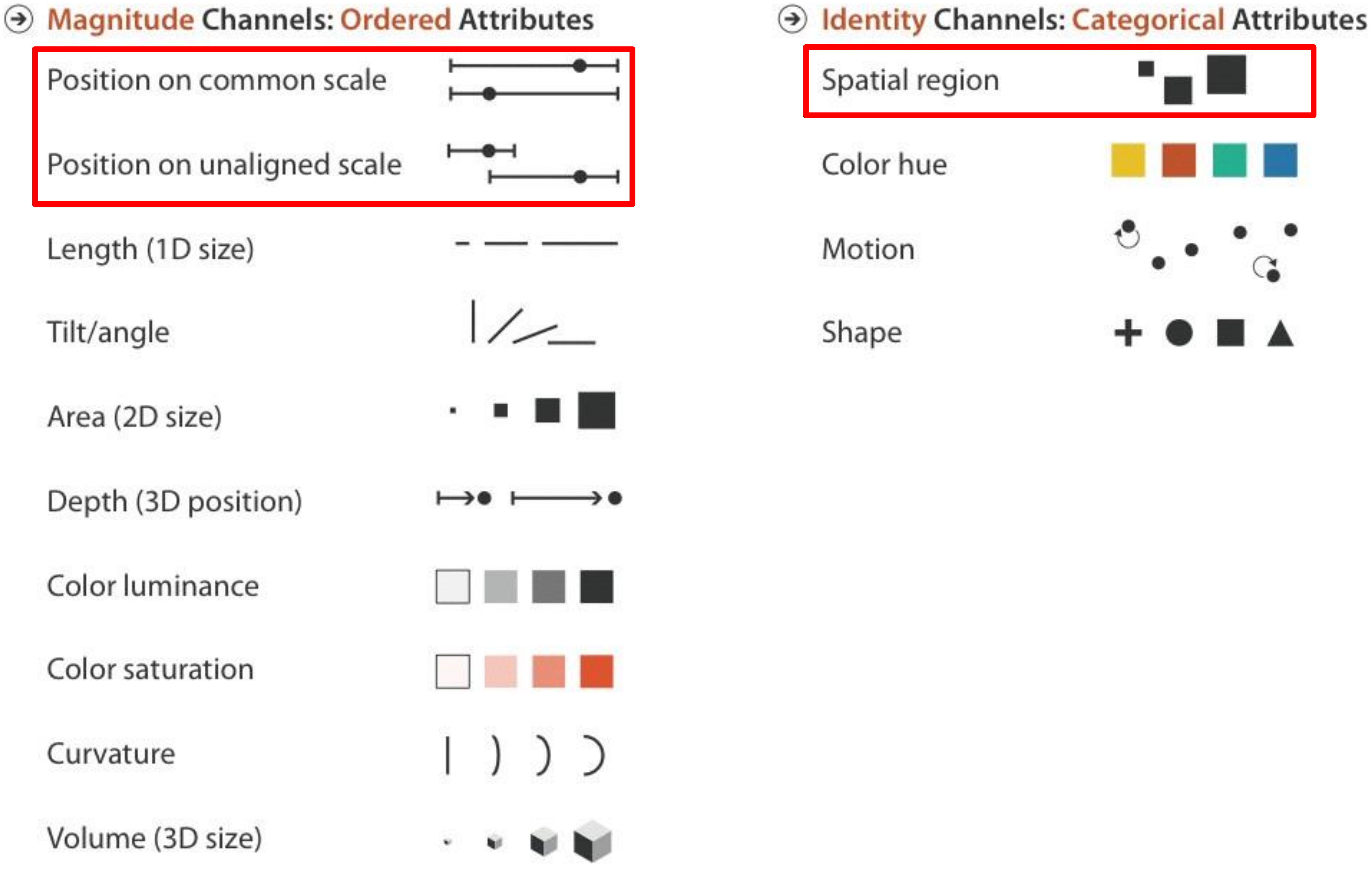
Graphical Code	Semantics
Small shapes defined by closed contour, texture, color, shaded solid.	Object, idea, entity, node.
Spatially ordered graphical objects.	Related information or a sequence. In a sequence the left-to-right ordering convention borrows from the western convention for written language.
Graphical objects in proximity.	Similar concepts, related information.
Graphical objects having the same shape, color, or texture.	Similar concepts, related information.
Size of graphical object Height of graphical object.	Magnitude, quantity, importance.
Shapes connected by contour.	Related entities, path between entities.
Thickness of connecting contour.	Strength of relationship.
Color and texture of connecting contour.	Type of relationship.
Shapes enclosed by a contour, or a common texture, or a common color.	Contained entities. Related entities.
Nested regions, partitioned regions.	Hierarchical concepts.
Attached shapes.	Parts of a conceptual structure.

+ perceptual effects (several of which we already discussed)

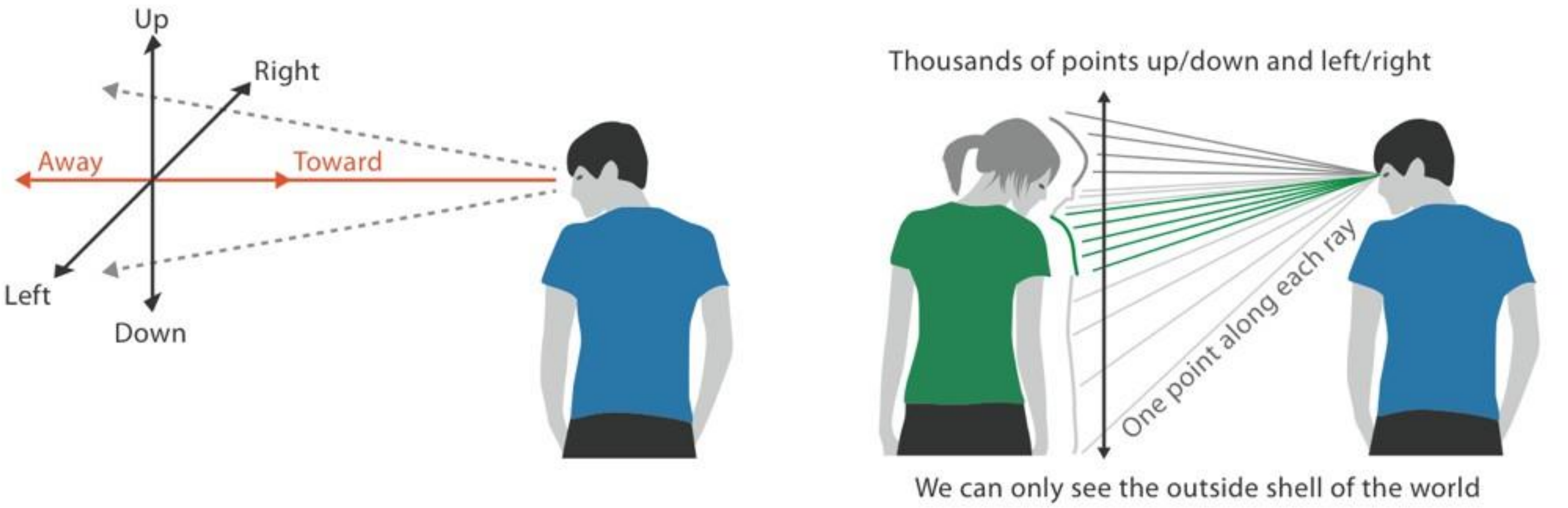
- pop-out
- steven’s power law
- weber’s law
- gestalt principles

planar position

- what‘s so special about the plane?

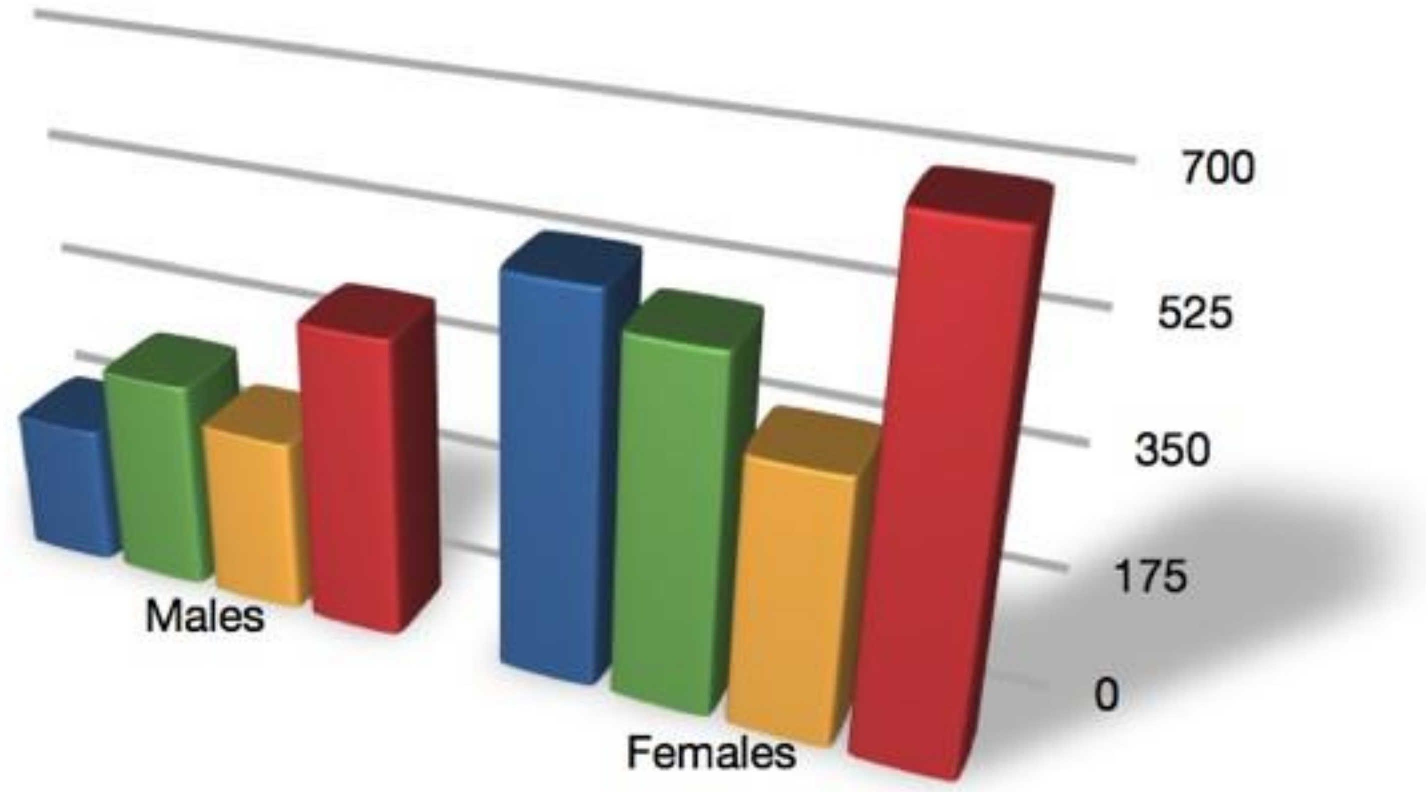

Magnitude Channels: Ordered Attributes
Position on common scale
Position on unaligned scale
Length (1D size)
Tilt/angle
Area (2D size)
Depth (3D position)
Color luminance
Color saturation
Curvature
Volume (3D size)
Identity Channels: Categorical Attributes
Spatial region
Color hue
Motion
Shape

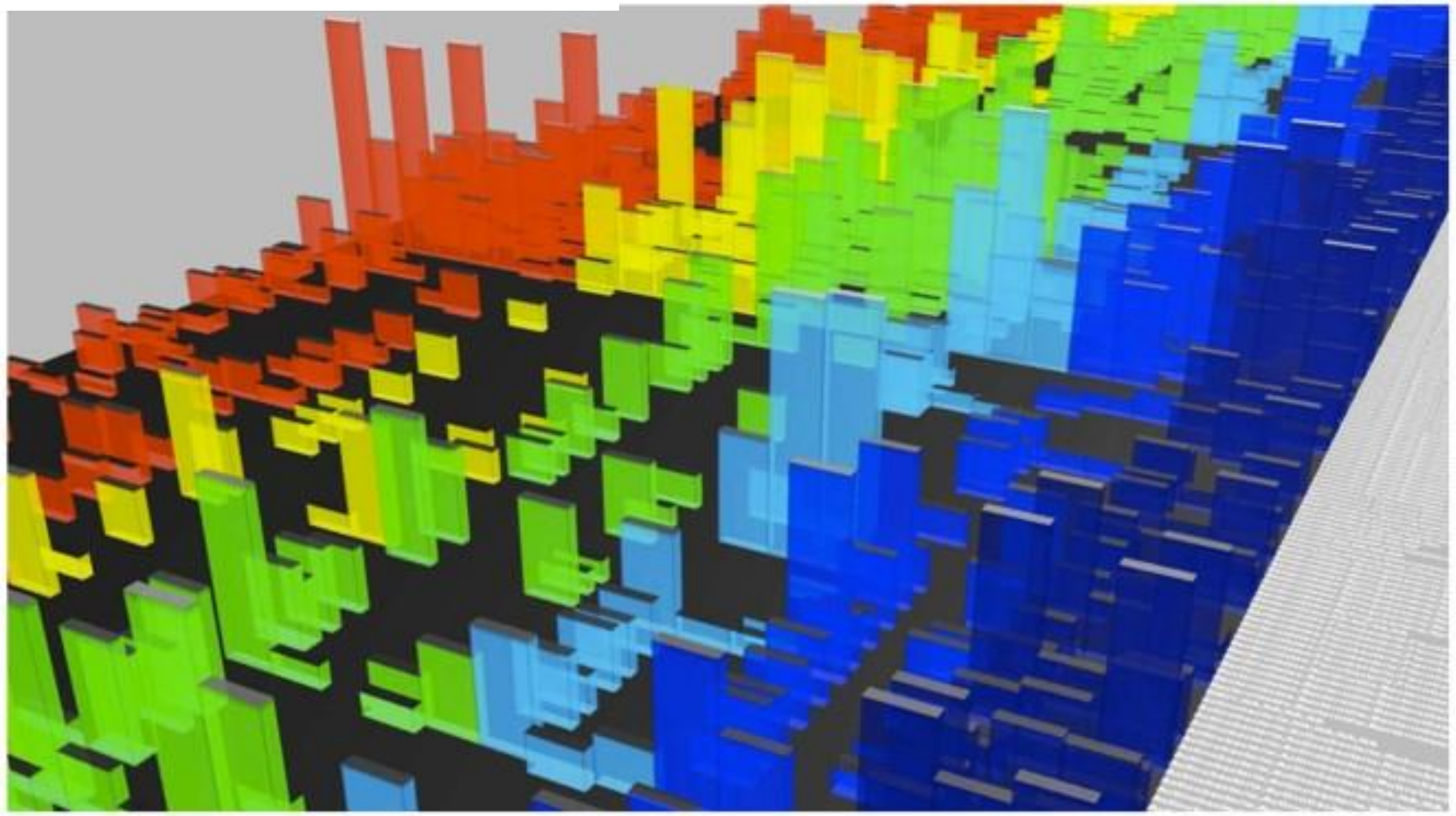
we see the world as a ~~2.5D~~ 2.05D space

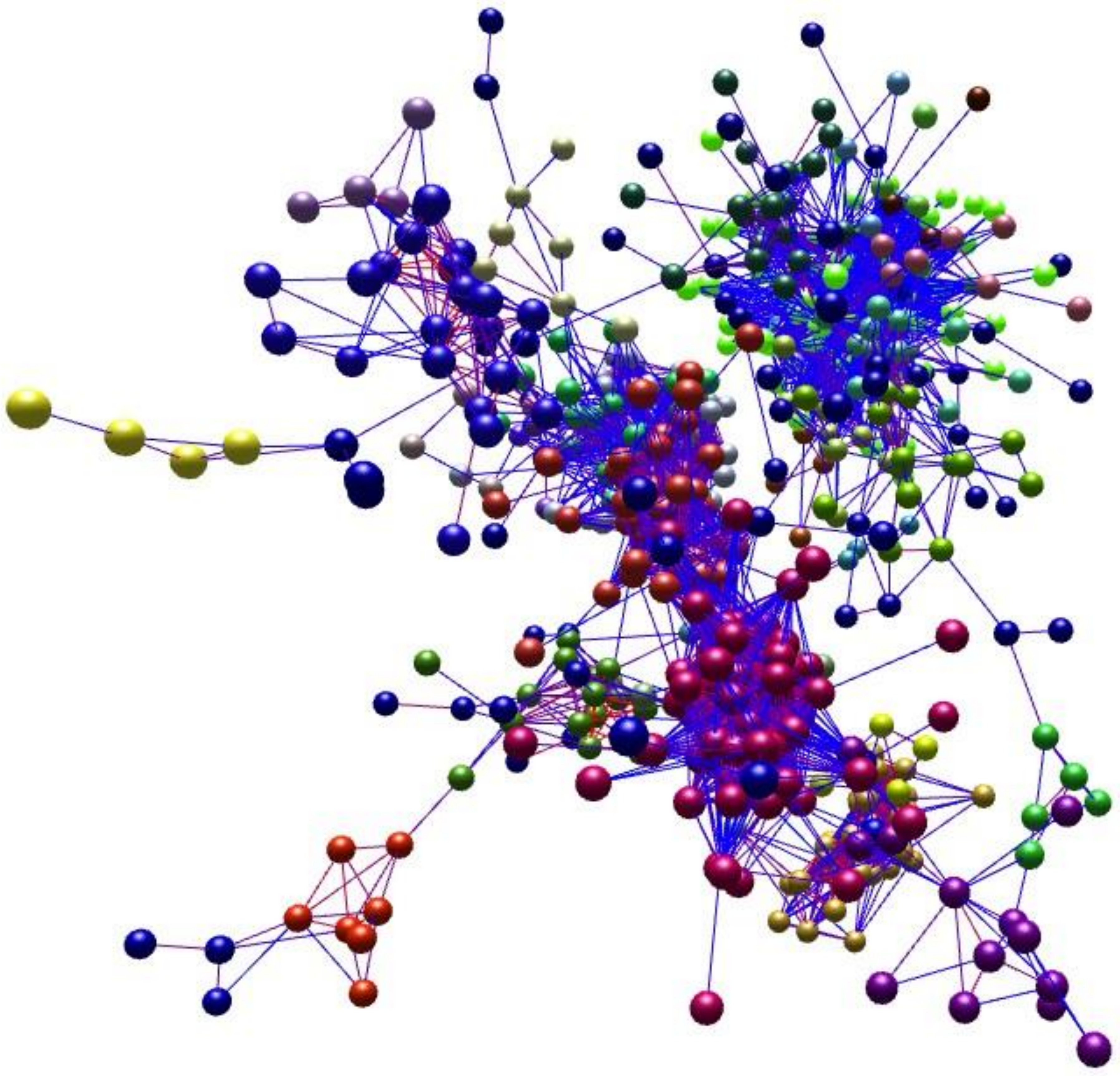


power does not extend to 3D

- perspective cues
  - interfere with color and size channels
- occlusion of data
- text legibility


700
525
350
175
0
Males
Females

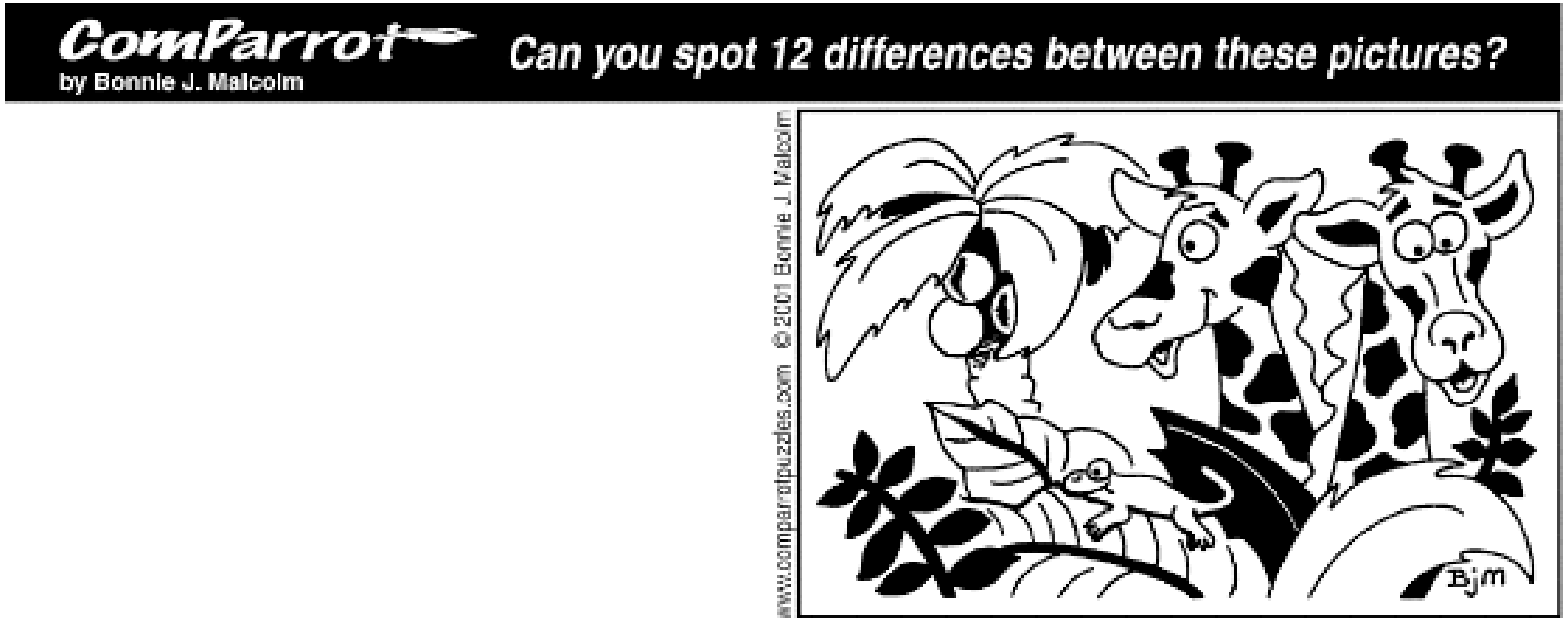


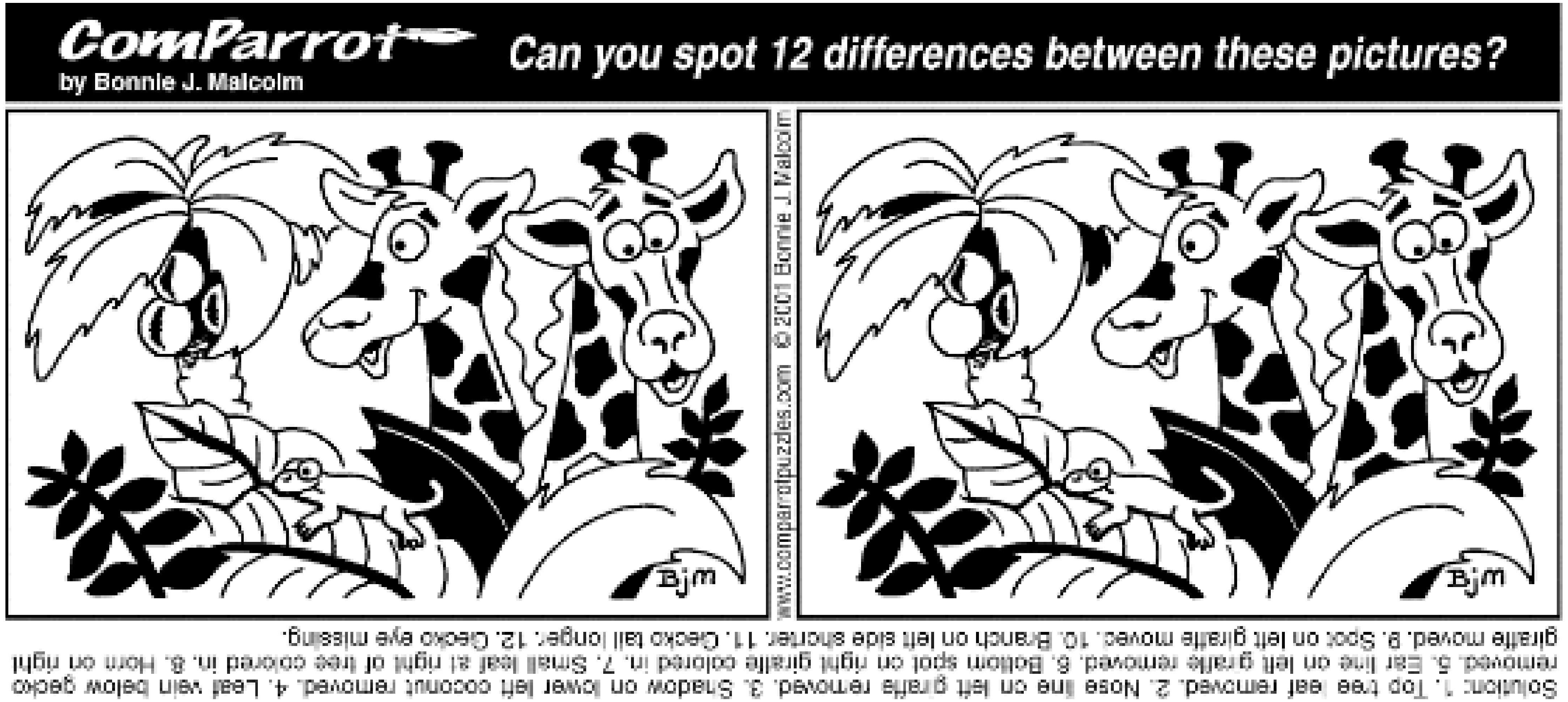


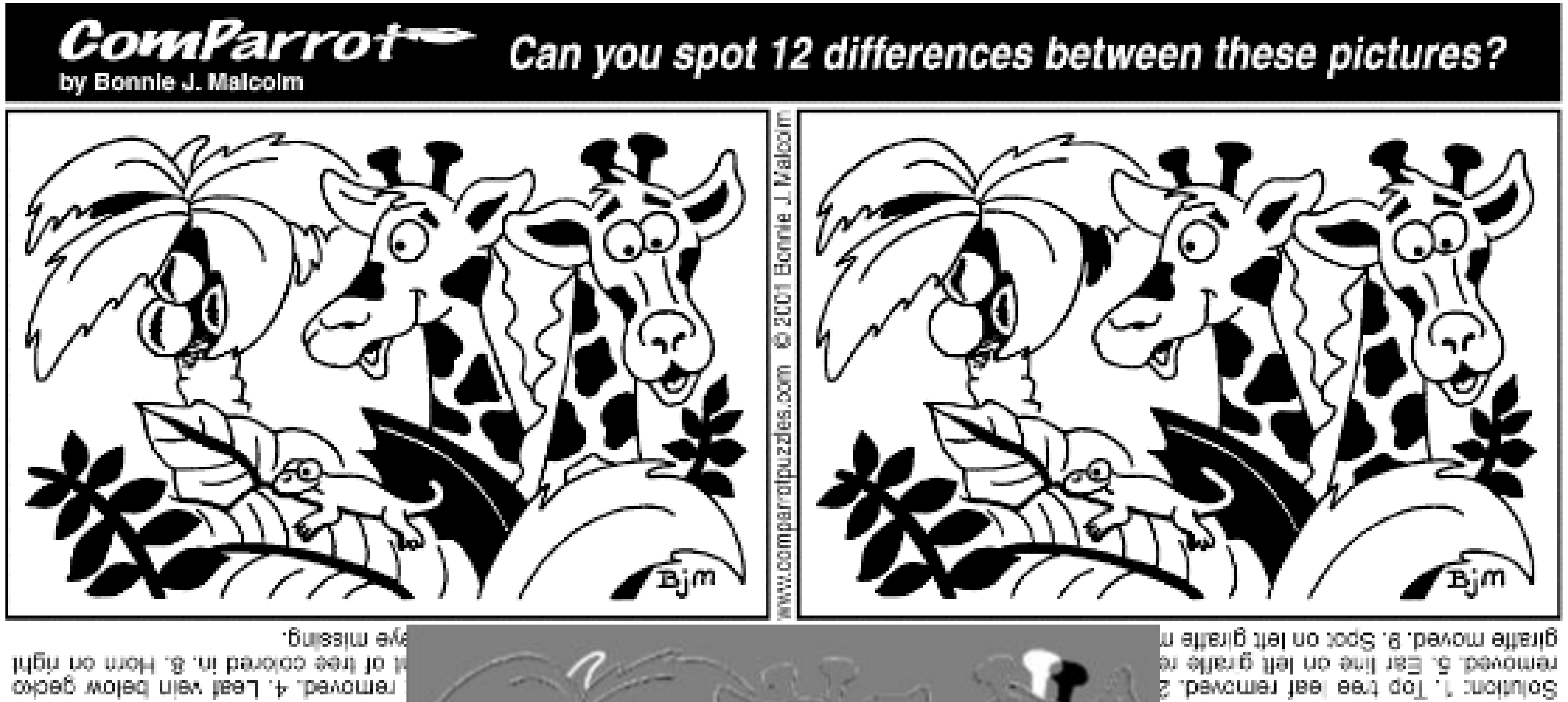
TIME AS ENCODING CHANNEL

- You'll remember, visualization uses pictures to enhance working memory
- external versus internal memory
  - *easy to compare views by moving eyes*
  - *hard to compare view to memory of what you saw*

ComParrot Can you spot 12 differences between these pictures?
by Bonnie J. Malcolm


ComParrot
by Bonnie J. Malcolm
Can you spot 12 differences between these pictures?
www.comparrotpuzzles.com © 2001 Bonnie J. Malcolm
Bjm


ComParrot
by Bonnie J. Malcolm
Can you spot 12 differences between these pictures?
www.comparrotpuzzles.com © 2001 Bonnie J. Malcolm
Bjm
Bjm
Solution: 1. Top tree leaf removed. 2. Nose line on left giraffe removed. 3. Shadow on lower left coconut removed. 4. Leaf vein below gecko removed. 5. Ear line on left giraffe removed. 6. Bottom spot on right giraffe colored in. 7. Small leaf at right of tree colored in. 8. Horn on right giraffe moved. 9. Spot on left giraffe moved. 10. Branch on left side shorter. 11. Gecko tail longer. 12. Gecko eye missing.


ComParrot
by Bonnie J. Malcolm
Can you spot 12 differences between these pictures?
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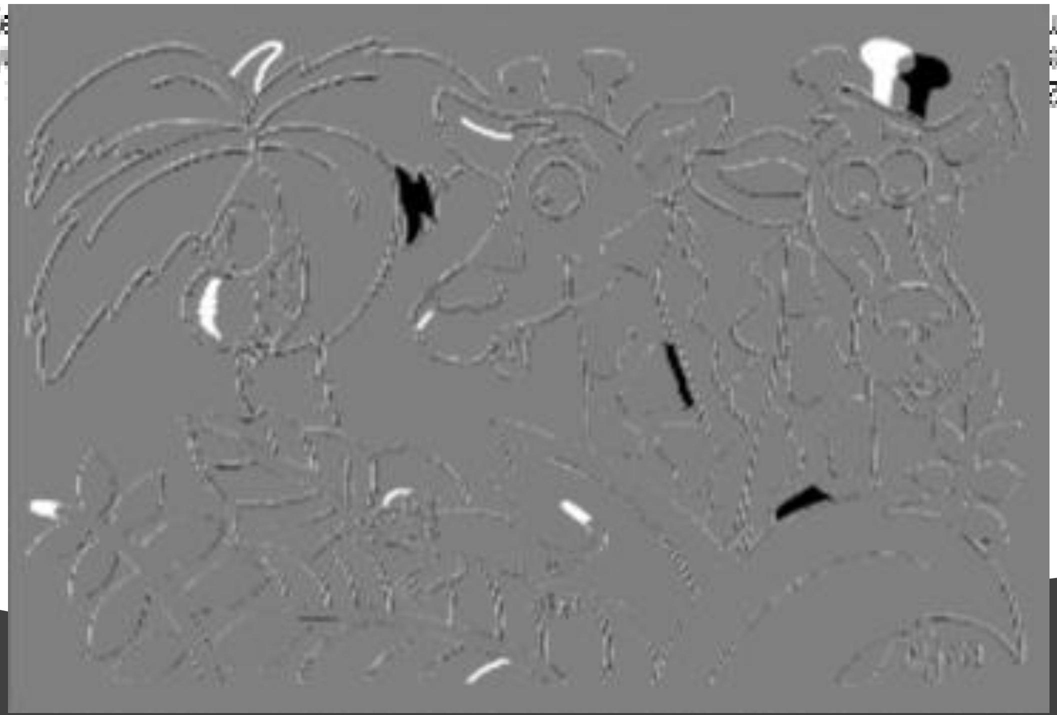
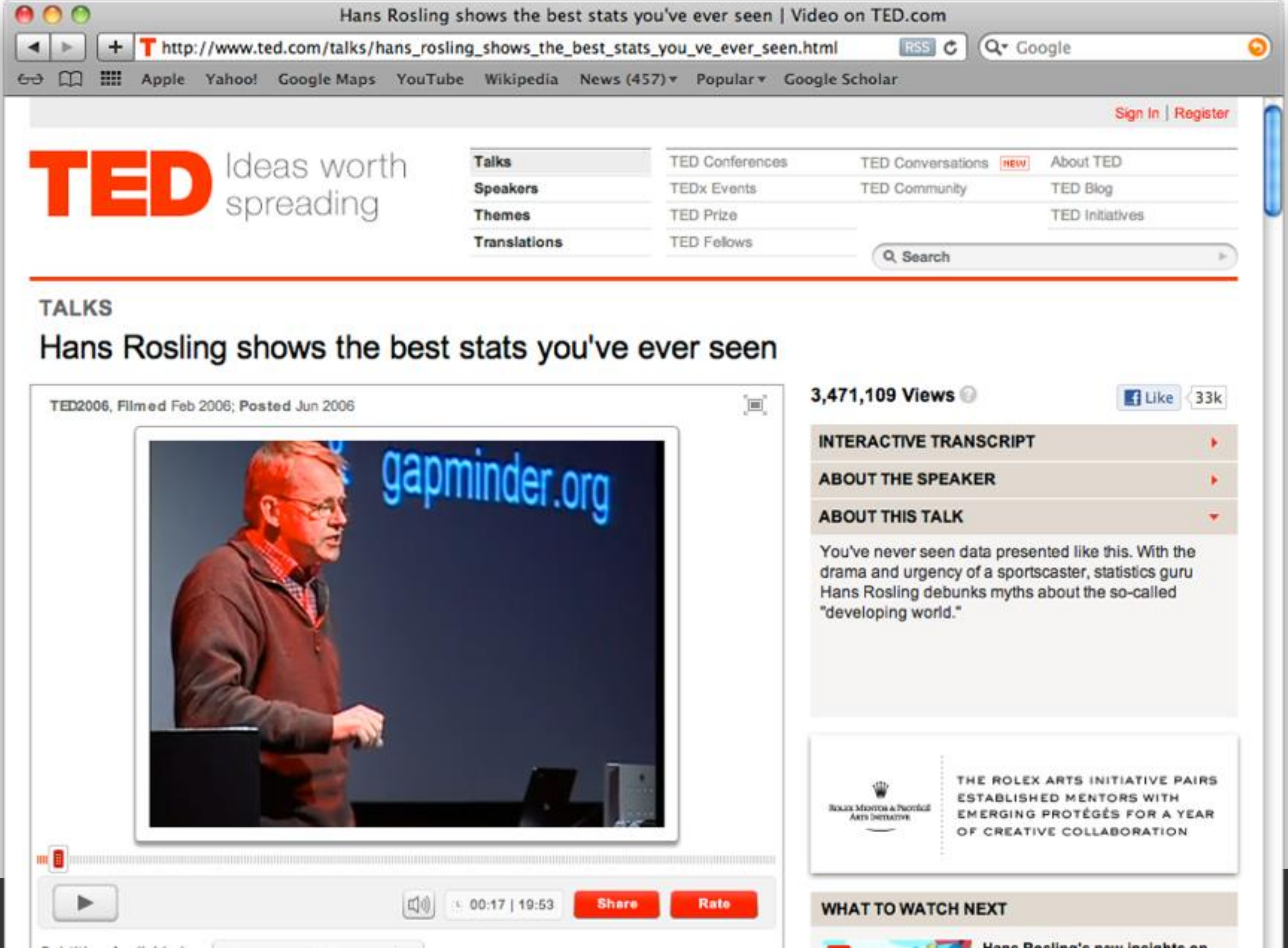
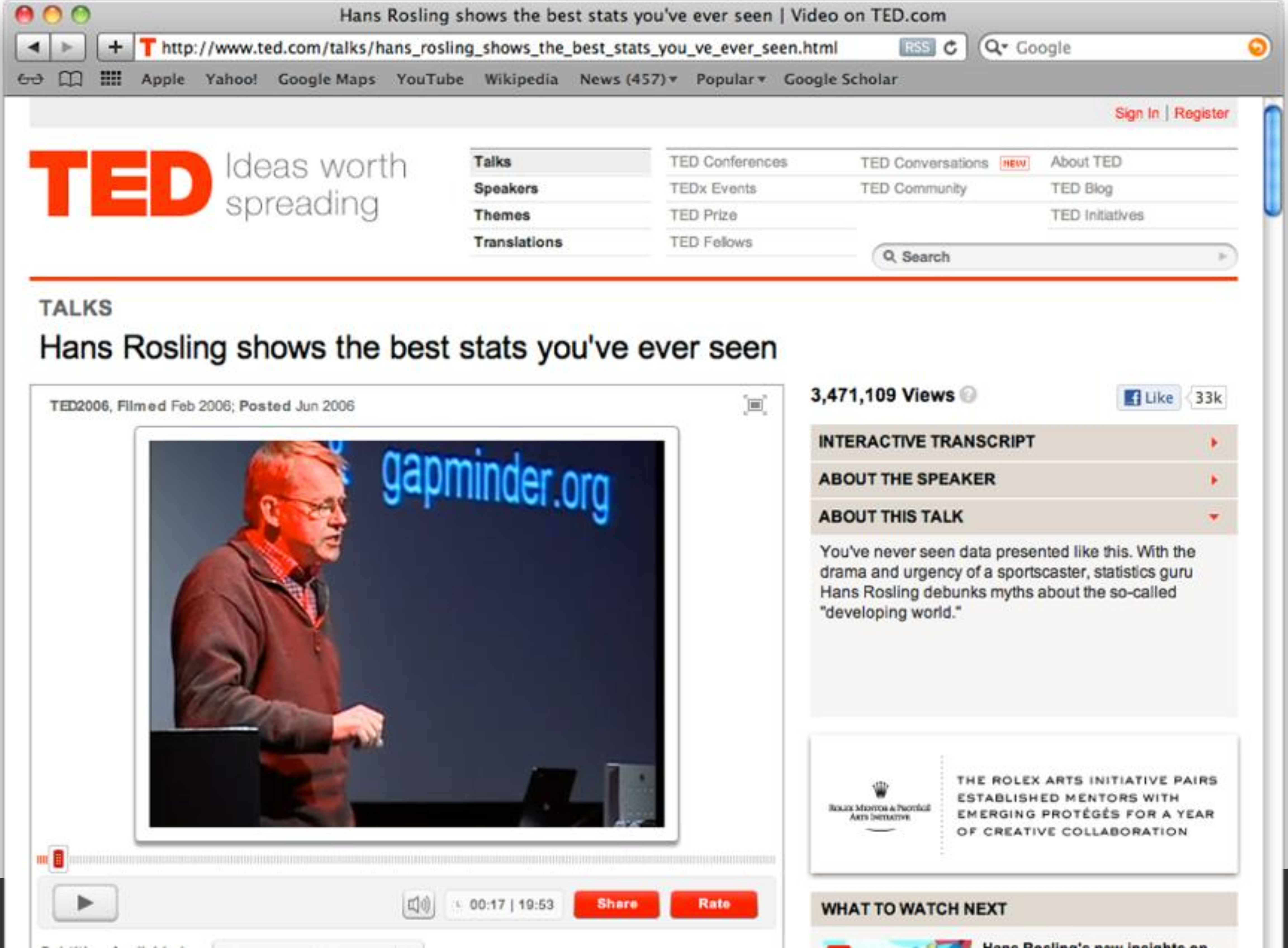


WHEN TO USE ANIMATION?

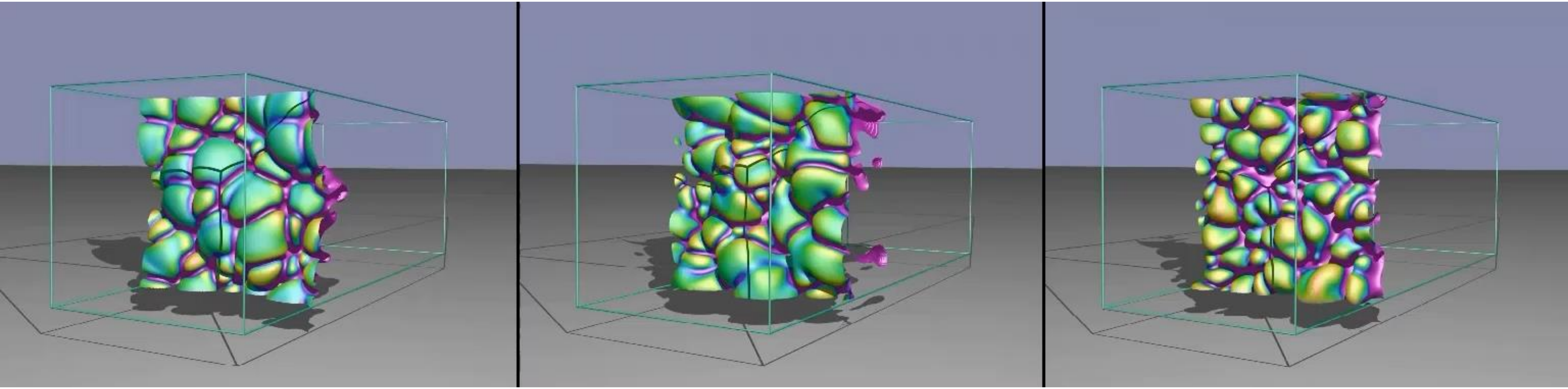
GOOD: STORYTELLING



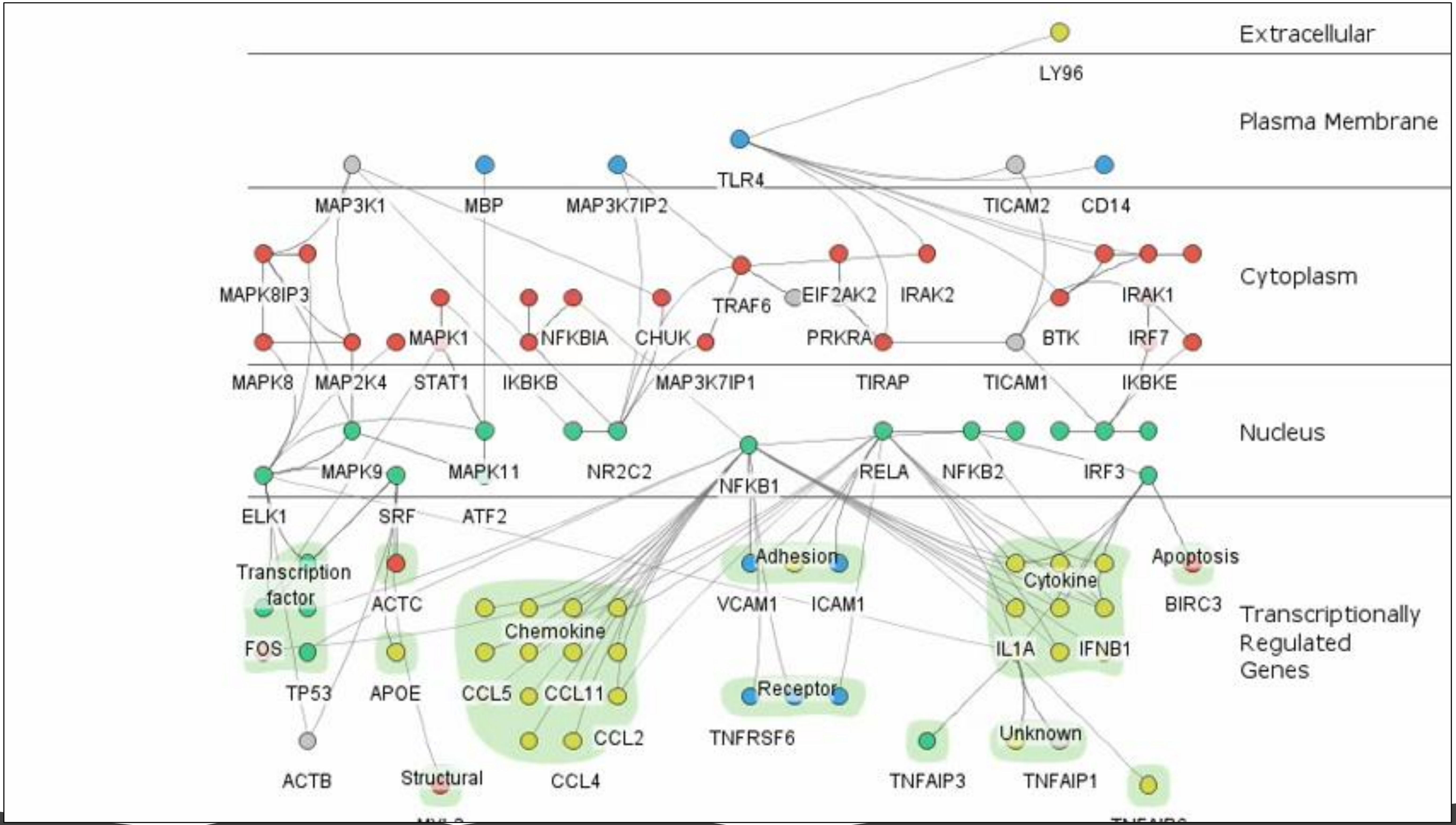
GOOD: TRANSITIONS



BAD: COMPARING COMPLEX STATE CHANGES OVER TIME



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES (use small multiples instead)