Visual perception

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Why does visualization work?

"Typically, **tasks** that can be performed on large multi-element displays in **less than 200 to 250 milliseconds** (msec) are considered **preattentive**."

Healey, C. G., & Enns, J. T. (2012). Attention and visual memory in visualization and computer graphics. IEEE Transactions on Visualization and Computer Graphics, 18(7), 1170–88.

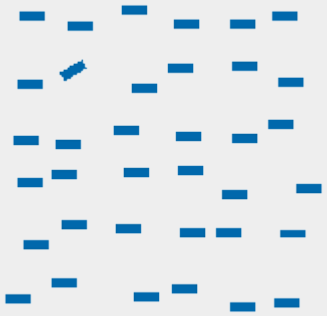
Why does visualization work?

“Preattentive features **pop-out**.”

Jon Schwabish (2016) at PRB data viz workshop.

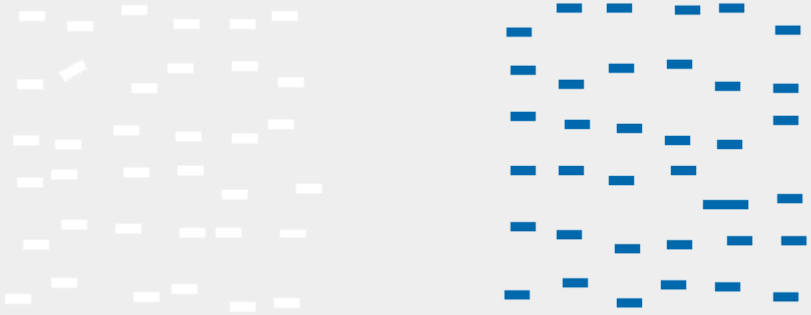
Grabbing attention
Preattentive features

Line orientation



Source: Christopher G. Healey

Line length



Source: Christopher G. Healey

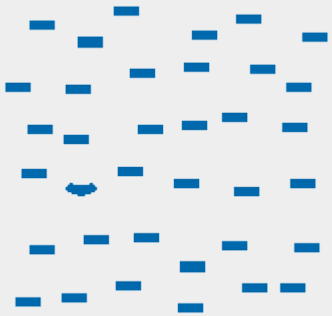
Closure

Source: Christopher G. Healey

Size

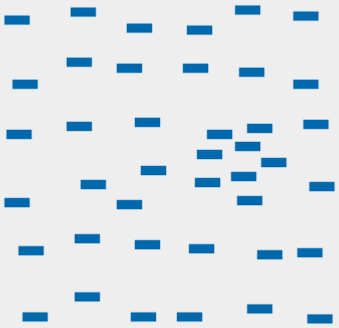
Source: Christopher G. Healey

Curvature



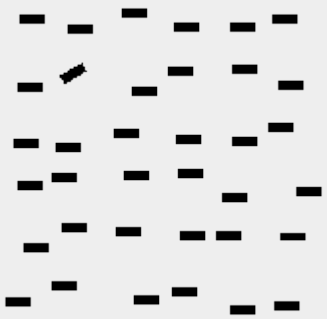
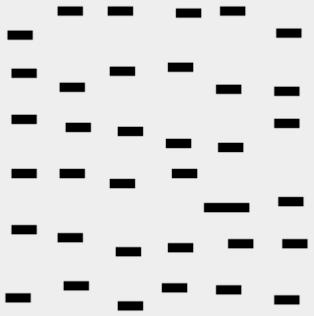
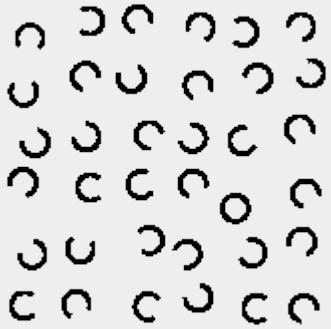
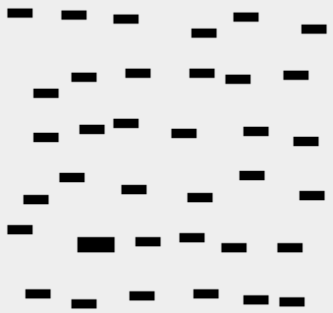
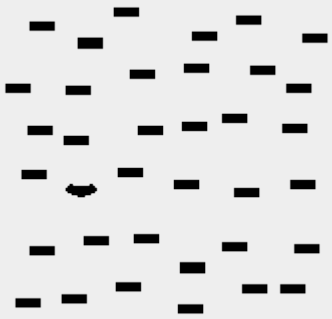
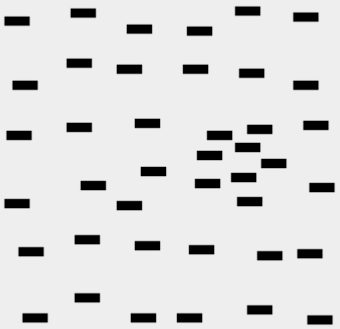
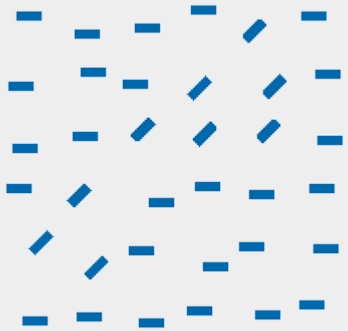
Source: Christopher G. Healey

Density



Source: Christopher G. Healey

Number

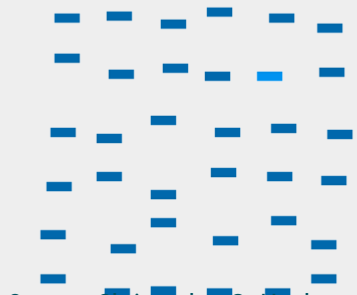








Source: Christopher G. Healey

Colour (hue)

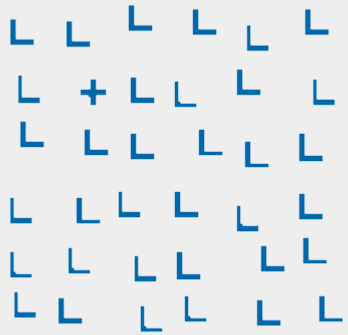
Source: Christopher G. Healey

Intensity



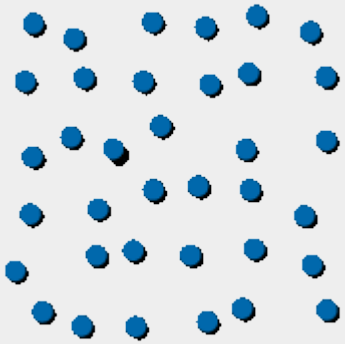
Source: Christopher G. Healey

Intersection



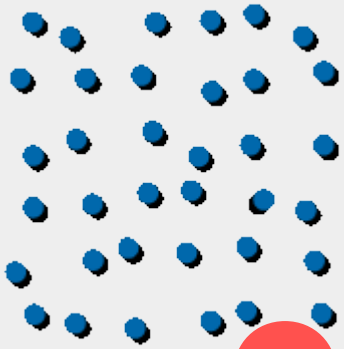
Source: Christopher G. Healey

3D depth cues



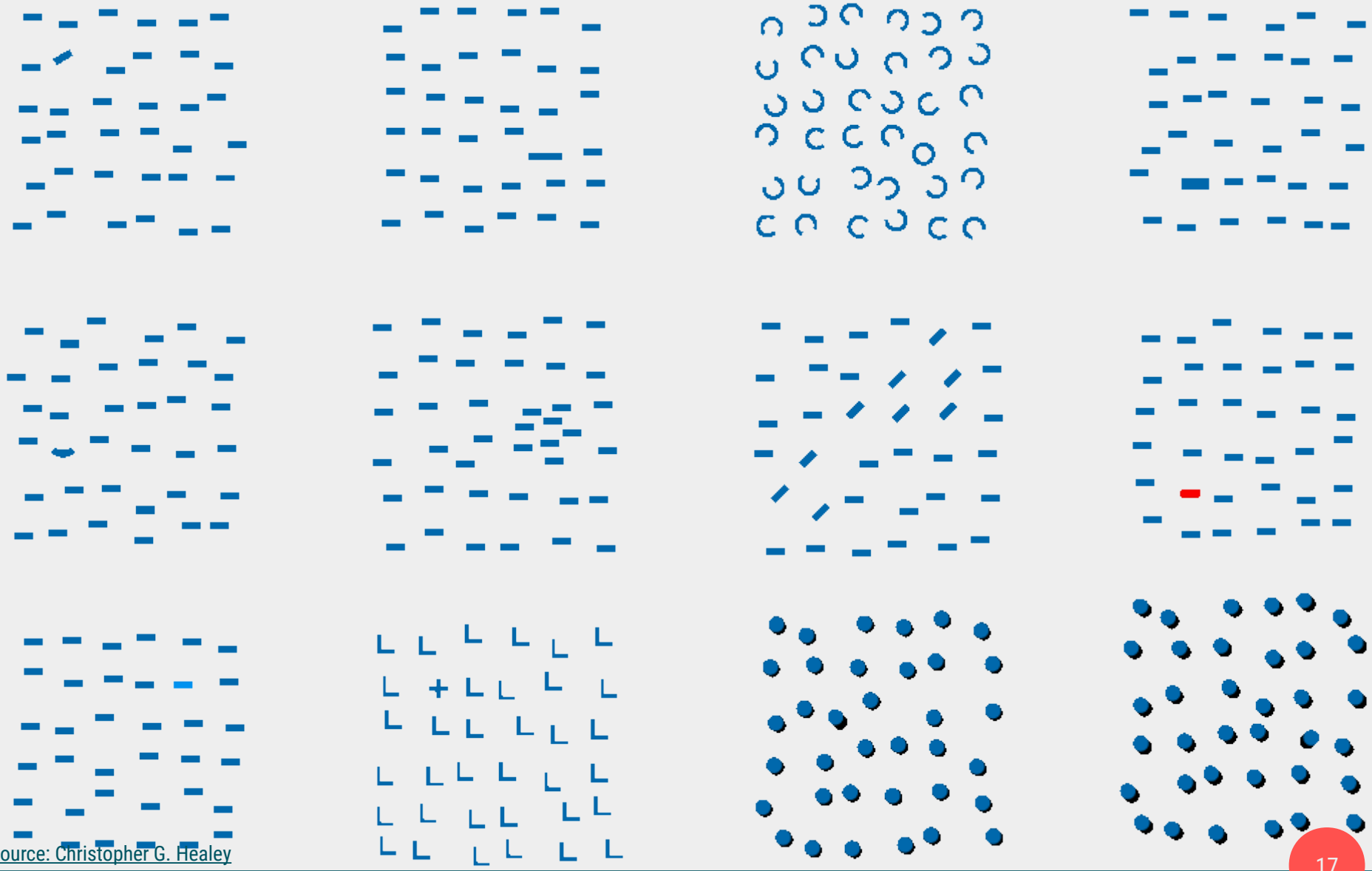
Source: Christopher G. Healey

Lighting direction



Source: Christopher G. Healey

Preattentive features



Source: Christopher G. Healey

Forming the whole from its parts

Gestalt psychology

Gestalt psychology

Gestalt (German): form, pattern

How do people organize visual information?
How do people unify visual sensations into a whole?

Proximity

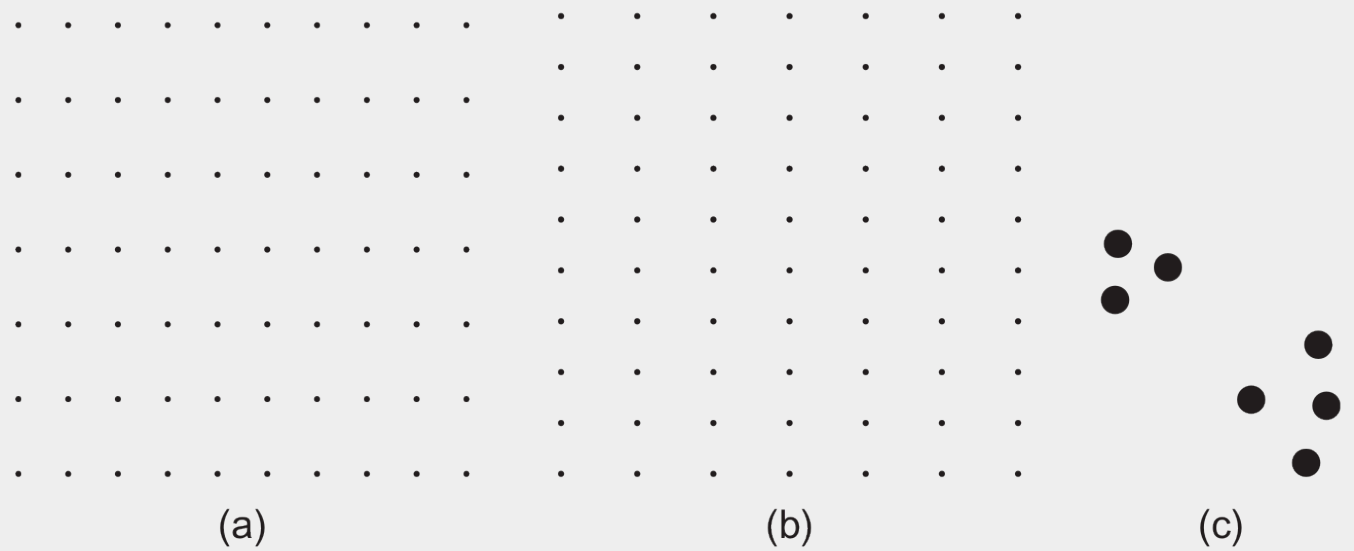


Figure 6.2 Spatial proximity is a powerful cue for perceptual organization. A matrix of dots is perceived as rows on the left (a) and columns on the right (b). In (c) we perceive two groups of dots because of proximity relationships.

Ware, C. (2013). Information Visualization. Perception for Design (3rd ed.). p. 182.

Proximity

(c) Jonas Schöley 2016.

Connectedness

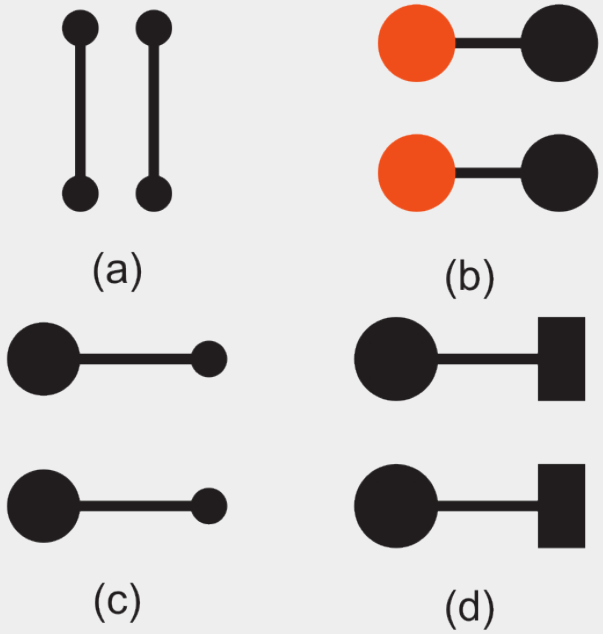
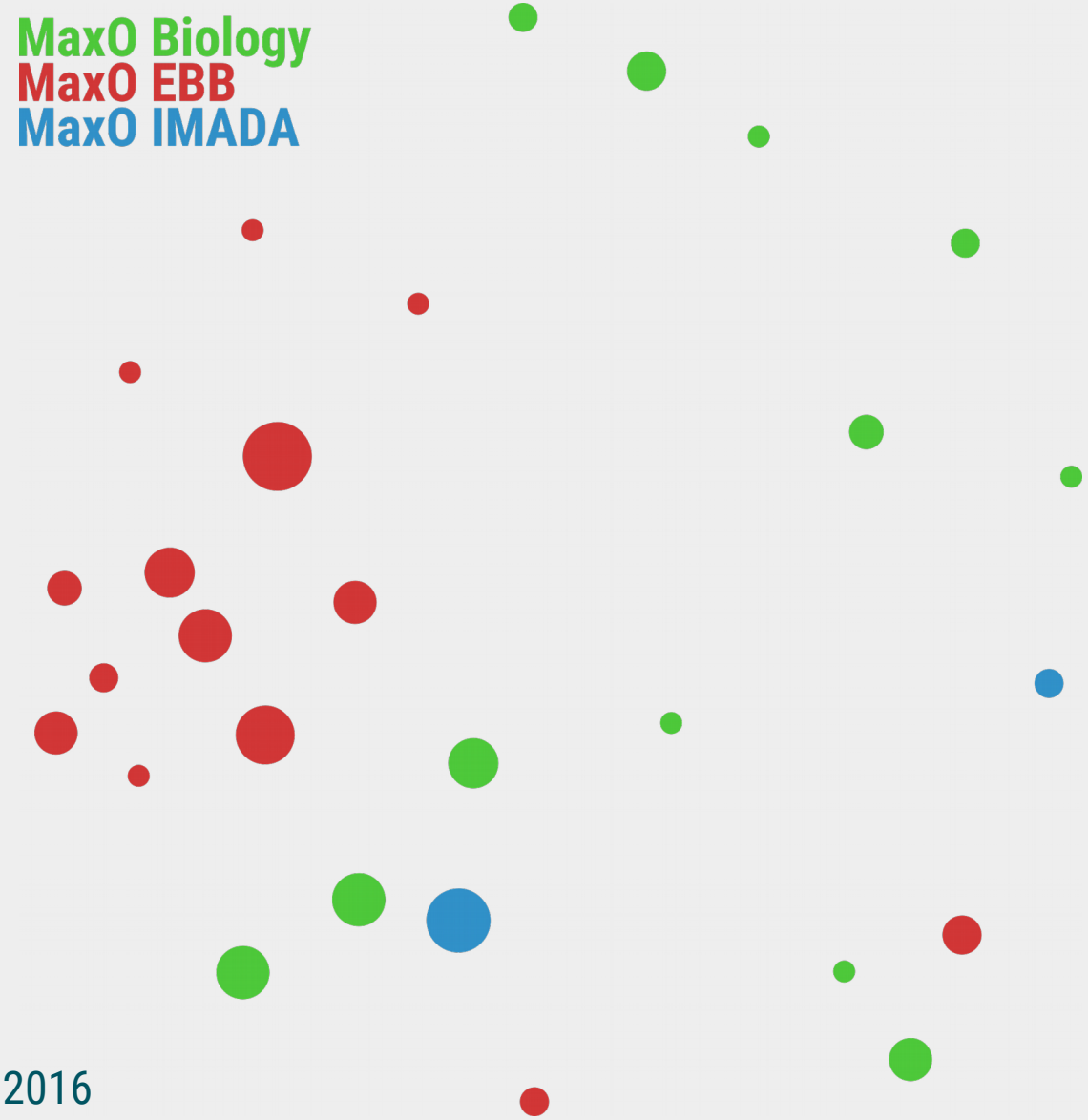


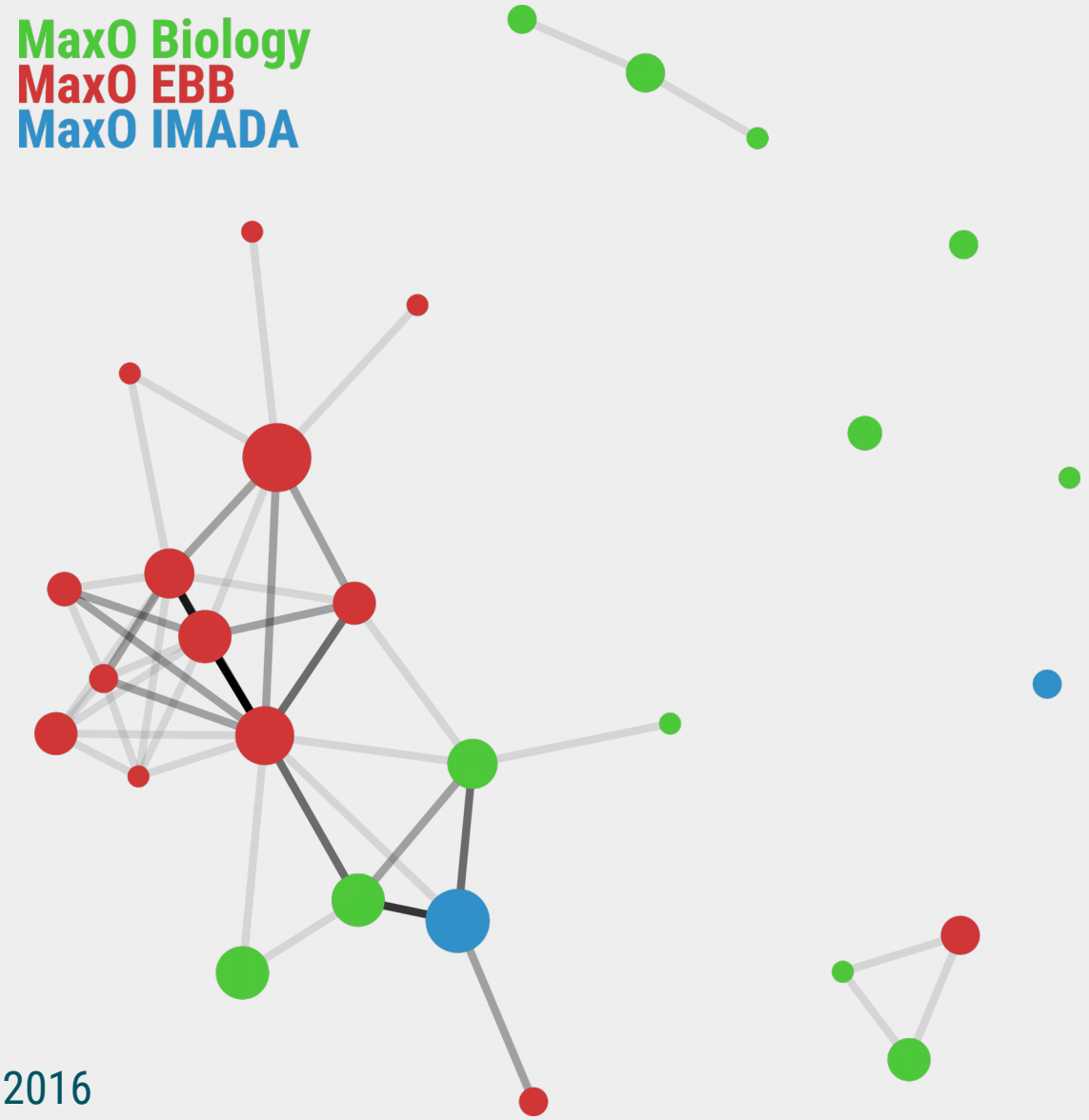
Figure 6.5 Connectedness is a powerful grouping principle that is stronger than (a) proximity, (b) color, (c) size, or (d) shape.

Ware, C. (2013). Information Visualization. Perception for Design (3rd ed.). p. 184.

Connectedness



Connectedness



Continuity

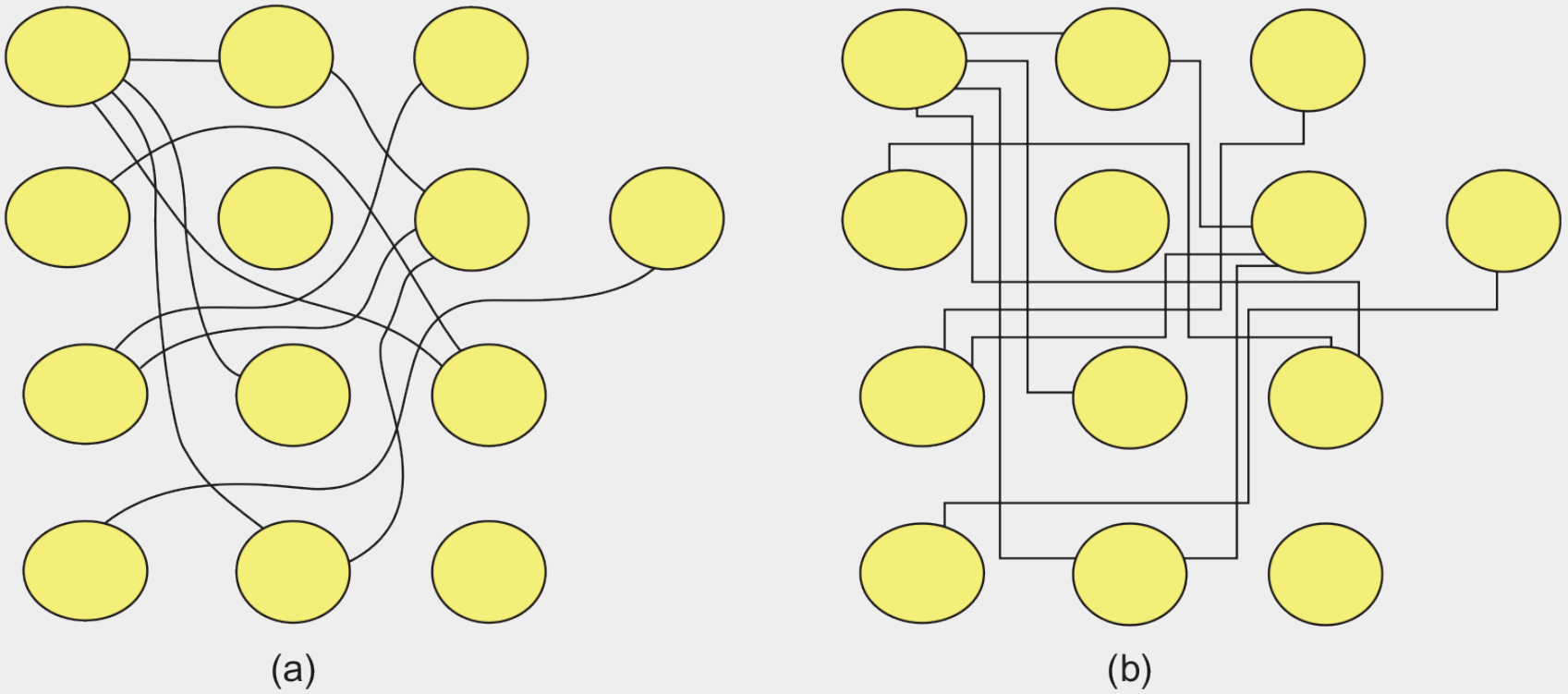
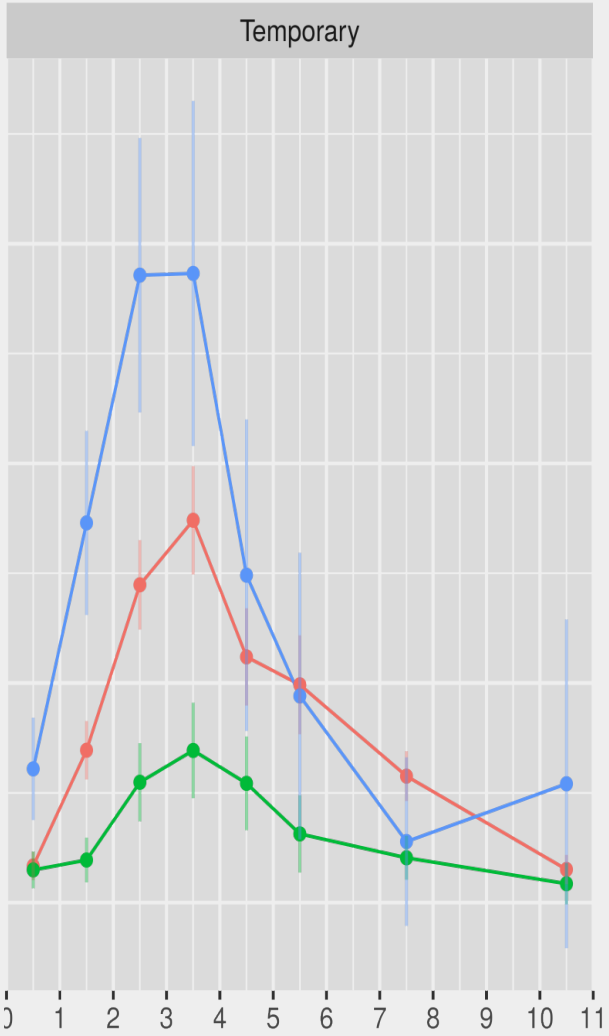
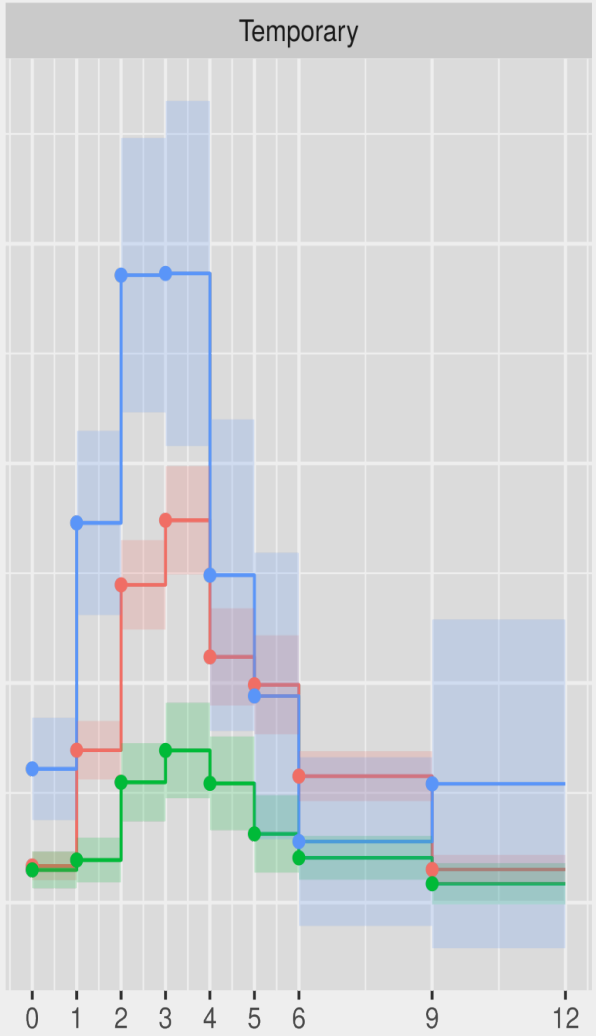


Figure 6.7 In (a), smooth continuous contours are used to connect nodes in the diagram; in (b), lines with abrupt changes in direction are used. It is much easier to perceive connections with the smooth contours.

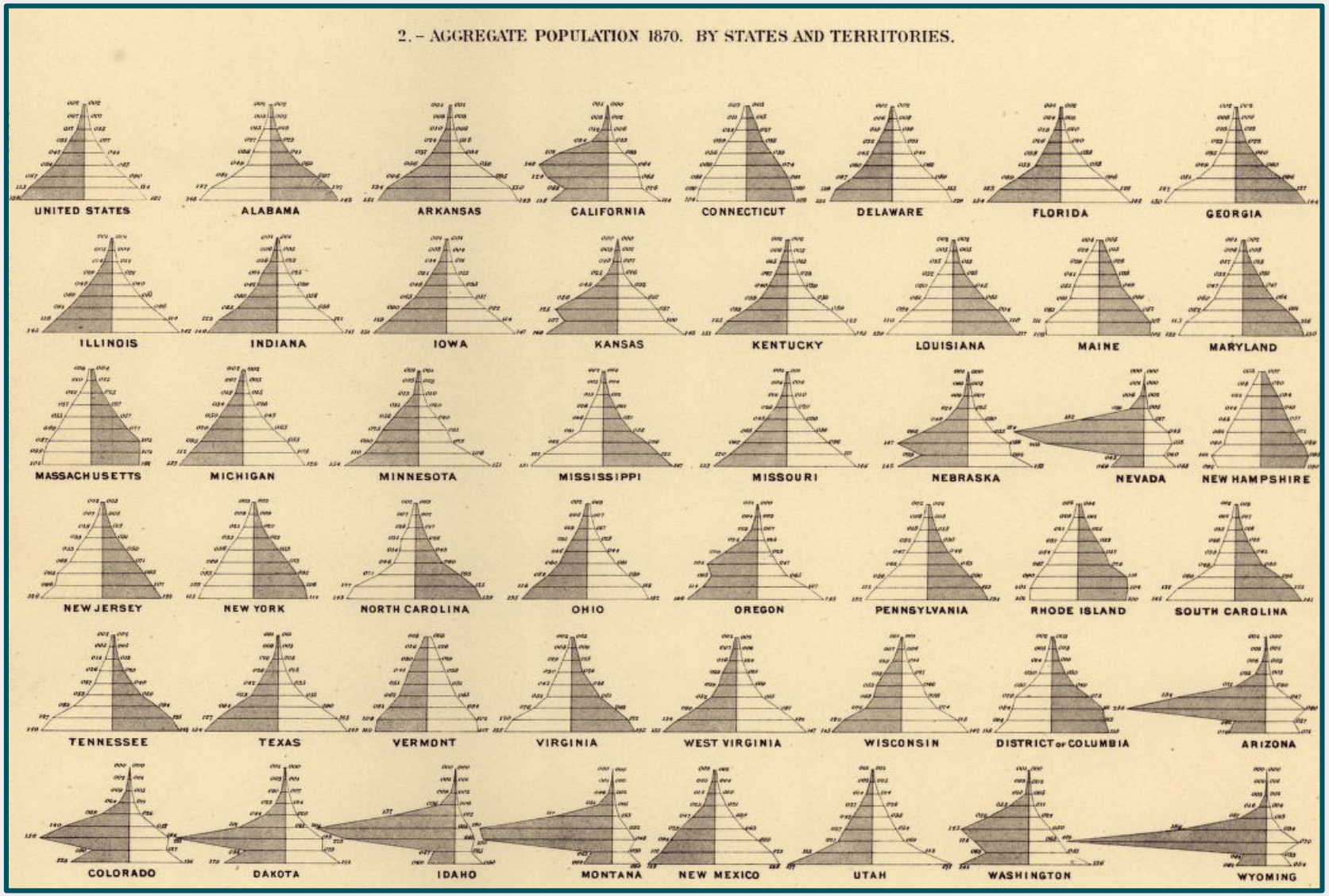
Ware, C. (2013). Information Visualization. Perception for Design (3rd ed.). p. 184.

Continuity



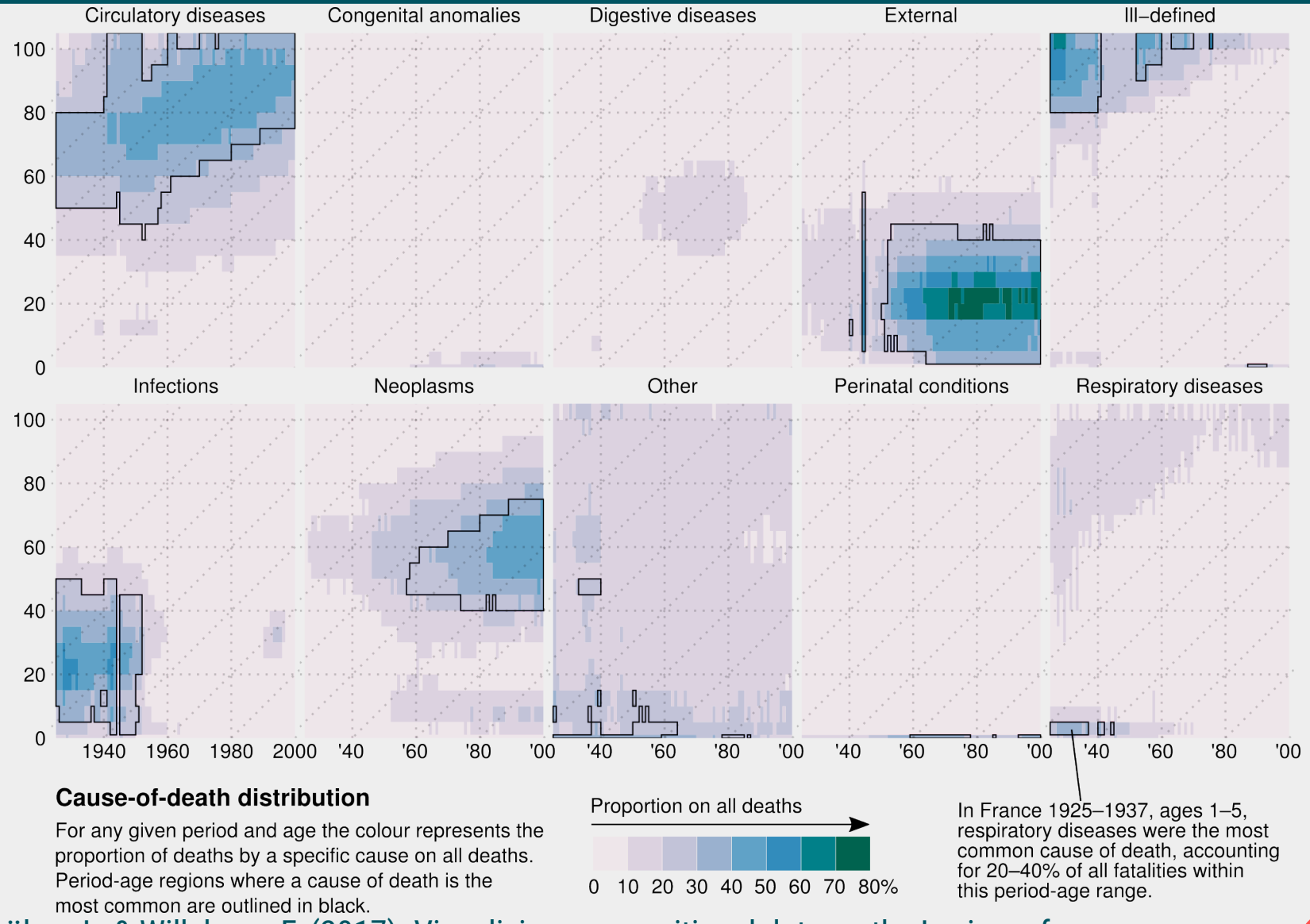


Symmetry



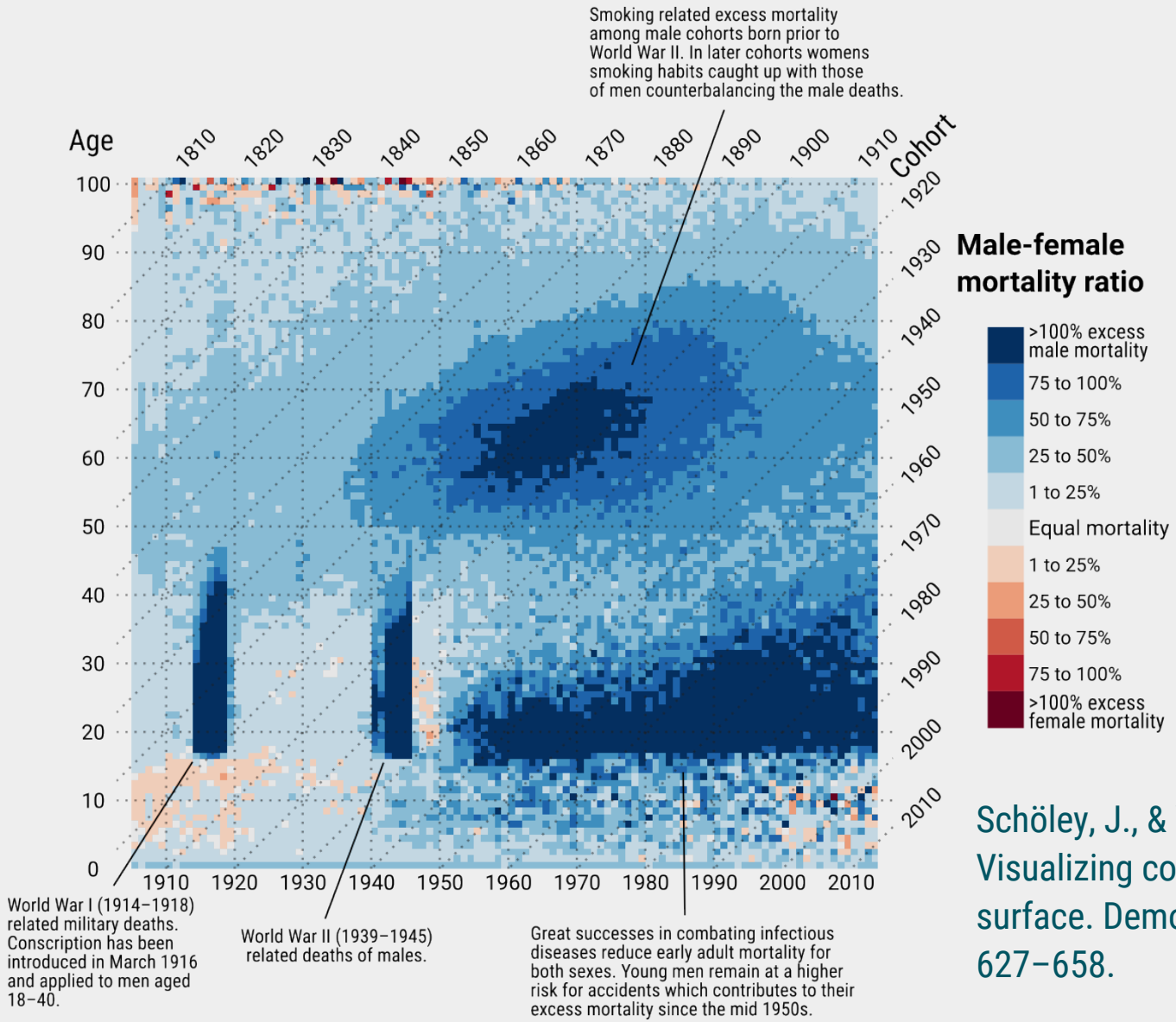
Walker, F. A. (1874). Statistical Atlas of the United States Based on the Results of the Ninth Census.

Closure and common region



Schöley, J., & Willekens, F. (2017). Visualizing compositional data on the Lexis surface.

Closure and common region

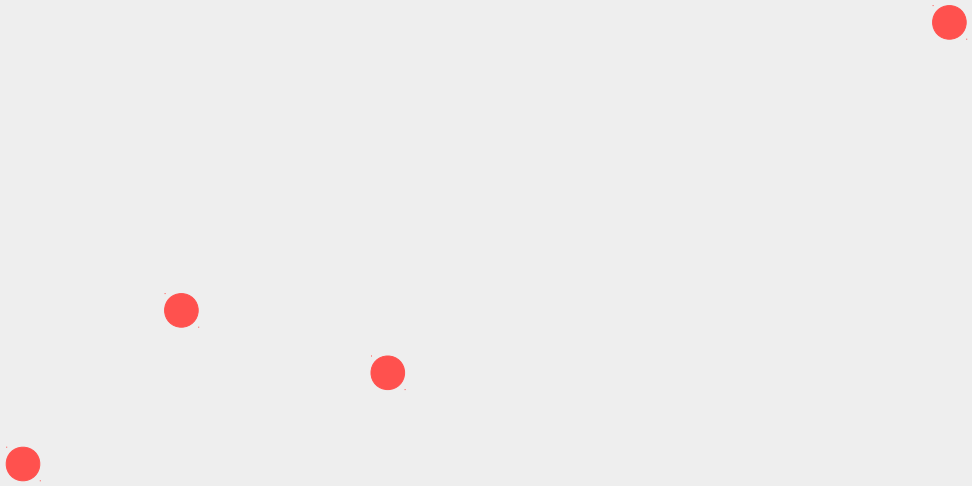


Schöley, J., & Willekens, F. (2017). Visualizing compositional data on the Lexis surface. Demographic Research, 36(1), 627–658.

The atoms of any visualization

Marks

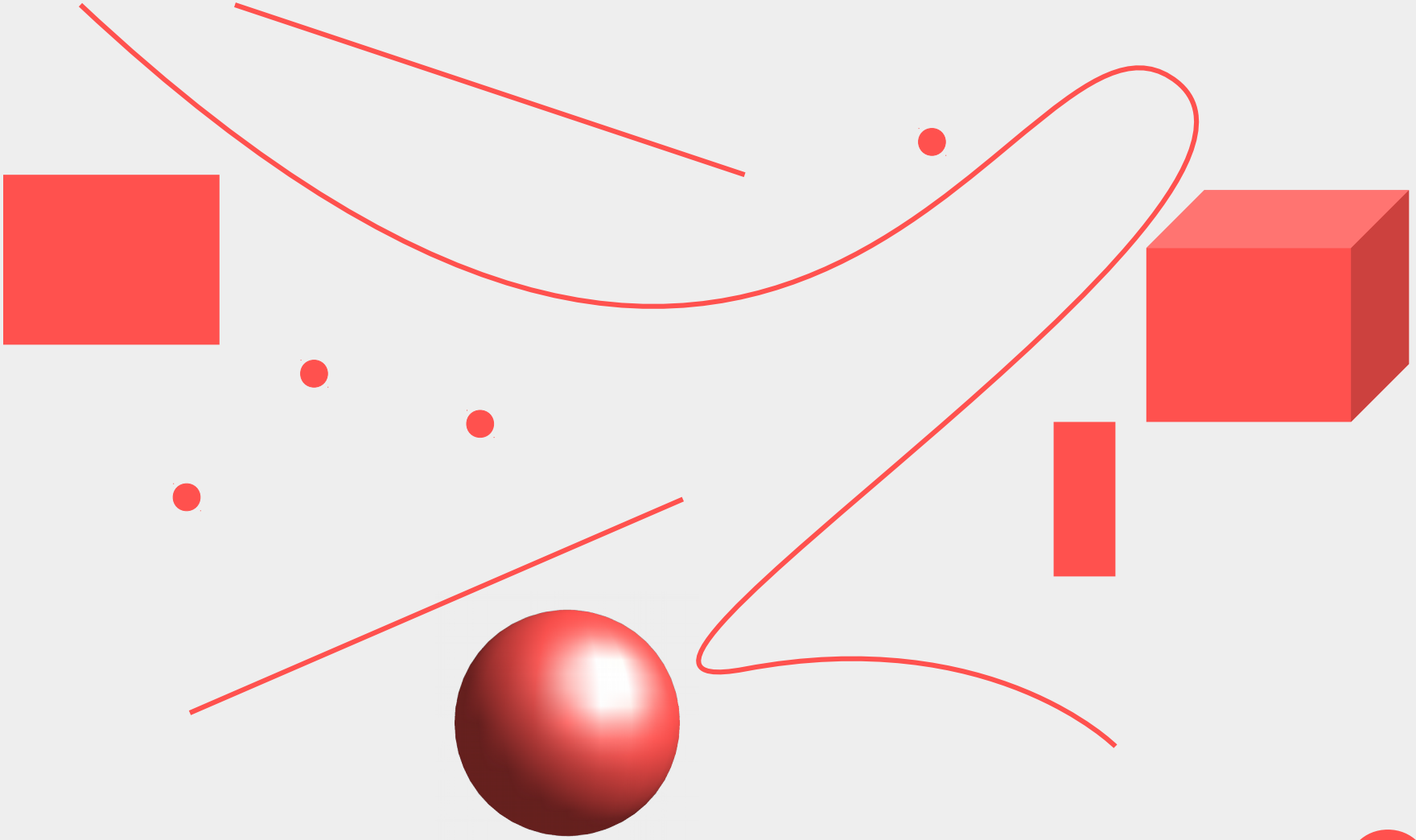
Points



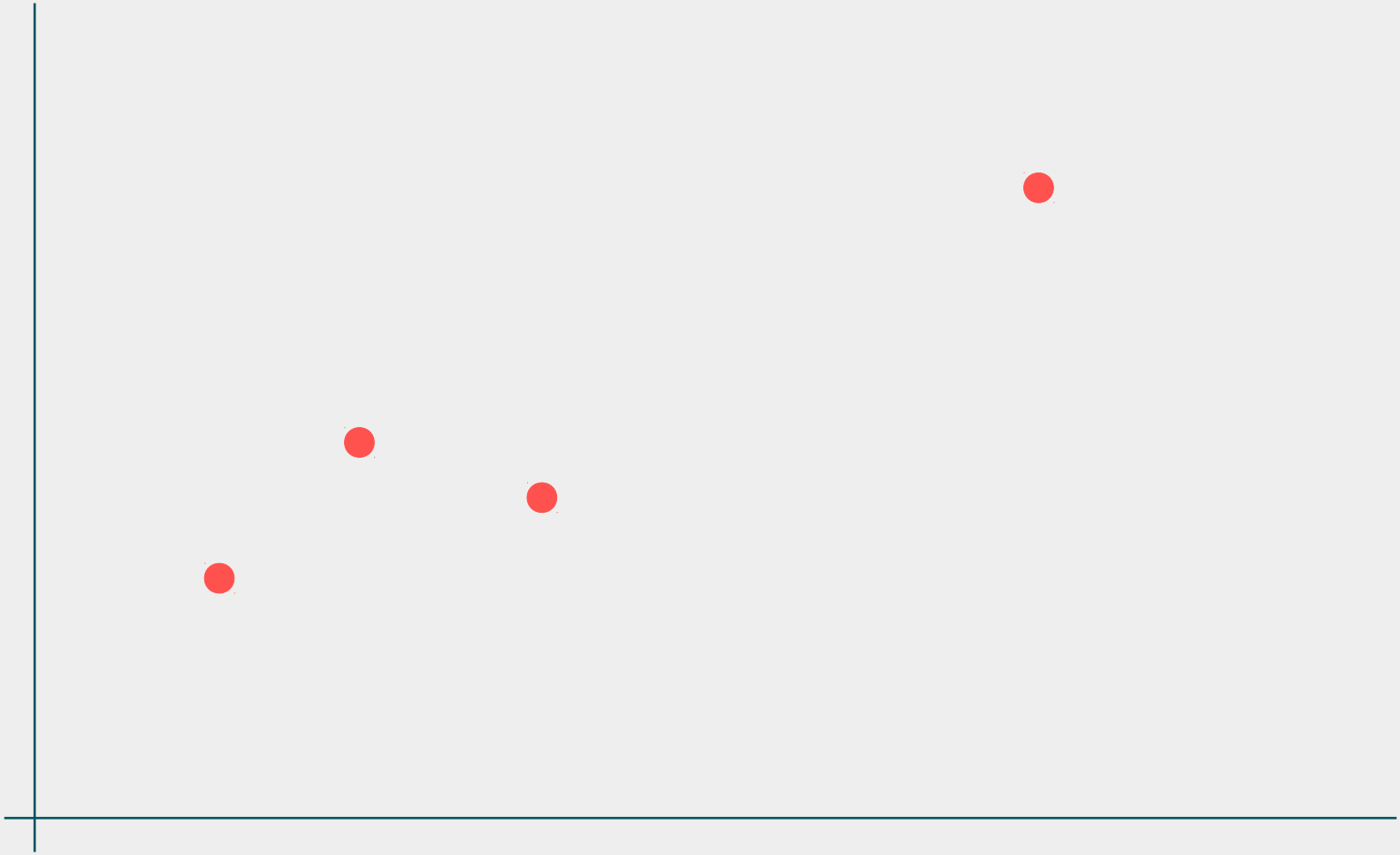
Lines

Areas

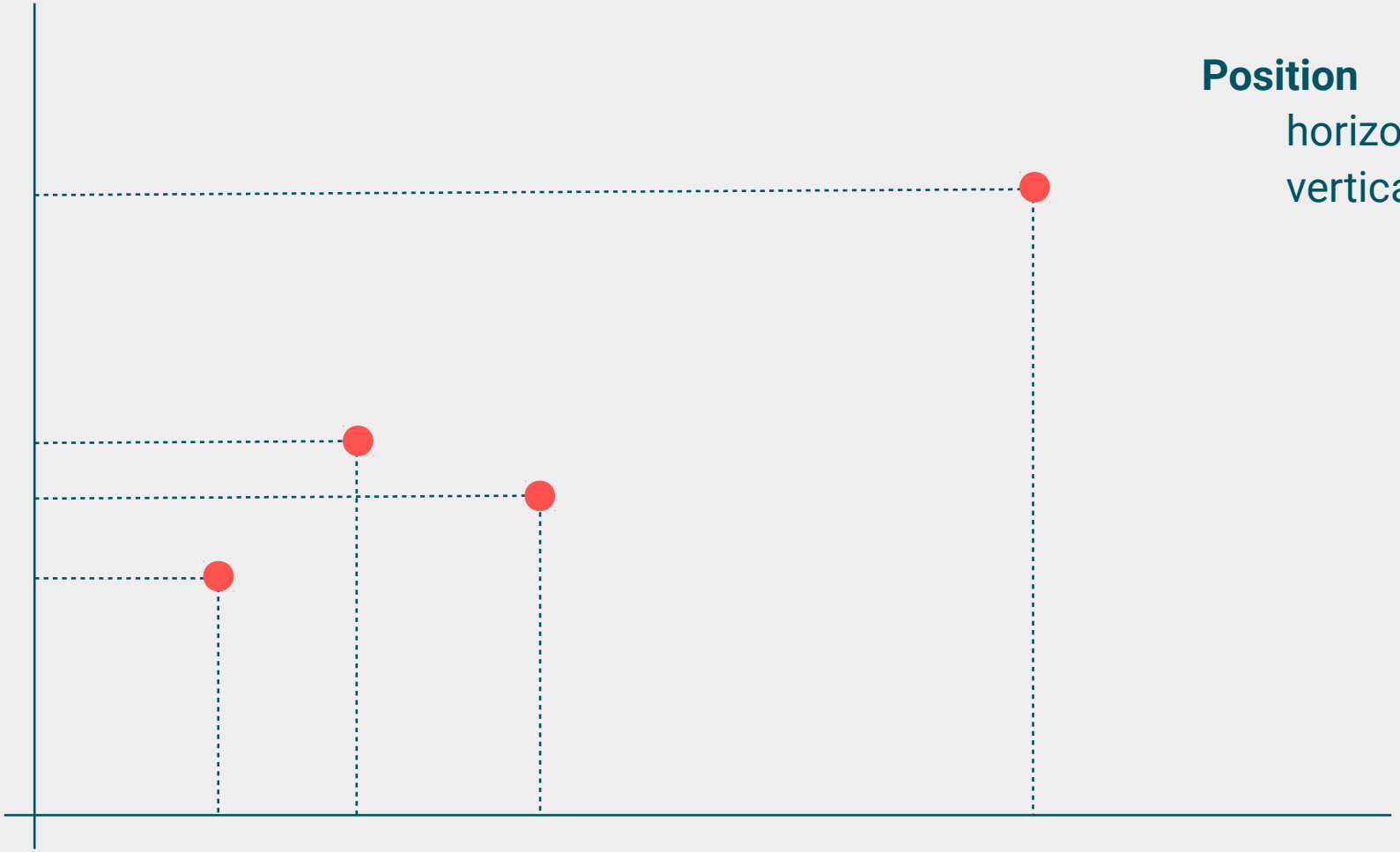
(Volumes)



Assigning marks to visual channels



Assigning marks to visual channels

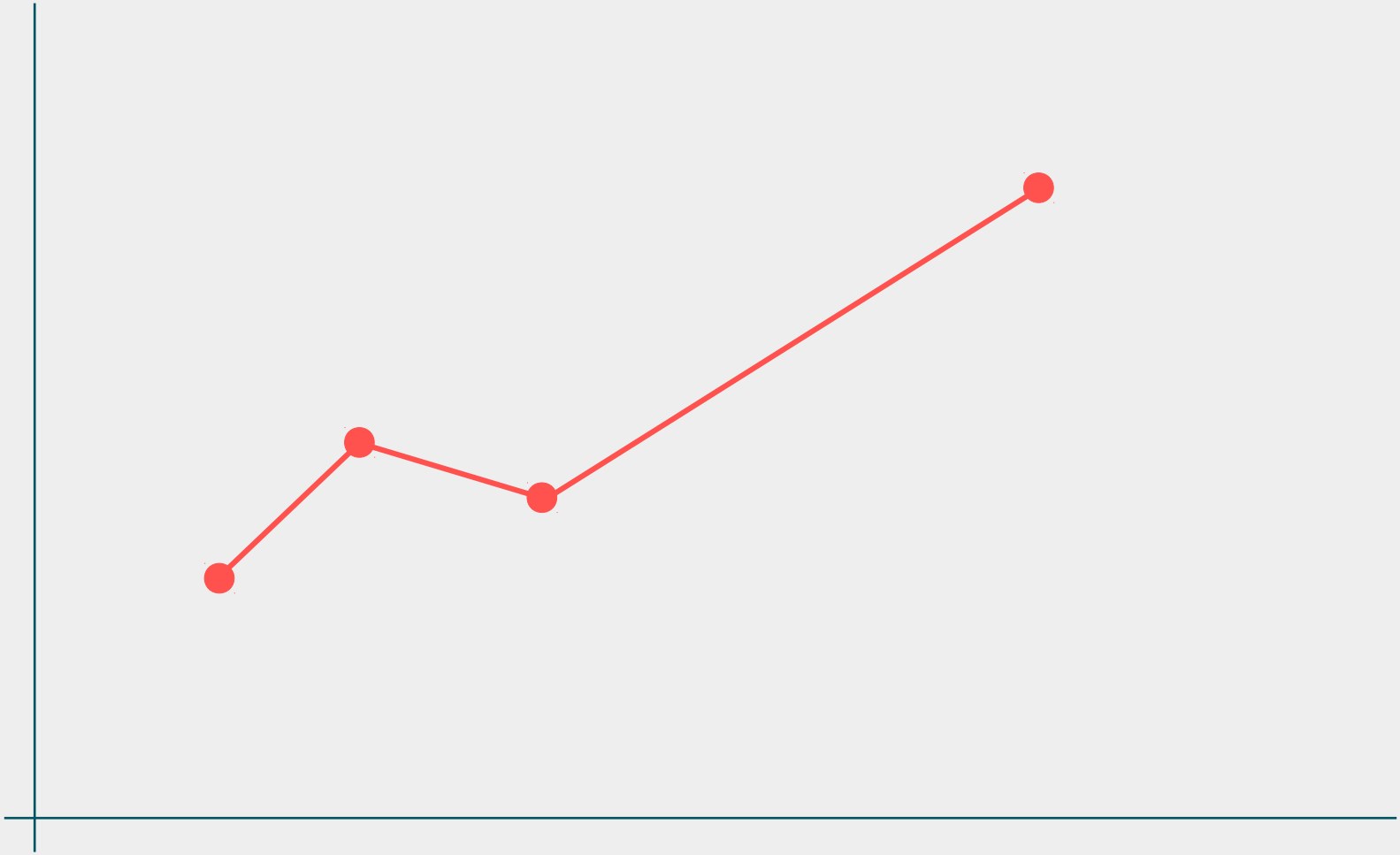


Position

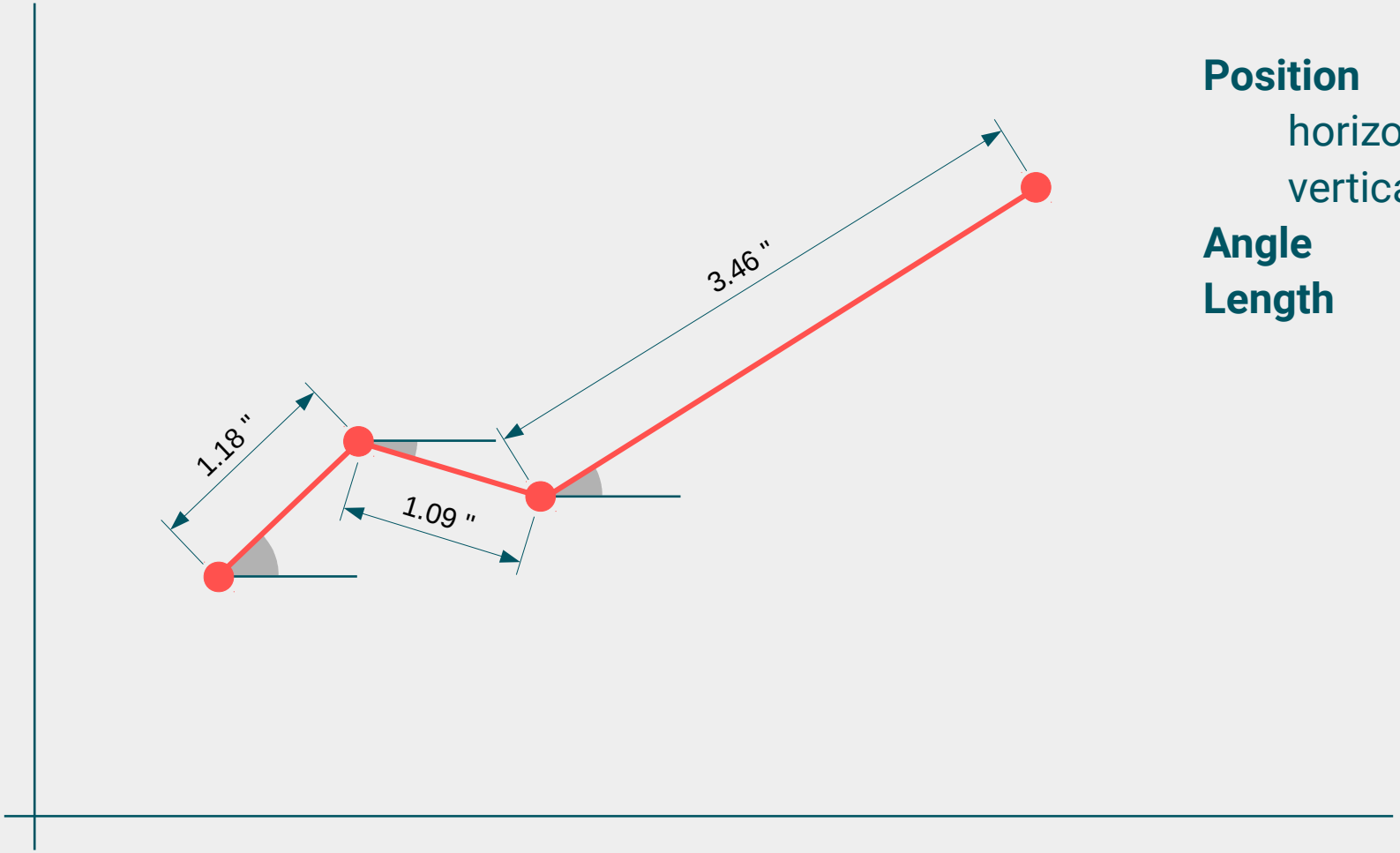
horizontal

vertical

Assigning marks to visual channels



Assigning marks to visual channels



Position

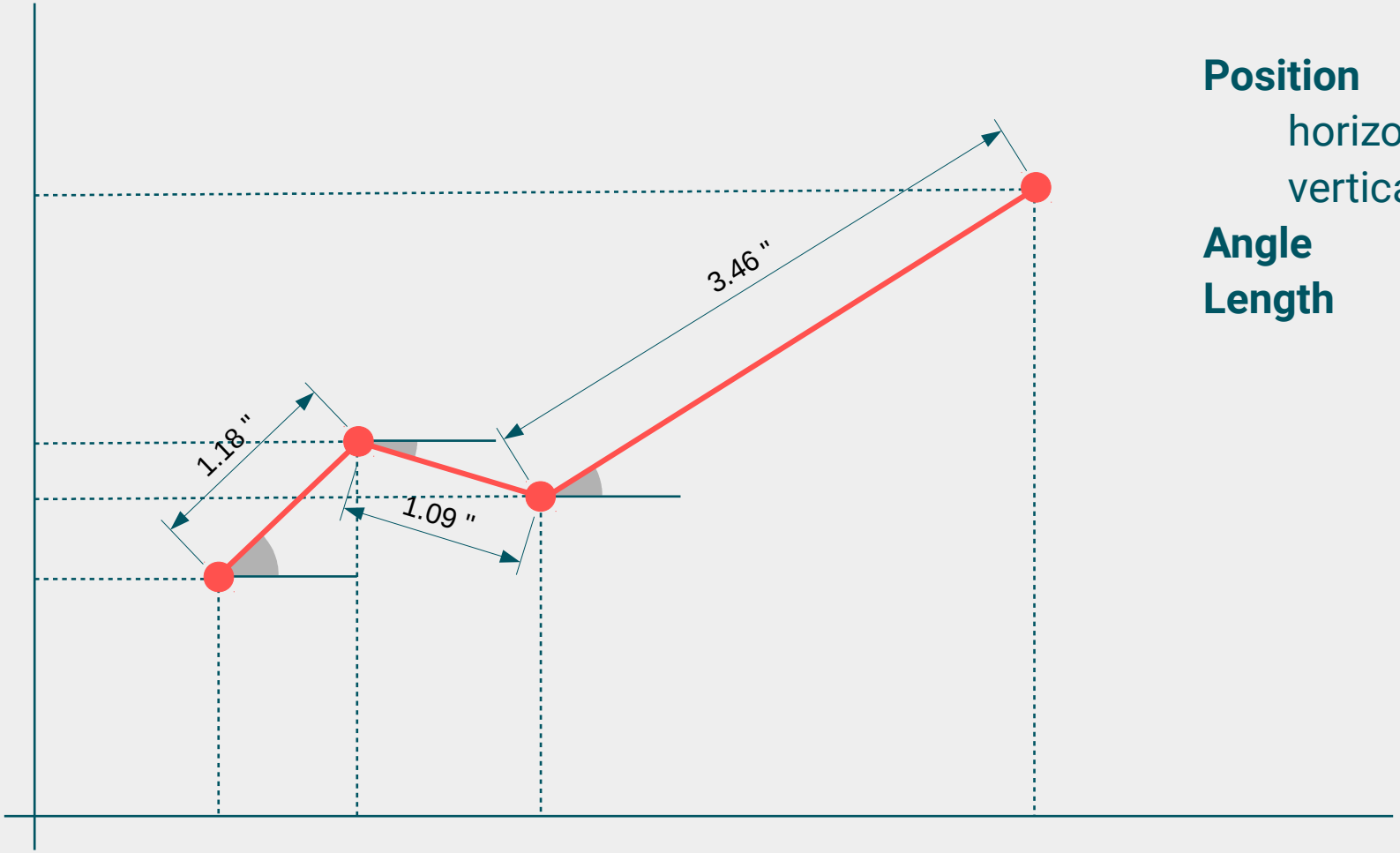
horizontal

vertical

Angle

Length

Assigning marks to visual channels



Position

horizontal

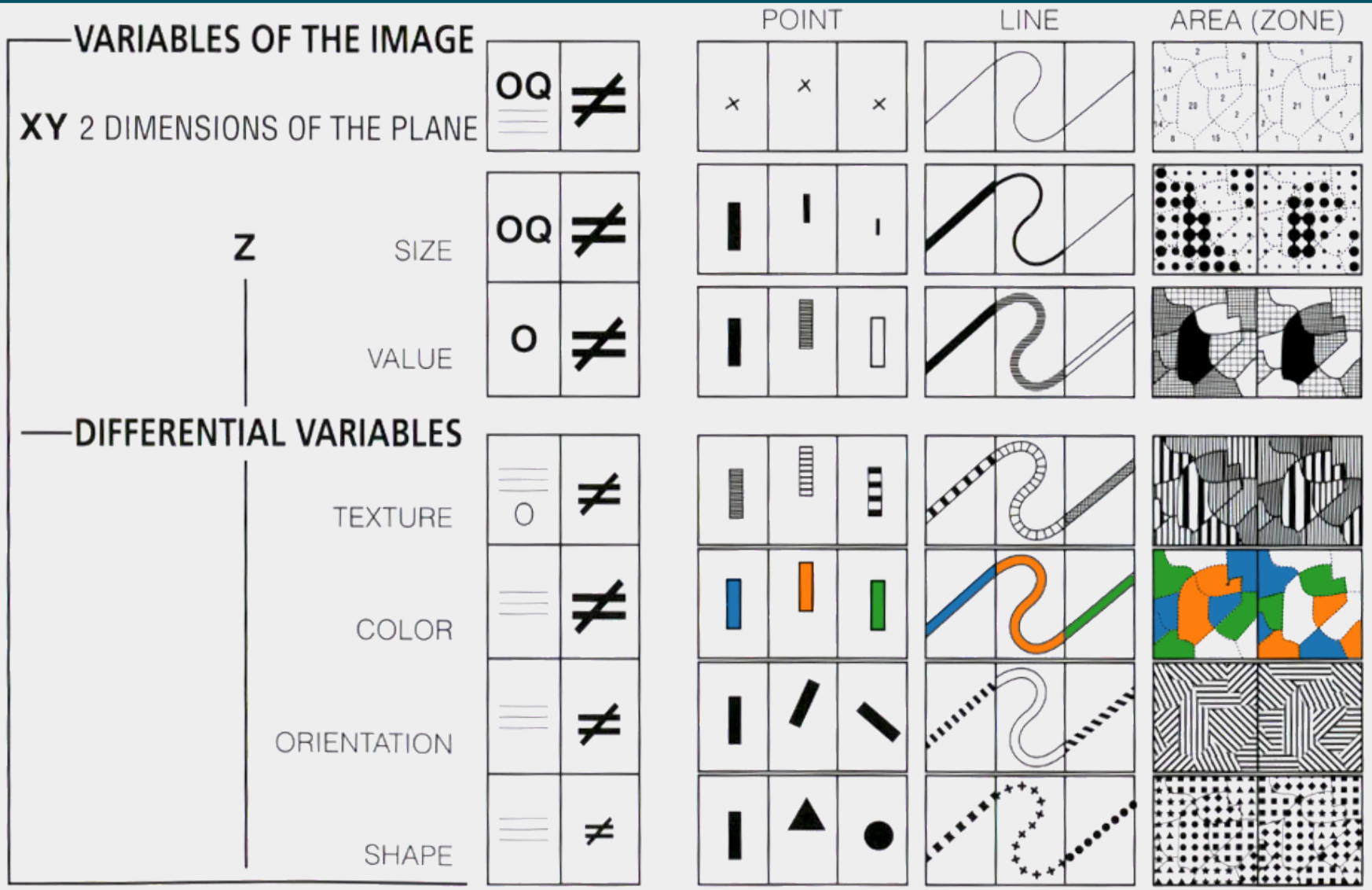
vertical

Angle

Length

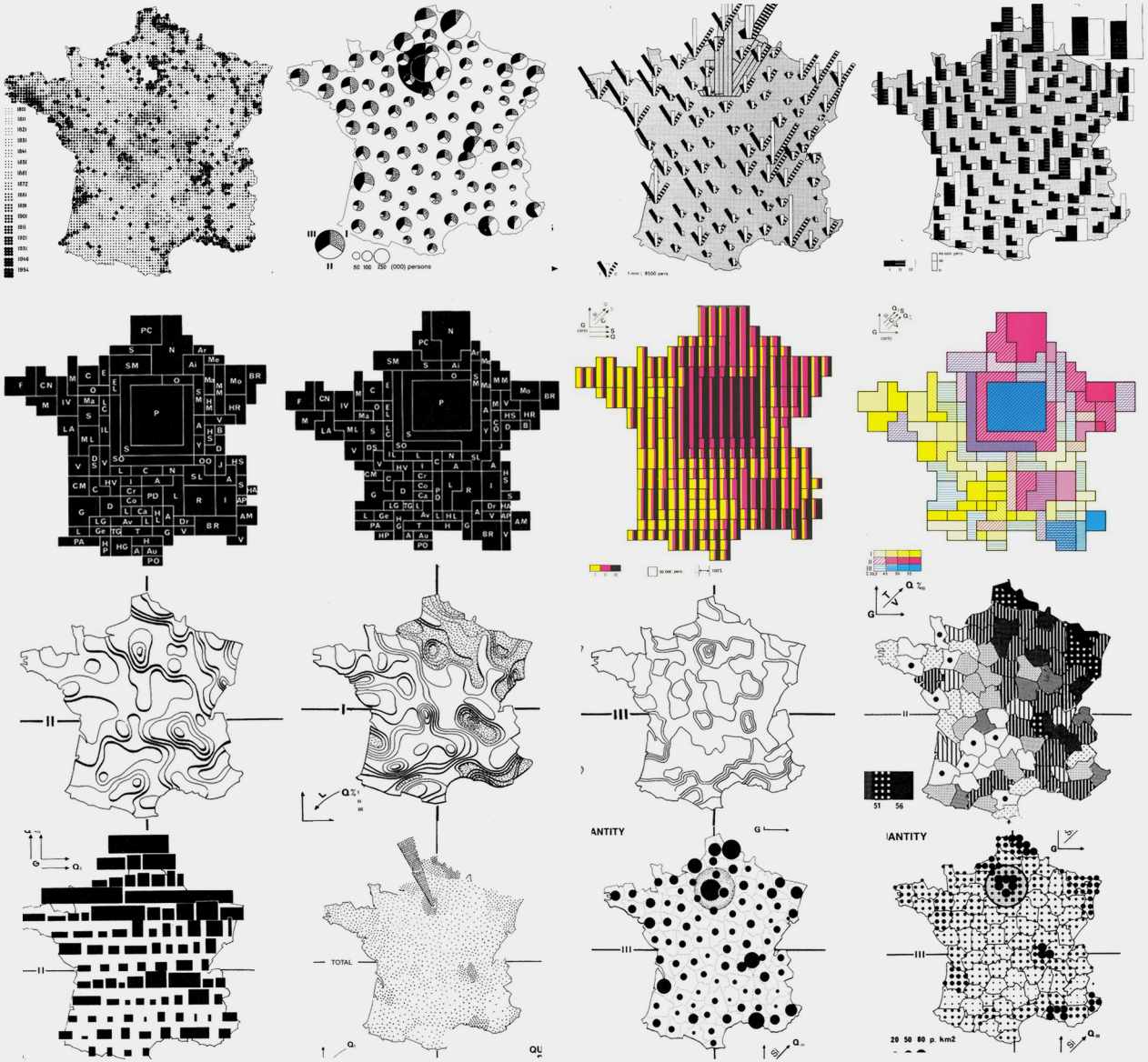
Encoding data via **Visual channels**

Visual primitives in data viz



Jaques Bertin. (1967). Sémiologie Graphique. Les diagrammes, les réseaux, les cartes.

Visual primitives in data viz



Jaques Bertin. (1967). Sémiologie Graphique. Les diagrammes, les réseaux, les cartes.

A hierarchy of visual channels

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)

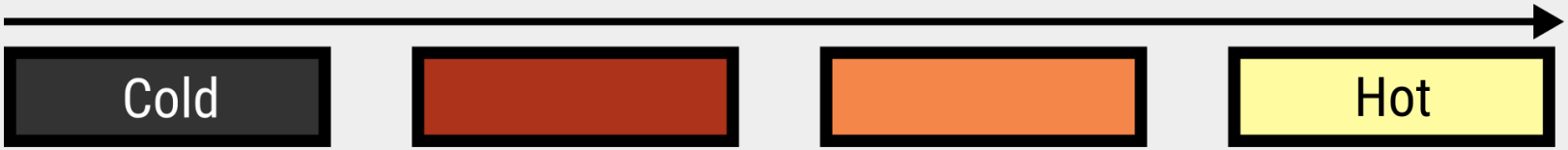
Identity Channels: Categorical Attributes

- Spatial region
- Color hue
- Motion
- Shape

Munzner, T. (2015). Visualization Analysis & Design (1st ed.). Boca Raton, U.S.A: CRC Press.

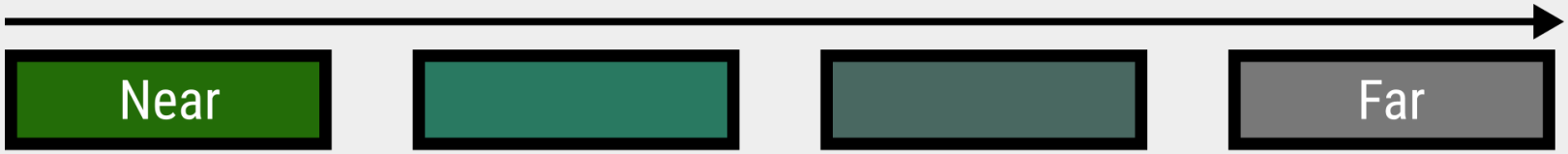
Color

Color-coding magnitudes



Hawaii Volcano Observatory (2003).

Color-coding magnitudes



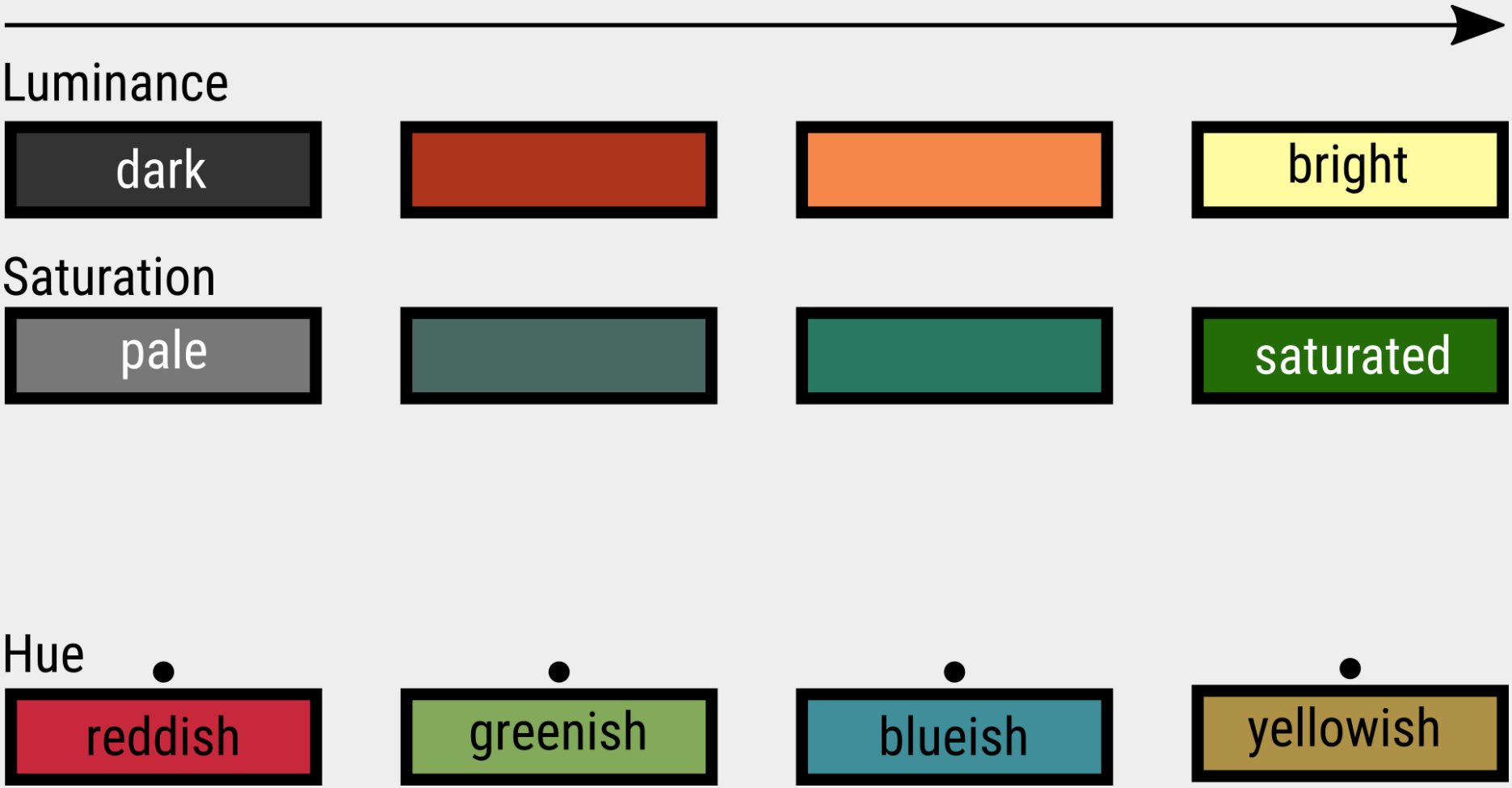
Milan Cernak (2011). “Pieniny from Magura”.

Color-coding categories

- Operations
- Captain
- Sciences
- Command

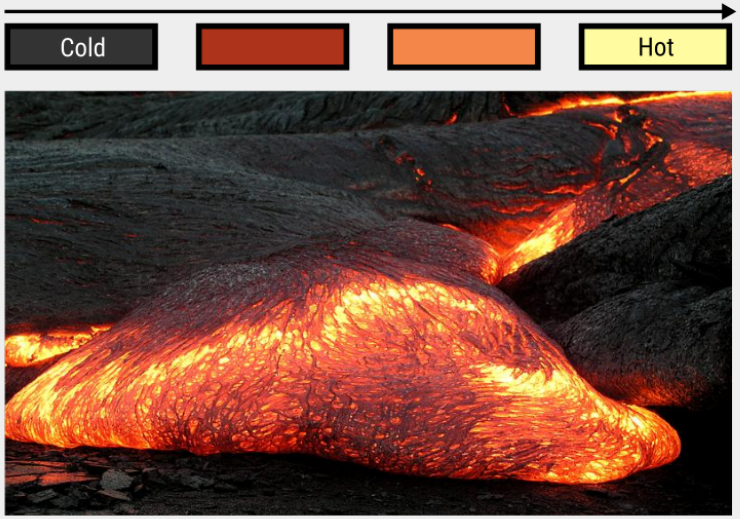
CBS Television.

Perceptual color dimensions

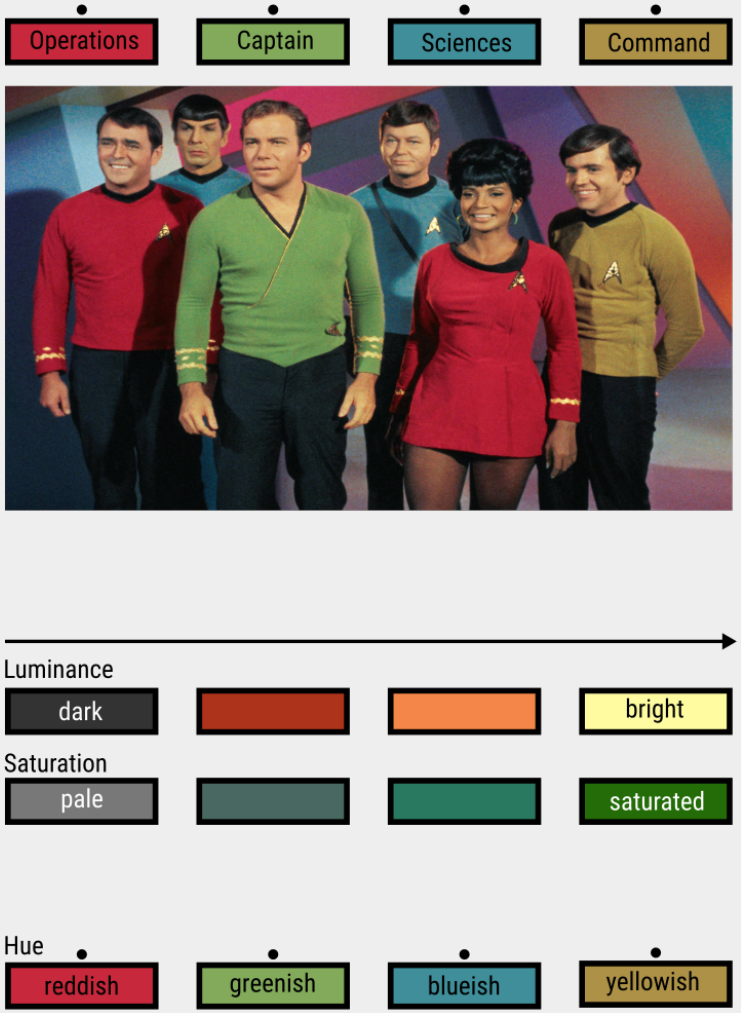


Matching color and data dimensions

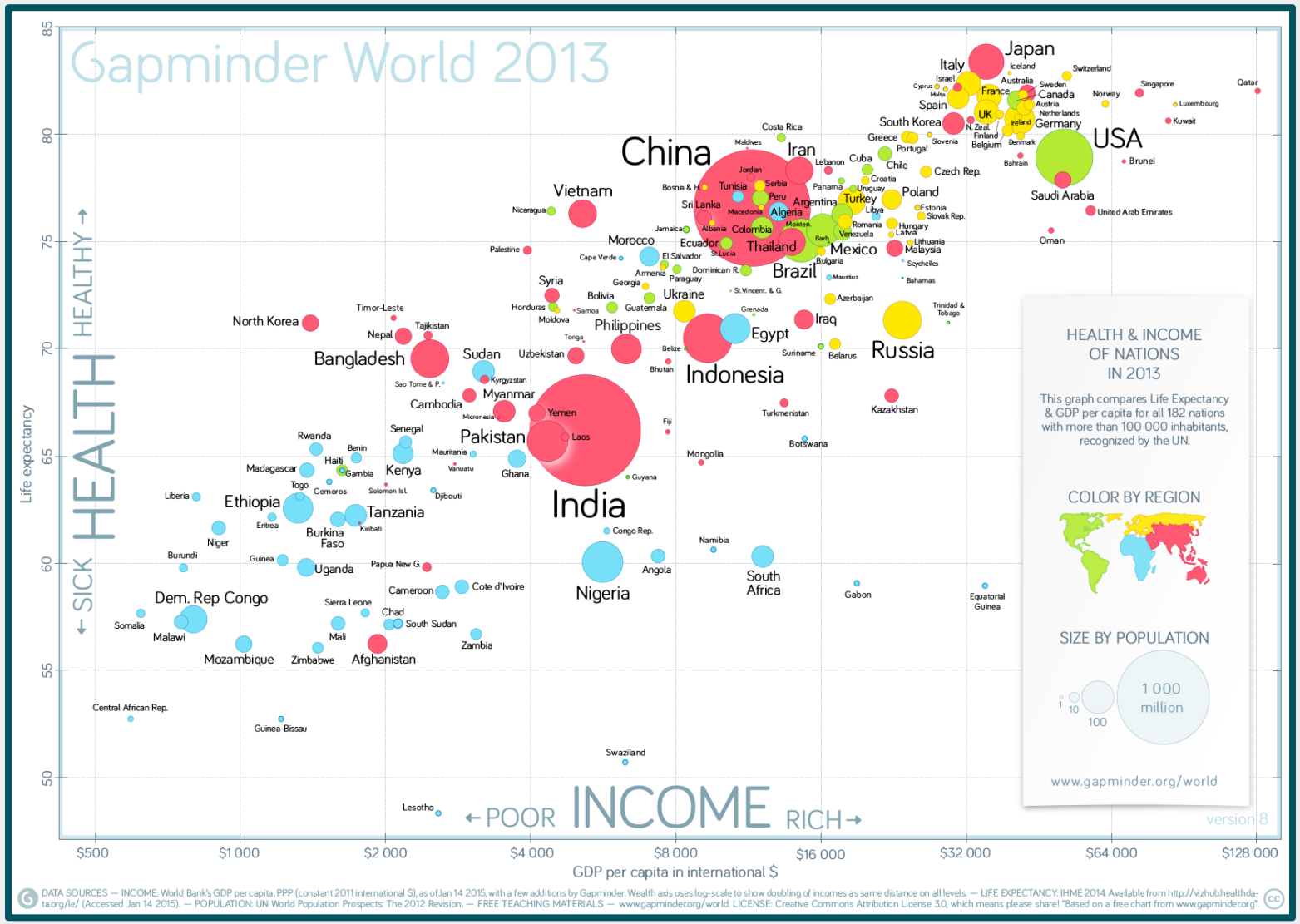
Magnitudes (ordered)



Categories (unordered)

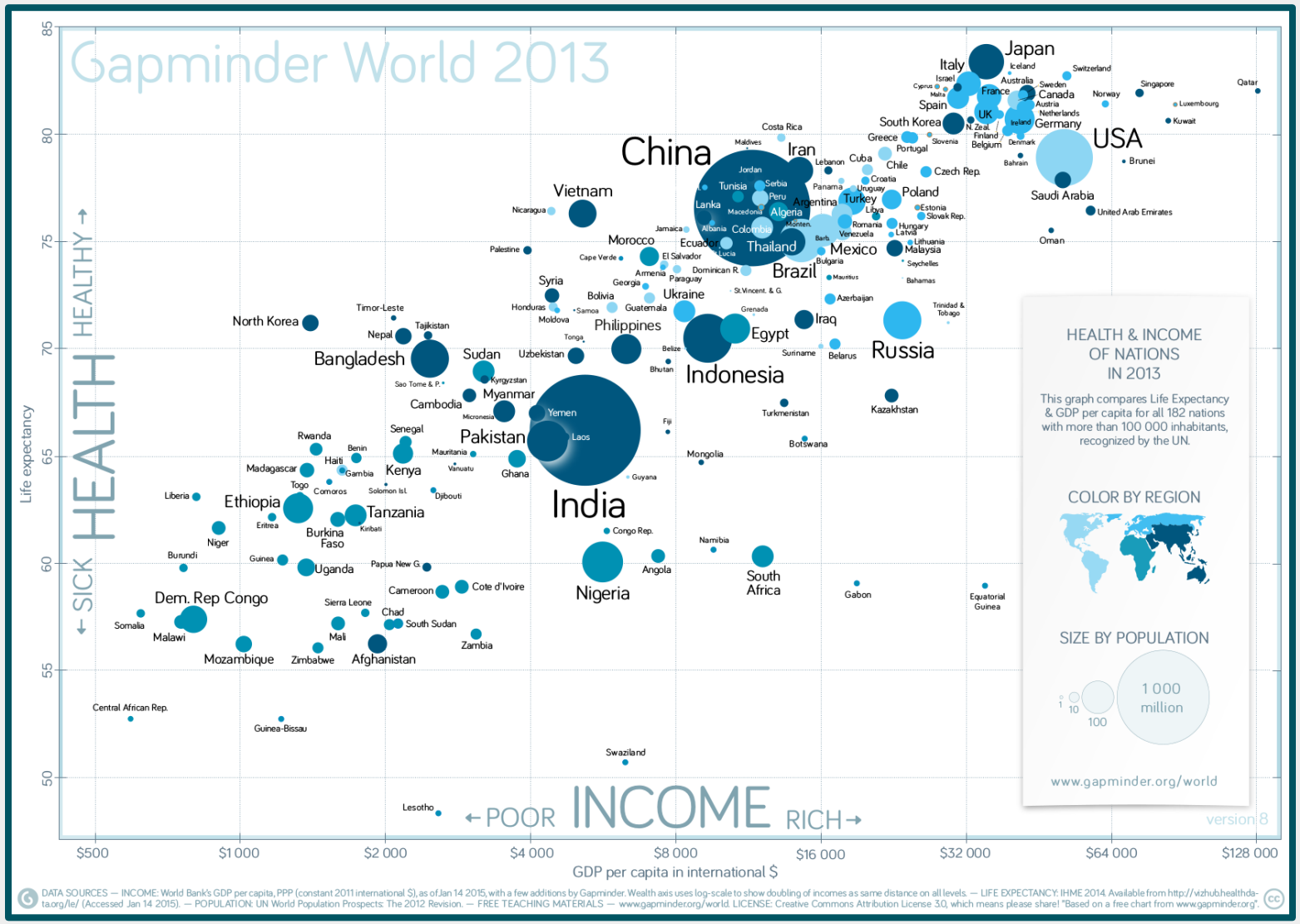


Color-coding categories



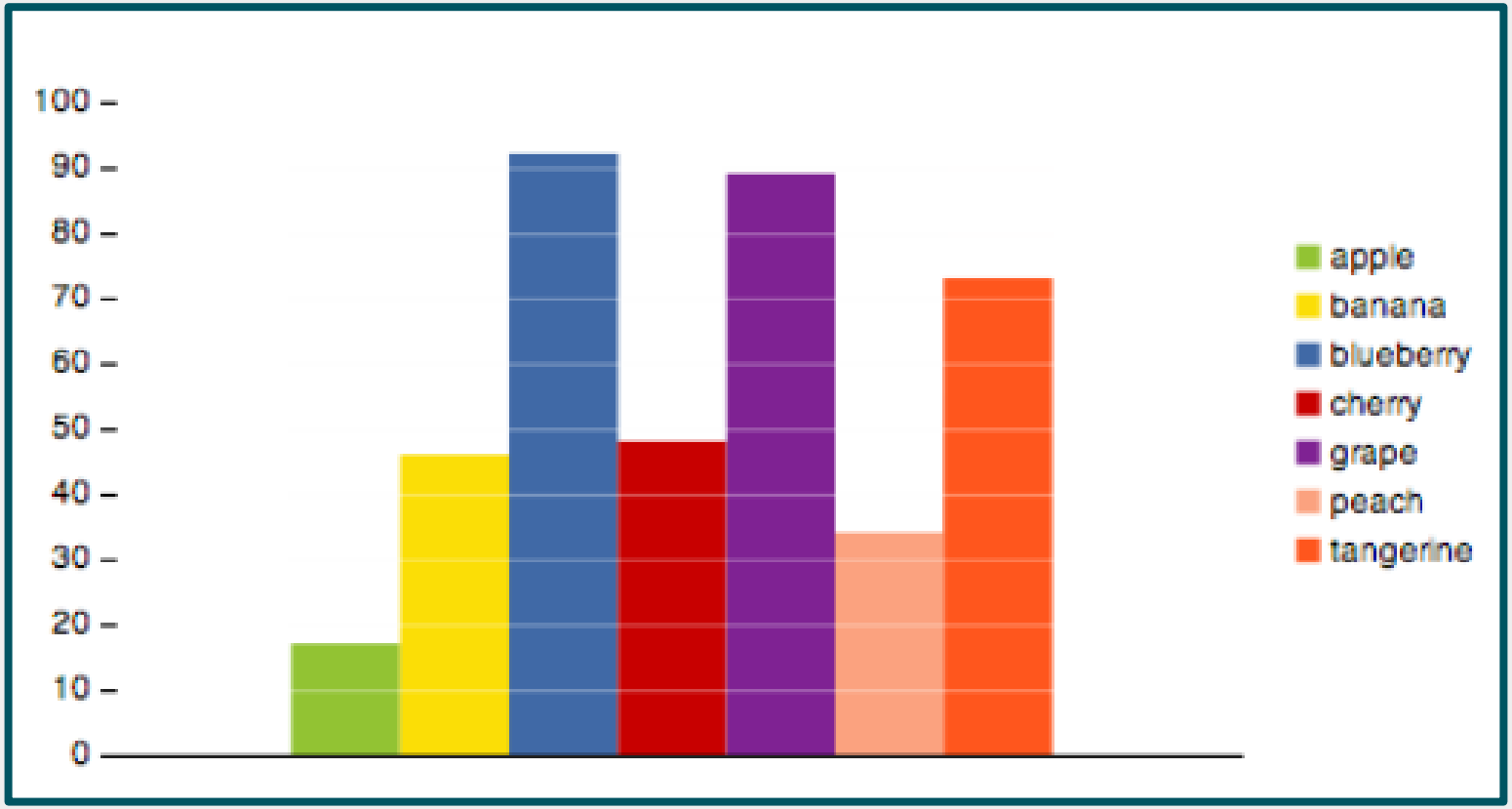
Gapminder World (2014).

Ineffective color-coding



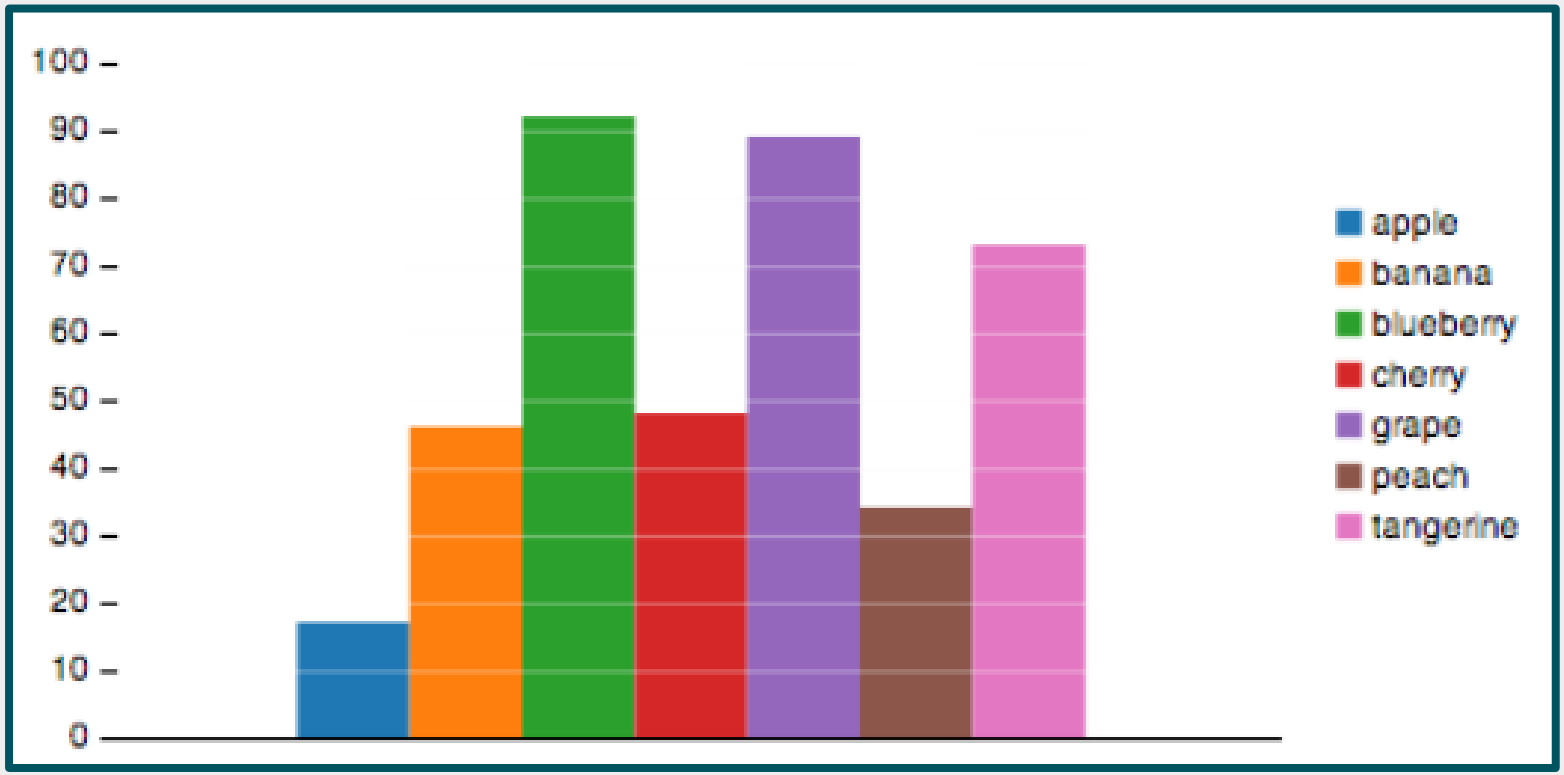
Redrawn from Gapminder World (2014).

Semantically resonant colors



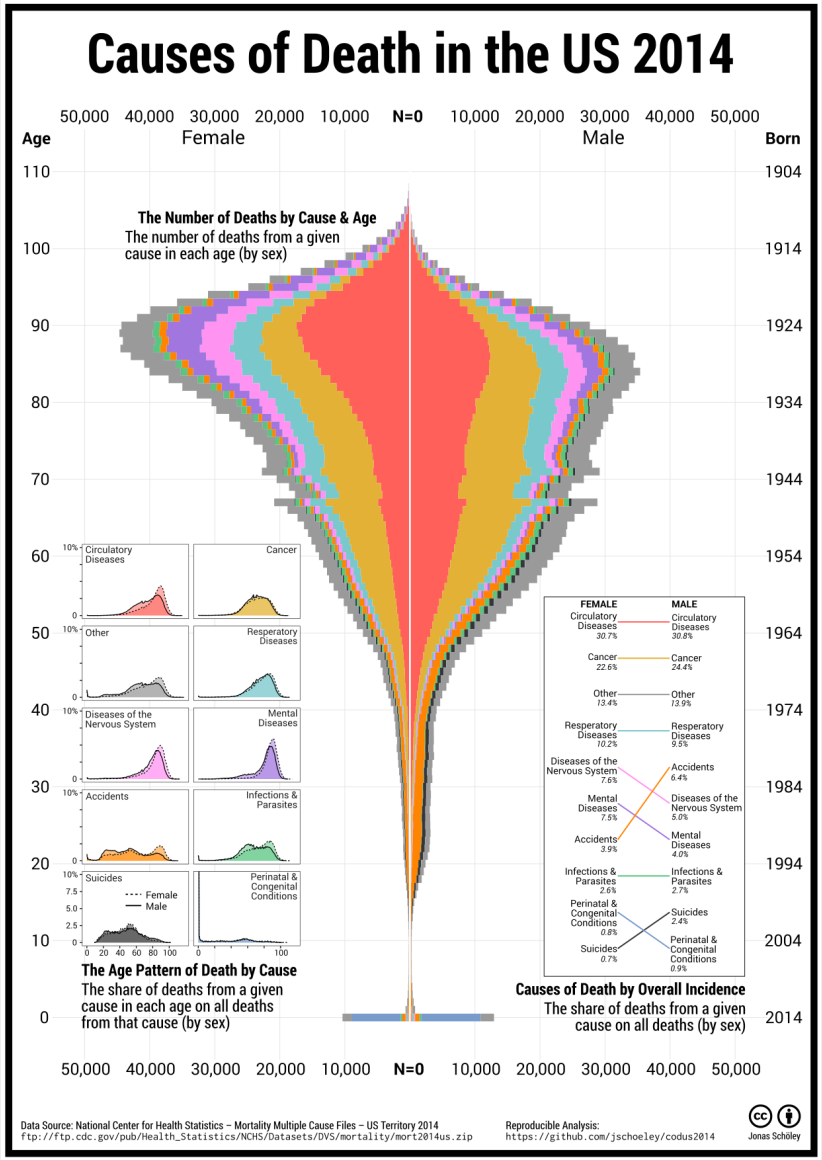
Sharon Lin et al. (2013). “Selecting Semantically-Resonant Colors for Data Visualization”. In: Computer Graphics Forum 32.3, pp. 401–410.

Semantically resonant colors



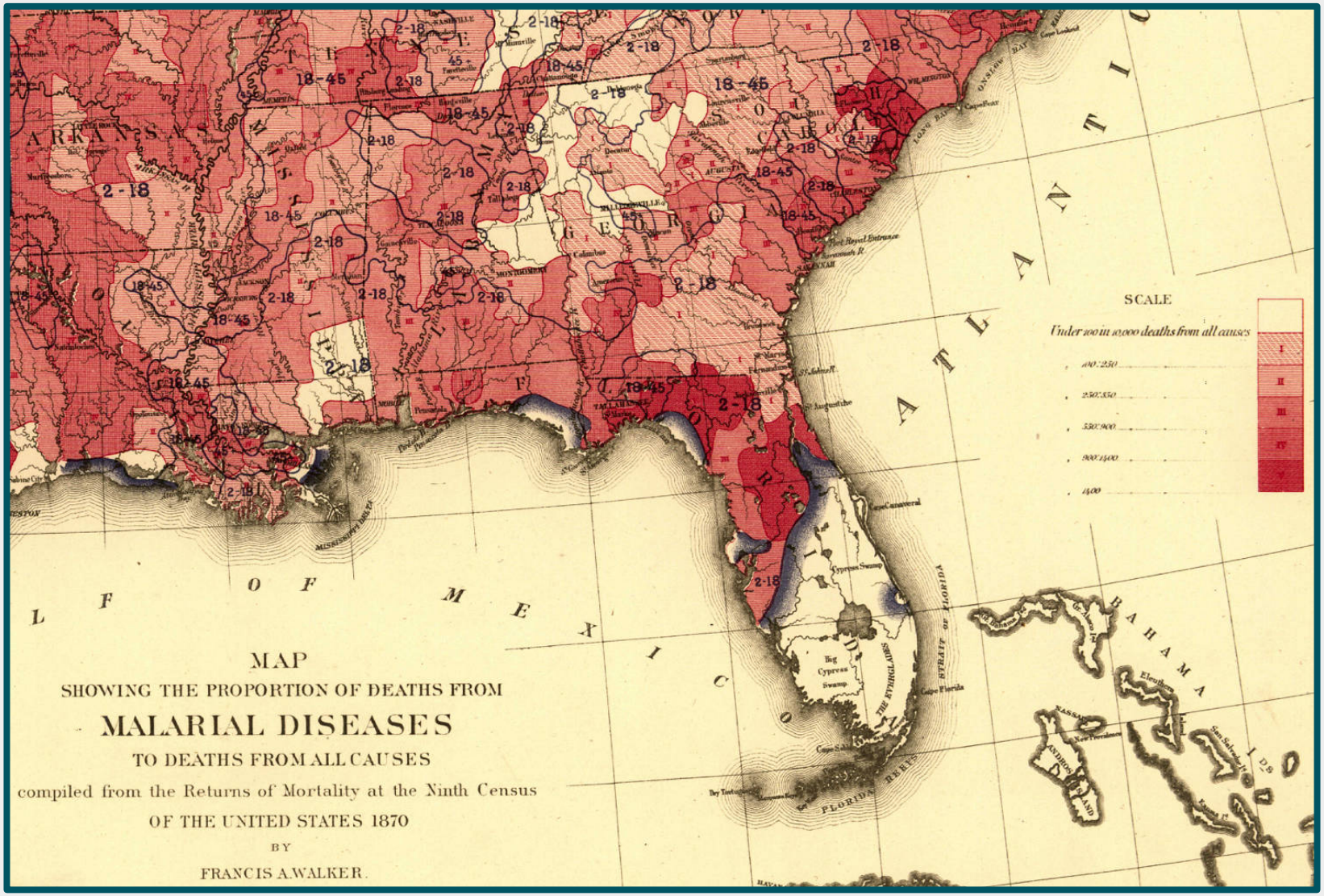
Sharon Lin et al. (2013). “Selecting Semantically-Resonant Colors for Data Visualization”. In: Computer Graphics Forum 32.3, pp. 401–410.

How would you color death?



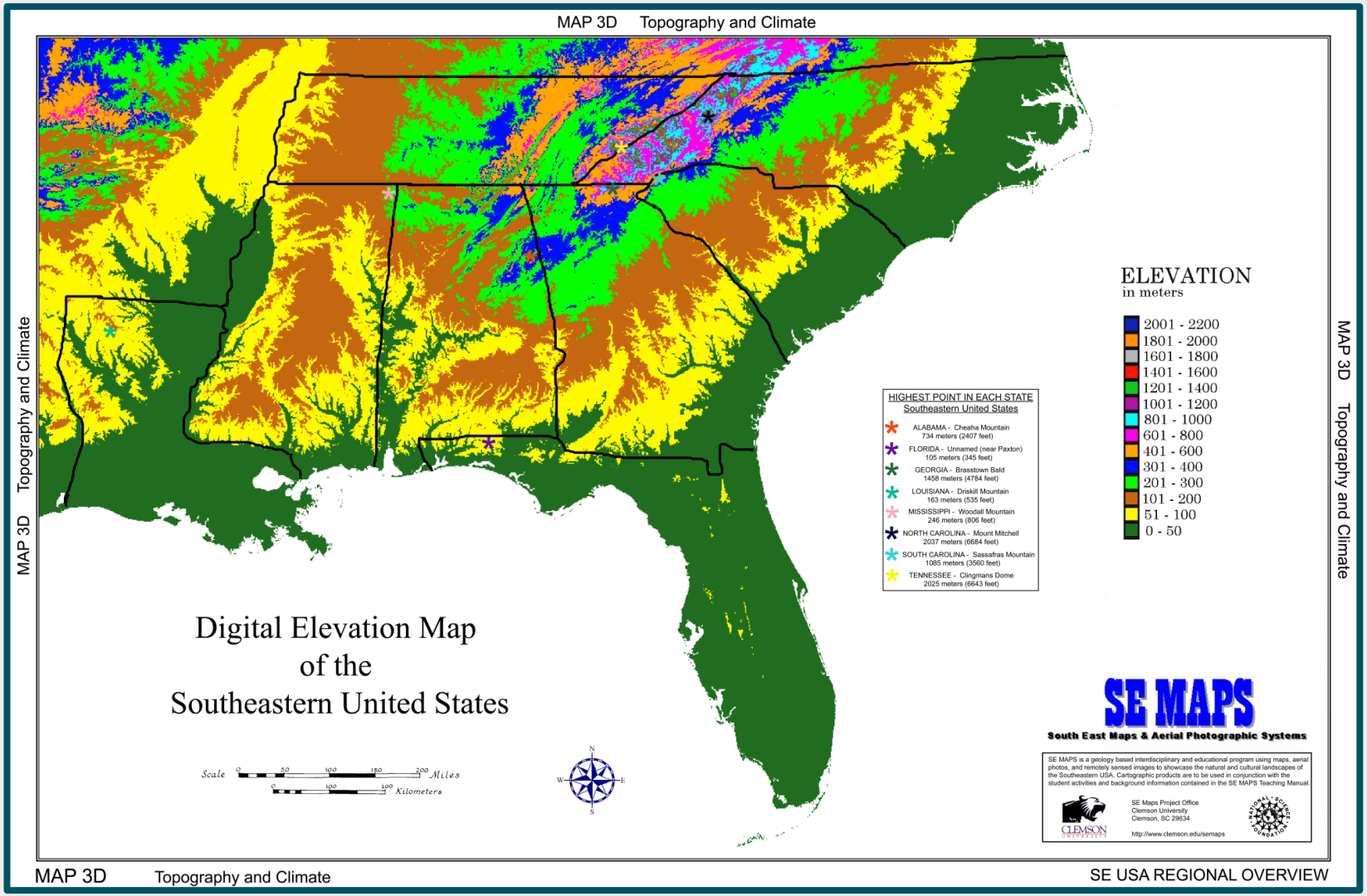
Jonas Schöley (2016).
github.com/jschoeley/codus2014

Color-coding magnitudes



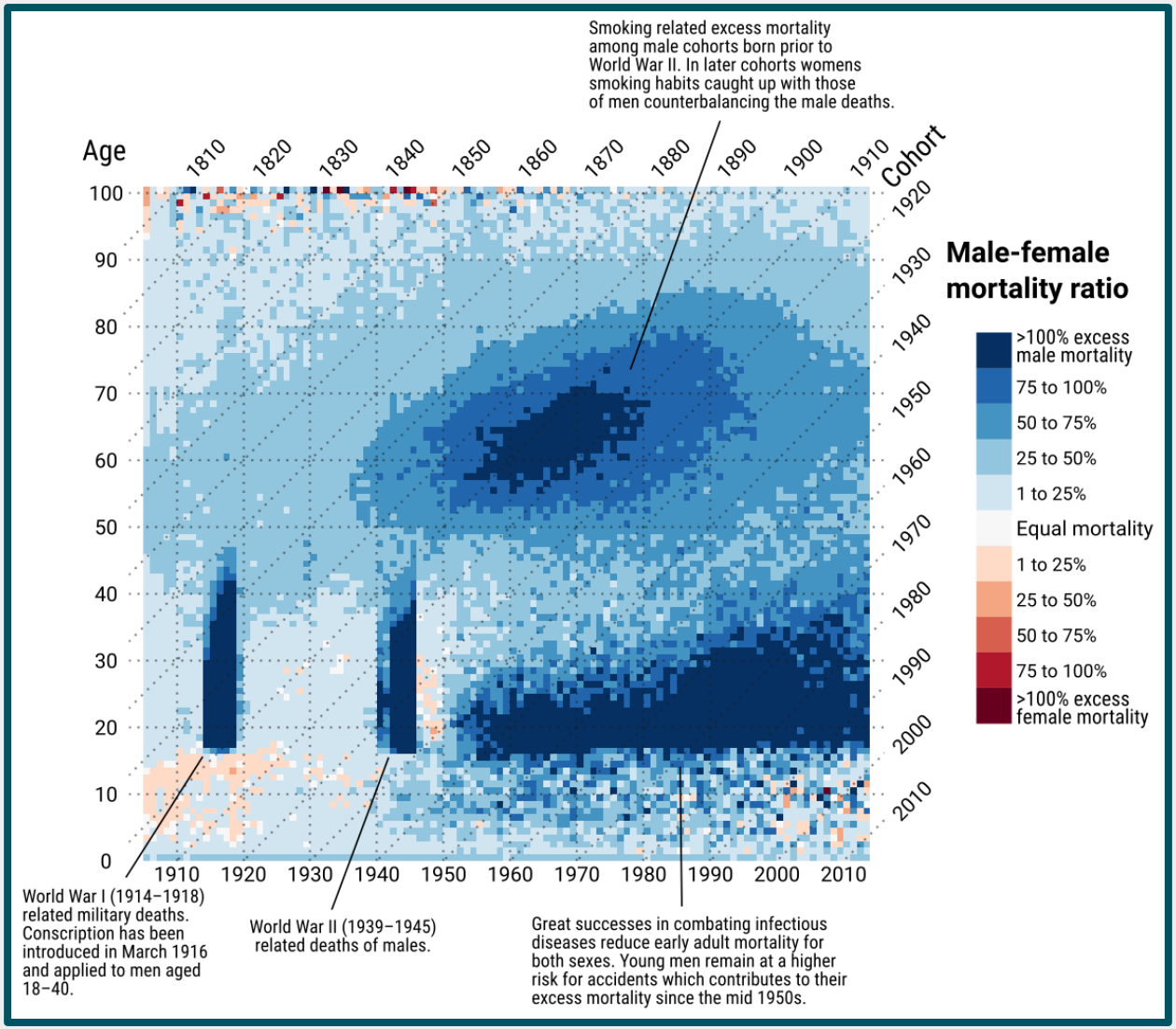
Francis Walker (1874). “Statistical Atlas of the United States” [cutout].

Ineffective color-coding



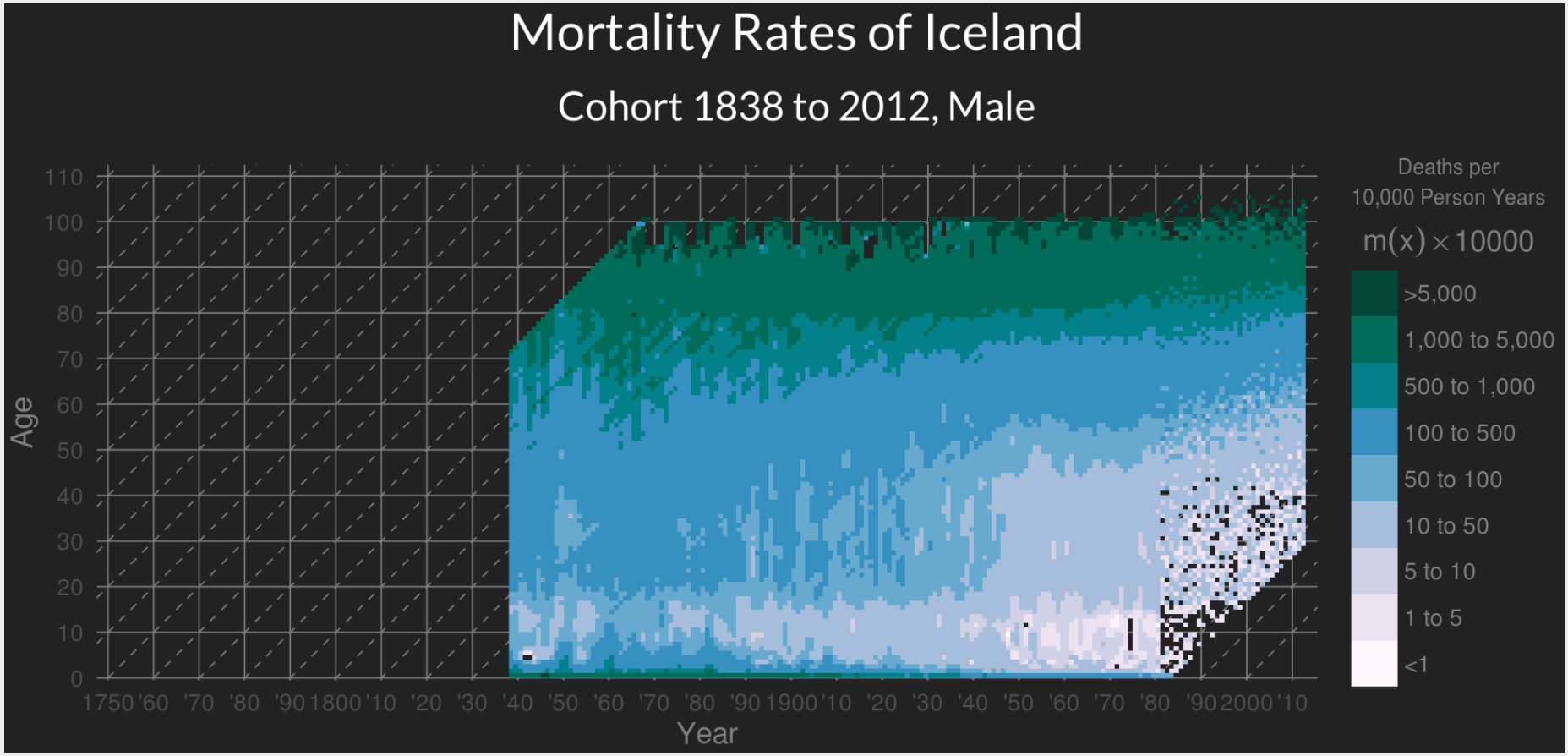
South East Maps & Aerial Photographic Systems.

Color-coding *divergent* magnitudes



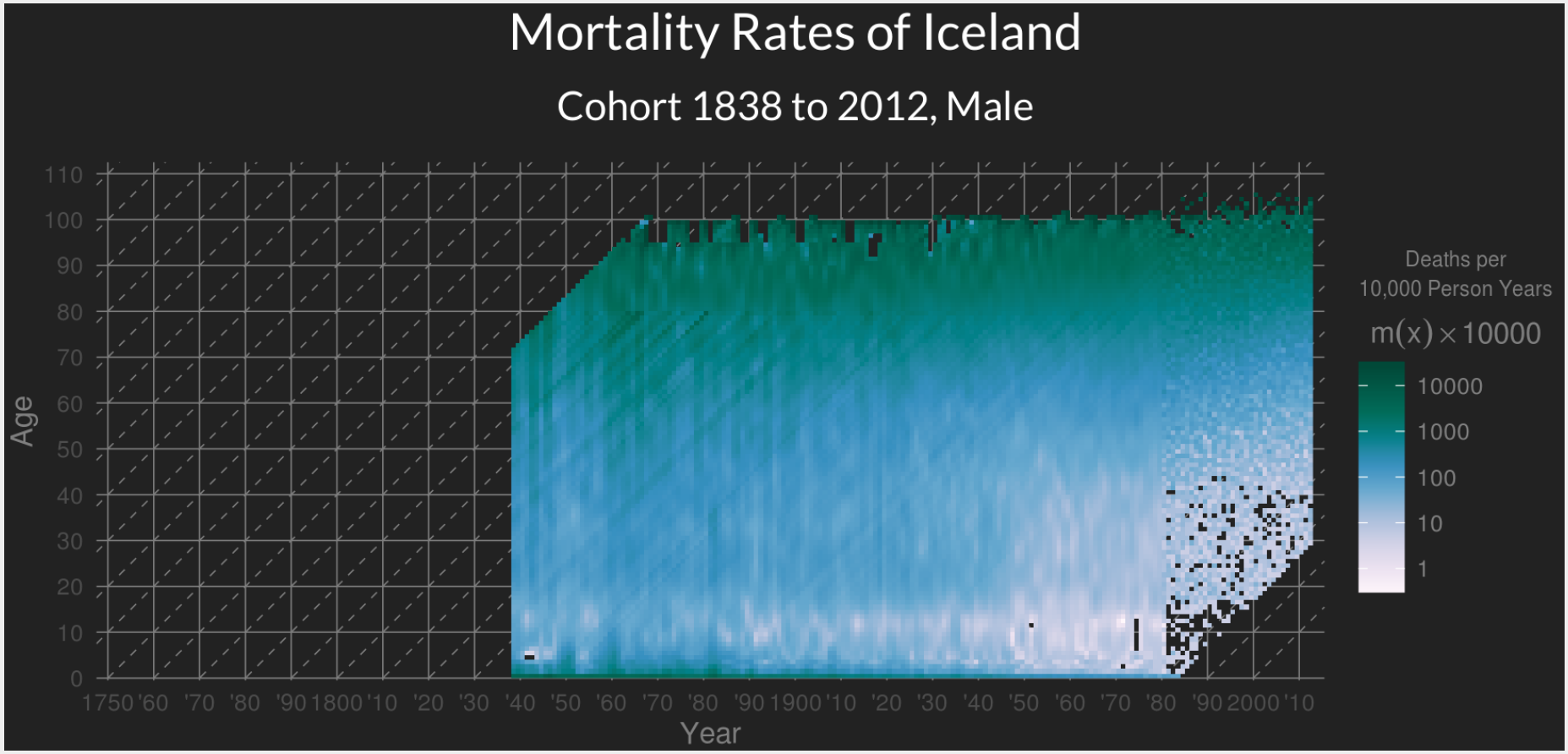
Schöley (2016). “Visualizing compositional data on the Lexis surface.” Data: HMD.

Discrete color scales



Jonas Schöley (2016). “The Human Mortality Explorer”.

Continous color scales

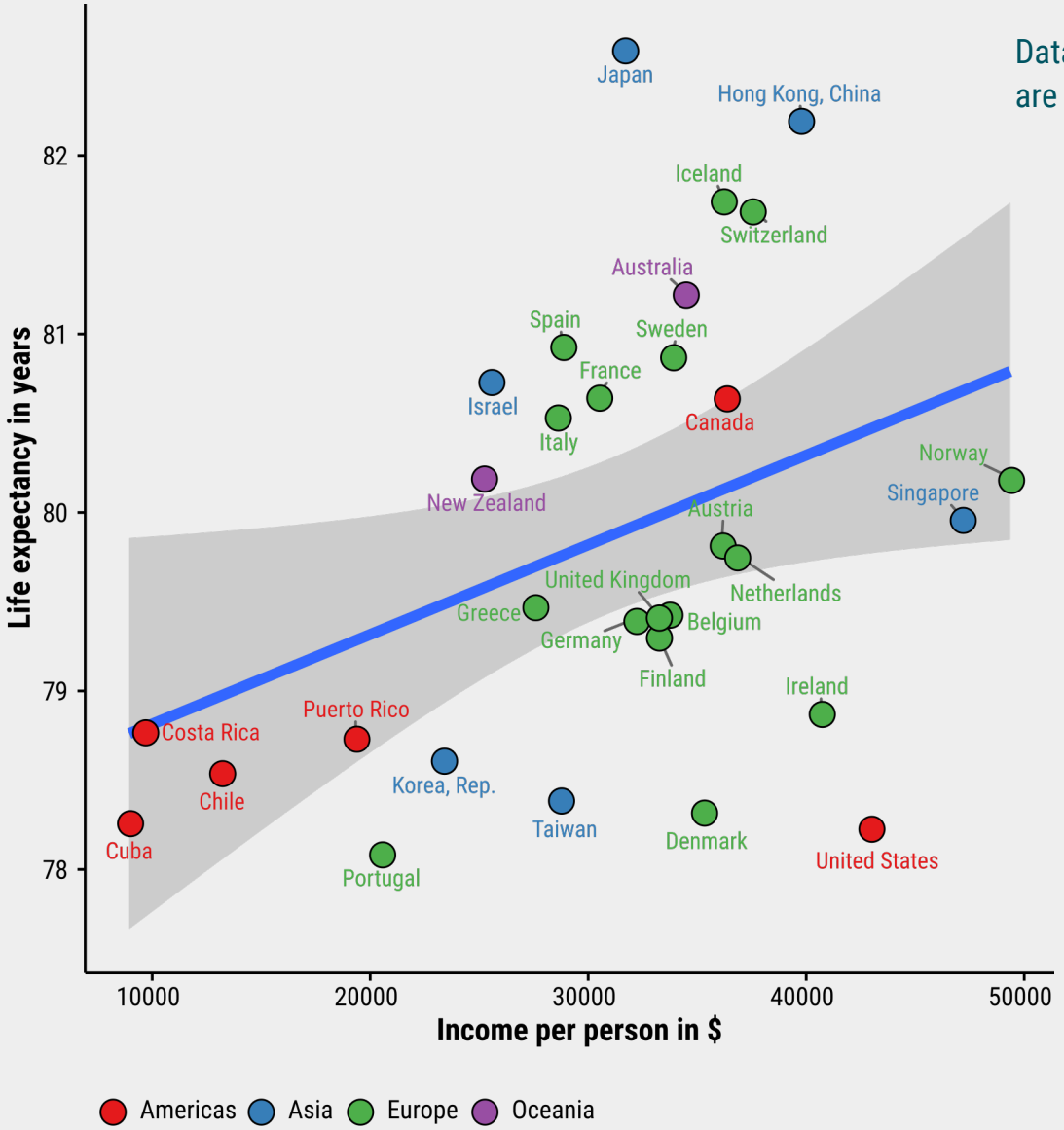


Jonas Schöley (2016). “The Human Mortality Explorer”.

Separating foreground & background

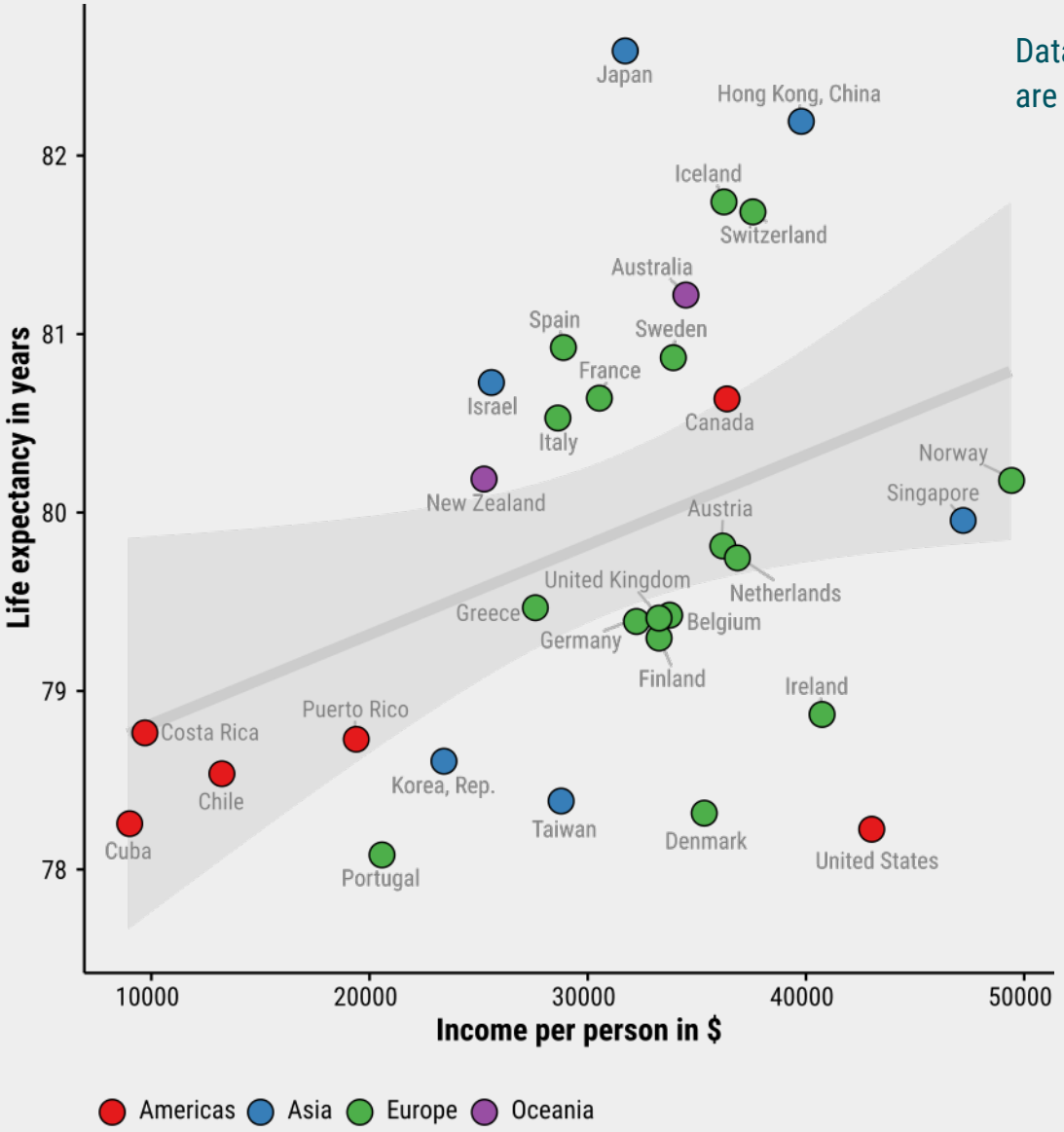
Pablo Picasso (1905). “Au Lapin Agile”.

Separating foreground & background



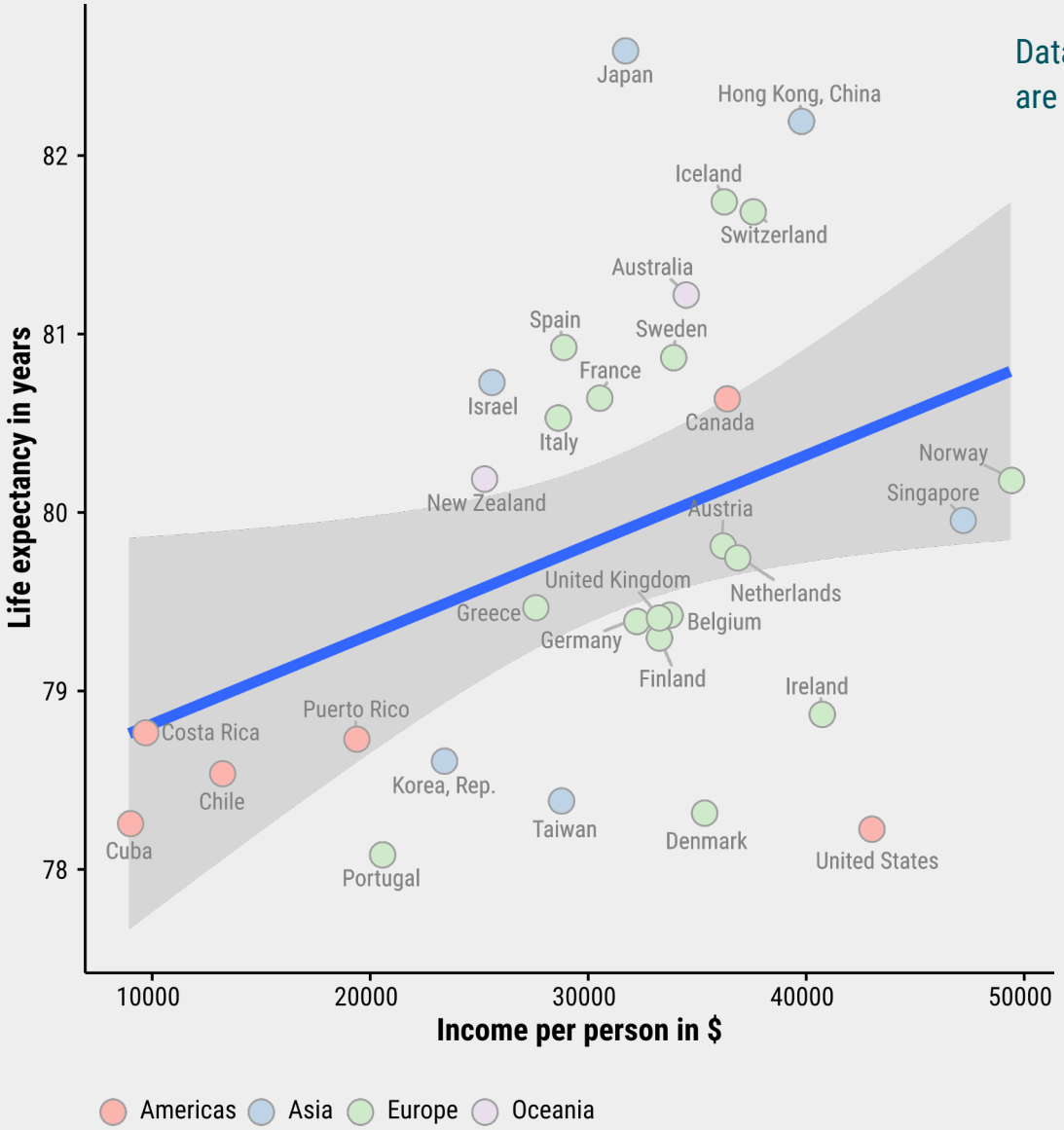
Data: gapminder.org – displayed are data for the year 2007.

Separating foreground & background



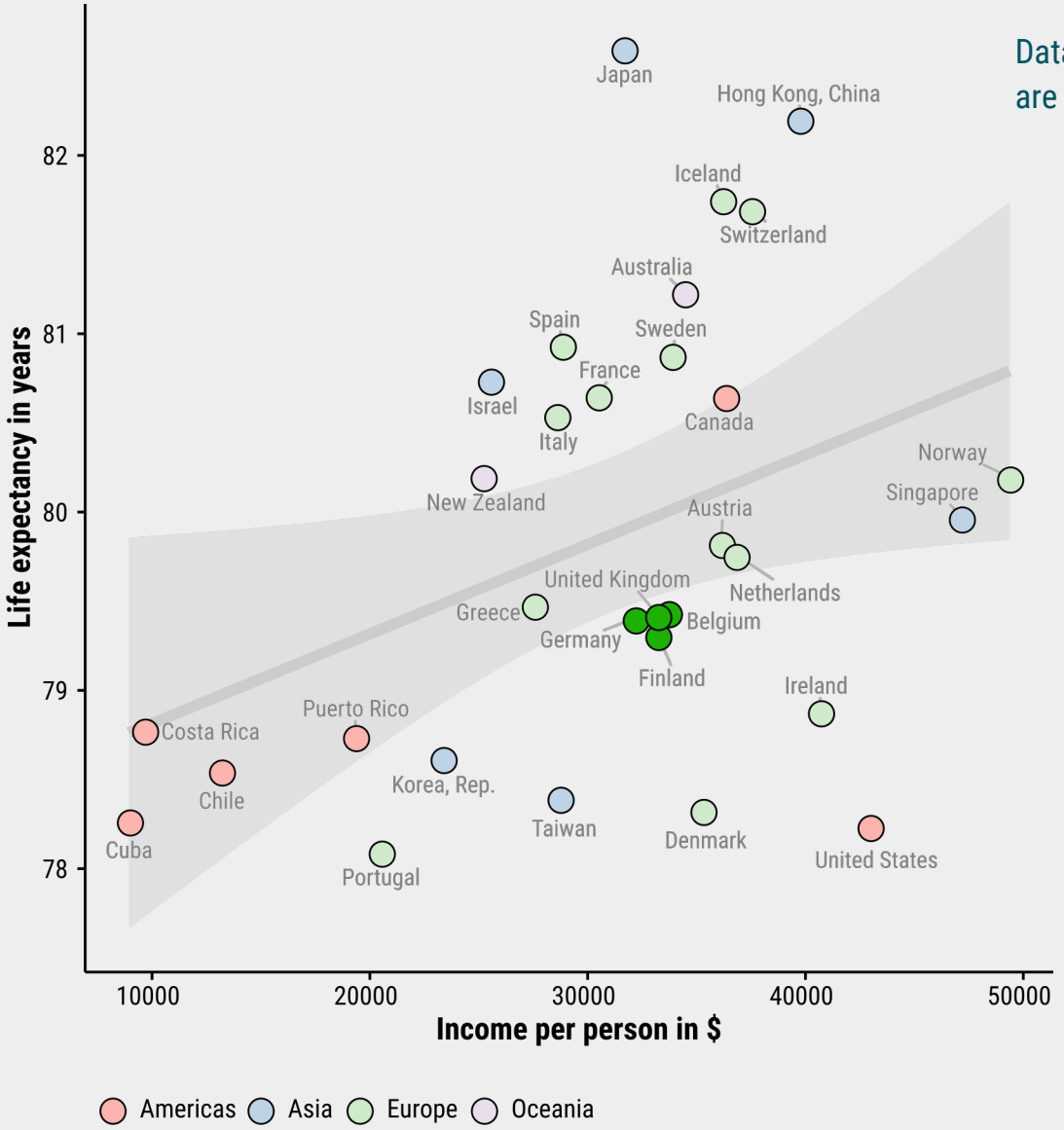
Data: gapminder.org – displayed are data for the year 2007.

Separating foreground & background



Data: gapminder.org – displayed are data for the year 2007.

Separating foreground & background



Data: gapminder.org – displayed are data for the year 2007.

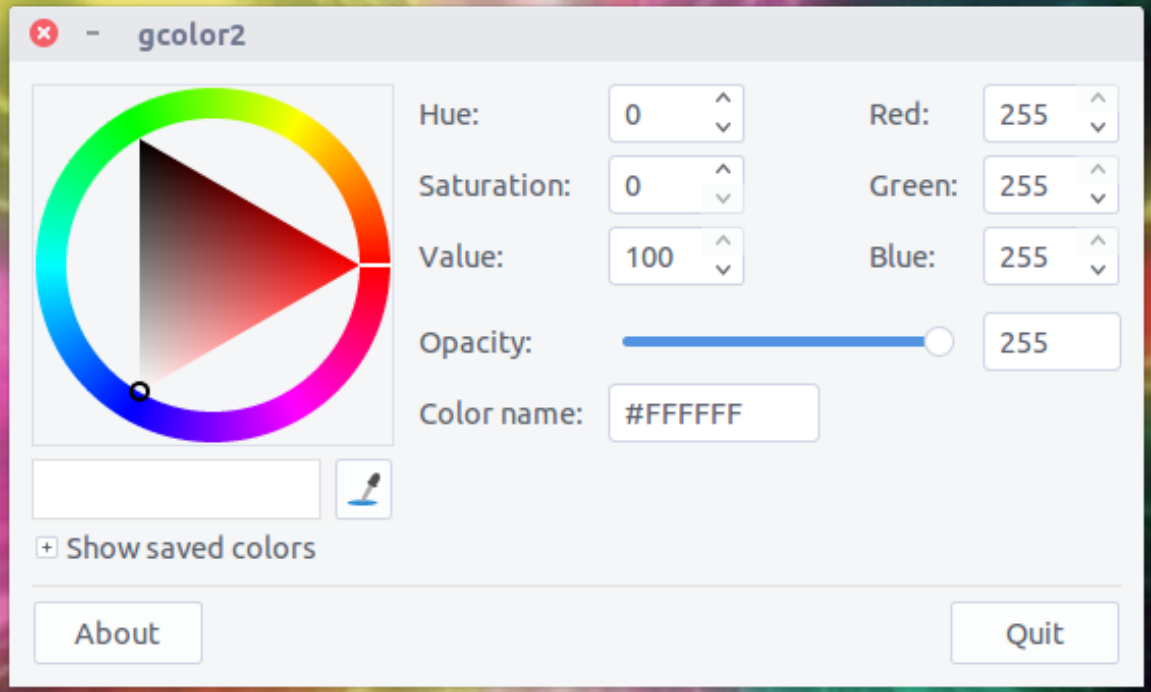
Further reading

Brilliant color advice from NASA
earthobservatory.nasa.gov/blogs/elegantfigures/2013/08/05/subtleties-of-color-part-1-of-6

Seminal paper on construction of qualitative, sequential, divergent color scales Brewer, Cynthia A. 1994. “Guidelines for Use of the Perceptual Dimensions of Color for Mapping and Visualization.” In SPIE, edited by Jan Bares, 2171:54–63. doi:10.1117/12.175328.

Color scales for data-viz colorbrewer2.org

You take control!



Slides available at
github.com/jschoeley/idem_viz

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