

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.

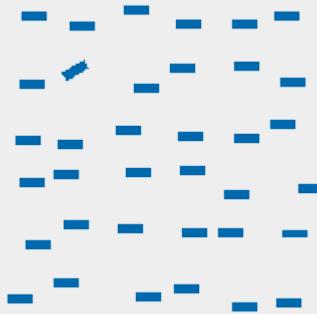
Why does visualization work?

“Preattentive features **pop-out**.”

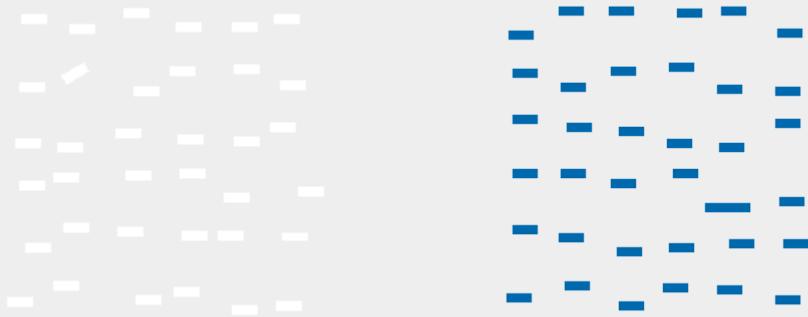
Jon Schwabish (2016) at PRB data viz workshop.

Grabbing attention **Preattentive features**

Line orientation



Line length



Closure



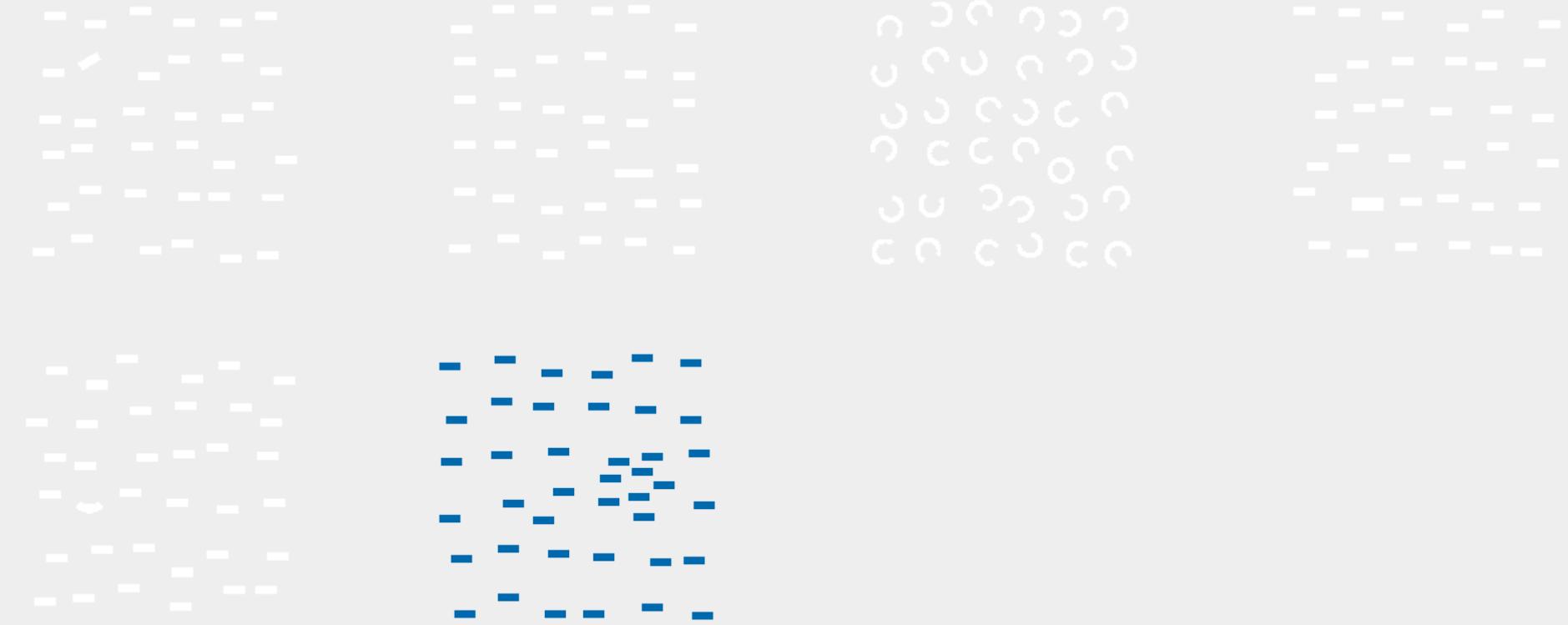
Size



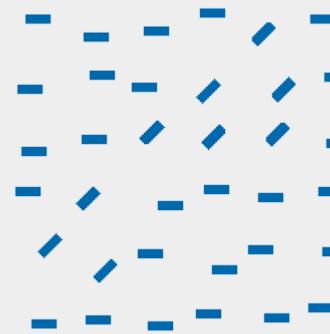
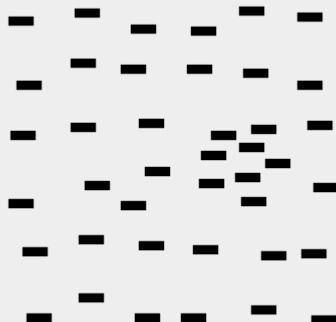
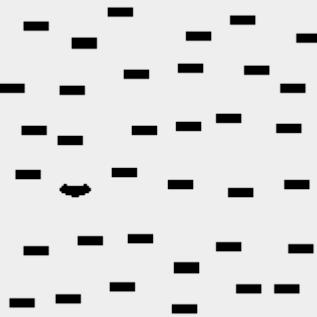
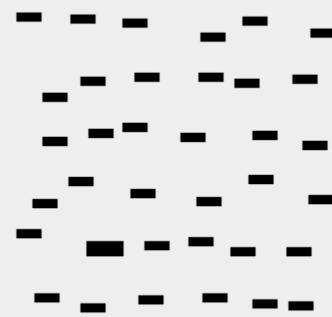
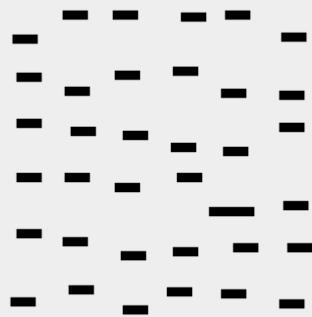
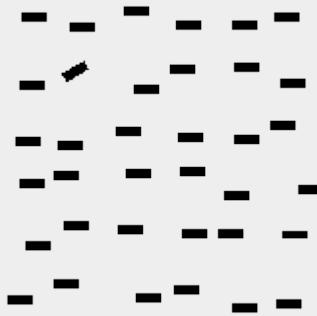
Curvature



Density



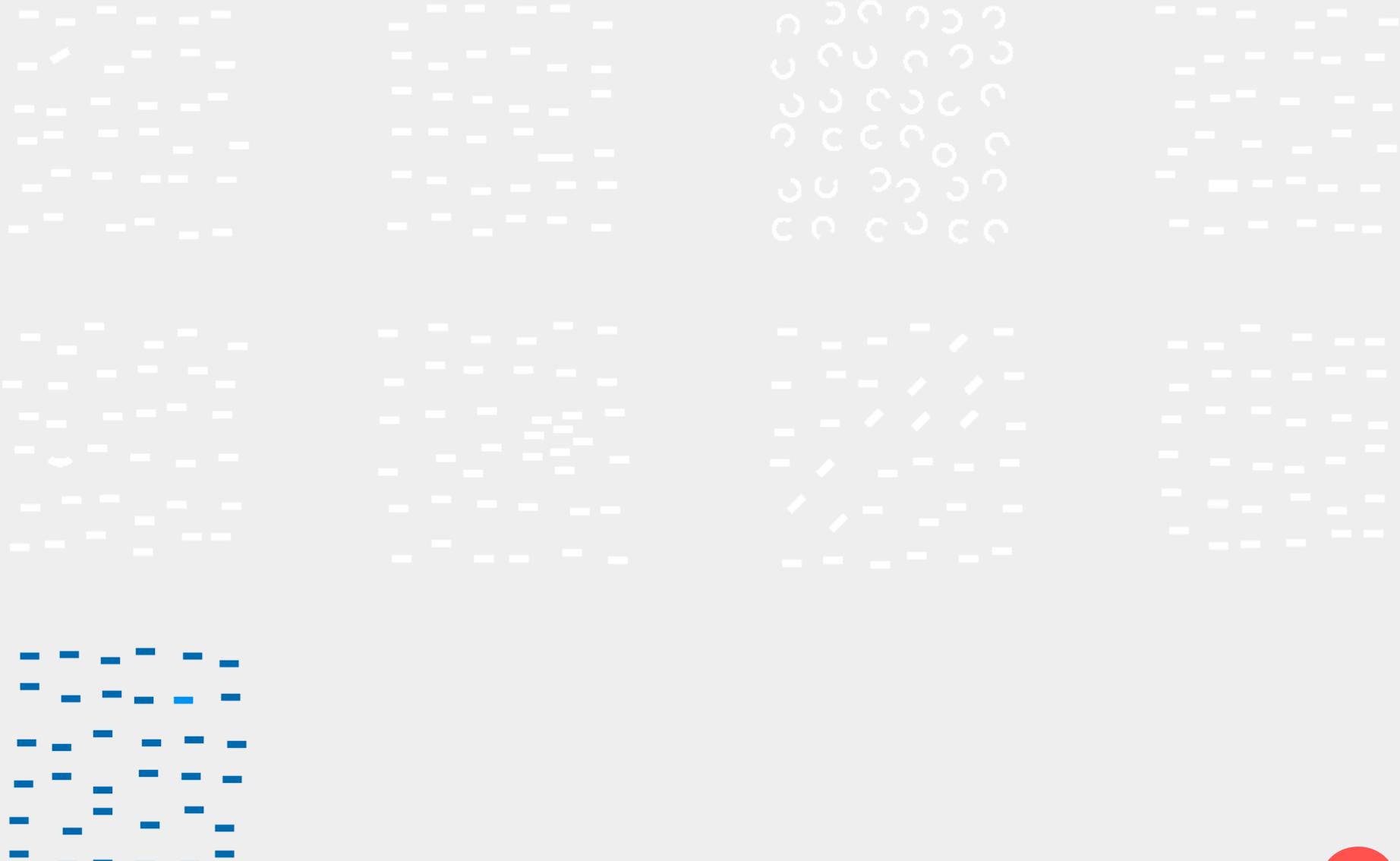
Number



Colour (hue)



Intensity



Source: Christopher G. Healey

Intersection

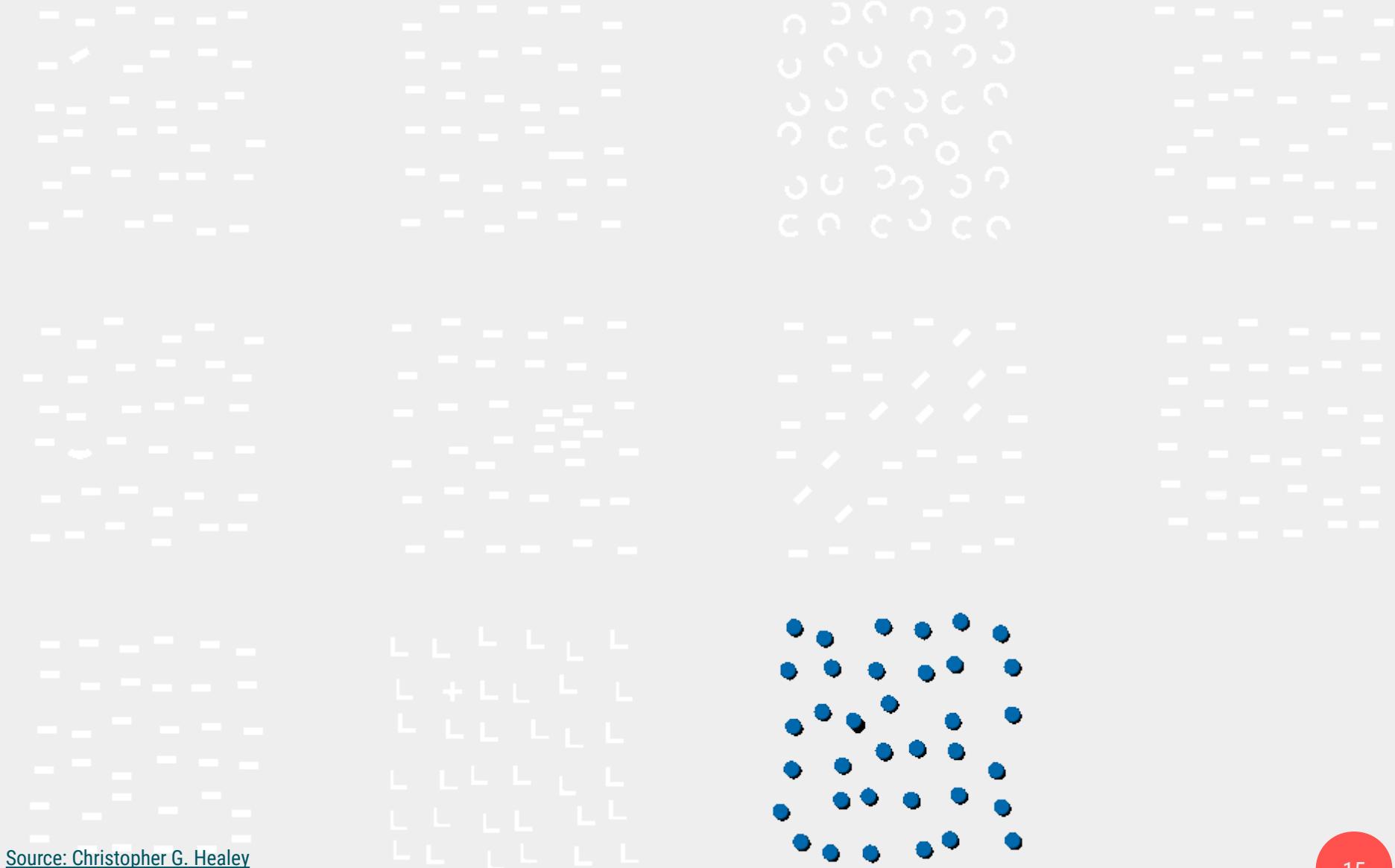
L L L L L
L + L L L
L L L L L
L L L L L
L L L L L

Source: Christopher G. Healey

EDSD 17/18

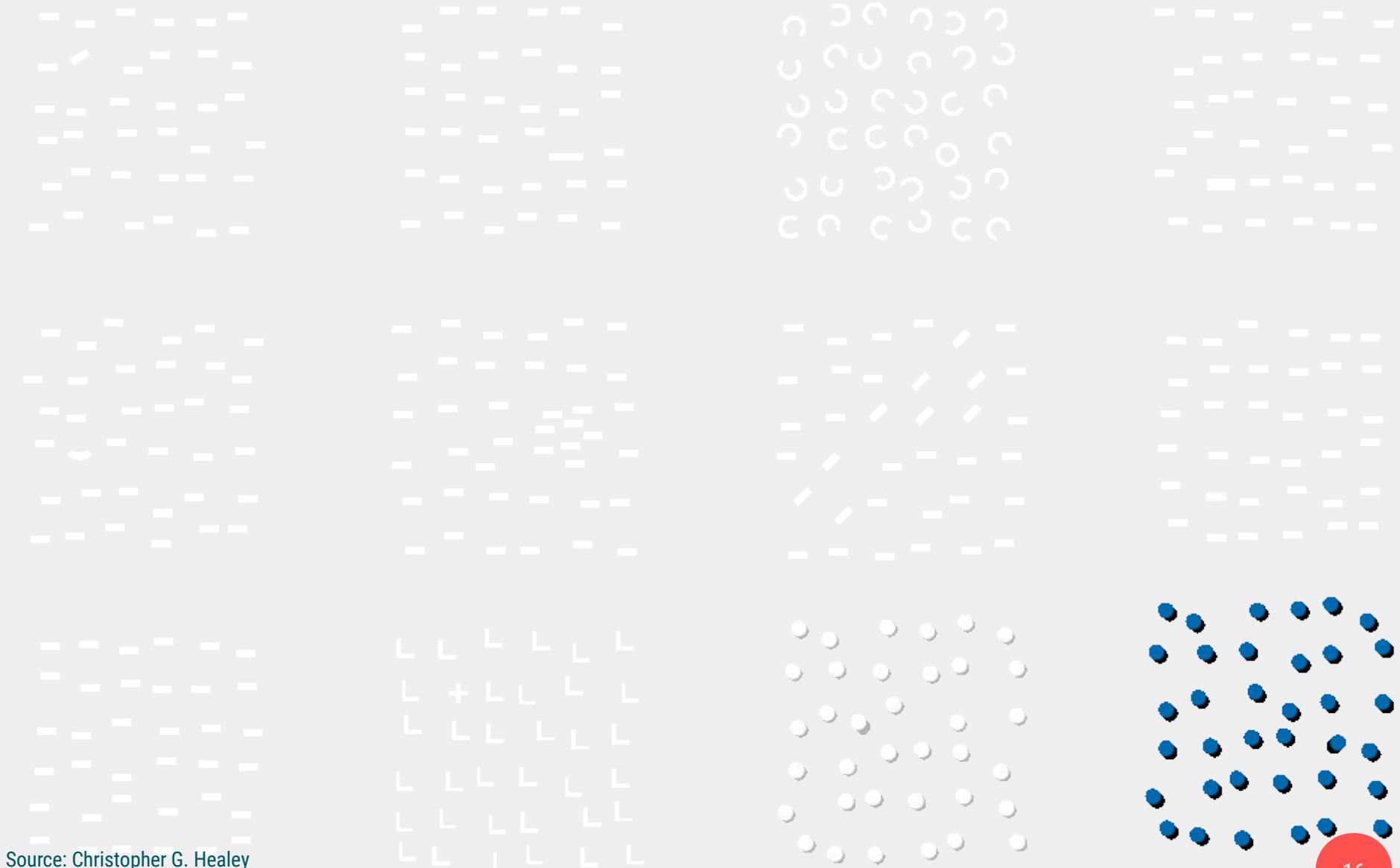
Jonas Schöley – Visual perception

3D depth cues



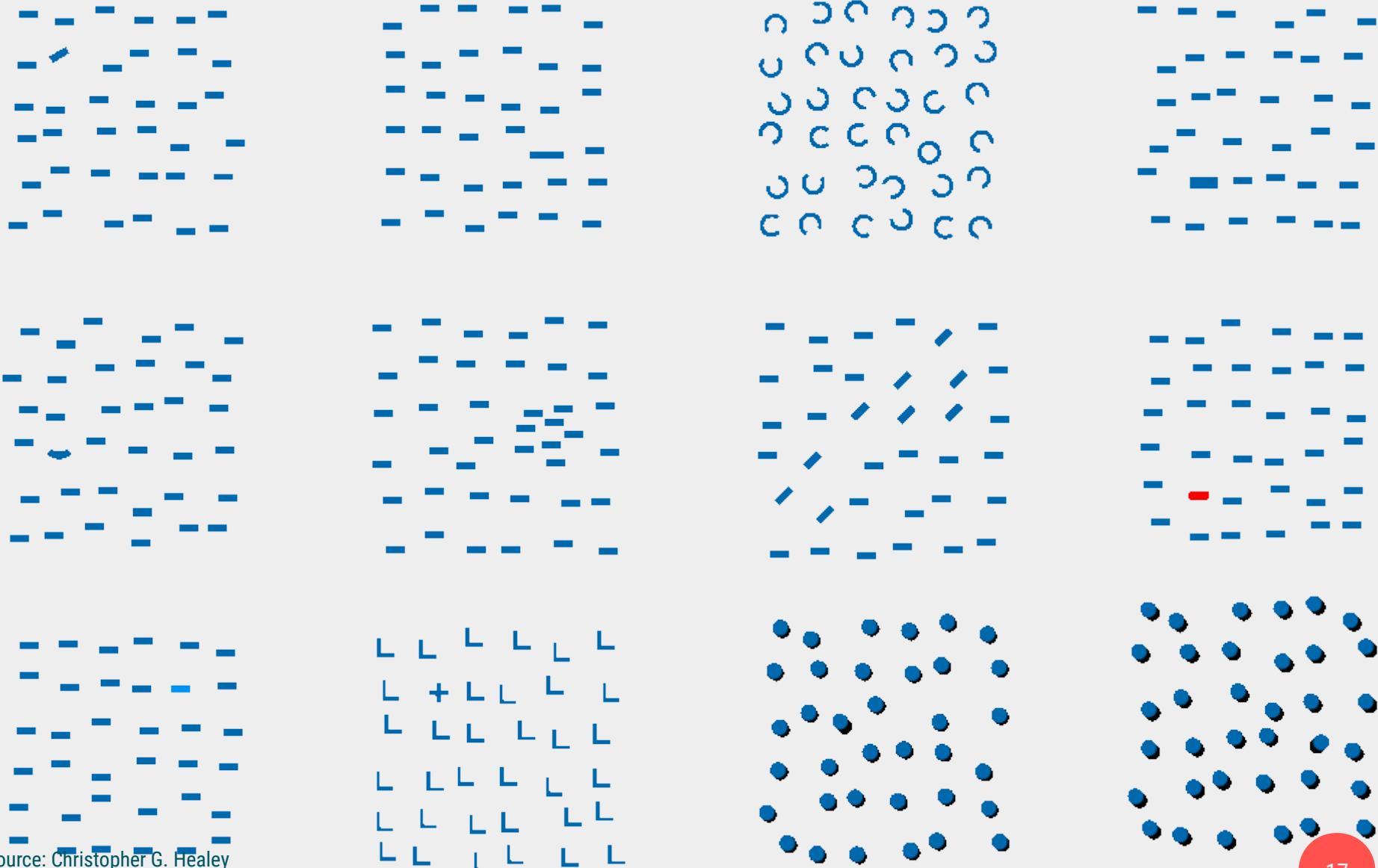
Source: Christopher G. Healey

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

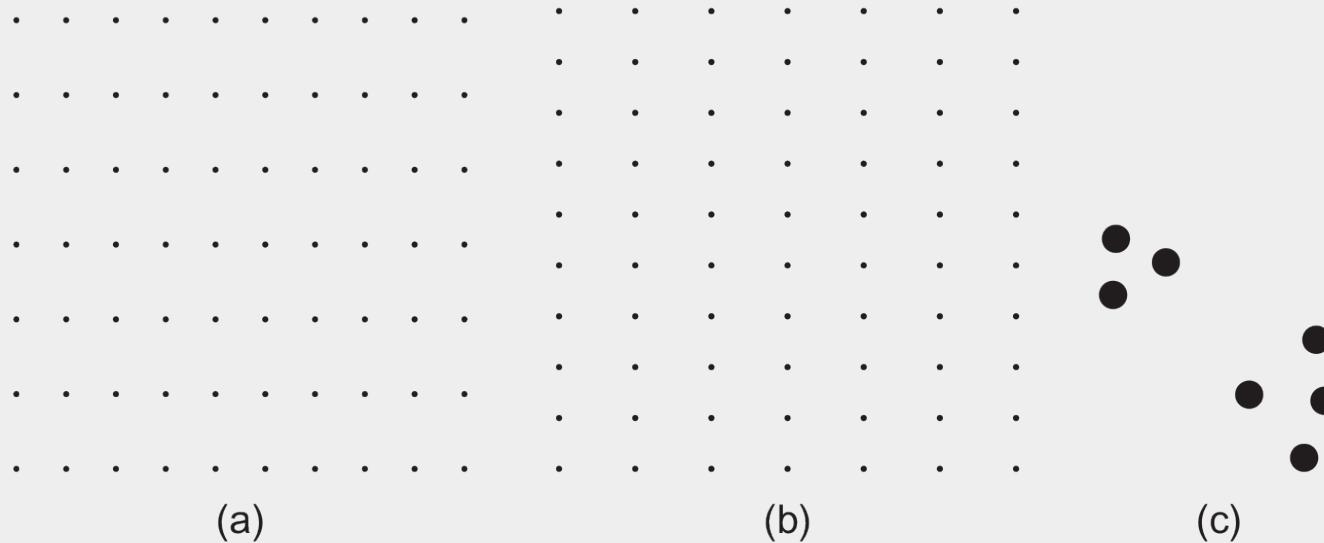


Figure 6.2 Spatial proximity is a powerful cue for perceptual organization. A matrix of dots is perceived as rows on the left (a) and columns on the right (b). In (c) we perceive two groups of dots because of proximity relationships.

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

Proximity



(c) Jonas Schöley 2016.

Connectedness

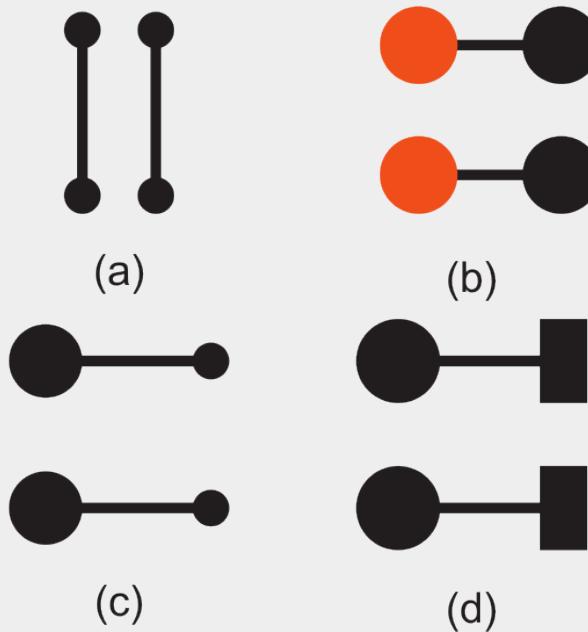
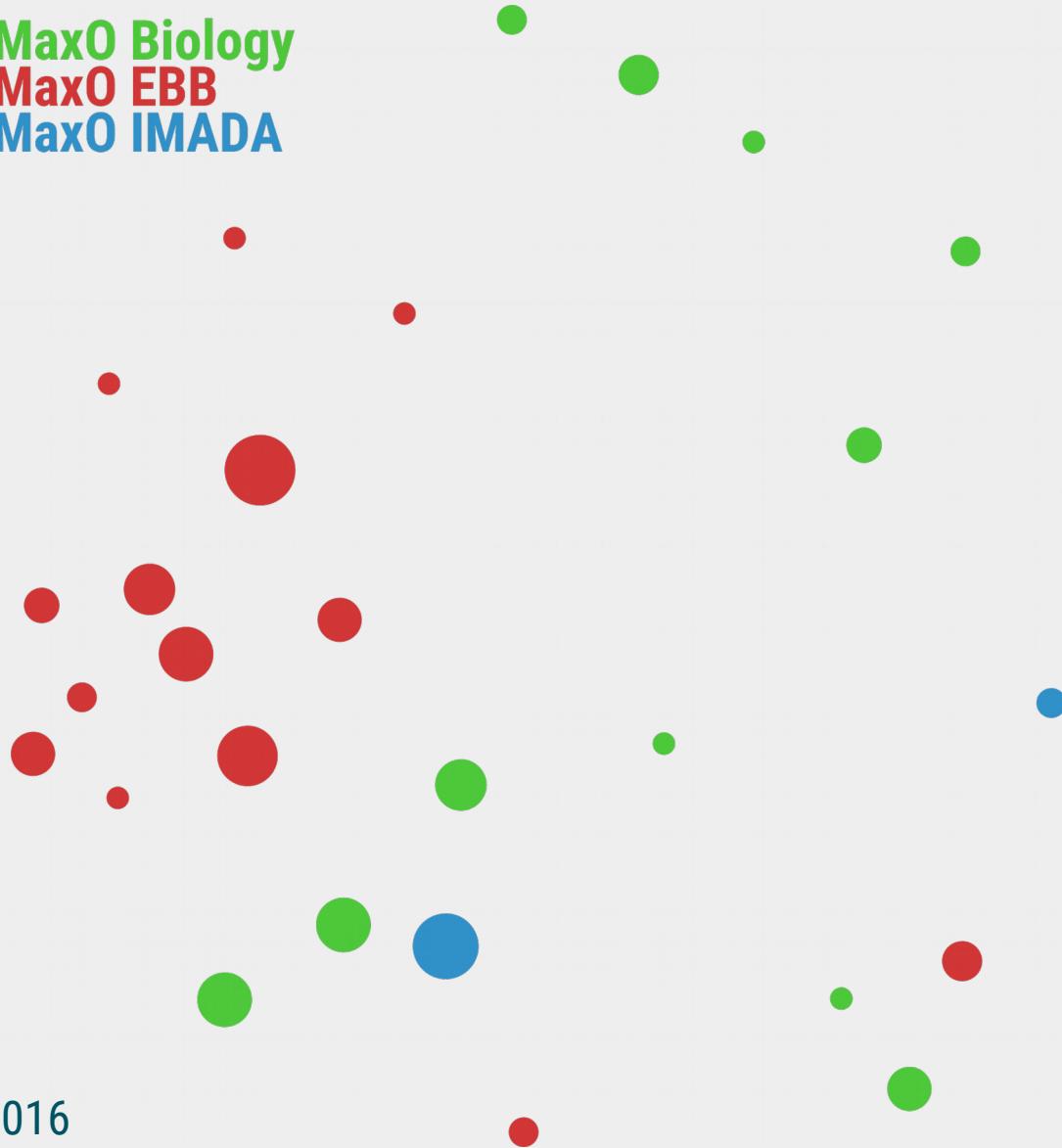


Figure 6.5 Connectedness is a powerful grouping principle that is stronger than (a) proximity, (b) color, (c) size, or (d) shape.

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

Connectedness

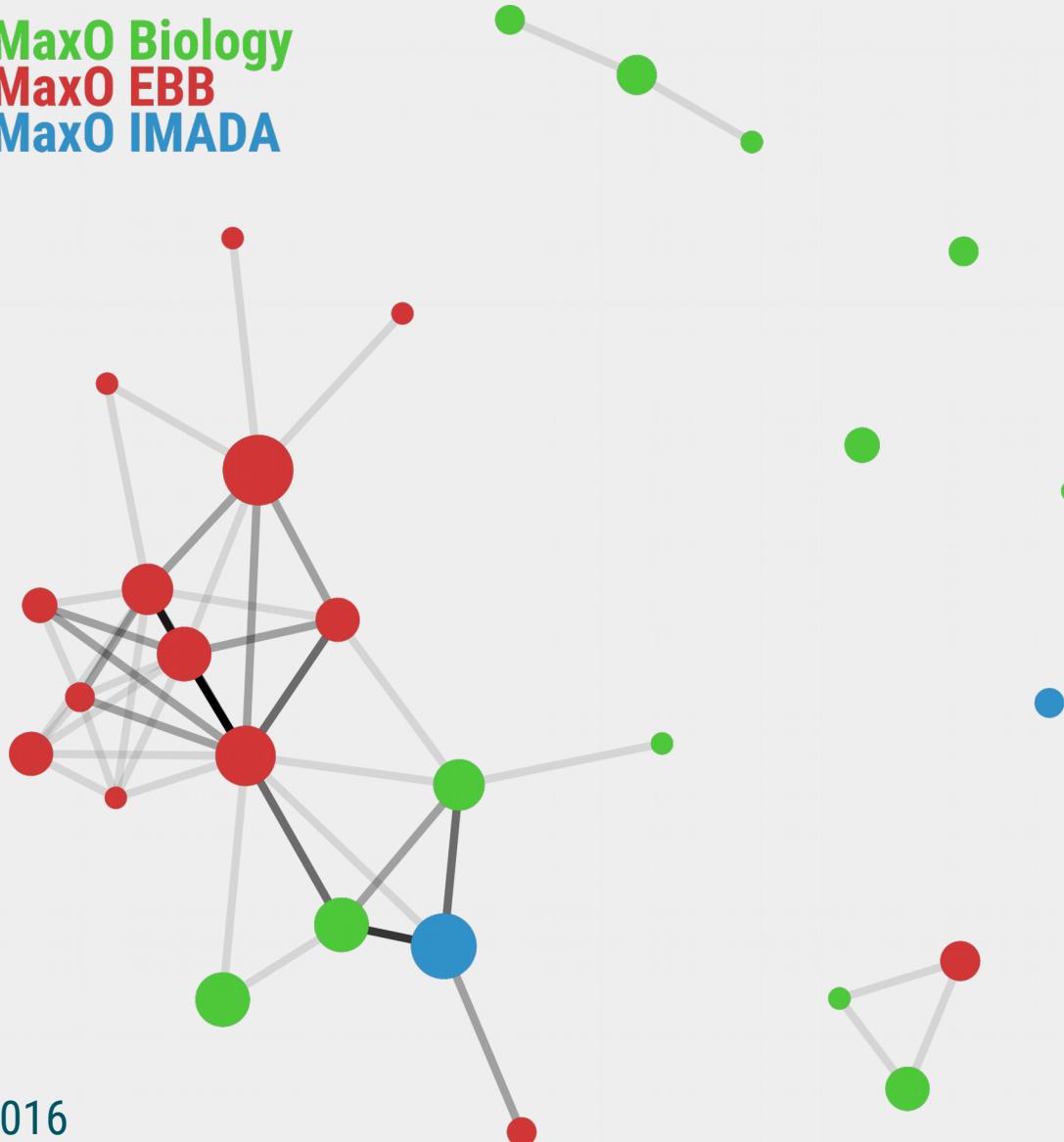
MaxO Biology
MaxO EBB
MaxO IMADA



(c) Jonas Schöley 2016

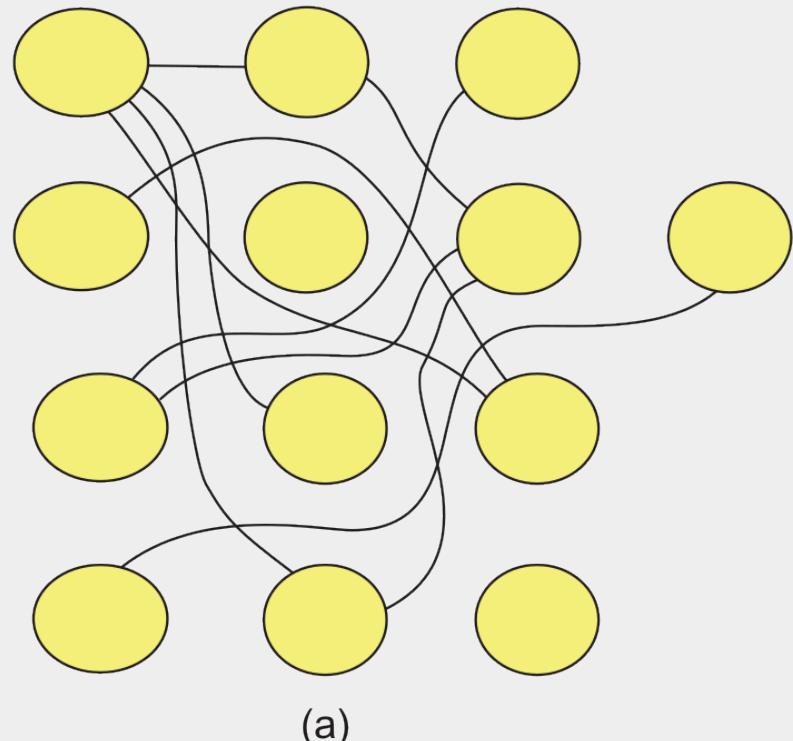
Connectedness

MaxO Biology
MaxO EBB
MaxO IMADA

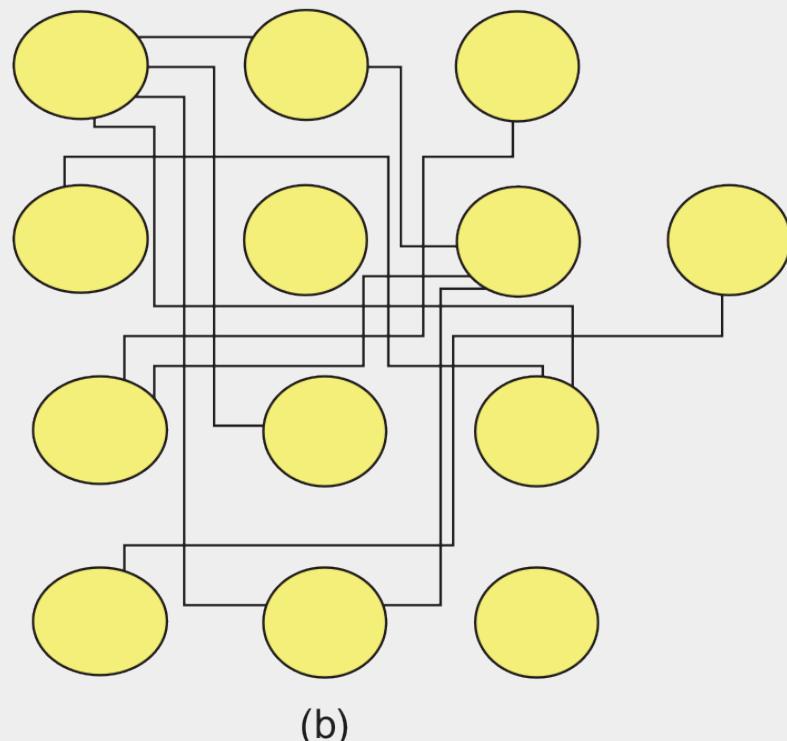


(c) Jonas Schöley 2016

Continuity



(a)

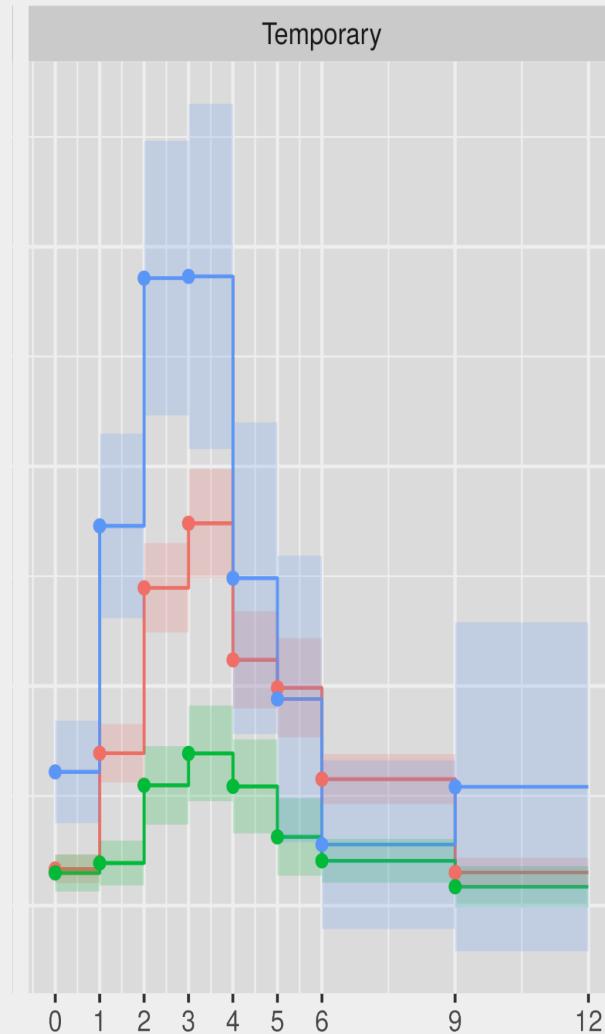
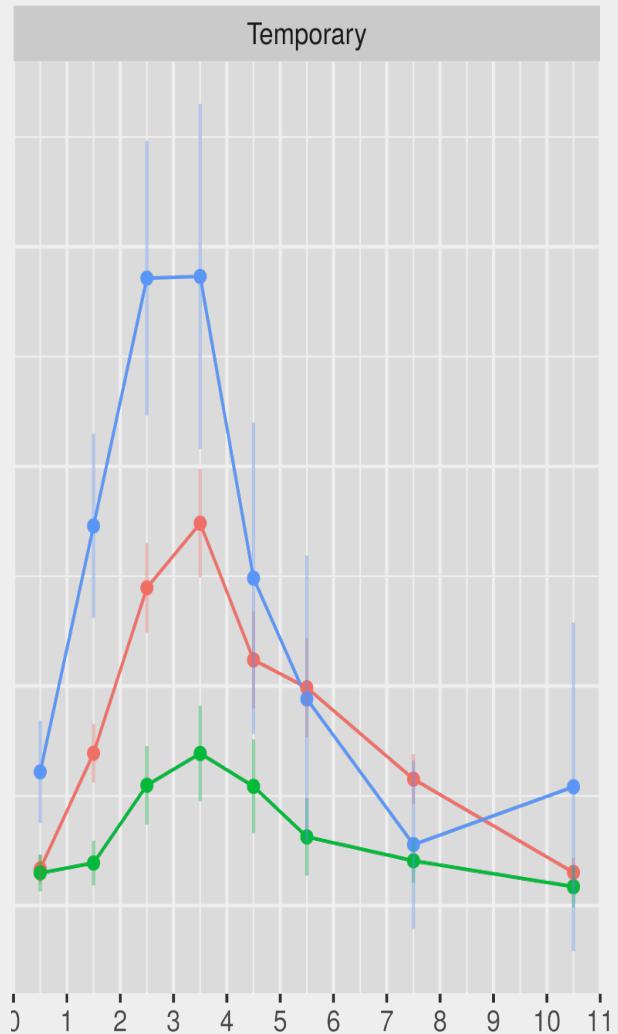


(b)

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.

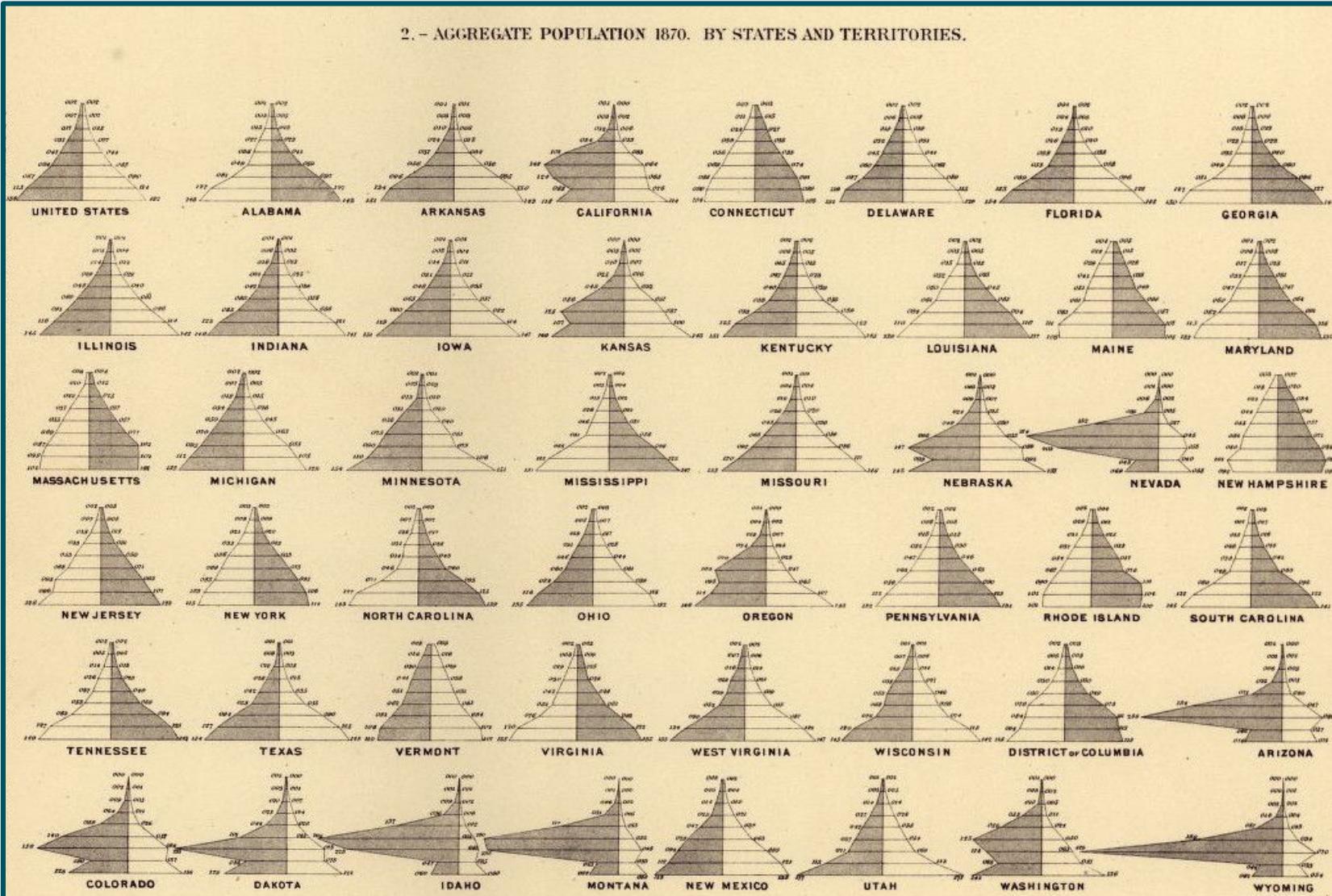
Ware, C. (2013). Information Visualization. Perception for Design (3rd ed.). p. 184.

Continuity



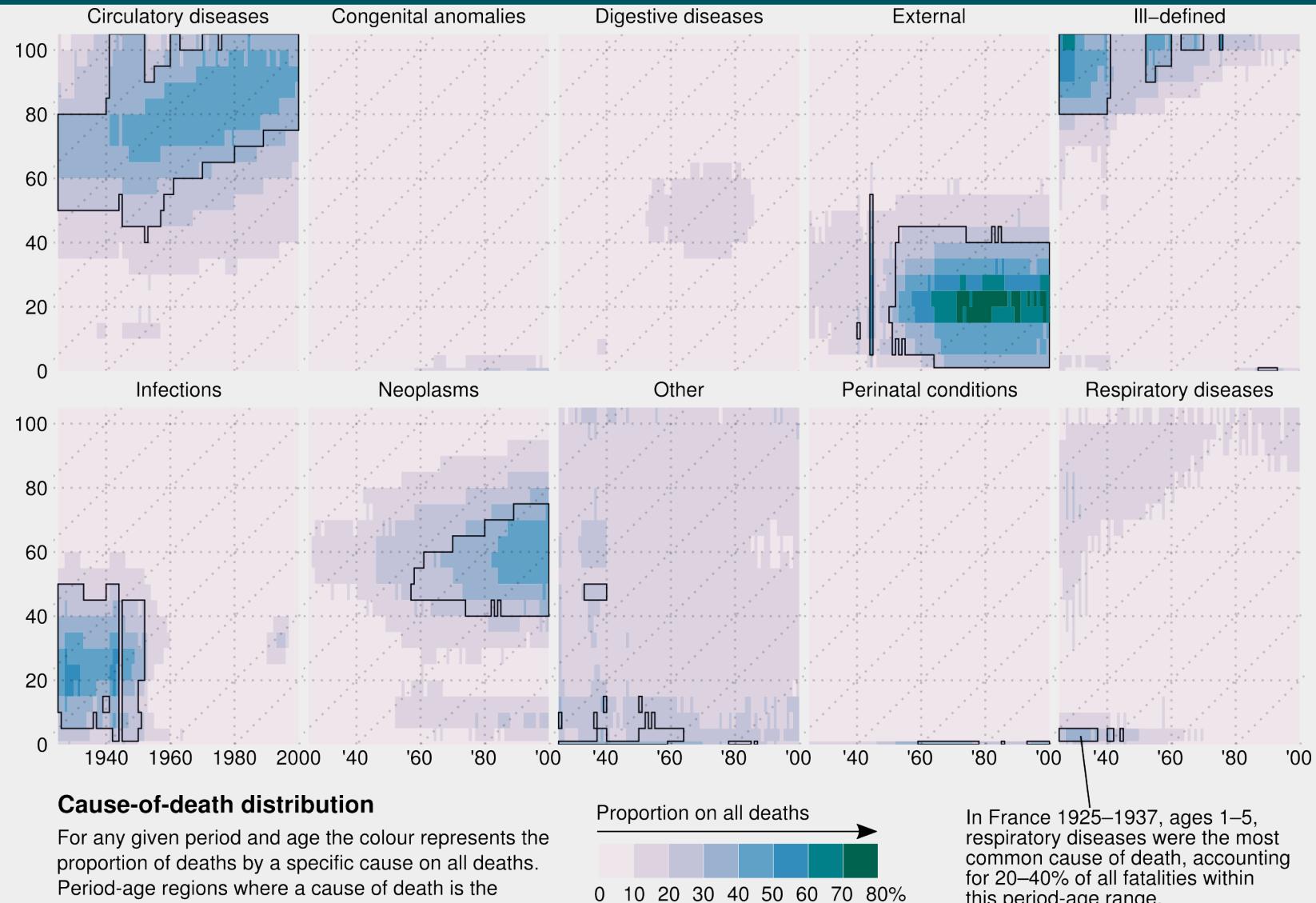
Symmetry

2. - AGGREGATE POPULATION 1870. BY STATES AND TERRITORIES.



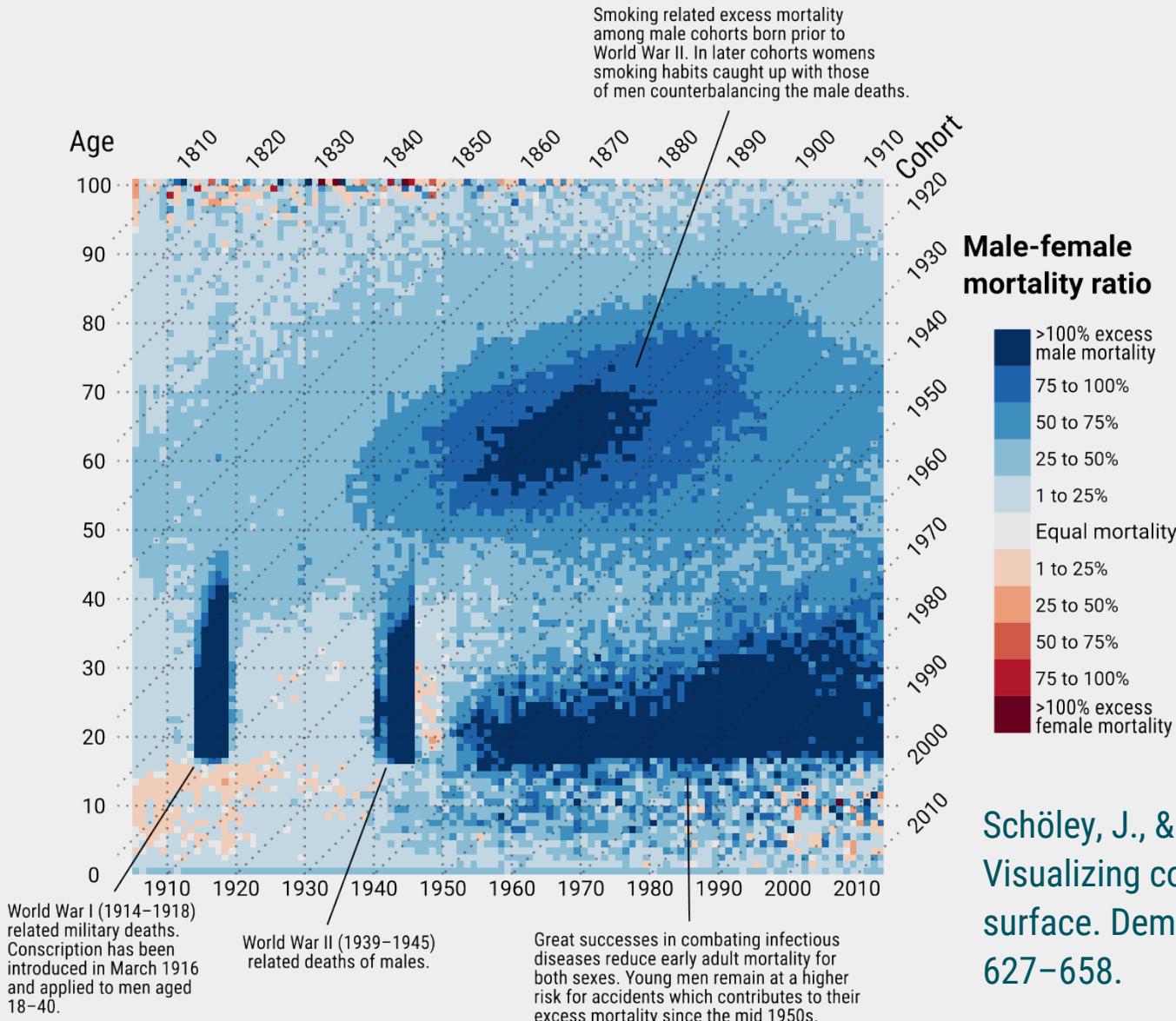
Walker, F. A. (1874). Statistical Atlas of the United States Based on the Results of the Ninth Census.

Closure and common region



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

Closure and common region

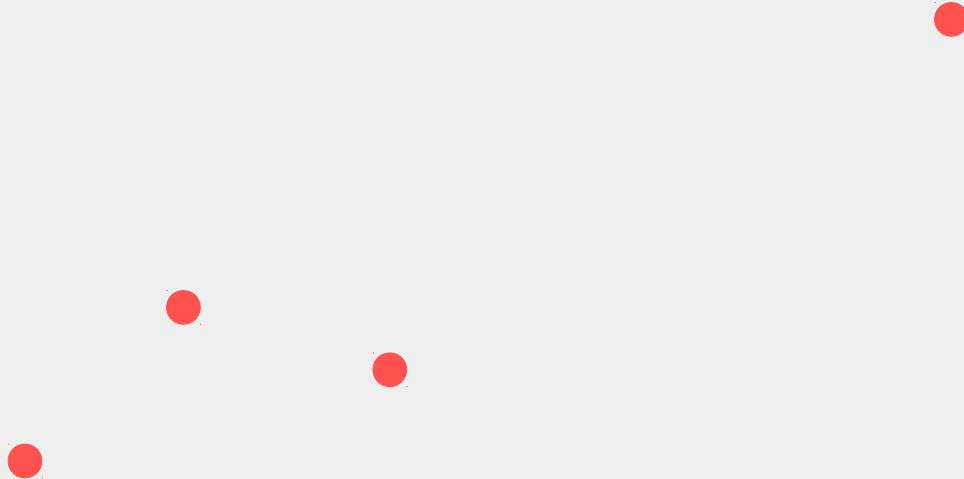


Schöley, J., & Willekens, F. (2017). Visualizing compositional data on the Lexis surface. *Demographic Research*, 36(1), 627–658.

The atoms of any visualization

Marks

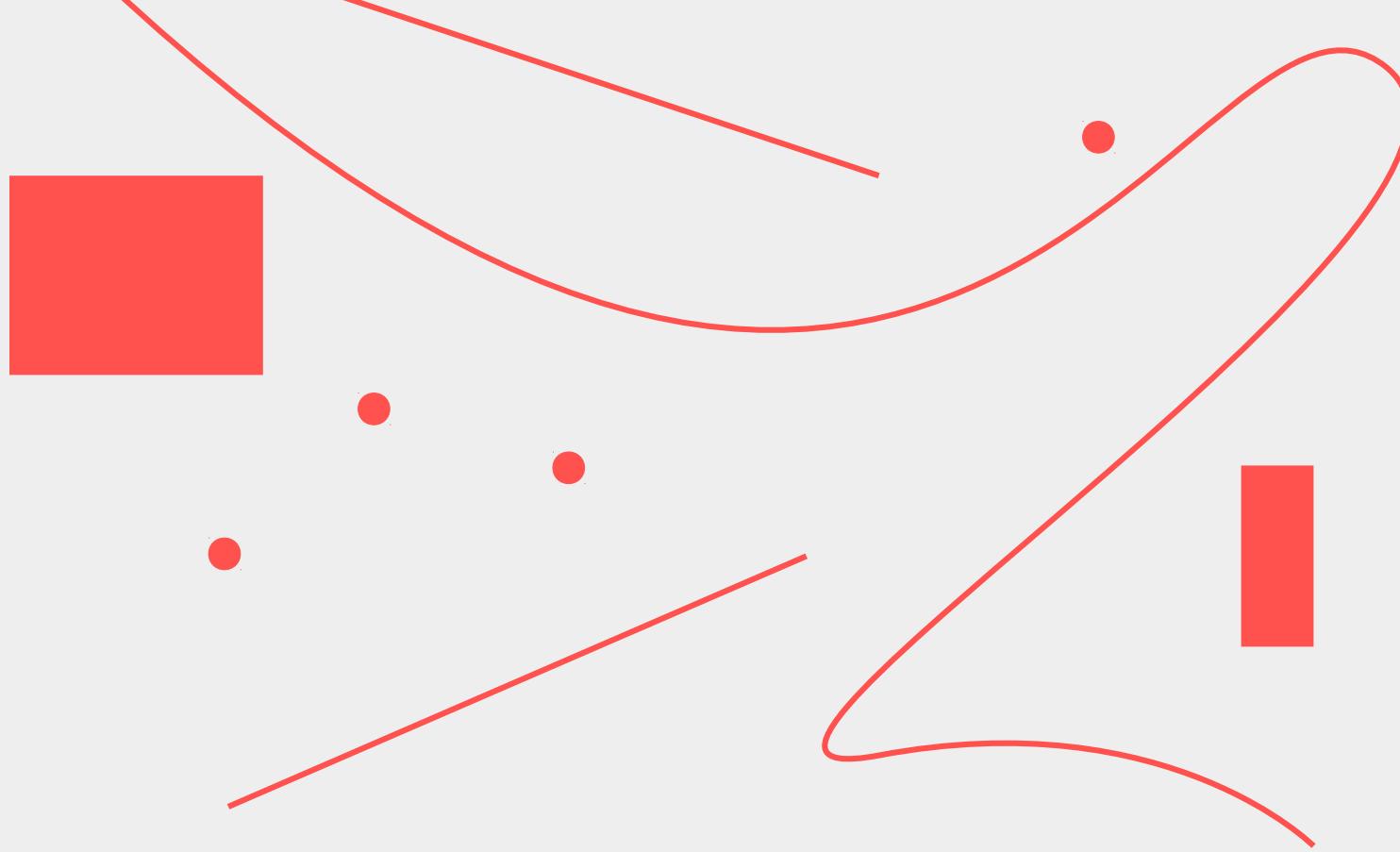
Points



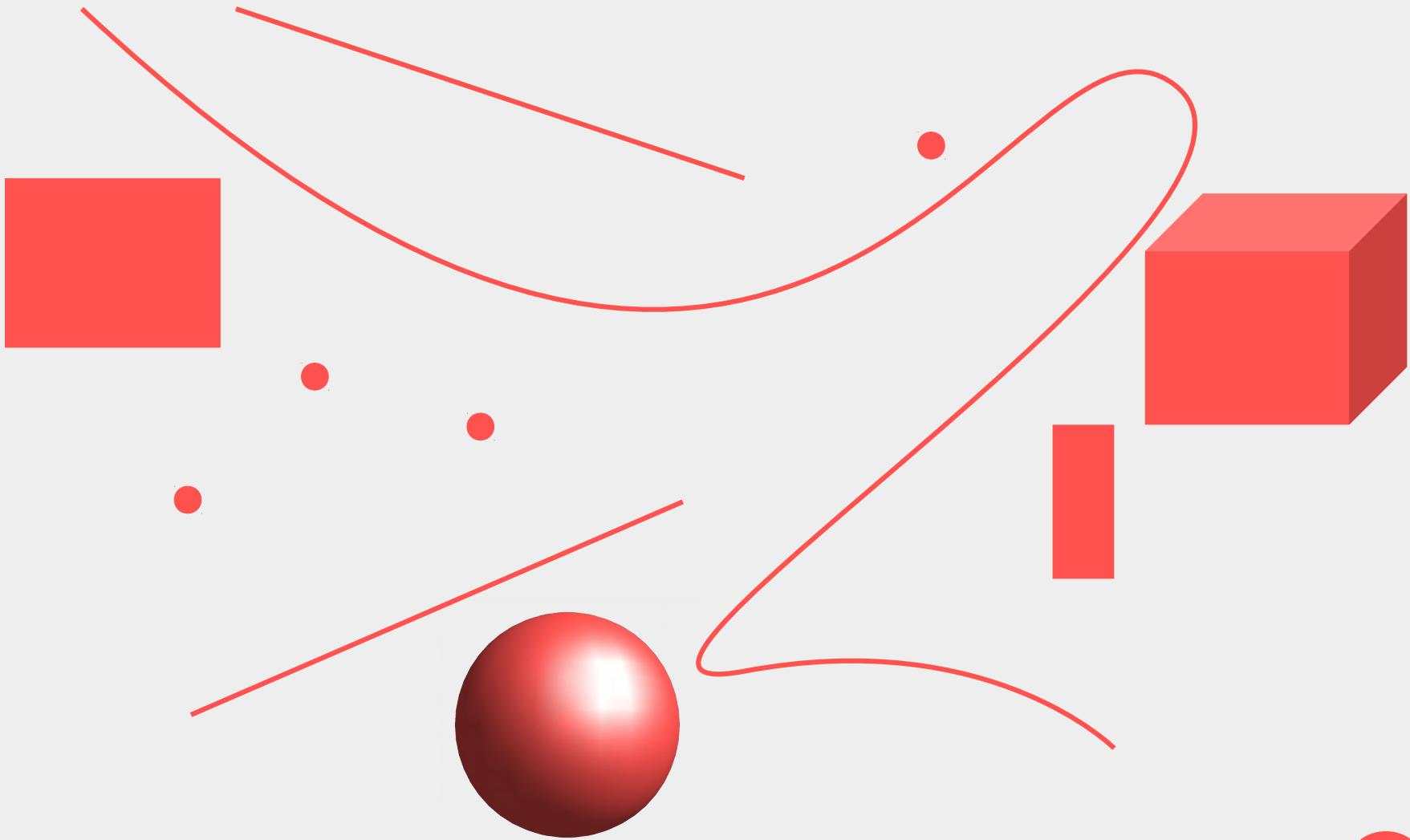
Lines



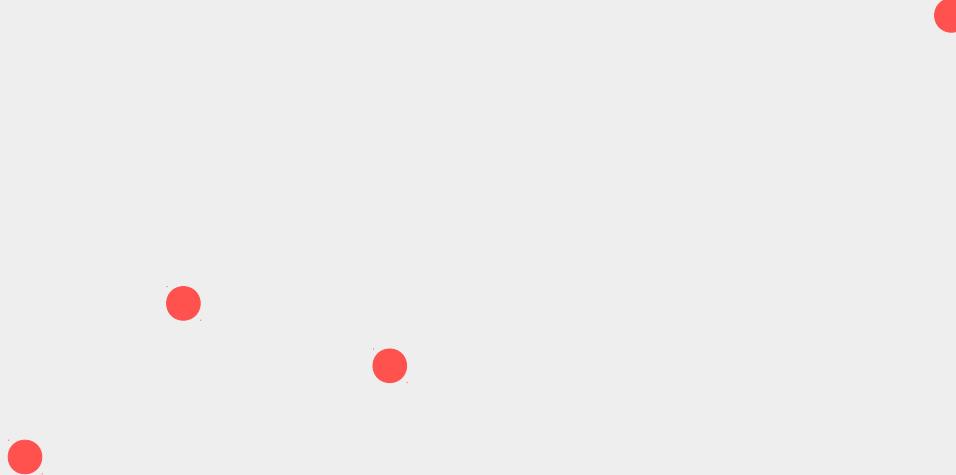
Areas



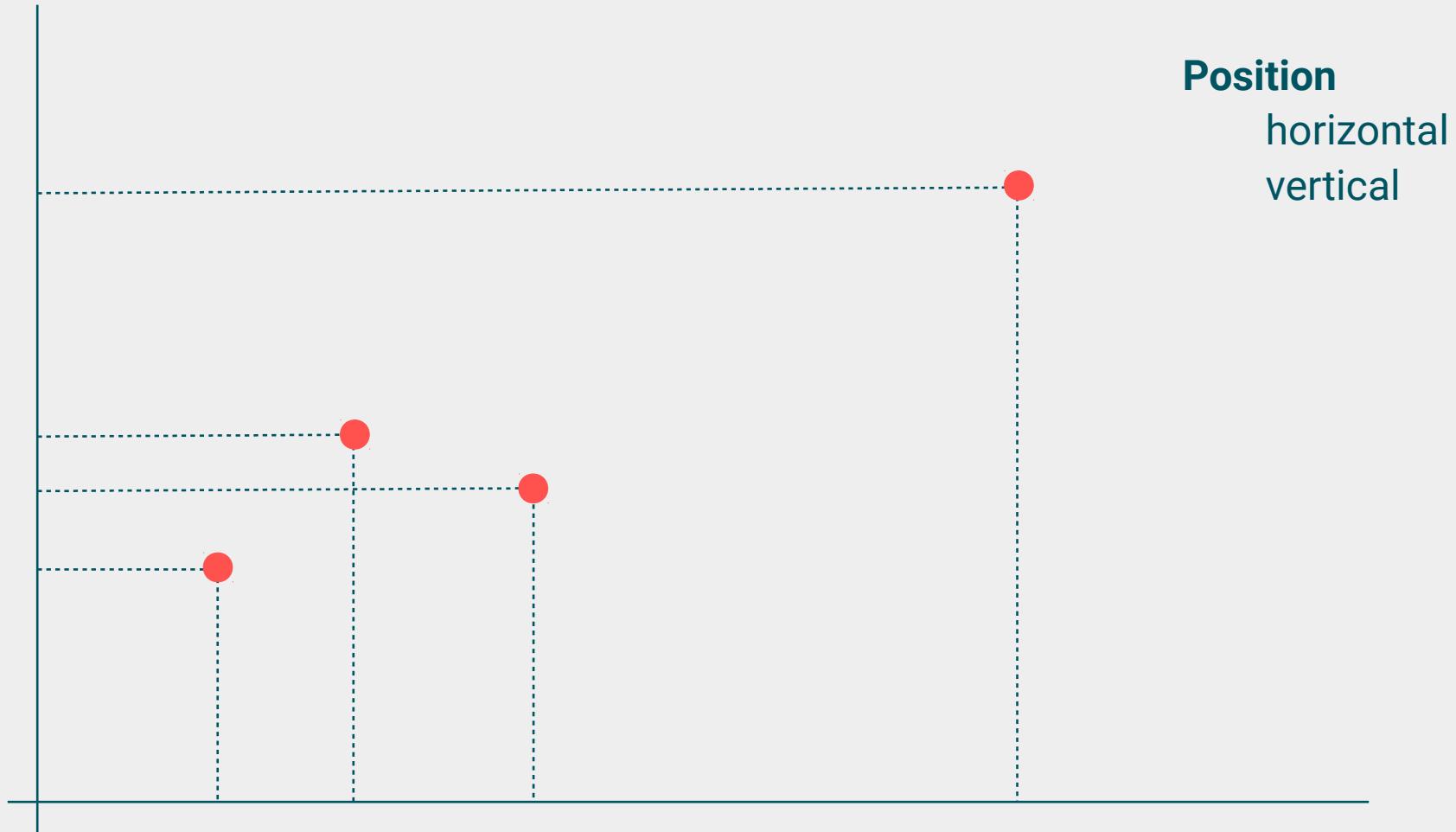
(Volumes)



Assigning marks to visual channels



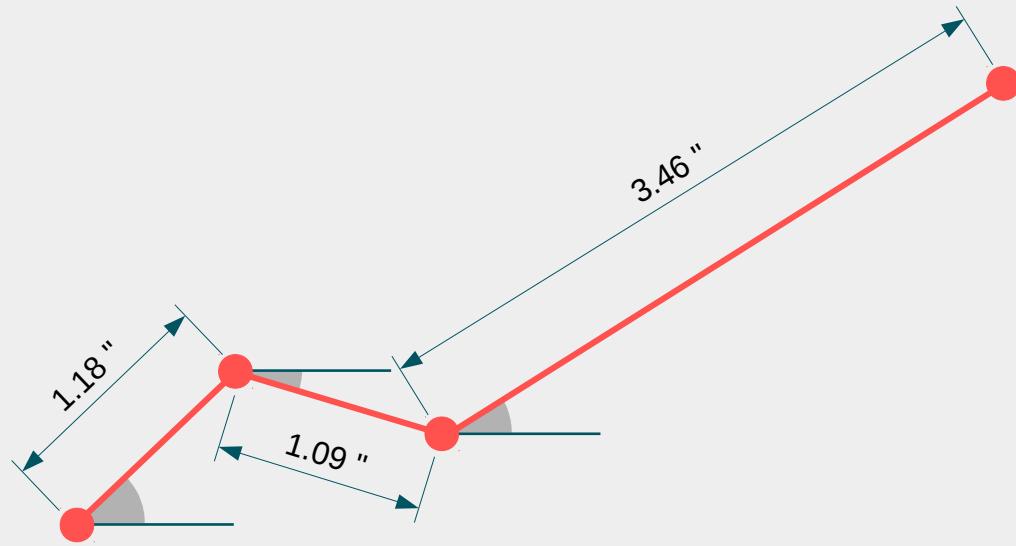
Assigning marks to visual channels



Assigning marks to visual channels



Assigning marks to visual channels



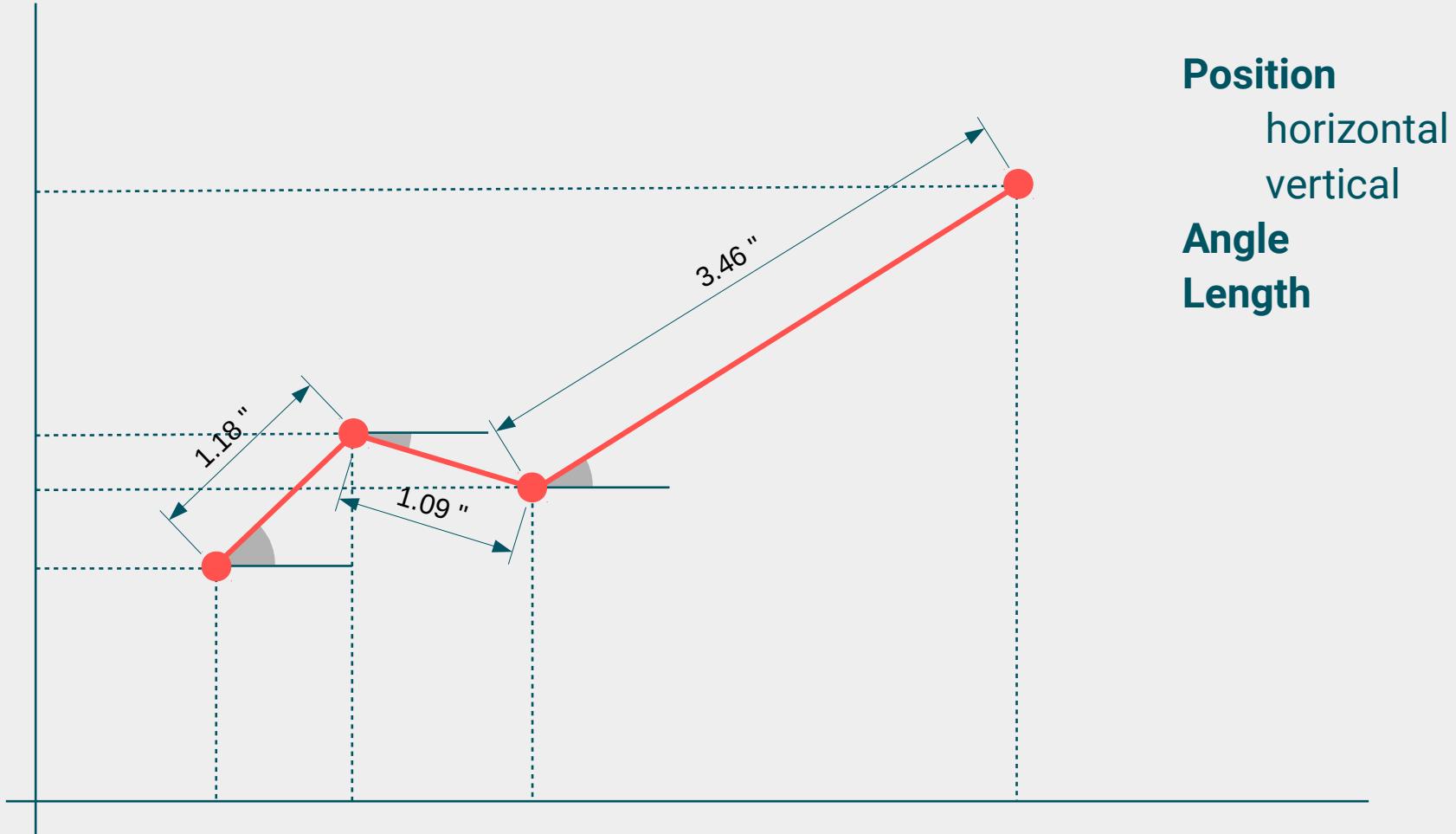
Position

horizontal
vertical

Angle

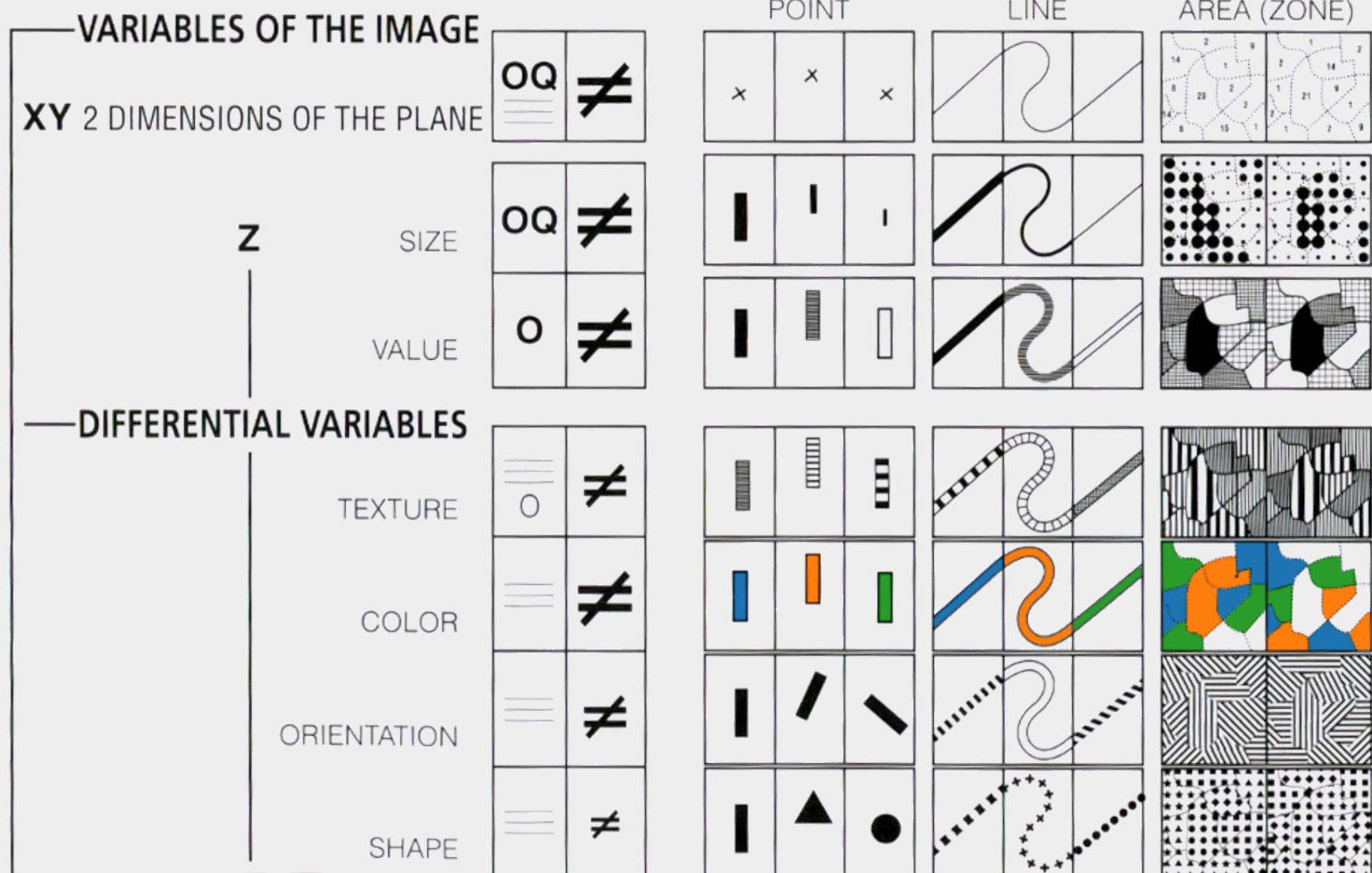
Length

Assigning marks to visual channels



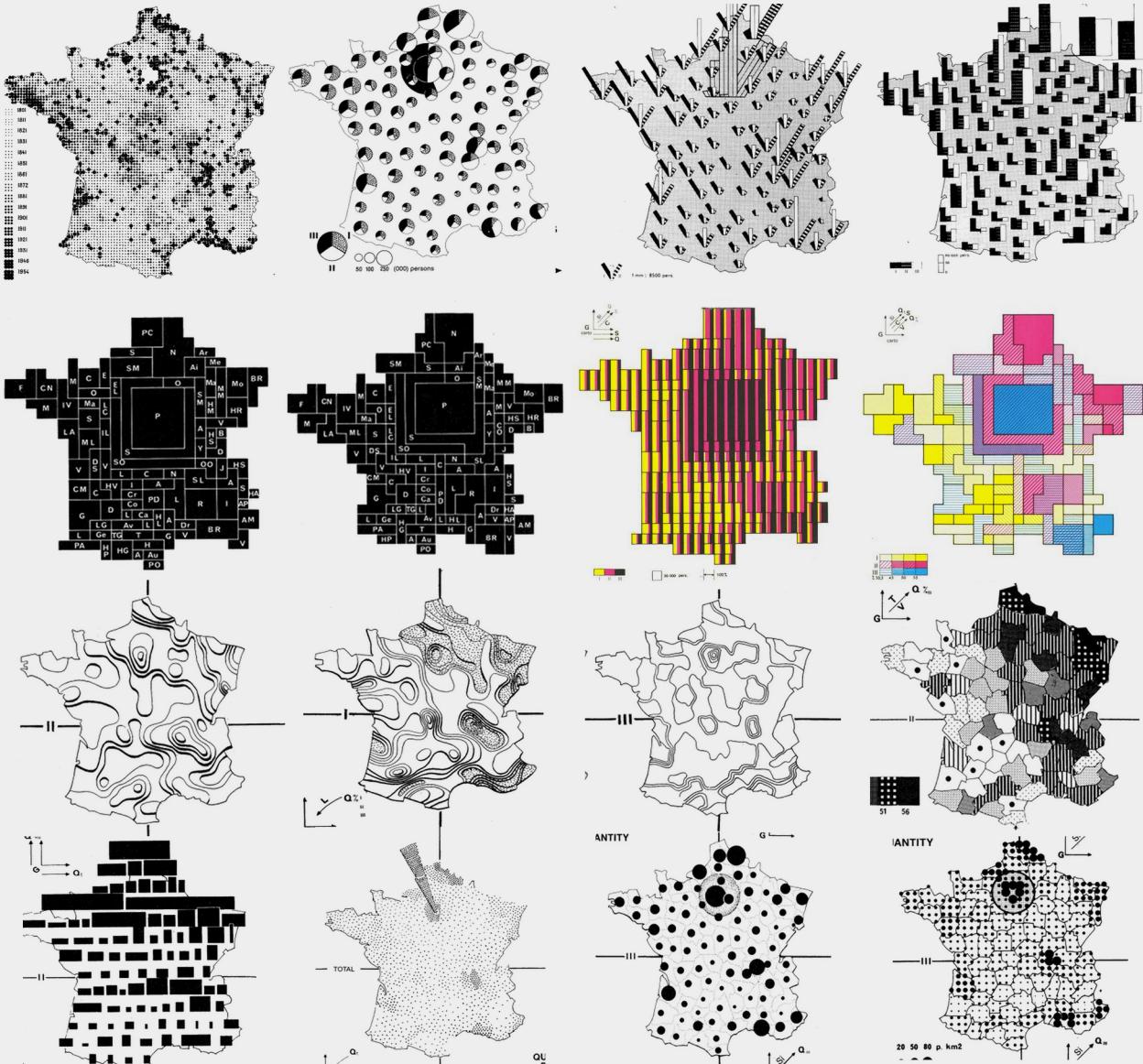
Encoding data via **Visual channels**

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



Same

Least ▲ ↑ Most

Color saturation



Same

Least ▲ ↑ Most

Curvature



Same

Least ▲ ↑ Most

Volume (3D size)



Same

Least ▲ ↑ Most

→ Identity Channels: Categorical Attributes

Spatial region



Color hue



Motion



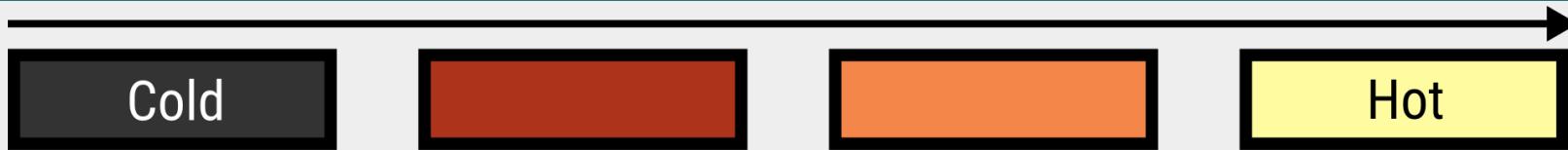
Shape



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

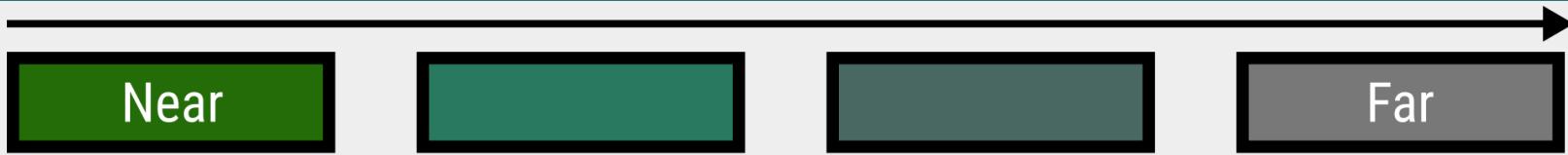
Color

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



Luminance

dark



bright

Saturation

pale



saturated

Hue

reddish

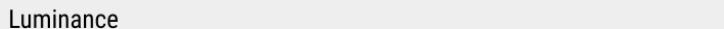


Matching color and data dimensions

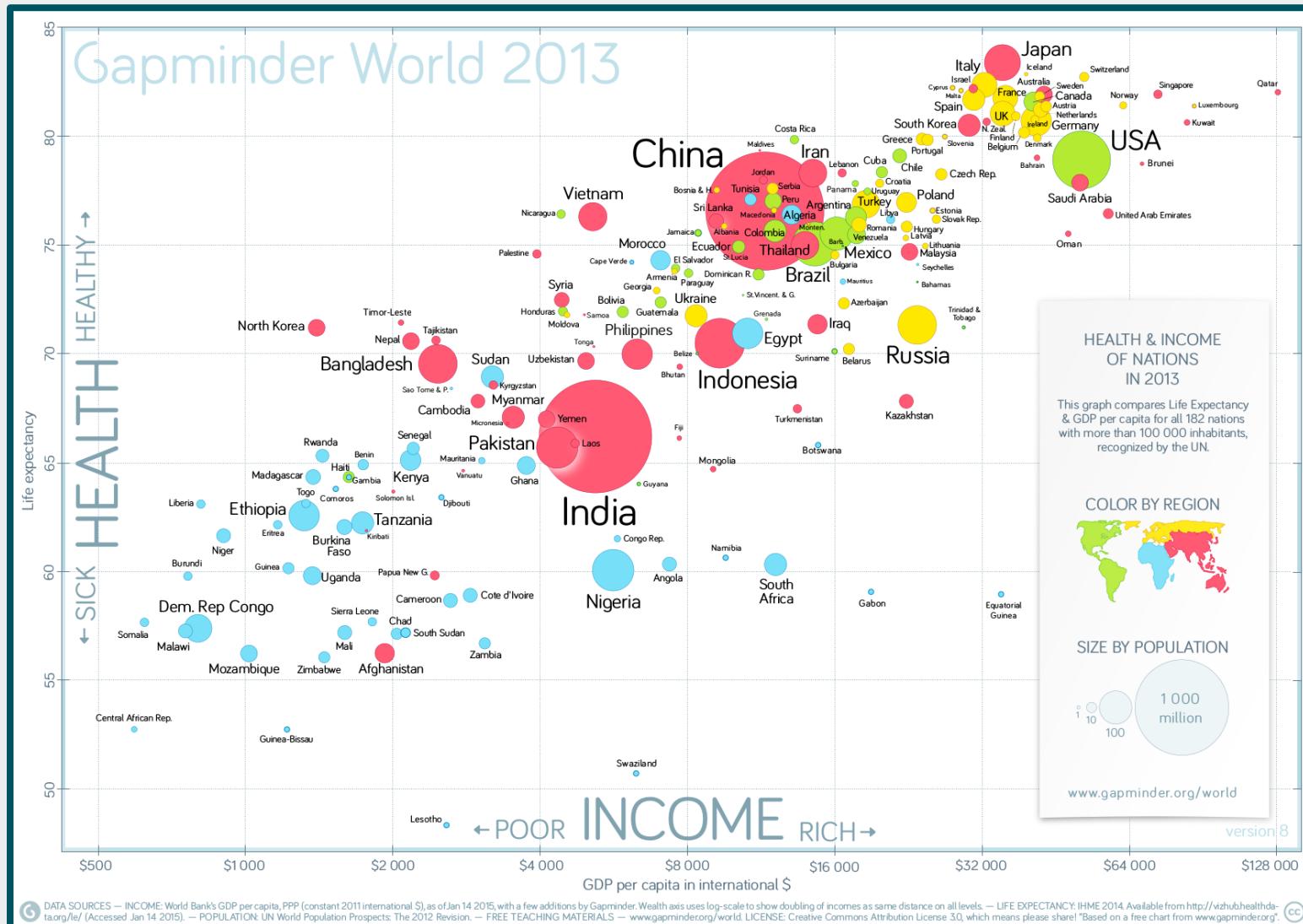
Magnitudes (ordered)



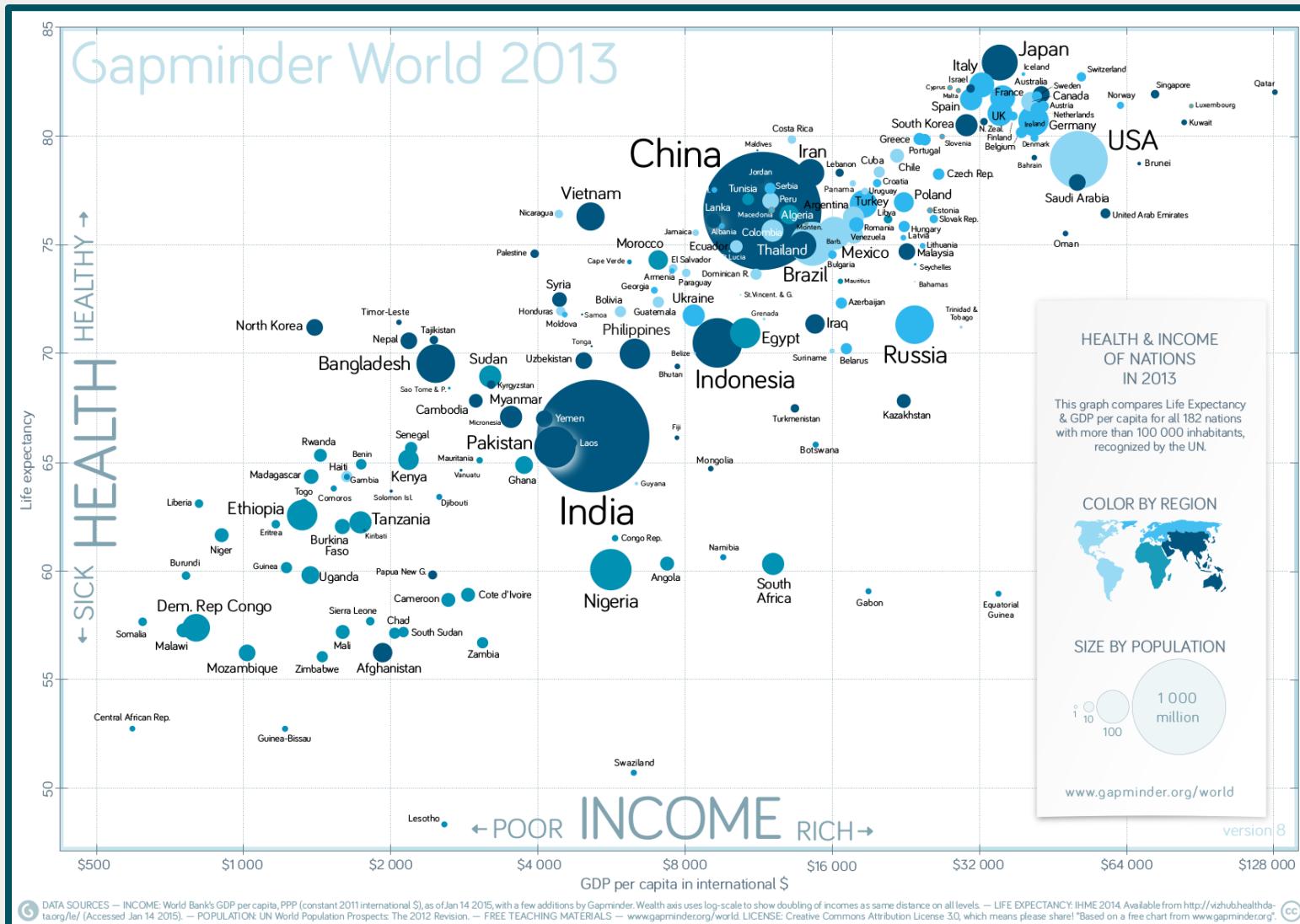
Categories (unordered)



Color-coding categories

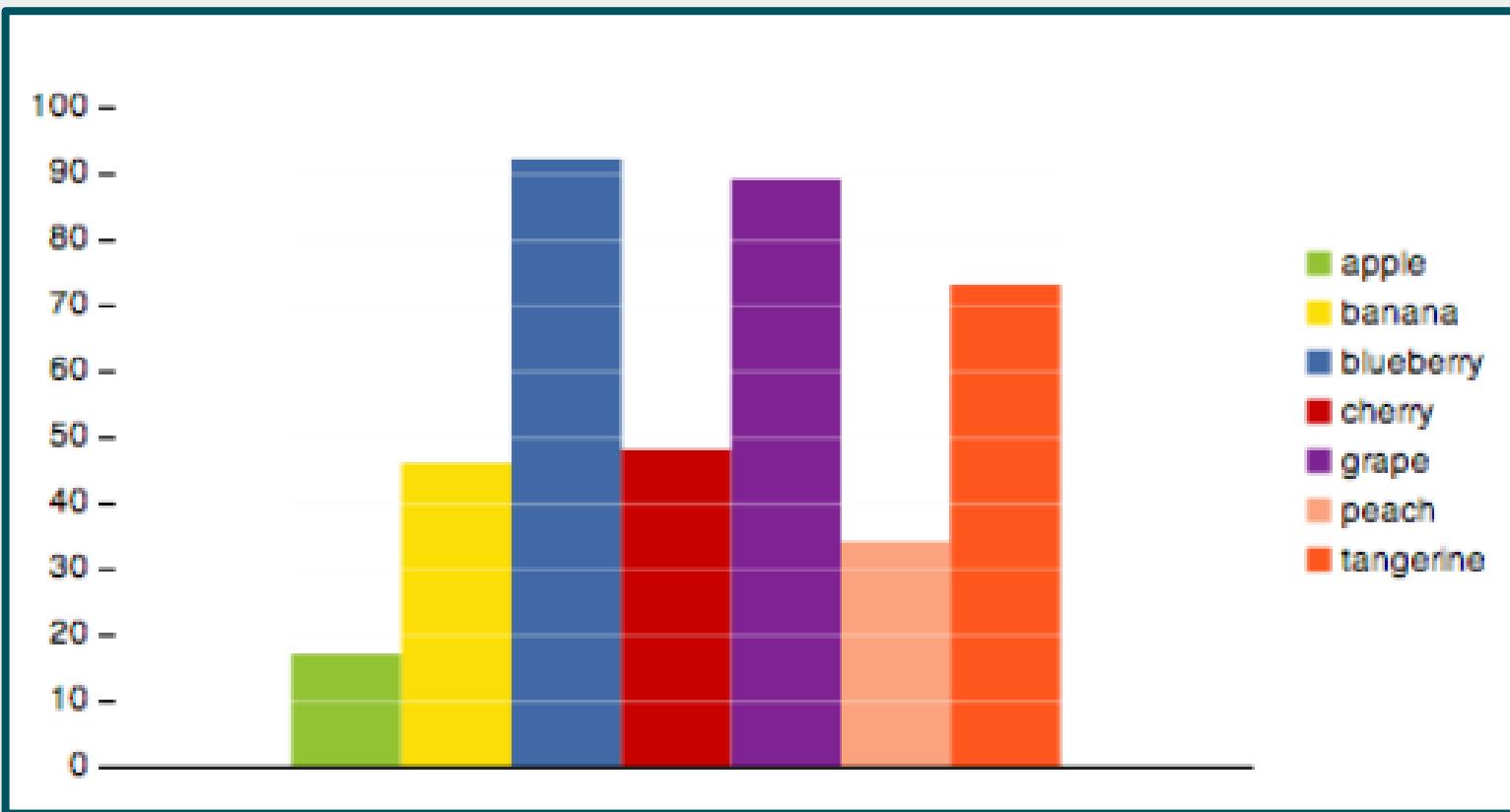


Ineffective color-coding



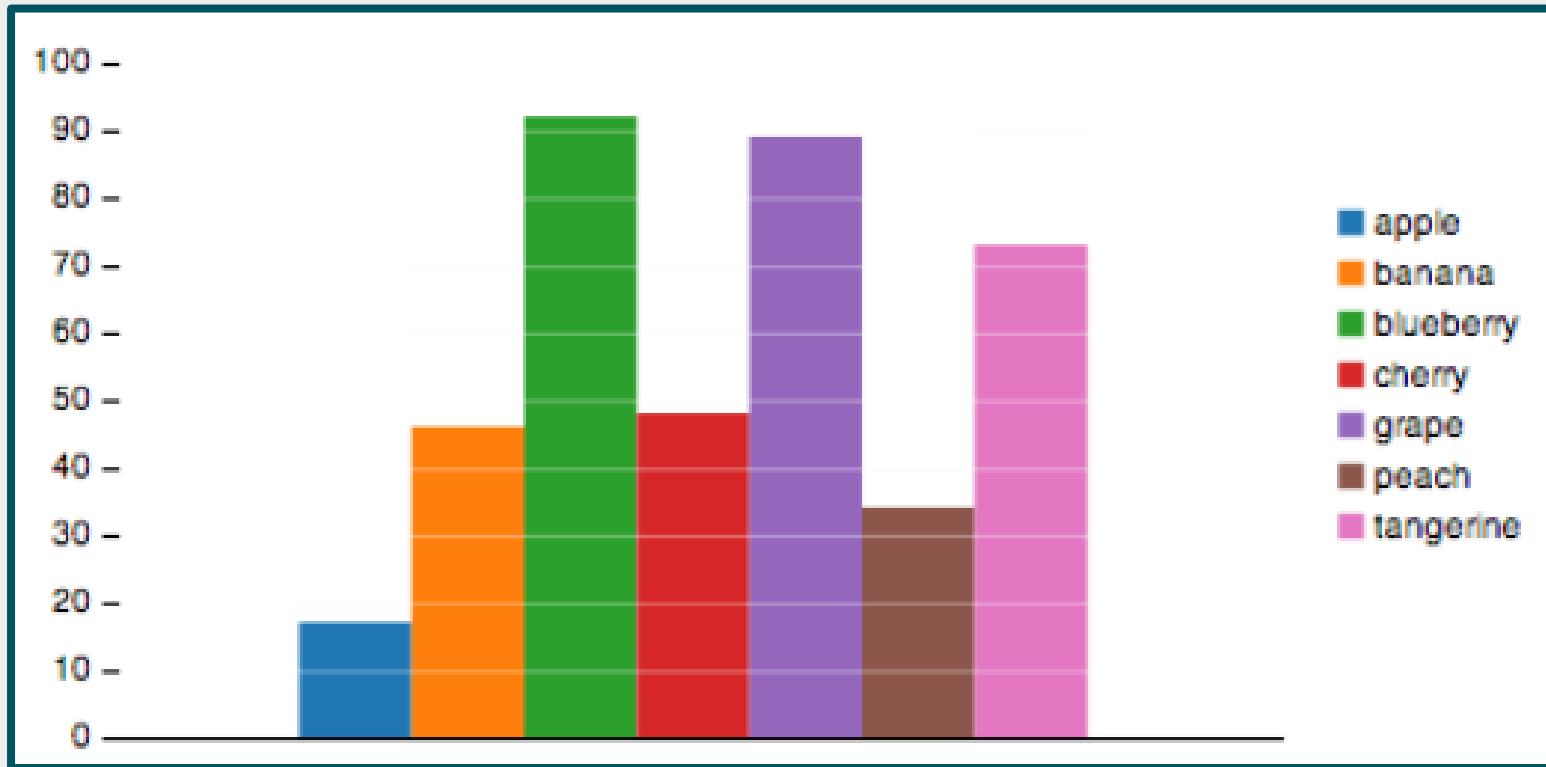
Redrawn from Gapminder World (2014).

Semantically resonant colors



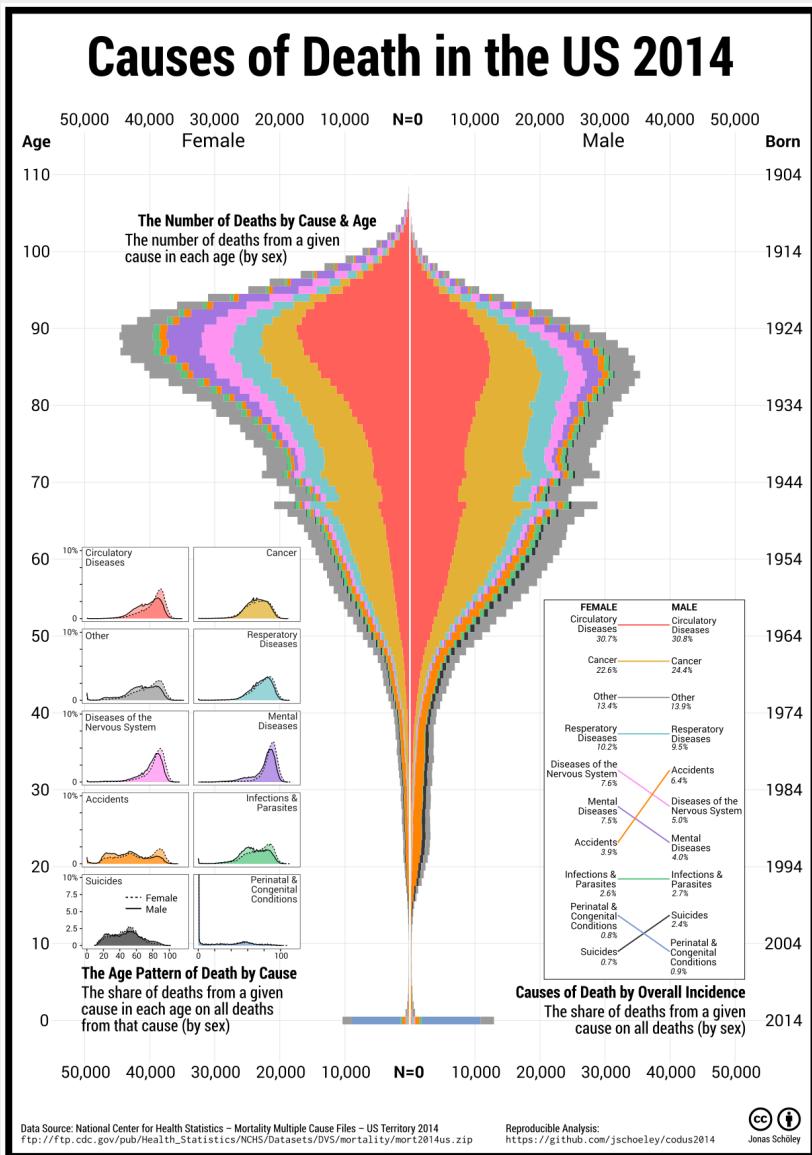
Sharon Lin et al. (2013). "Selecting Semantically-Resonant Colors for Data Visualization". In: Computer Graphics Forum 32.3, pp. 401–410.

Semantically resonant colors

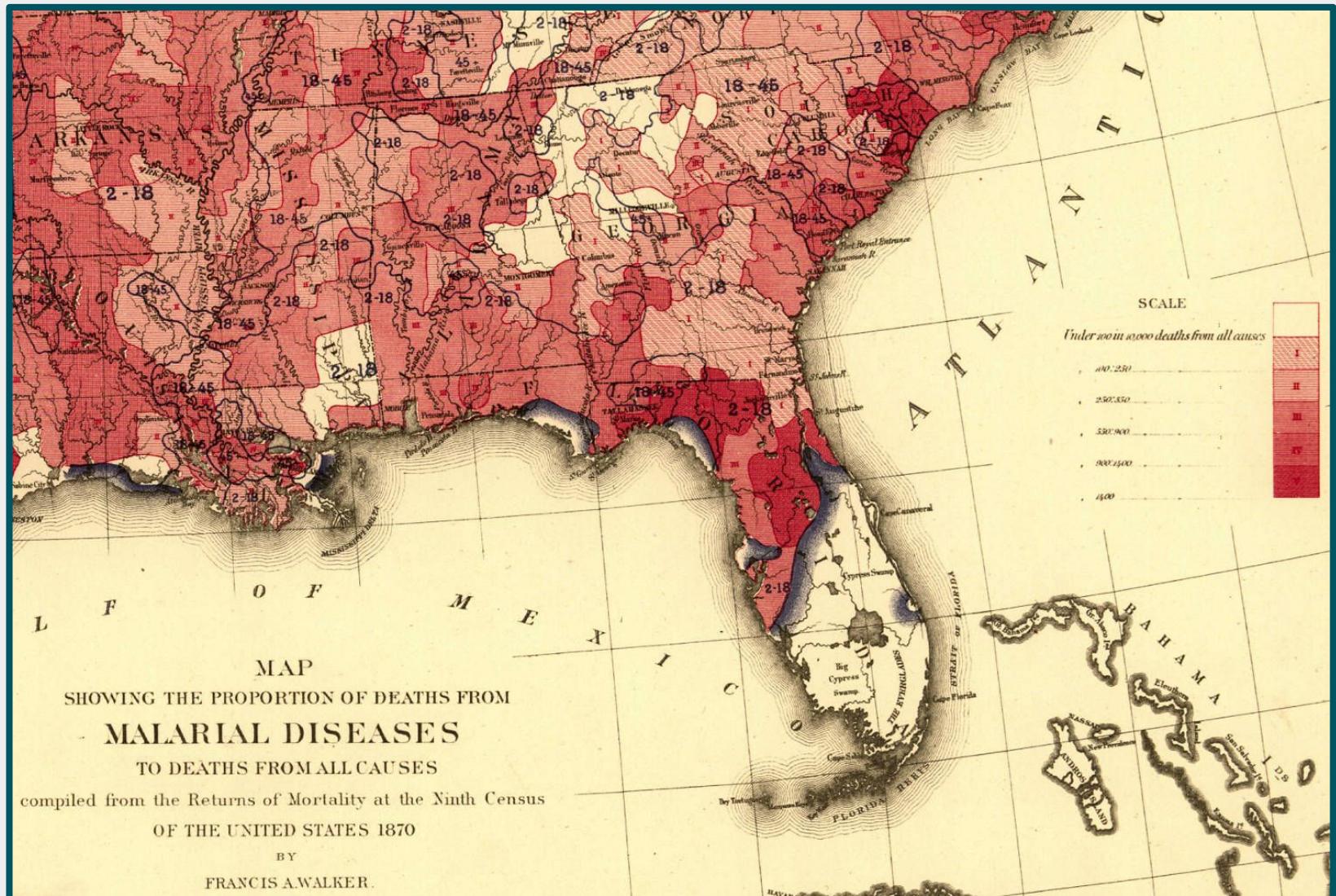


Sharon Lin et al. (2013). "Selecting Semantically-Resonant Colors for Data Visualization". In: Computer Graphics Forum 32.3, pp. 401–410.

How would you color death?

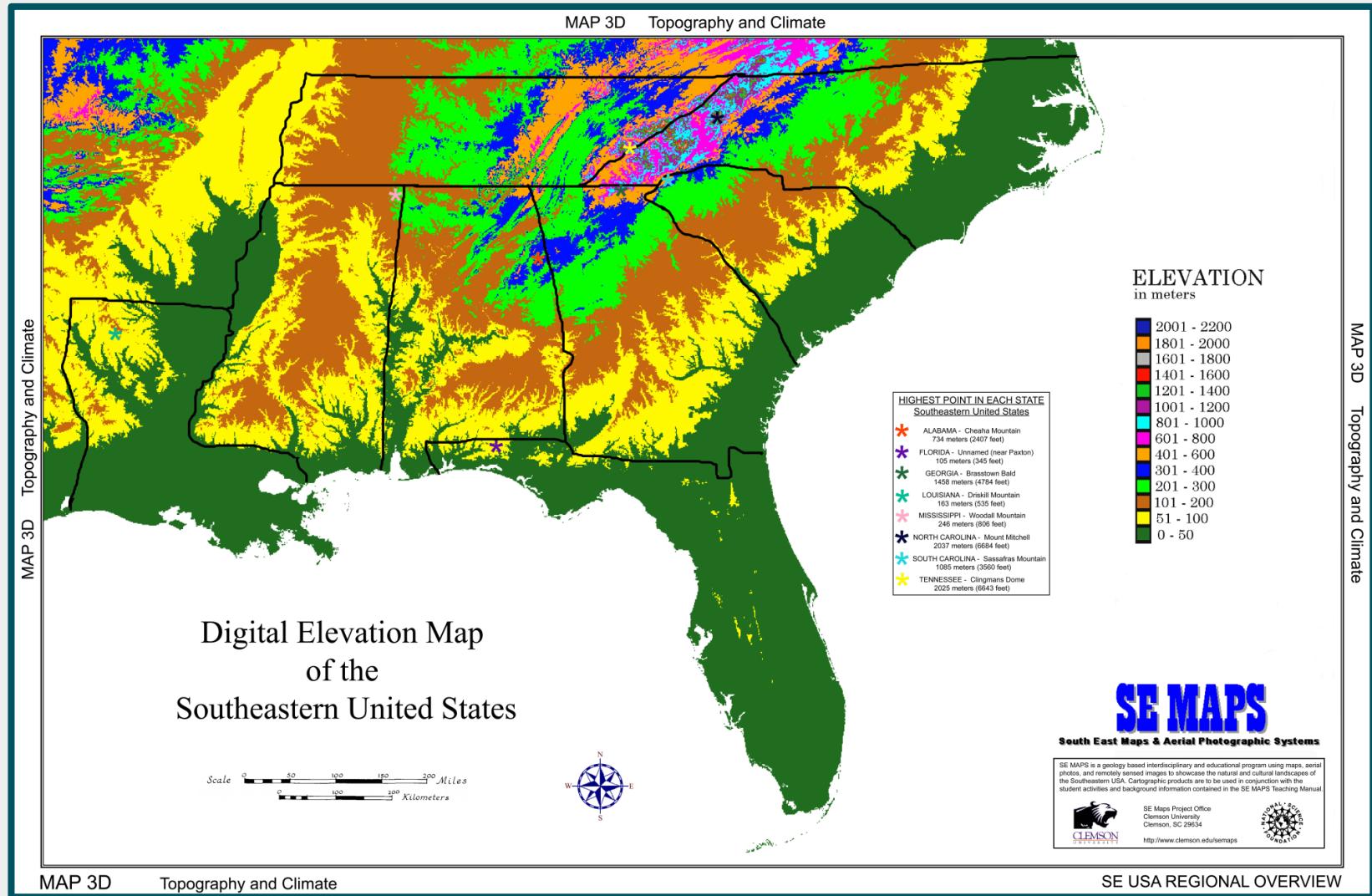


Color-coding magnitudes



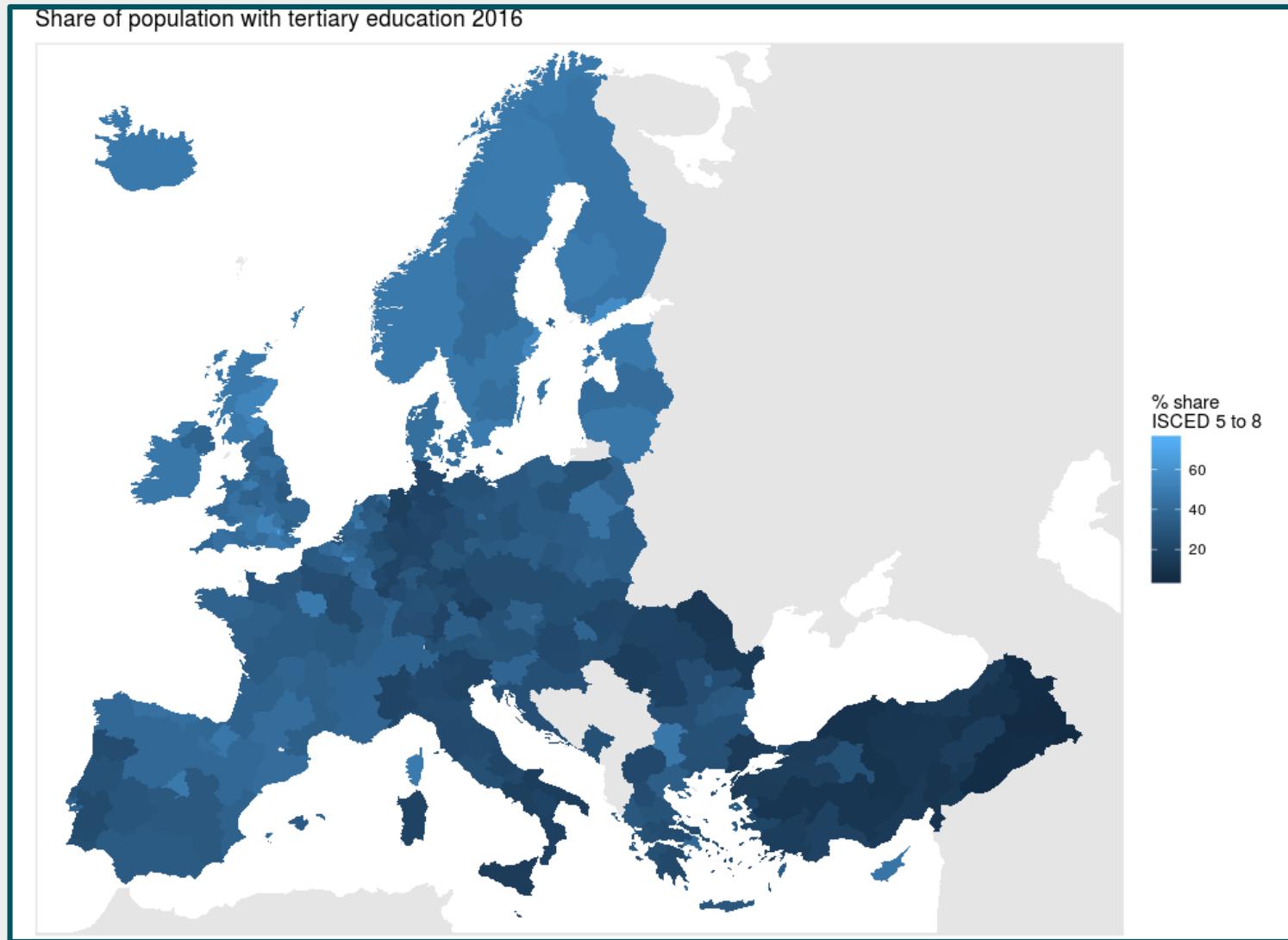
Francis Walker (1874). "Statistical Atlas of the United States" [cutout].

Ineffective color-coding

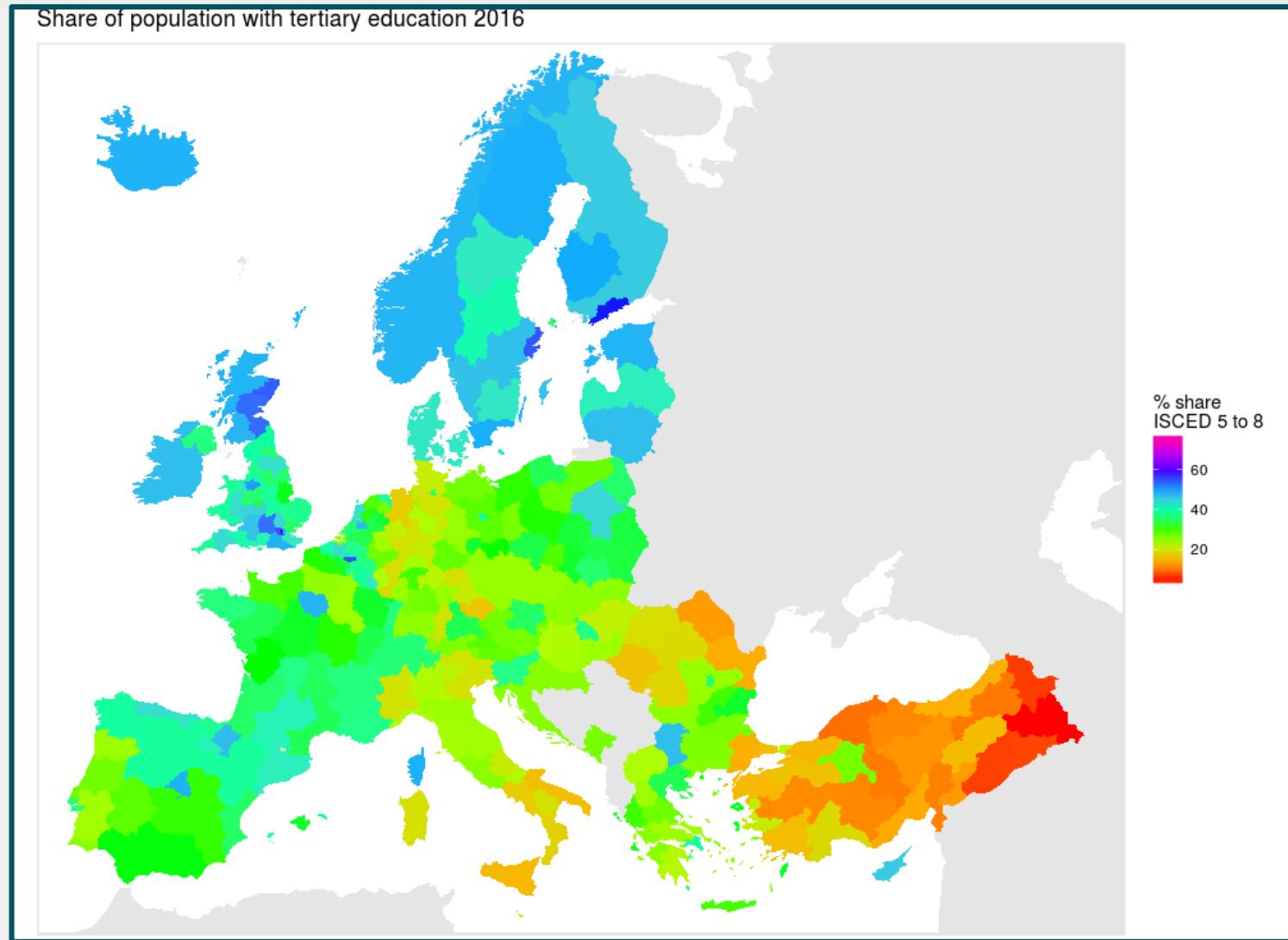


South East Maps & Aerial Photographic Systems.

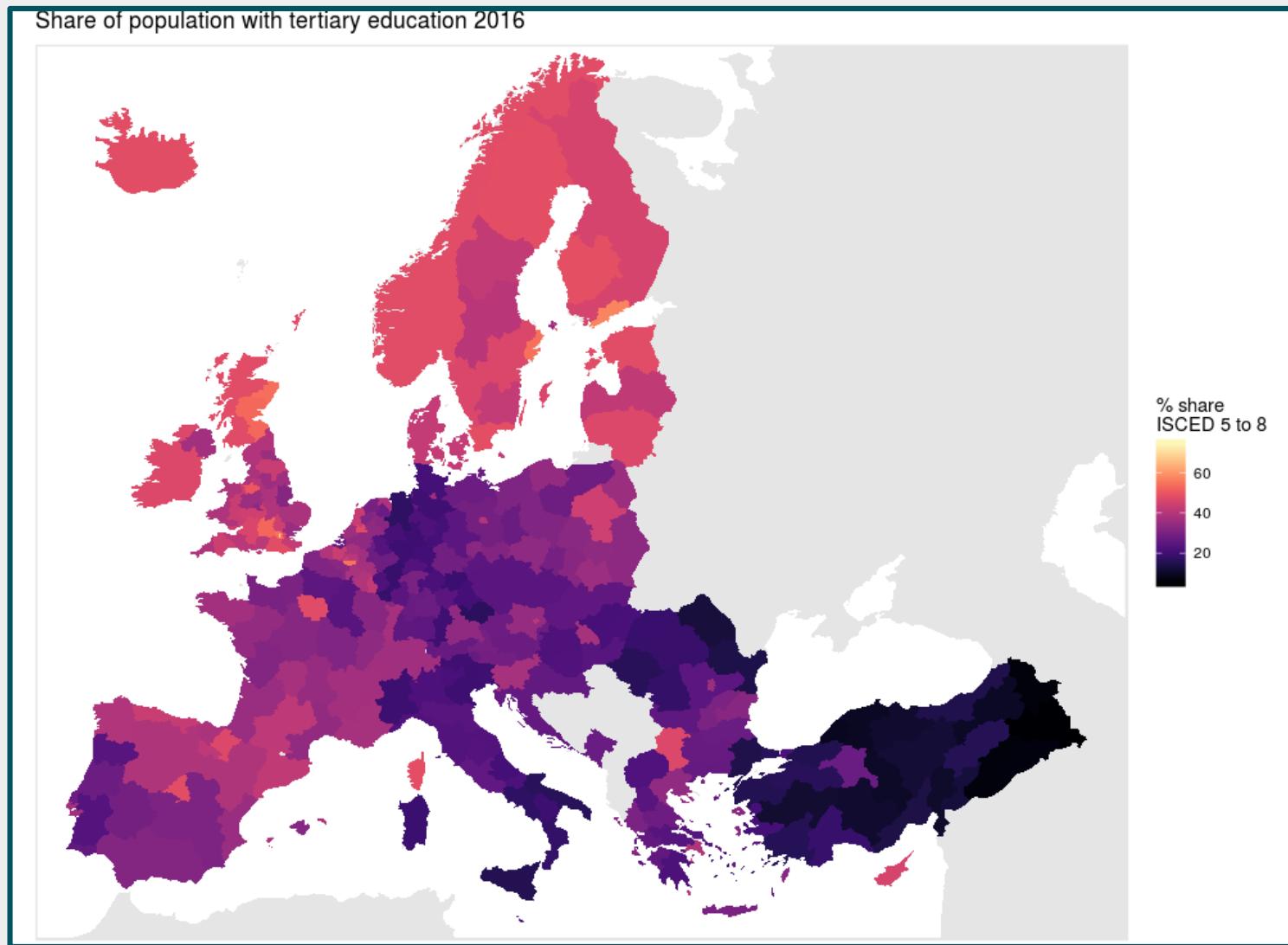
Low discriminability



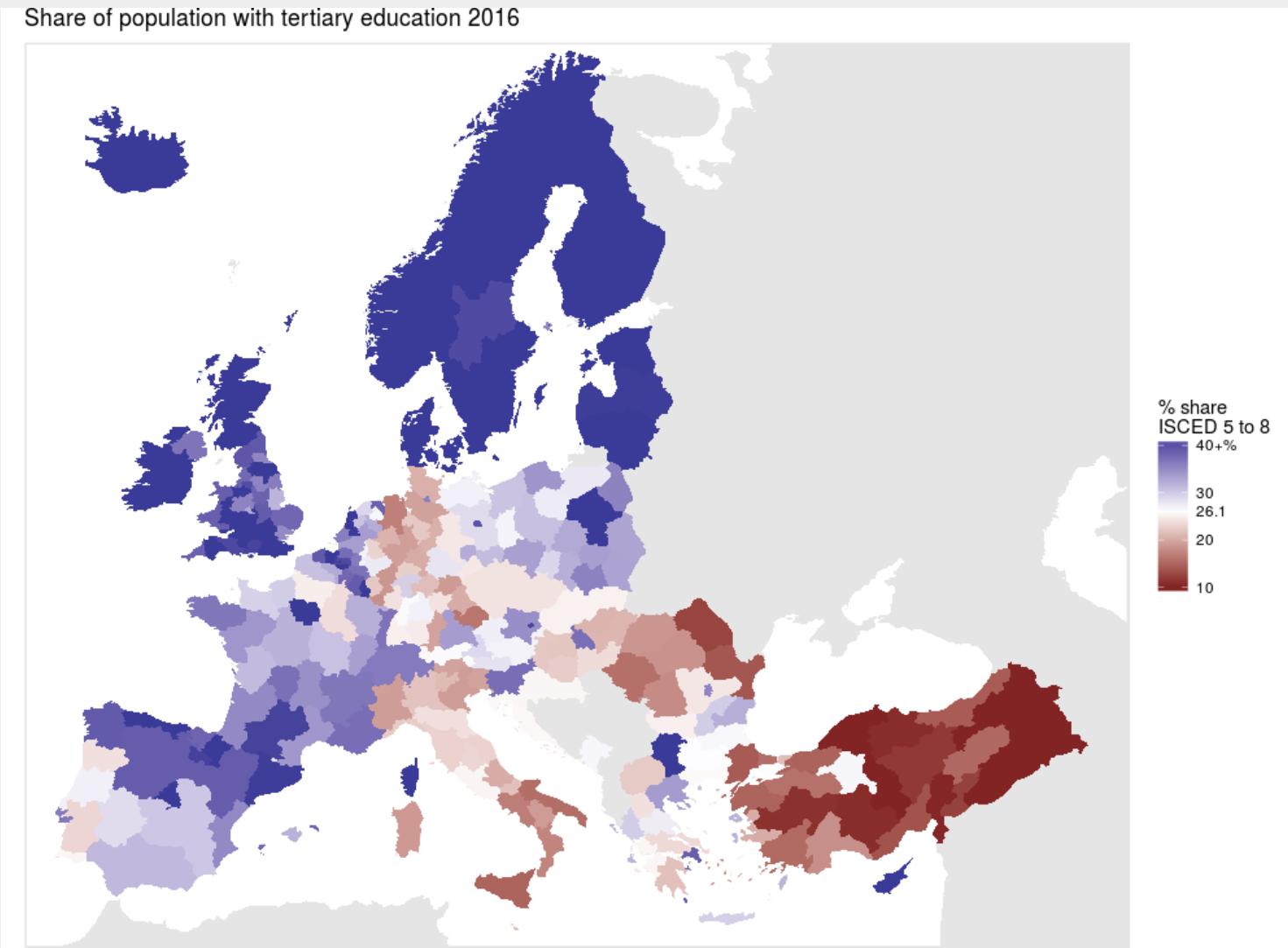
High discriminability, but unbalanced



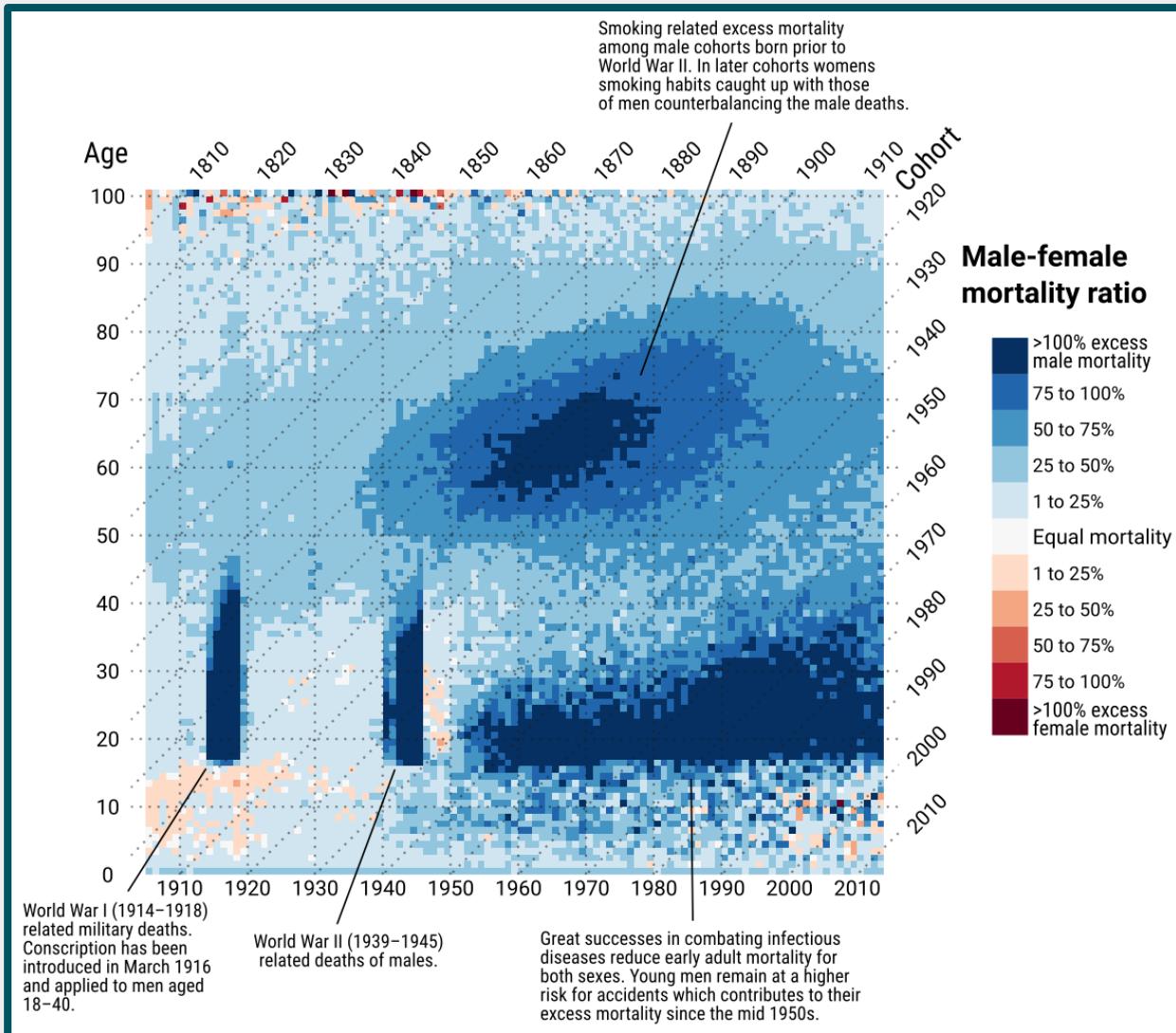
High discriminability and balanced



High discriminability, balanced, centered



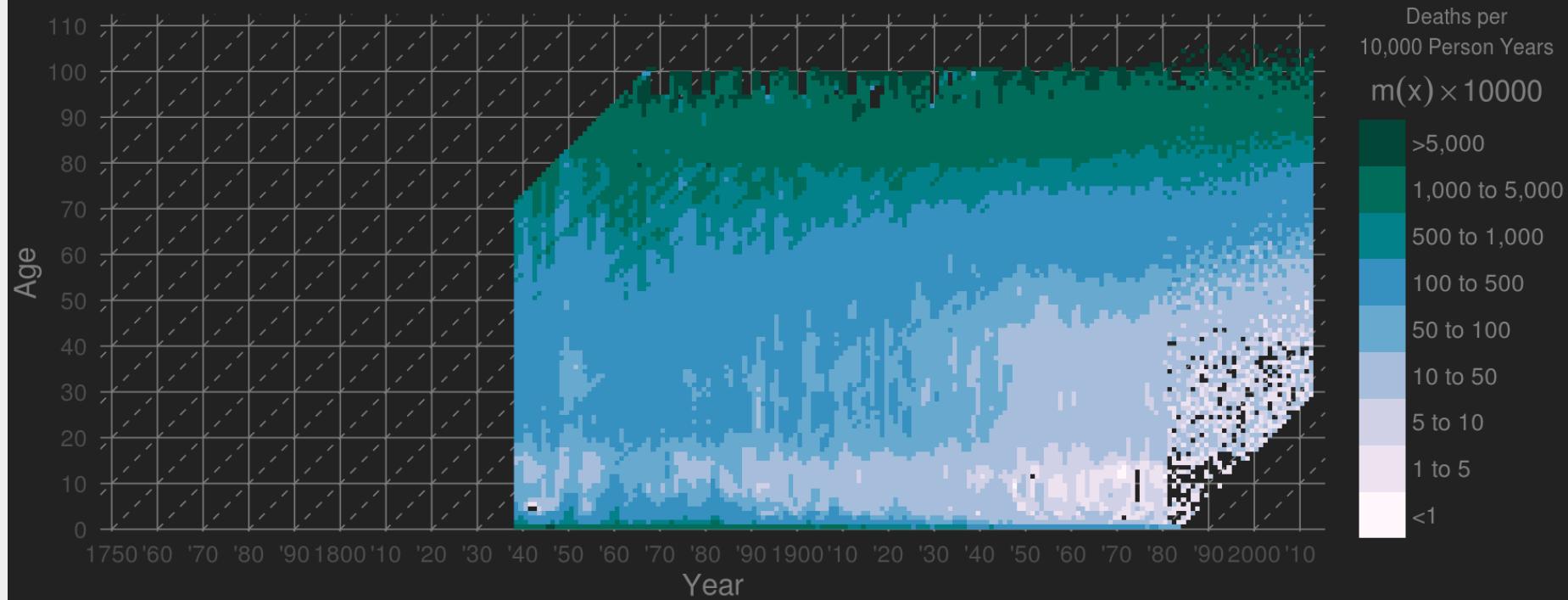
Color-coding divergent magnitudes



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

Discrete color scales

Mortality Rates of Iceland
Cohort 1838 to 2012, Male



[Jonas Schöley \(2016\). "The Human Mortality Explorer".](#)

Continuous color scales



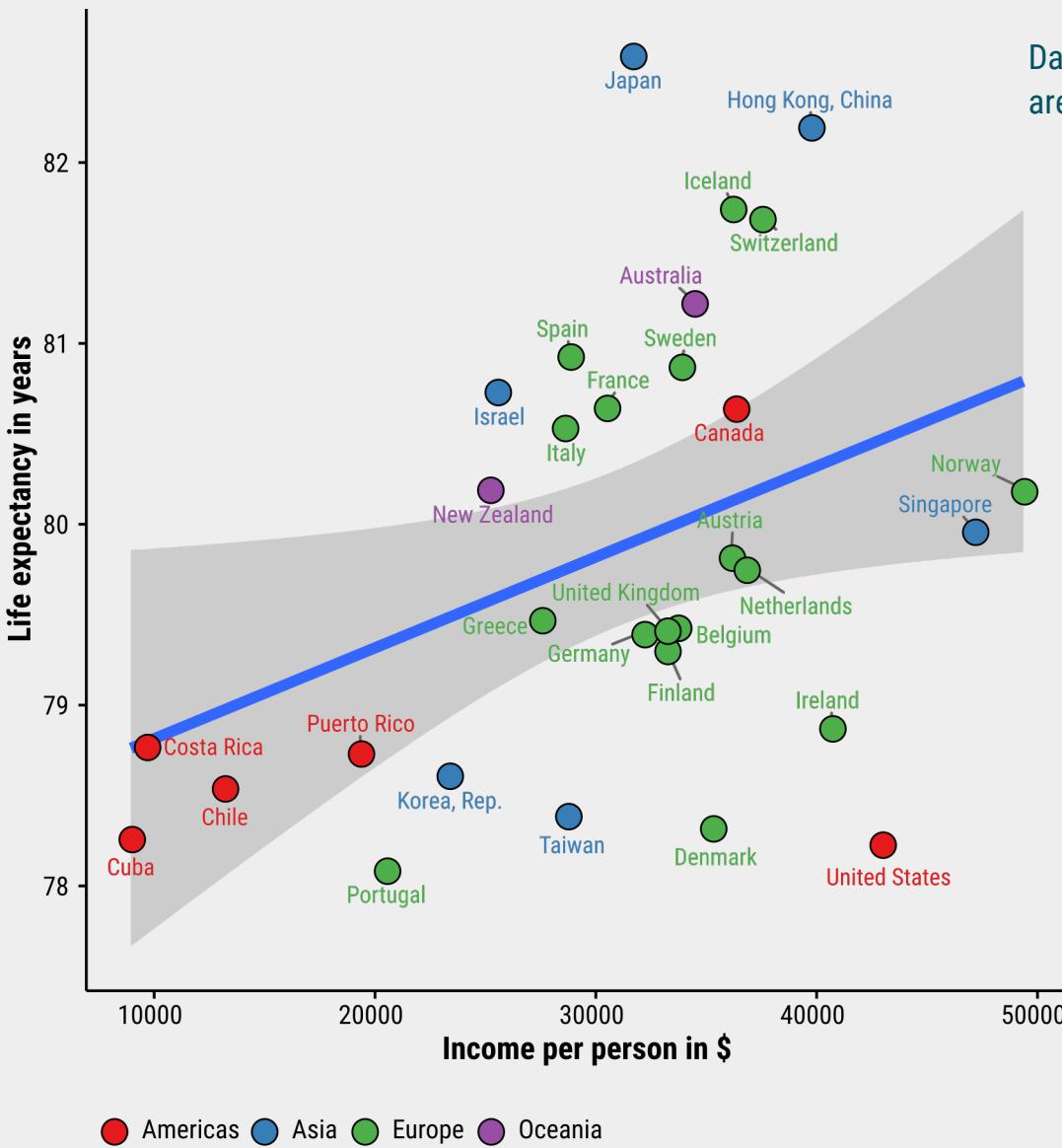
[Jonas Schöley \(2016\). "The Human Mortality Explorer".](#)

Separating foreground & background



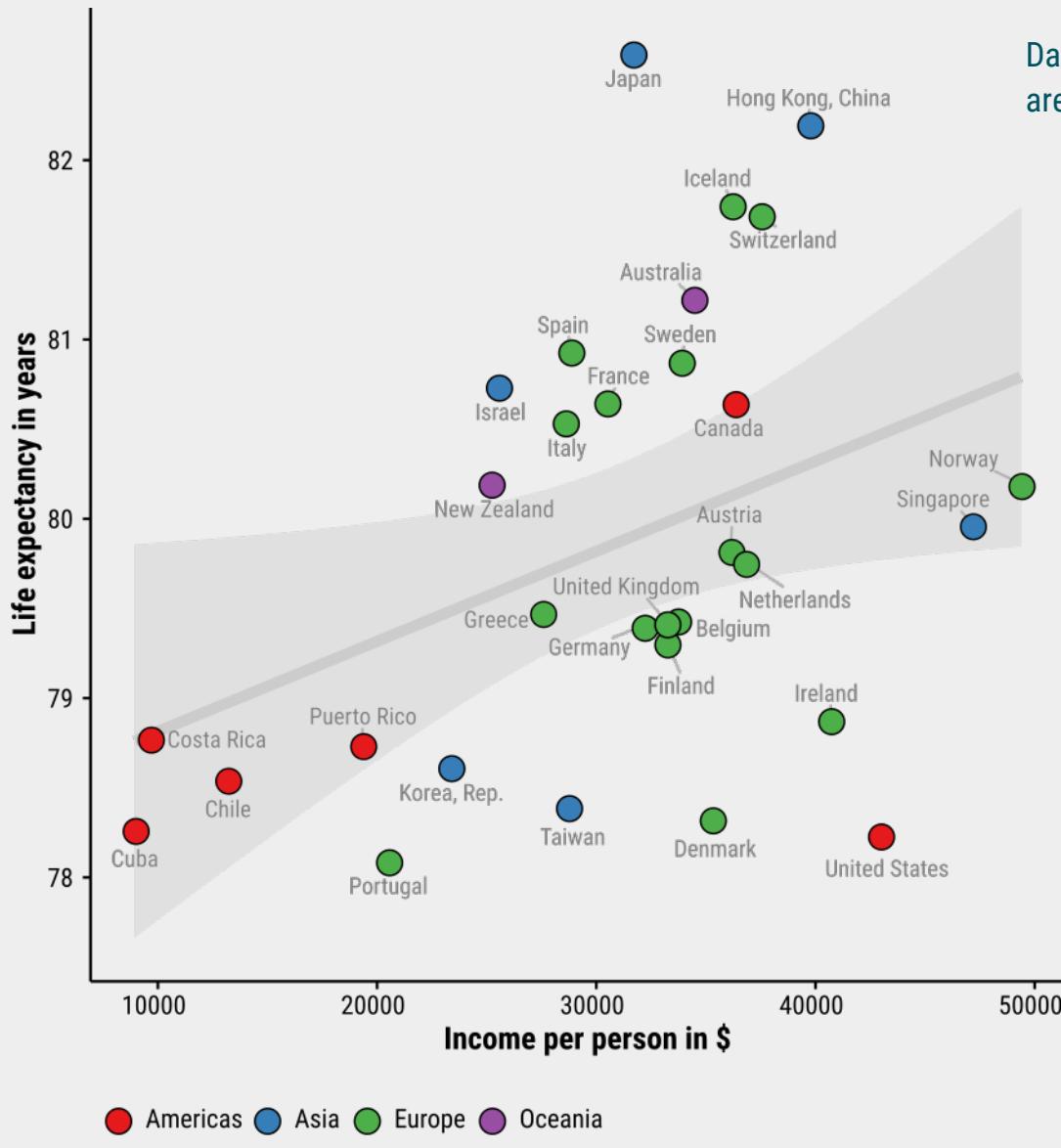
Pablo Picasso (1905). "Au Lapin Agile".

Separating foreground & background



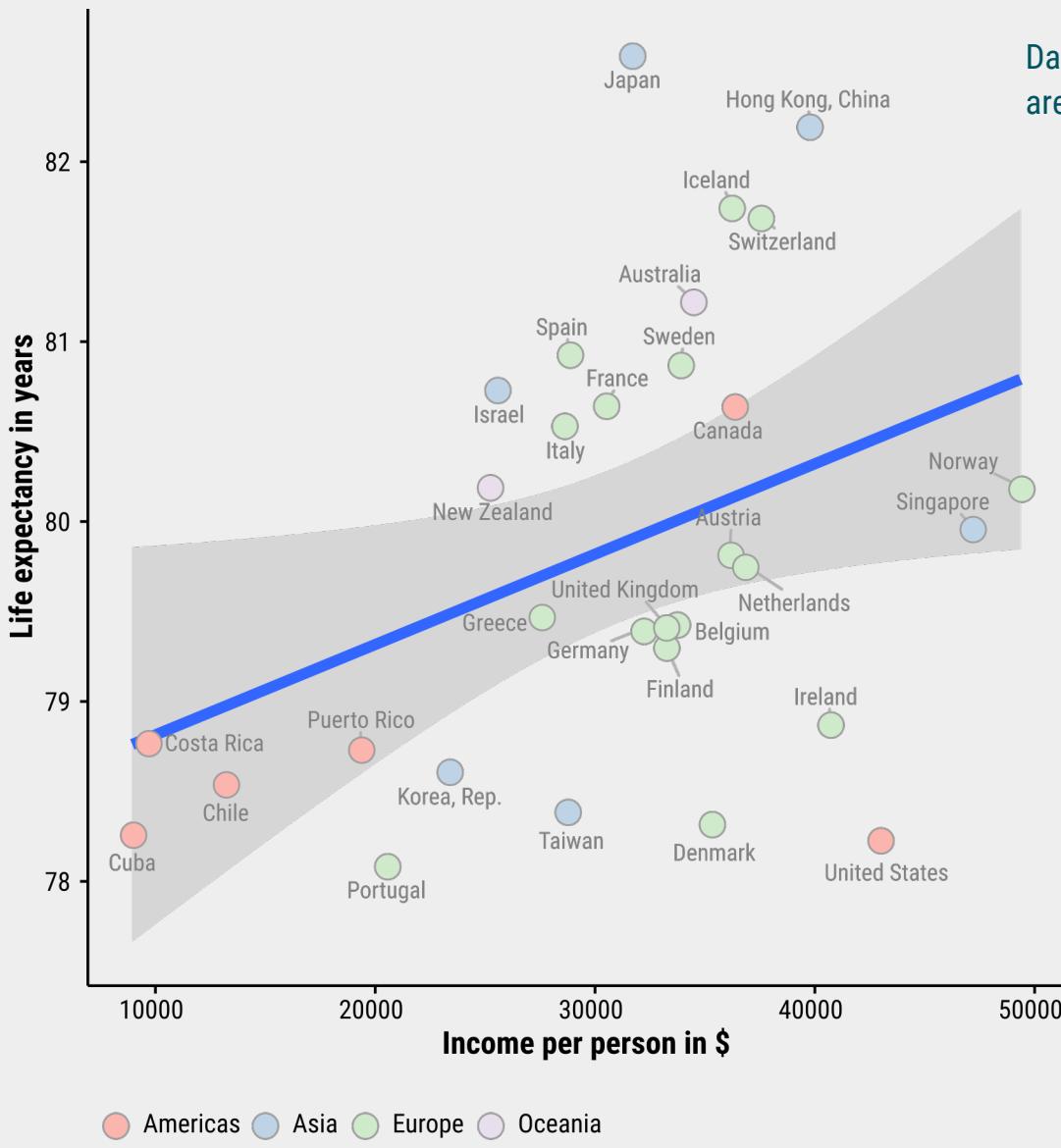
Data: gapminder.org – displayed are data for the year 2007.

Separating foreground & background

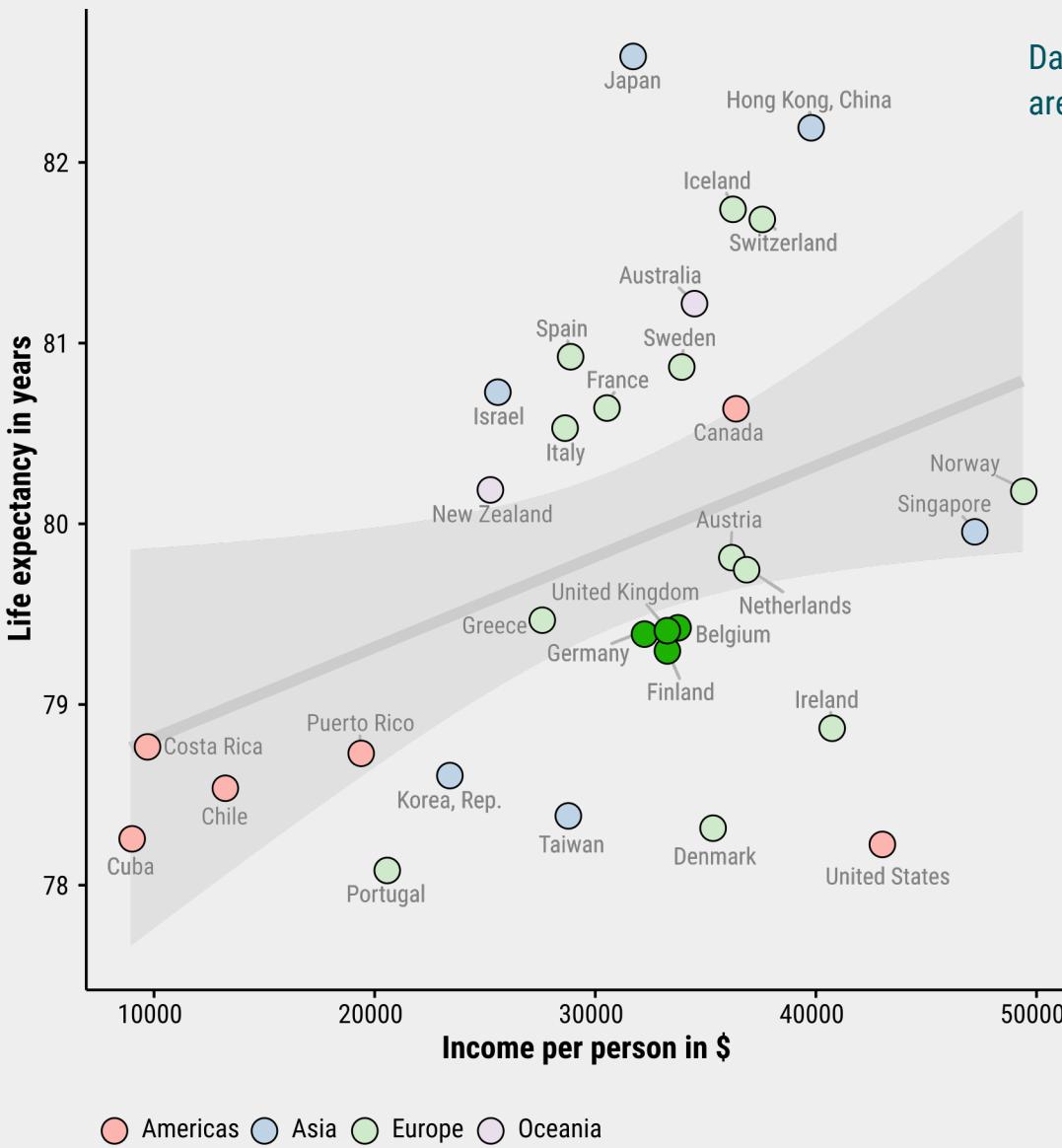


Data: gapminder.org – displayed are data for the year 2007.

Separating foreground & background



Separating foreground & background



Further reading

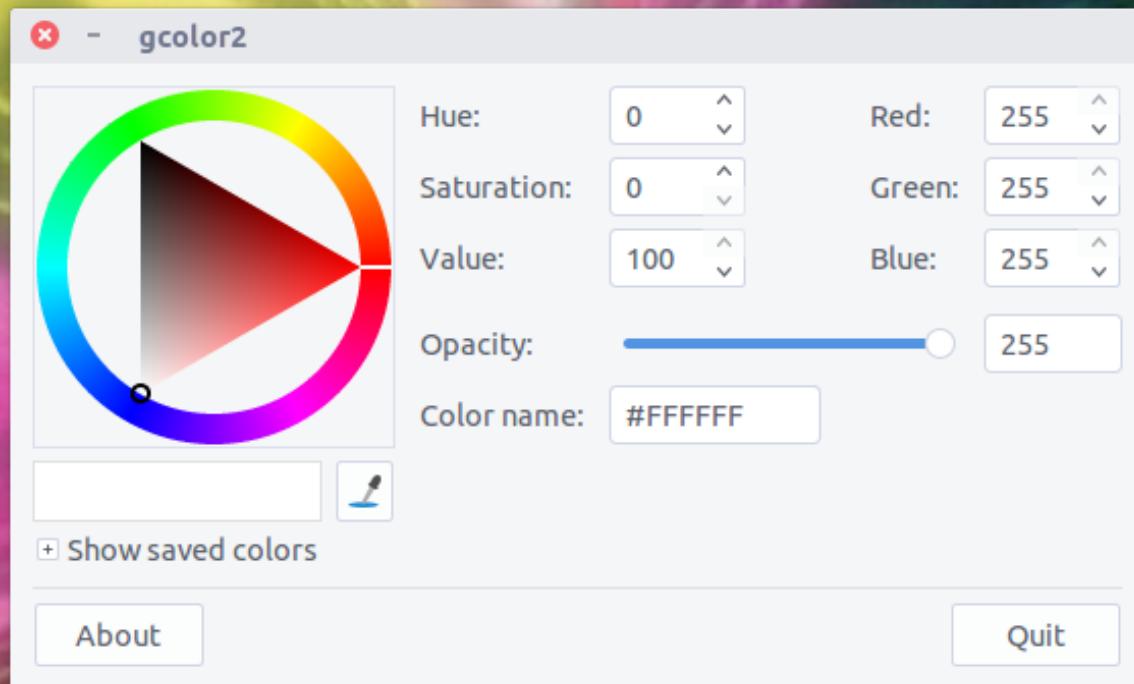
Brilliant color advice from NASA

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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