Using Visual Perception

to find patterns in data and drive insight

help others

Alex Gurvich, Ph.D.
NASA Scientific Visualization Studio
R Gov. & Public Sector, Oct. 29, 2024

Using Visual Perception

to find patterns in data and drive insight

help others

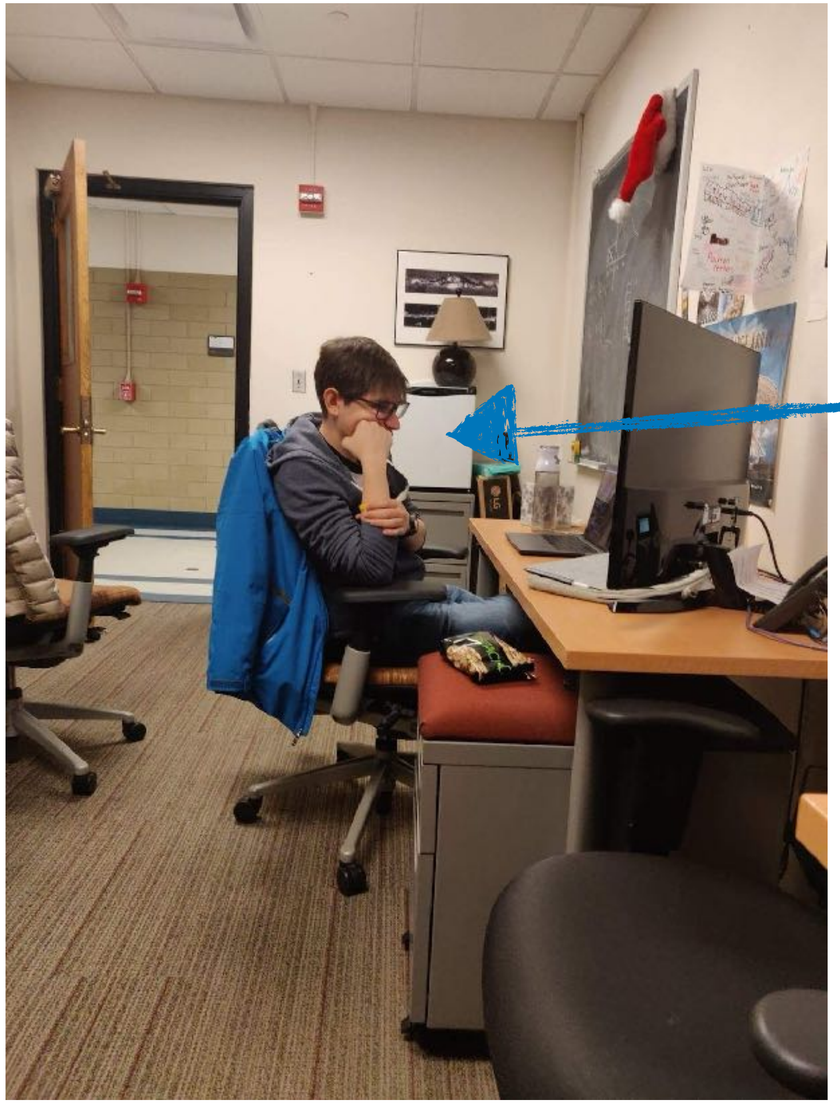
a.k.a. a book report evangelizing the work of Northwestern professor Steve Franconeri's

Visual Thinking Lab

We study visual thinking: how it works, and how education + design can make it work better.

Alex Gurvich, Ph.D.
NASA Scientific Visualization Studio
R Gov. & Public Sector, Oct. 29, 2024

When I was in grad school I attended a workshop and saw one of Steve's presentations and it inspired me to become a data visualizer.



me in grad school @ NU on my way to deciding to become a data visualizer

Humans are hardwired to quickly process visual information for aggregate stats, as visualizers we want to take advantage of this.

without even having to focus, your brain has turned on a powerful parallel processing engine to analyze the photo on the right.

Humans are hardwired to quickly process visual information for aggregate stats, as visualizers we want to take advantage of this.

without even having to focus, your brain has turned on a powerful parallel processing engine to analyze the photo on the right.

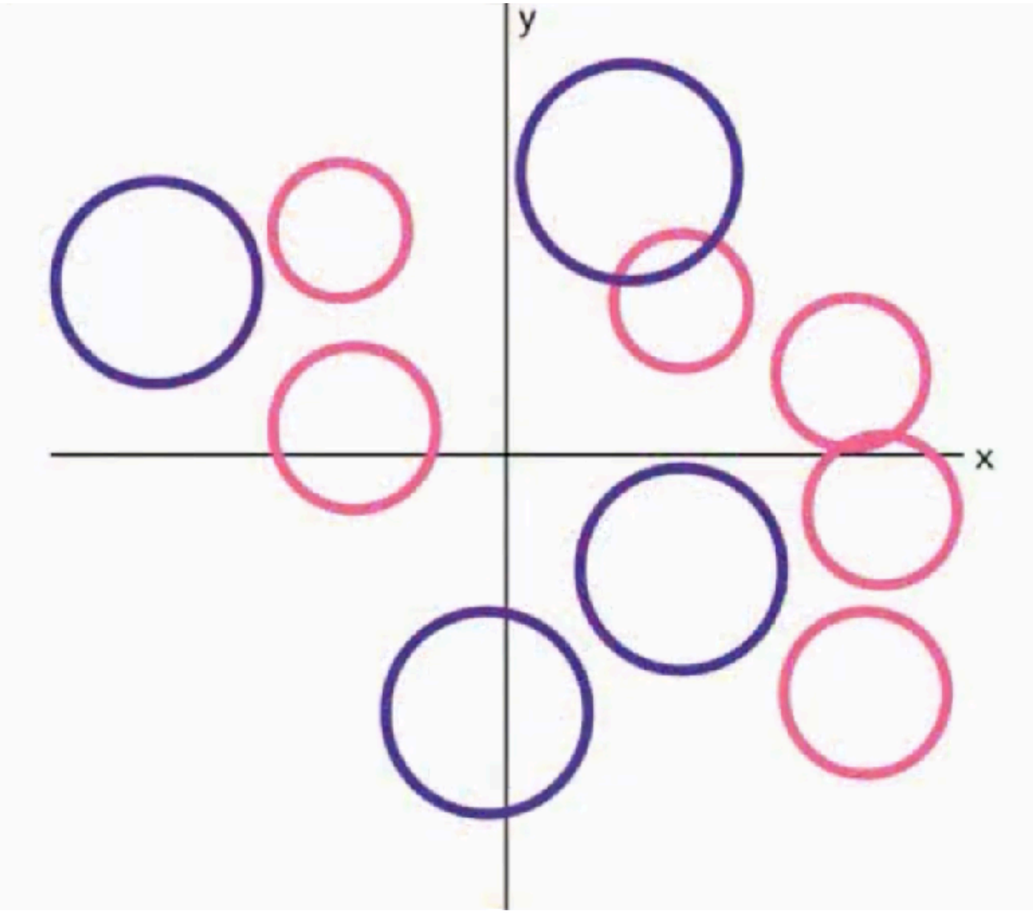
you can quickly and automatically identify clusters, relative sizes, and the overall number of objects.

Humans are hardwired to quickly process visual information for aggregate stats, as visualizers we want to take advantage of this.

without even having to focus, your brain has turned on a powerful parallel processing engine to analyze the photo on the right.

you can quickly and automatically identify clusters, relative sizes, and the overall number of objects.

we want to hijack the visual system, which evolved to avoid predators and forage for food, to instead identify abstract relationships in complex data



The language center of our brain isn't as fast as the visual processing center and presents a bottleneck to data interpretation.

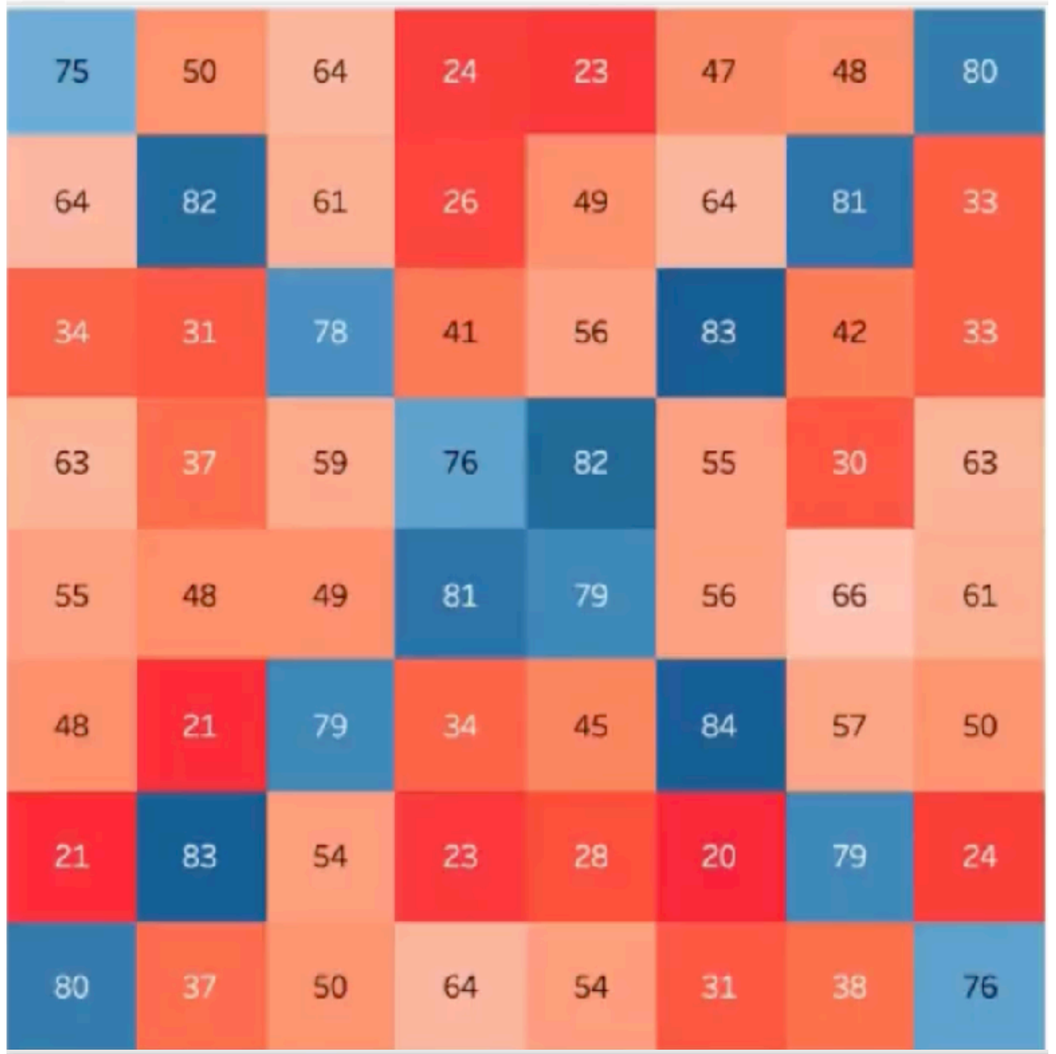
Identifying a pattern in a table of numbers is difficult on its own, and requires the language processing center of the brain, which is slower than the visual processing center.

75	50	64	24	23	47	48	80
64	82	61	26	49	64	81	33
34	31	78	41	56	83	42	33
63	37	59	76	82	55	30	63
55	48	49	81	79	56	66	61
48	21	79	34	45	84	57	50
21	83	54	23	28	20	79	24
80	37	50	64	54	31	38	76

The language center of our brain isn't as fast as the visual processing center and presents a bottleneck to data interpretation.

Identifying a pattern in a table of numbers is difficult on its own, and requires the language processing center of the brain, which is slower than the visual processing center.

applying conditional formatting makes the pattern immediately jump out.



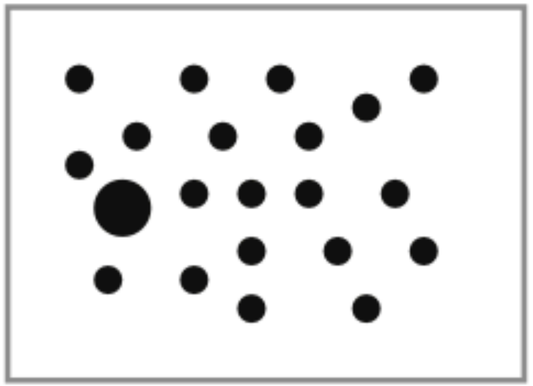
Fast visual processing happens at the intersection of preattentive processing and the Gestalt Principles.

Preattentive Processing

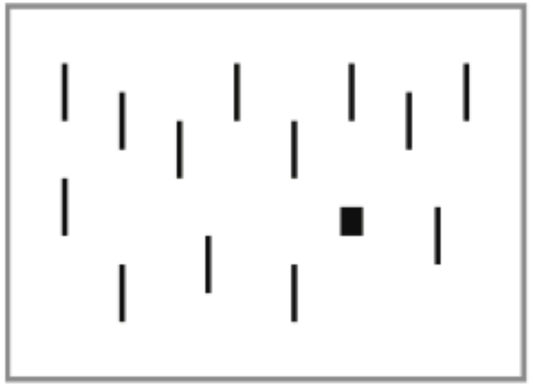
Gestalt Principles

Preattentive processing is the set of filters we apply to our visual input before we pass it to our brain to interpret.

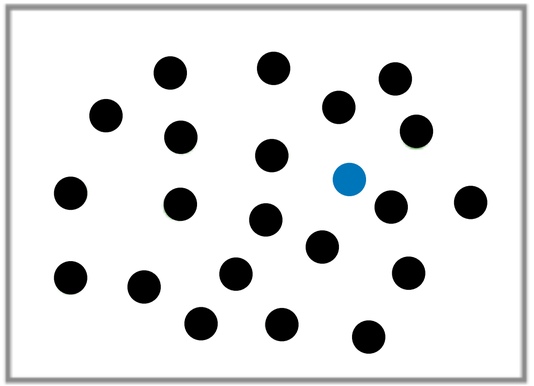
Area



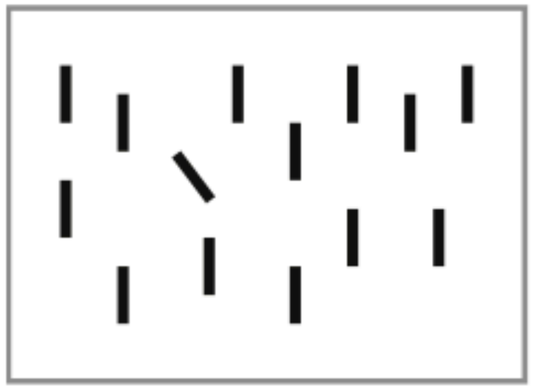
Shape



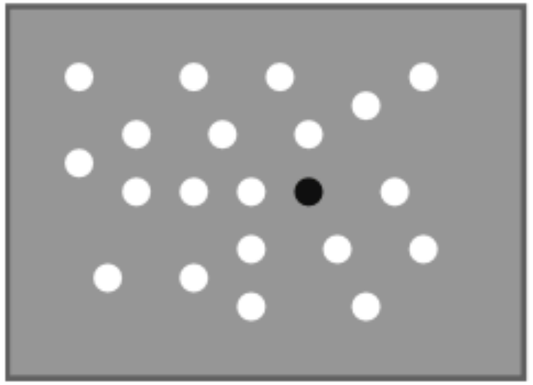
Color



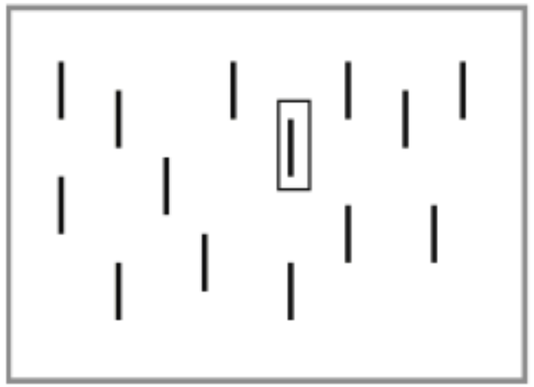
Angle



Intensity



Addition



Colin Ware, *Information Visualization Perception for Design*

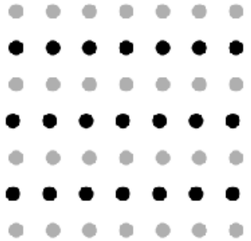
The Gestalt Principles codify how we reduce cognitive effort by perceiving an organized whole rather than a collection of parts.

Proximity

elements that are close together are perceived as part of the same group.

Similarity

elements that look similar (in color, shape, size, etc.) are seen as related or belonging together.

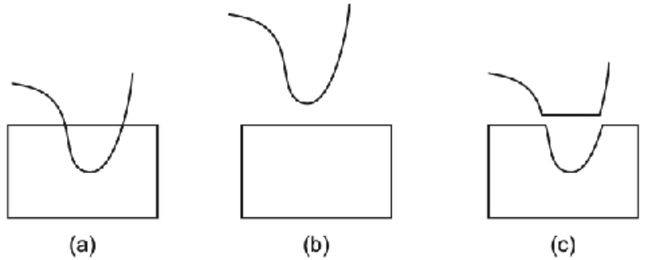


Connectedness

elements that are literally connected overpower other implicit groupings

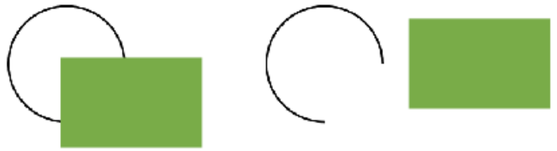
Continuity

our eyes naturally follow lines and paths, so elements aligned in a direction tend to be grouped.



Closure

our brains fill in missing parts to see a complete, enclosed shape, so elements that suggest a closed contour are grouped.



Colin Ware, *Information Visualization Perception for Design*

Effective data visualization is focused, intentional,
and has high signal-to-noise for communicating concepts.

"...induce the viewer to think about the substance rather than about the methodology, graphic design, the technology of graphic production, or something else"

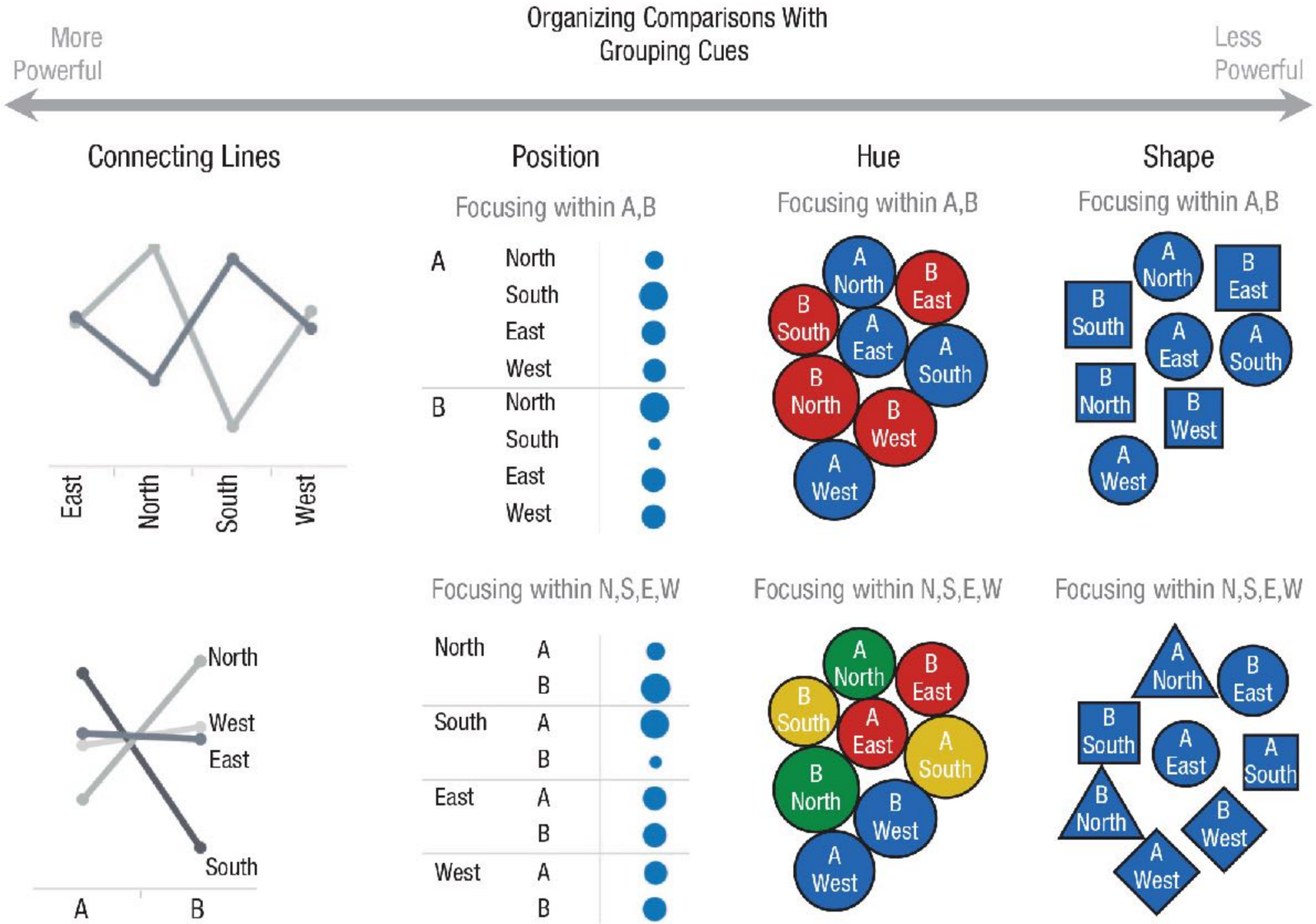
- Edward Tufte, *The Visual Display of Quantitative Information*

"A visualization that is designed to guide viewers to make the "right" visual comparisons can lead those viewers to make [more] meaningful insights than they would make on their own."

- Franconeri+21

Take advantage of preattentive processing and the Gestalt Principles to guide viewers to the comparisons, and insights, you want them to take.

use grouping and attention directing cues to guide focus toward the takeaways

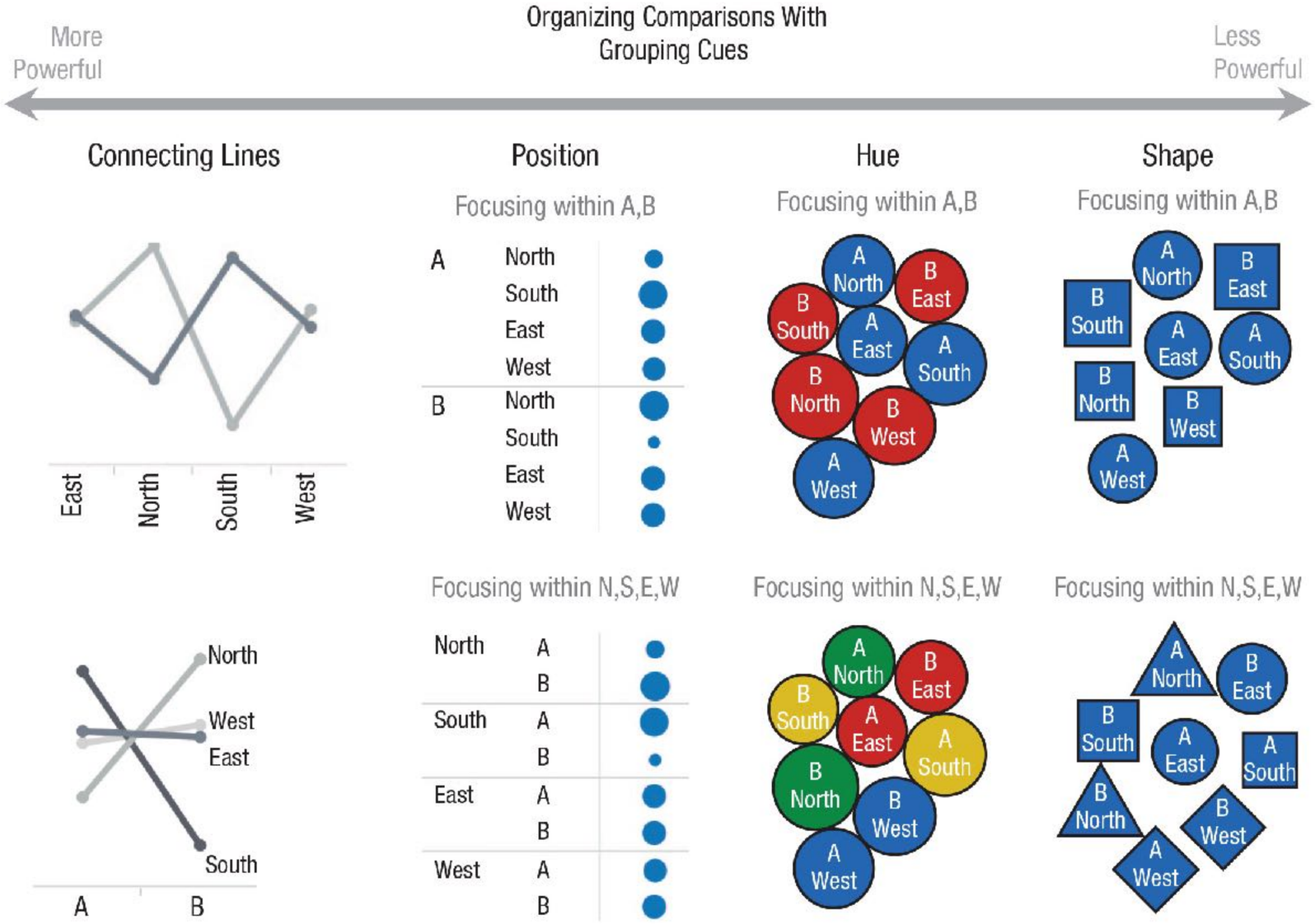


Franconeri+21, Fig. 8

Take advantage of preattentive processing and the Gestalt Principles to guide viewers to the comparisons, and insights, you want them to take.

use grouping and attention directing cues to guide focus toward the takeaways

the visualization needs to overcome the curse of your expertise in order to help others see what you see in the data



Franconeri+21, Fig. 8

Takeaway messages can be influenced by choice of visualization and grouping.

What Does the Chart Say? Grouping Cues Guide Viewer Comparisons and Conclusions in Bar Charts

Cindy Xiong Bearfield, Chase Stokes, Andrew Lovett, and Steven Franconeri

arxiv:2310.02076

choice of comparison grouping

East beats west overall **vs** **A beats B overall**

Bearfield+23, Fig. 3

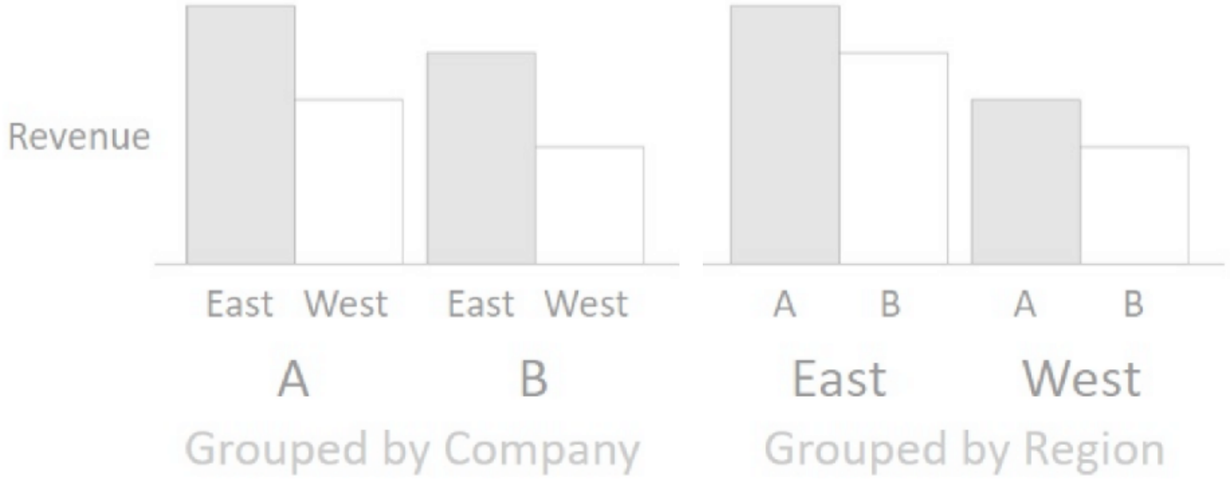
Takeaway messages can be influenced by choice of visualization and grouping.

What Does the Chart Say? Grouping Cues Guide Viewer Comparisons and Conclusions in Bar Charts

Cindy Xiong Bearfield, Chase Stokes, Andrew Lovett, and Steven Franconeri

arxiv:2310.02076

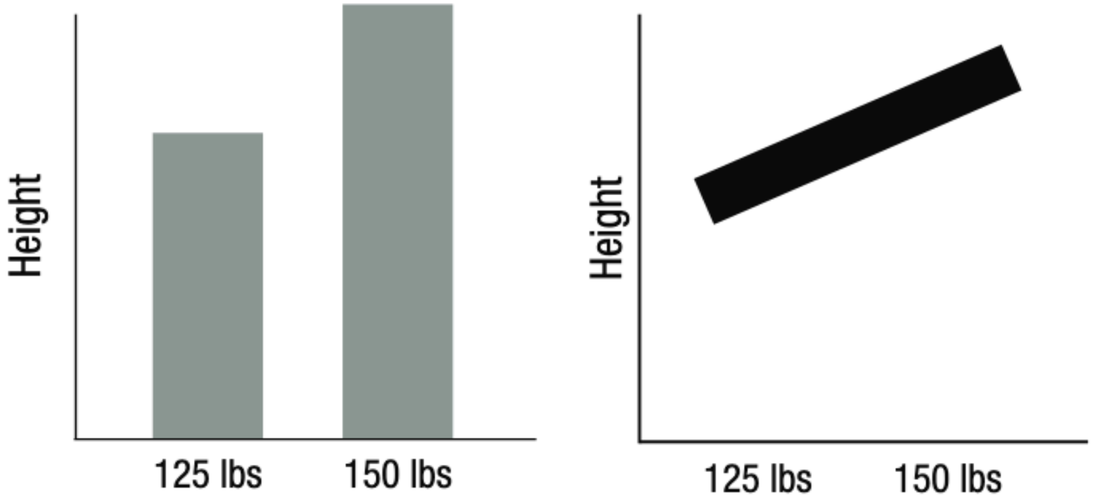
choice of comparison grouping



East beats west overall vs **A beats B overall**

Bearfield+23, Fig. 3

choice of visualization type



150 lb people are taller vs **height increases with weight**

Franconeri+21, Fig. 18

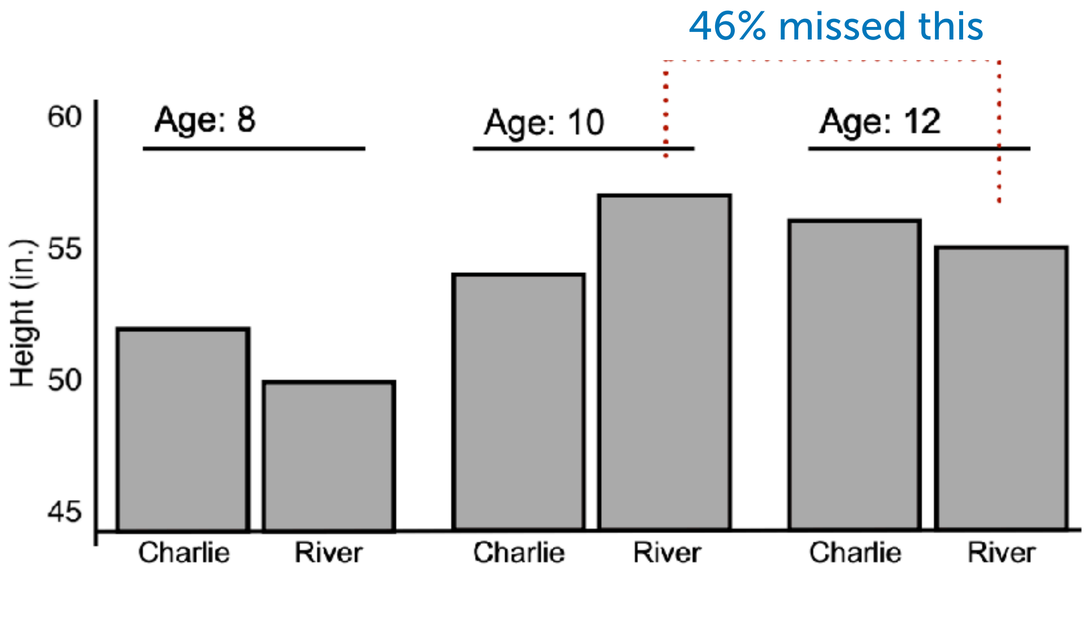
The translation from visual to verbal is slow, semantic links from data to meaning activate the language center of the brain.

Reading a Graph Is Like Reading a Paragraph

Tal Boger[1] and Steven Franconeri[2]
[1] Department of Psychological & Brain Sciences, Johns Hopkins University
[2] Department of Psychology, Northwestern University

doi.org/10.1037%2Fxge0001604

Hides improbable relationship



The translation from visual to verbal is slow, semantic links from data to meaning activate the language center of the brain.

Reading a Graph Is Like Reading a Paragraph

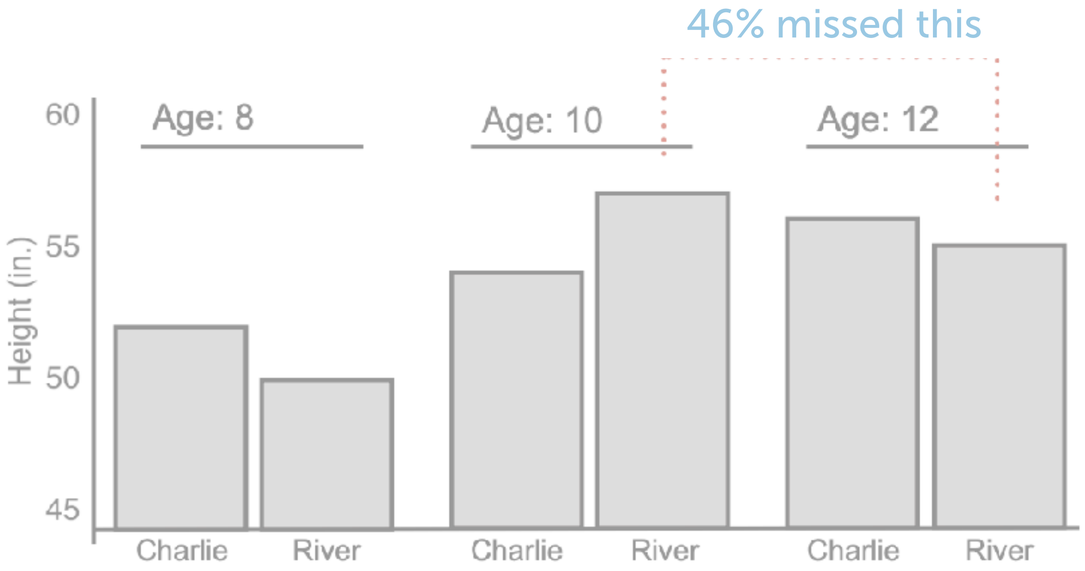
Tal Boger[1] and Steven Franconeri[2]

[1] Department of Psychological & Brain Sciences, Johns Hopkins University

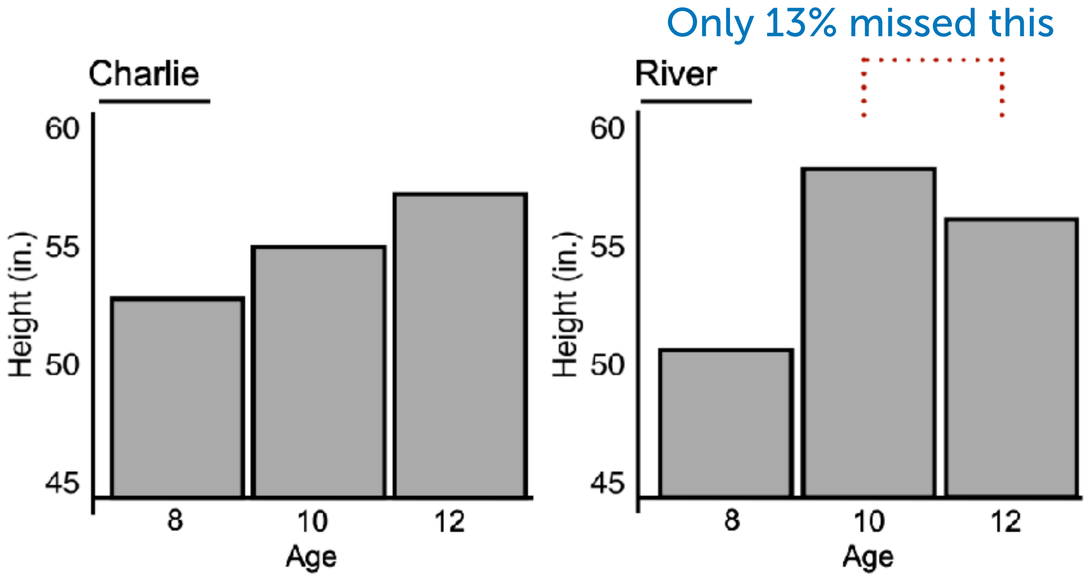
[2] Department of Psychology, Northwestern University

doi.org/10.1037%2Fxge0001604

Hides improbable relationship



Highlights improbable relationship



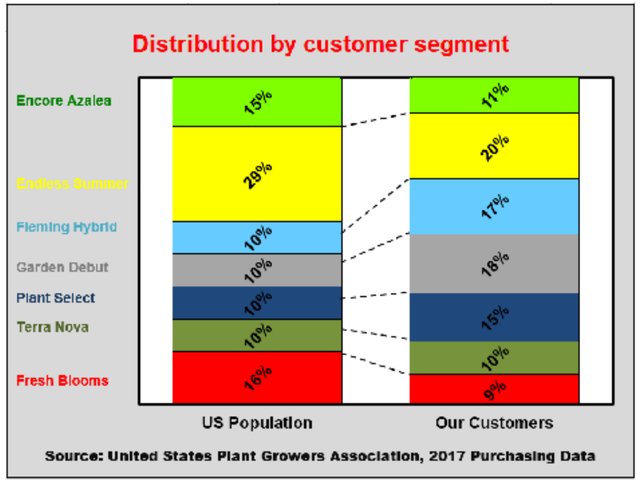
Focusing with highlighted color, annotations, and a clear takeaway message leads to more effective comprehension and retention.

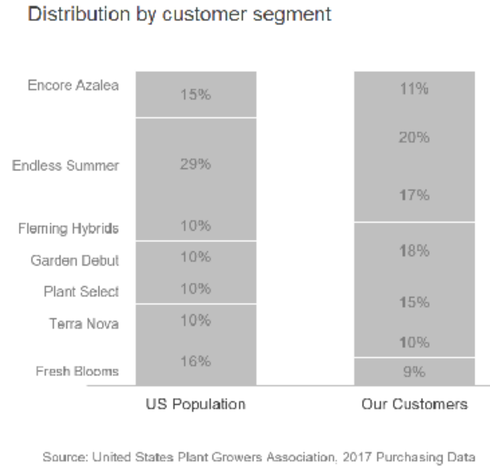
a clear headline plus color highlighting led to 3.5x more effective retention

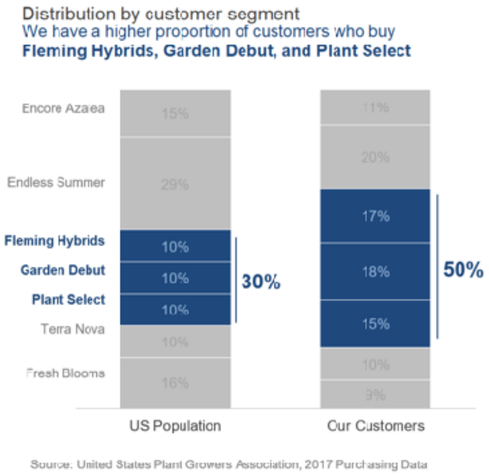
Declutter and Focus: Empirically Evaluating Design Guidelines for Effective Data Communication

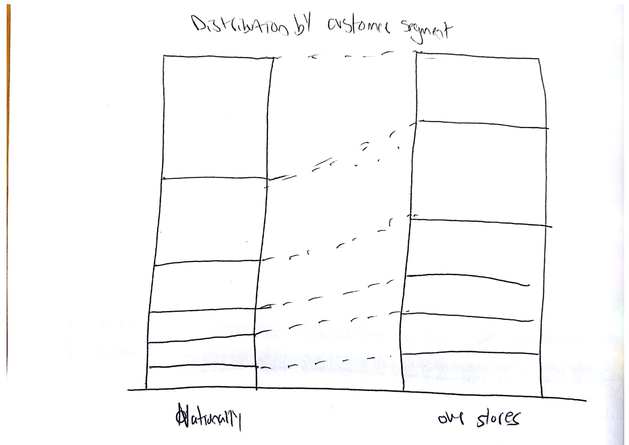
Kiran Ajani, Elsie Lee, Cindy Xiong, Cole Nussbaumer Knaflic, William Kemper, and Steven Franconeri, *Member, IEEE*

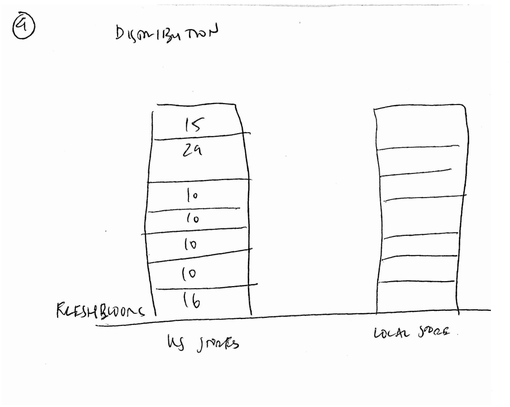
doi.org/10.1109/TVCG.2021.3068337

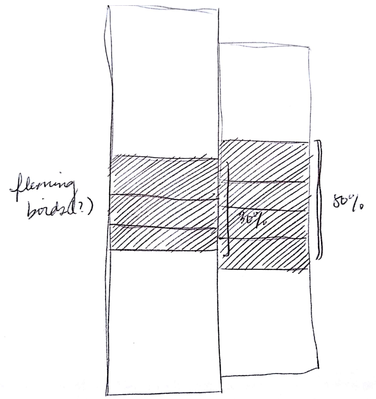












If you enjoyed this talk and want to learn more, go watch Steve's keynote from Outlier or check out his 2021 review paper.

https://youtu.be/OdHLpZQF-Zs

aps
ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

The Science of Visual Data Communication: What Works

Psychological Science in the Public Interest
2021, Vol. 22(3) 110–161

DOI: 10.1177/1529100621051956
www.psychologicalscience.org/PSPI
SAGE

Steven L. Franconeri[1], Lace M. Padilla[2], Priti Shah[3], Jeffrey M. Zacks[4], and Jessica Hullman[5]
[1]Department of Psychology, Northwestern University; [2]Department of Cognitive and Information Sciences, University of California, Merced; [3]Department of Psychology, University of Michigan; [4]Department of Psychological & Brain Sciences, Washington University in St. Louis; and [5]Department of Computer Science, Northwestern University

"Extracting global statistics is fast, but comparing between subsets of values is slow. Effective graphics avoid taxing working memory, guide attention, and respect familiar conventions."

doi.org/10.1177/1529100621051956

You can find an extended version of these slides (with extra resources) and more at alexbgurvi.ch

Steve's Talk

Steve's Paper

Me

alexbgurvich

alex-b-gurvich

www.alexbgurvi.ch

DO

use labels directly on the visualization

add annotations to features of the visualization

put a descriptive title with takeaway

use color to highlight points

use recognizable chart types unless absolutely necessary or if communicating with experts

DON'T

use complicated legends that require the viewer to look back and forth

put lots of "chartjunk" on the plot like extraneous axes lines

require viewers to compare things that are far away

require viewers make series of comparisons that use different perceptual filters

Other tools and resources that you may find useful

Color Palette Generators

https://colorbrewer2.org/

https://python-graph-gallery.com/color-palette-finder/

https://vis4.net/labs/multihue/

https://colororacle.org/

Books

Cole Nussbaumer Knaflic
Storytelling with data: A data visualization guide for business professionals

Kat Greenbrook
Data Storytellers Handbook

Stephen Few
Data Storytellers Handbook

Alberto Cairo
The truthful art: Data, charts, and maps for communication.
&
The Art of Insight

Alli Torban
Chart Spark

John Schwabish
Better data visualizations: A guide for scholars, researchers, and wonks.

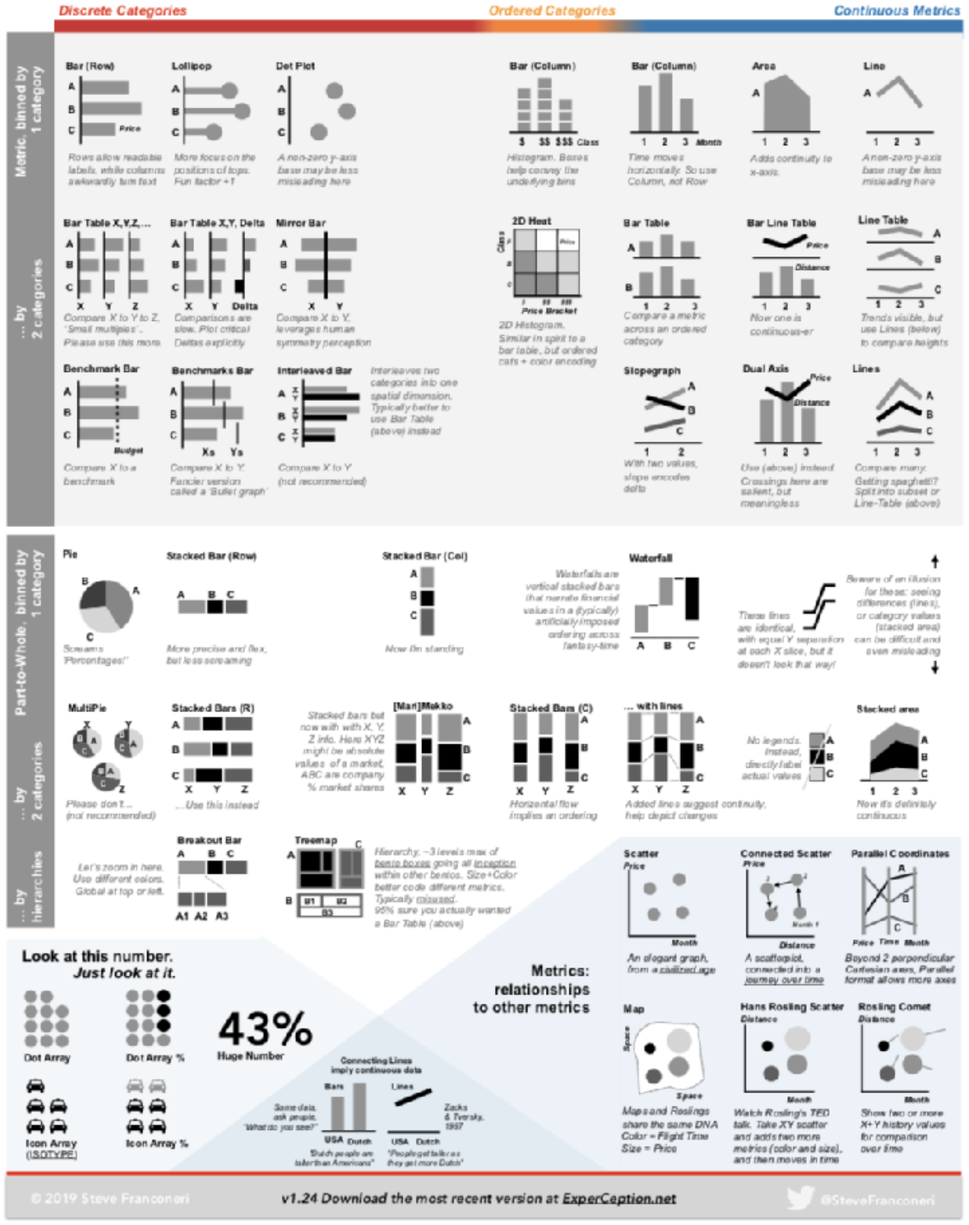
Amanda Makulec
Big Book of Dashboards (TBD)

Which Visualization? A Quick Reference

You have the following data (sample):
Discrete Categories,
Ordered categories,
and Continuous Metrics

Here's how to plot them

Categories		Ordered Cats		Continuous Metrics			
City	Airline	Class	PriceBracket	Month	Distance	FlightTime	Price
Alphaville	XeroTrip	Coach	$	1	300	120	250
Betastan	YoloFly	Business	$$	2	500	185	1,525
Chicago	ZeusAir	First	$$$	3	650	240	4,023
...	...	...	...	...	...	...	...



Steve Franconeri

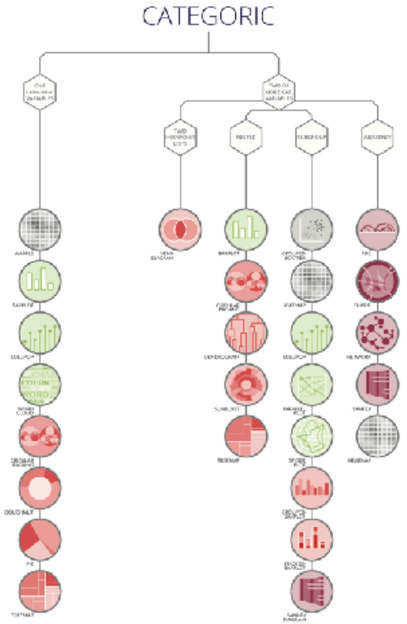
from Data to Viz

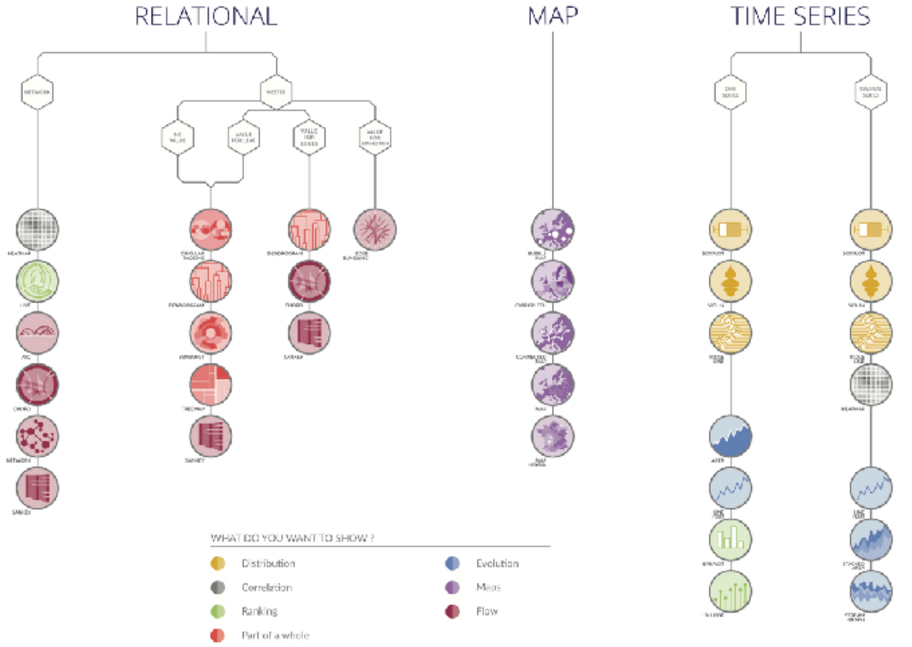
'From Data to Viz' is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps :

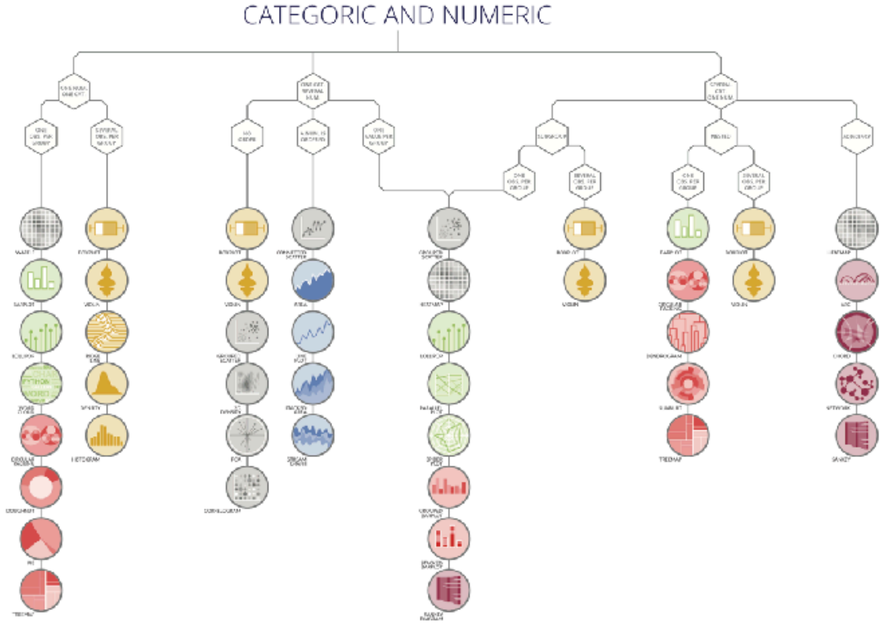
1. Identify what type of data you have.
2. Go to the corresponding decision tree and follow it down to a set of possible charts.
3. Choose the chart from the set that will suit your data and your needs best.

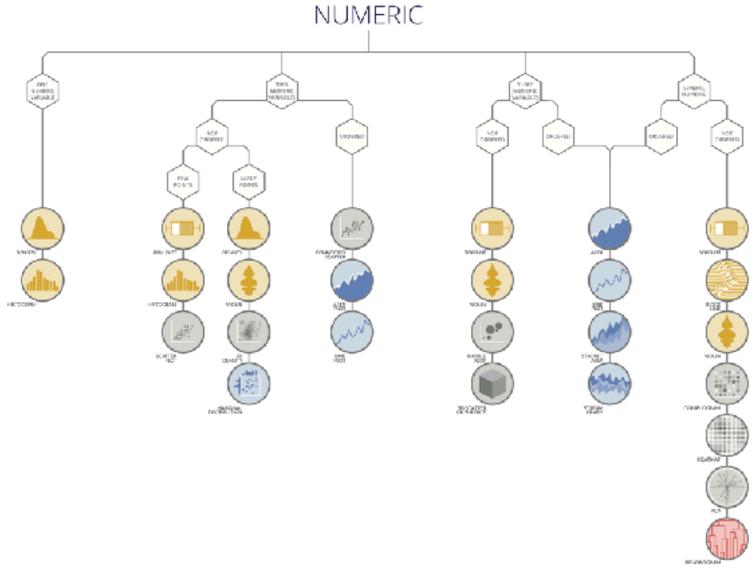
Dataviz is a world with endless possibilities and this project does not claim to be exhaustive. However it should provide you with a good starting point. For an interactive version and much more, visit:

data-to-viz.com









Yan Holz