Evaluating the Quality of Assessment and Survey Items Using (Interactive) Visualizations

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Outline

01 **Overview**

Why data visualization?

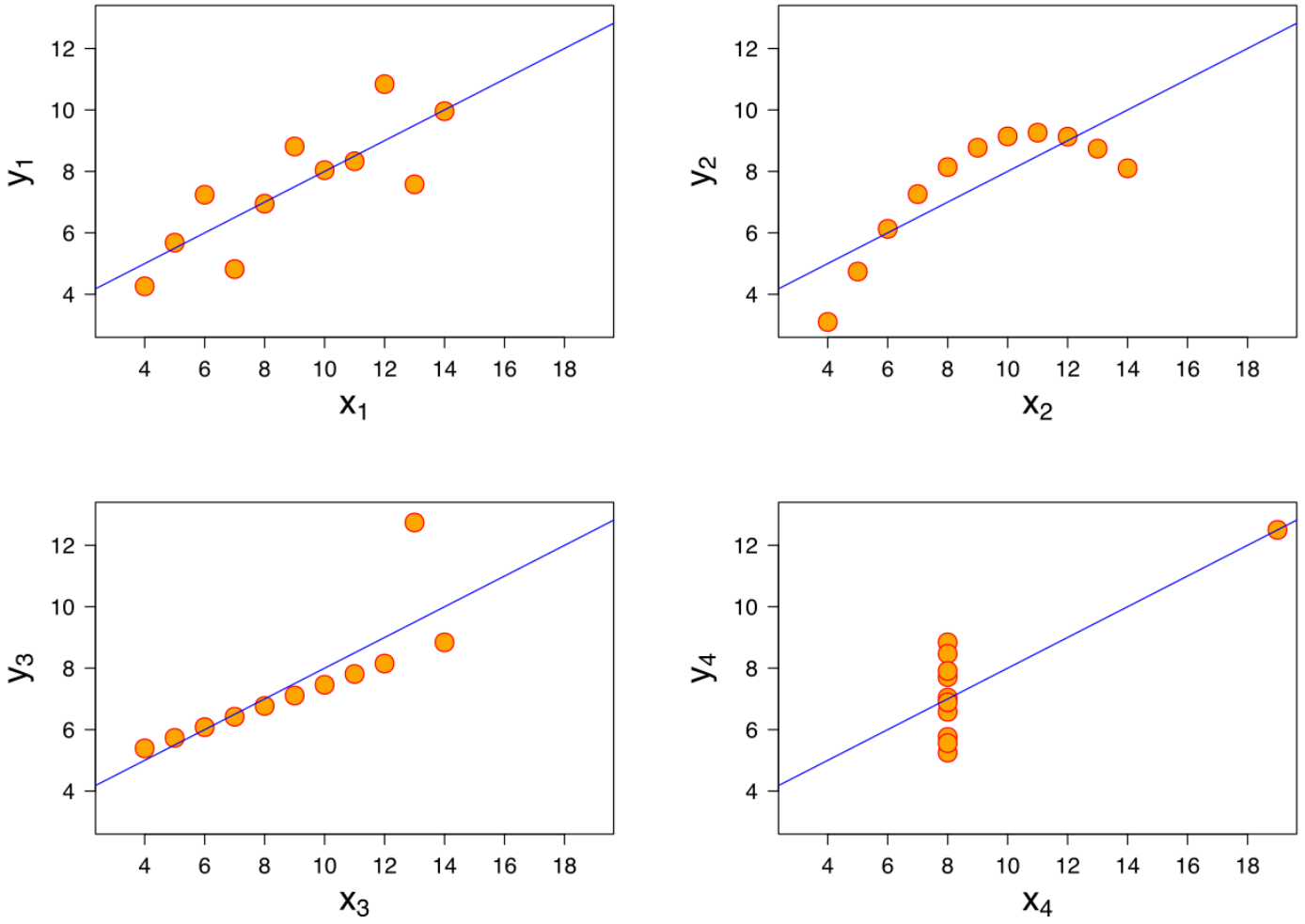
02 **Data visualization principles**

What are the key principles in developing visualizations?

03 **Evaluating items visually**

What are the visual analysis options for evaluating survey items?

Why Visualization?



Four datasets with nearly identical simple descriptive statistics for x and y but they have very different distributions…

Property	Value
Mean of x	9
Mean of y	7.50
SD of x	3.32
SD of y	2.03
Correlation of x and y	0.82

Source: https://en.wikipedia.org/wiki/Anscombe%27s_quartet

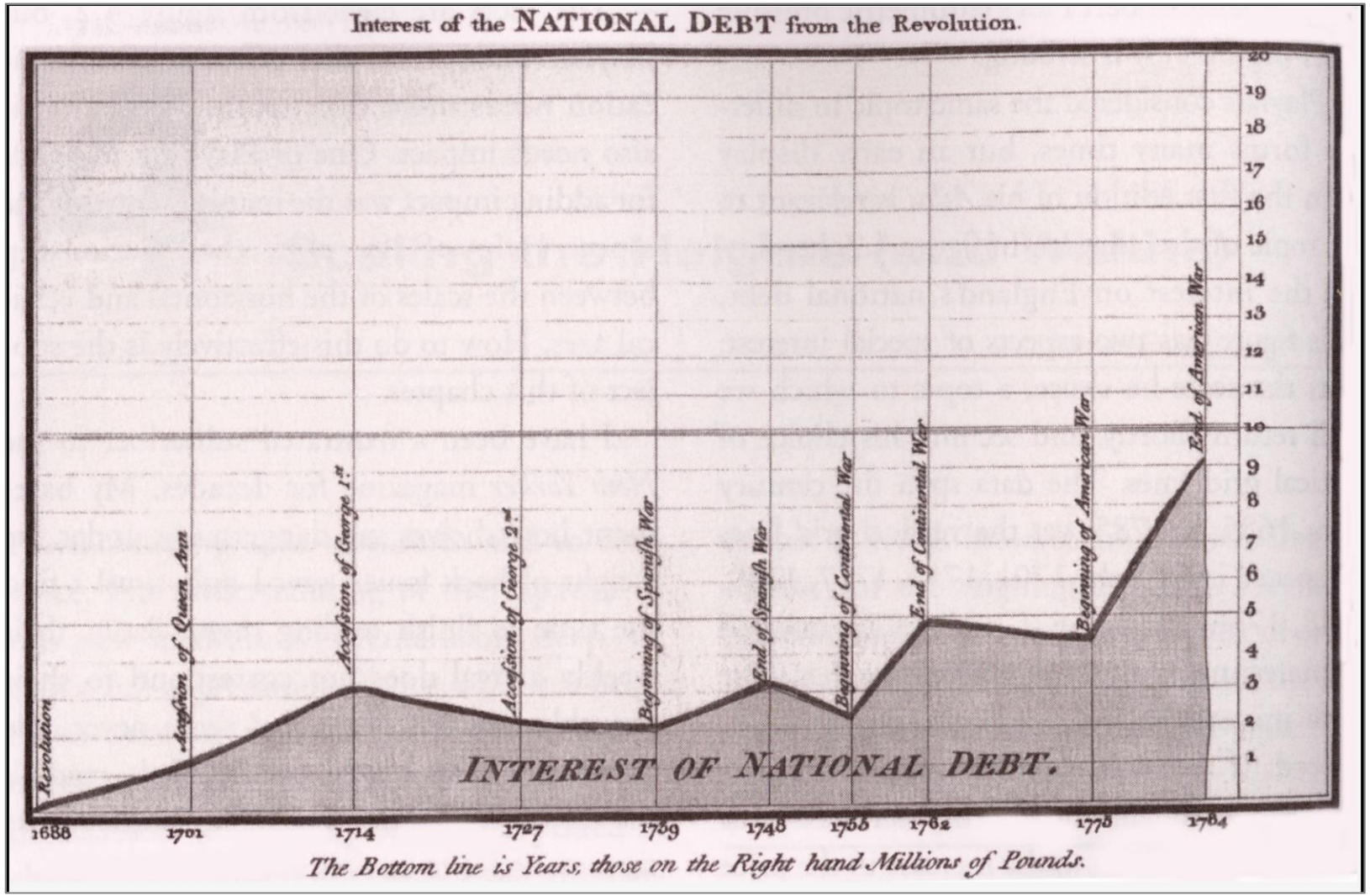
To move a huge amount of information into the brain very quickly

To identify patterns and communicate relationships and meaning

To inspire new questions and further exploration

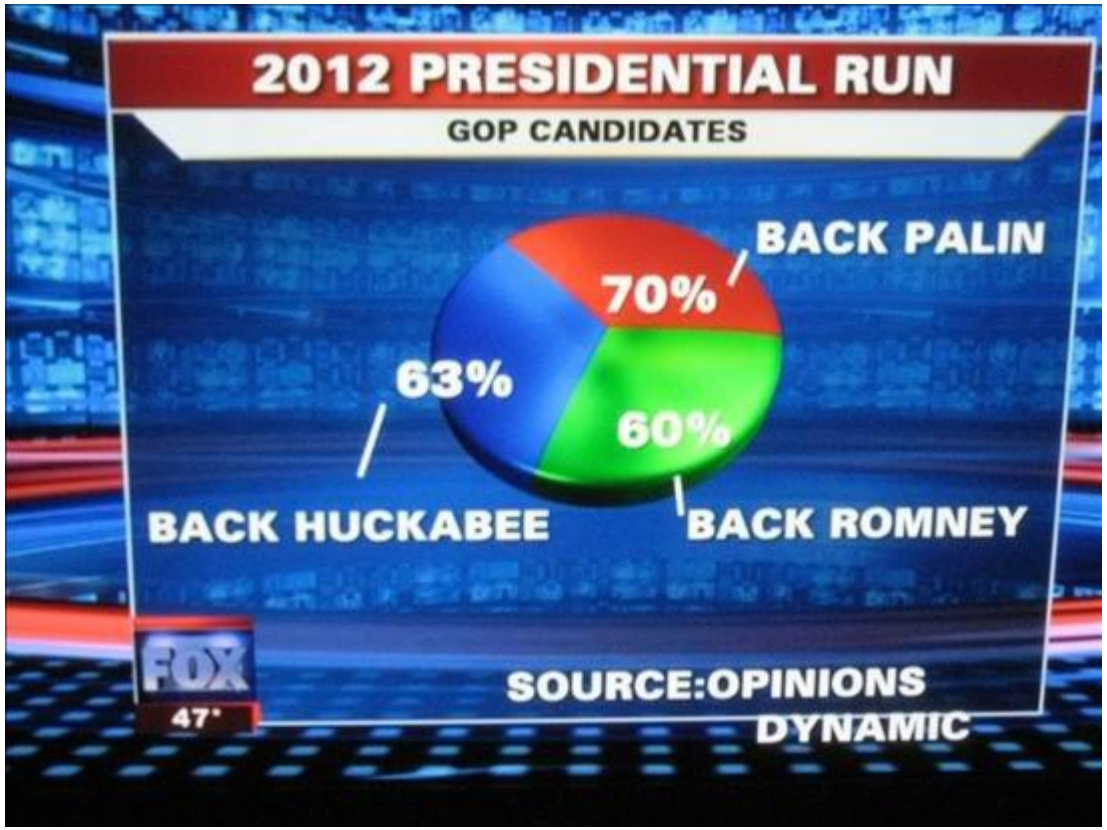
To help identify sub-problems

To discover or search for interesting or specific data points in a larger field



Source: Hand drawn by William Playfair (1786) in The Commercial and Political Atlas – *to make a case against England's policy of financing colonial wars through national debt*.

Did we get any better?

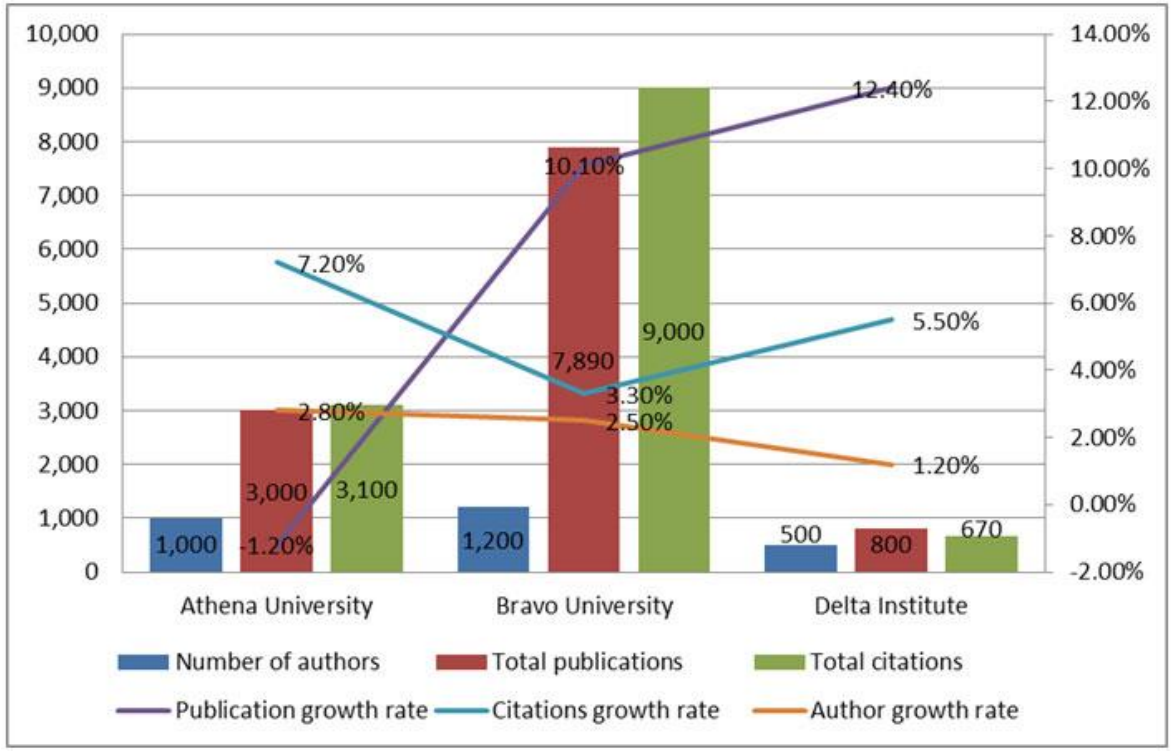


Source: Fox News – the percentages add up to 193%...

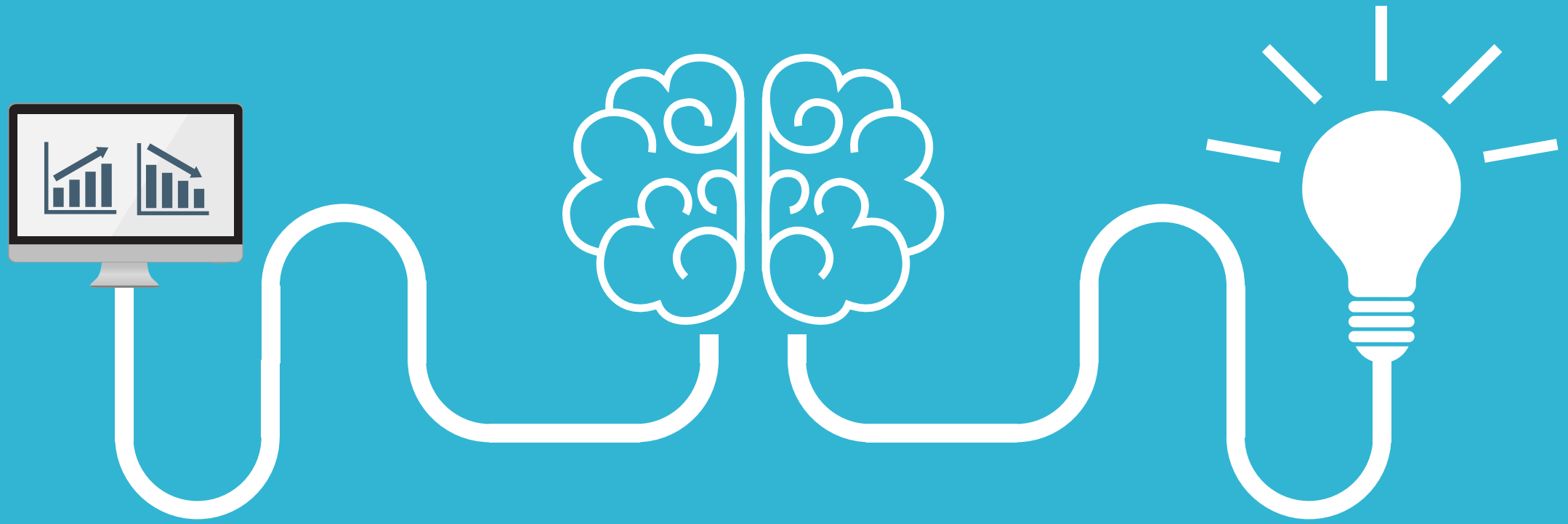
“The key function of data visualization is to move information from point **A** to point **B**.”

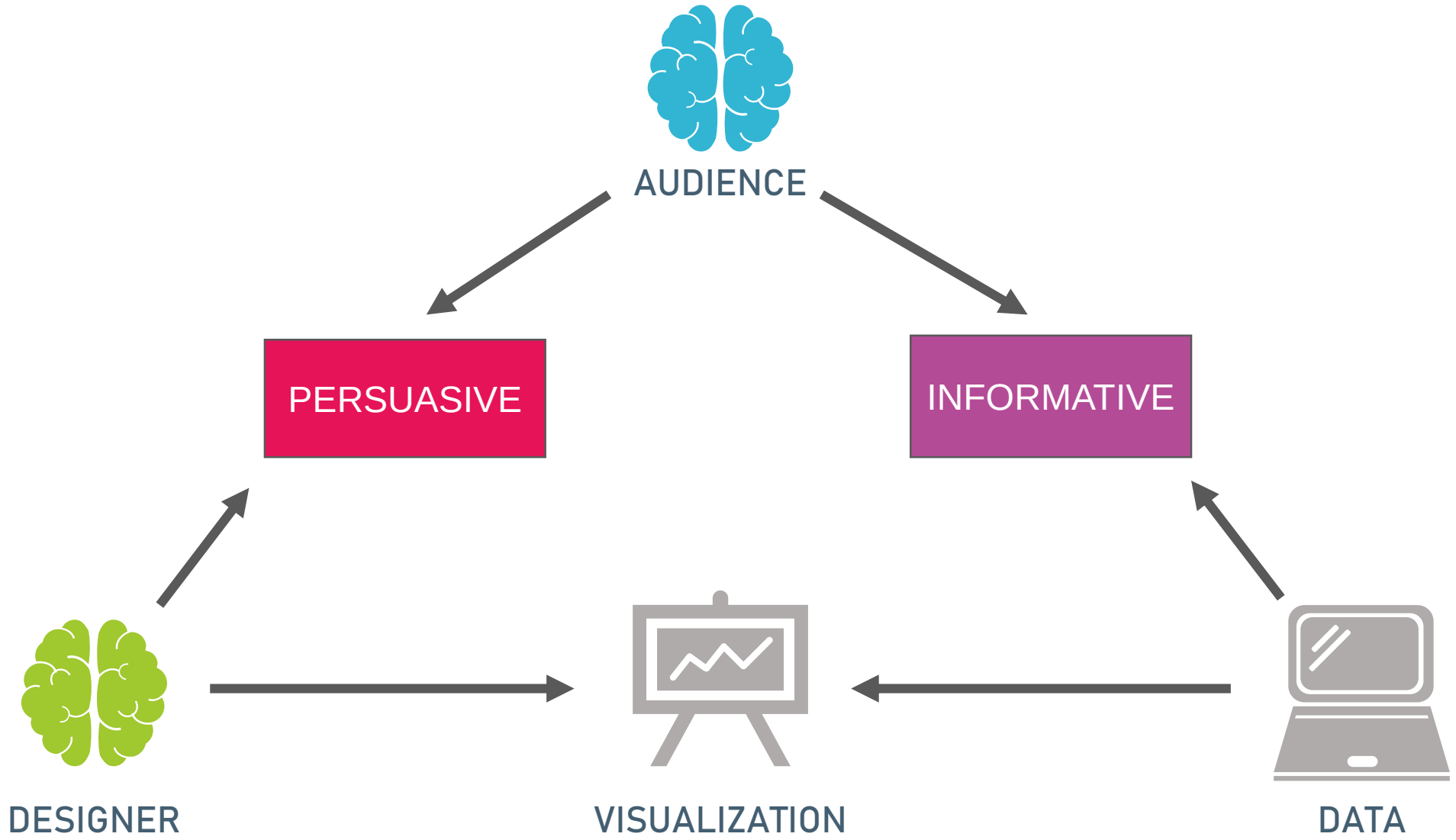
-- Iliinsky and Steele (2011)

We have all done this…



Purpose





Source: Adapted from Iliinsky and Steele (2011, p. 9)

In practice, we…

EXPLORE (Informative)

Potential issues in the data:

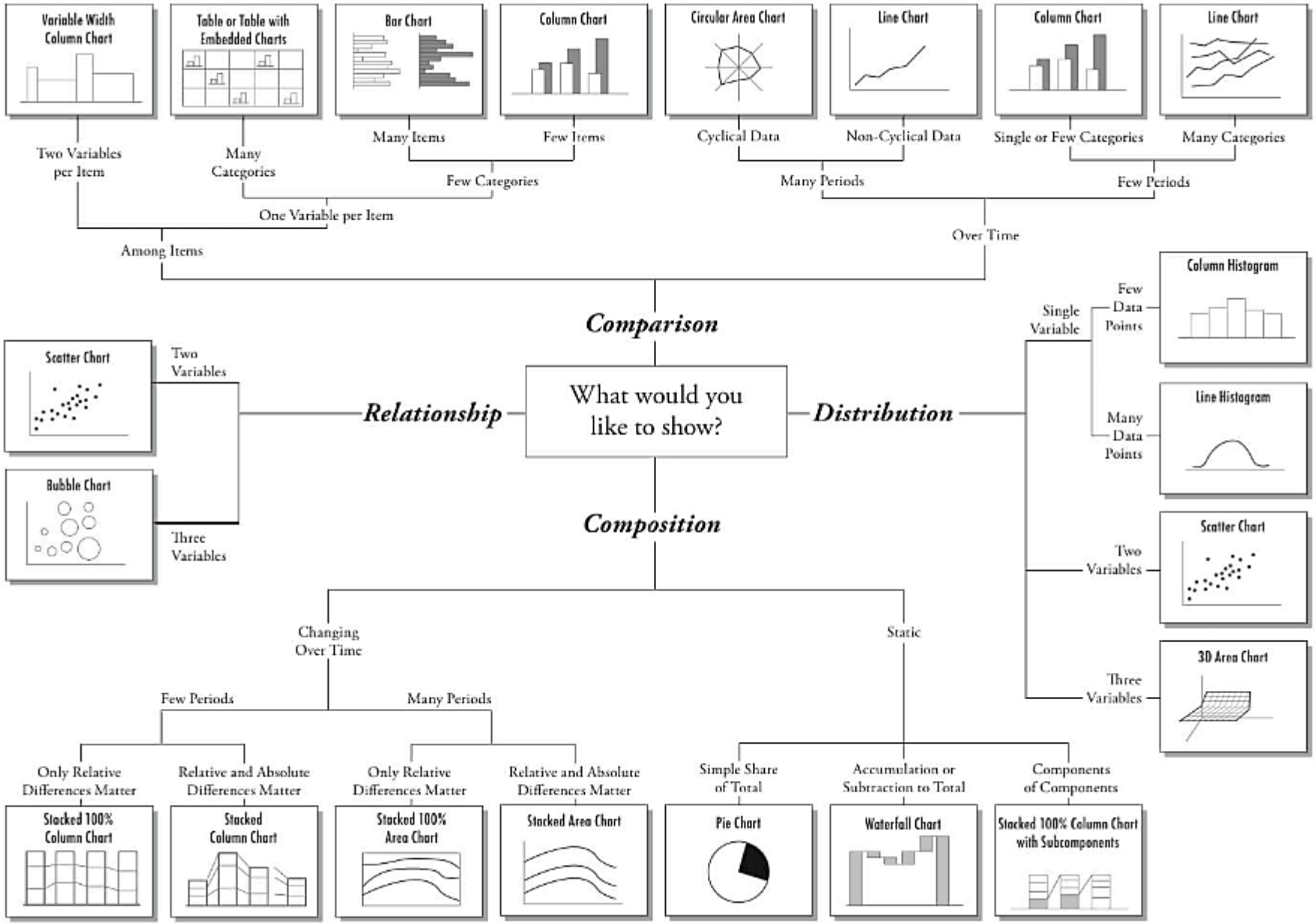
- Missingness
- Outliers
- Non-normality
- Non-linearity
- Extreme skewness and kurtosis

EXPLAIN (Informative)

Relationships between variables; correlations; interactions; patterns over time

PROVE (Persuasive)

Statistical models (e.g., regression); model fit; accuracy; predictions; inferences



Source: https://extremepresentation.com/

Some Design Principles…

Determine the number of dimensions

Number of variables

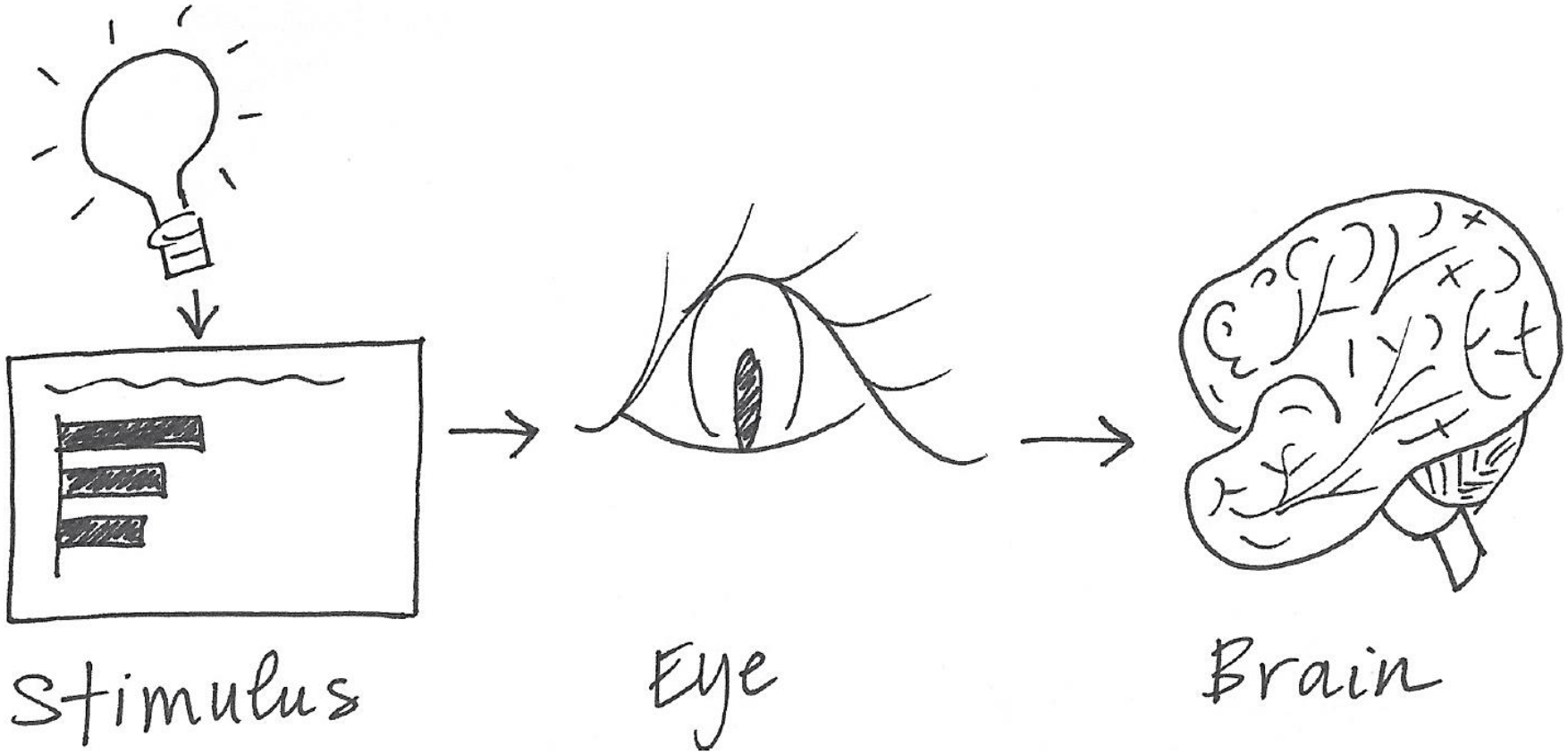
Colours and shading

Shapes and lines

Size and thickness

Font and font size

Short-term memory → **Long**-term memory

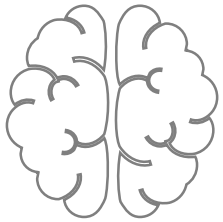


Source: Cole Nussbaumer Knaflic (2015, p.100)

Decoding → Understanding

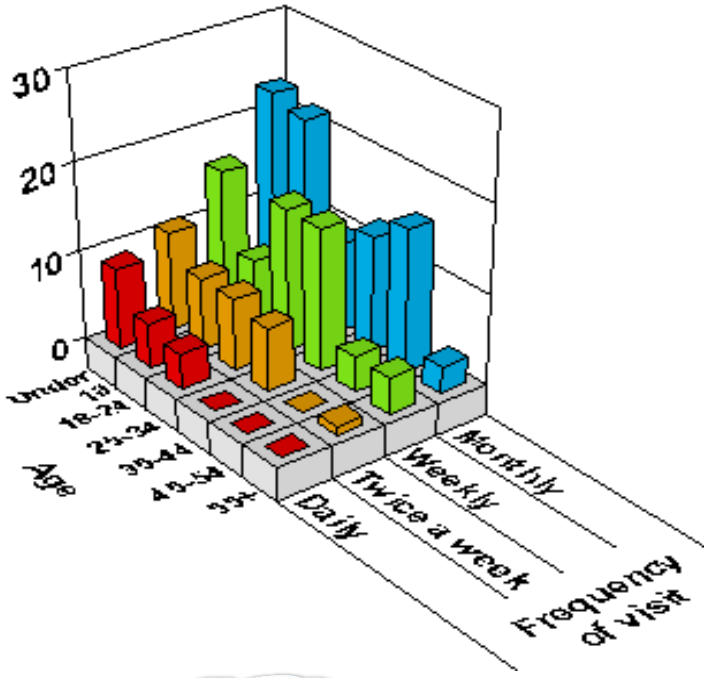
Brainpower used for **decoding**	Brainpower left for **understanding**

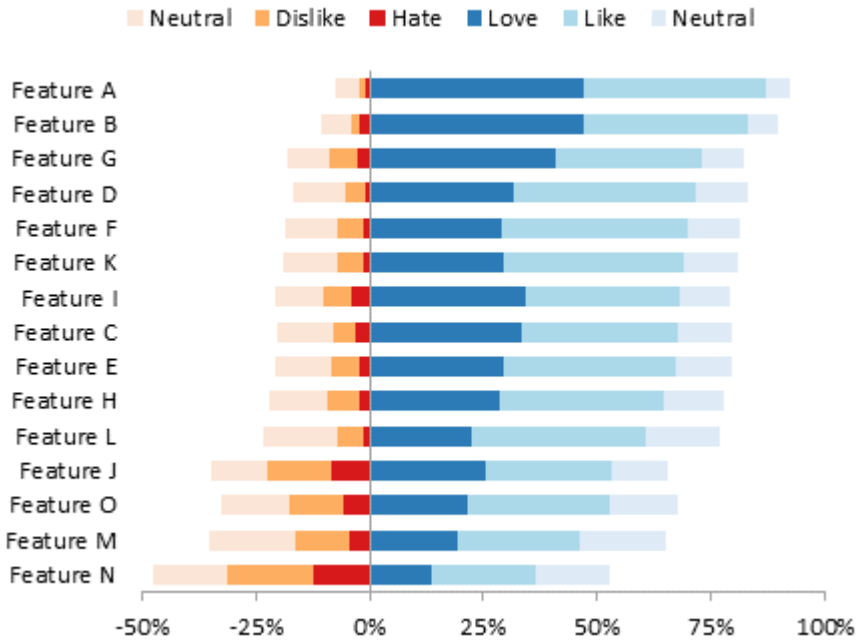
TOTAL BRAINPOWER AVAILABLE



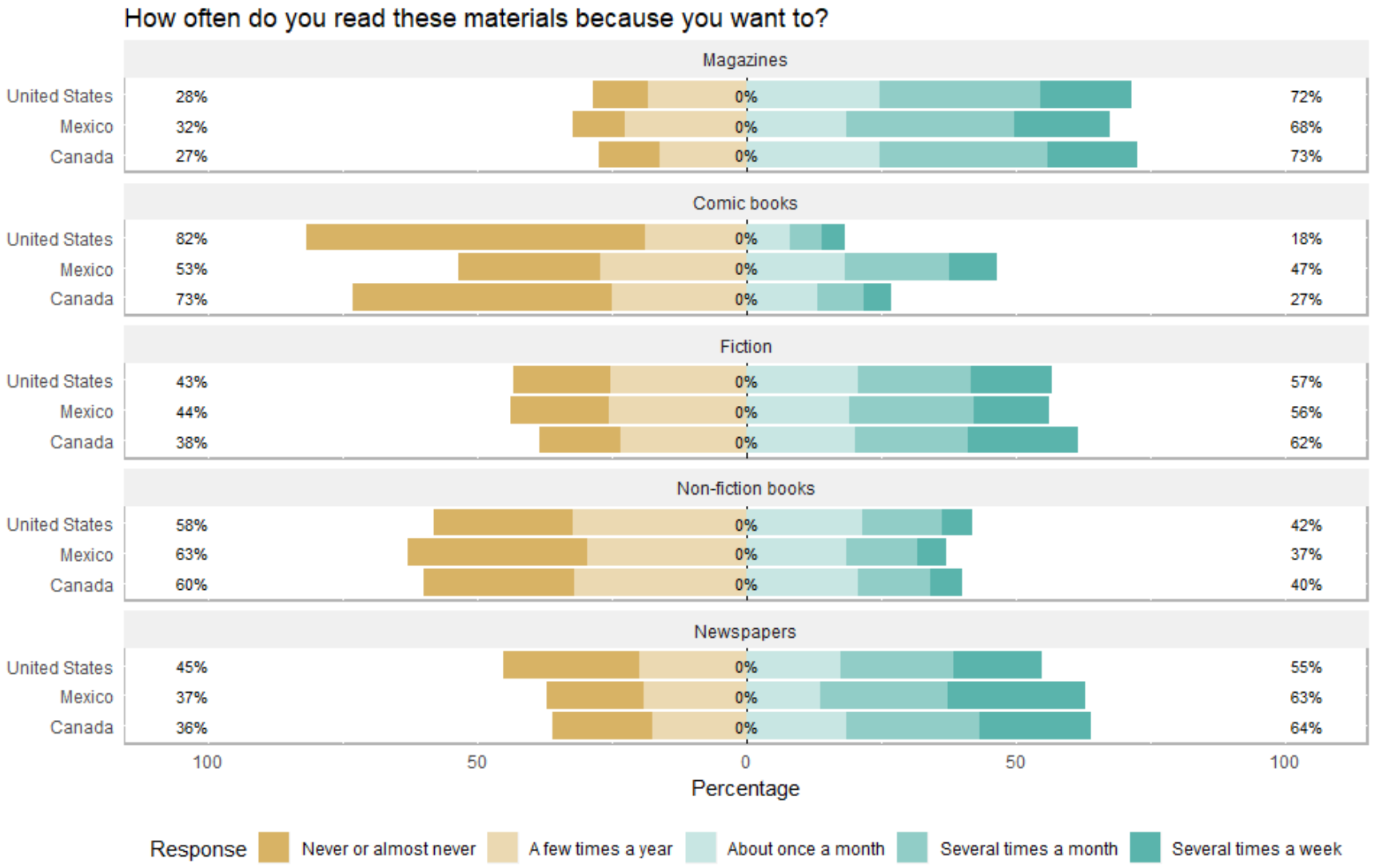
Source: Adapted from Iliinsky and Steele (2011, p.24)

More Complex ≠ Better





What is the **takeaway** message in this figure?



Source: PISA 2009

“**Simplicity** is the ultimate sophistication.”

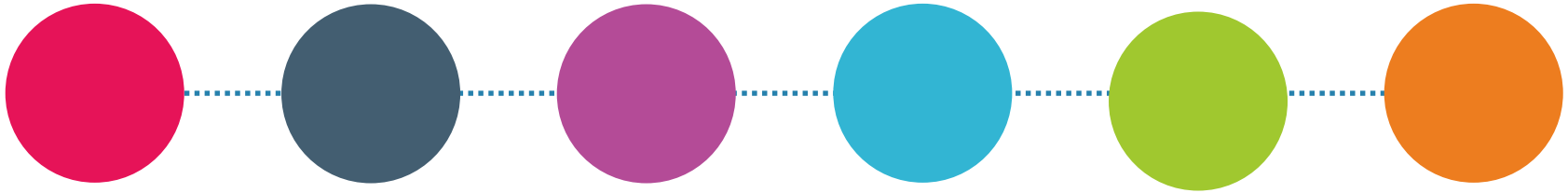
-- Leonardo da Vinci

Source: https://www.darkhorseanalytics.com/blog/data-looks-better-naked

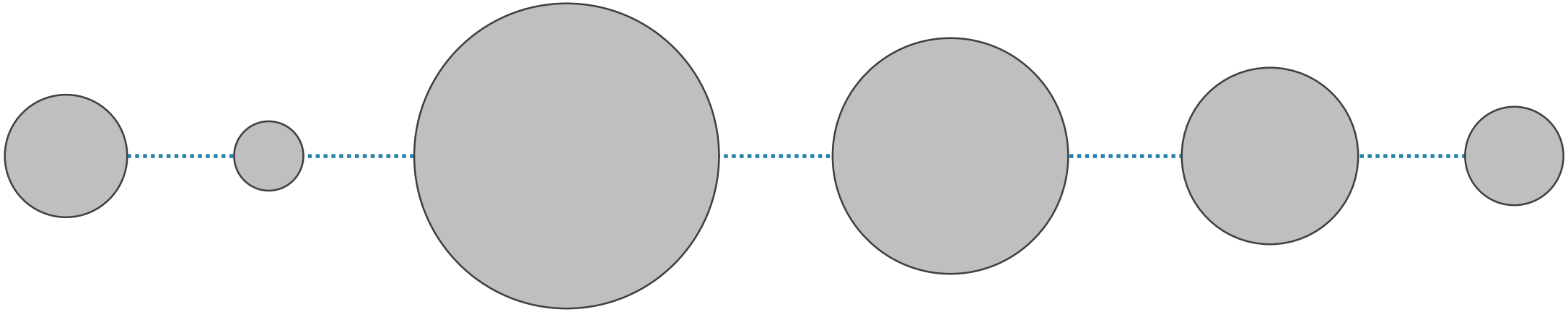
Source: https://www.darkhorseanalytics.com/blog/salvaging-the-pie

Ordering Values

Colour

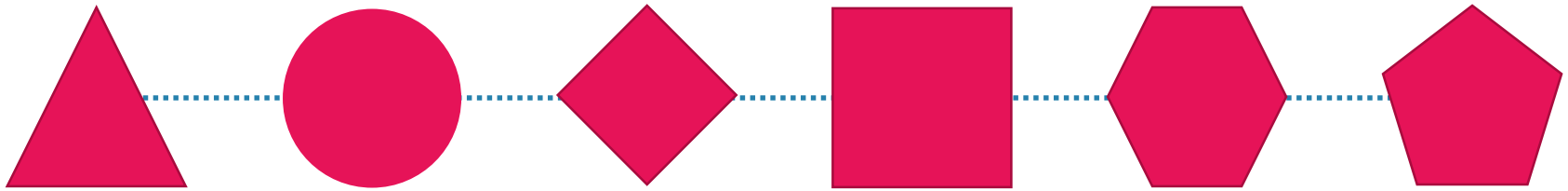


Size

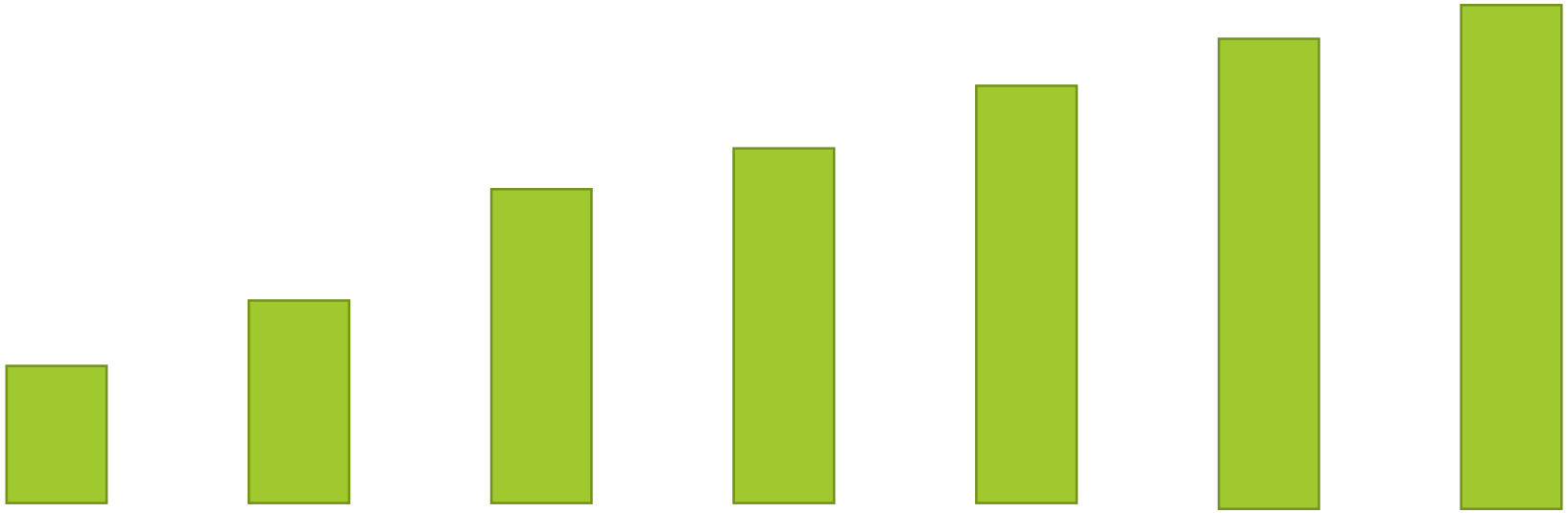


Ordering Values

Shape



Length



Ordering Values

Rainbow distribution in color indicates sales rank in given country from #1 (red) to #10 or higher (dark purple)

Country	A	B	C	D	E
AUS	1	2	3	6	7
BRA	1	3	4	5	6
CAN	2	3	6	12	8
CHI	1	2	8	4	7
FRA	3	2	4	8	10
GER	3	1	6	5	4
IND	4	1	8	10	5
ITA	2	4	10	9	8
MEX	1	5	4	6	3
RUS	4	3	7	9	12
SPA	2	3	4	5	11
TUR	7	2	3	4	8
UK	1	2	3	6	7
US	1	2	4	3	5

RANK 1 2 3 4 5+

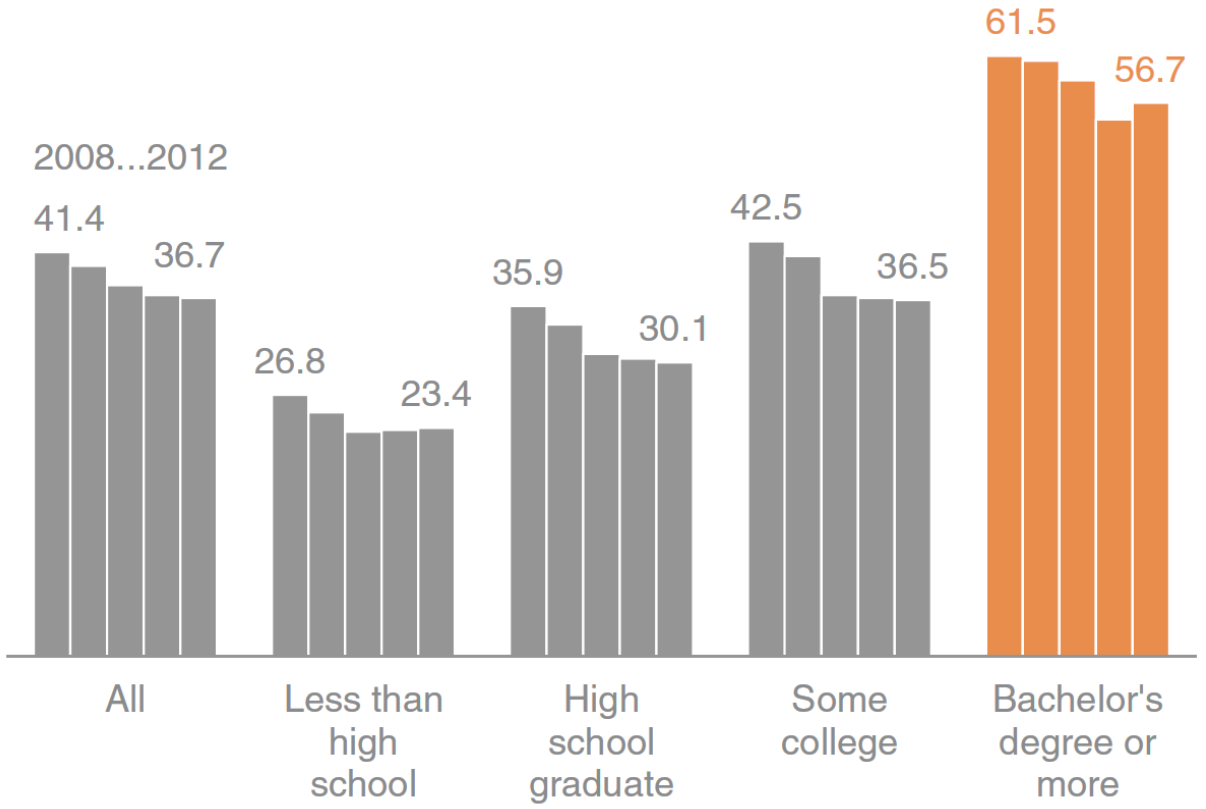
COUNTRY | DRUG

	A	B	C	D	E
Australia	1	2	3	6	7
Brazil	1	3	4	5	6
Canada	2	3	6	12	8
China	1	2	8	4	7
France	3	2	4	8	10
Germany	3	1	6	5	4
India	4	1	8	10	5
Italy	2	4	10	9	8
Mexico	1	5	4	6	3
Russia	4	3	7	9	12
Spain	2	3	4	5	11
Turkey	7	2	3	4	8
United Kingdom	1	2	3	6	7
United States	1	2	4	3	5

Source: Cole Nussbaumer Knaflic (2015, p.119)

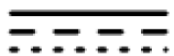
Ordering Values

Number of newly married adults per 1,000 marriage eligible adults

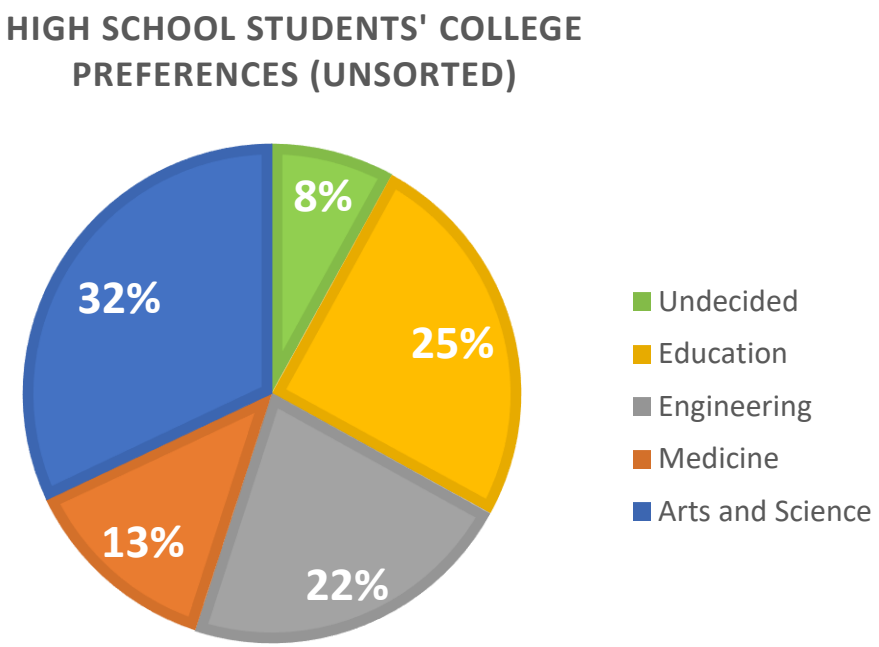


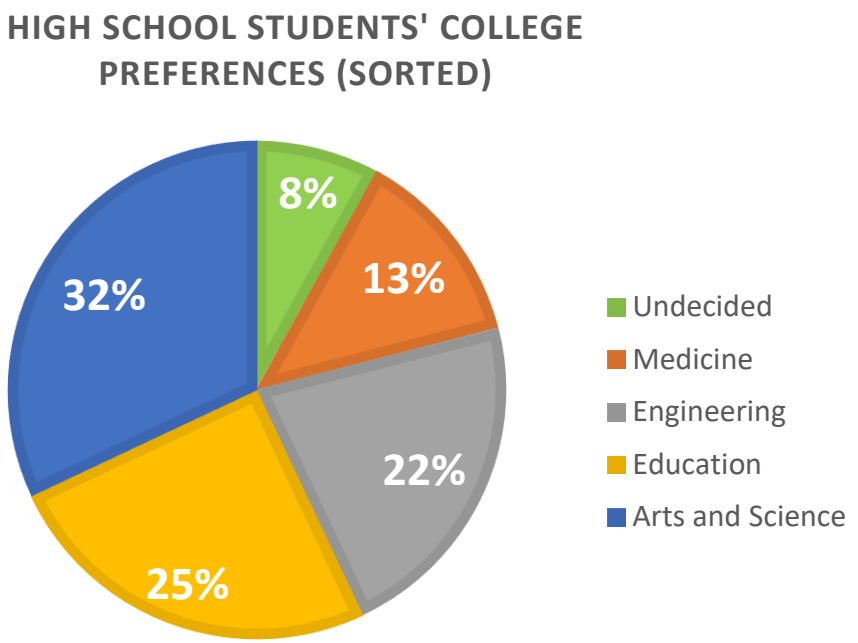
Note: Marriage eligible includes the newly married plus those widowed, divorced, or never married at interview.

Source: U.S. Census

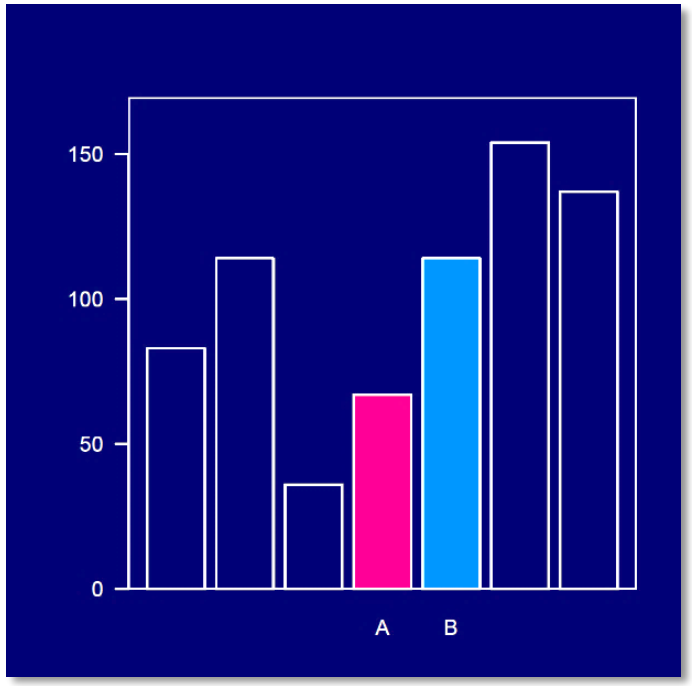
Example	Encoding	Ordered	Useful values	Quantitative	Ordinal	Categorical	Relational
	position, placement	yes	infinite	Good	Good	Good	Good
1, 2, 3; A, B, C	text labels	optional alpha or num	infinite	Good	Good	Good	Good
	length	yes	many	Good	Good		
	size, area	yes	many	Good	Good		
	angle	yes	medium	Good	Good		
	pattern density	yes	few	Good	Good		
	weight, boldness	yes	few		Good		
	saturation, brightness	yes	few		Good		
	color	no	few (<20)			Good	
	shape, icon	no	medium			Good	
	pattern texture	no	medium			Good	
	enclosure, connection	no	infinite			Good	Good
	line pattern	no	few				Good
	line endings	no	few				Good
	line weight	yes	few		Good		

Ordering Values

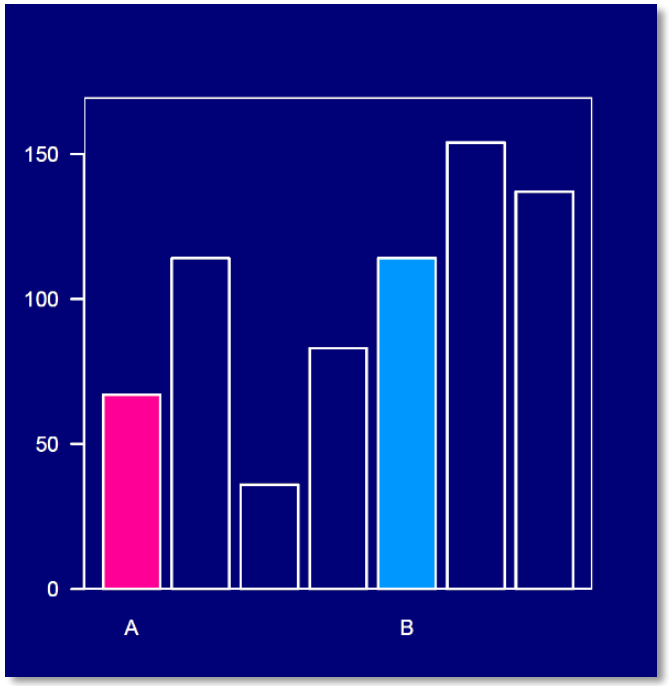




Which comparison is easier?

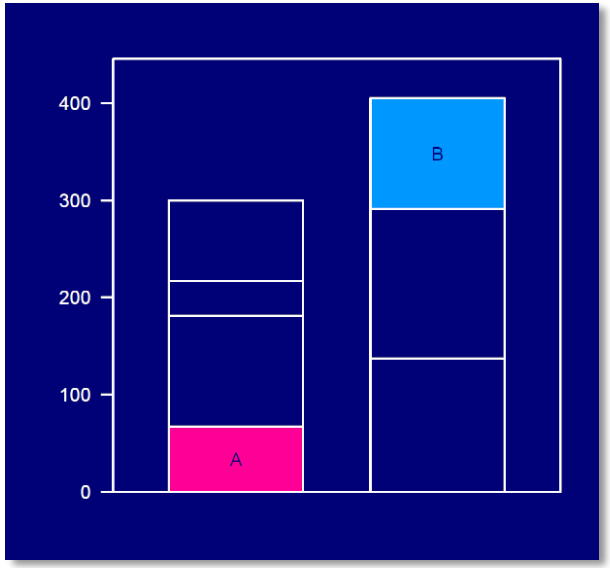


1

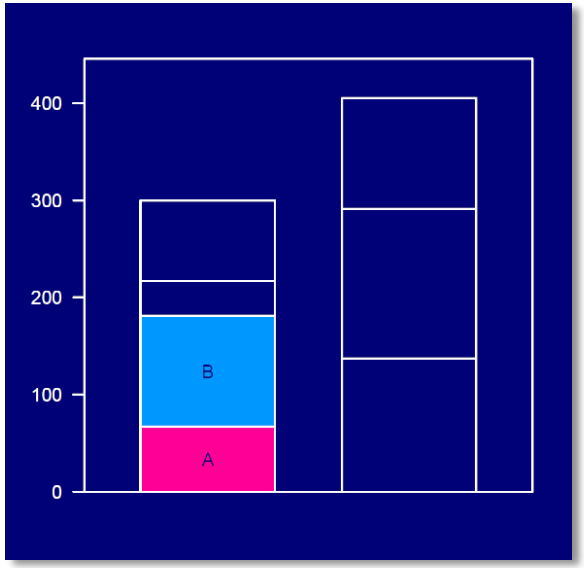


2

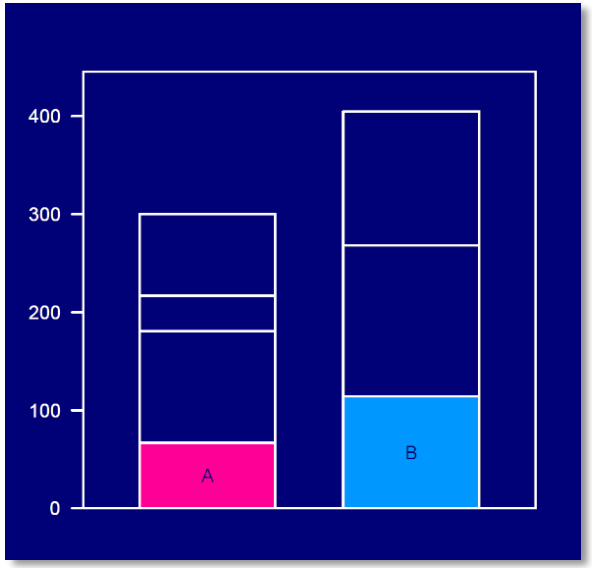
Which comparison is the easiest?



1

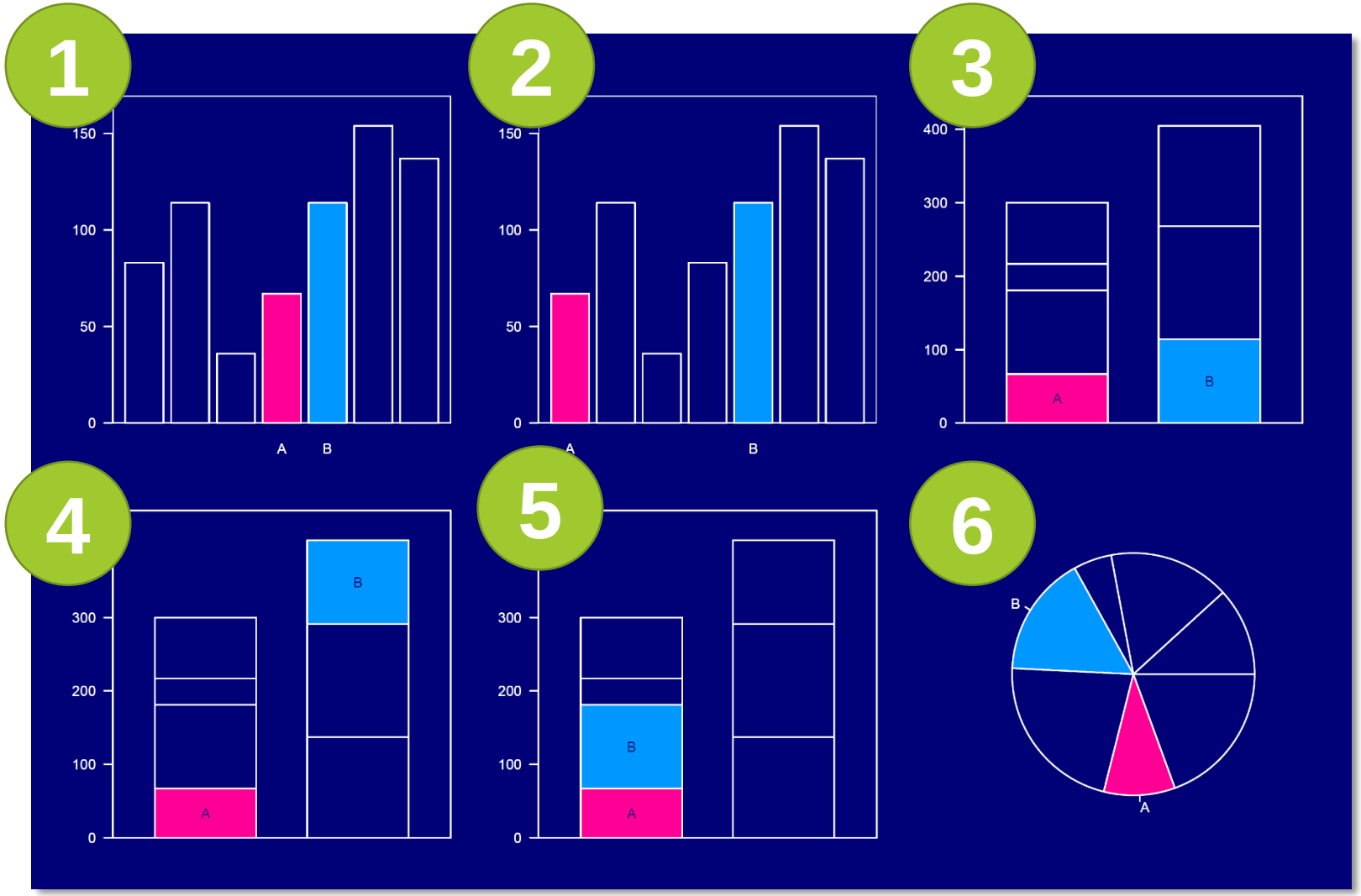


2

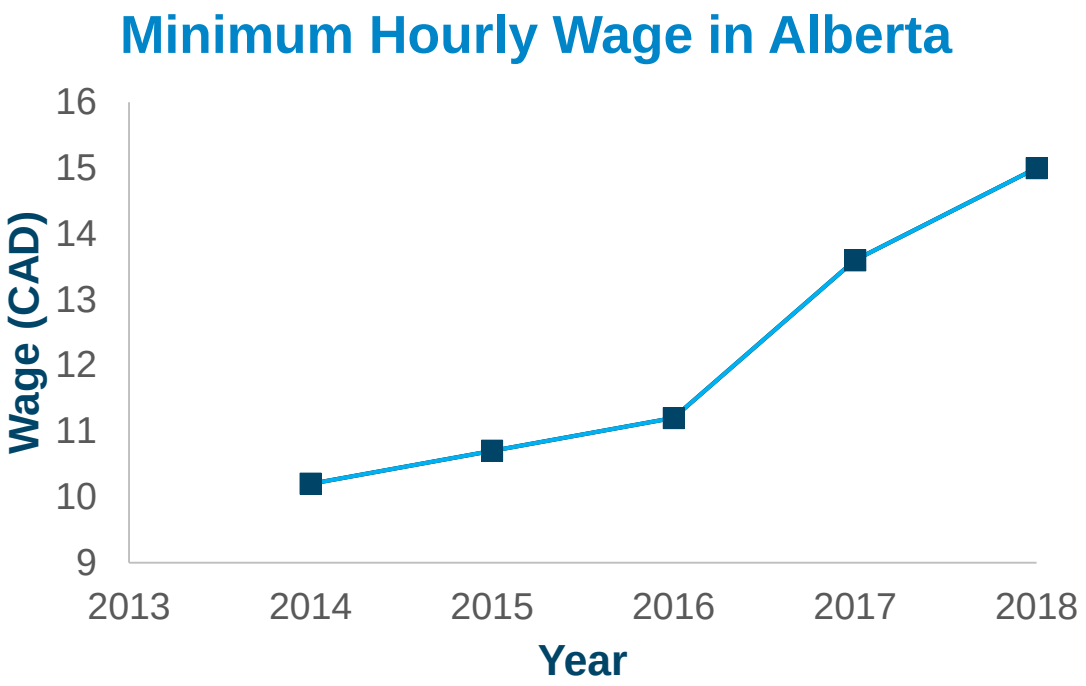


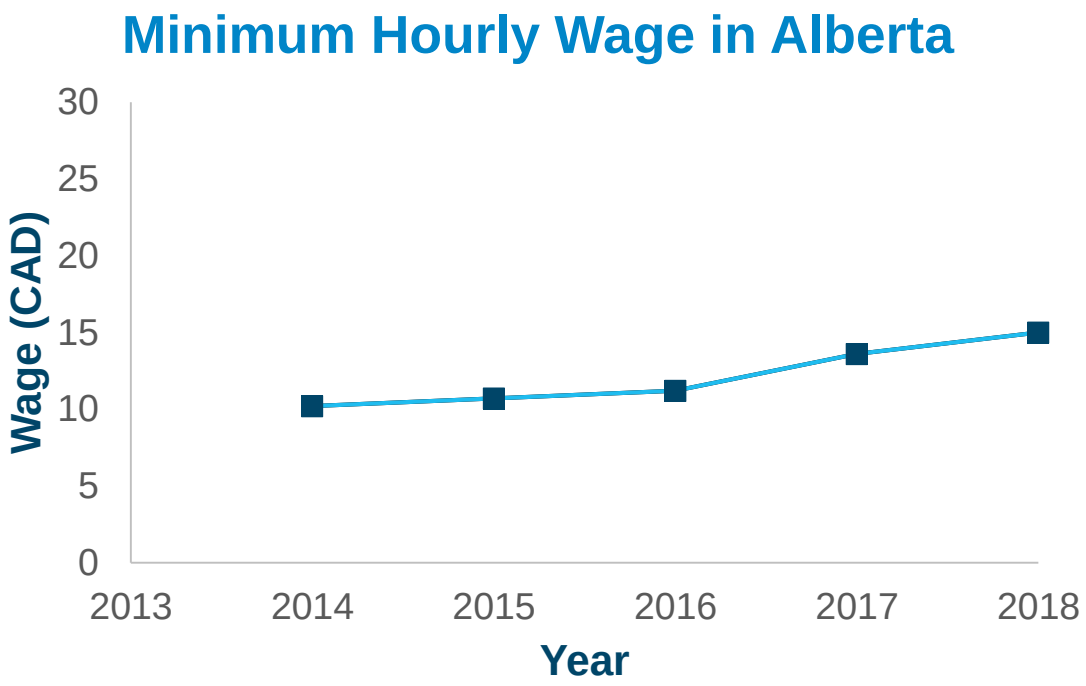
3

Which comparison is the easiest?



Decide the scale carefully

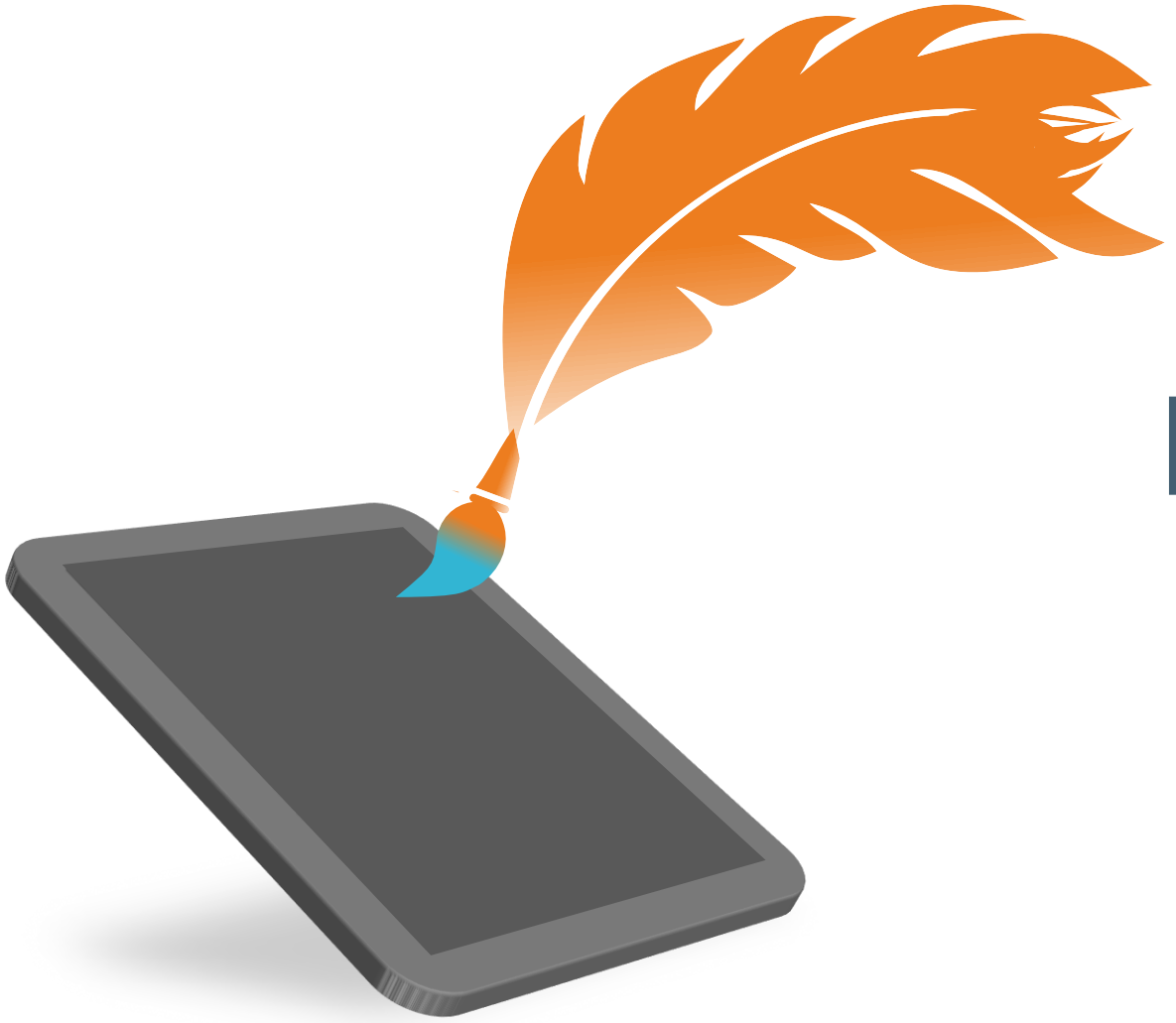




The success of your visualization is measured by **your audience**'s understanding.

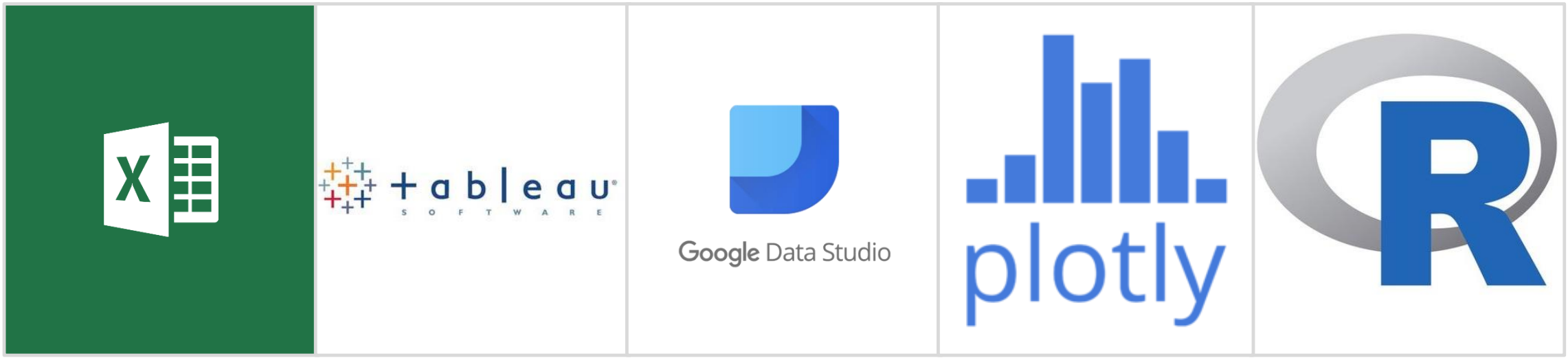
They are **not** you...

Understand the **context** in which your audience is thinking.



Data Visualization Software

Software Options



https://www.microsoft.com https://www.tableau.com https://datastudio.google.com https://plot.ly/ https://cran.r-project.org/

Software Options

	Excel	Tableau	Google Data Studio	Plotly	R
$	Commercial	Commercial + Public	Commercial + Public	Commercial + Public	Open-source & Free
⧗	Easy	Moderate to High	Moderate to High	Moderate to High	High Difficulty
🖼	Moderate quality	High quality	High quality	High quality	High quality
🖱	Static	Static + Interactive	Interactive	Interactive	Static + Interactive

Other Software Options

1 jamovi

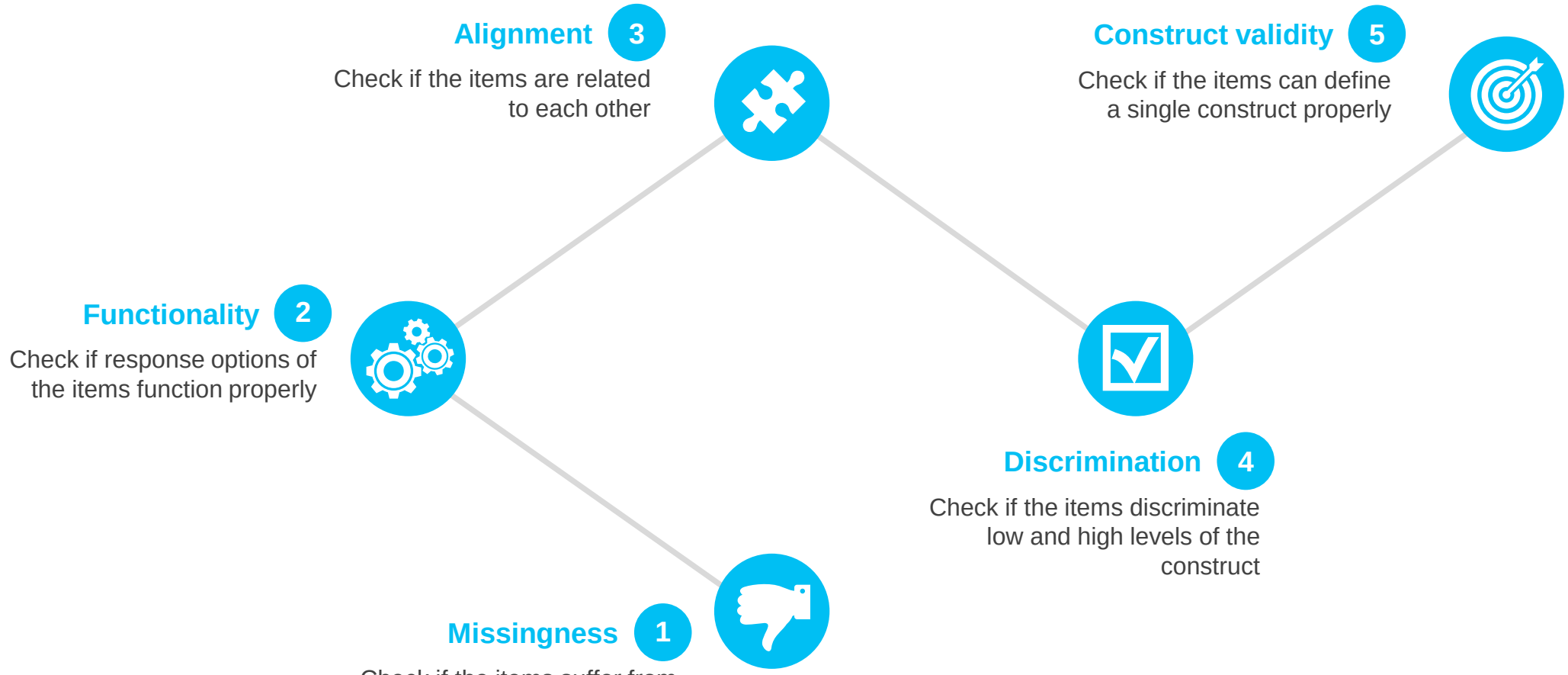
- https://www.jamovi.org/
- Free (utilizing R in the background)
- Compatible with Windows, Mac, and Linux
- Good for both statistical analysis and data visualizations

2 Modrian

- http://mondrian.theusrus.de/
- Free and open source
- Compatible with Windows, Mac, and Linux
- Good for a variety of visualizations (from basic to complex plots)

Visualizing Survey Items

Checklist for Evaluating Items



Example

- http://www.oecd.org/pisa/
- A large-scale, international assessment for 15-year-old students
- Administered every 3 years
- 540,000 students from 72 countries participated in PISA 2015
- Reading, science, and math assessments (plus additional subject areas)
- Student, teacher, and school survey items to learn more about students

Example

- Alberta students who participated in PISA 2015 (*n* = 2,133)

- Data files are available at: https://github.com/okanbulut/dataviz
  - PISA_Alberta.xlsx
  - PISA_Alberta.csv
  - PISA_Alberta.sav

- 10 Likert-type survey items ***potentially*** measuring “attitudes towards teamwork”

- Each question has the following response options:

1 = Strongly disagree **2** = Disagree **3** = Agree **4** = Strongly agree

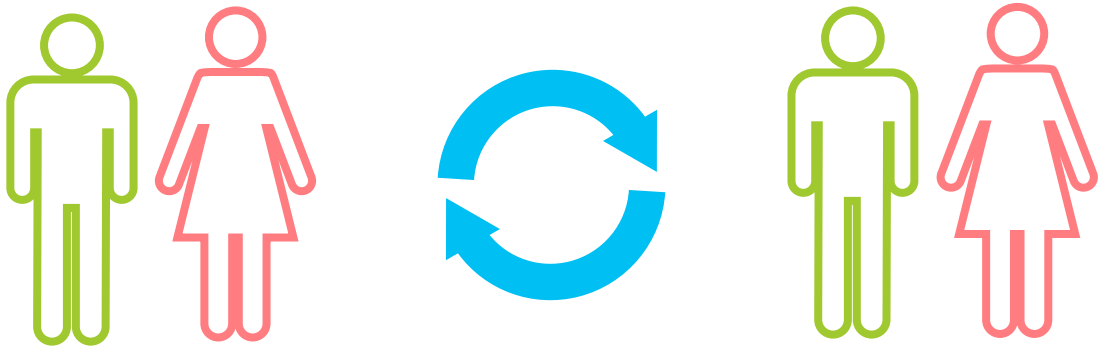
First eight questions share the same statement:

“To what extent do you disagree or agree about yourself?”

1. I prefer working as part of a team to working alone.
2. I am a good listener.
3. I enjoy seeing my classmates be successful.
4. I take into account what others are interested in.
5. I find that teams make better decisions than individuals.
6. I enjoy considering different perspectives.
7. I find that teamwork raises my own efficiency.
8. I enjoy cooperating with peers.

The other two items are independent:

9. I make friends easily at school.
10. Other students seem to like me.



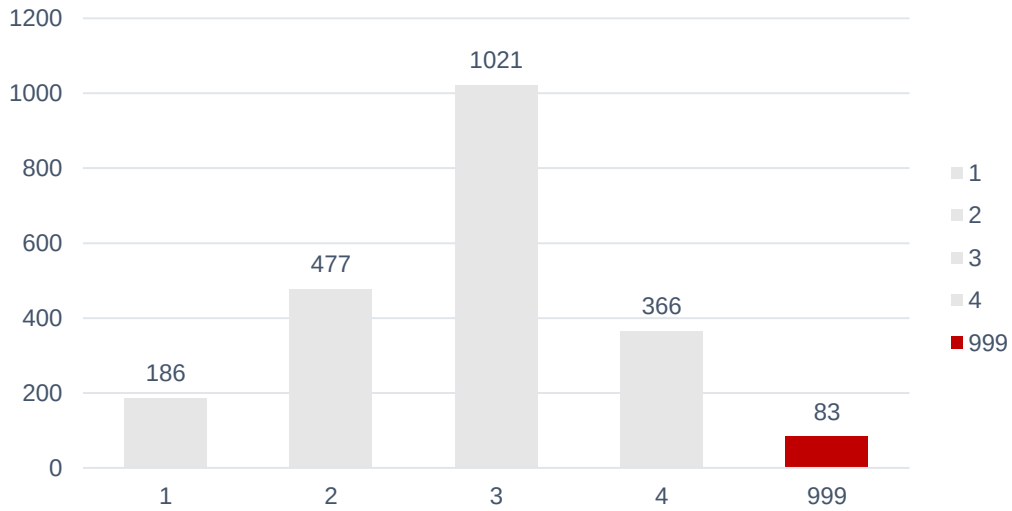
Missingness

01

Microsoft Excel

- Make sure that missing values are labeled with a distinct value (e.g., 999).
- Create a pivot table for each item (see this tutorial on how to create pivot tables in Excel)
- Insert a bar graph to examine missingness visually (see the example file that I shared at https://github.com/okanbulut/dataviz.

Row Labels	Count of ST082Q01NA
1	186
2	477
3	1021
4	366
999	83
Grand Total	**2133**

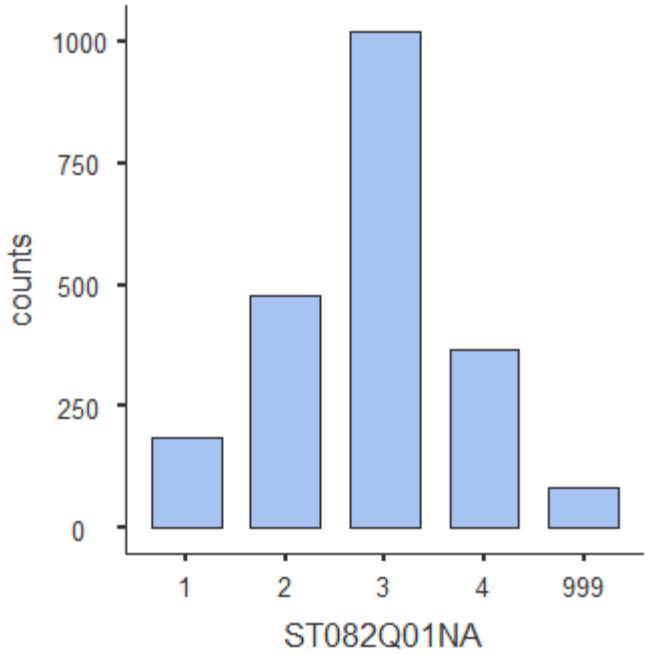


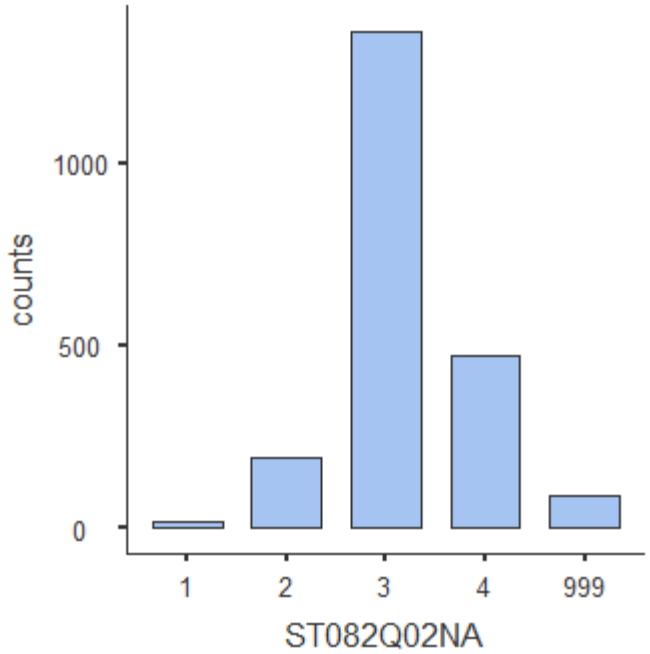
Missingness

02

jamovi

- Make sure that missing values are labeled with a distinct value (e.g., 999).
- Import the data into jamovi.
- Exploration → Descriptives → Bar Plots (see my tutorial video HERE)





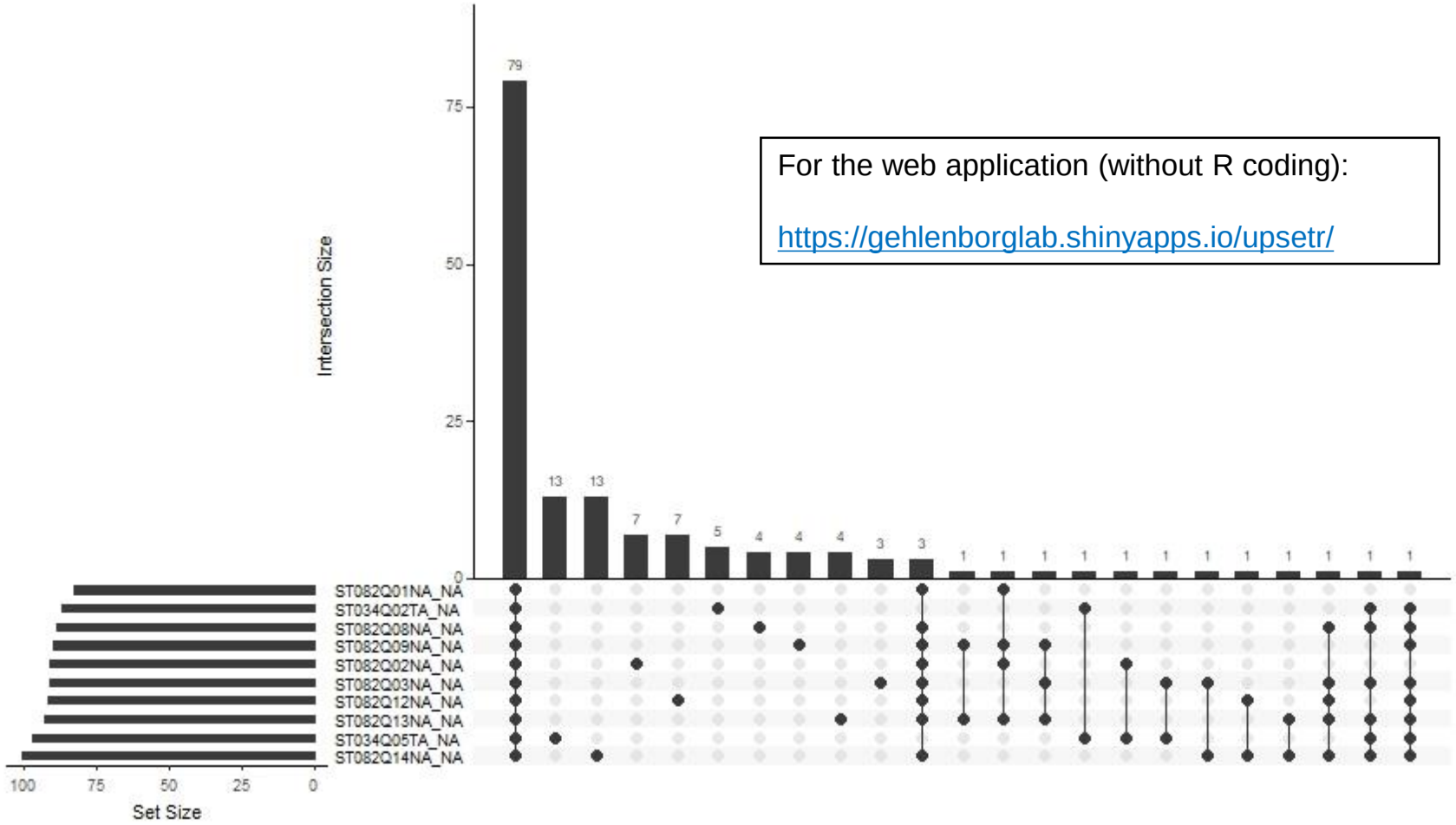
Missingness

03

naniar package in R

- Check out this nice vignette on the naniar package.

```
install.packages("naniar")
library("naniar")
mydata <- read.csv("PISA_Alberta.csv", header = TRUE, na.strings = 999)
# Select only the survey items
gg_miss_upset(mydata[, 6:15], nsets = 10)
```



For the web application (without R coding):

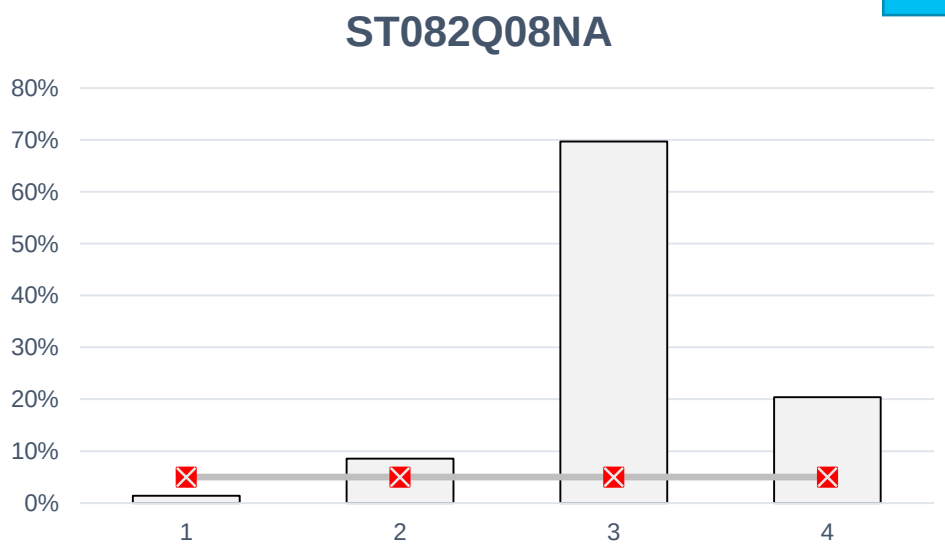
https://gehlenborglab.shinyapps.io/upsetr/

Functionality

Microsoft Excel

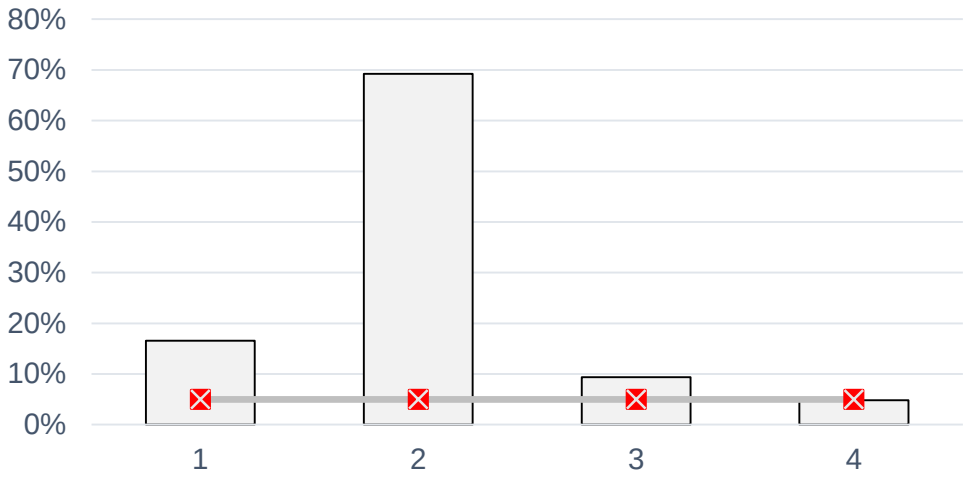
- Make sure that missing values are **NOT** labeled this time (i.e., replace 999 with null)
- Create a new pivot table for each item (this time missing is **NOT** included) and calculate percentages based on counts.
- Insert a bar graph to examine the percentages for each response option for a given item.
- My threshold for an acceptable response rate is typically 5%. So, you can add a horizontal line at 5% as a threshold (see this nice tutorial on how to add such a line into Excel)

Which response option(s) are not functioning well?



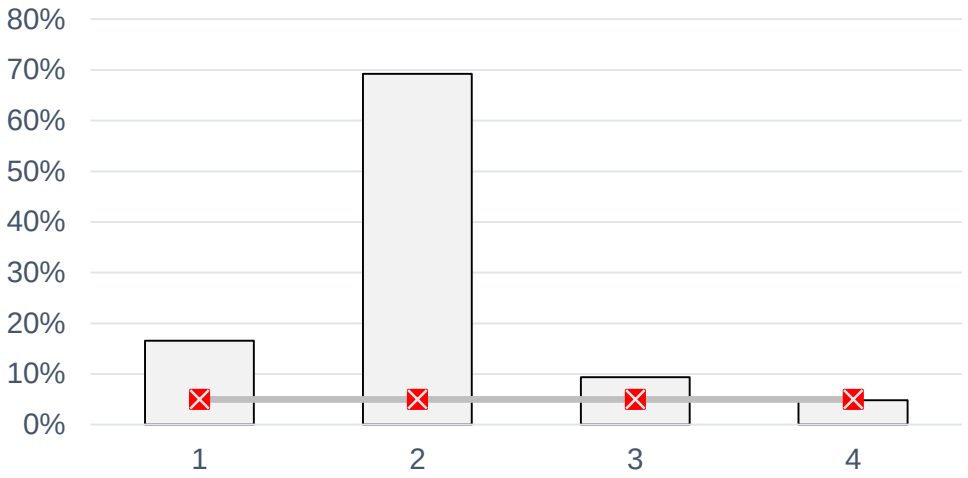
I take into account what others are interested in.

ST082Q01NA



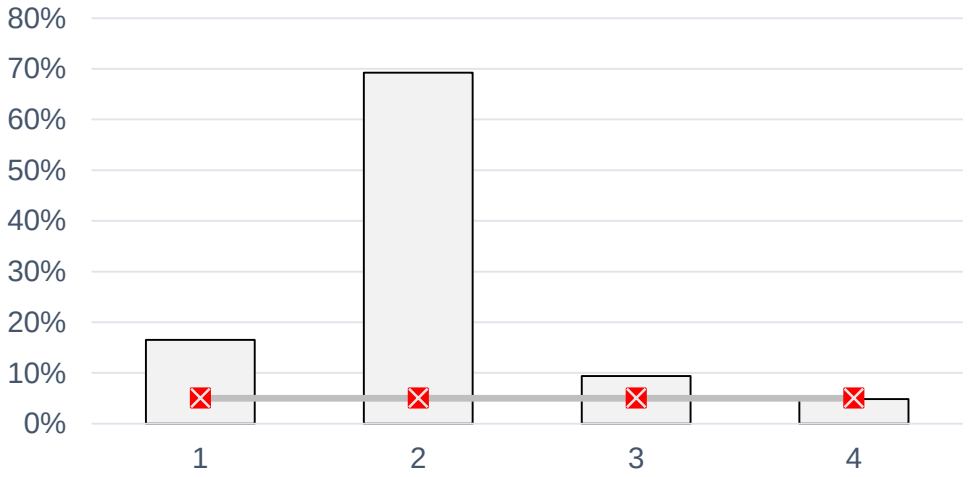
I prefer working as part of a team to working alone.

ST082Q02NA



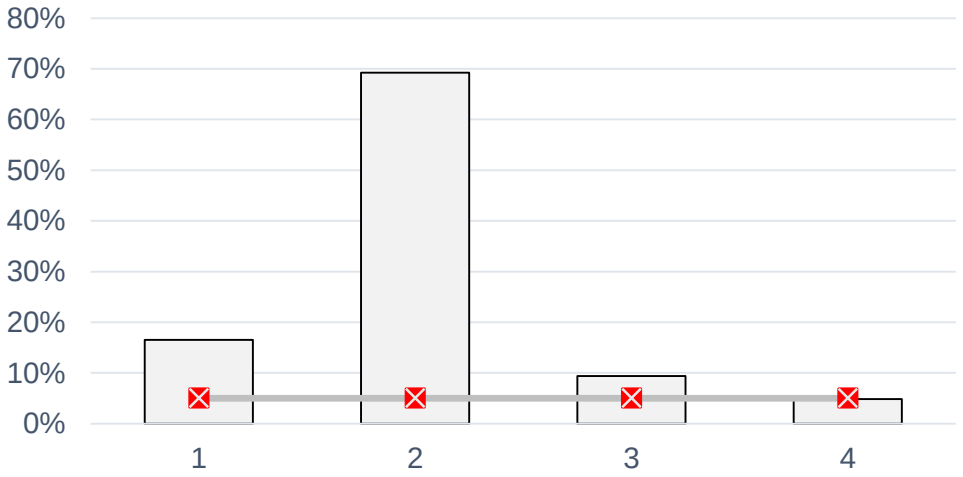
I am a good listener.

ST082Q03NA



I enjoy seeing my classmates be successful.

ST034Q05TA

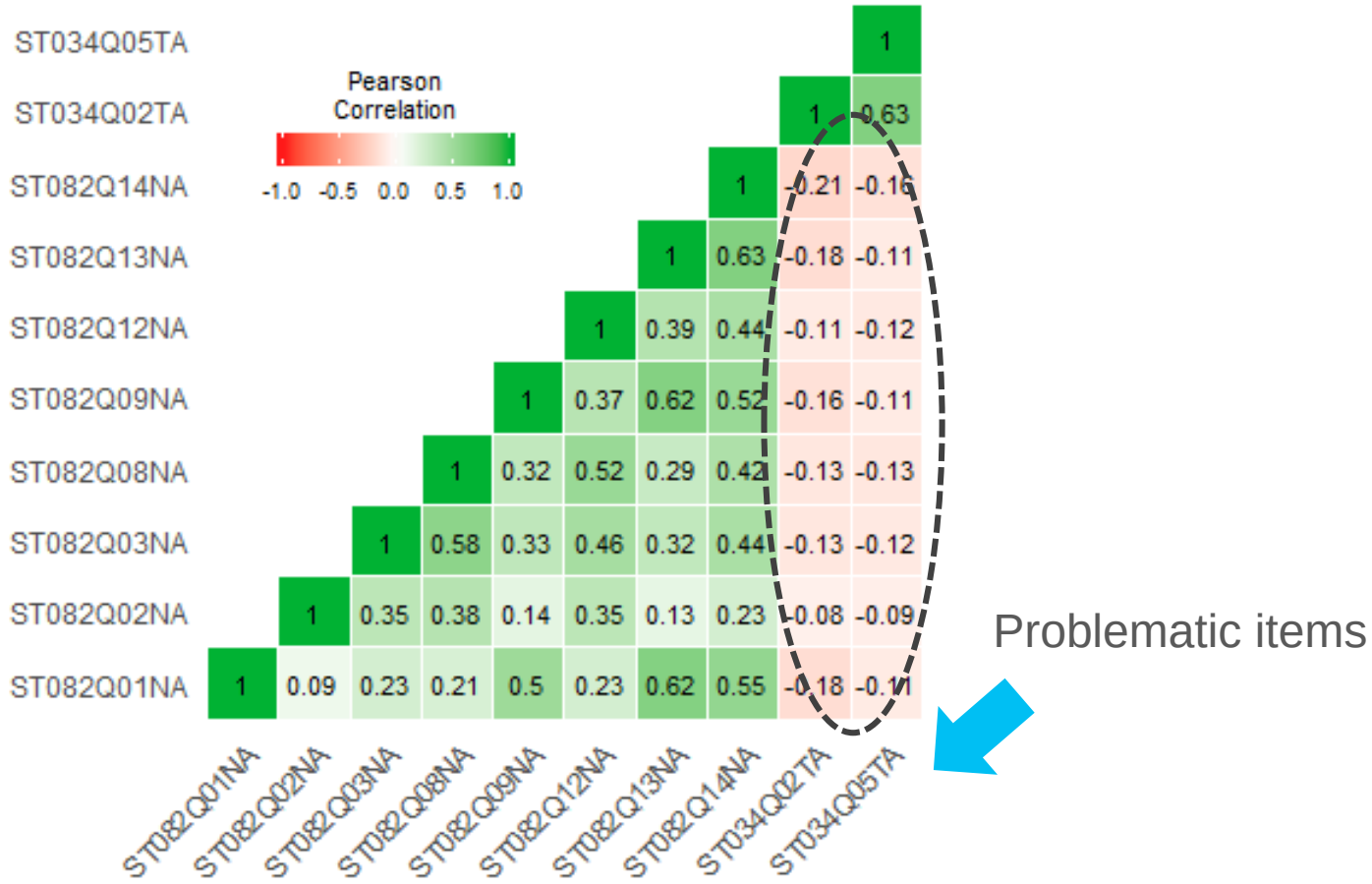


Other students seem to like me.

Alignment

jamovi

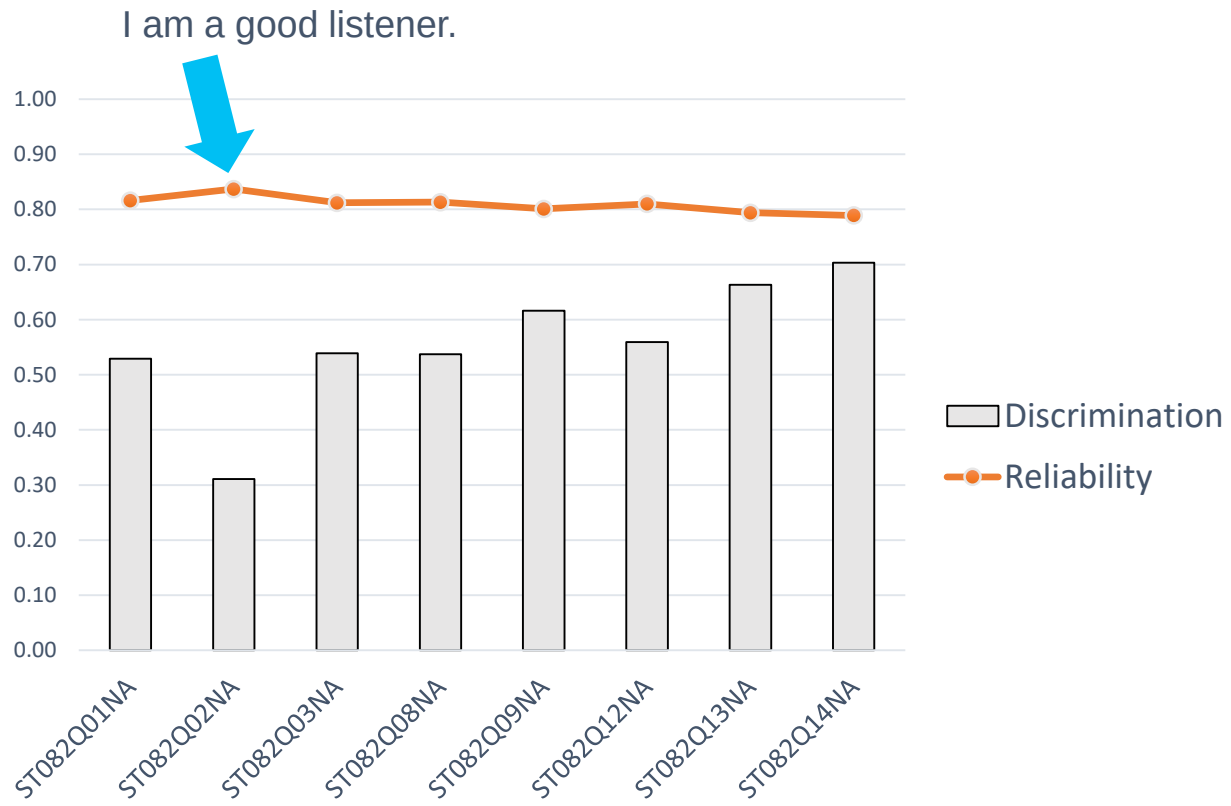
- Make sure that missing values are **NOT** labeled with a distinct value (e.g., missing is null).
- Import the data into jamovi.
- Factor → Reliability Analysis → Correlation heatmap (see my tutorial video HERE)



Discrimination

jamovi + Microsoft Excel

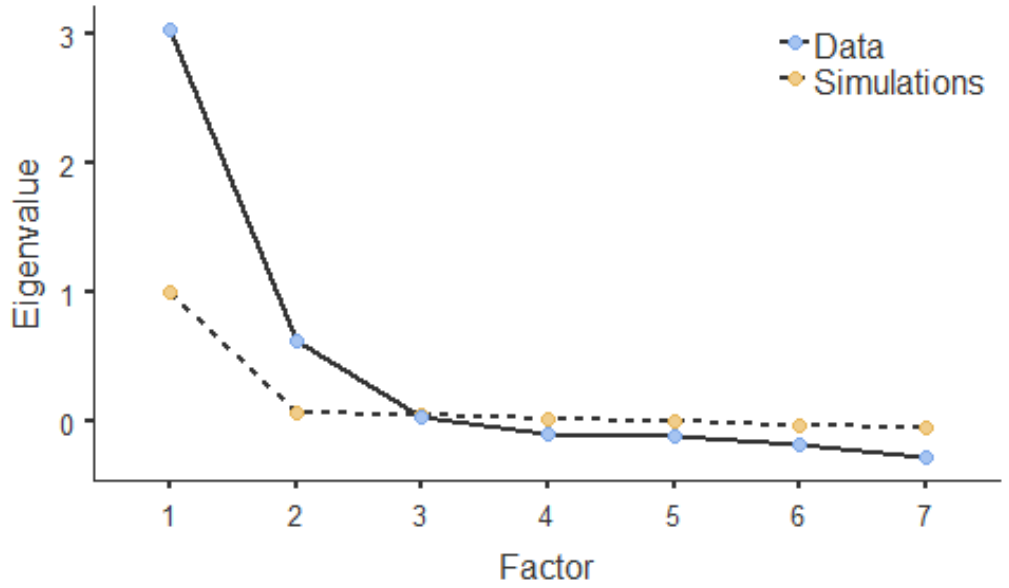
- Make sure that missing values are **NOT** labeled with a distinct value (e.g., missing is null).
- Import the data into jamovi.
- Factor → Reliability Analysis → Cronbach's α & Item-rest correlation (see my tutorial video HERE)
- Copy the output table and paste it into an Excel spreadsheet



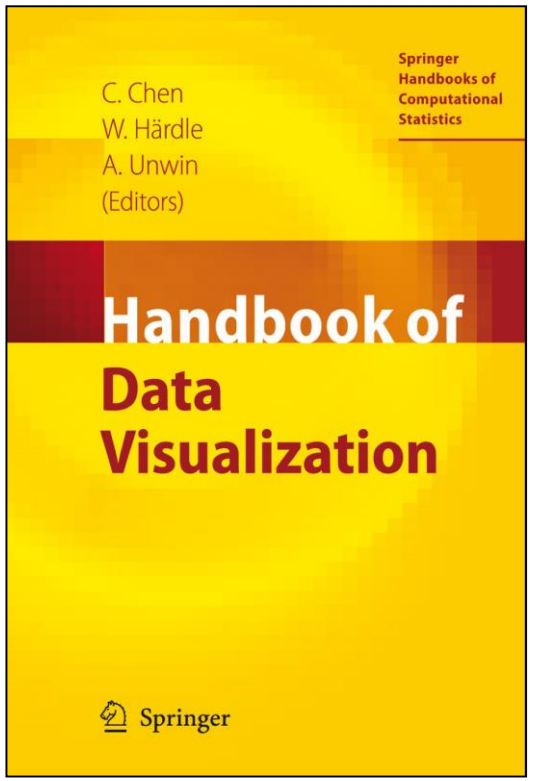
Construct Validity

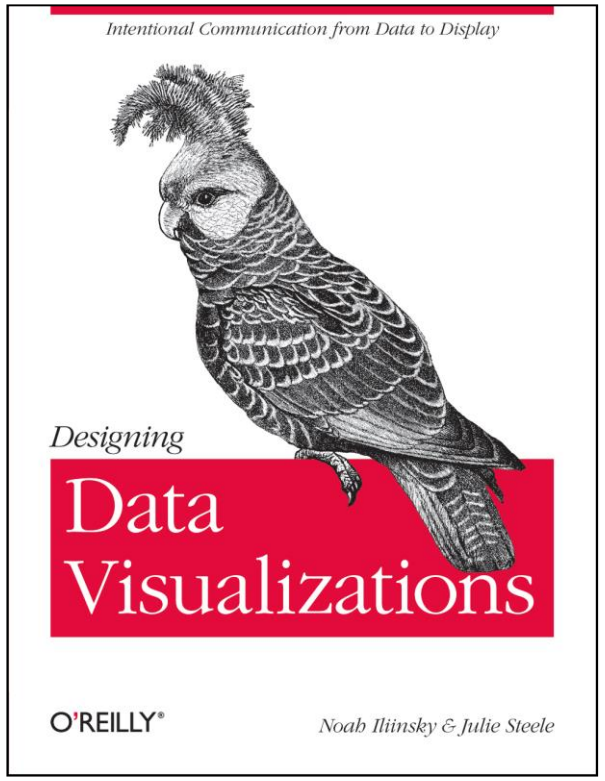
jamovi

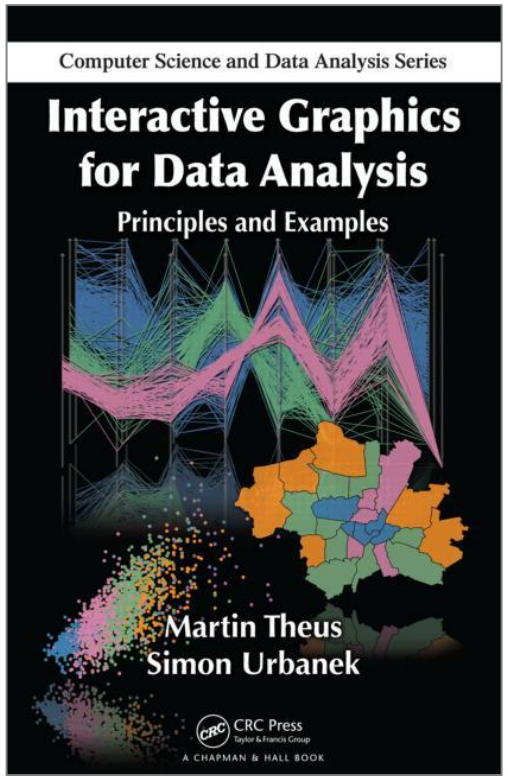
- Make sure that missing values are **NOT** labeled with a distinct value (e.g., missing is null).
- Import the data into jamovi.
- Factor → Exploratory Factor Analysis → Scree plot (see my tutorial video HERE)

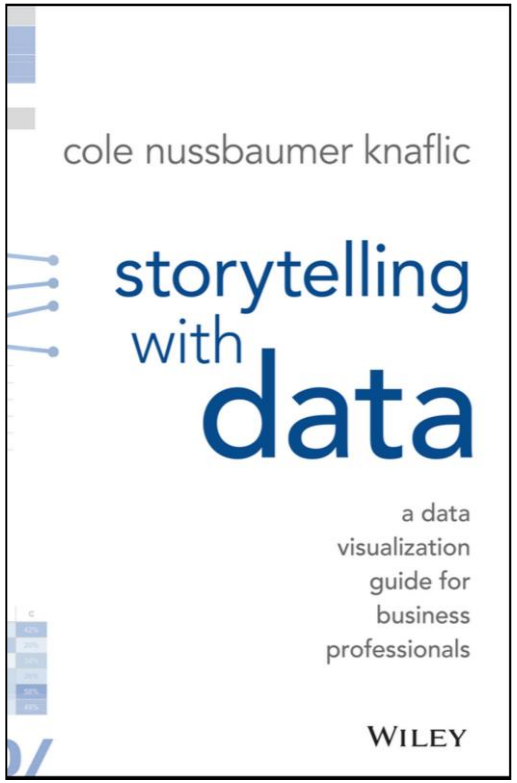


Some Resources…









Some Resources…

- Navarro and Foxcroft - **Learning Statistics with jamovi**
- Santiago Ortiz - **45 ways to communicate two quantities**
- Stephanie Evergreen - **Data Visualization Checklist**
- Financial Times - **Visualization Vocabulary**
- Darkhorse Analytics - **Visualizing Distributions**
- Chez Voila - **Glass Ceiling Visuals Remake**
- Eager Eyes - **Understanding Pie Charts**

Thank You

For questions and comments: **bulut@ualberta.ca**