

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

Okan Bulut

Centre for Research in Applied Measurement and Evaluation
University of Alberta

To download this presentation: <http://bit.ly/csse2019dataviz>



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?

LEARNING STYLES

“Learning styles” suggest that each individual learns differently.



VISUAL



AUDITORY



TACTILE



LEARNING STYLES

Please fill out the learning style inventory in the following link:

<https://goo.gl/JY6Vjq>

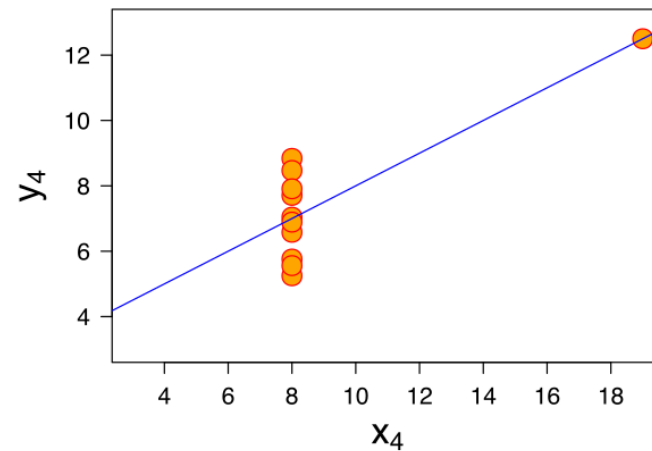
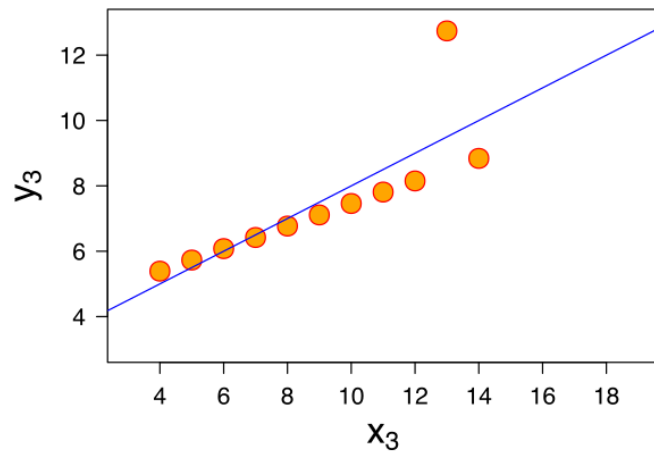
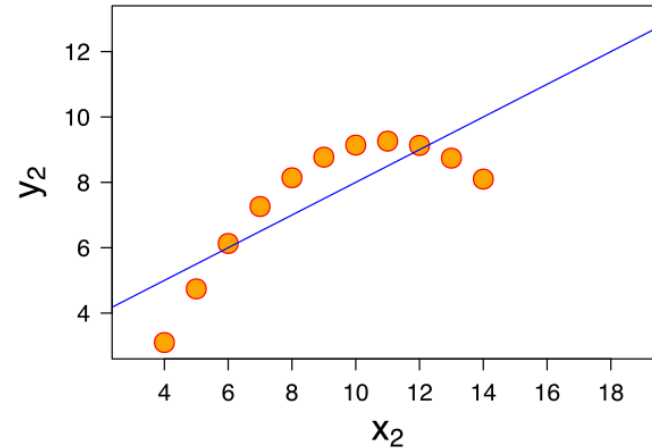
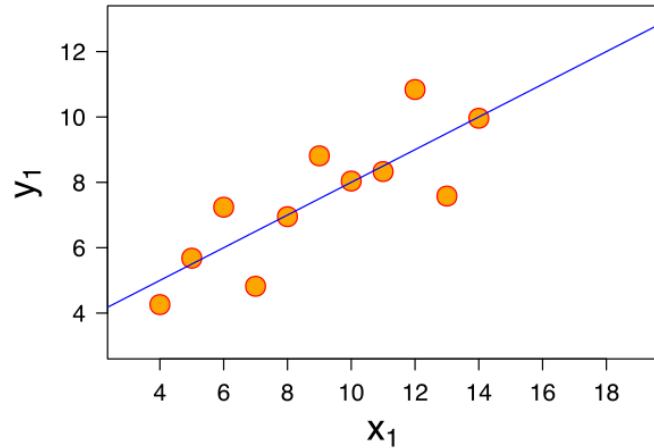
1

2



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



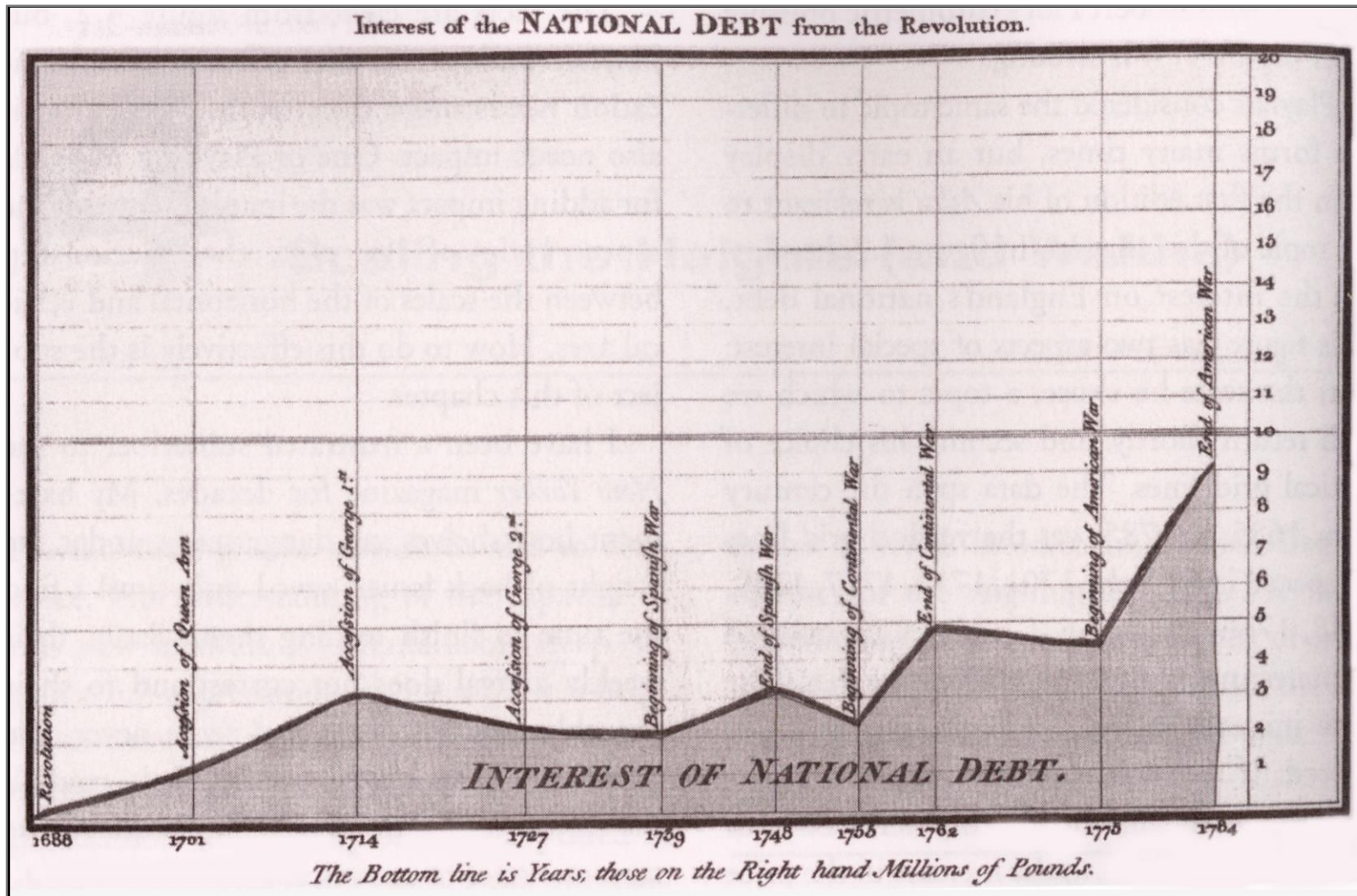
To inspire new questions and further exploration



To help identify sub-problems

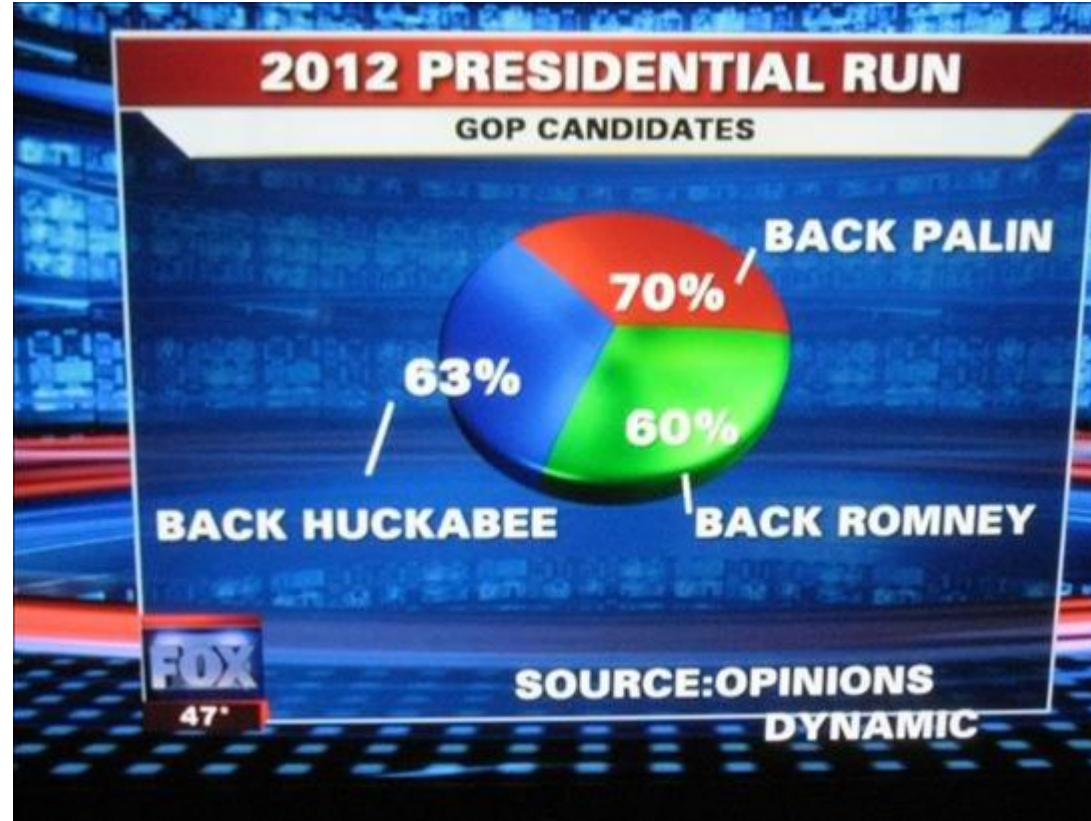


To discover or search for interesting or specific data points in a larger field



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?



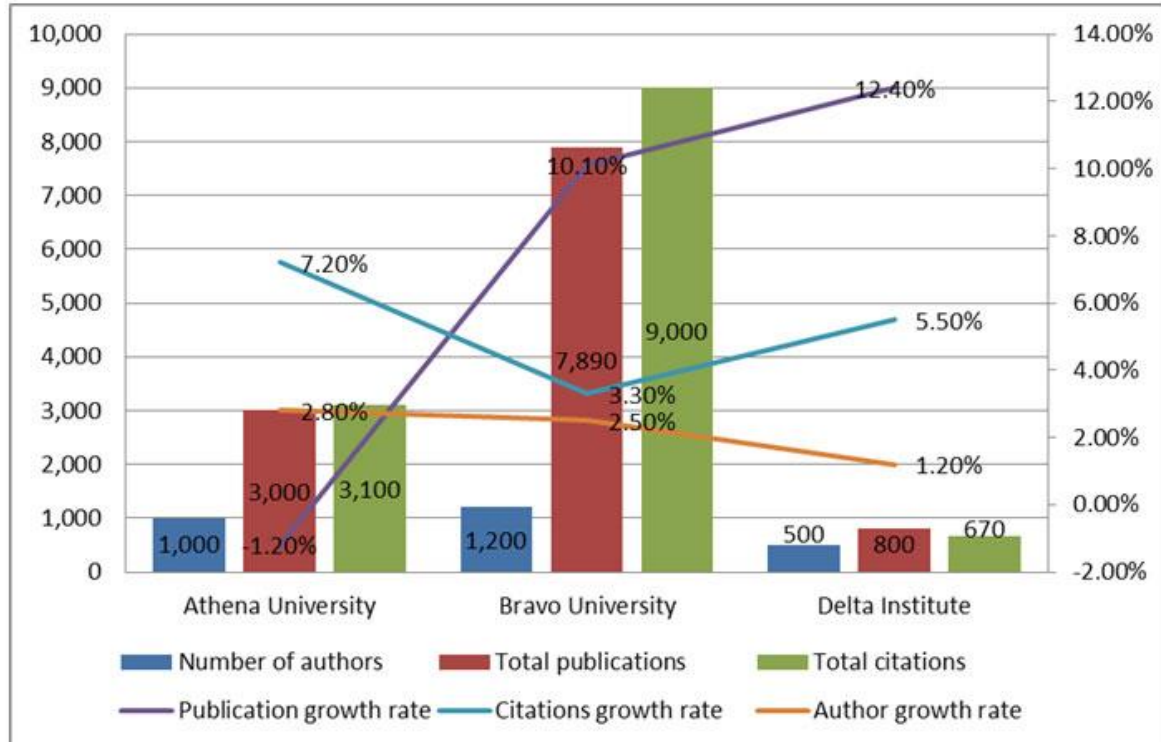
Source: Fox News – the percentages add up to 193%...

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

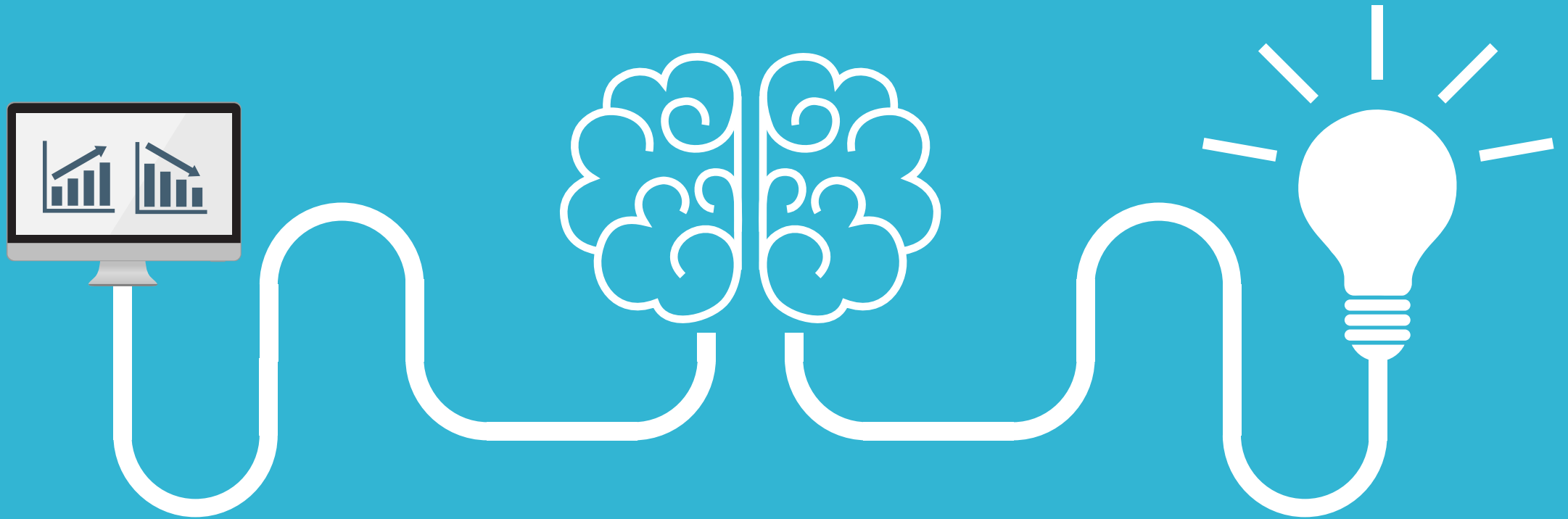
-- Iliinsky and Steele (2011)

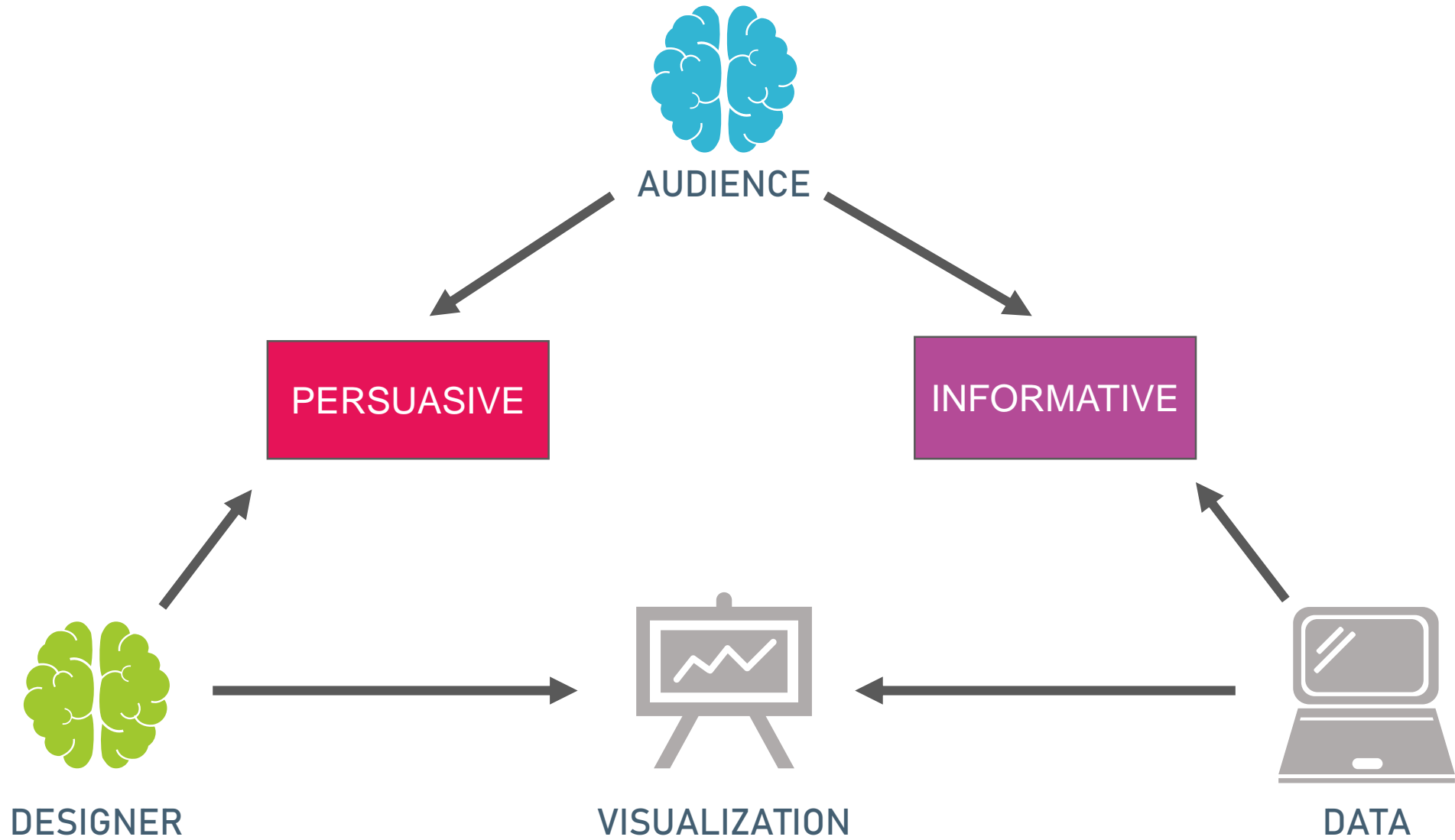


We have all done this...



Purpose







In practice, we...



EXPLORE (Informative)

Potential issues in the data:

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



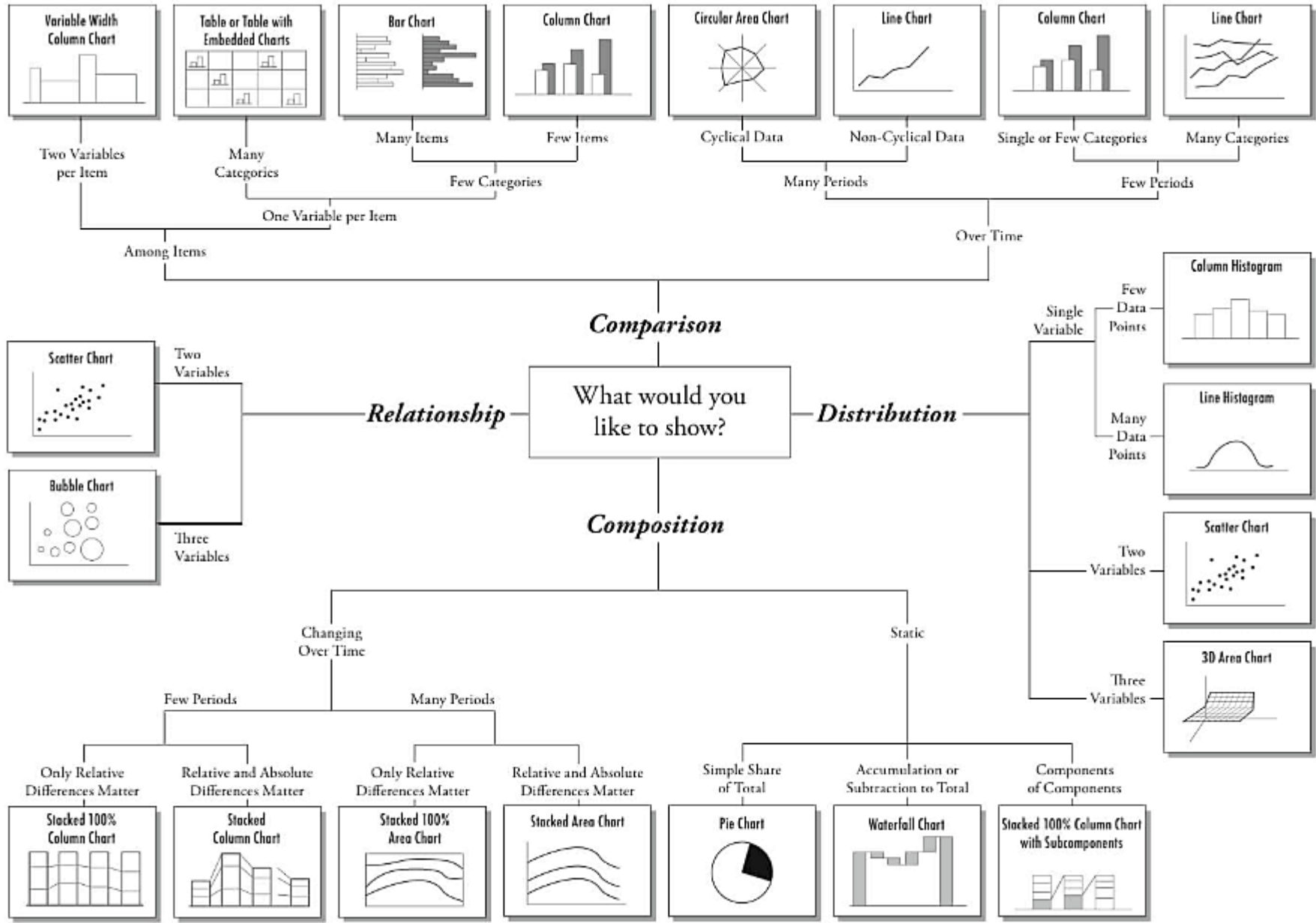
EXPLAIN (Informative)

Relationships between variables;
correlations; interactions; patterns over
time



PROVE (Persuasive)

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



Some **Design** Principles...



Determine the number of dimensions

Number of variables

Colours and shading

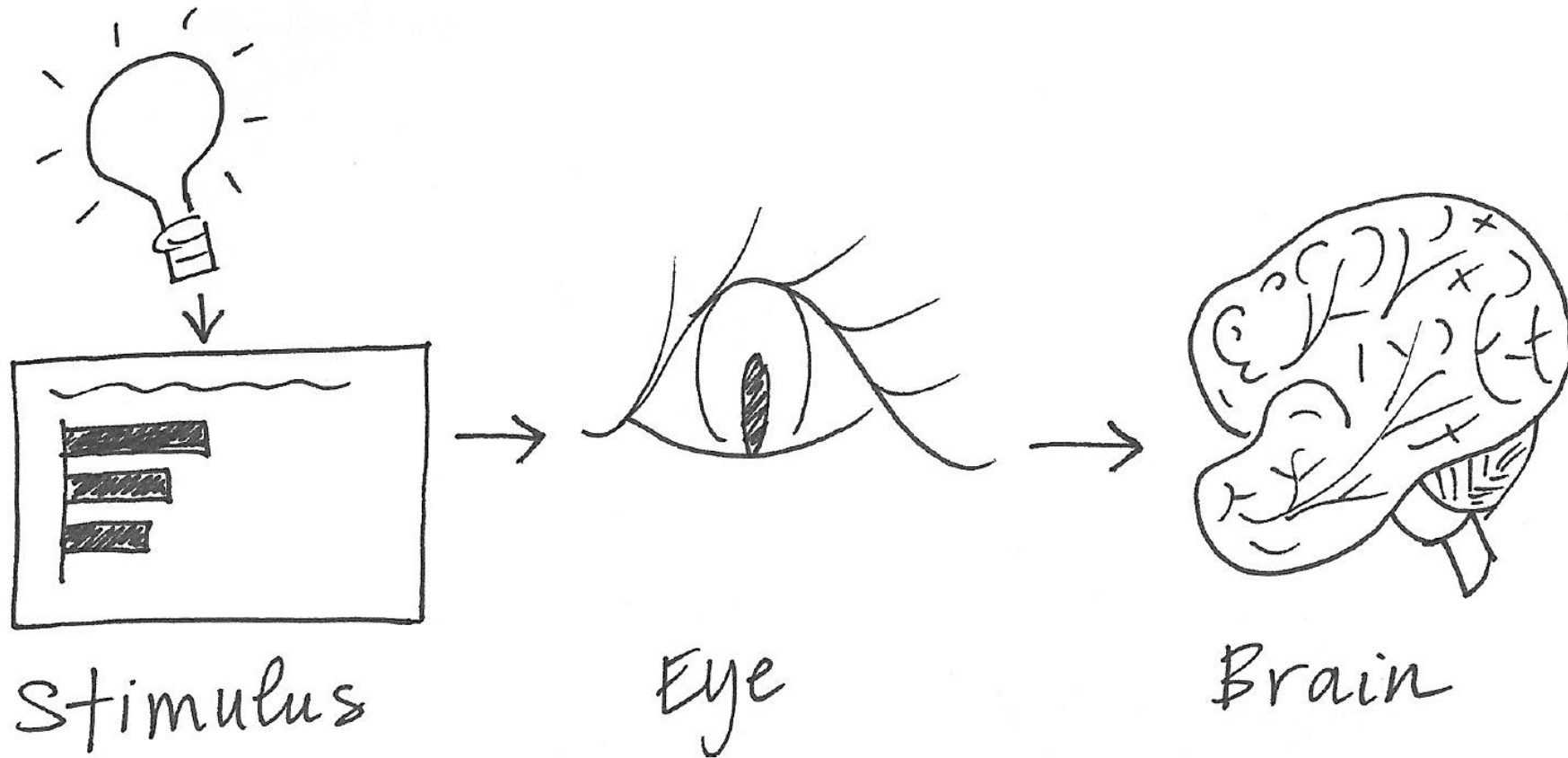
Shapes and lines

Size and thickness

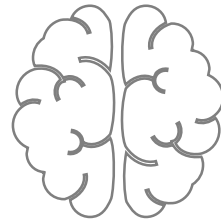
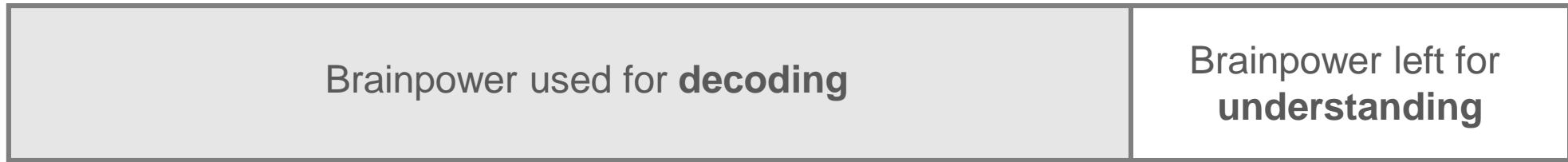
Font and font size



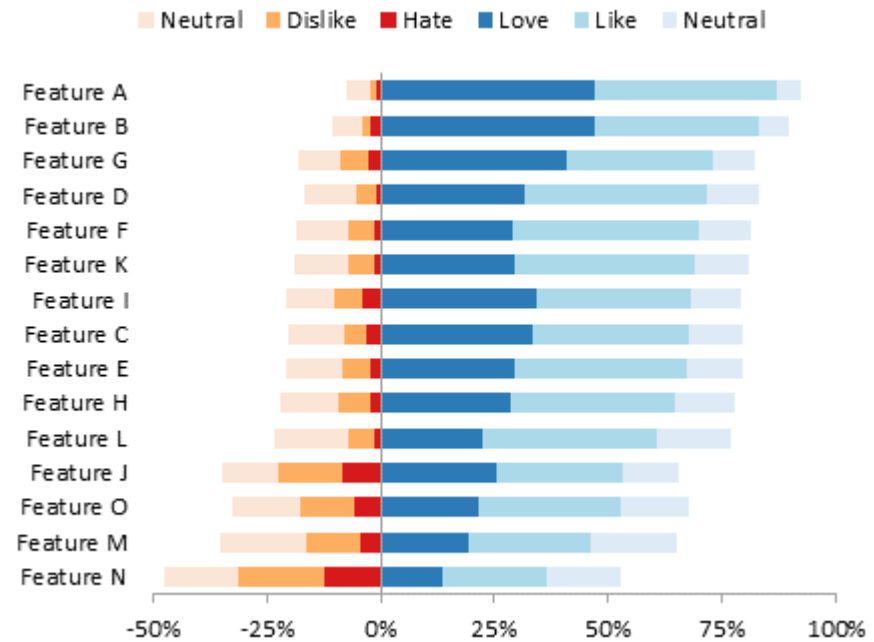
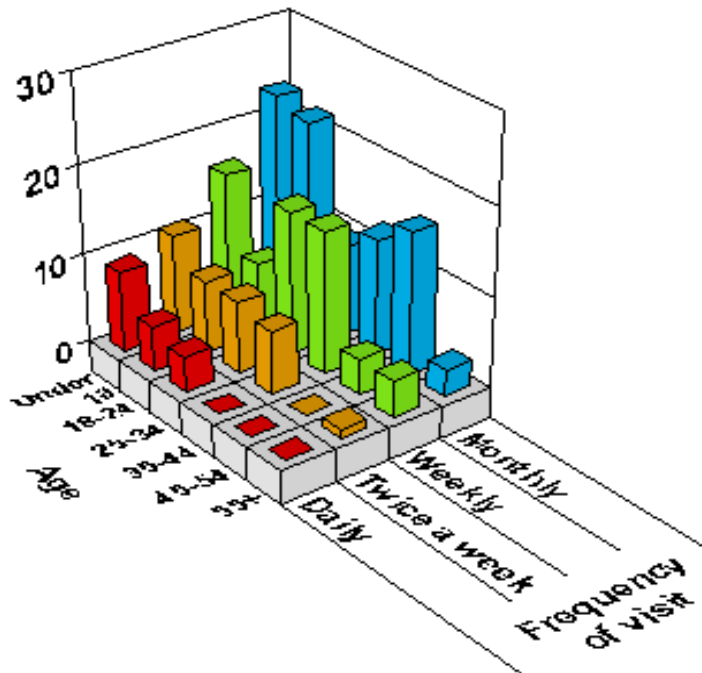
Short-term memory → Long-term memory



Decoding → Understanding

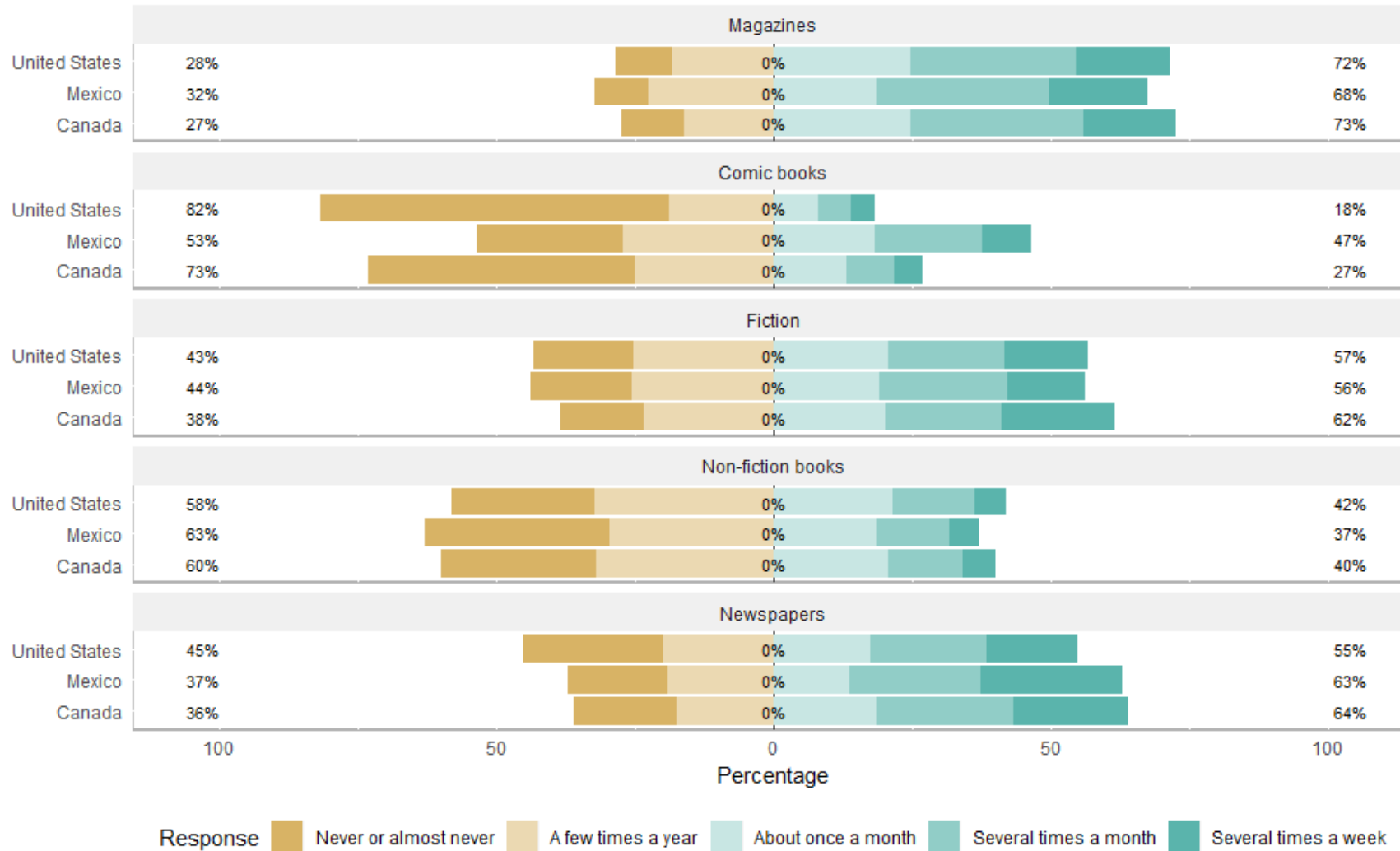


More Complex \neq Better



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

How often do you read these materials because you want to?



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

-- Leonardo da Vinci

Remove

to improve
(the **data-ink** ratio)

Created by Darkhorse Analytics

www.darkhorseanalytics.com

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

Remove to improve the **pie chart** edition

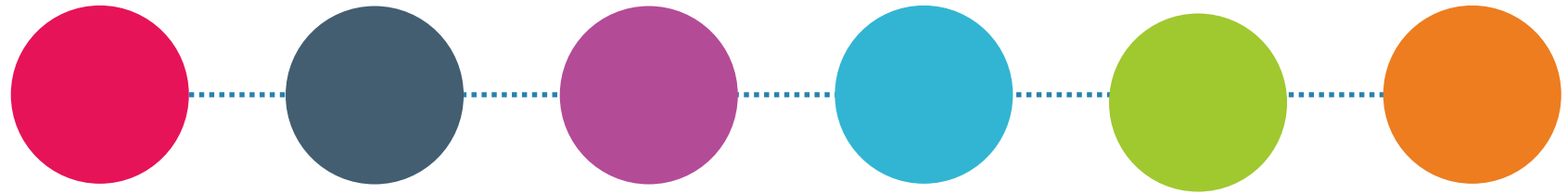
Created by Darkhorse Analytics

www.darkhorseanalytics.com

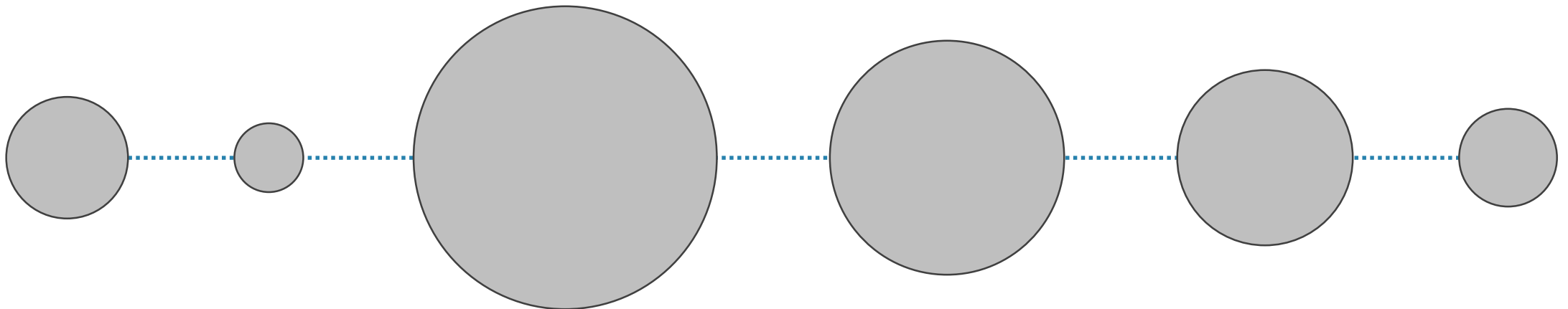
Source: <https://www.darkhorseanalytics.com/blog/salvaging-the-pie>

Ordering Values

Colour

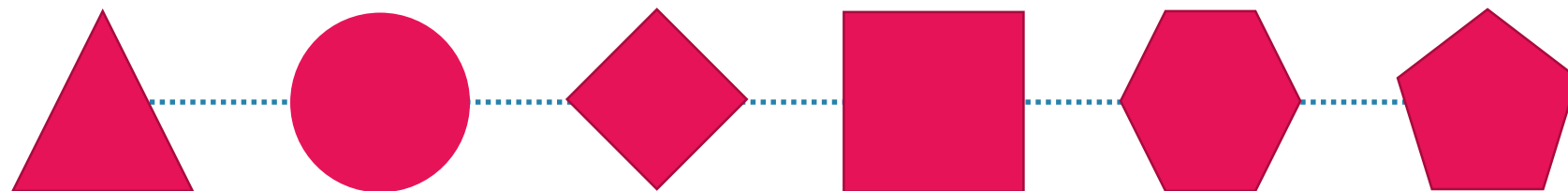


Size

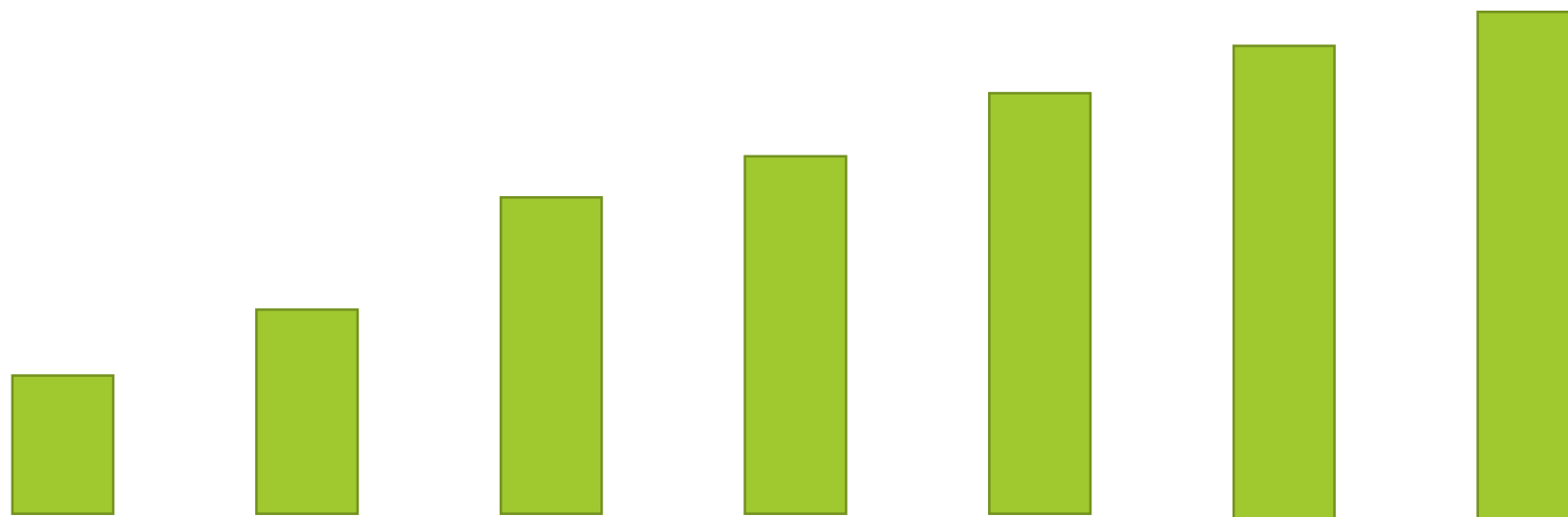


Ordering Values

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

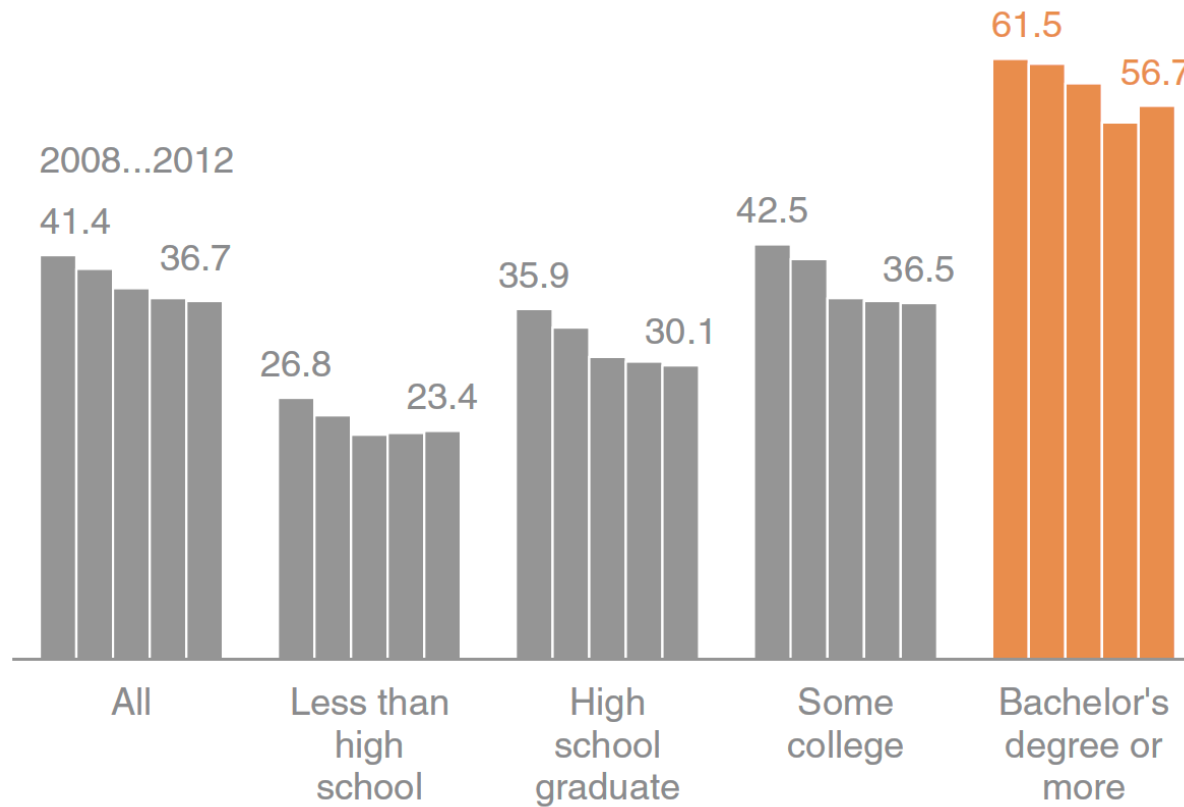
RANK	1	2	3	4	5+
------	---	---	---	---	----

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

Ordering Values

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

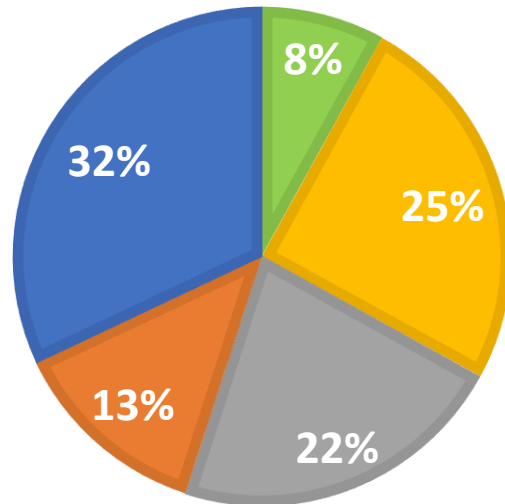


Note: Marriage eligible includes the newly married plus those widowed, divorced, or never married at interview.

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		

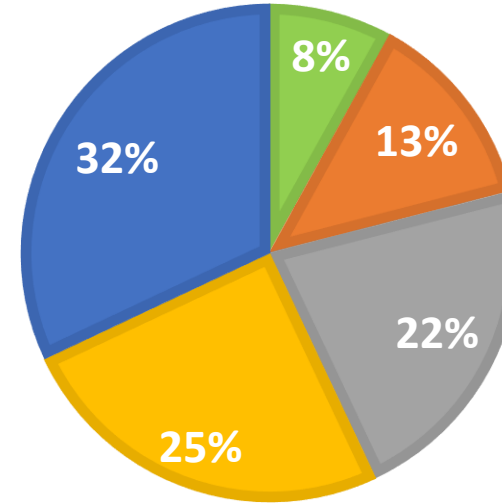
Ordering Values

HIGH SCHOOL STUDENTS' COLLEGE PREFERENCES (UNSORTED)



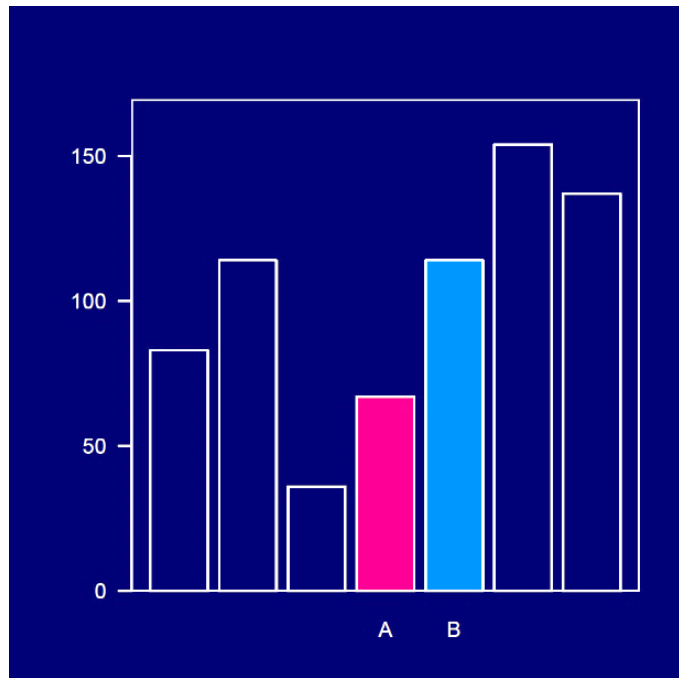
- Undecided
- Education
- Engineering
- Medicine
- Arts and Science

HIGH SCHOOL STUDENTS' COLLEGE PREFERENCES (SORTED)

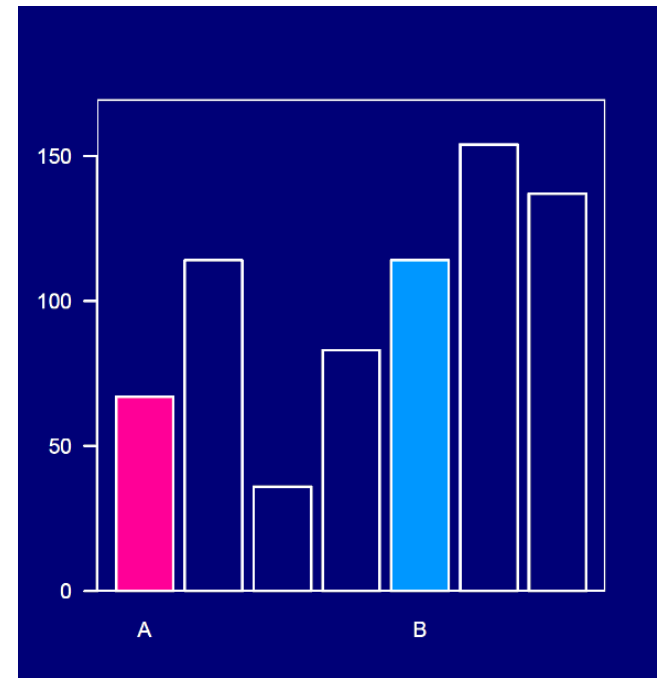


- Undecided
- Medicine
- Engineering
- Education
- Arts and Science

Which comparison is easier?

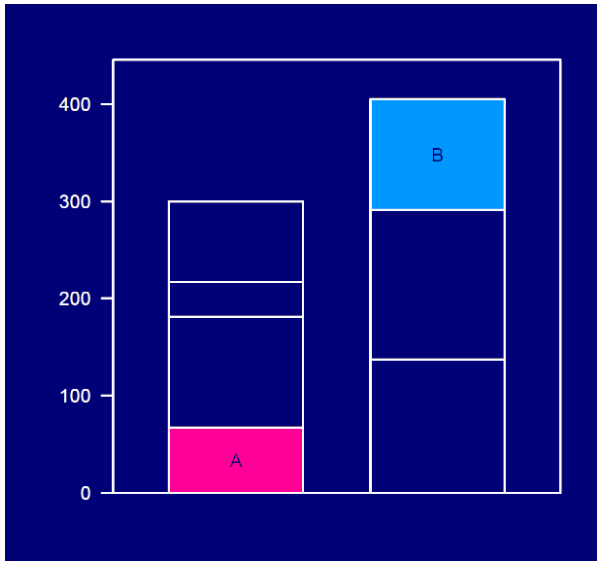


1

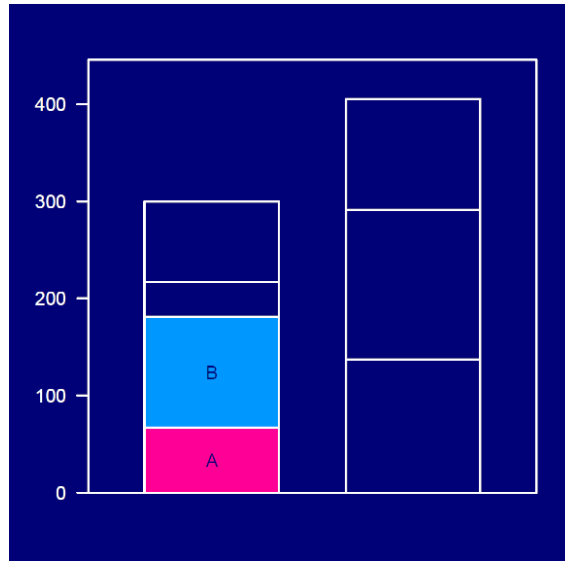


2

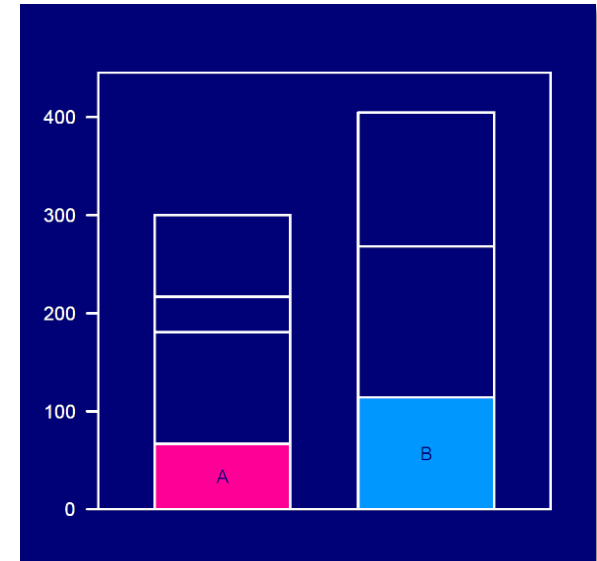
Which comparison is the easiest?



1

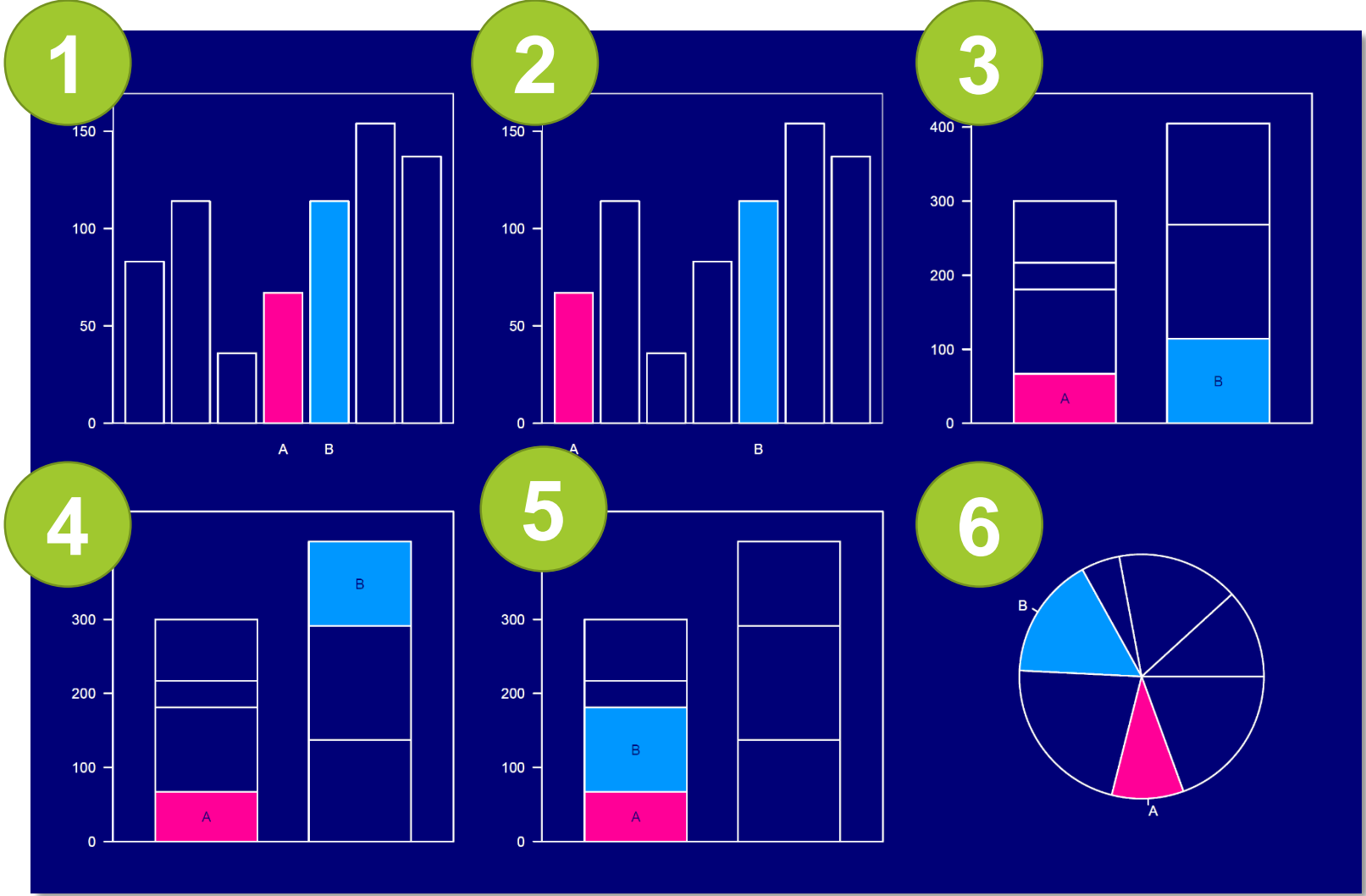


2



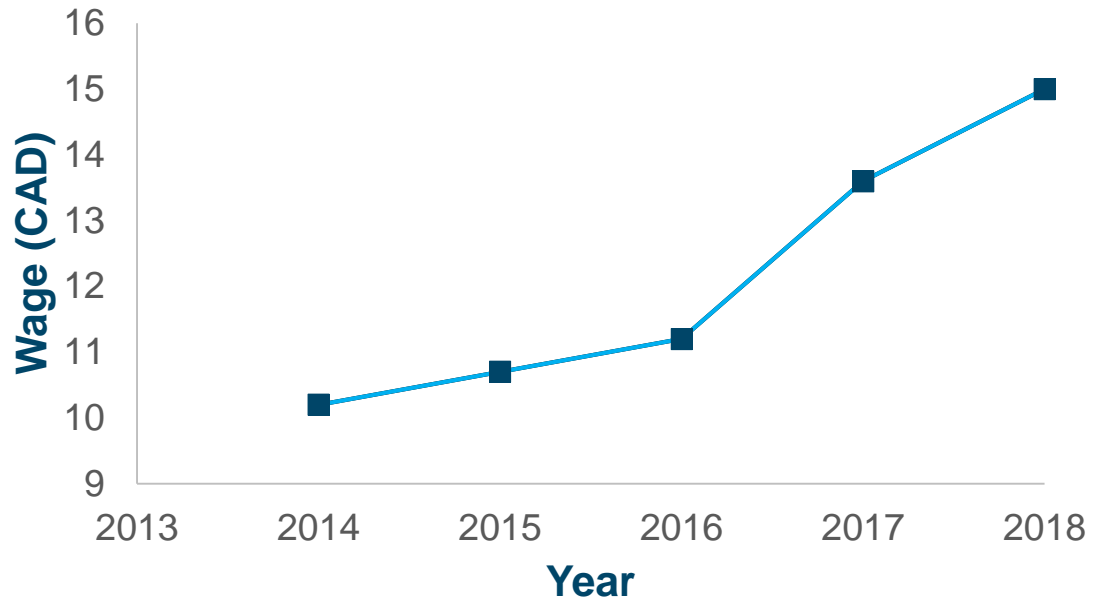
3

Which comparison is the easiest?

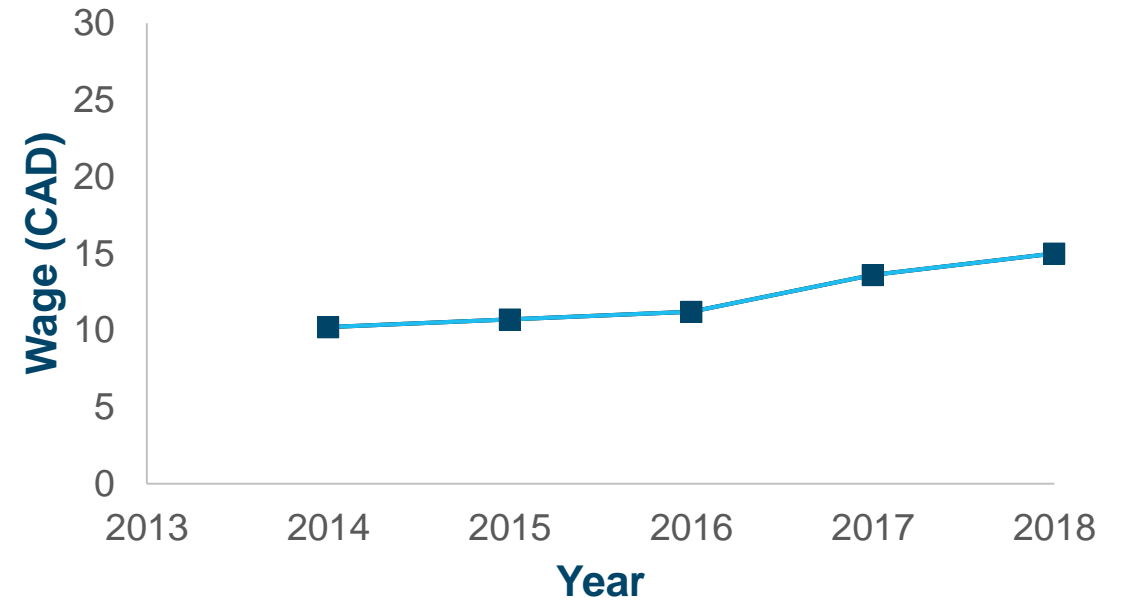


Decide **the scale** carefully

Minimum Hourly Wage in Alberta



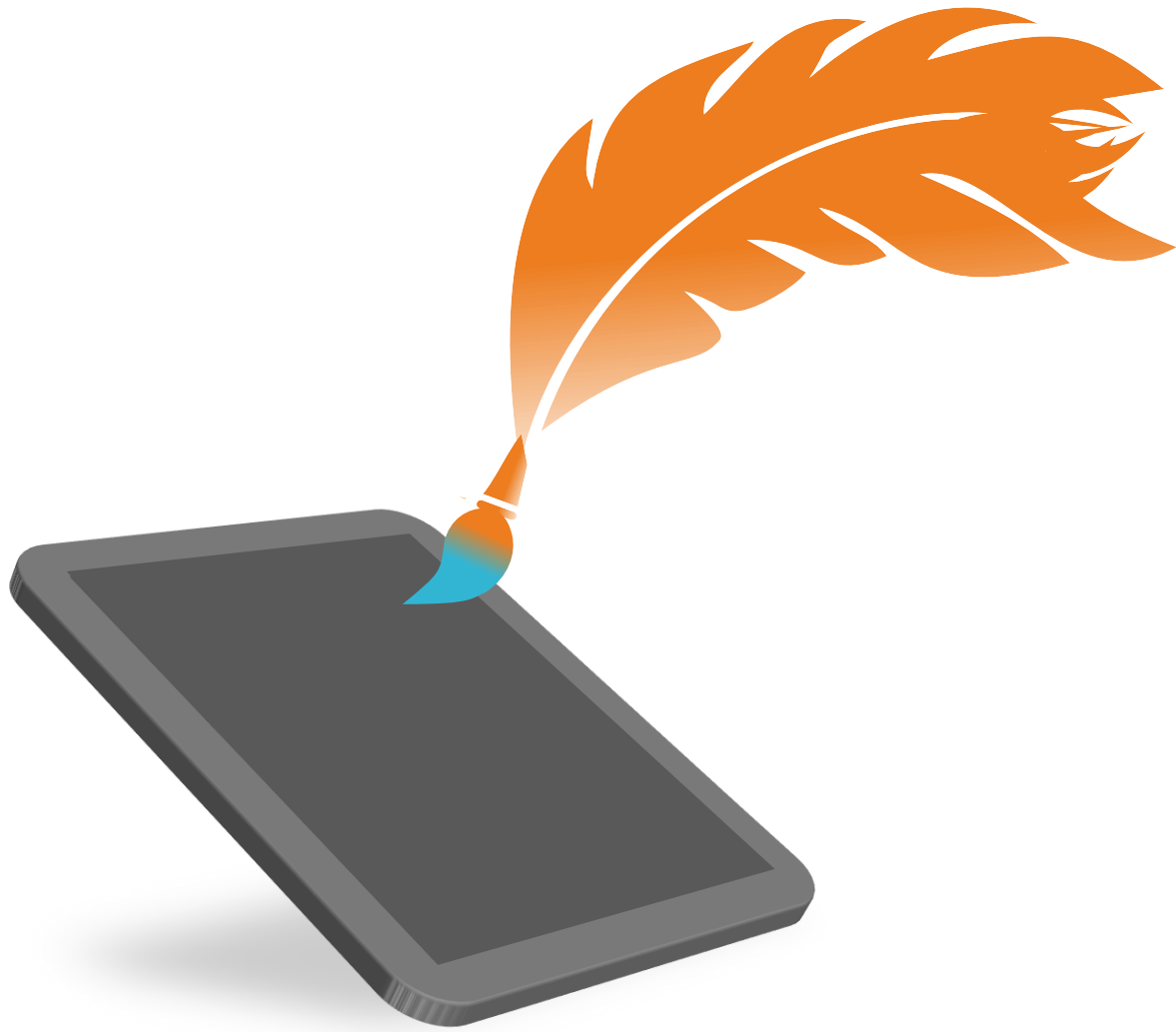
Minimum Hourly Wage in Alberta



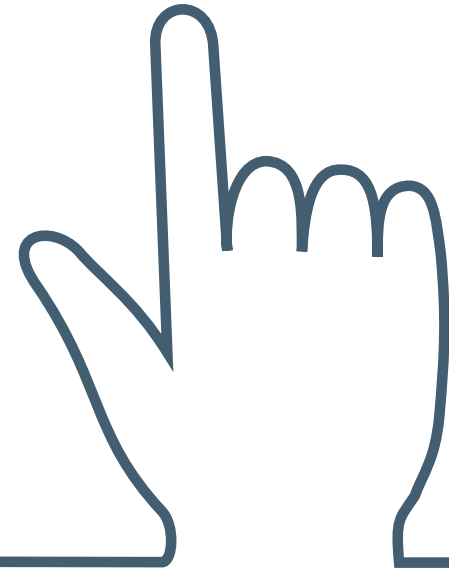
The success of your visualization is measured
by **your audience**'s understanding.

They are **not** you...

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



Data Visualization Software



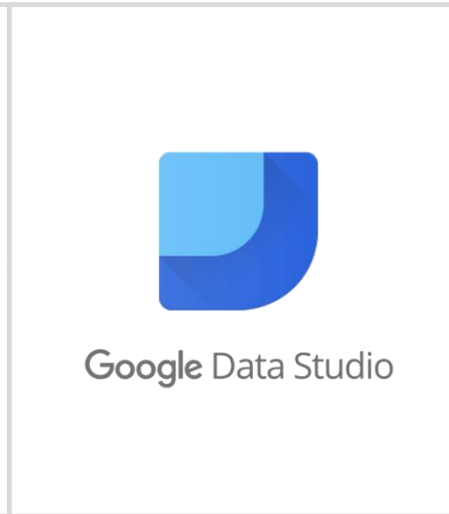
Software Options



<https://www.microsoft.com>



<https://www.tableau.com>



<https://datastudio.google.com>







<https://plot.ly/>



<https://cran.r-project.org/>

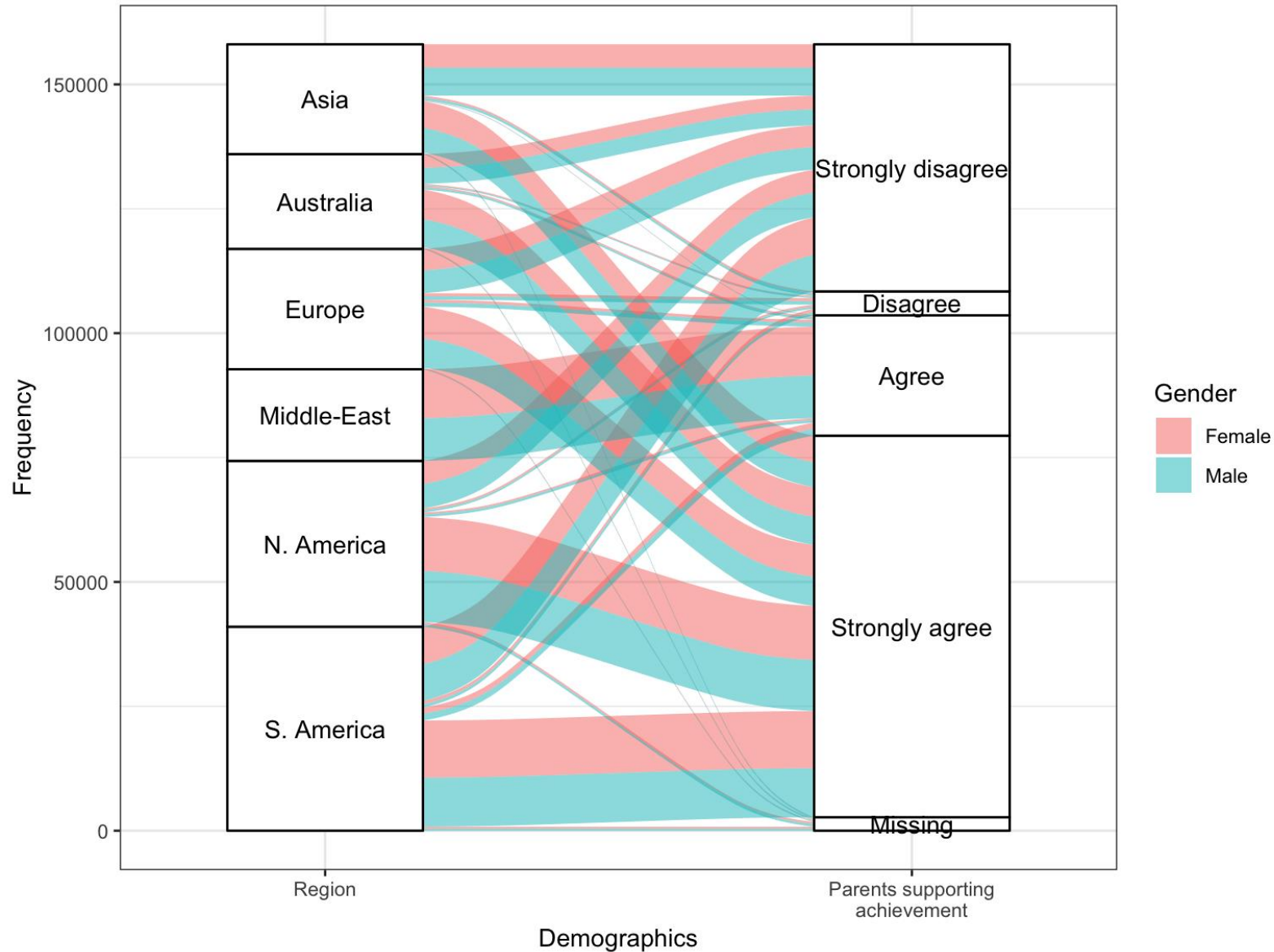


Software Options

	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



Alluvial Plot



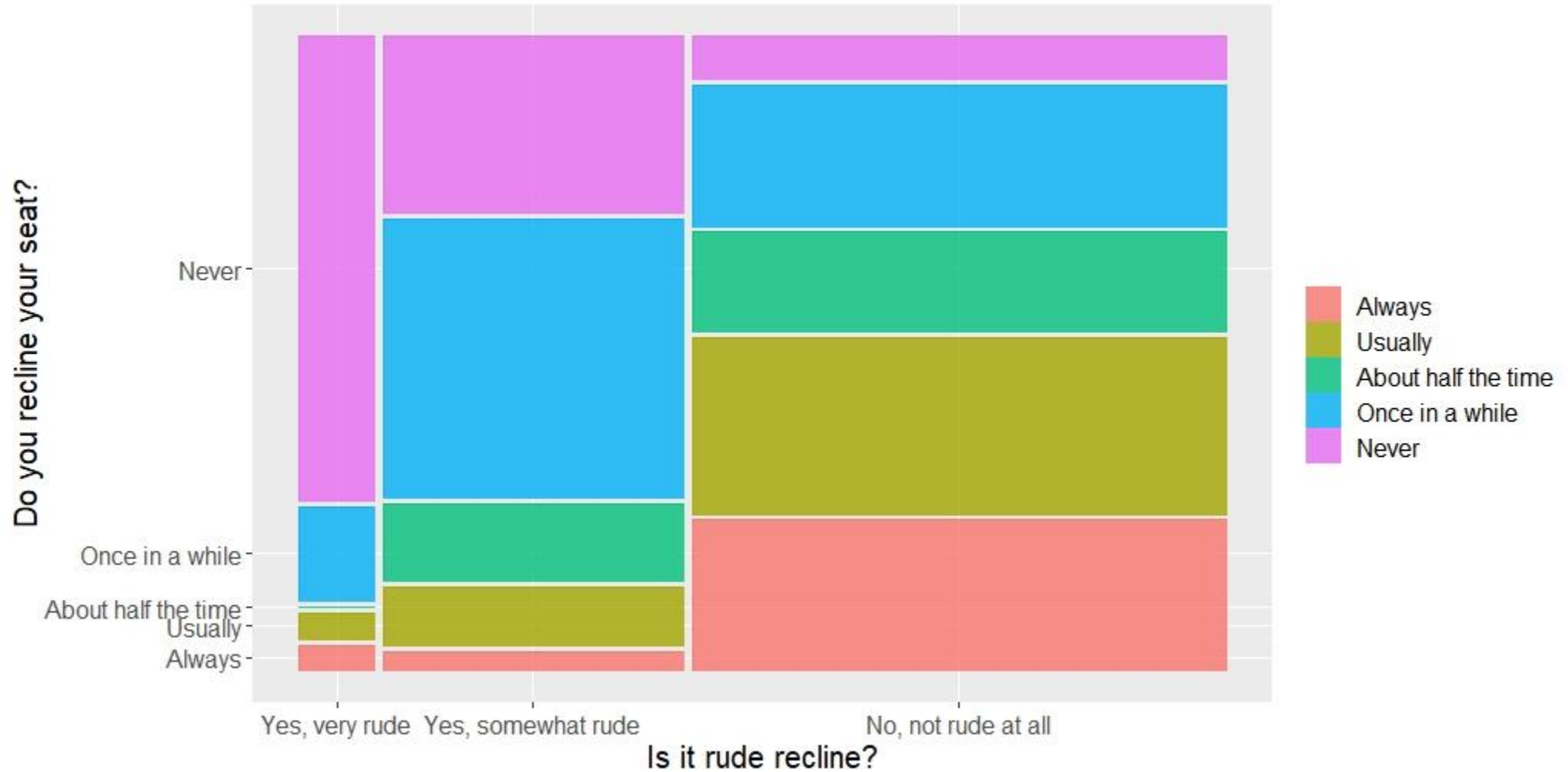
My parents support my educational efforts and achievements.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

Source: [PISA 2015](#)



Mosaic Plot



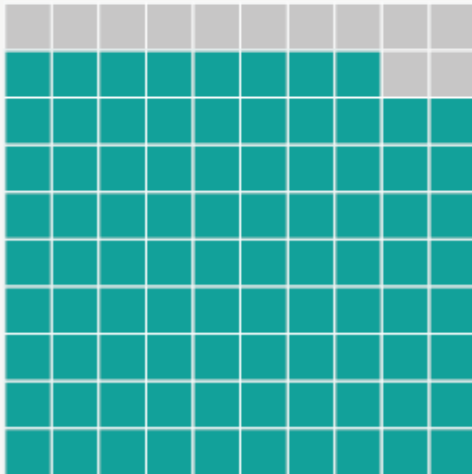
Source: Flying Etiquette Survey - <https://fivethirtyeight.com/features/airplane-etiquette-recline-seat/>



Waffle (Square Pie) Chart

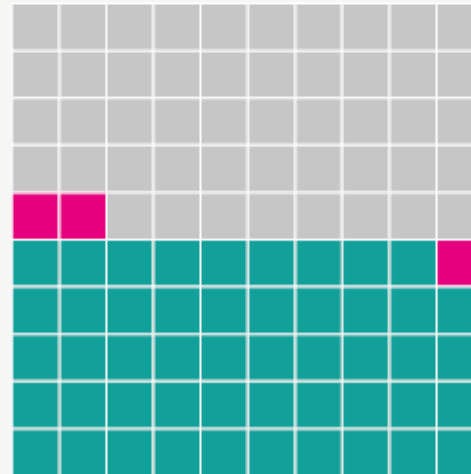
**March
2003**

Microsoft's **Internet Explorer**
(**88.0%**) achieves peak
dominance in browser usage



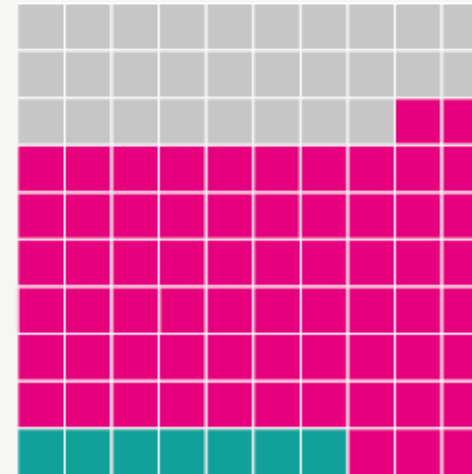
**September
2008**

Diminishing share for
IE (**49.0%**) as **Chrome** (**3.1%**)
is launched by Google



**May
2015**

As **Chrome** (**64.9%**) achieves
peak usage share, **IE** (**7.1%**)
ebbs further away



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

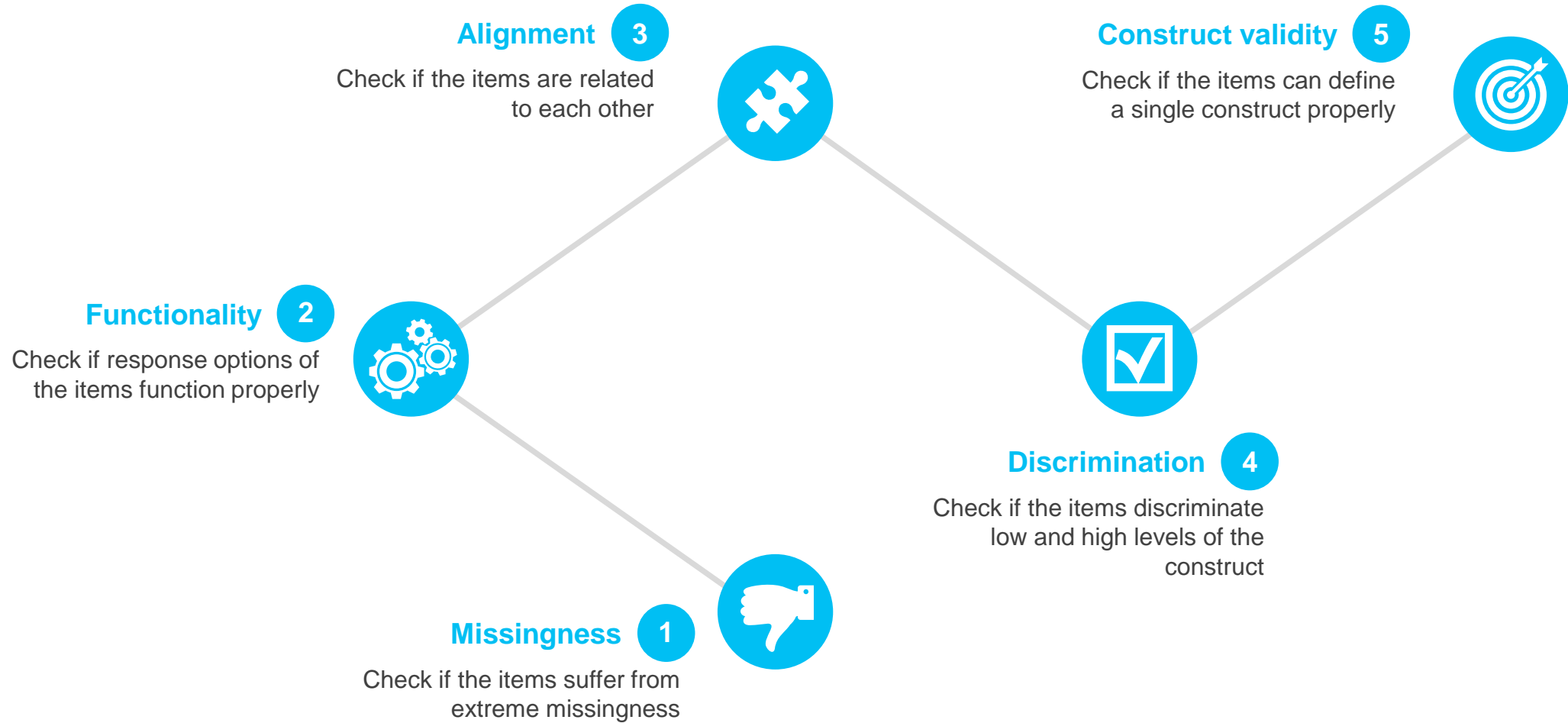
- <http://mondrian.theusrus.de/>
- Free and open source
- Compatible with Windows, Mac, and Linux
- Good for a variety of visualizations (from basic to complex plots)



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**

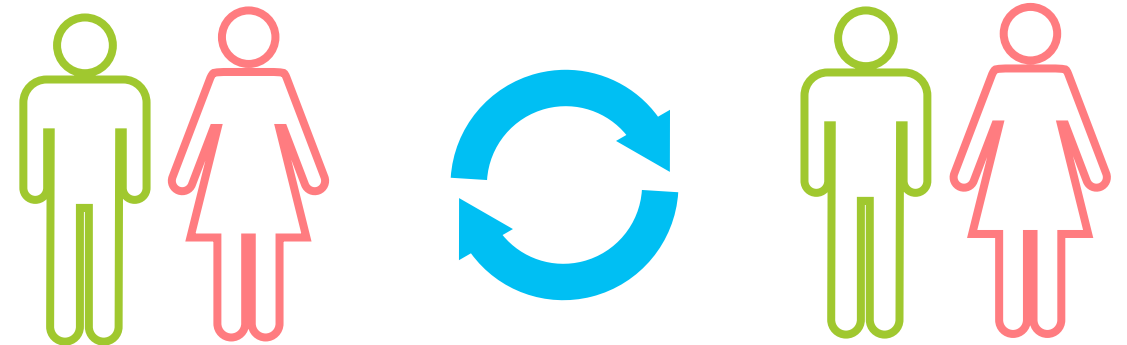
First eight questions share the same statement:

“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

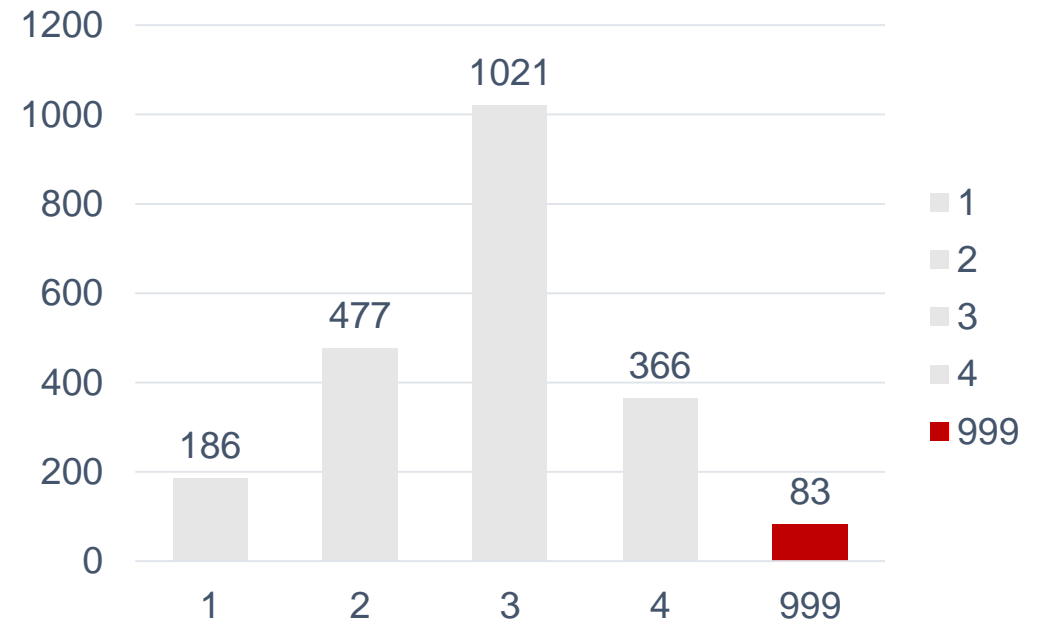


01

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>).

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



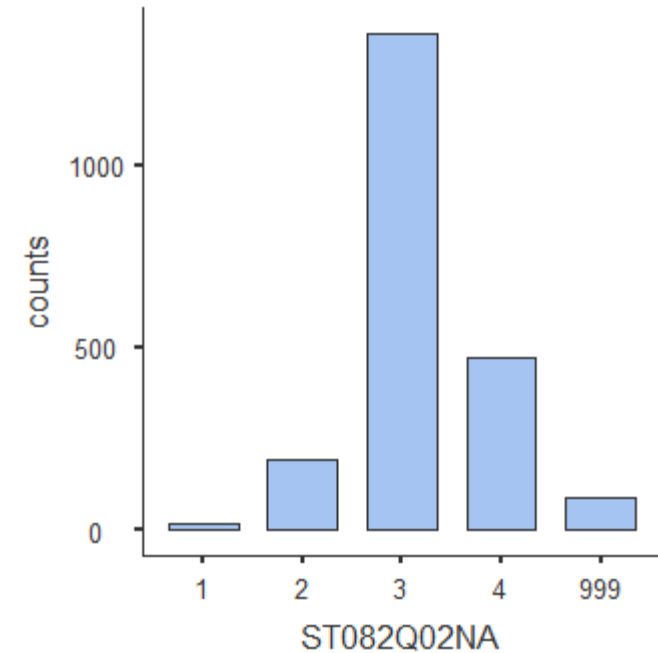
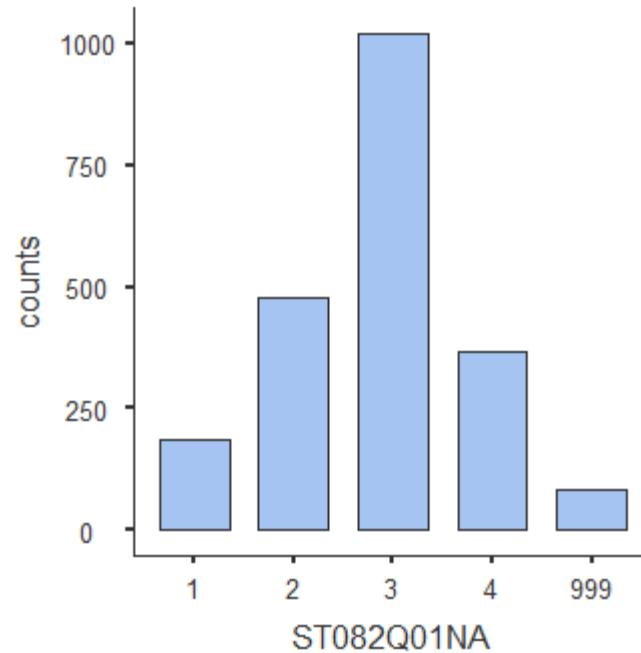
Missingness

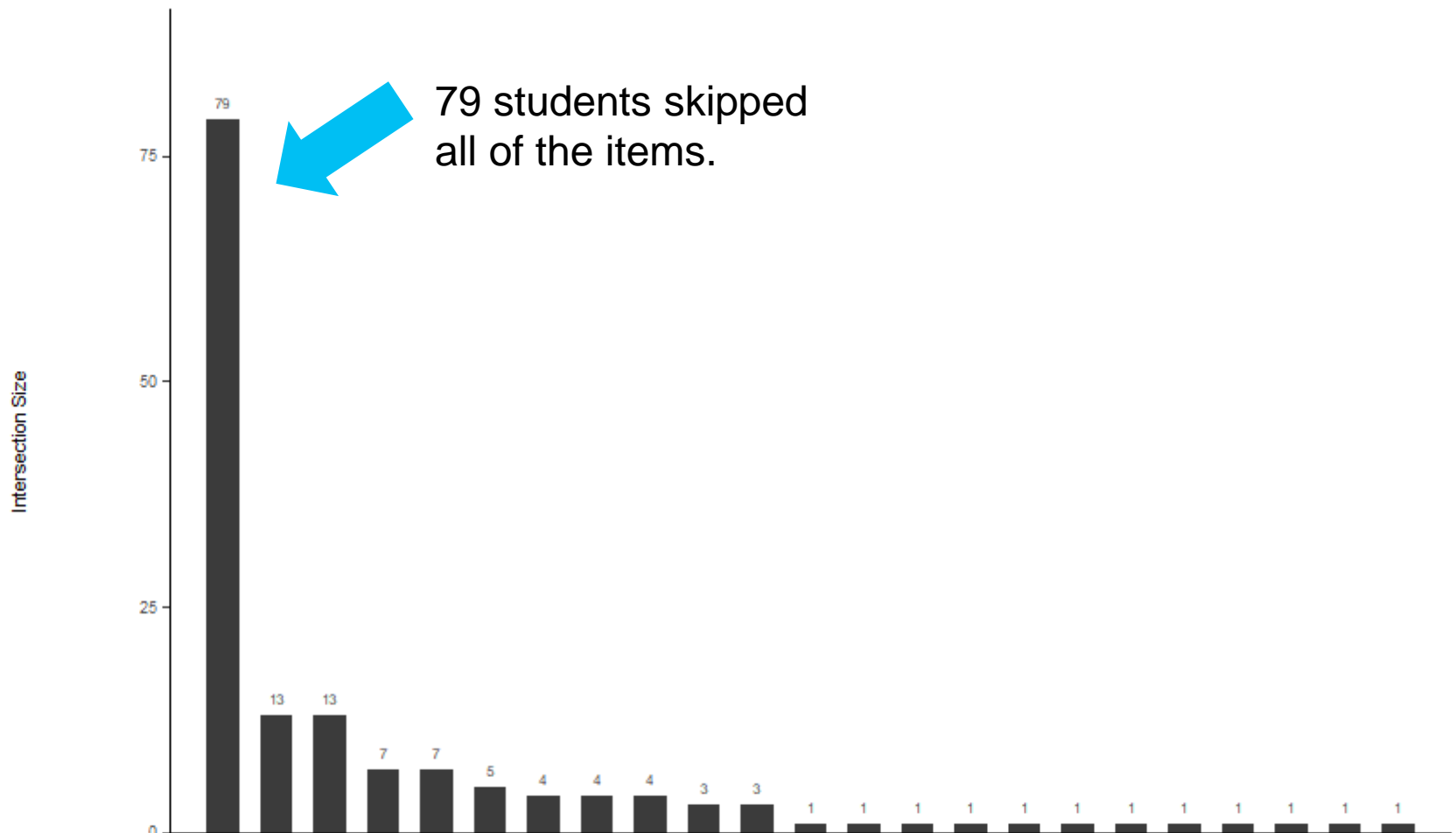


02

jamovi

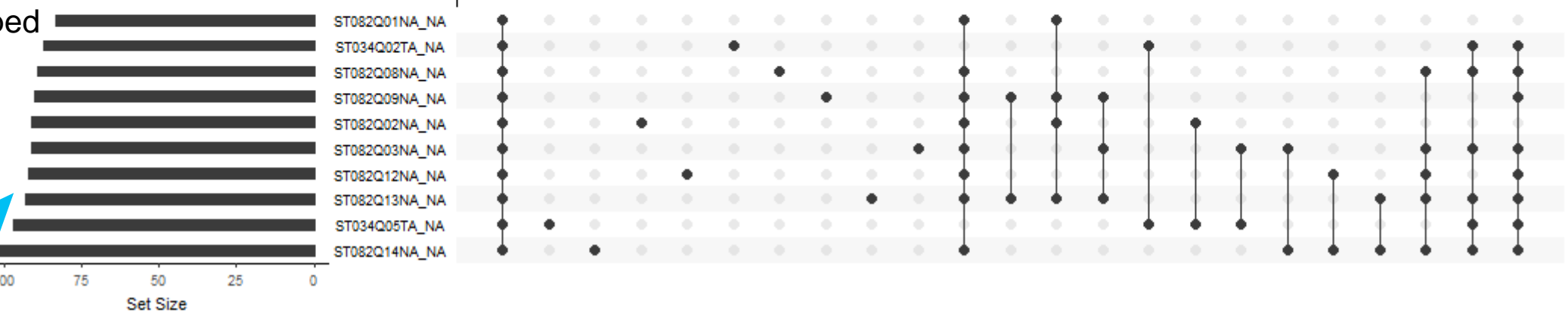
- Make sure that missing values are labeled with a distinct value (e.g., 999).
- Import the data into jamovi.
- Exploration → Descriptives → Bar Plots (see my tutorial video [HERE](#))



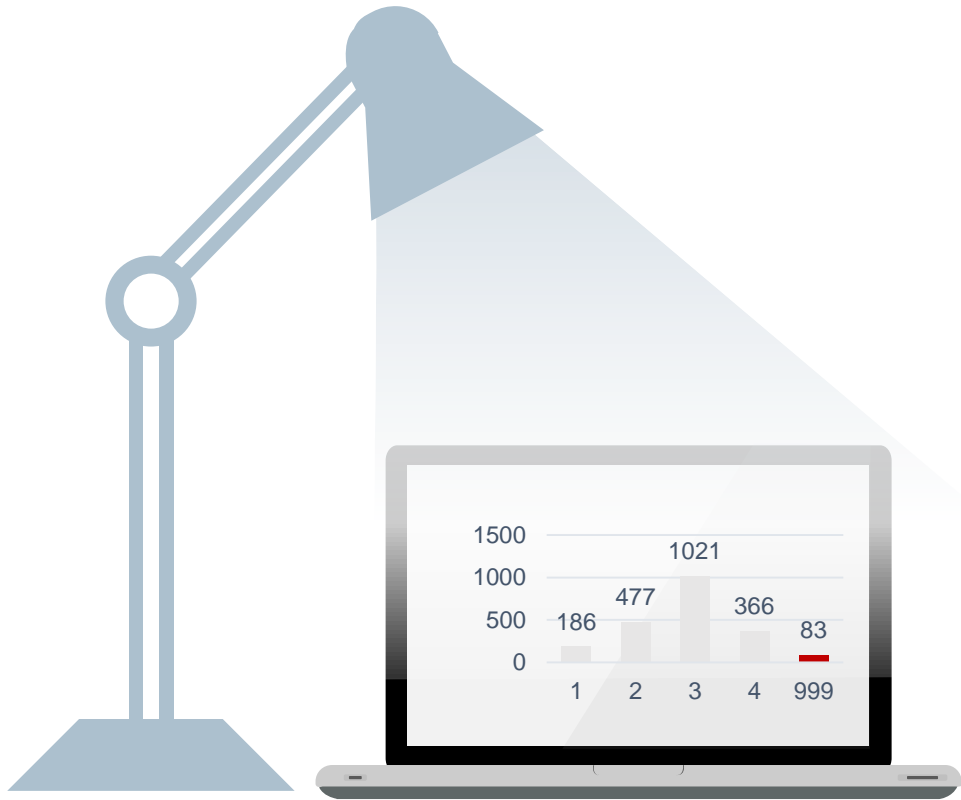


79 students skipped all of the items.

Most skipped item



Should we worry about missingness?

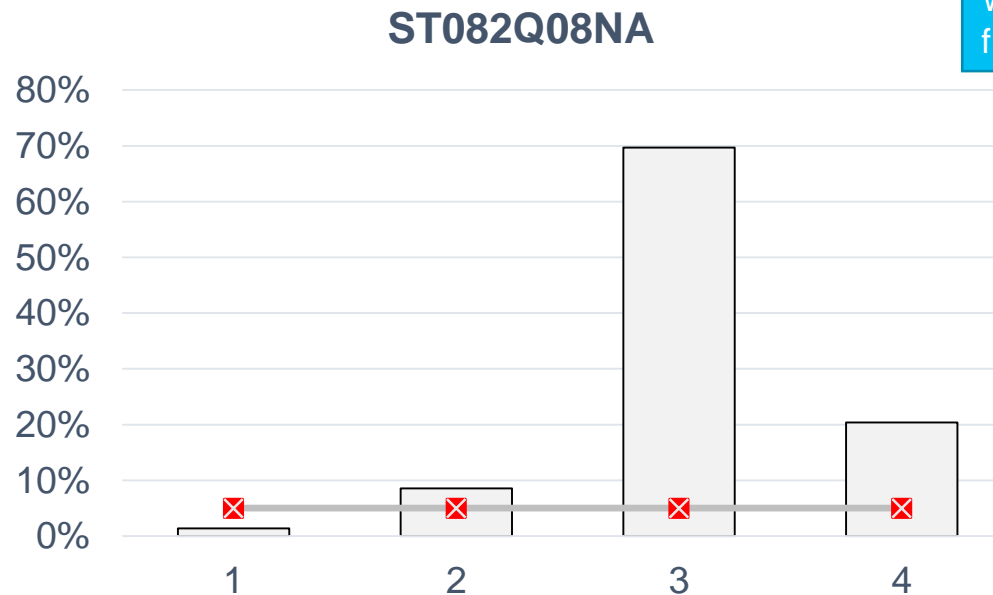


Functionality



Microsoft Excel

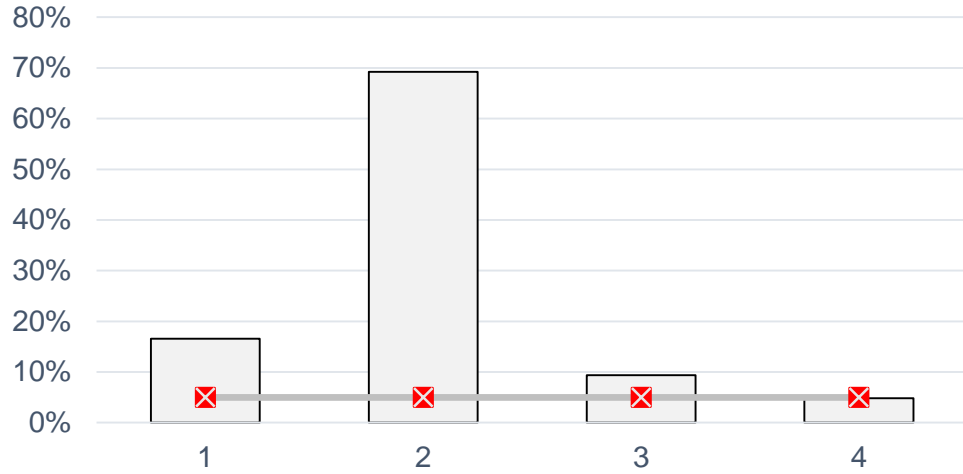
- Make sure that missing values are **NOT** labeled this time (i.e., replace 999 with null)
- Create a new pivot table for each item (this time missing is **NOT** included) and calculate percentages based on counts.
- Insert a bar graph to examine the percentages for each response option for a given 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?

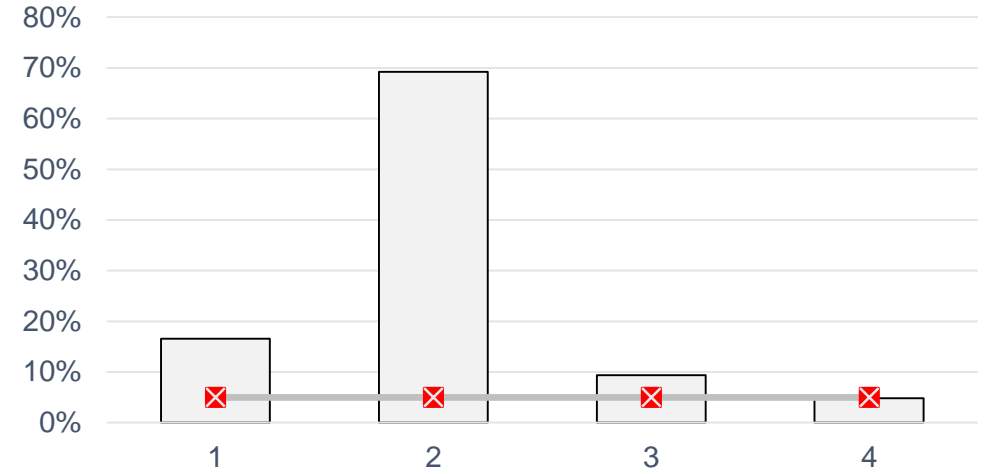
I take into account what others are interested in.

ST082Q01NA



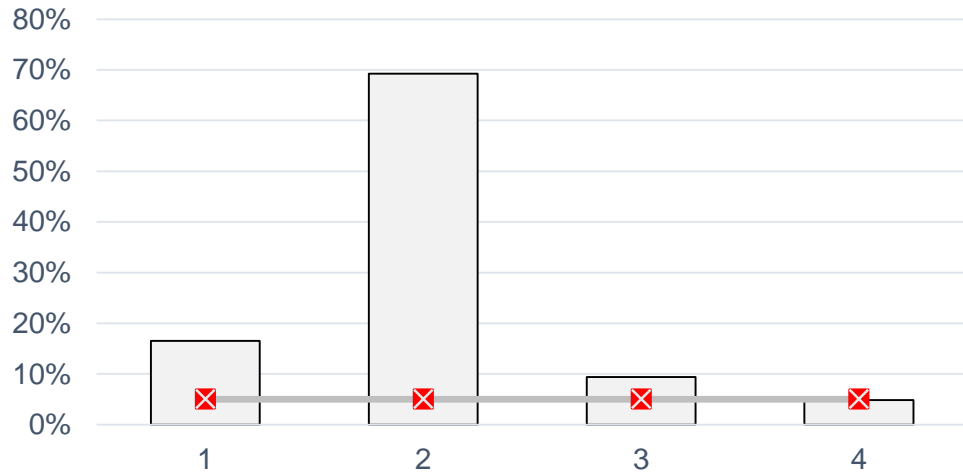
I prefer working as part of a team to working alone.

ST082Q02NA



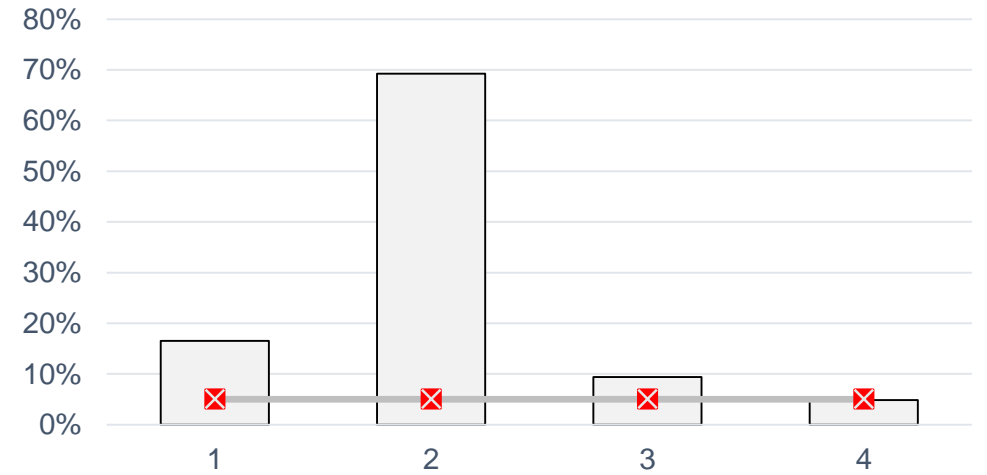
I am a good listener.

ST082Q03NA



I enjoy seeing my classmates be successful.

ST034Q05TA



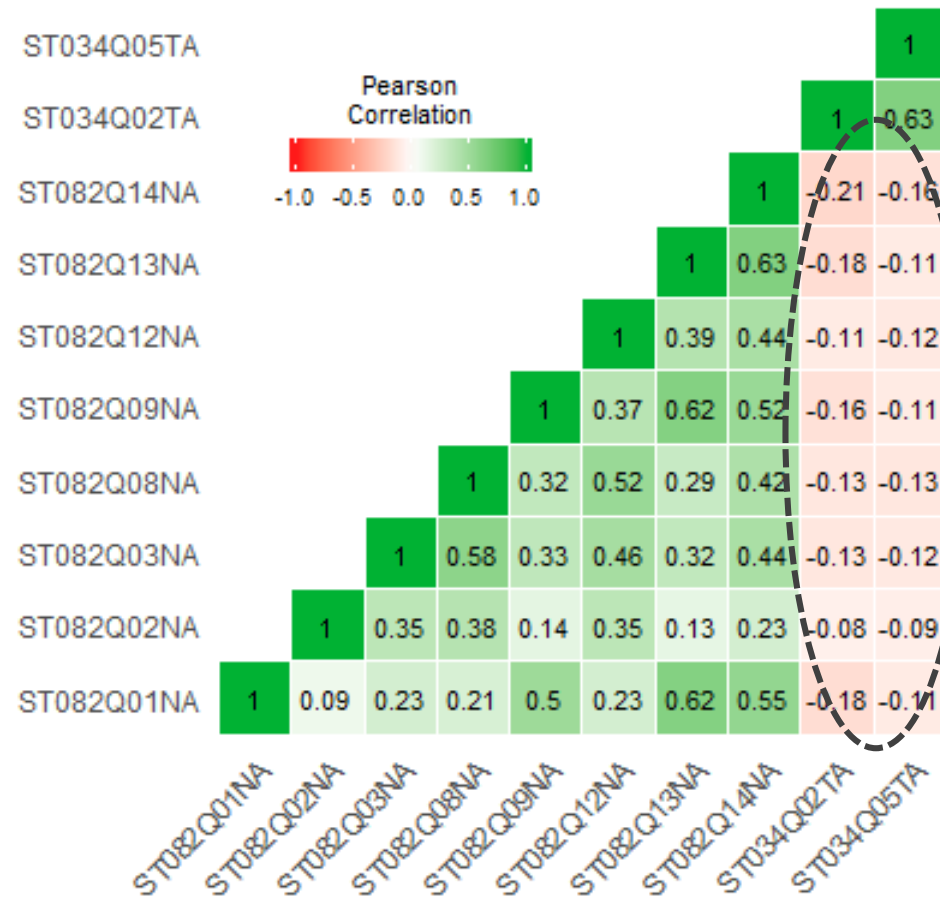
Other students seem to like me.

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](#))



Problematic items

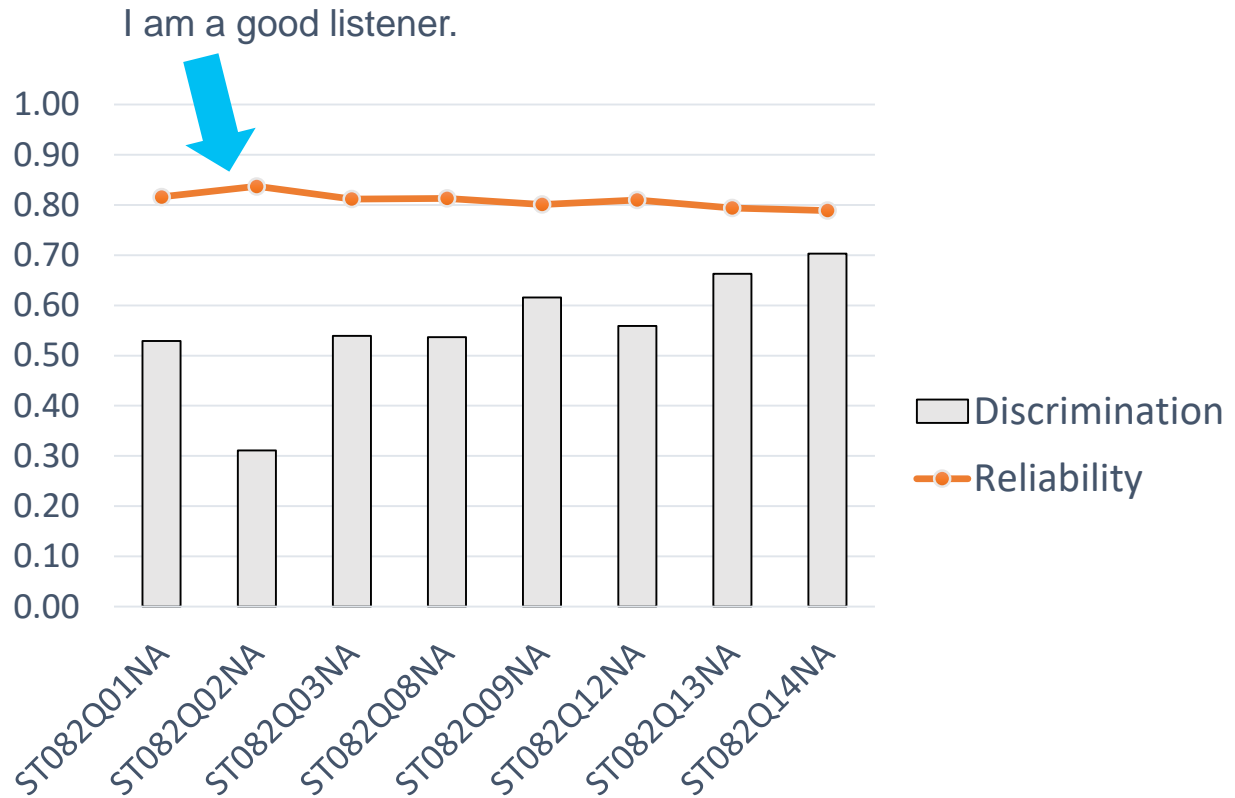


Discrimination



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

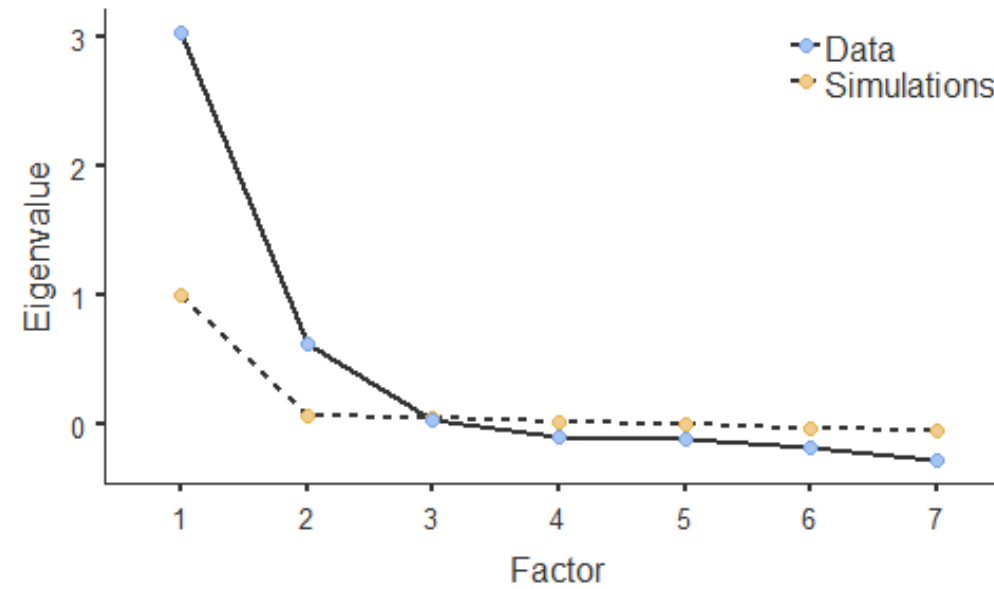


Construct Validity

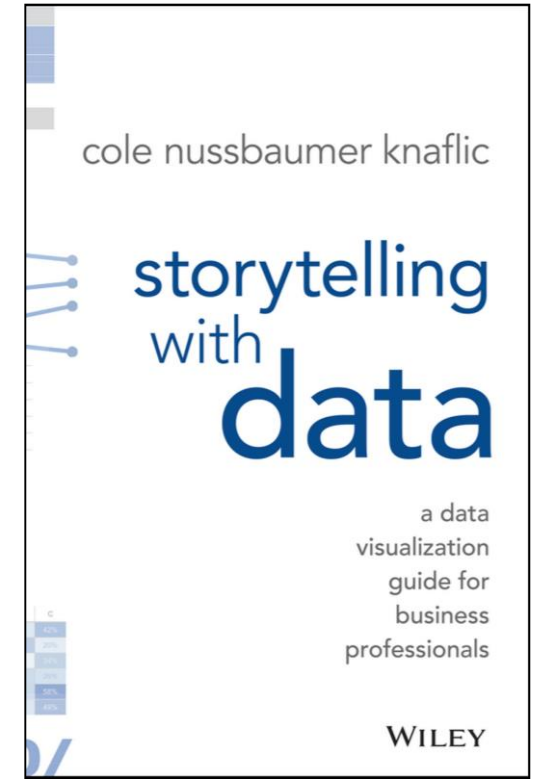
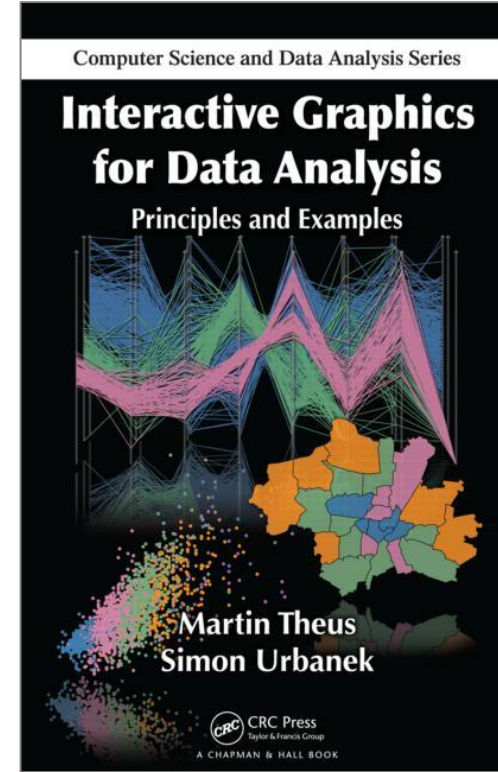
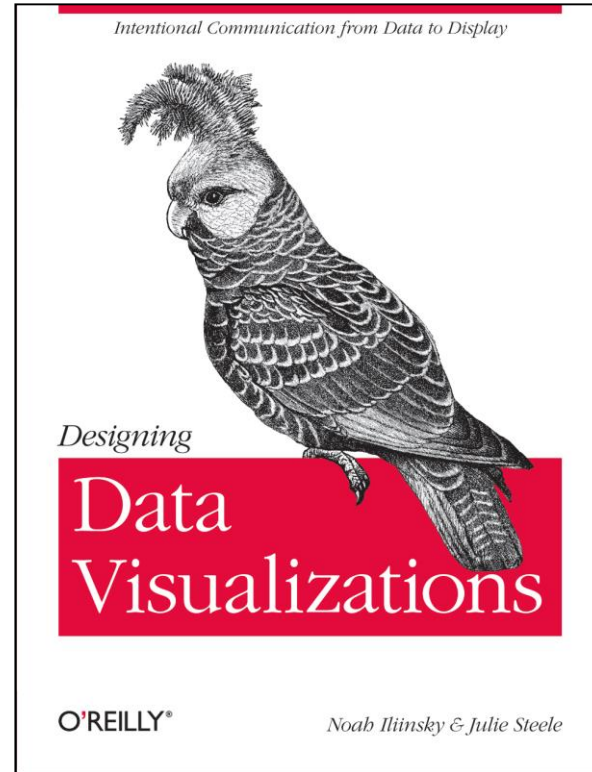
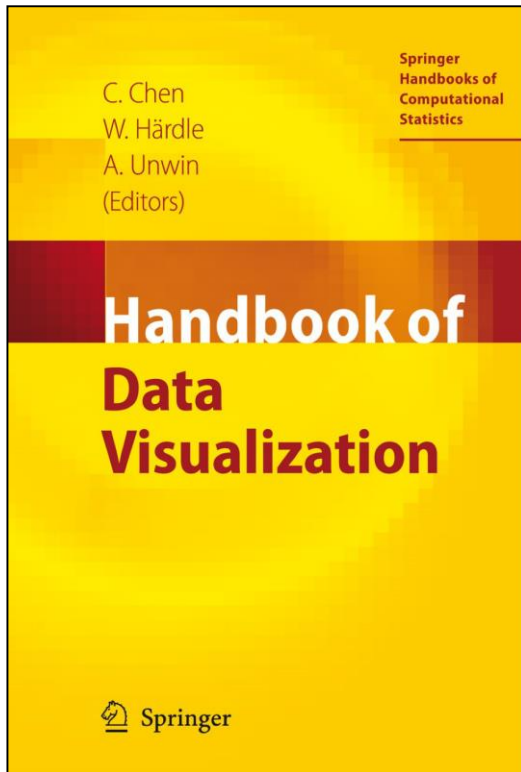


jamovi

- 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](#))

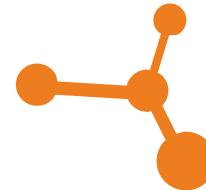
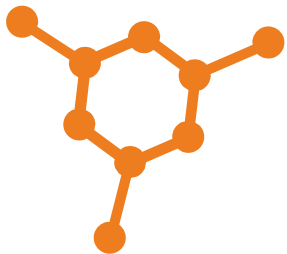


Some Resources...



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

