



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

Okan Bulut

Centre for Research in Applied Measurement and Evaluation  
University of Alberta



# 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

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

<https://goo.gl/JY6Vjq>

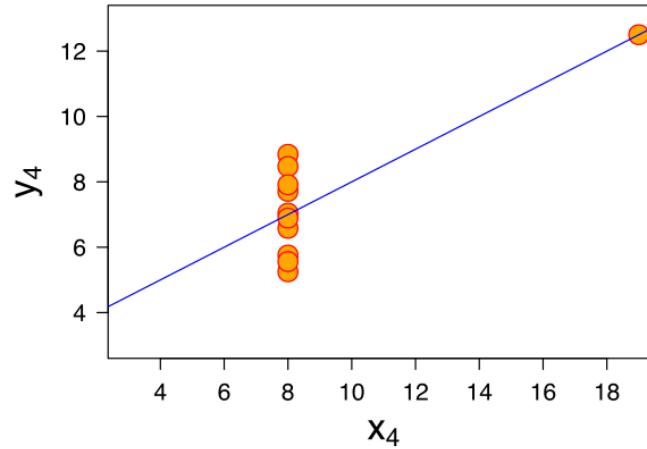
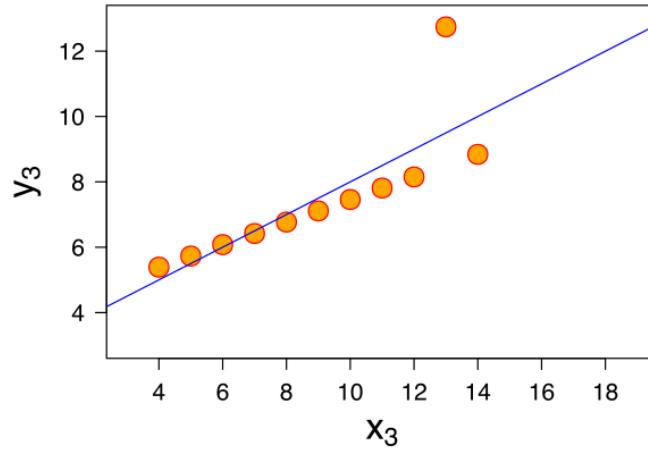
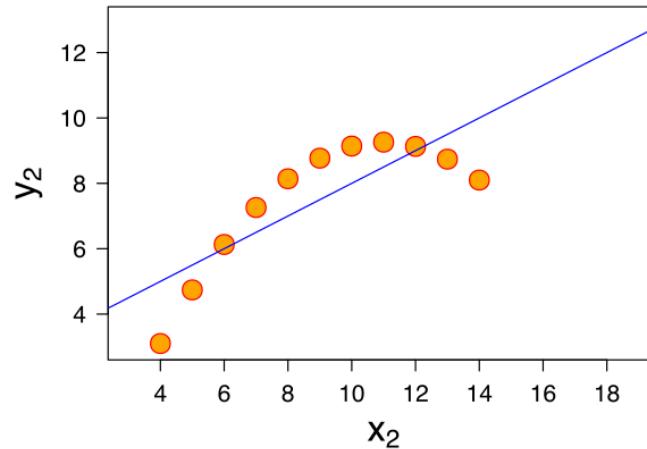
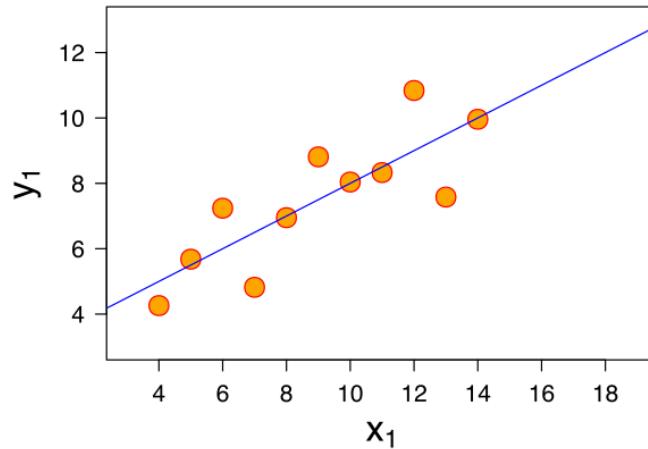
1

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](https://en.wikipedia.org/wiki/Anscombe%27s_quartet)



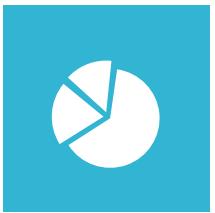
To move a huge amount of information into the brain very quickly



To identify patterns and communicate relationships and meaning



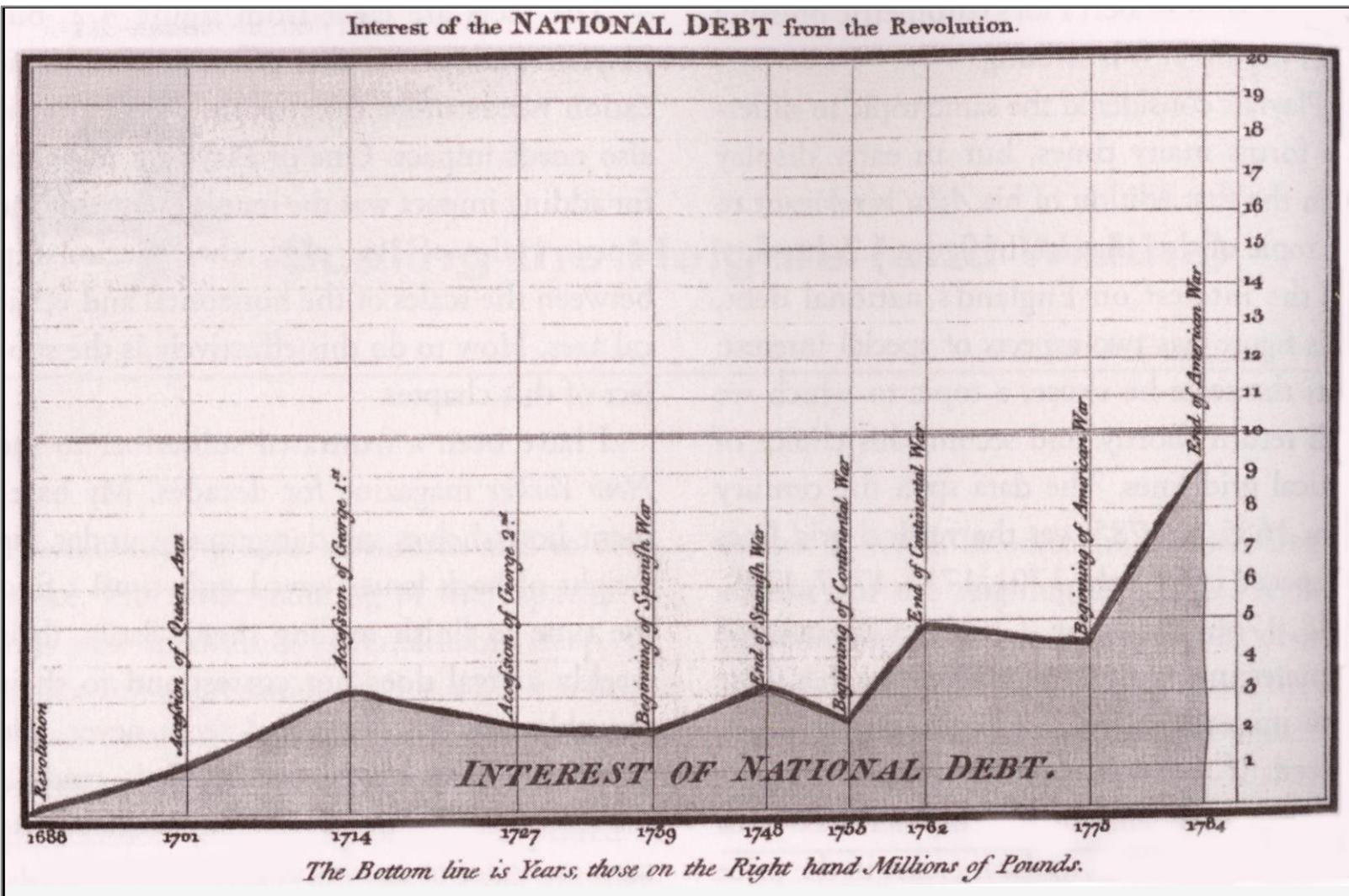
To inspire new questions and further exploration



To help identify sub-problems

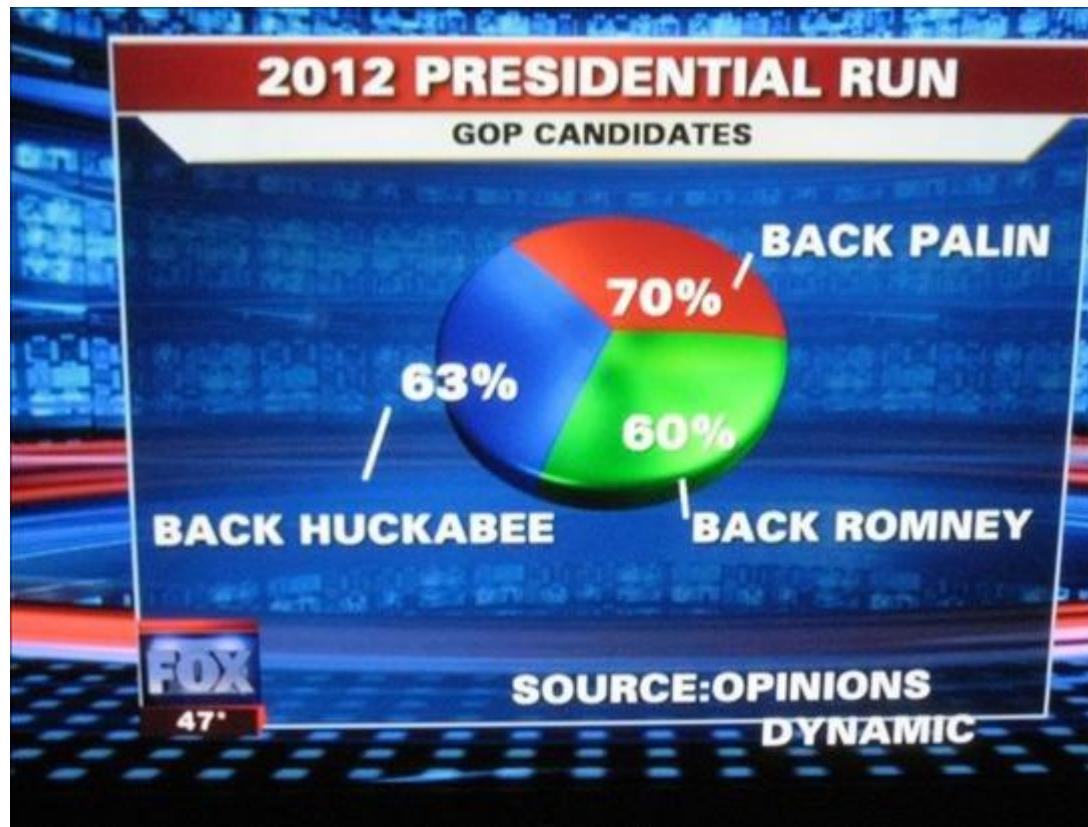


To discover or search for interesting or specific data points in a larger field



**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?



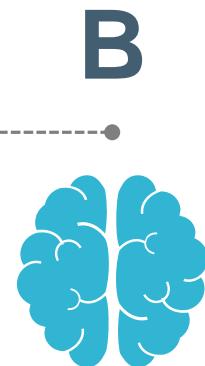
Source: Fox News – the percentages add up to 193%...

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

-- Iliinsky and Steele (2011)

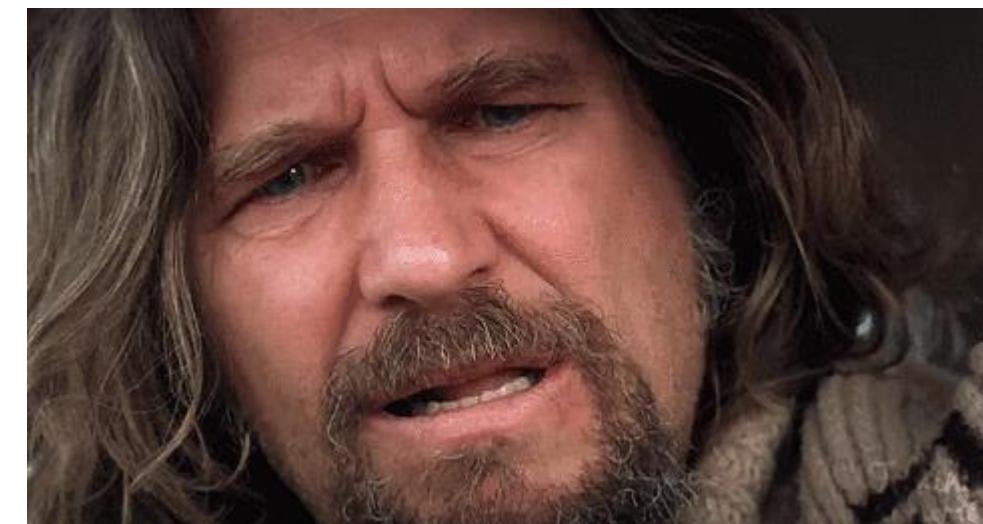
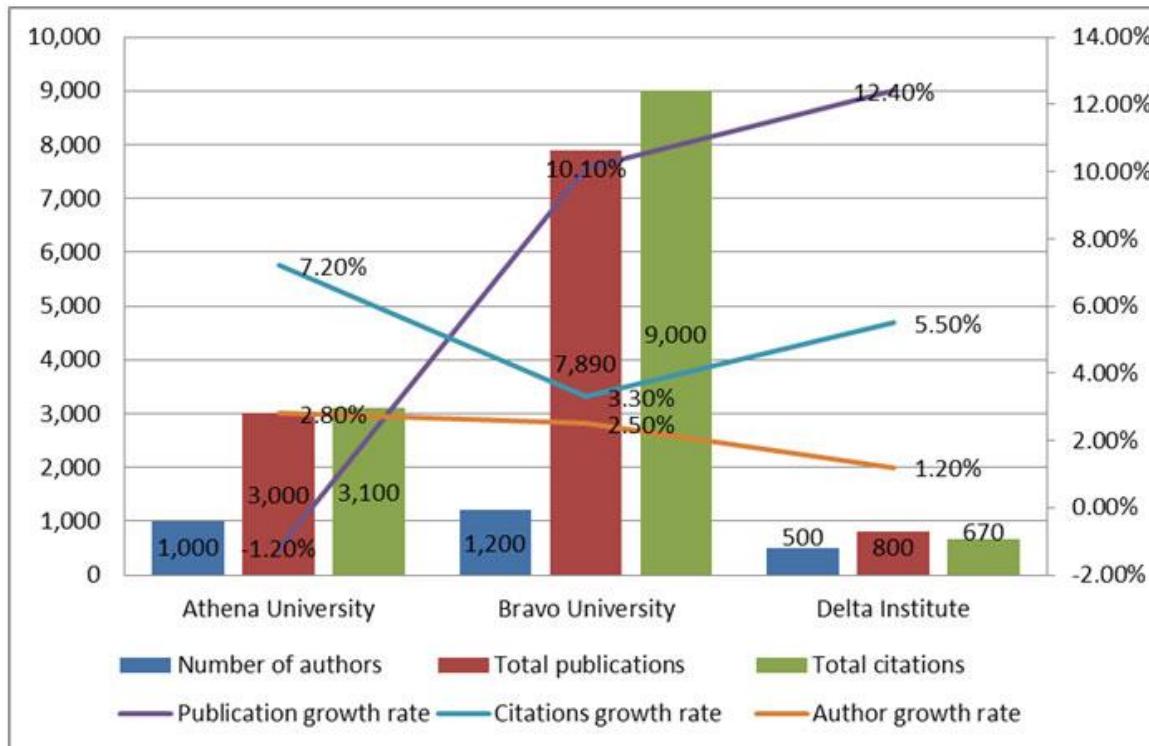


DESIGNER

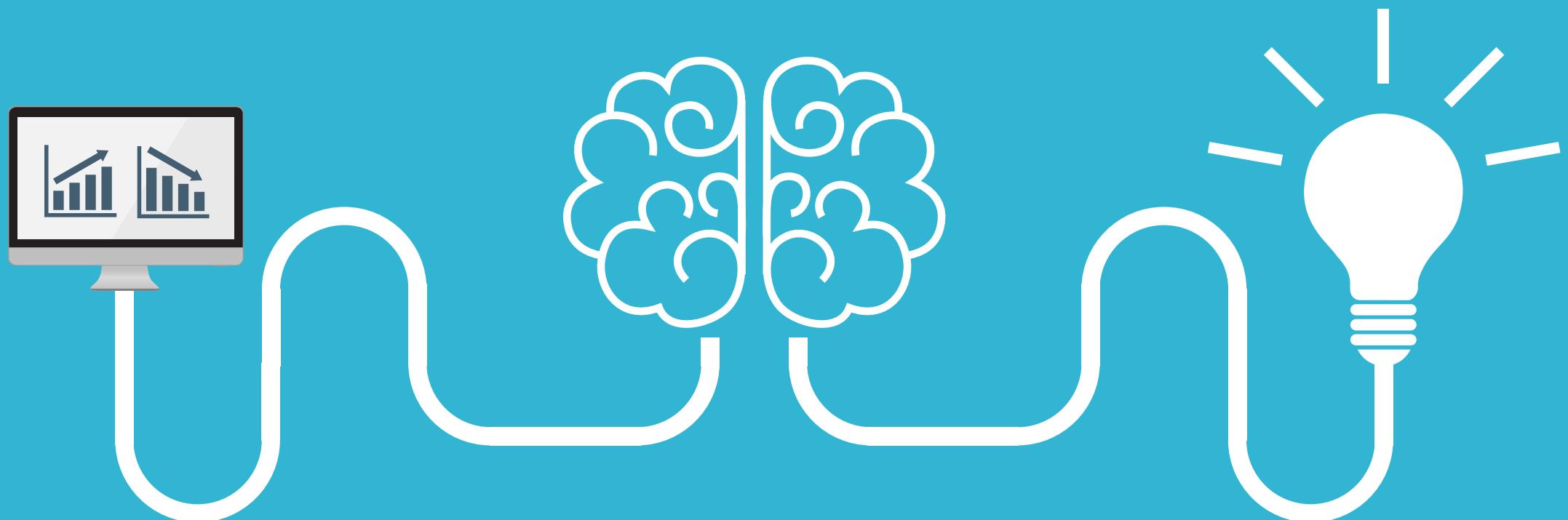


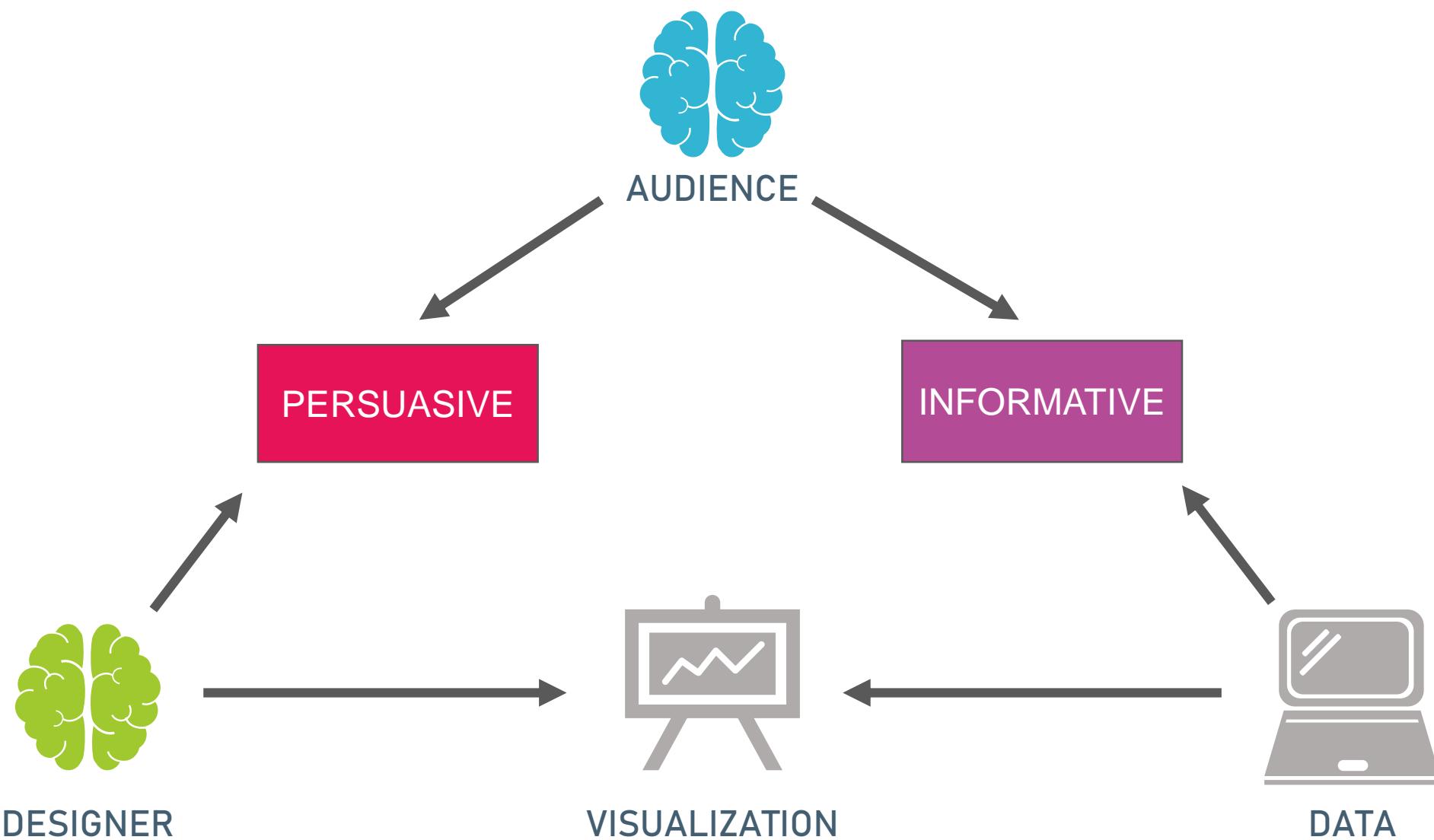
AUDIENCE

# We have all done this...



# Purpose







# In practice, we...

## **EXPLORE (Informative)**

Potential issues in the data:

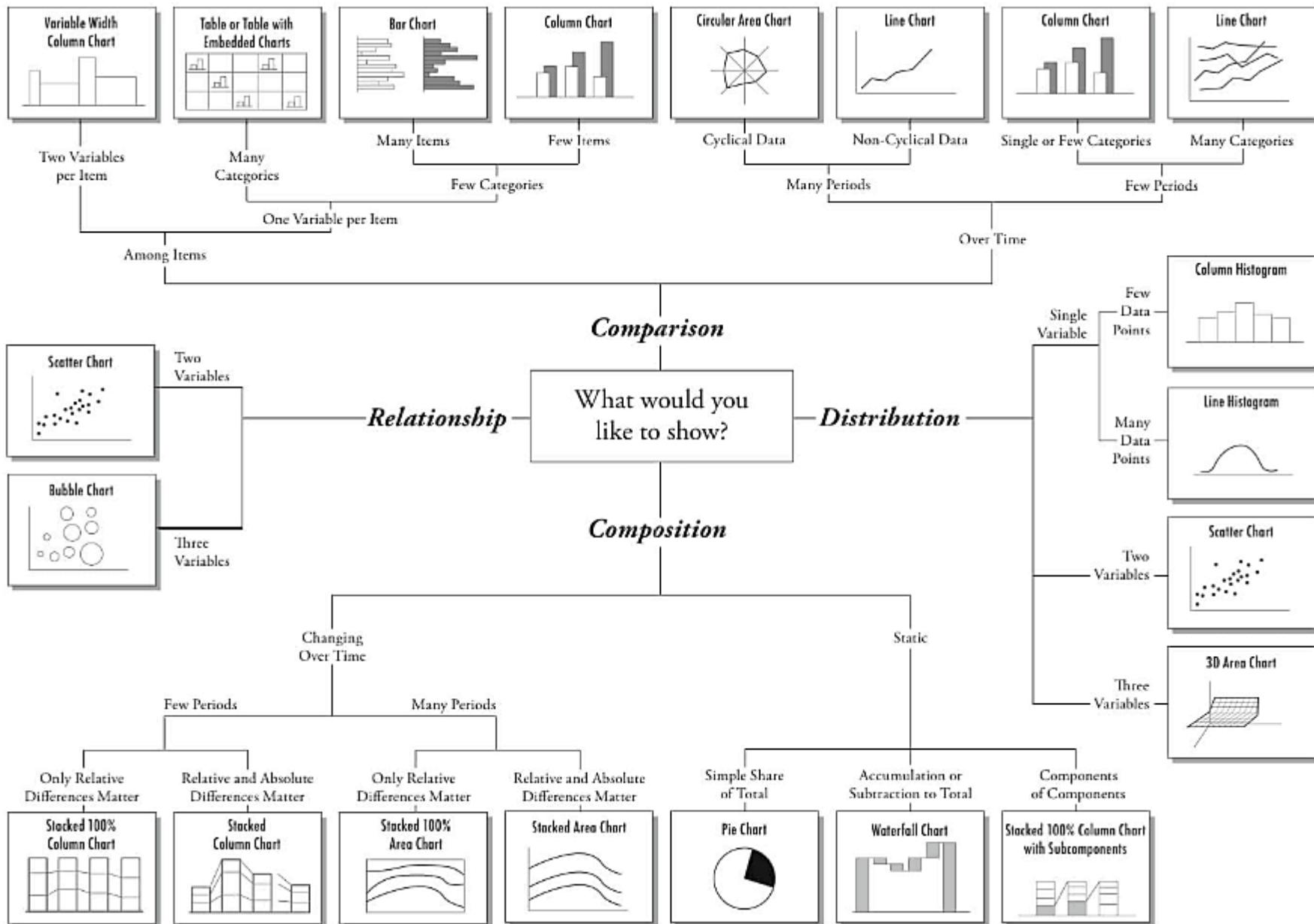
- Missingness
- Outliers
- Non-normality
- Non-linearity
- Extreme skewness and kurtosis

## **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

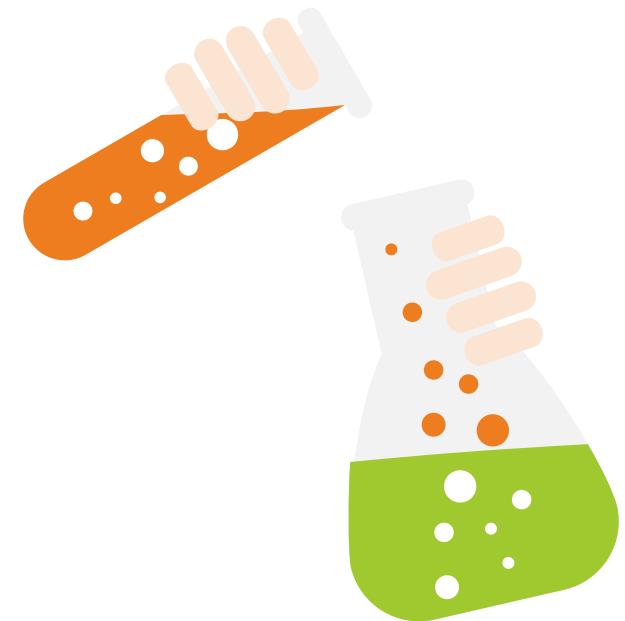
Number of variables

Colours and shading

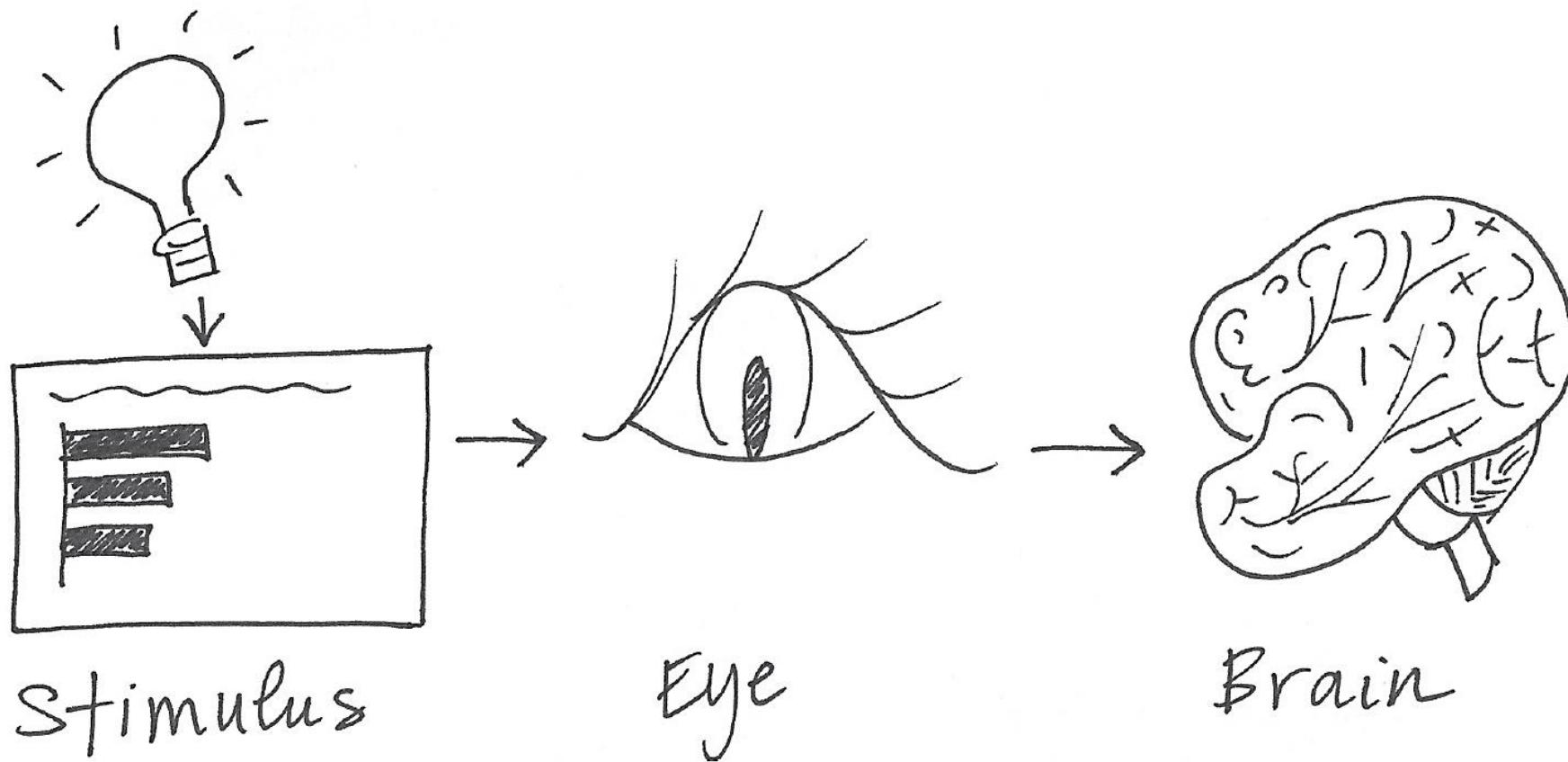
Shapes and lines

Size and thickness

Font and font size

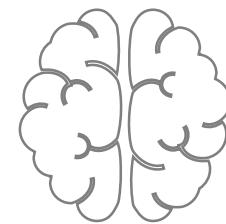
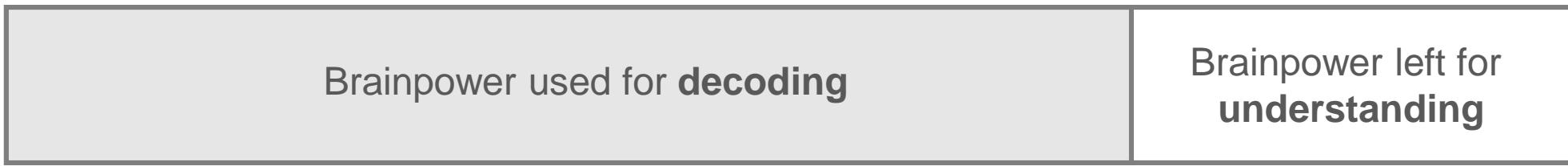


# Short-term memory → Long-term memory



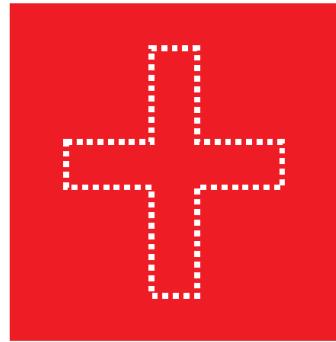
Source: [Cole Nussbaumer Knaflic \(2015, p.100\)](#)

# Decoding → Understanding

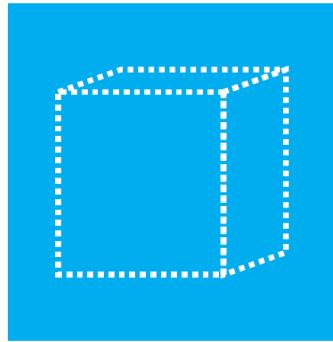


**S = Shape C = Colour**

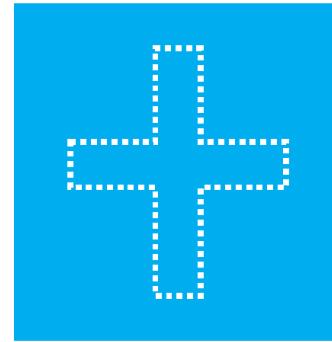
**S**



**S**



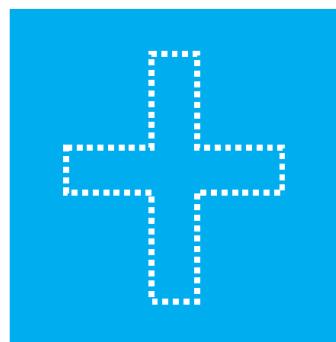
**C**



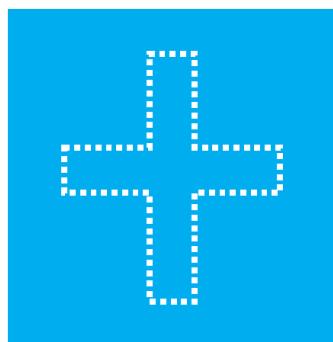
**C**



**C**



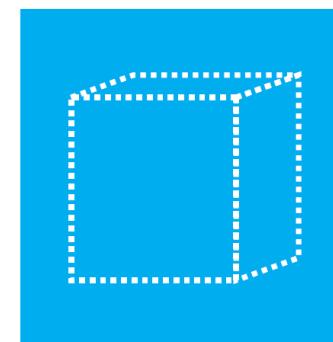
**S**



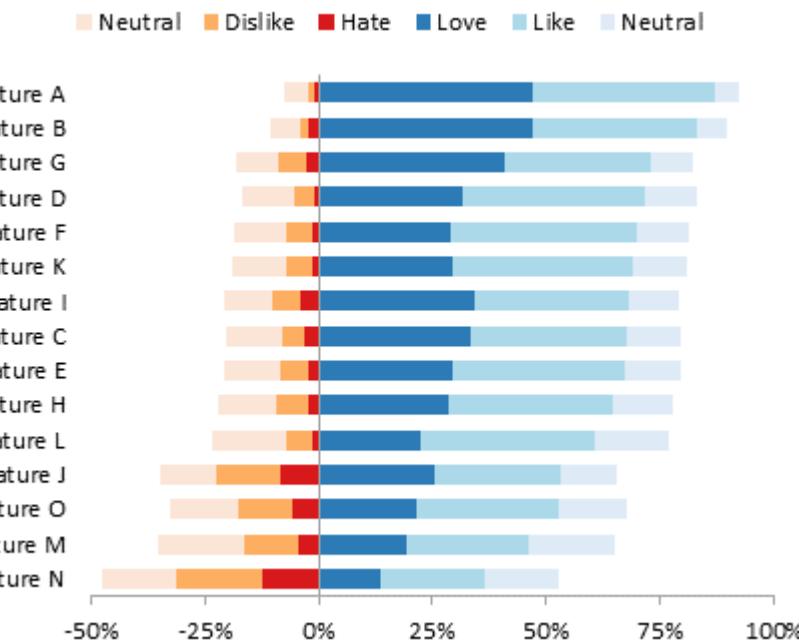
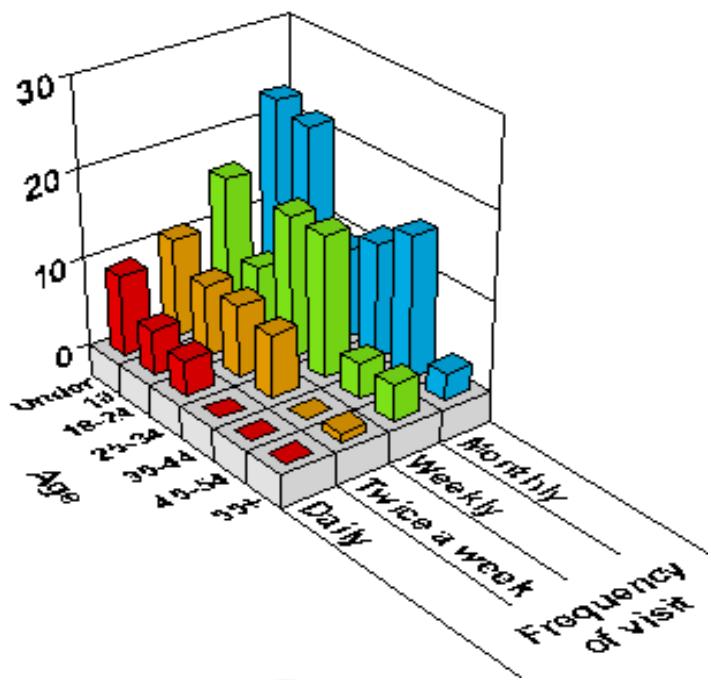
**S**



**C**

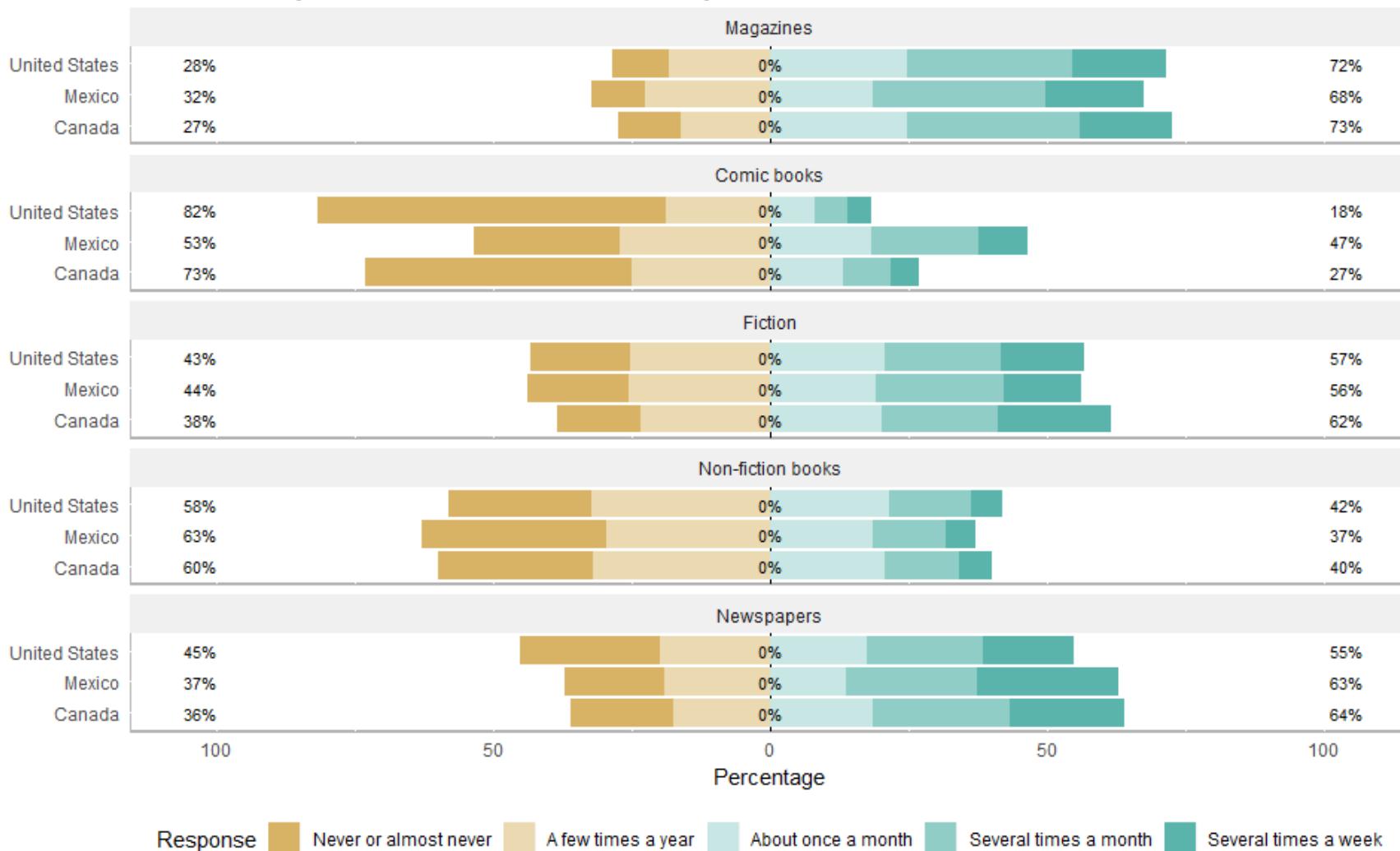


# More Complex ≠ Better



# 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](http://www.darkhorseanalytics.com)

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

# **Remove** to improve the **pie chart** edition

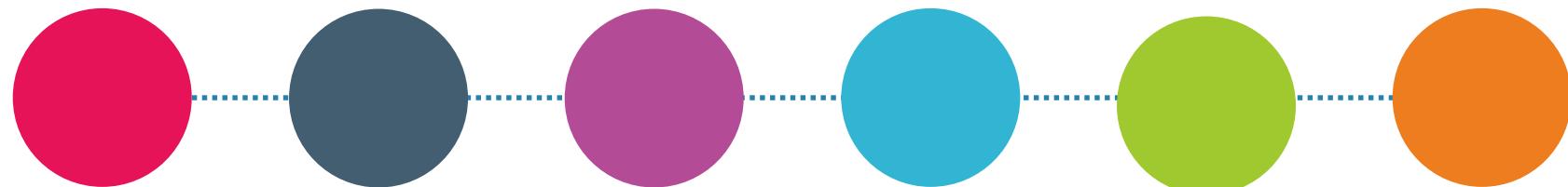
Created by Darkhorse Analytics

[www.darkhorseanalytics.com](http://www.darkhorseanalytics.com)

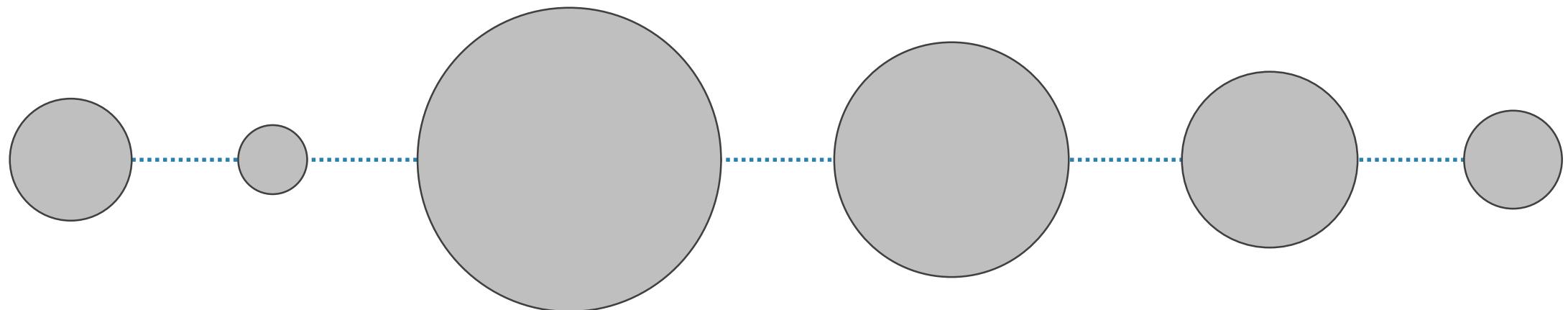
Source: <https://www.darkhorseanalytics.com/blog/salvaging-the-pie>

# Ordering Values

Colour

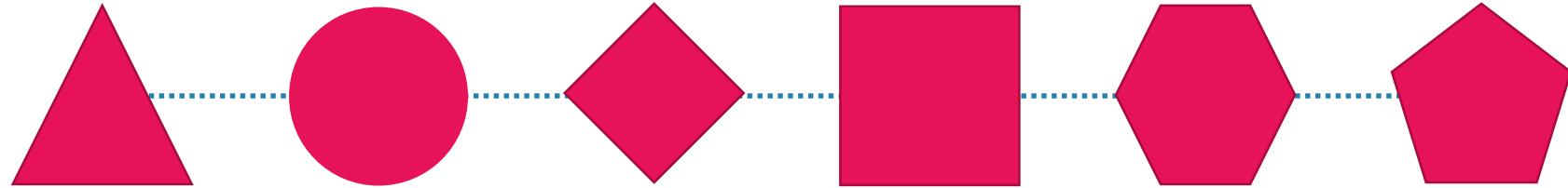


Size

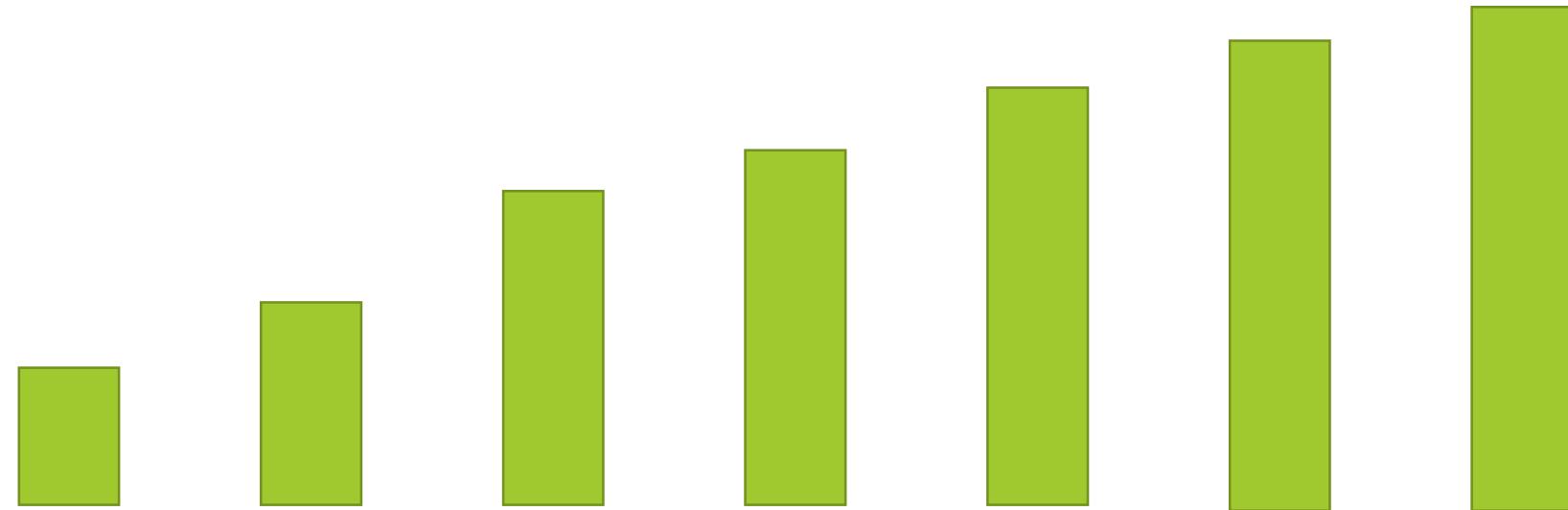


# Ordering Values

Shape



Length



# Ordering Values

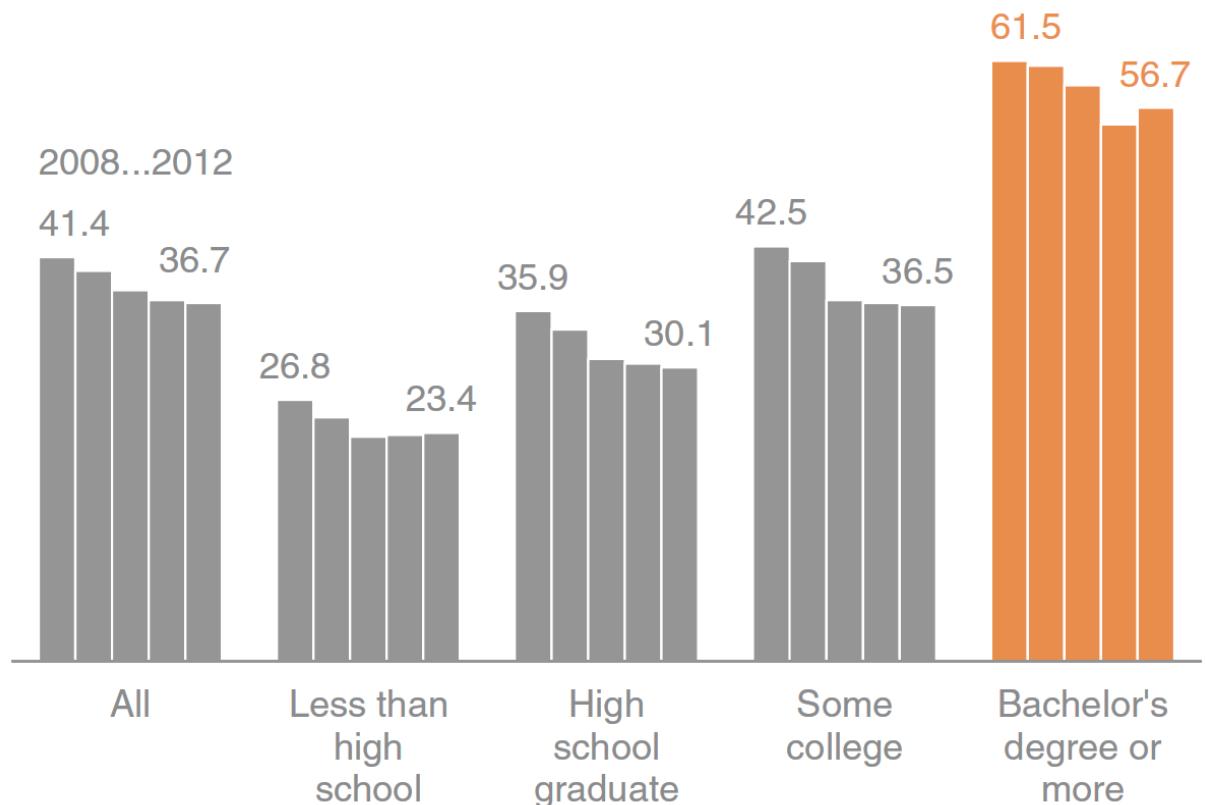
Rainbow distribution in color indicates sales rank in given country from #1 (red) to #10 or higher (dark purple)

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

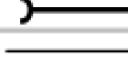
RANK	1	2	3	4	5+
COUNTRY   DRUG	A	B	C	D	E
Australia	1	2	3	6	7
Brazil	1	3	4	5	6
Canada	2	3	6	12	8
China	1	2	8	4	7
France	3	2	4	8	10
Germany	3	1	6	5	4
India	4	1	8	10	5
Italy	2	4	10	9	8
Mexico	1	5	4	6	3
Russia	4	3	7	9	12
Spain	2	3	4	5	11
Turkey	7	2	3	4	8
United Kingdom	1	2	3	6	7
United States	1	2	4	3	5

# Ordering Values

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

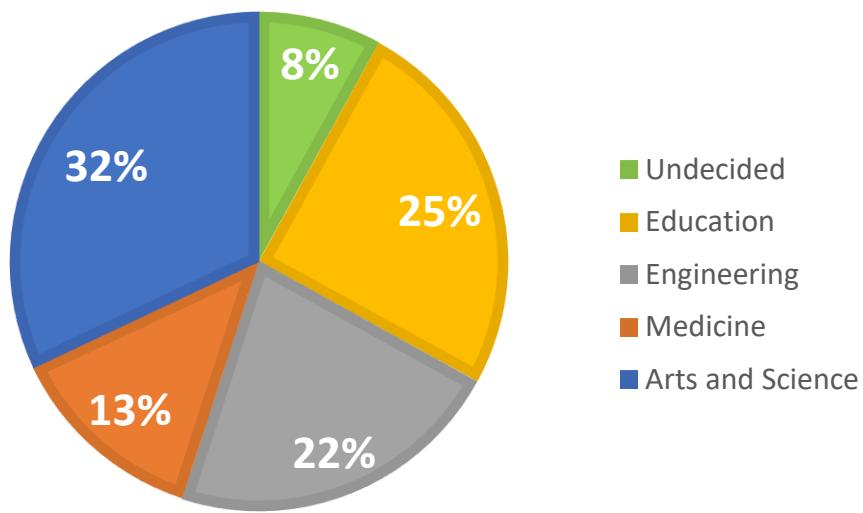


Note: Marriage eligible includes the newly married plus those widowed, divorced, or never married at interview.

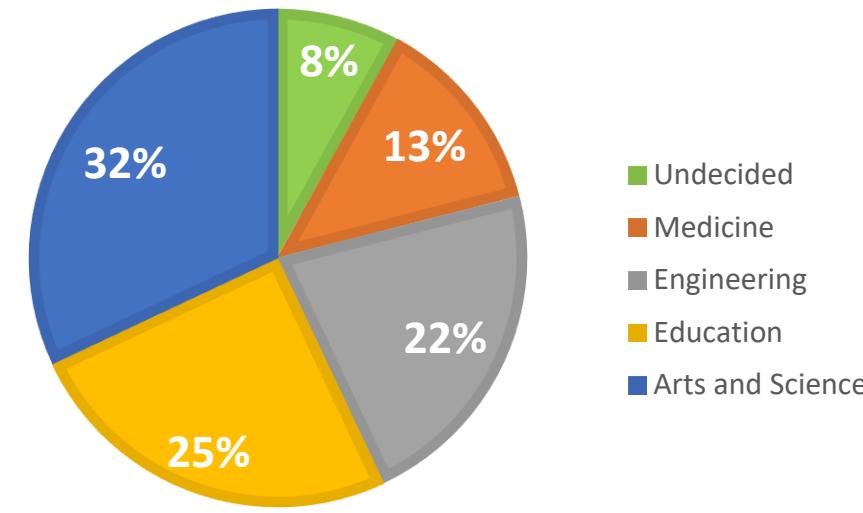
Example	Encoding	Ordered	Useful values	Quantitative	Ordinal	Categorical	Relational
	position, placement	yes	infinite	Good	Good	Good	Good
1, 2, 3; A, B, C	text labels	optional alpha or num	infinite	Good	Good	Good	Good
	length	yes	many	Good	Good		
	size, area	yes	many	Good	Good		
	angle	yes	medium	Good	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

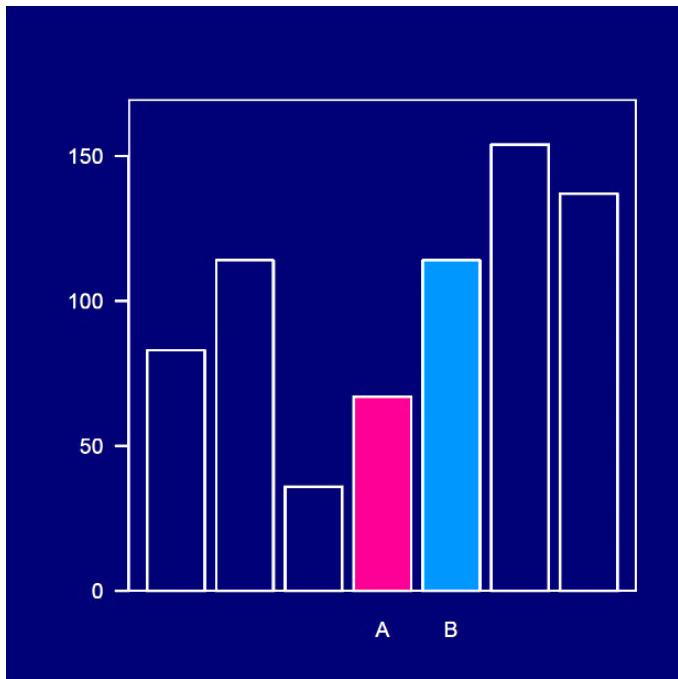
HIGH SCHOOL STUDENTS' COLLEGE  
PREFERENCES (UNSORTED)



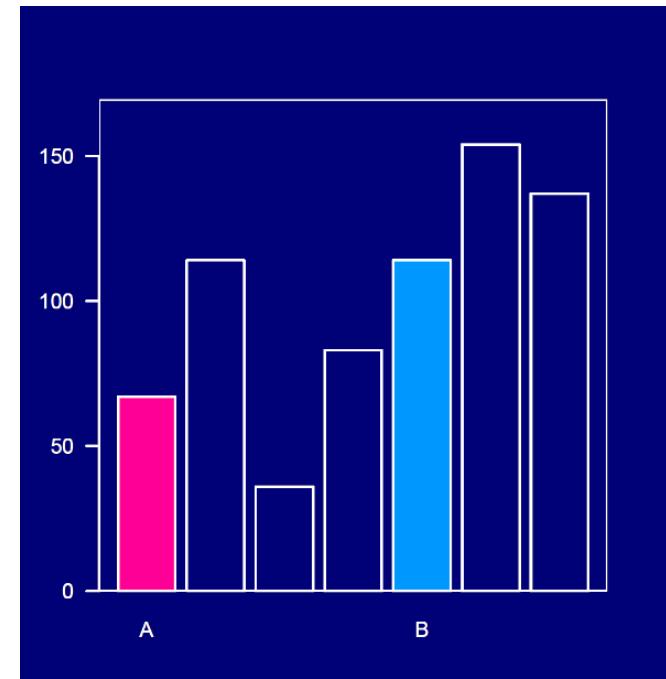
HIGH SCHOOL STUDENTS' COLLEGE  
PREFERENCES (SORTED)



# Which comparison is easier?

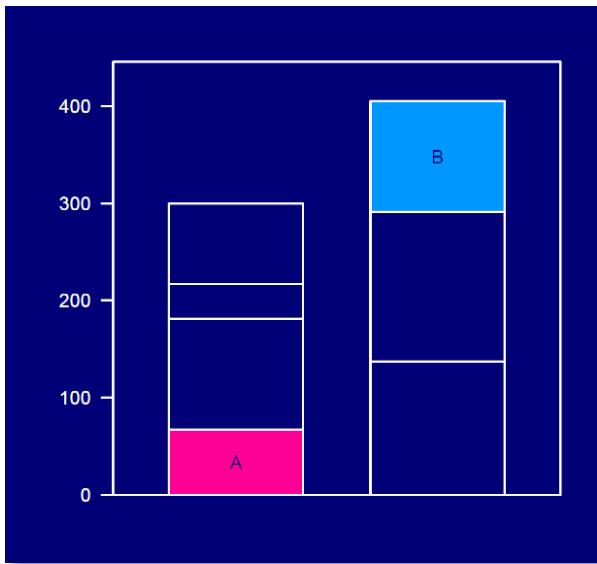


1

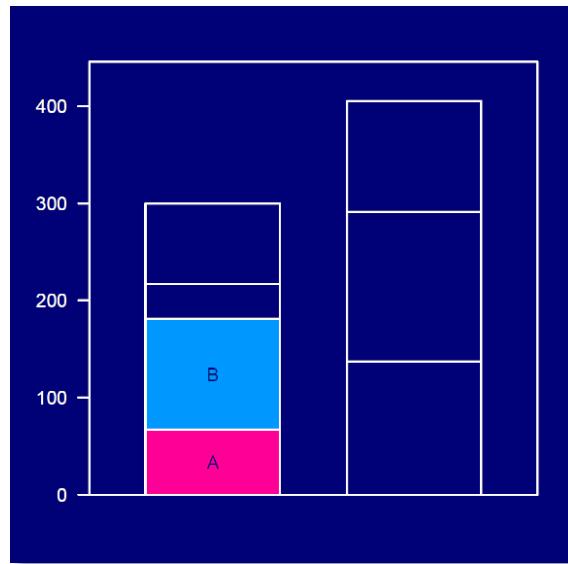


2

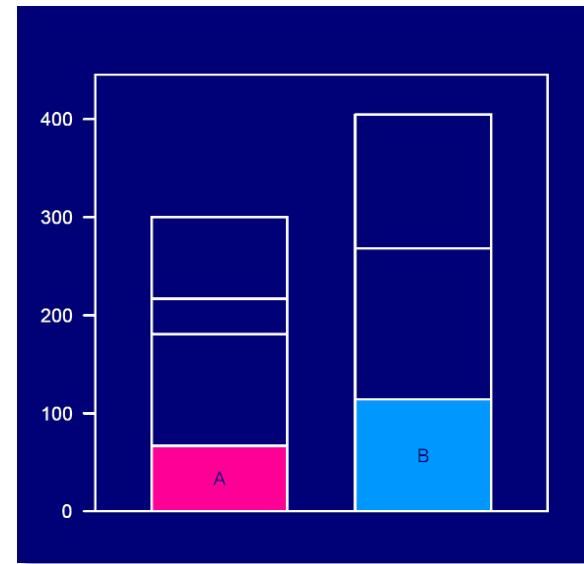
# Which comparison is the easiest?



1



2

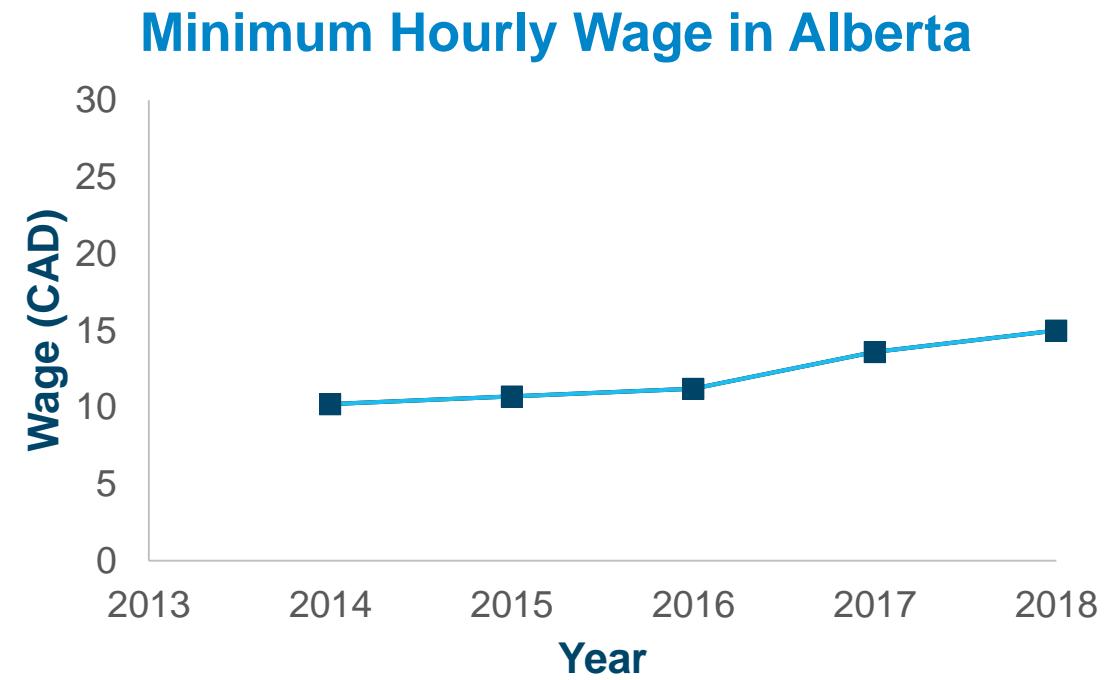
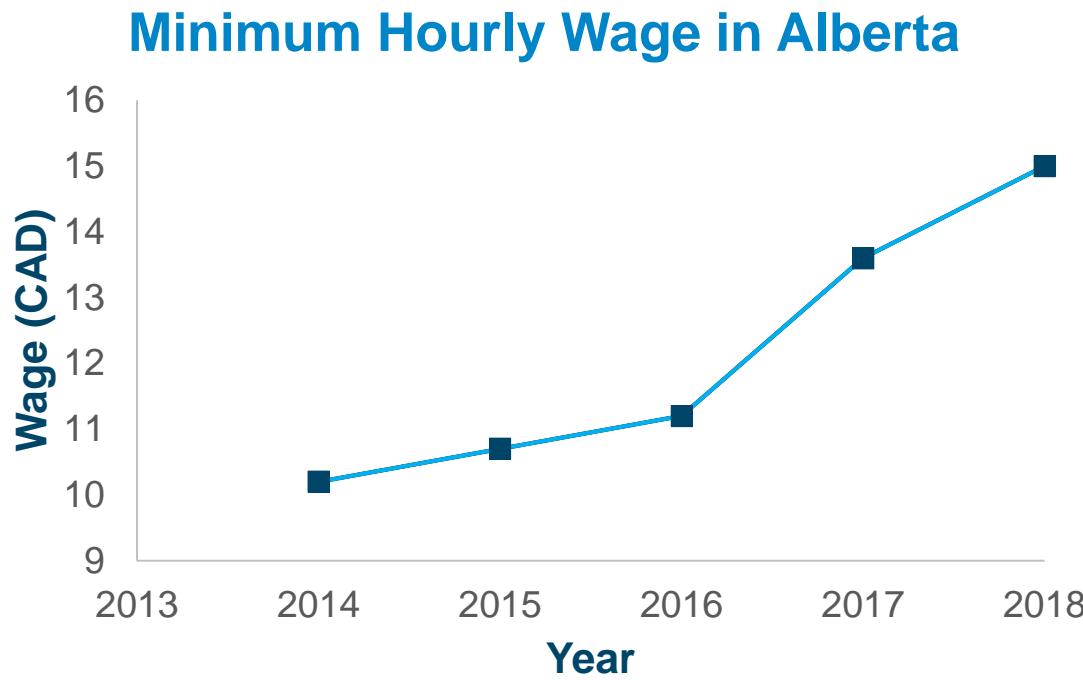


3

# Which comparison is the easiest?



# Decide the scale carefully



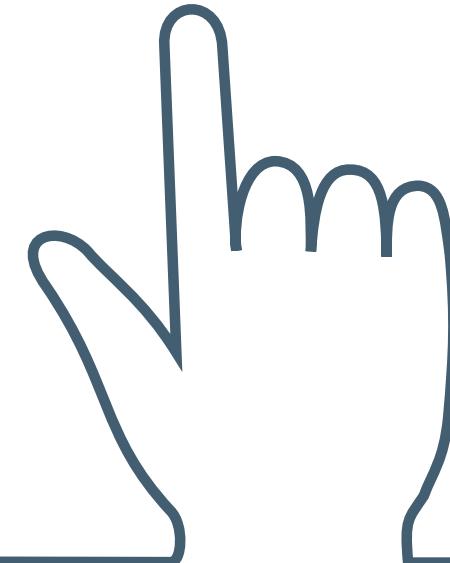
The success of your visualization is measured  
by **your audience**'s understanding.

They are **not** you...

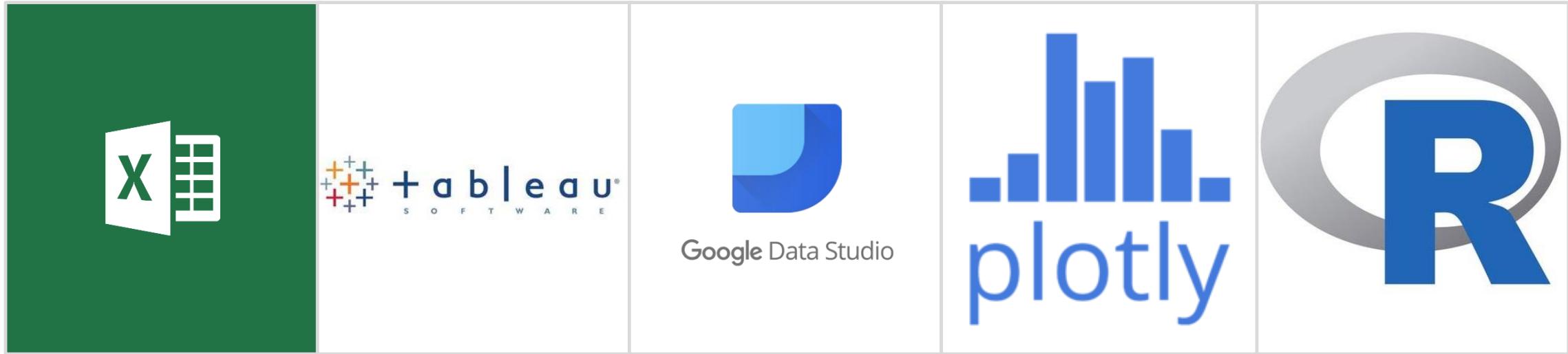
Understand the **context** in which your  
audience is thinking.



# 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/>

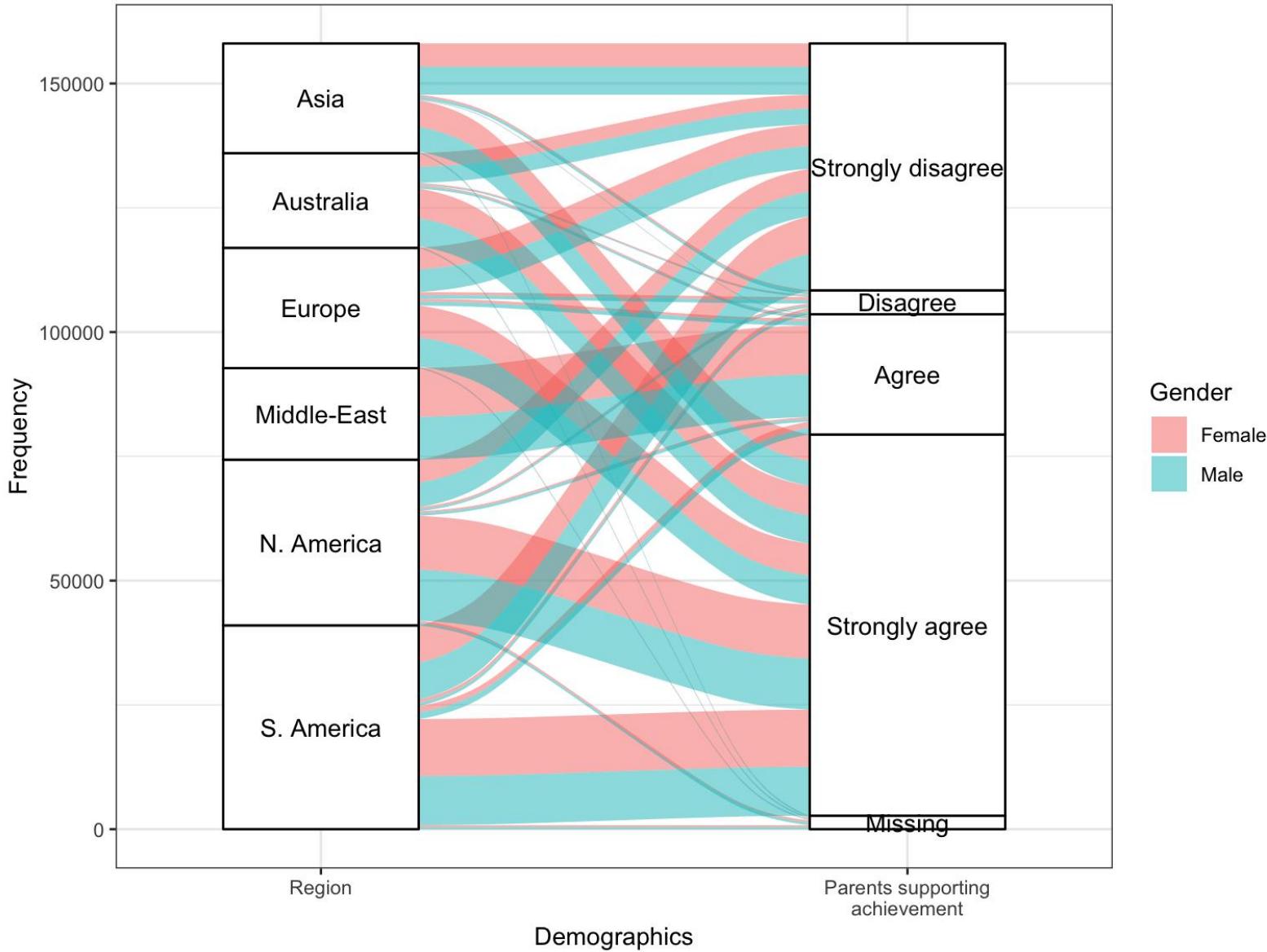


# Software Options

	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



# Alluvial Plot

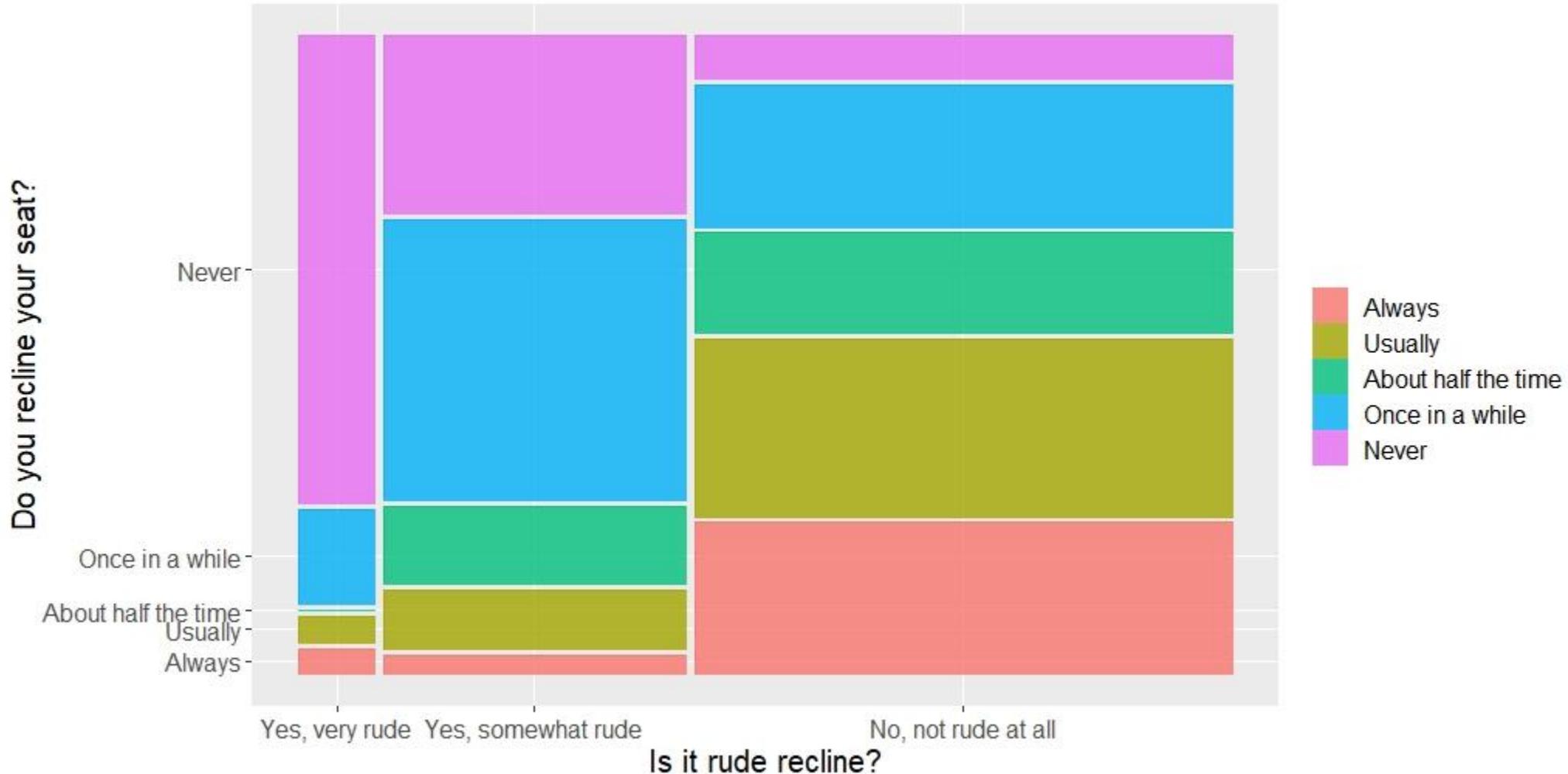


My parents support my educational efforts and achievements.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

Source: [PISA 2015](#)

# Mosaic Plot



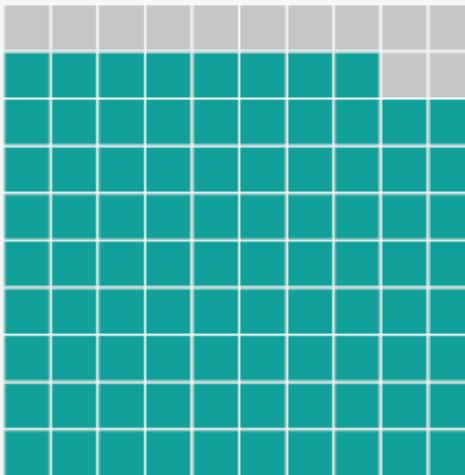
Source: Flying Etiquette Survey - <https://fivethirtyeight.com/features/airplane-etiquette-recline-seat/>



# Waffle (Square Pie) Chart

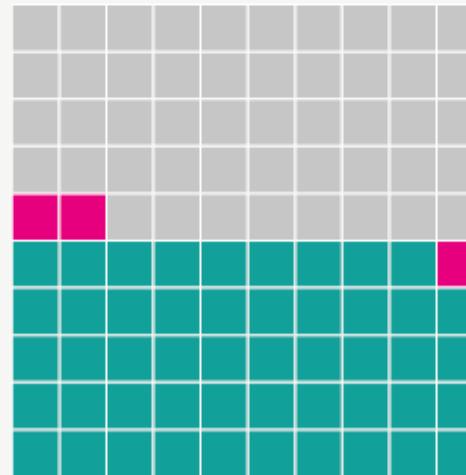
**March  
2003**

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



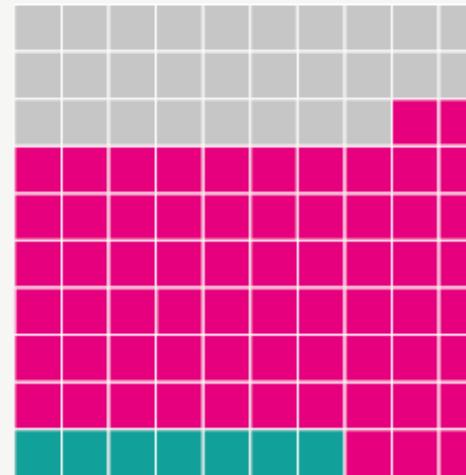
**September  
2008**

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

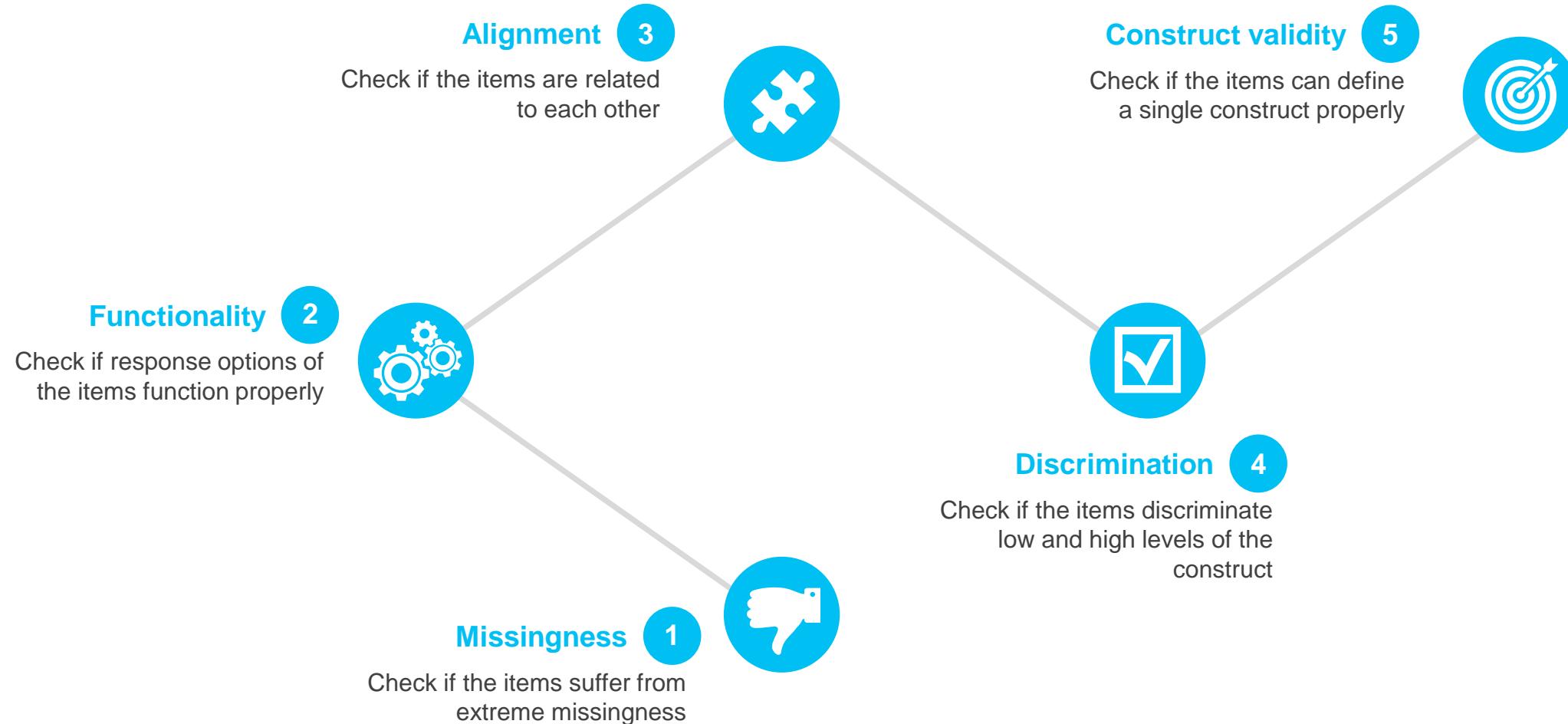
- <http://mondrian.theusrus.de/>
- Free and open source
- Compatible with Windows, Mac, and Linux
- Good for a variety of visualizations (from basic to complex plots)



# 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

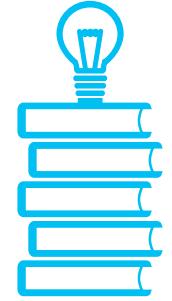


- Alberta students who participated in PISA 2015 ( $n = 2,133$ )
- Data files are available at: <https://github.com/okanbulut/dataviz>
  - PISA\_Alberta.xlsx
  - PISA\_Alberta.csv
  - PISA\_Alberta.sav
- 10 Likert-type survey items *potentially* measuring “attitudes towards teamwork”
- Each question has the following response options:

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

**First eight questions share the same statement:**

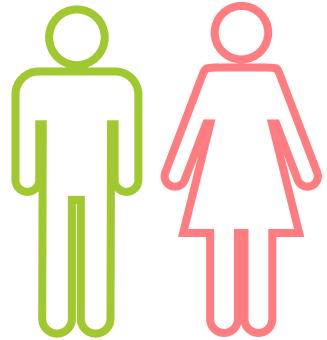
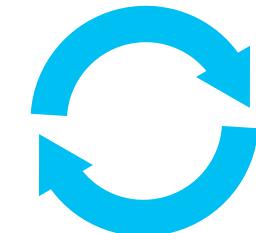
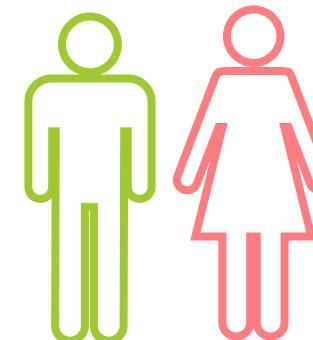
**“To what extent do you disagree or agree about yourself?”**



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

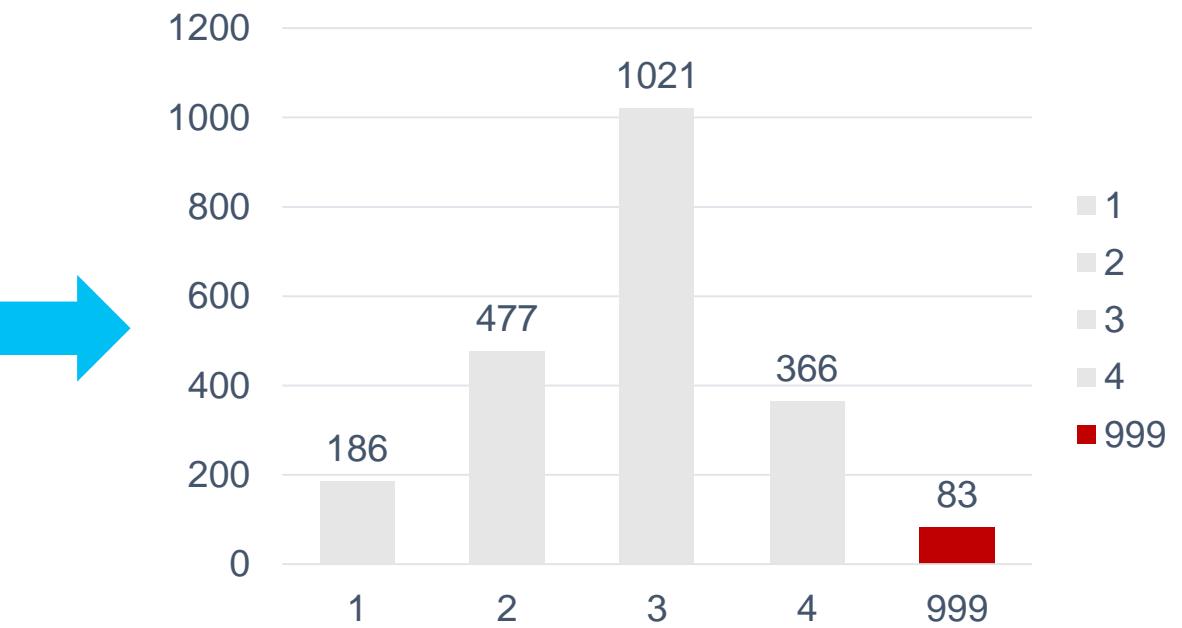


01

## 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
<b>Grand Total</b>	<b>2133</b>



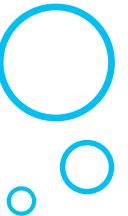
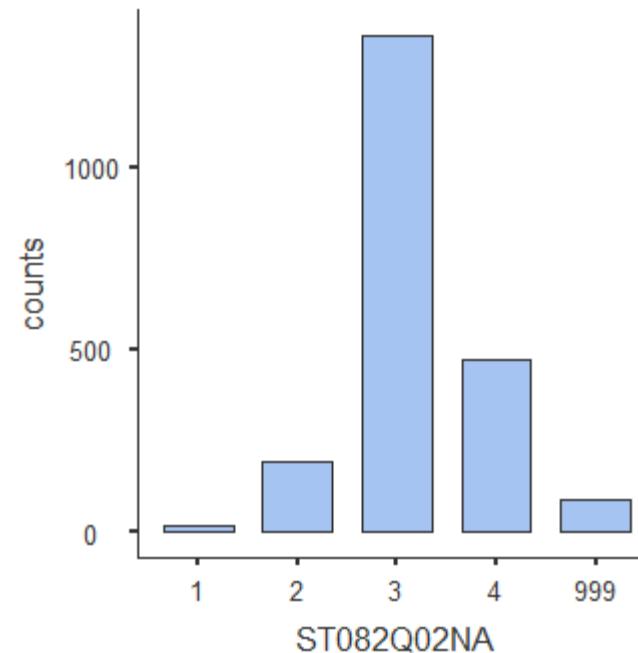
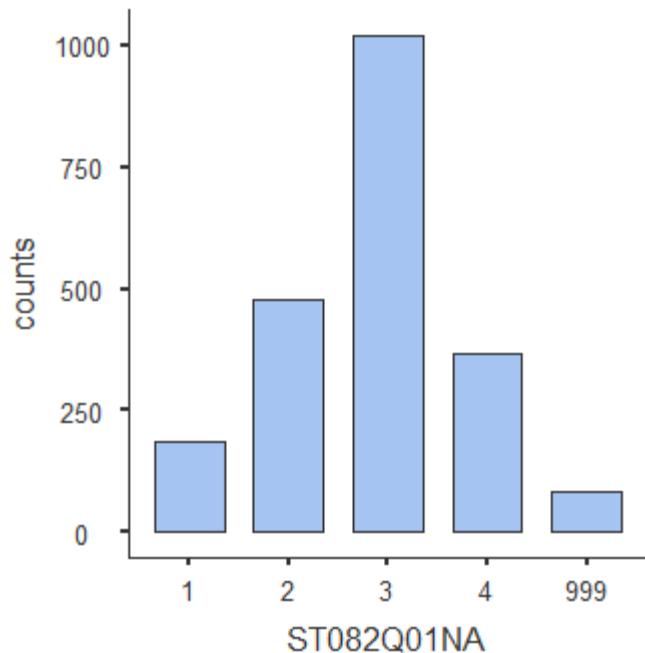
# Missingness



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

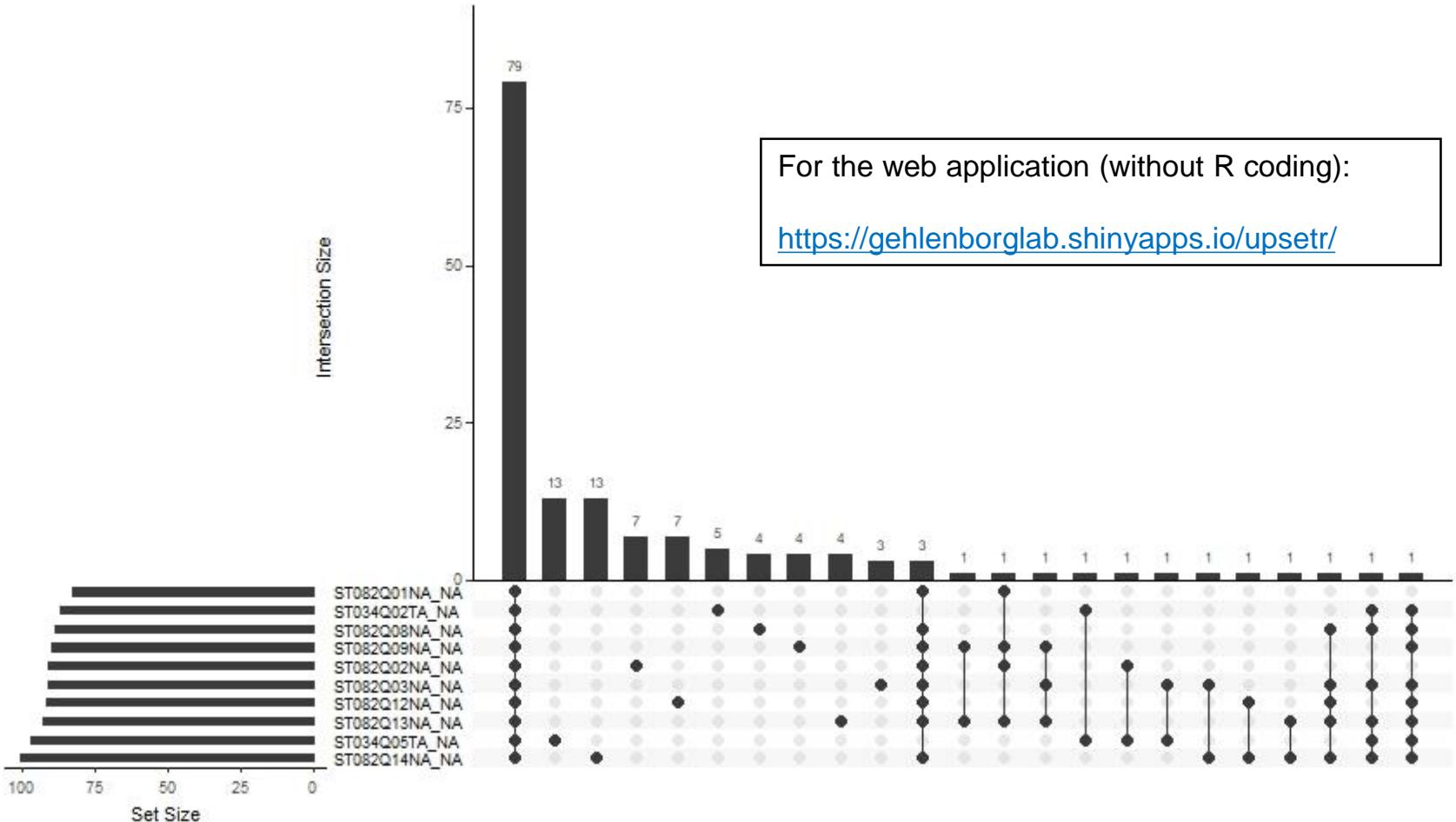


03

## naniar package in R

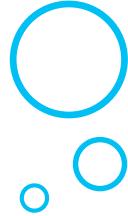
- Check out [this nice vignette](#) on the naniar package.

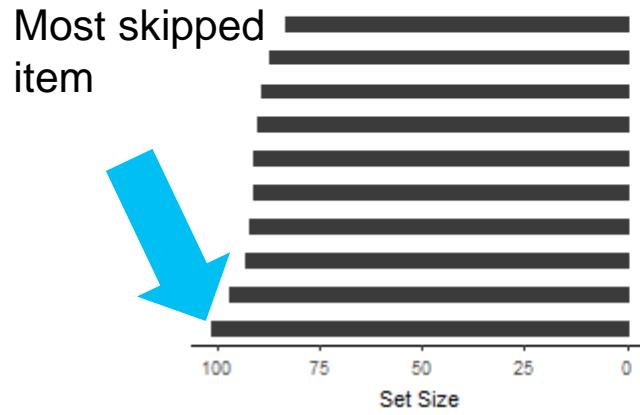
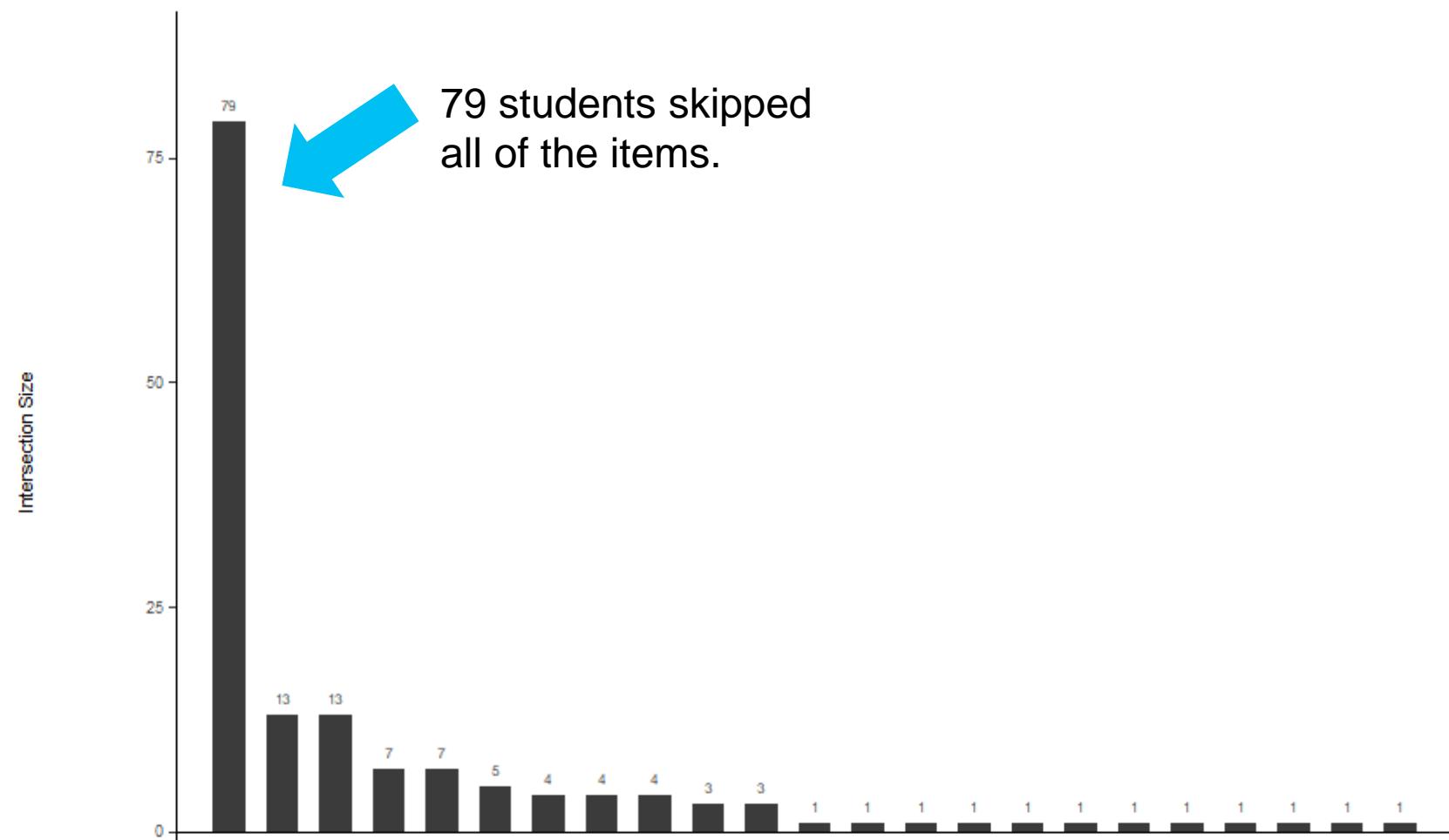
```
install.packages("naniar")
library("naniar")
mydata <- read.csv("PISA_Alberta.csv", header = TRUE, na.strings = 999)
# Select only the survey items
gg_miss_upset(mydata[, 6:15], nsets = 10)
```



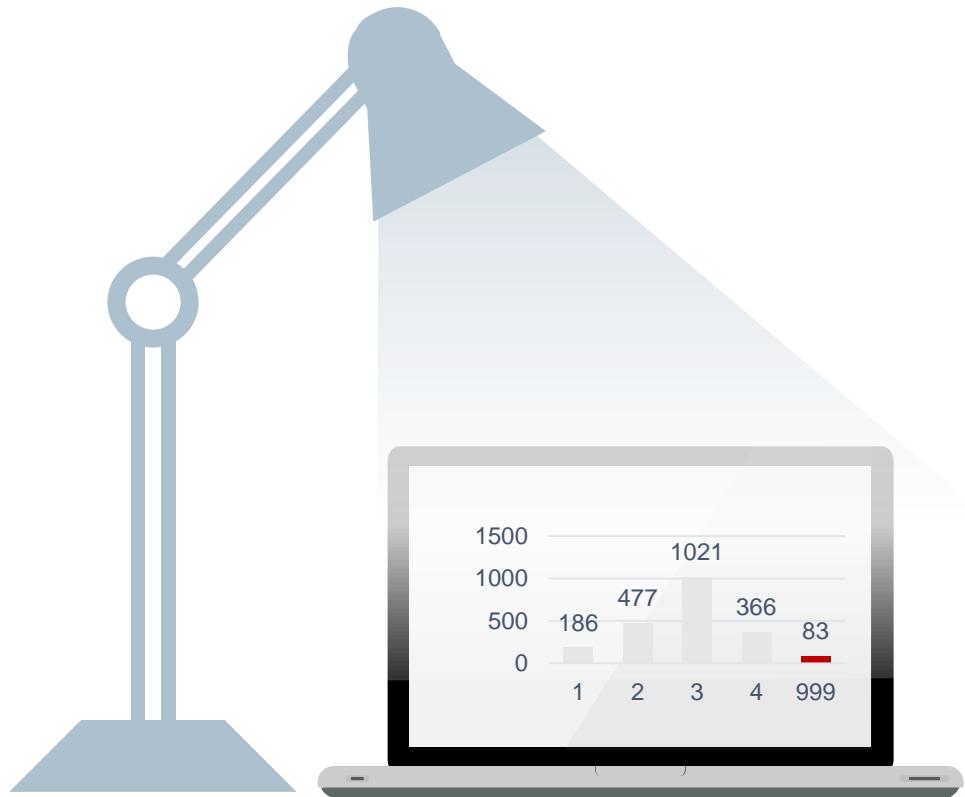
For the web application (without R coding):

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

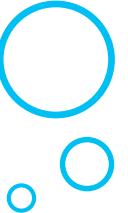




# Should we worry about missingness?

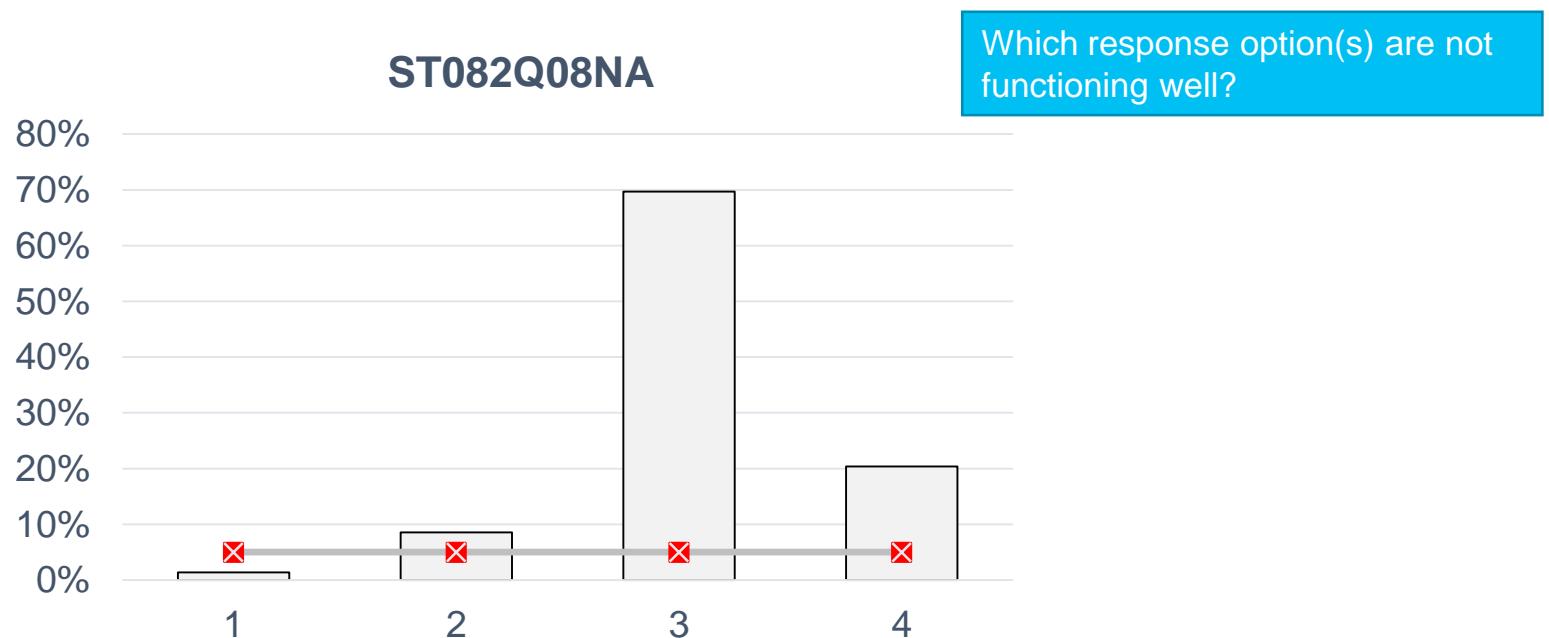


# Functionality



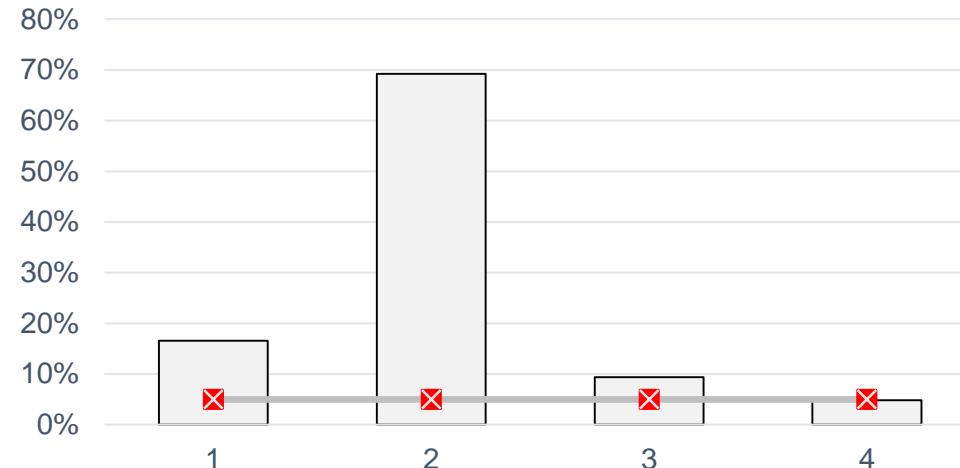
## Microsoft Excel

- 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)



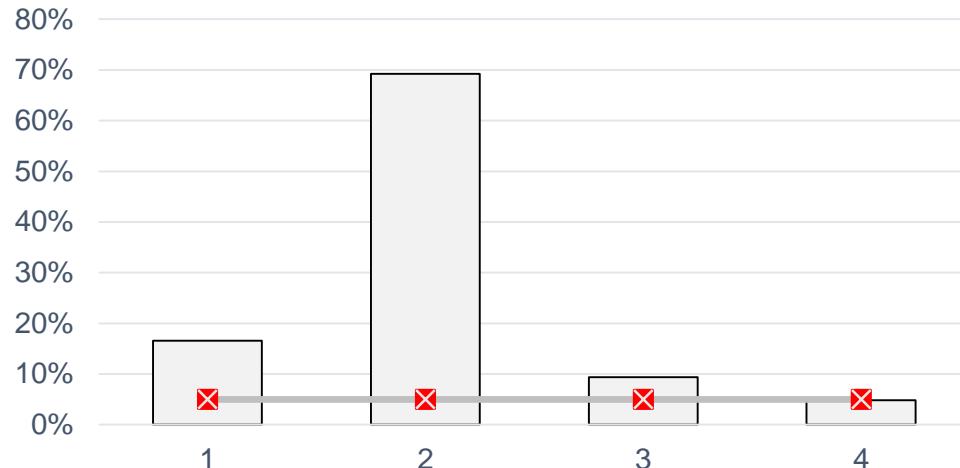
I take into account what others are interested in.

**ST082Q01NA**



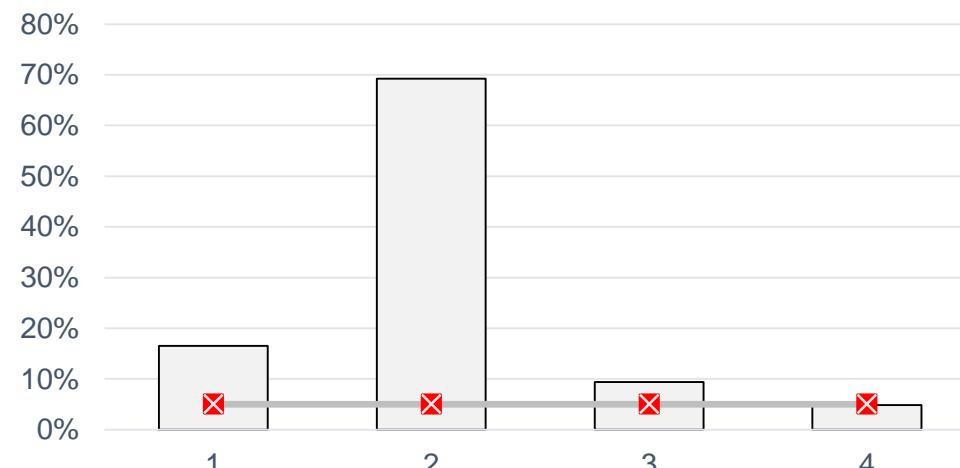
I prefer working as part of a team to working alone.

**ST082Q02NA**



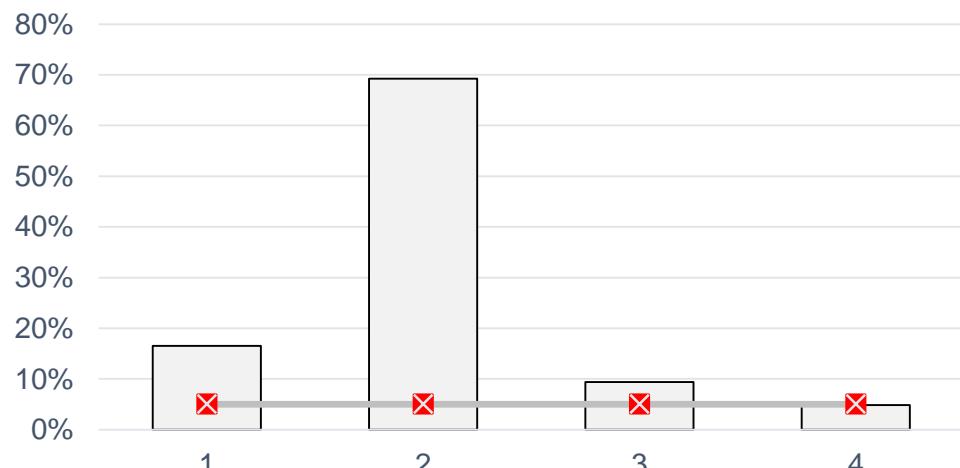
I am a good listener.

**ST082Q03NA**



I enjoy seeing my classmates be successful.

**ST034Q05TA**



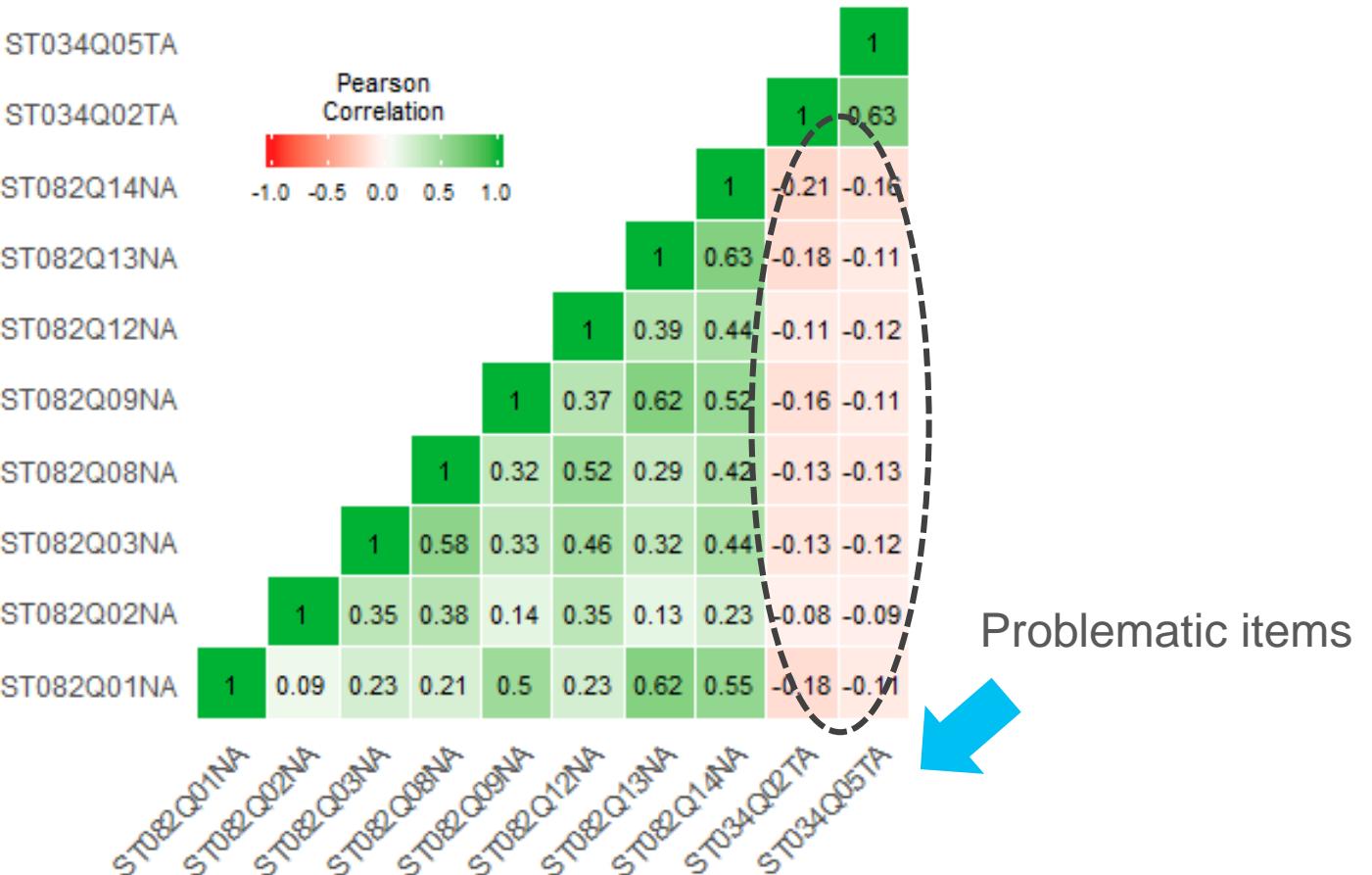
Other students seem to like me.

# 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](#))

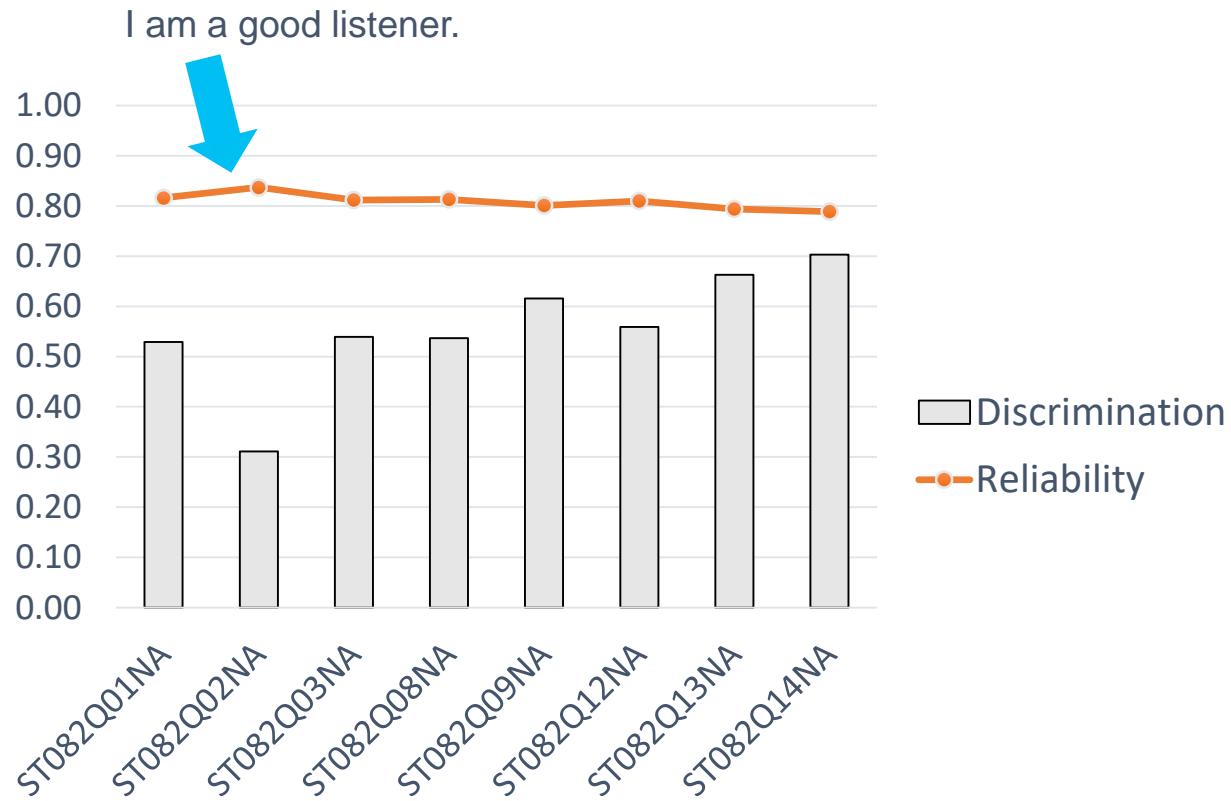


# Discrimination



## 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  $\alpha$  & Item-rest correlation (see my tutorial video [HERE](#))
- Copy the output table and paste it into an Excel spreadsheet

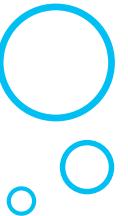
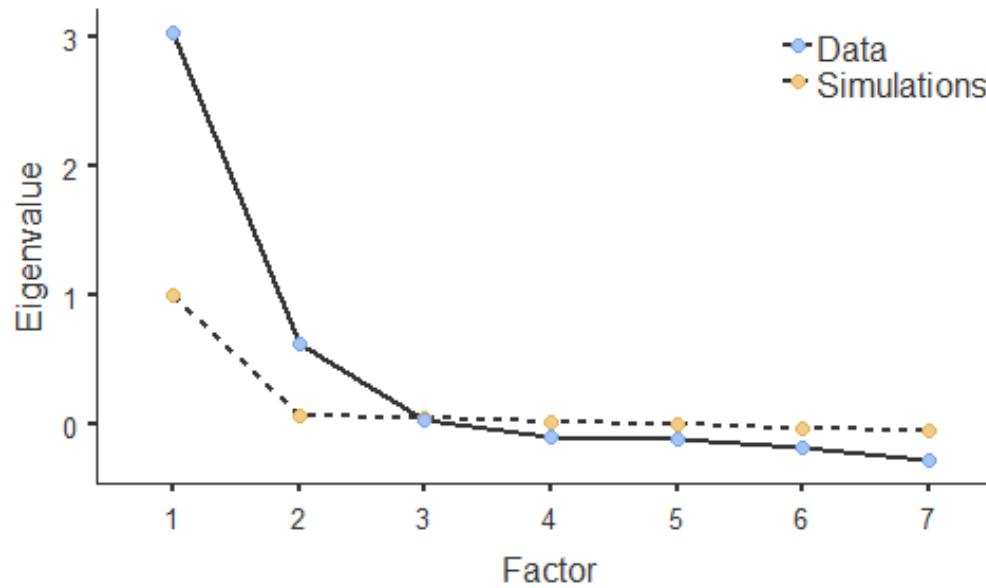


# Construct Validity

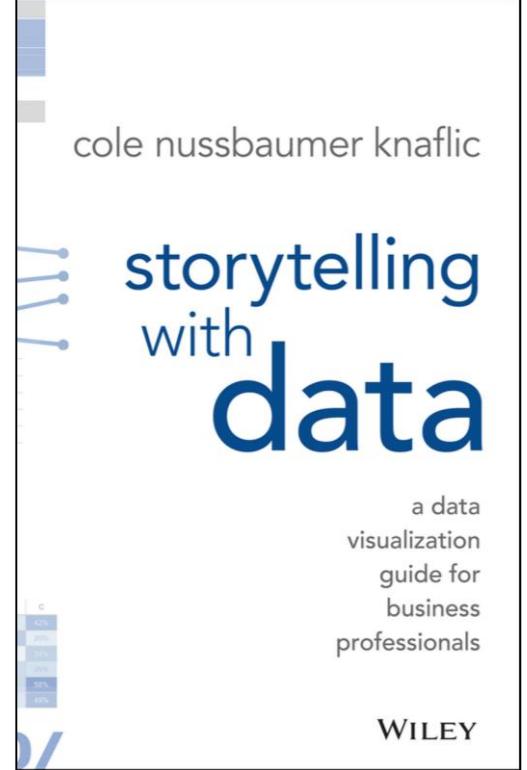
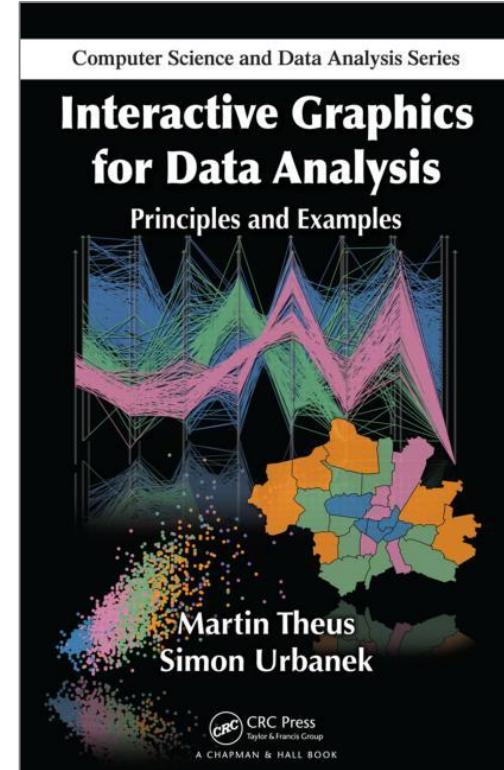
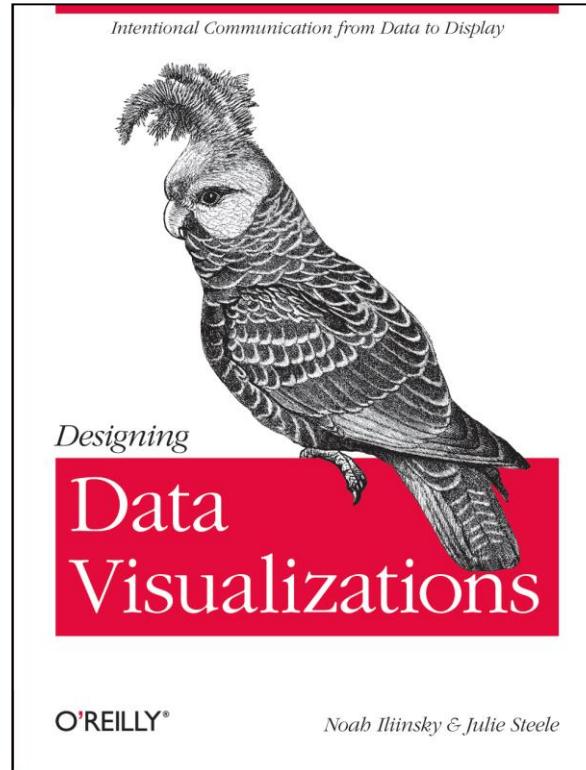
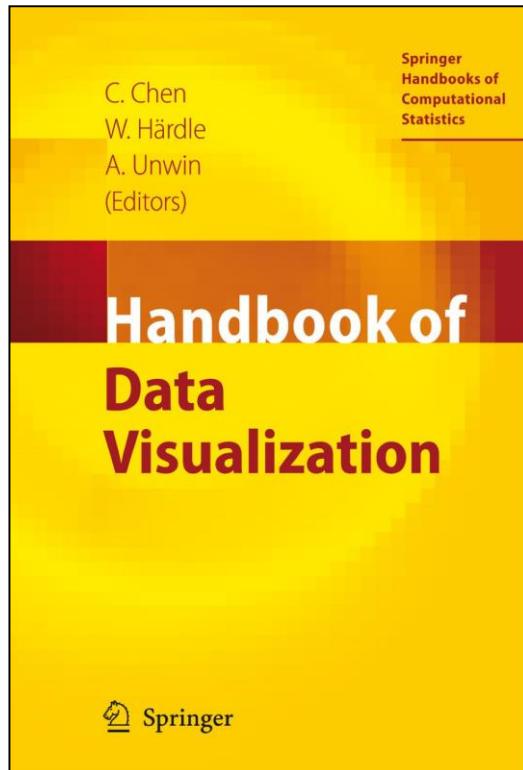


## jamovi

- 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](#))

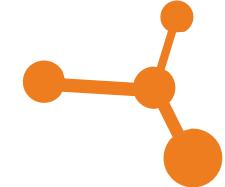
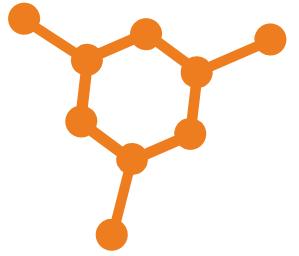


# Some Resources...



# 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](mailto:bulut@ualberta.ca)*

