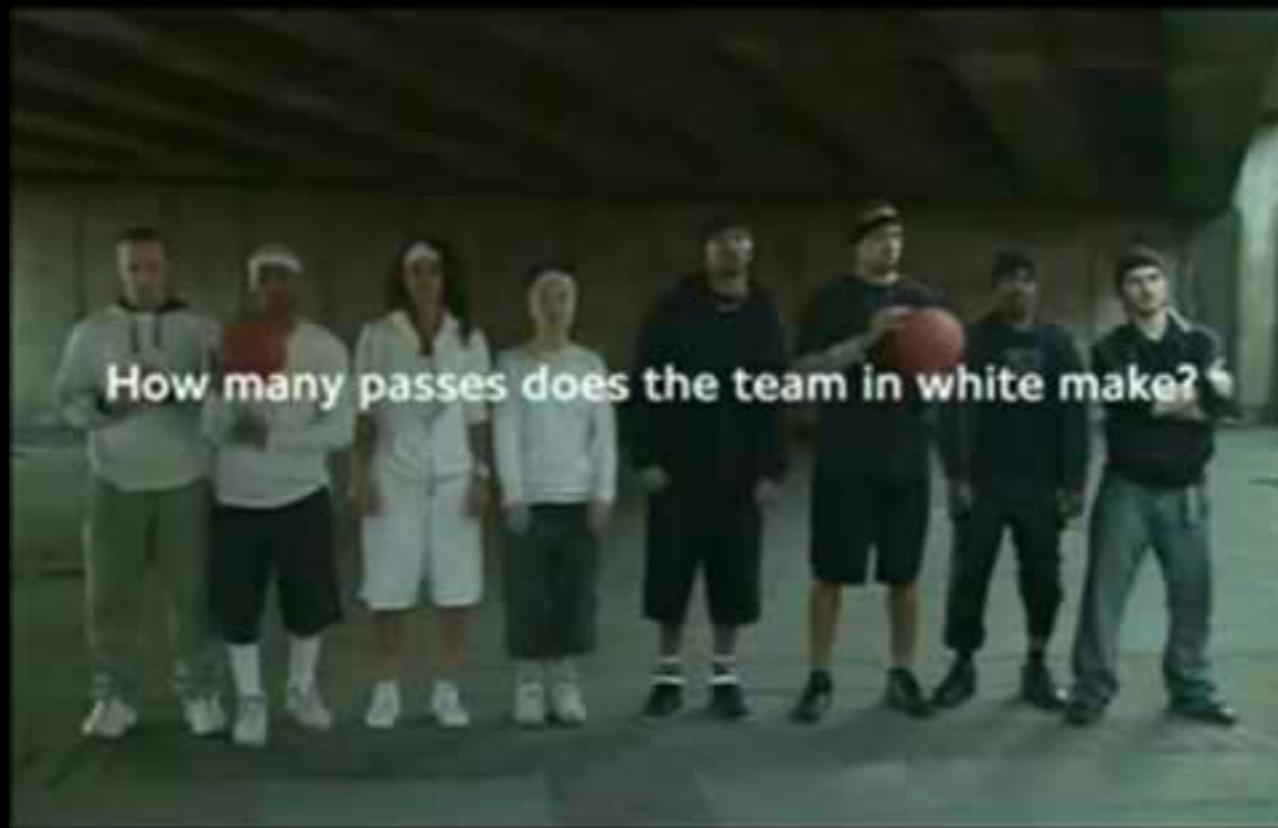


Pitfalls in Data Science



**BEFORE WE START.... A LITTLE
EXPERIMENT**



How many passes does the team in white make? ↗

<https://www.youtube.com/watch?v=z-Dg-06nrnc>

We're blind, and we're blind to our blindness.

Pitfalls in Data Science



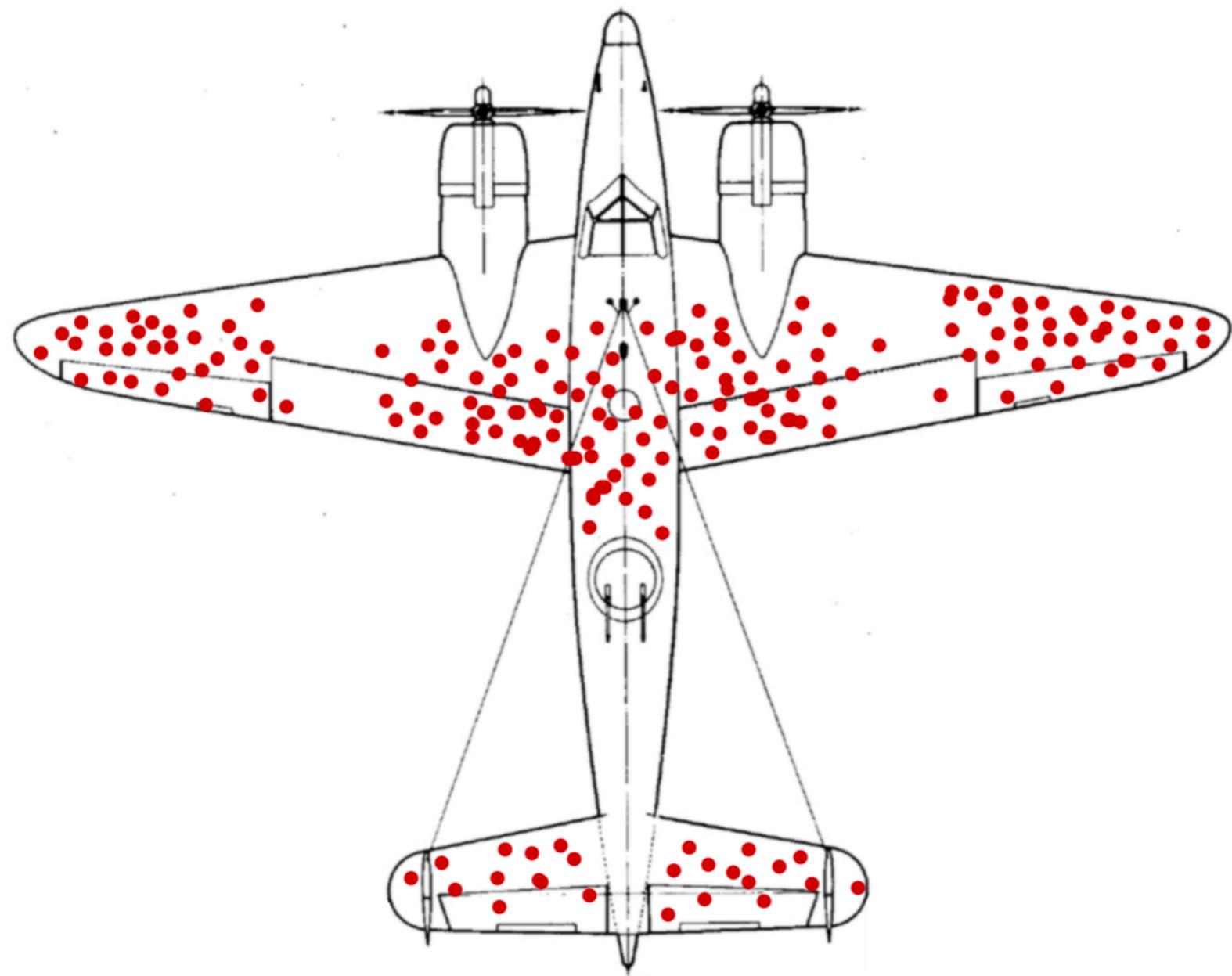
DATA

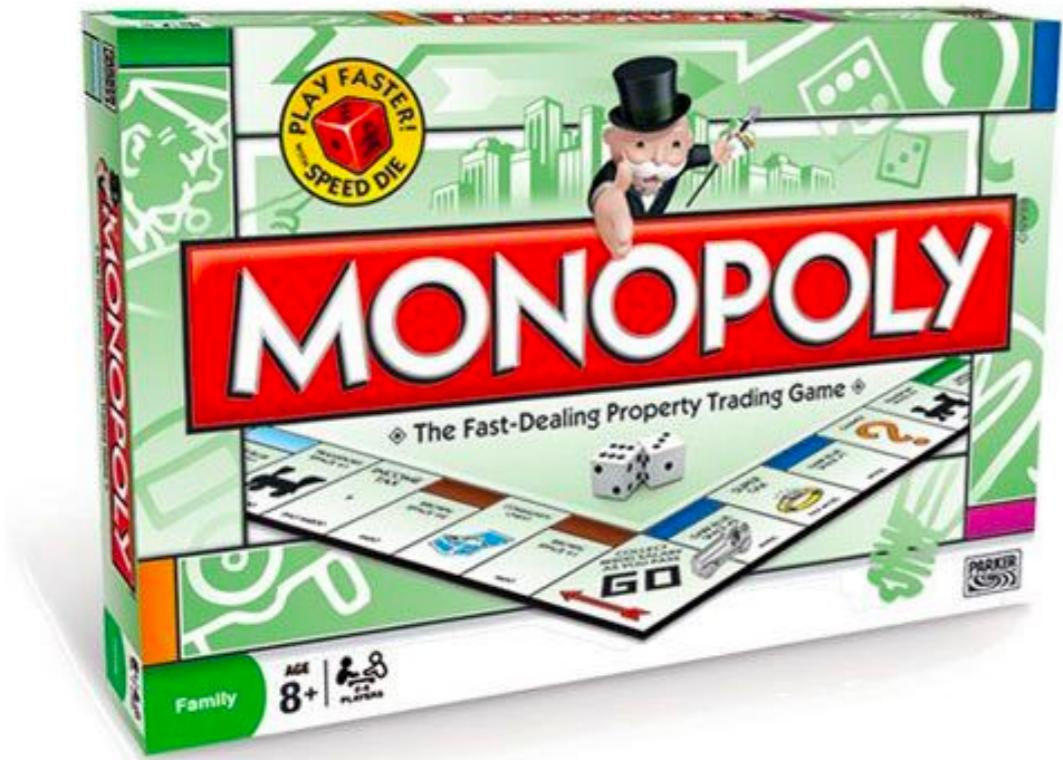
BOMBERS REINFORCEMENT



BOMBERS REINFORCEMENT

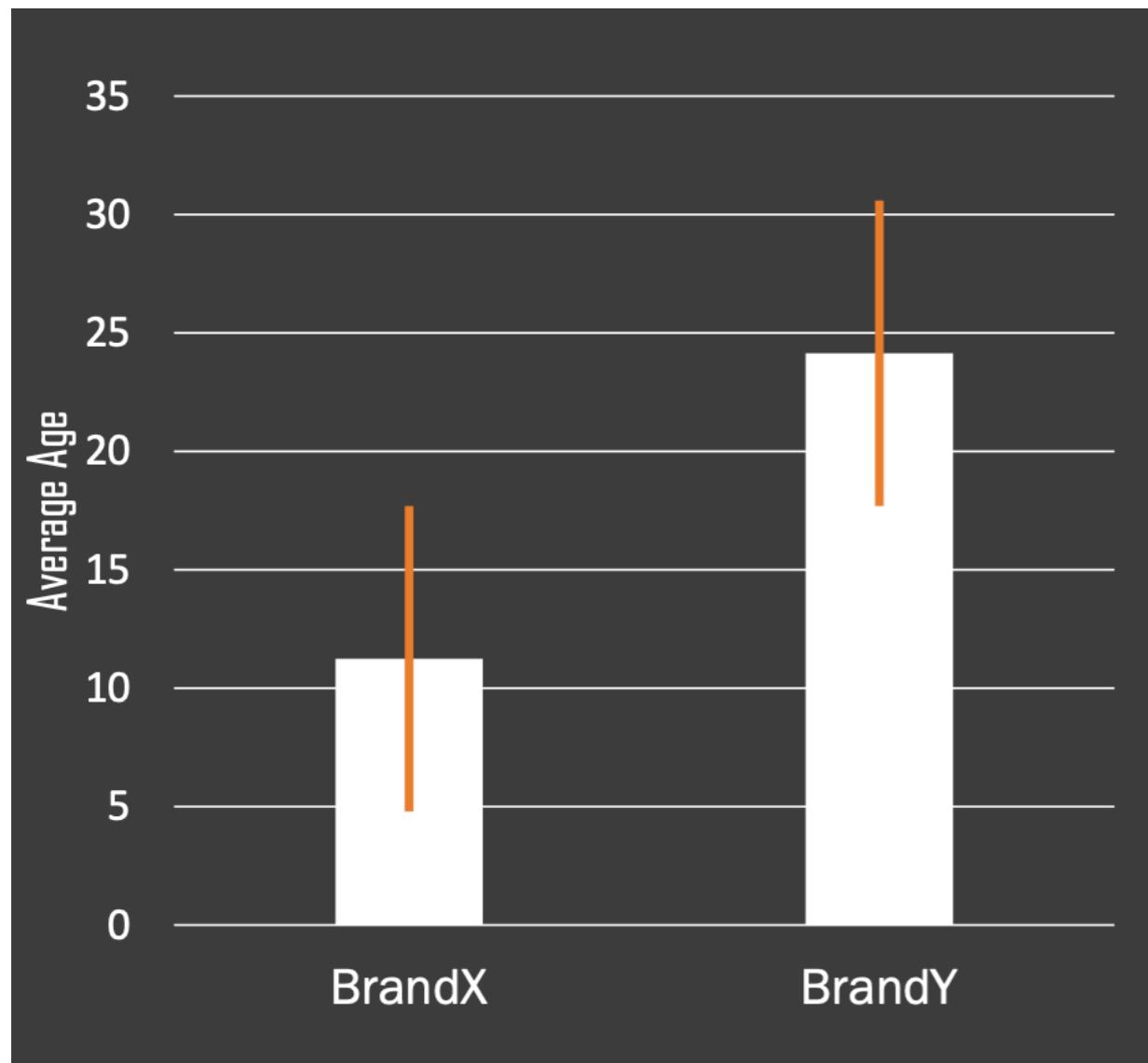
After each mission, the bullet holes and damage from each bomber returning to the base was painstakingly reviewed and recorded.





We gave 100 children toys from Brands X and Y. We then asked them which toys they preferred.

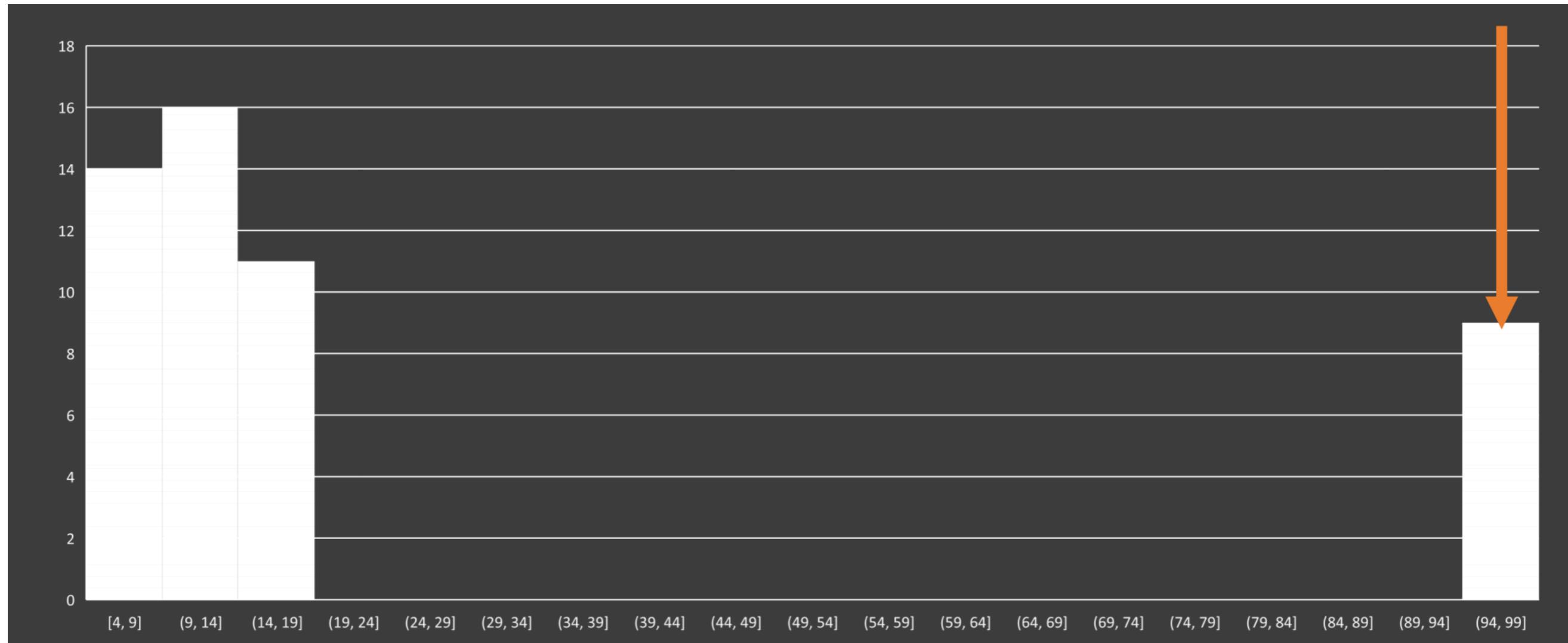
Does **age** have an effect on
brand preference?



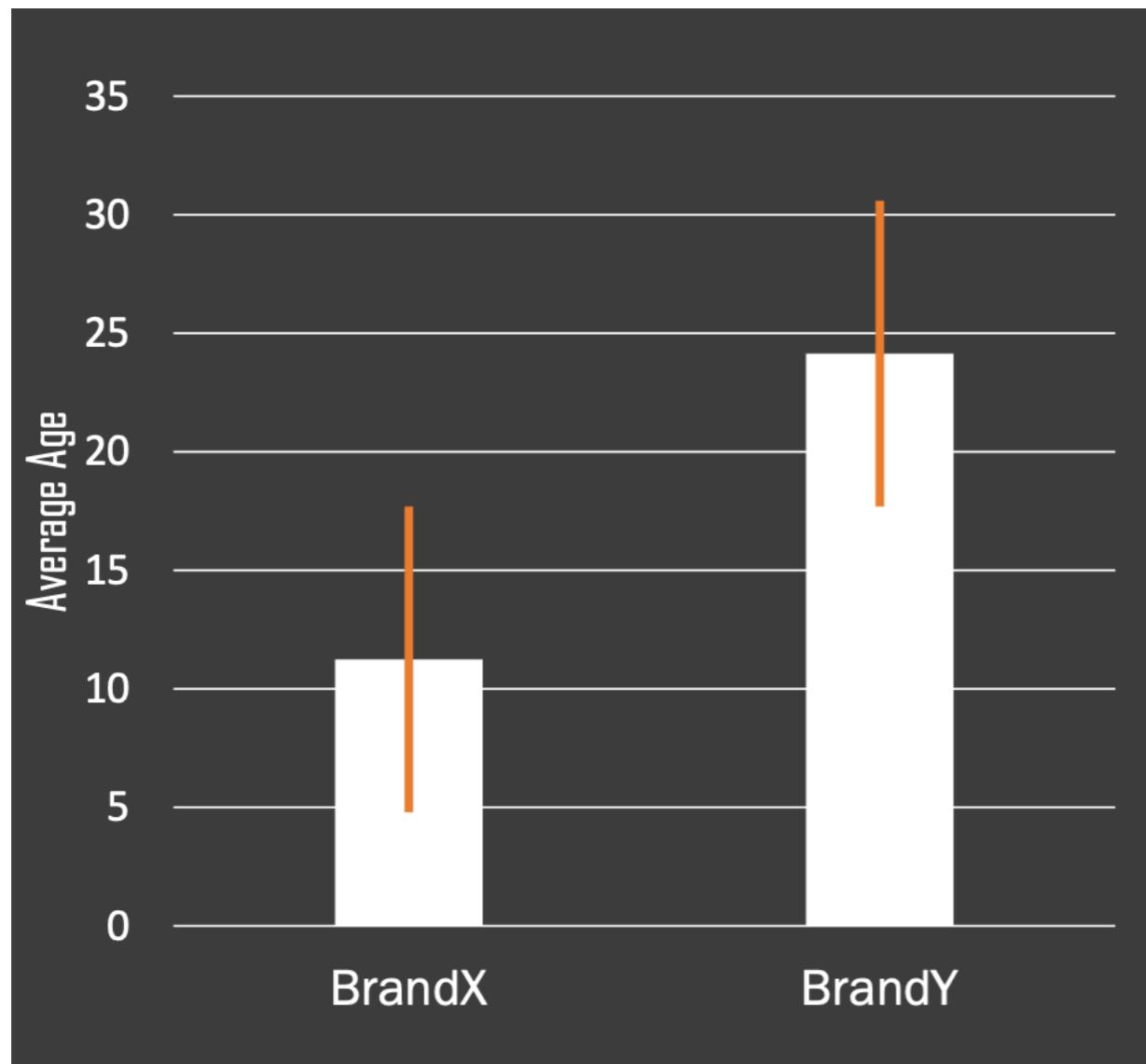
We gave 100 children toys from Brands X and Y. We then asked them which toys they preferred.

Does **age** have an effect on
brand preference?

DISTRIBUTION OF AGE

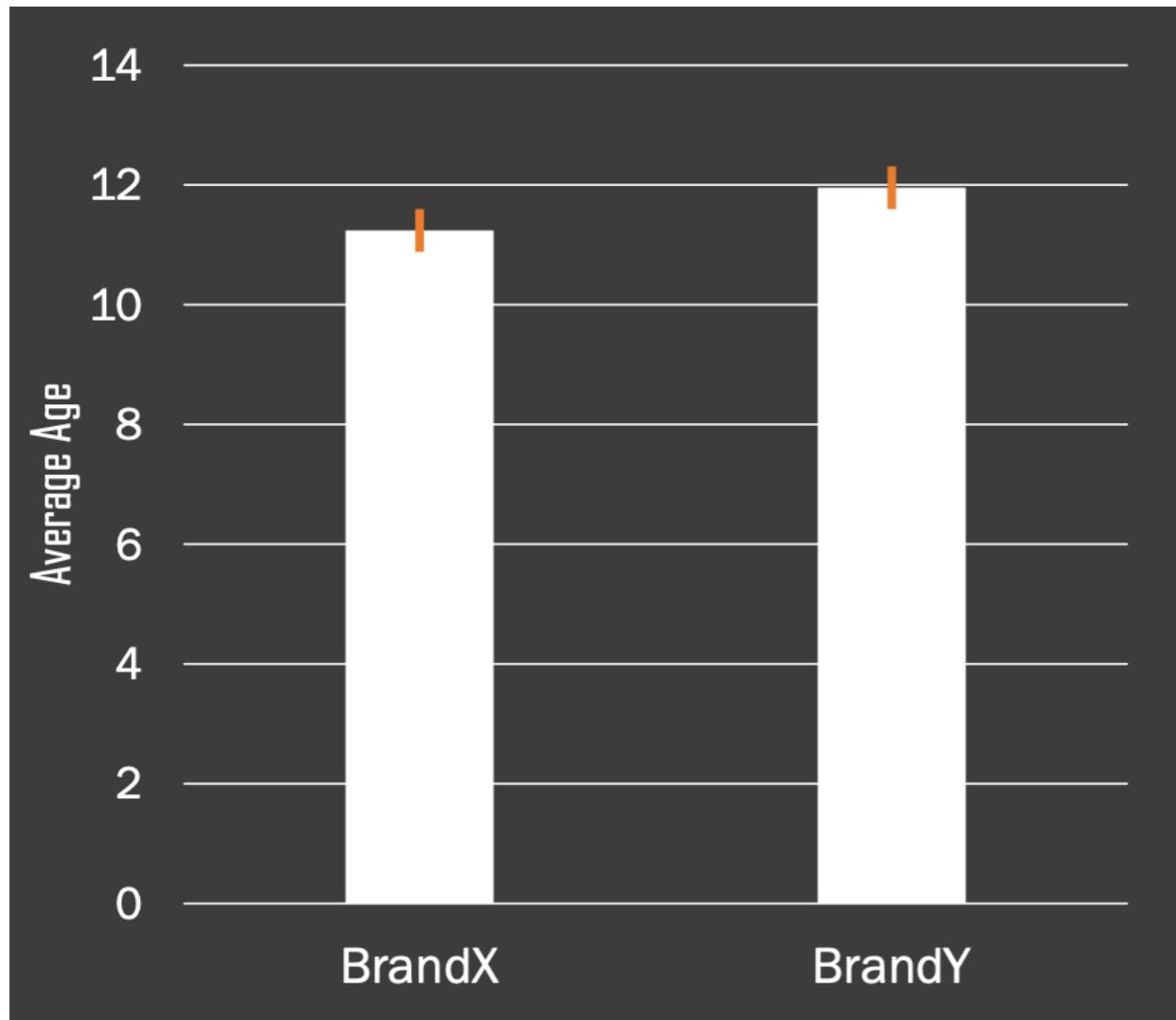


Credit: Michael Correll, Tableau Research



Age	Prefers
99	BrandX
99	BrandX
99	BrandY
16	BrandX
4	BrandX
10	BrandX
16	BrandX
10	BrandY

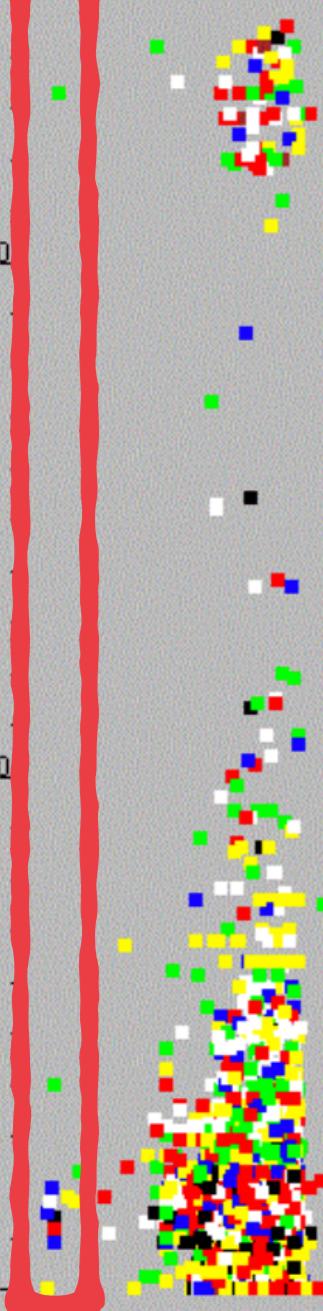
Credit: Michael Correll, Tableau Research



Does **age** have an effect
on **brand preference**?

Information Visualization & Exploration Environment

Days to Intake Decision



Showdata_popup	
ISYS Number:	205522
DOB:	0
Age:	95
Sex:	Female
Race:	Caucasian
County (Res):	Prince Georges
Zip Code (Res):	20770
Received:	940706
Complaint Sequence:	1
Source:	Citizen
Reason:	Delinquent
Alleged Offense:	HARAS
Offense Level:	2 - Misdemeanor
County (Off):	Prince Georges
Zip Code (Off):	20770
Area:	V
Office:	71610
Intake Decision Date:	940729
Intake Decision:	Closed
Days to ID:	23
Court Finding:	NONE
Disposition Date:	0
Disposition:	

Alleged Offense: ALL

A	B	CD	EFGHLMNR	ST	UV
---	---	----	----------	----	----

Offense Level: ALL

1 - Status Offenses	6 - Se
2 - Misdemeanors Type II	7 - Dr
3 - Narcotics Possession	8 - Fel
4 - Misdemeanors Type I	9 - Vic
5 - Other Felony	

County (Off): ALL

I	Out of State
II	V
III	VI
IV	

Area: ALL

D	FGH	K	MOPQS	TW
---	-----	---	-------	----

Office: 600 91800

Closed	Informal
Disapproved	Pending
Formal (Petition Authorize)	Reverse
Formal (SA Office)	

Intake Decision:

Query Result: 4792 out of 4792 (100%)

TC Reset Quit

	age	body_type	diet	drinks	drugs	education	essay0	essay1	essay2	essay3	...	location	offspring	orientation
25324	109	athletic	mostly other	NaN	never	working on masters program	NaN	NaN	NaN	nothing	...	san francisco, california	might want kids	straight

See previous lectures

Background

X

Ethnicity

- Asian
- Indian
- Pacific Islander
- Black
- Middle Eastern
- White
- Hispanic / Latin
- Native American
- Other

Speaks

English

—

Russian

Somewhat

Education

—

University

Religion

Judaism

SaveCancel

Details

Smokes

No

Drinks

Not at all

Drugs

Never

Kids

Doesn't have kids

but wants them

Pets

- Has dogs
- Has cats

Sign

Gemini

Diet

Kosher

SaveCancel

Ok Cupid forms



Jacques Bistro Du Parc

126 Cumberland St, Toronto, Ontario M5R 1A6, Canada

Your first-hand experiences really help other travellers. Thanks!

Your overall rating of this restaurant



Click to rate

Draft saved at 20:15.

Title of your review

Summarize your visit or highlight an interesting detail

Your review

Tips for writing a great review

Tell people about your experience: your meal, atmosphere, service?

(100 character minimum)

What sort of visit was this?

Couples Family Friends Business Solo

Were you here for...

Select one

When did you visit?

Select one

Could you say a little more about it? (optional)

Can a vegan person get a good meal at this restaurant?

Yes No Not Sure

Does this restaurant offer table service?

Yes No Not Sure

Can a gluten free person get a good meal at this restaurant?

Yes No Not Sure

Does this place accept credit cards?

Yes No Not Sure

Is this restaurant good for dinner?

Yes No Not Sure

Is this restaurant good for lunch?

Yes No Not Sure

Click to select a rating

Service



Click to rate

Food



Click to rate

Value



Click to rate

How expensive is this restaurant? ?

Cheap Eats

Mid-range

Fine Dining

What dish or dishes do you recommend?

Tripadvisor review form

How would you collect data
to measure **relationship satisfaction**?

Something that cannot be directly measured is called a **construct**. To measure these constructs, you need an **operational definition** of the construct, which is a (set of) procedure(s) for quantifying it.

RELATIONSHIP ASSESSMENT SCALE

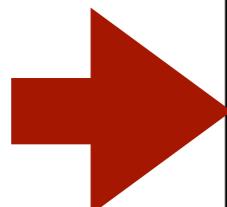
[Hendrick et al. 1998]

	Low				High
1. How well does your partner meet your needs?	1	2	3	4	5
2. In general, how satisfied are you with your relationship?	1	2	3	4	5
3. How good is your relationship compared to most?	1	2	3	4	5
4. How often do you wish you hadn't gotten into this relationship?	1	2	3	4	5
5. To what extent has your relationship met your original expectations?	1	2	3	4	5
6. How much do you love your partner?	1	2	3	4	5
7. How many problems are there in your relationship?	1	2	3	4	5

RELATIONSHIP ASSESSMENT SCALE

[Hendrick et al. 1998]

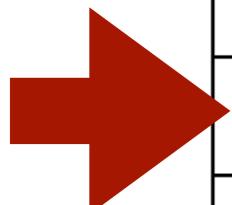
	Low				High
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RELATIONSHIP ASSESSMENT SCALE

[Hendrick et al. 1998]

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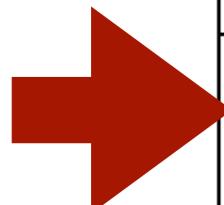


|—————|
2x as much?

RELATIONSHIP ASSESSMENT SCALE

[Hendrick et al. 1998]

	Low				High
1. How well does your partner meet your needs?	1	2	3	4	5
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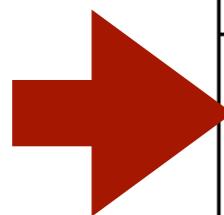
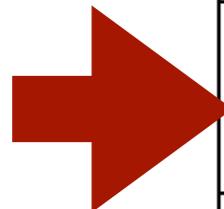


RESPONSE BIAS

	Low				High
1. How well does your partner meet your needs?	1	2	3	4	5
2. In general, how satisfied are you with your relationship?	1	2	3	4	5
3. How good is your relationship compared to most?	1	2	3	4	5
4. How often do you wish you hadn't gotten into this relationship?	1	2	3	4	5
5. To what extent has your relationship met your original expectations?	1	2	3	4	5
6. How much do you love your partner?	1	2	3	4	5
7. How many problems are there in your relationship?	1	2	3	4	5

REVERSE PHRASING

	Low				High
1. How well does your partner meet your needs?	1	2	3	4	5
2. In general, how satisfied are you with your relationship?	1	2	3	4	5
3. How good is your relationship compared to most?	1	2	3	4	5
4. How often do you wish you hadn't gotten into this relationship?	1	2	3	4	5
5. To what extent has your relationship met your original expectations?	1	2	3	4	5
6. How much do you love your partner?	1	2	3	4	5
7. How many problems are there in your relationship?	1	2	3	4	5



VALIDITY AND RELIABILITY

validity

the instrument measures what it sets out to measure

reliability

the instrument can be interpreted consistently across situations

VALIDITY

face validity

do the items relate to the construct they measure?

criterion validity

are scores consistent with real-world observations?

content validity

do items represent the construct they measure, and cover the full range of the construct?

RELIABILITY

test-re-test reliability

does testing the same person twice under the same conditions produce similar scores?

SELF-REPORTED DATA



SEE, THEY ASKED HOW MUCH MONEY I SPEND ON GUM EACH WEEK, SO I WROTE, "\$500." FOR MY AGE, I PUT "43," AND WHEN THEY ASKED WHAT MY FAVORITE FLAVOR IS, I WROTE "GARLIC/CURRY."



How would you design a question that prompts for a **percentage**?



2 Labels



3 Labels



5 Labels



11 Labels



3 Ticks



5 Ticks



11 Ticks



3 Ticks and Labels



5 Ticks and Labels



11 Ticks and Labels



Banded, 2 Labels



Banded, 3 Labels

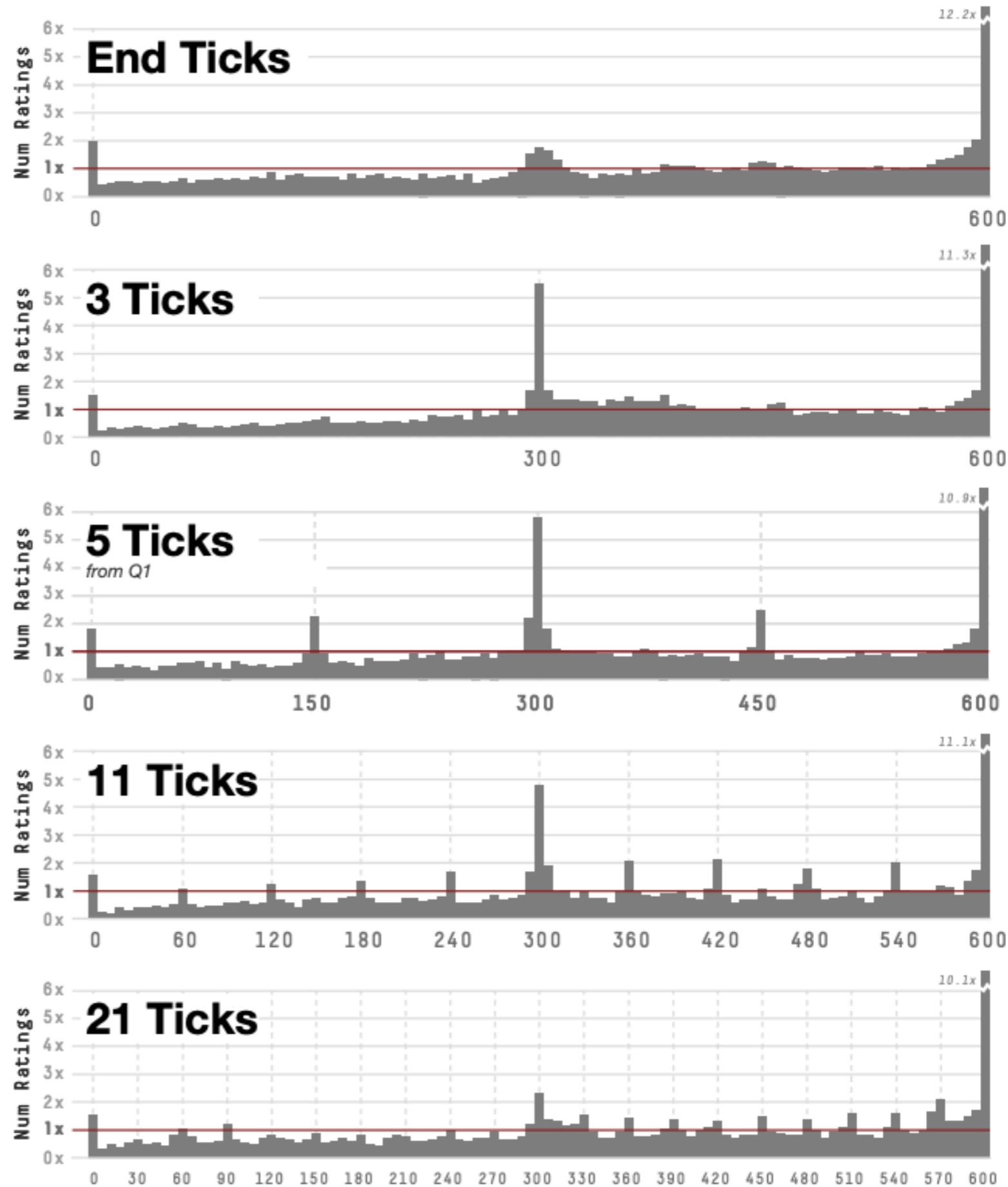
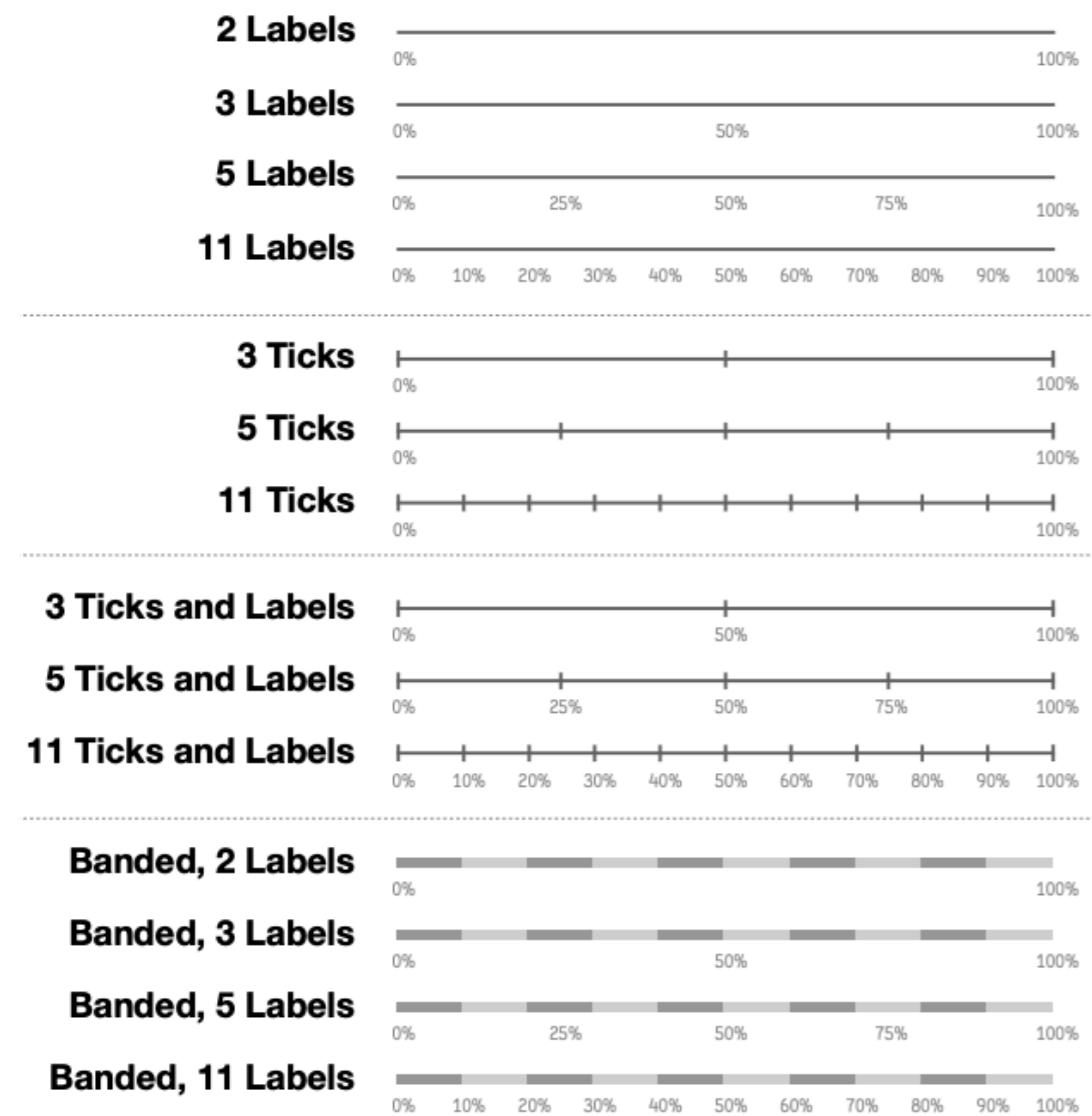


Banded, 5 Labels



Banded, 11 Labels





AVOIDING DATA PITFALLS

Think critically about the data you work with.

- Where does the data come from? Who generated it?
- Is data missing?
- How was it collected?
- When was it collected?
- What is the granularity of the observations?
- Has the data been processed?

Understand and consider the **limitations of the data** in your analyses and conclusions.

**PROBLEM /
QUESTION**

THE MILKSHAKE

A fast-food chain wanted to improve the sales of their milkshakes.



THE MILKSHAKE

A fast-food chain wanted to improve the sales of their milkshakes.

Product: More toppings, creamier taste, more flavours.
Made a better milkshake than the competition's.

Opinions: Focus groups with customers, questions about how to improve the product.
Made the milkshake people said they wanted.

Market segments: What demographics of people tend to buy milkshakes? What do they value?
Made a milkshake offering for each persona

None of it worked!

WHY?

The missing research questions:

Why were people buying milkshakes in the first place?

What need was the milkshake satisfying?

What was the context in which it was being purchased?

FINDING THE RIGHT PROBLEM

Researchers performed naturalistic observation, recording data such as:

- Time of day
- What did customers buy alongside milkshakes?
- Did they shop individually or in groups?
- Did they take their milkshakes to go?

RESULTS

40% of the milkshakes were purchased under the following conditions:

Time of day	Early morning (before 9am)
Customers	Individuals
Ordered	Single milkshake only
For here or to go?	To go

FOLLOW-UP INTERVIEW

“What job are you trying to get done that caused you to come here and hire a milkshake at 6:30 am?”

Researchers discovered that these customers wanted:

- to have something to do while driving to work
- to stay full until noon
- to get something they could consume with one hand without it getting messy and to be able to put it down if needed

FOLLOW-UP INTERVIEW

“Tell me about a time when you were in the same situation but you didn’t buy a milkshake. What did you buy instead?”

Banana	Hard to eat, gone too fast, doesn’t keep me full
Bagel	Dry and tasteless OR messy
Snickers bar	Can’t put it down, gone too fast
Coffee	Gone too fast

RIGHT QUESTION, RIGHT PROBLEM RIGHT SOLUTION

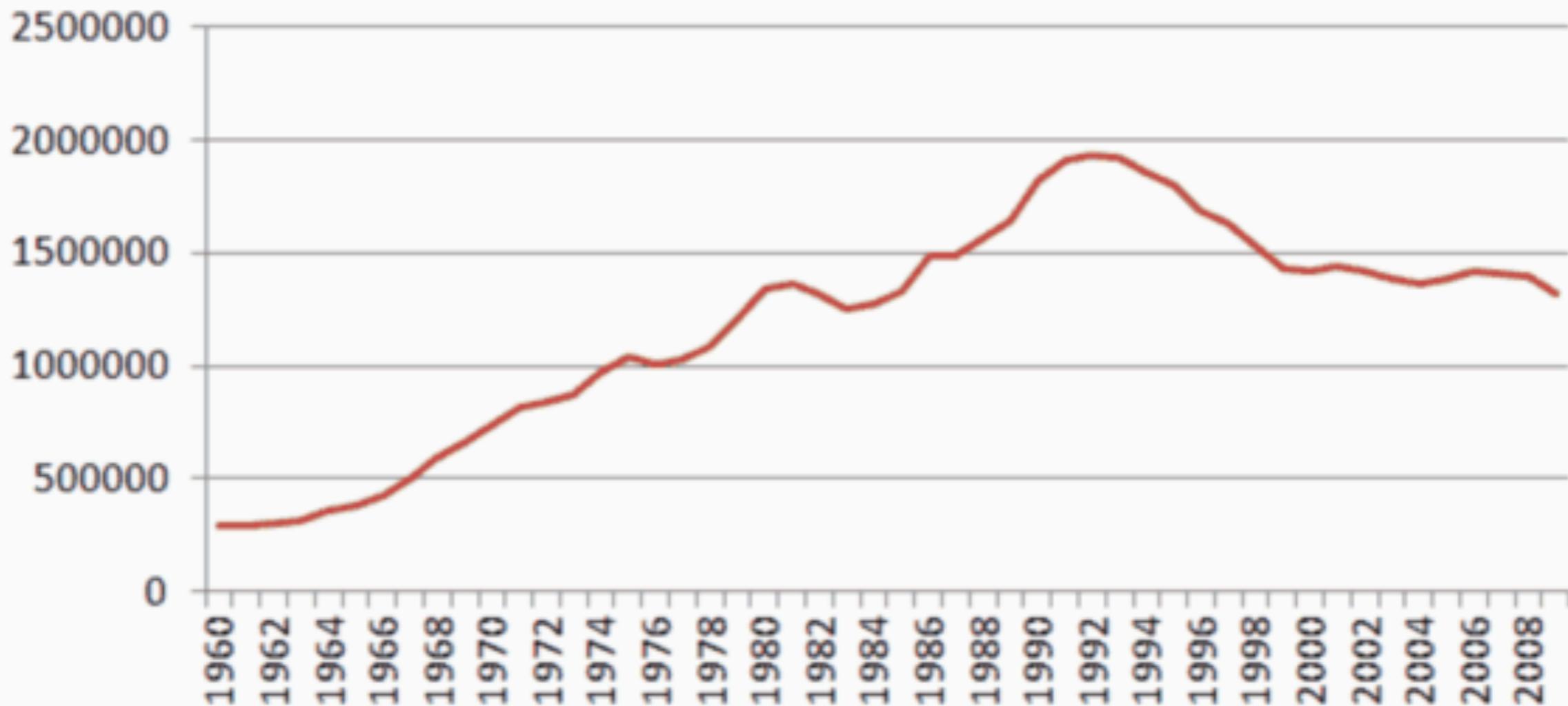
Initial improvements did not work because the important features to customers had nothing to do with taste.

Adding features does not mean adding value

Improvements:

- To-go milkshake kiosks and prepaid cards
- More viscous milkshakes that take longer to drink
- Small pieces of fruit for a more interesting sip

United States-Total Violent Crime 1960 - 2009



from: FBI - Uniform Crime Reporting Statistics

EXPLANATIONS

A.

- Tighter gun laws
- A surging economy
- More capital punishment

B.

- More police officers
- More people sent to prison
- The decline of the crack-cocaine market

EXPLANATIONS

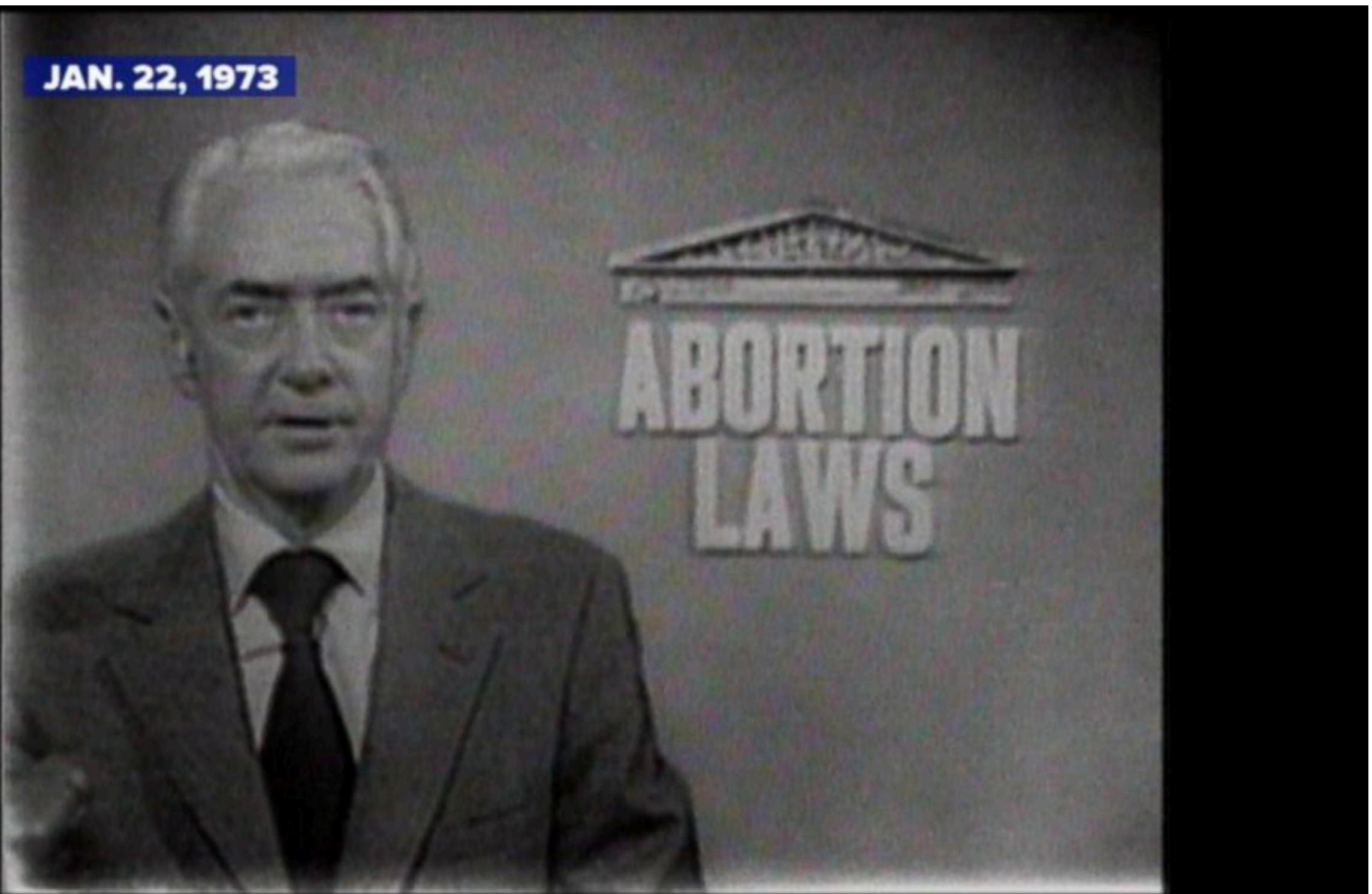
A.

- Tighter gun laws
- A surging economy
- More capital punishment

B.

- More police officers
- More people sent to prison
- The decline of the crack-cocaine market

FINDING THE ROOT CAUSE



AVOIDING PROBLEM DEFINITION PITFALLS

Think critically about the question you pose.

- Is the question interesting?
- Have you considered alternative hypotheses?
- Have you tried to re-formulate the problem?
- Have you looked at more data?

ANALYSES

Chocolate with high Cocoa content as a weight-loss accelerator

ORIGINAL

Abstract

Background: Although the focus of scientific studies on the beneficial properties of chocolate with a high cocoa content has increased in recent years, studies determining its importance for weight regulation, in particular within the context of a controlled dietary measure, have rarely been conducted.

Methodology: In a study consisting of several weeks, we divided men and women between the ages of 19-67 into three groups. One group was instructed to keep a low-carb diet and to consume an additional daily serving of 42 grams of chocolate with 81% cocoa content (chocolate group). Another group was instructed to follow the same low-carb diet as the chocolate group, but without the chocolate intervention (low-carb group). In addition, we asked a third group to eat at their own discretion, with unrestricted choice of food. At the beginning of the study, all participants received extensive medical advice and were thoroughly briefed on their respective diet. At the beginning and the end of the study, each participant gave a blood sample. Their weight, BMI, and waist-to-hip ratio were determined and noted. In addition to that, we evaluated the Giessen Subjective Complaints List. During the study, participants were encouraged to weigh themselves on a daily basis, assess the quality of their sleep as well as their mental state, and to use urine test strips.

Result: Subjects of the chocolate intervention group experienced the easiest and most successful weight loss. Even though the measurable effect of this diet occurred with a delay, the weight reduction of this group exceeded the results of the low-carb group by 10% after only three weeks ($p = 0.04$). While the weight cycling effect already occurred after a few weeks in the low-carb group, with resulting weight gain in the last fifth of the observation period, the chocolate group experienced a steady increase in weight loss. This is confirmed by the evaluation of the ketone reduction. Initially, ke-

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Diana Koch¹,
Peter Homm¹,
Alexander Driehaus¹

¹ Institute of Diet and Health, Poststr. 37.
55126 Mainz, GERMANY

Contact information:

 johannes@instituteofdiet.com.

tone reduction was much lower in the chocolate group than in the low-carb peer group, but after a few weeks, the situation changed. The low-carb group had a lower ketone reduction than in the previous period, they reduced 145 mg/dl less ketones, whereas the chocolate group had an average reduction of an additional 145mg/dl. Effects were similarly favorable concerning cholesterol levels, triglyceride levels, and LDL cholesterol levels of the chocolate group. Moreover, the subjects of the chocolate group found a significant improvement in their well-being (physically and mentally). The controlled improvement compared to the results of the low-carb group was highly significant ($p < 0.001$).

Conclusion: Consumption of chocolate with a high cocoa content can significantly increase the success of weight-loss diets. The weight-loss effect of this diet occurs with a certain delay. Long-term weight loss, however, seems to occur easier and more successfully by adding chocolate. The effect of the chocolate, the so-called "weight loss turbo," seems to go hand in hand with personal well-being, which was significantly higher than in the control groups.

Introduction

Although there has been an increased focus on the beneficial properties of high cocoa content chocolate in recent years, there are still very few studies concerning its use in weight-loss diets.

A large number of studies have proven the positive health effects of chocolate on the coronary vasculature [1], insulin secretion [2, 3, 4] and endothelial function [5, 6]. Additionally, the lowering effects of dark chocolate on high blood pressure have already been well documented. [7, 8] Moreover, in a systematic review, Ried et al. were able to prove its health benefits and antihypertensive effect. [9]

In terms of nutritional interventions, there have been interesting first attempts with the use of chocolate. In 2012, Golomb et al. showed a connection between regular chocolate consumption and a lower body mass index. [10] However, this study was limited to the mere collection and analysis of

chocolate consumption and a possible connection to the BMI.

Moreover, recent research approaches suggest that the selective use of high cocoa content chocolate can also support active weight loss. A long-term study with mice shows that even with a high-fat diet combined with high cocoa content chocolate, the weight of laboratory mice remains low. [11] A similar study with humans has not been published yet.

Methodology

Study Design

The study is based on the evaluated results of three parallel groups that underwent various dietary interventions in January 2015. They were under medical supervision and were examined at the beginning,

No change



+



We used facebook to recruit subjects around Frankfurt, offering 150 Euros to anyone willing to go on a diet for 3 weeks. On a cold January morning, 5 men and 11 women showed up, aged 19 to 67.

After a round of questionnaires and blood tests to ensure that no one had eating disorders, diabetes, or other illnesses that might endanger them, we randomly assigned the subjects to one of three diet groups.

Participants weighed themselves each morning for 21 days, and the study finished with a final round of questionnaires and blood tests.

Both of the treatment groups lost about 5 pounds over the course of the study, while the control group's average body weight fluctuated up and down around zero.

But the people on the low-carb diet plus chocolate? They lost weight 10 percent faster. Not only was that difference statistically significant, but the chocolate group had better cholesterol readings and higher scores on the well-being survey.

If you measure a **large number of things** about a **small number of people**, you are almost guaranteed to get a “statistically significant” result.

The study included **18 different measurements**—weight, cholesterol, sodium, blood protein levels, sleep quality, well-being, etc.—**from 15 people**. (One subject was dropped.)

That study design is a recipe for false positives.



14 Snarky Tweets That Sum Up The IPL Finale

Boss, Kangana Ranaut Rejected The Fairness Cream Ad Nearly Two Years Ago

Excellent News: Chocolate Can Help You Lose Weight!

ANI

Posted: 31/03/2015 16:21 IST | Updated: 31/03/2015 16:21 IST



4

8

1

[f Share](#) [Tweet](#) [Comment](#)

A new research has revealed that chocolate can aid weight loss when combined with a low-carb diet.

Johannes Bohannon, research director of the nonprofit Institute of Diet and Health, said that what is important is the specific combination of foods in your diet when trying to shed those extra pounds, the Daily Express reported.

Bohannon added that just lowering the proportion of carbohydrates is not a reliable



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Scientists say eating chocolate can help you lose weight

10.6K 34

Monday, March 30, 2015

Adding chocolate to a diet led to the "easiest and most successful weight loss", scientists said.



P-HACKING

Hack Your Way To Scientific Glory

You're a social scientist with a hunch: **The U.S. economy is affected by whether Republicans or Democrats are in office.** Try to show that a connection exists, using real data going back to 1948. For your results to be publishable in an academic journal, you'll need to prove that they are "statistically significant" by achieving a low enough p-value.

1 CHOOSE A POLITICAL PARTY

Republicans Democrats

2 DEFINE TERMS

Which politicians do you want to include?

Presidents
 Governors
 Senators
 Representatives

How do you want to measure economic performance?

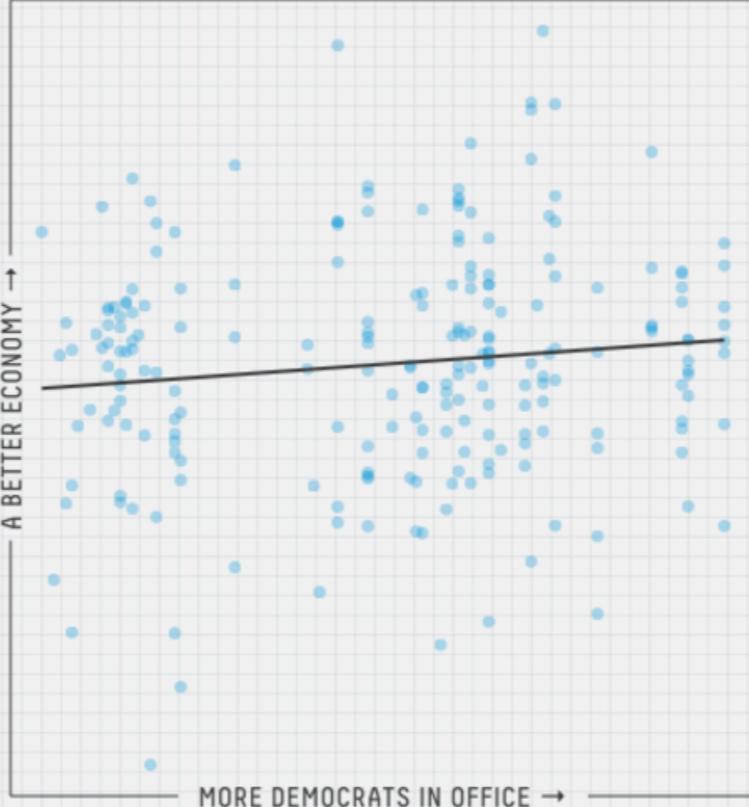
Employment
 Inflation
 GDP
 Stock prices

Other options

Factor in power
Weight more powerful positions more heavily
 Exclude recessions
Don't include economic recessions

3 IS THERE A RELATIONSHIP?

Given how you've defined your terms, does the economy do better, worse or about the same when more Democrats are in office? Each dot below represents one month of data.



4 IS YOUR RESULT SIGNIFICANT?

If there were no connection between the economy and politics, what is the probability that you'd get results at least as strong as yours? That probability is your p-value, and by convention, you need a p-value of 0.05 or less to get published.



Result: Almost

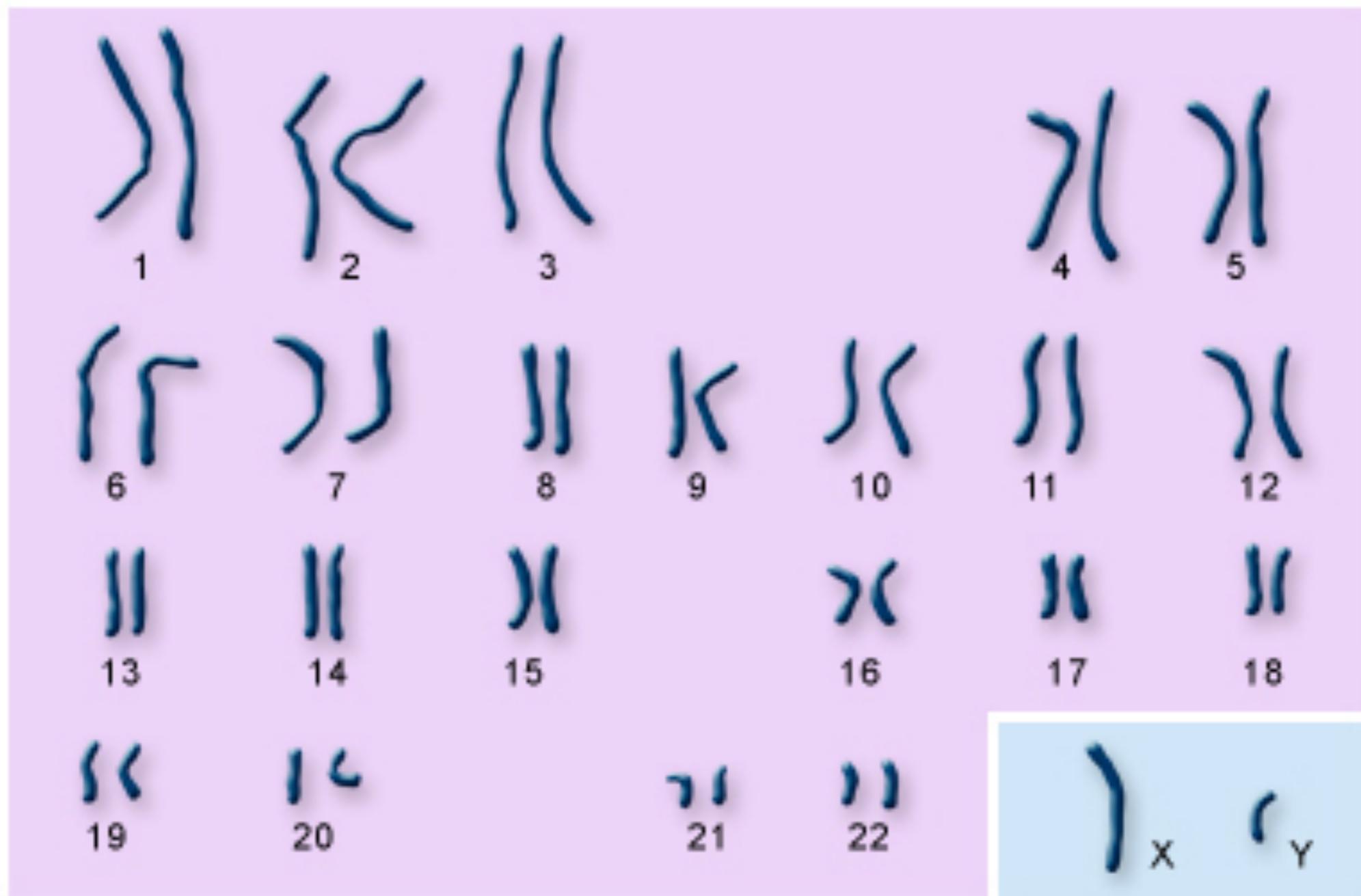
Your **0.08 p-value** is close to the 0.05 threshold. Try tweaking your variables to see if you can push it over the line!

If you're interested in reading real (and more rigorous) studies on the connection between politics and the economy, see the work of Larry Bartels and Alan Binder and Mark Watson.

Data from The @unitedstates Project, National Governors Association, Bureau of Labor Statistics, Federal Reserve Bank of St. Louis and Yahoo Finance.

<https://fivethirtyeight.com/features/science-isnt-broken/#part1>

HOW MANY CHROMOSOMES?



autosomes

sex chromosomes

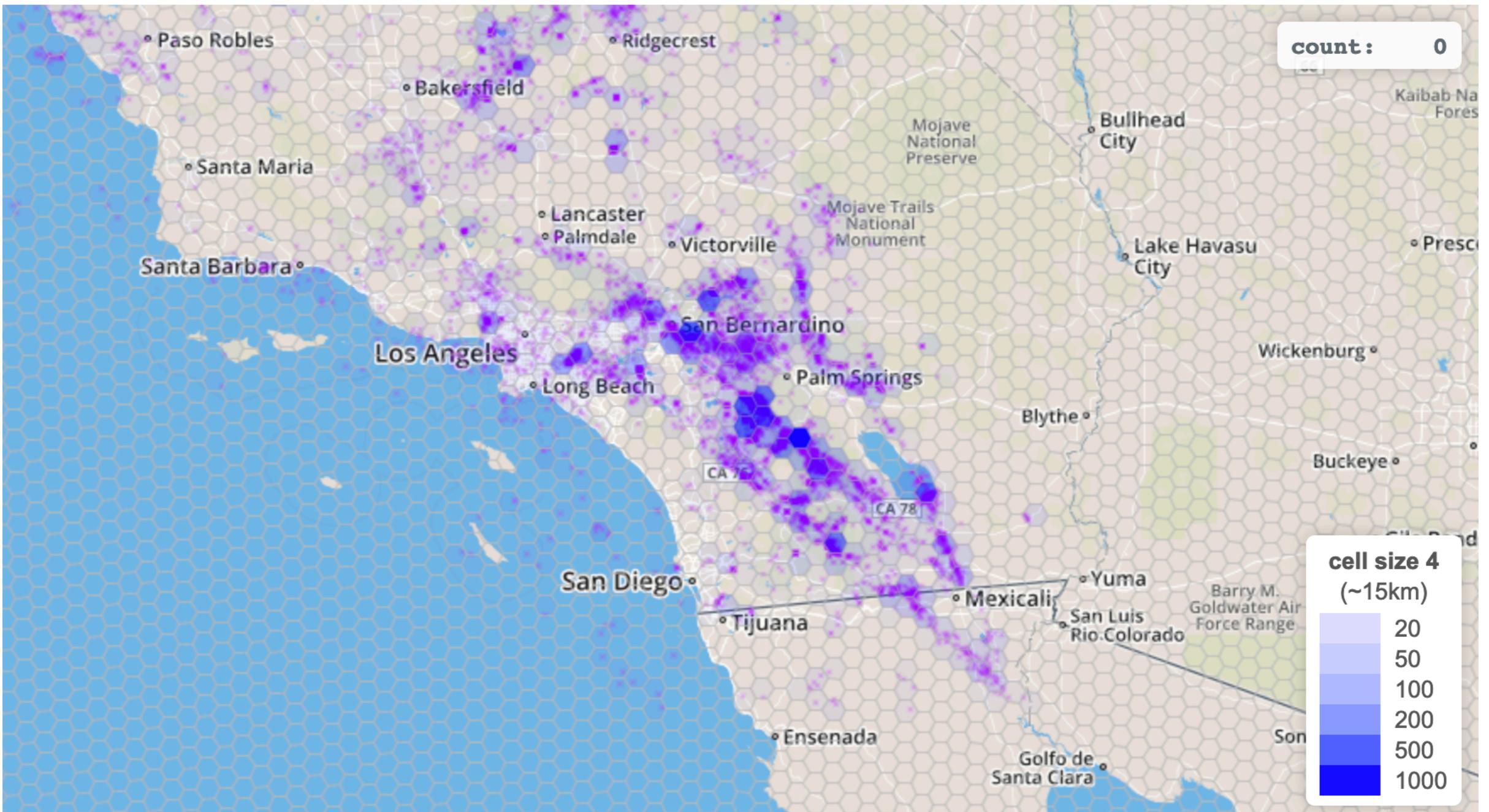
AVOIDING ANALYSIS PITFALLS

Think critically about the analyses you perform.

- Beware of not cherry-picking “interesting” results
- Beware of confirmatory bias and arguments of authority
- Different analyses may yield different results
(more about this next week...)
- Reference all of your sources, explain all of your methods

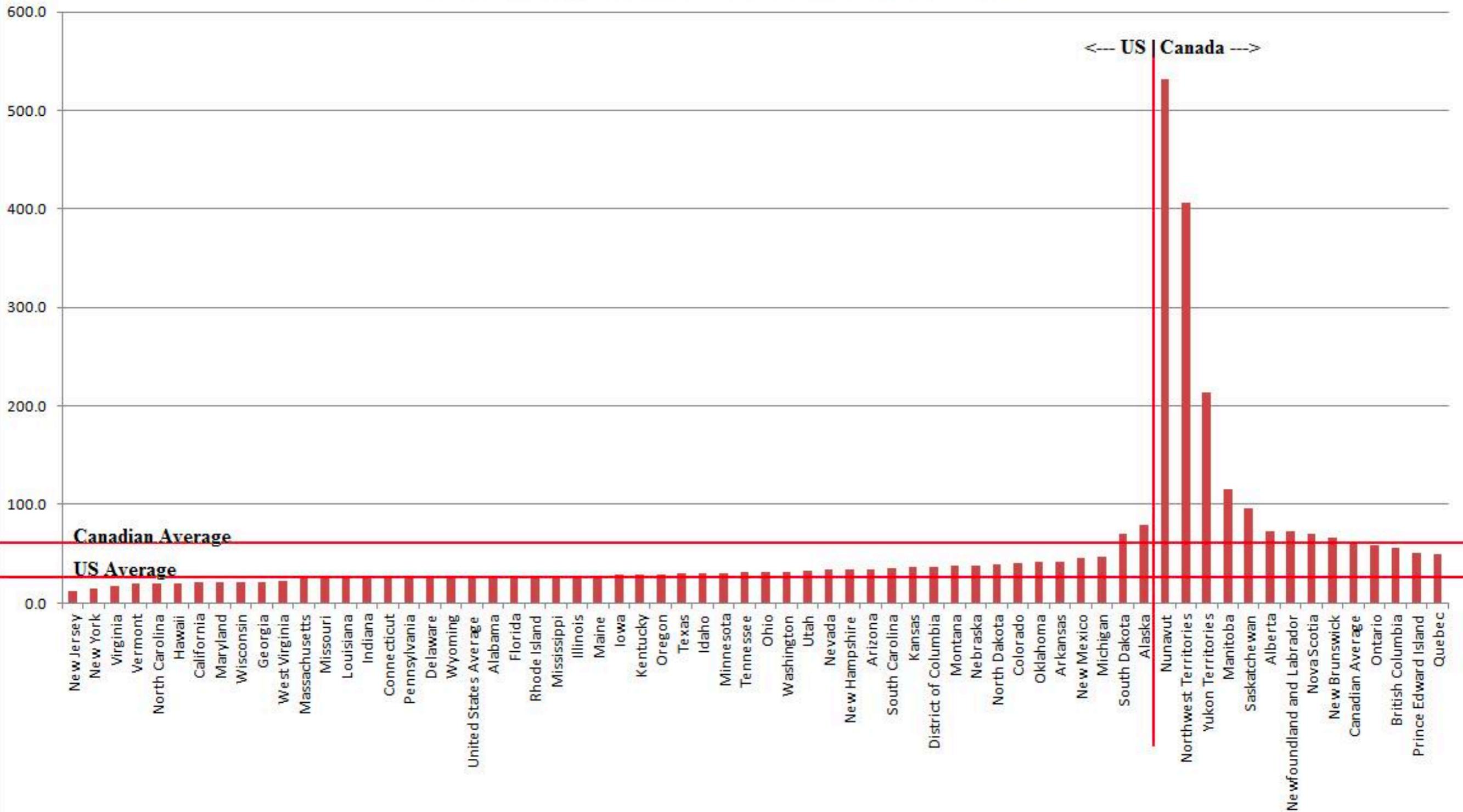
COMMUNICATION

SPATIAL AGGREGATION



<https://tinlizzie.org/spatial/>

Forcible Rape Rate per 100K in US and Canada



U.S. data source: US Crime Stats, including state by state forcible rape statistics

Canada data source: Canadian Crime Stats including Sexual Assault level 1-3

“FORCIBLE RAPE”

Forcible rape, as defined in the FBI's Uniform Crime Reporting (UCR) Program, is the carnal knowledge of a female forcibly and against her will. Attempts or assaults to commit rape by force or threat of force are also included; however, **statutory rape (without force) and other sex offenses are excluded.**

The UCR Program counts one offense for each female victim of a forcible rape, attempted forcible rape, or assault with intent to rape, regardless of the victim's age. A rape by force involving a female victim and a familial offender is counted as a forcible rape and not an act of incest. All other crimes of a sexual nature are considered to be Part II offenses; as such, the UCR Program collects only arrest data for those crimes. The offense of statutory rape, in which no force is used but the female victim is under the age of consent, is included in the arrest total for the sex offenses category. Sexual attacks on males are counted as aggravated assaults or sex offenses, depending on the circumstances and the extent of any injuries.

“FORCIBLE RAPE”

The incident-based Uniform Crime Reporting (UCR2) Survey captures criminal incidents that have come to the attention of the police, which includes 4 different types of sexual offences as defined by the Criminal Code.

Sexual assault level 1 (s.271): An assault committed in circumstances of a sexual nature such that the sexual integrity of the victim is violated. Level 1 involves minor physical injuries or no injuries to the victim.

Sexual assault level 2 (s.272): Sexual assault with a weapon, threats, or causing bodily harm.

Aggravated sexual assault (level 3): Sexual assault that results in wounding, maiming, disfiguring or endangering the life of the victim.

Other sexual offences: A group of offences that are meant to primarily address incidents of sexual abuse directed at children. The Criminal Code offences included in this category are: Sexual interference (s.151), Invitation to sexual touching (s.152), Sexual exploitation (s.153), Incest (s.155), Anal intercourse (s.159), and Bestiality (s.160).

CHALLENGER SPACE SHUTTLE (1986)



Source: Space Shuttle Challenger Disaster, Wikipedia

CHALLENGER SPACE SHUTTLE (1986)



ice on the launch tower, hours before
Challenger launch

7 crew members died during the explosion

The disaster could have been avoided

- Weather forecast for Jan. 28th announced exceptionally cold morning, with temperatures close to -0.5°C
- Morton Thiokol engineers, in charge of the solid rocket booster (SRB), were concerned about low temperatures
- Engineers feared the effect of low temperature on the joint resistance

CHALLENGER SPACE SHUTTLE (1986)

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS							
	SRM No.	Erosion Depth (in.)	Cross Sectional View Perimeter Affected (deg)	Nominal Dia. (in.)	Top View Length Of Max Erosion (in.)	Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36°--66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.60	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

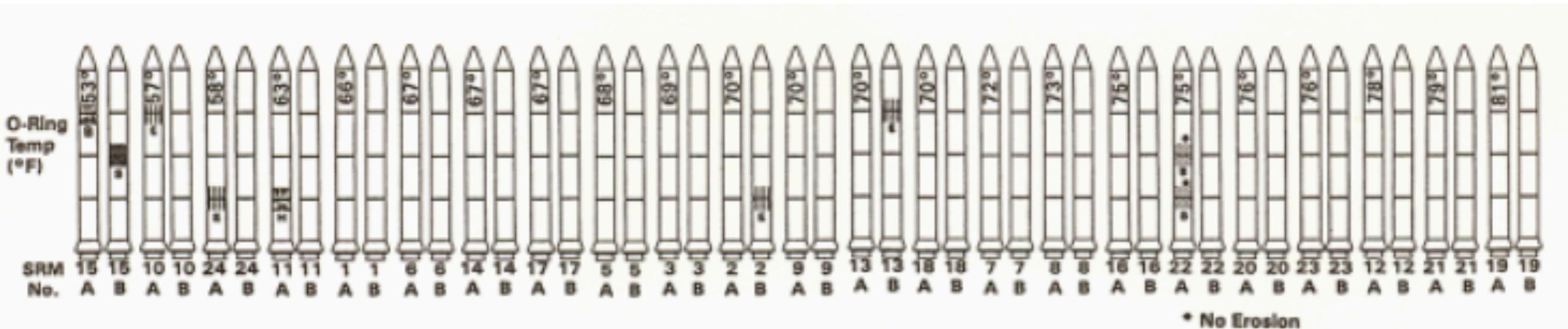
Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

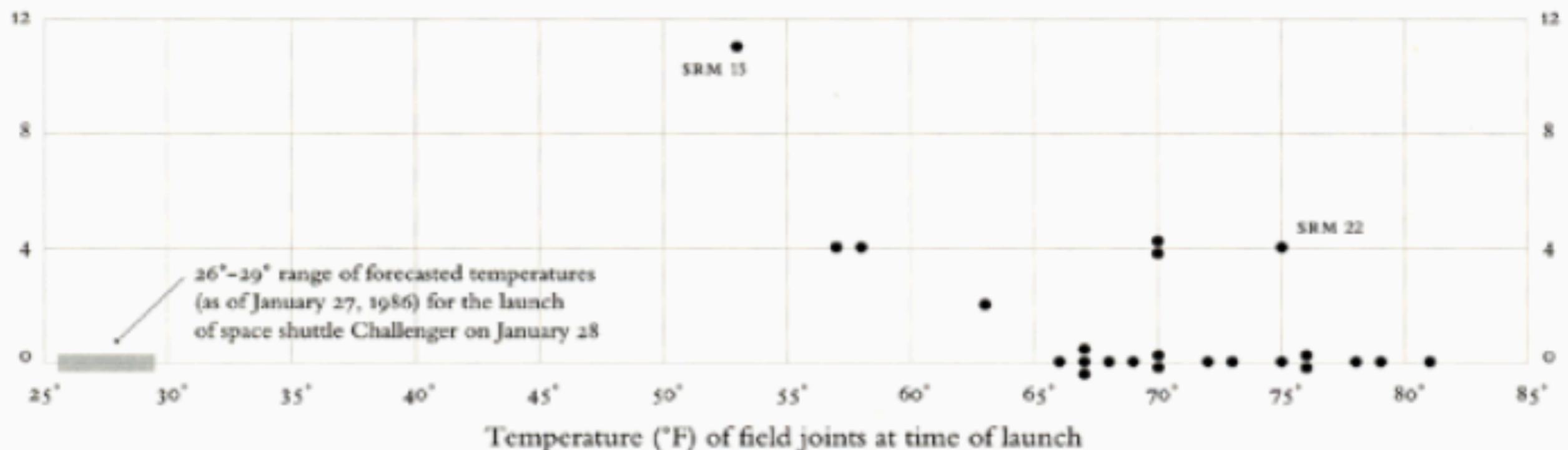
SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

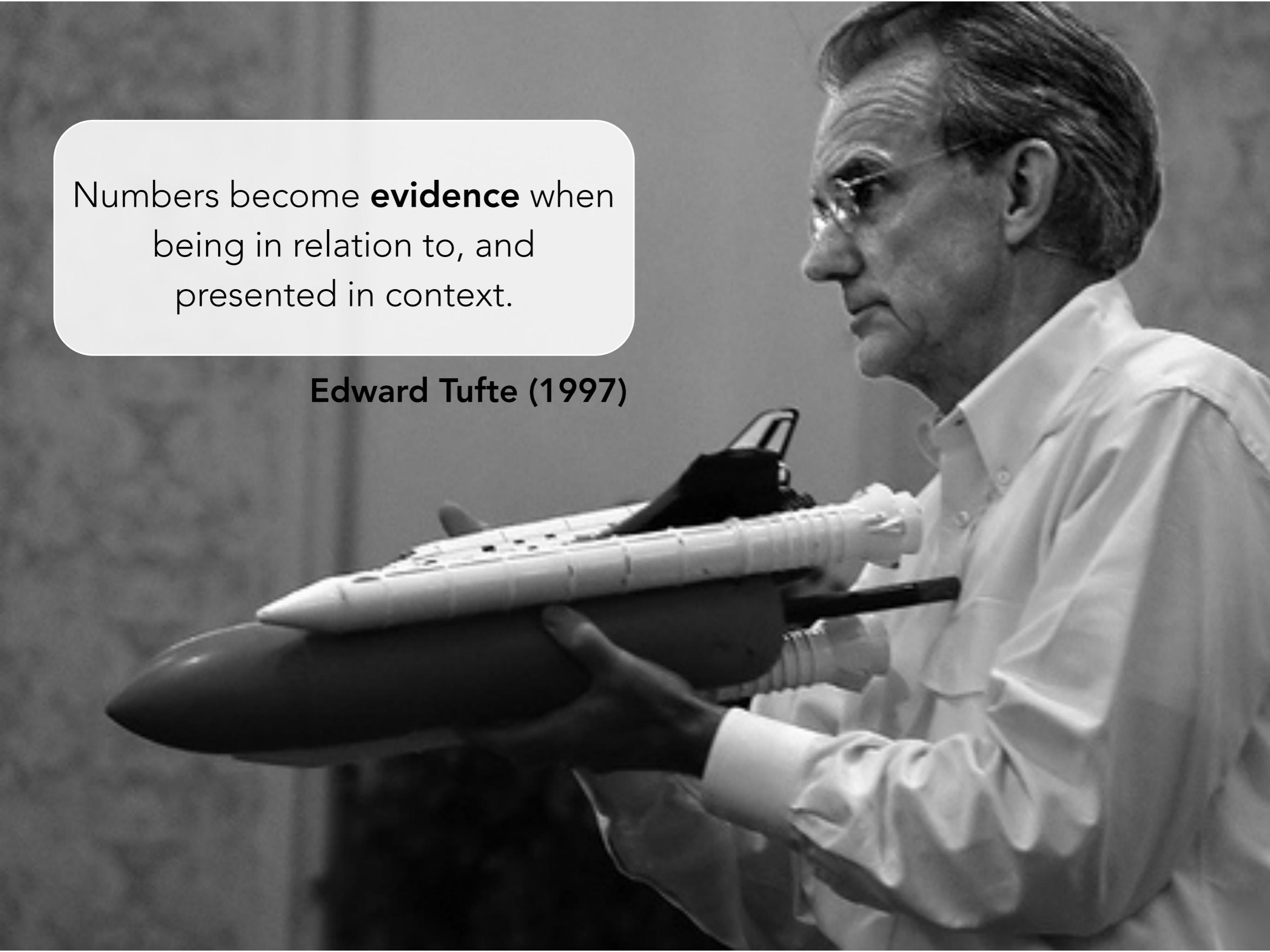
BLOW BY HISTORY	HISTORY OF O-RING TEMPERATURES (DEGREES - F)				
SRM-15 WORST BLOW-BY	MOTOR	MBT	AMB	O-RING	WIND
○ 2 CASE JOINTS (80°), (110°) ARC	DM-1	68	36	47	10 MPH
○ MUCH WORSE VISUALLY THAN SRM-22	DM-2	76	45	52	10 MPH
SRM 22 Blow-by	QM-3	72.6	40	48	10 MPH
○ 2 CASE JOINTS (30-40°)	QM-4	76	48	51	10 MPH
	SRM-15	52	64	53	10 MPH
SRM-13A, 15, 16A, 18, 23A 24A	SRM-22	77	78	75	10 MPH
○ NOZZLE Blow-by	SRM-25	55	26	29	10 MPH
				27	25 MPH

CHALLENGER SPACE SHUTTLE (1986)



O-ring damage index, each launch



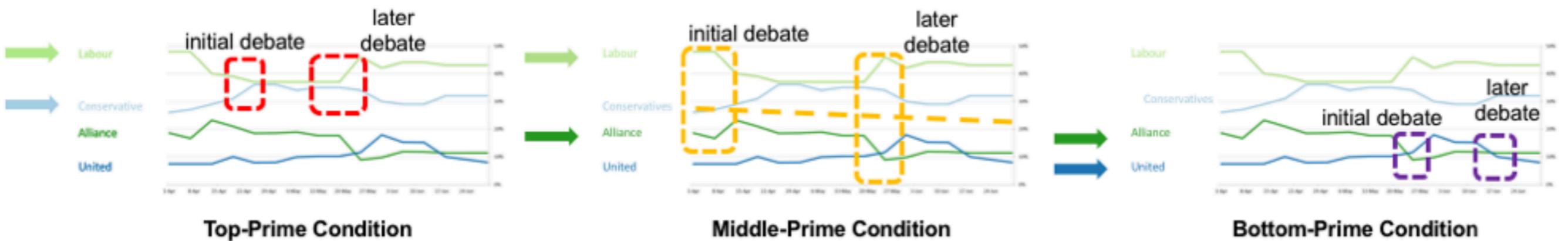


Numbers become **evidence** when
being in relation to, and
presented in context.

Edward Tufte (1997)

The Curse of Knowledge in Visual Data Communication

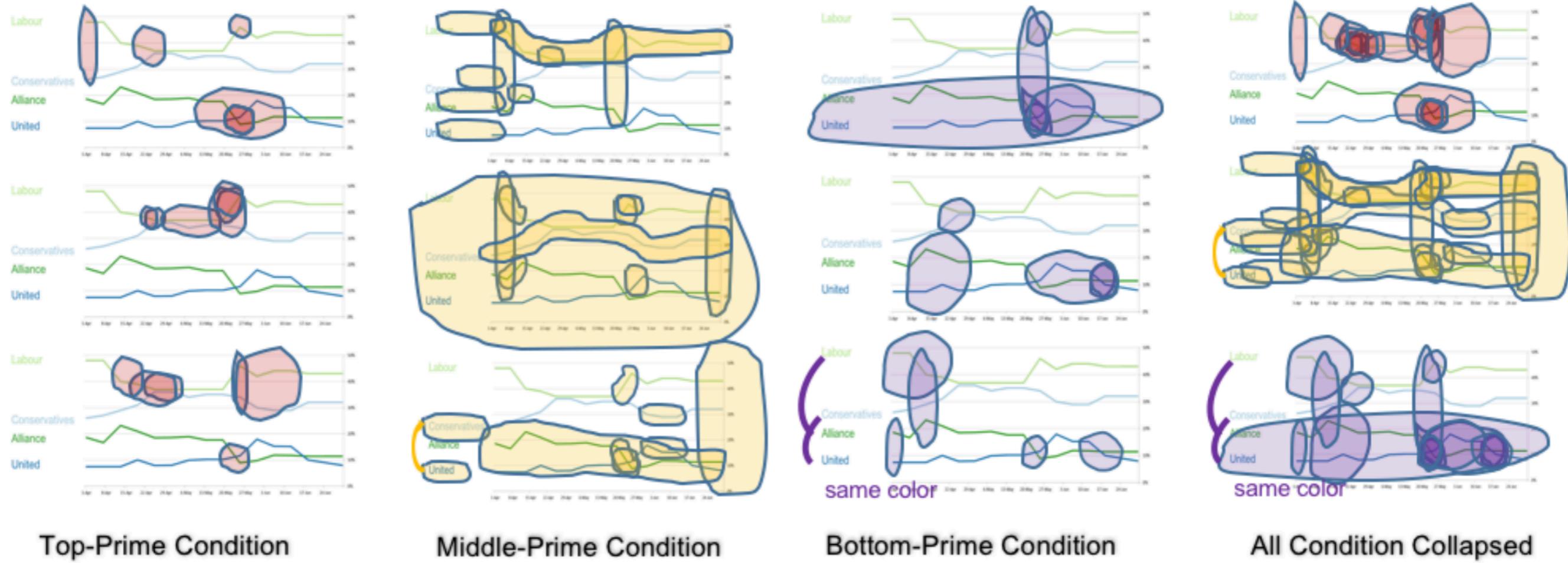
Cindy Xiong, Lisanne van Weelden, and Steven Franconeri



Top-Prime Condition

Middle-Prime Condition

Bottom-Prime Condition



Top-Prime Condition

Middle-Prime Condition

Bottom-Prime Condition

All Condition Collapsed

same color

COMMUNICATION PITFALLS

Think critically about how you present your results.

- Know your audience!
- Don't assume your audience knows what you know
- Be deliberate about the words in your narrative, and conscious about possible implications (bias) on the reader
- Be deliberate about the visual design, and conscious about possible implications (bias) on the viewer
- Reference all of your sources, explain all of your methods

**PUTTING IT ALL
TOGETHER...**

AVOIDING PITFALLS IN DATA SCIENCE

Think critically about every step of your process. Question everything:

- assess data quality and understand its limitations
- find the right problem: are you asking an interesting question? have you tried to reformulate the problem?
- is the data relevant to the question?
- don't stop your investigations, keep seeking for new data, look at the problem differently
- be deliberate about the analysis and communication methods, and understand their limitations and biases
- do you give enough details for replication and interpretation of your results? do you provide sufficient background for the targeted audience?

