Uncertainty and Review

DSC 106: Data Visualization

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UC San Diego

Announcements

Final Project Prototype due tomorrow.

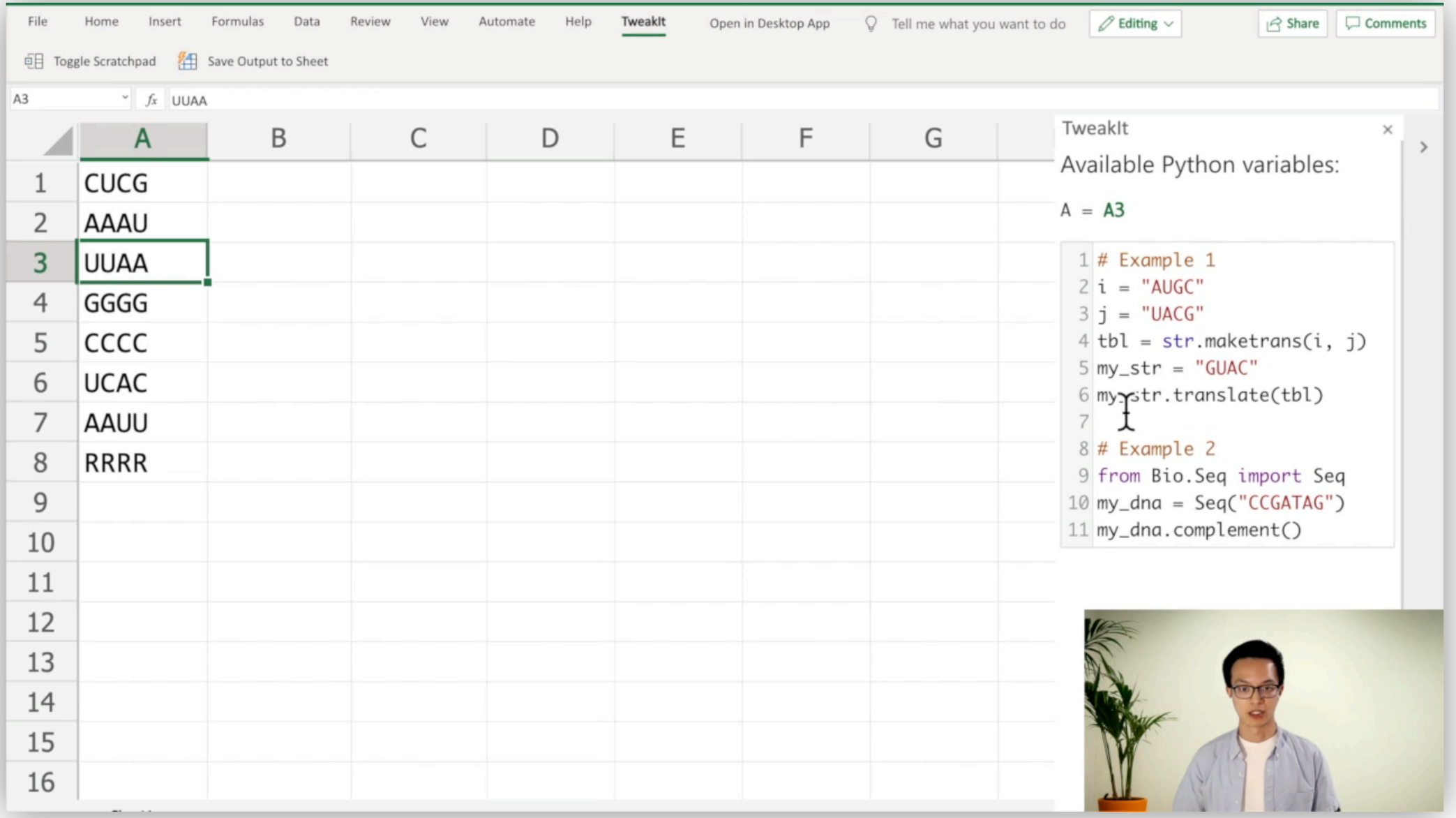
No class Wed and Fri (happy Thanksgiving!)

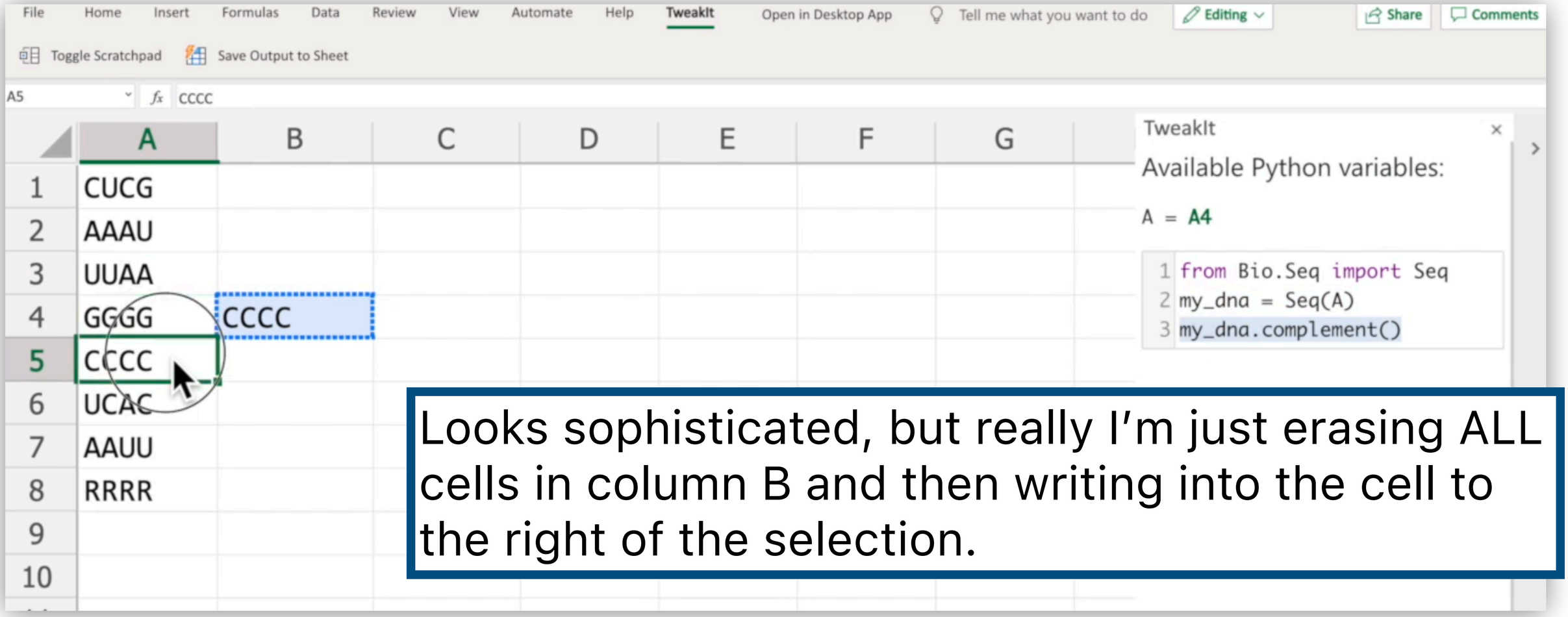
Final Project Demo Video due next week Tues

FAQs:

1. **Why is the demo video due next week (before we've even finished our final projects)?** To make your demo video, your final project doesn't need to be 100% working. Just show the 20% that is working well! We want you to start thinking seriously about your project story.

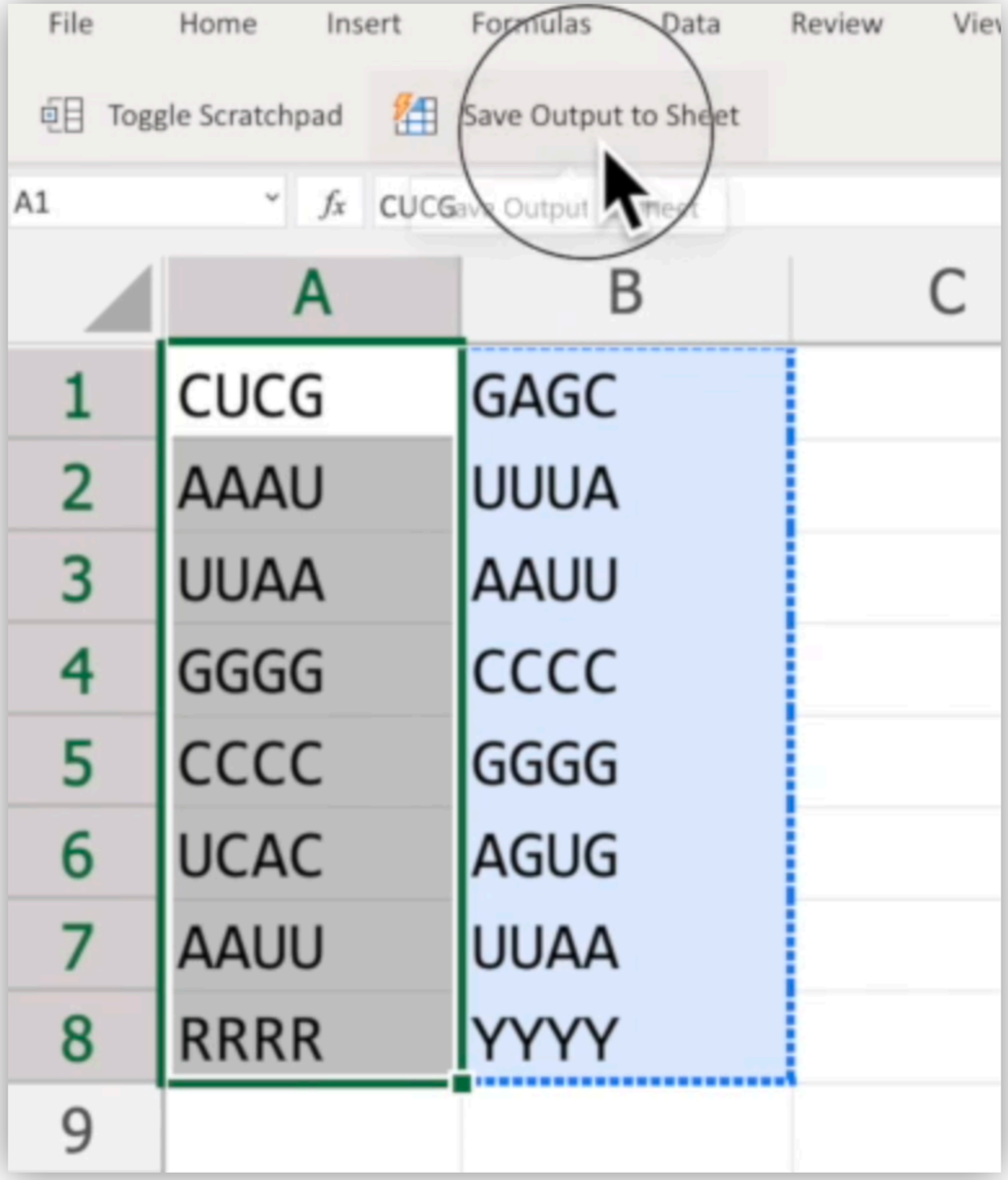
A peek behind the curtain: demo videos


File
Home
Insert
Formulas
Data
Review
View
Automate
Help
TweakIt
Open in Desktop App
Tell me what you want to do
Editing
Share
Comments
Toggle Scratchpad
Save Output to Sheet
A3
UUAA
A
B
C
D
E
F
G
1 CUCG
2 AAAU
3 UUAA
4 GGGG
5 CCCC
6 UCAC
7 AAUU
8 RRRR
TweakIt
Available Python variables:
A = A3
# Example 1
i = "AUGC"
j = "UACG"
tbl = str.maketrans(i, j)
my_str = "GUAC"
my_str.translate(tbl)
# Example 2
from Bio.Seq import Seq
my_dna = Seq("CCGATAG")
my_dna.complement()



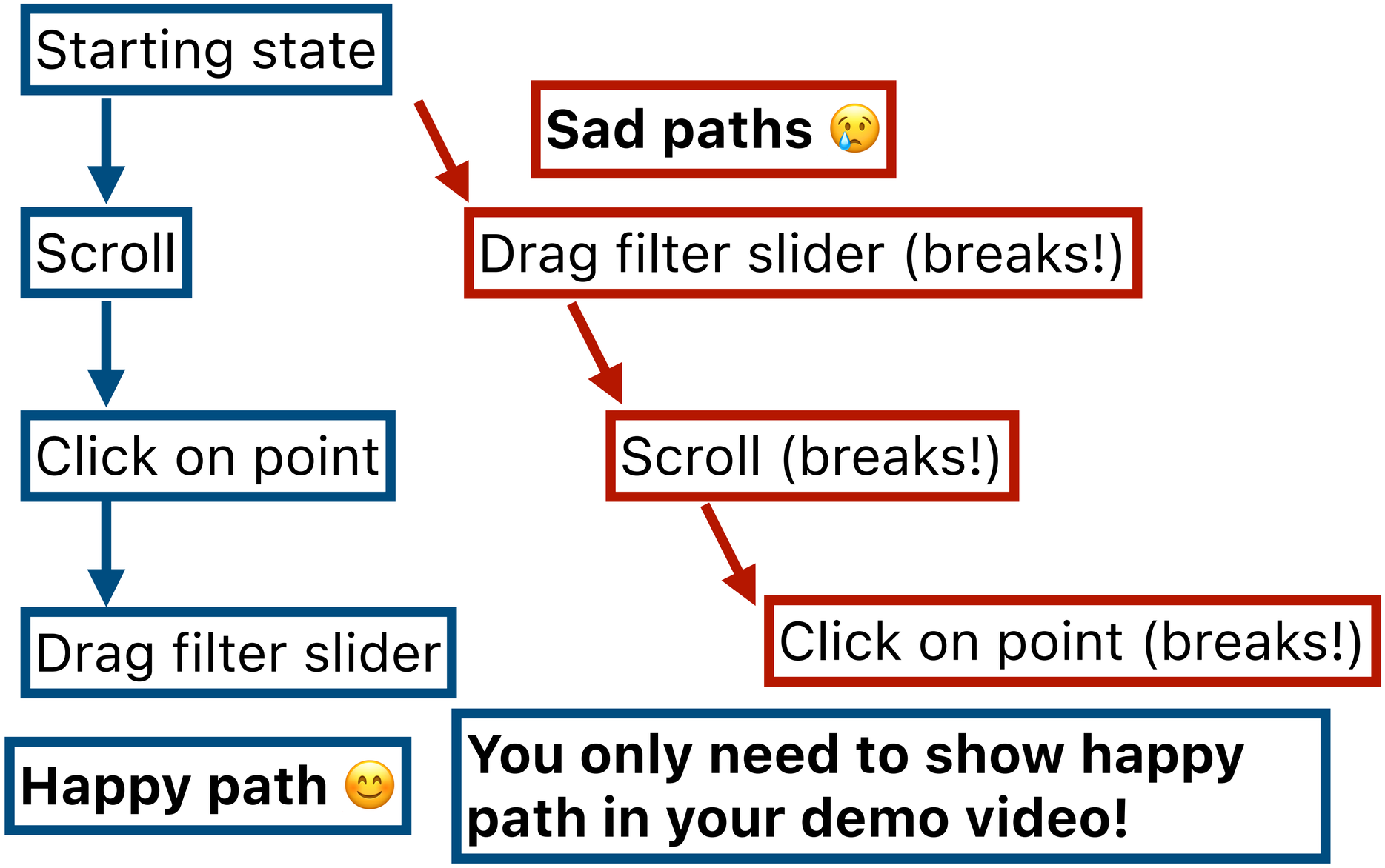
Looks sophisticated, but really I'm just erasing ALL cells in column B and then writing into the cell to the right of the selection.

If there was other data in the spreadsheet, it would be wiped out!



Clicking “Save Output” just removes the blue background from column B. (It doesn’t actually work!)

Making a cool demo video



How to ace your final project

Component	Excellent	Satisfactory	Poor
Web page URL, video URL, and Repo		The web page is publicly viewable on GitHub pages, the project video is linked (or embedded) within the web page, and the repository is publicly available. (+1 point)	The submitted web page URL, project video, or repository URL is broken. (+0 points)
Hook		The project opens with a hook – an interesting research question or attention-grabbing statement. (+1 point)	The project doesn't open with a hook (e.g. it immediately shows a visualization without explanation). (+0 points)
Storytelling	The project tells a compelling story. It follows the and-but-therefore structure and also incorporates elements of surprise, personalization, or emotion. (+3 points)	The project tells a story – it follows the and-but-therefore structure. (+2 points)	The project does not tell a story (e.g. it doesn't follow the and-but-therefore structure or something similar). (+1 point)
Visual Encodings	The project visualizations do not violate the expressiveness criteria and the design choices (marks and encoding channels) are clear, evocative, and effective. (+3 points)	The project visualizations do not violate the expressiveness criteria, but another set of design choices (marks and encoding channels) could have been more effective (e.g. using the area visual channel instead of position when possible). (+2 points)	The project visualizations violate the expressiveness criteria (e.g. heavy overplotting, encodings that imply incorrect readings, etc.), and these violations are not addressed using the available interactions (e.g. overplotting that cannot be filtered or zoomed into). (+1 point)

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Most common mistake: no video linked in webpage

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Most common mistake: straight into visualization without hook

Component			
Web page URL, video URL, and Repo			
Hook			
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Require "surprise, personalization, or emotion" for Excellent.

See Narrative lecture for ideas.

Missing and-but-therefore? Score capped at Poor!

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As always, will grade on visual encodings. Avoid overplotting, use appropriate channels, bin your colors, etc.

Interaction	The interactive elements of the project are polished, bug-free, and enable the reader to discover interesting patterns in the data or the concept being explored. (+3 points)	The interactive elements of the project are functional and enable the reader to discover interesting patterns, but a static plot (perhaps with a different encoding) could have conveyed the same information just as effectively. (+2 points)	The plot would have been substantially more effective as a static plot without the interaction; or, the interaction has major bugs that preclude use. (+1 point)
Annotations		The visualizations contain helpful	
Takeaways		takeaway and explains why your visualization demonstrates this	ends with a takeaway message but
Viewing experience		The project is easy to view: all images are clearly visible and all text is legible on a typical laptop screen size. (+1 point)	The project is difficult to view (e.g. some images and text are too small to see clearly). (+0 points)

Similar to Project 3; do we learn something new from your interactions that isn't possible without the interactions?

First question to answer is: What is interesting about your **data**? (Not: what is interesting about your interactions?)

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Annotations		The visualizations contain helpful annotations (e.g. text, coloring, shading) that draw attention to interesting findings. (+1 point)	The visualizations contain no annotations. (+0 points)
Takeaways		one thing that everyone should learn from your project? And why does your project succeed at explaining it? (+2 points)	focuses too much on the implementation of the visualization). (+1 point)
Viewing experience		The project is easy to view: all images are clearly visible and all text is legible on a typical laptop screen size. (+1 point)	The project is difficult to view (e.g. some images and text are too small to see clearly). (+0 points)

Common mistake: lots of plots, no annotations on plots themselves

Interaction	The interactive elements of the project are polished, bug-free, and enable the reader to discover interesting patterns in the data or the concept being	The interactive elements of the project are functional and enable the reader to discover interesting patterns, but a static plot (perhaps with a different encoding) could have conveyed the same information just as effectively. (+2	The plot would have been substantially more effective as a static plot without the interaction; or, the interaction has major bugs that preclude use. (+1 point)
Annotations			
Takeaways		The project ends with an interesting takeaway and explains why your visualization demonstrates this takeaway effectively. What is the one thing that everyone should learn from your project? And why does your project succeed at explaining it? (+2 points)	The project is missing a takeaway, or ends with a takeaway message but the presentation could be improved (e.g. the takeaway isn't surprising, or focuses too much on the implementation of the visualization). (+1 point)
Viewing experience		The project is easy to view: all images are clearly visible and all text is legible on a typical laptop screen size. (+1 point)	The project is difficult to view (e.g. some images and text are too small to see clearly). (+0 points)

Common mistake: takeaway that is common knowledge (e.g. "there are lots of forest fires, so we should support firefighters")

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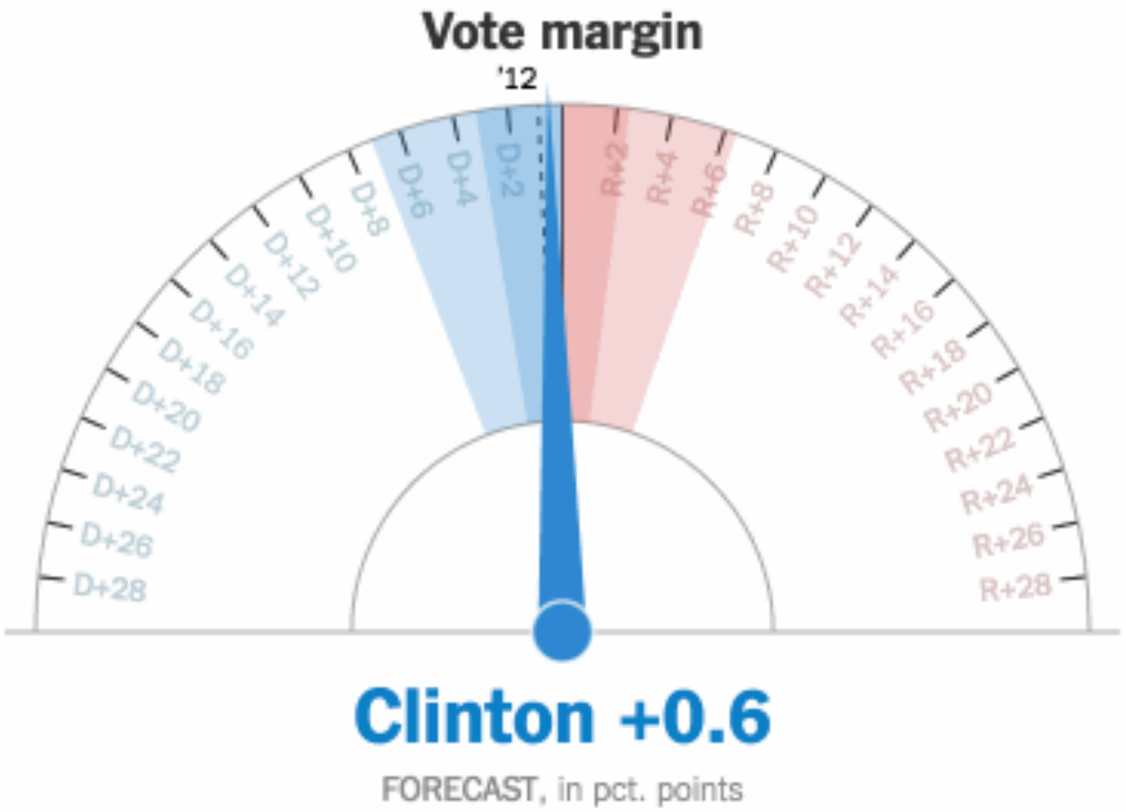
Takeaways		The project ends with an interesting takeaway and explains why your visualization demonstrates this takeaway effectively. What is the one thing that everyone should learn from your project? And why does	The project is missing a takeaway, or ends with a takeaway message but the presentation could be improved (e.g. the takeaway isn't surprising, or focuses too much on the
Viewing experience		The project is easy to view: all images are clearly visible and all text is legible on a typical laptop screen size. (+1 point)	The project is difficult to view (e.g. some images and text are too small to see clearly). (+0 points)

Common mistake: fonts too small, images blurry

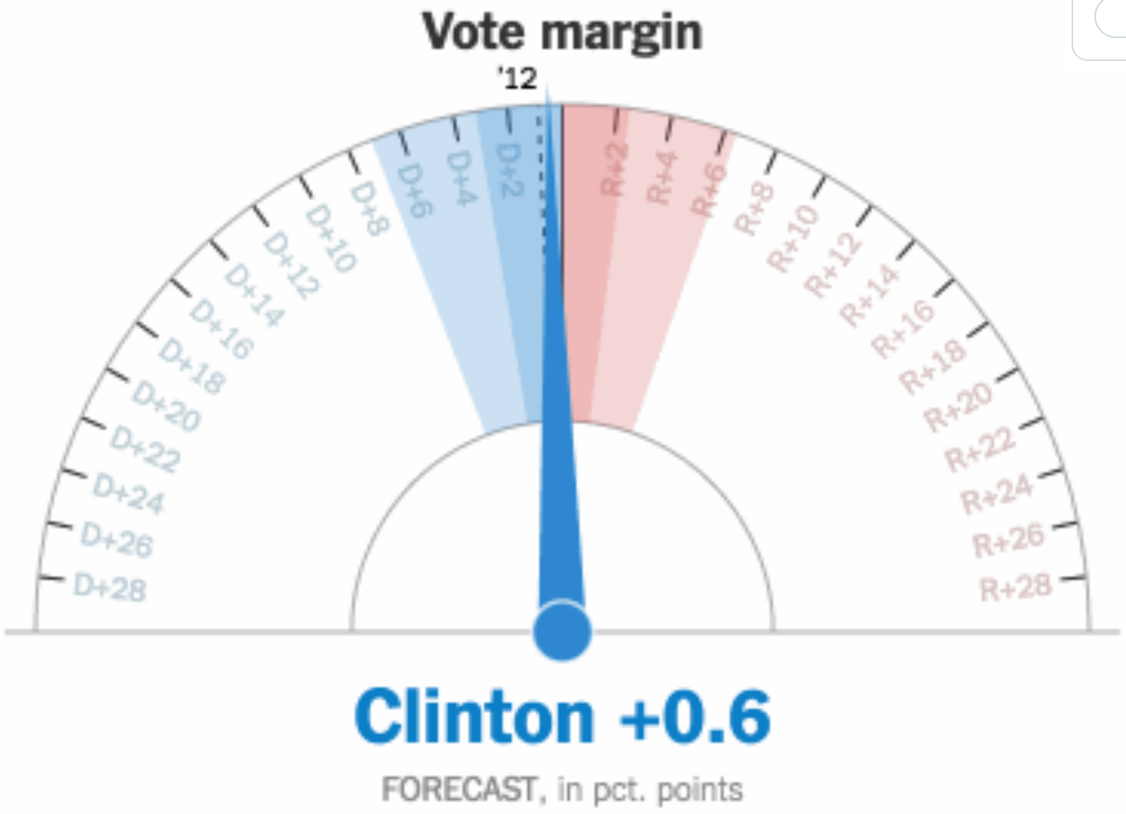
Uncertainty



What is being visualized?

What are the strengths and weaknesses of this visualization?

tryclassbuzz.com
Code: **needle**



(gobsmacked)
@nv... Follow

I'm taking
damn NY

10:08 PM ·

2

Danielle Rosen
@Daniel_Rosen · **Follow**

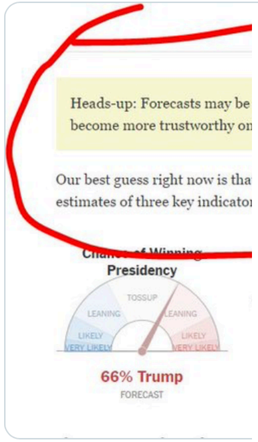
The NYT needle jittering is going to be in my nightmares no matter what happens tonight.

10:00 PM · Nov 8, 2016

2

Paul D. Shinkman
@PDShinkman · **Follow**

Has @nytimes caught on to Dems' election-night hair-greying freakout?

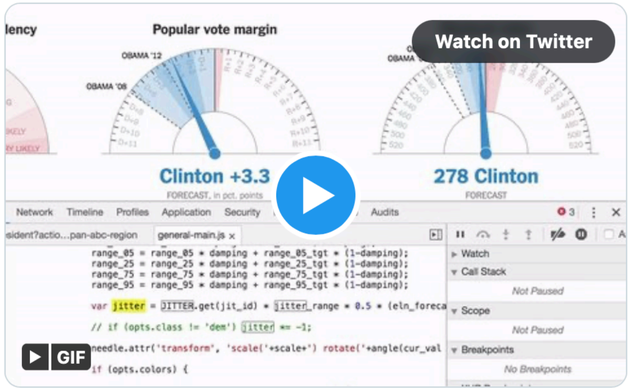


10:03 PM · Nov 8, 2016

Reply S

Alp Toker · Nov 8, 2016
@atoker · **Follow**

Looking for trends in @nytimes's presidential forecast needle? Don't look too hard - the bounce is random jitter from your PC, not live data



@gka@vis.social
@driven_by_data · **Follow**

not just random. this noise is conveying the uncertainty in our forecast (jitter range is from 25th–75th pctl in sims.)

10:01 PM · Nov 8, 2016

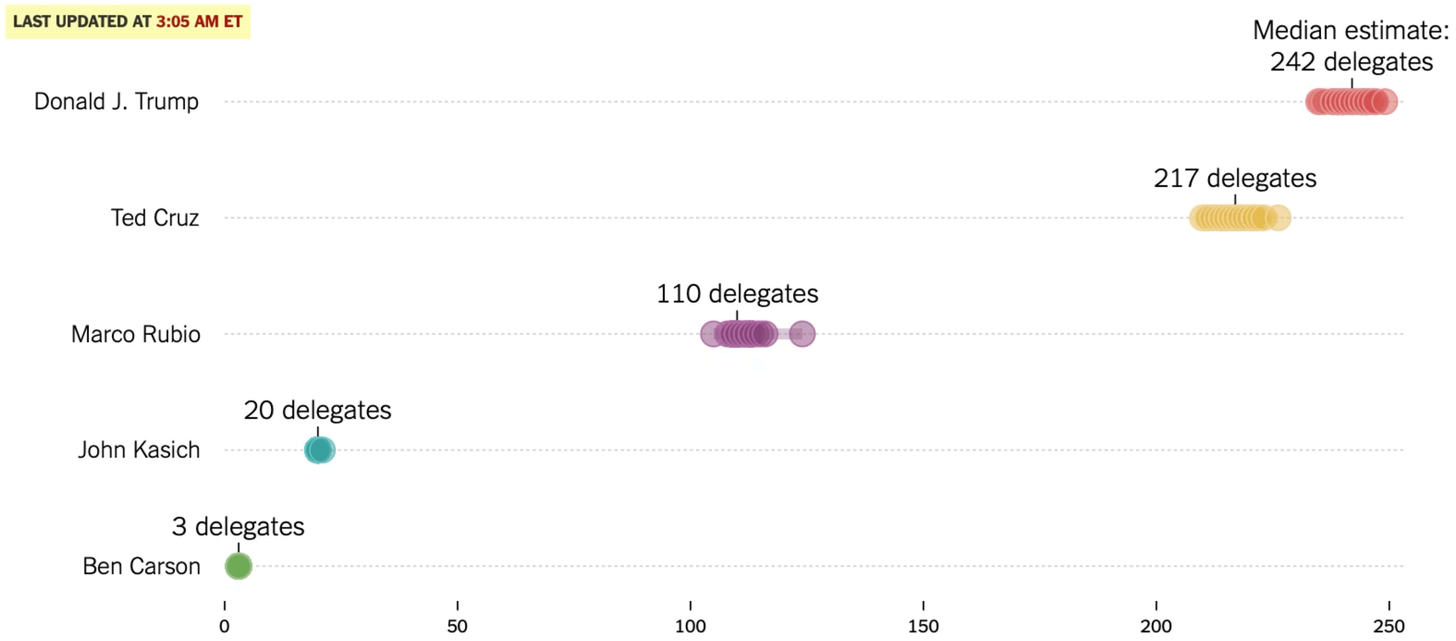
33 Reply Share

Read 5 replies

TheUpshot Live Models

Who Will Win Super Tuesday? Live Estimates of Tonight's Final Republican Delegate Count

By AMANDA COX, JOSH KATZ and KEVIN QUEALY MARCH 1, 2016



We're simulating the number of delegates each candidate will pick up on Super Tuesday. The dots above represent a range of possible outcomes.

What is being visualized?

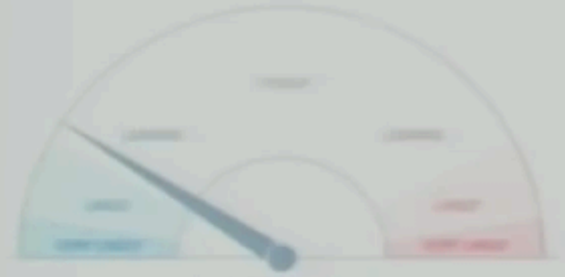
What are the strengths and weaknesses of this visualization?

How does it compare to the needle?

Live Presidential Forecast

Updated 7:55:14 PM ET

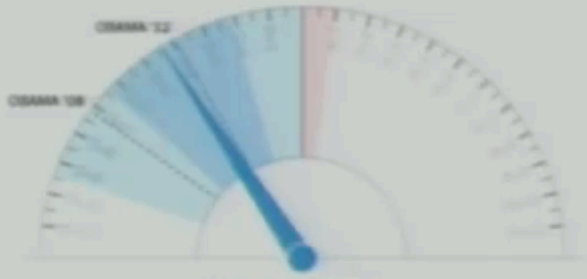
Chance of Winning Presidency



82% Clinton

FORECAST

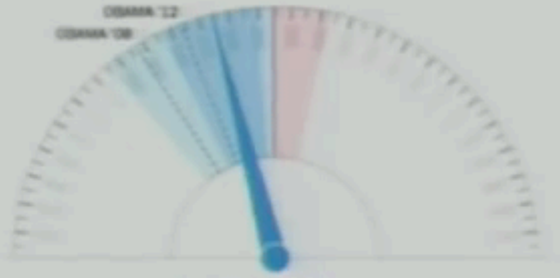
Popular vote margin



Clinton +4.4

FORECAST

Electoral votes

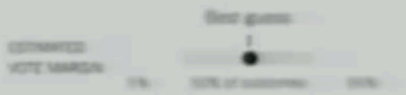


307 Clinton

FORECAST

The projections for each state are based on the votes reported so far and how those places have voted in previous elections.

We're showing the closest states by default. Show all states



State	Est. pct. of votes	Reported margin	NYT projection	NYT win prob.	15%	10%	5%	Even	+5%	+10%	+15%	+20%	+25%
Michigan	0%	–	Clinton +6.5	75% Dem.									
New Mexico	0%	–	Clinton +6.4	76% Dem.									
Wisconsin	0%	–	Clinton +5.4	75% Dem.									

OPEN VIS 2017 CONF

Uncertainty

What does it mean?

How should I visualize it?

Uncertainty

What does it mean?

How should I visualize it?

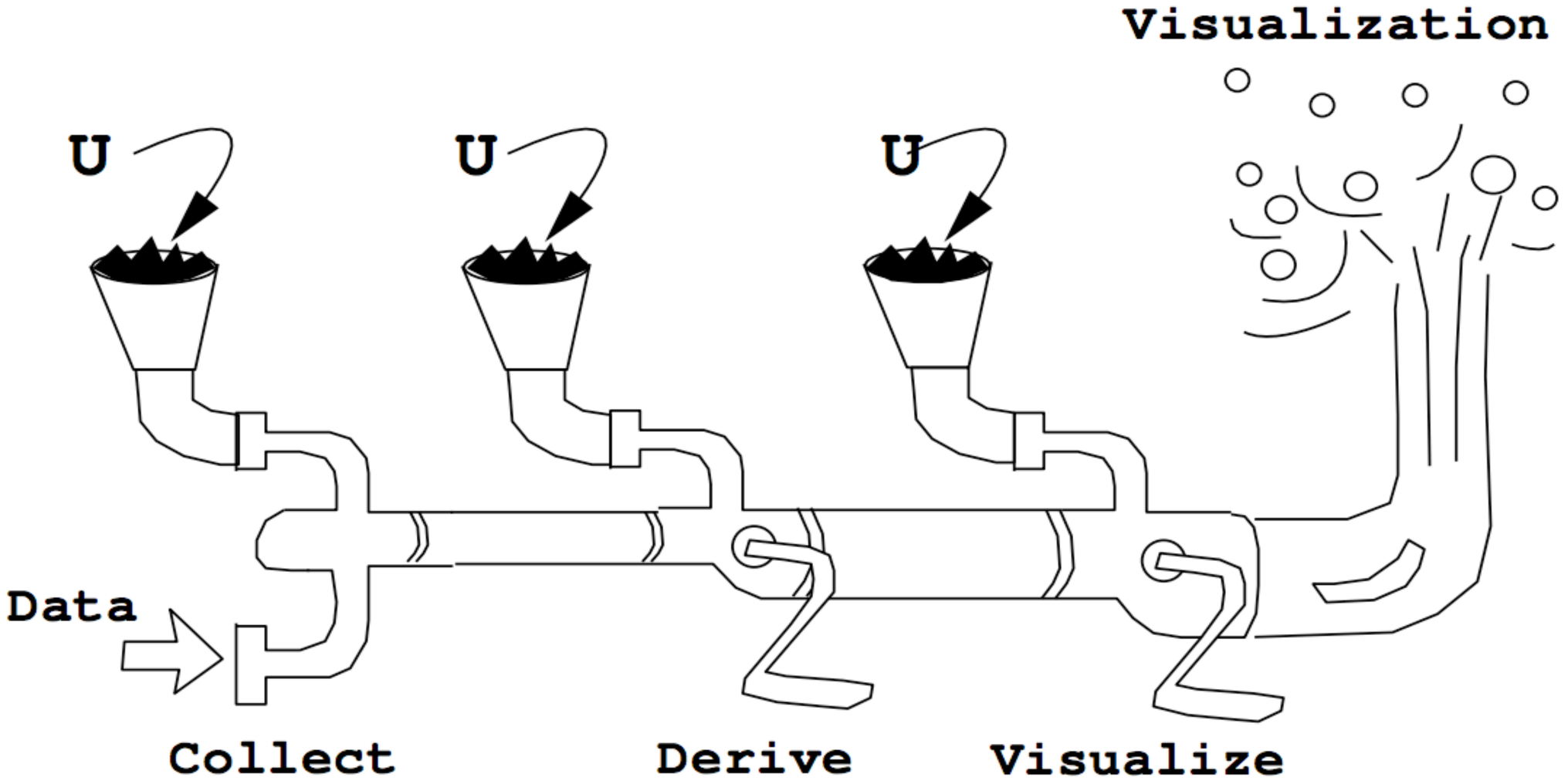
Uncertainty

What does it mean?

How should I visualize it?

Doubt
Risk
Variability
Error
Lack of knowledge
Hedging
etc...

Sources and Types of Uncertainty

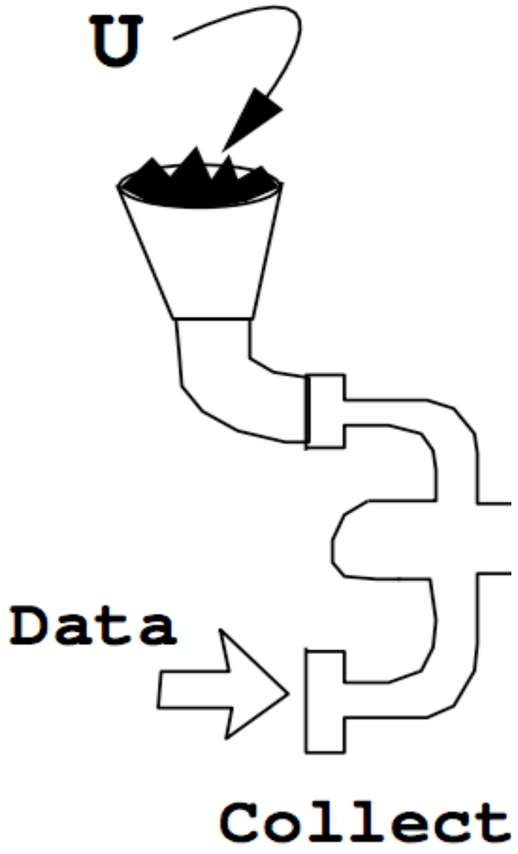


Pang, Wittenbrink, Lodha. Approaches to Uncertainty Visualization, 1997.

Sources and Types of Uncertainty

Measurement Uncertainty

How and how much should we sample the data?



Precision

Accuracy

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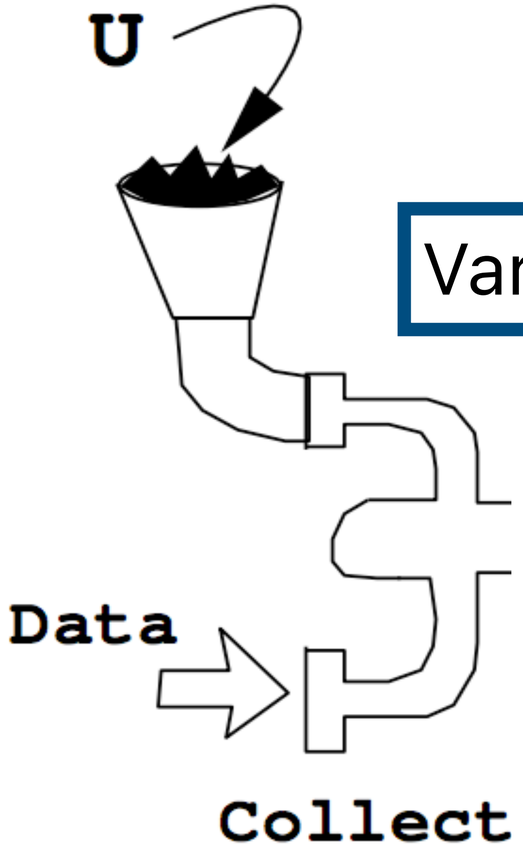
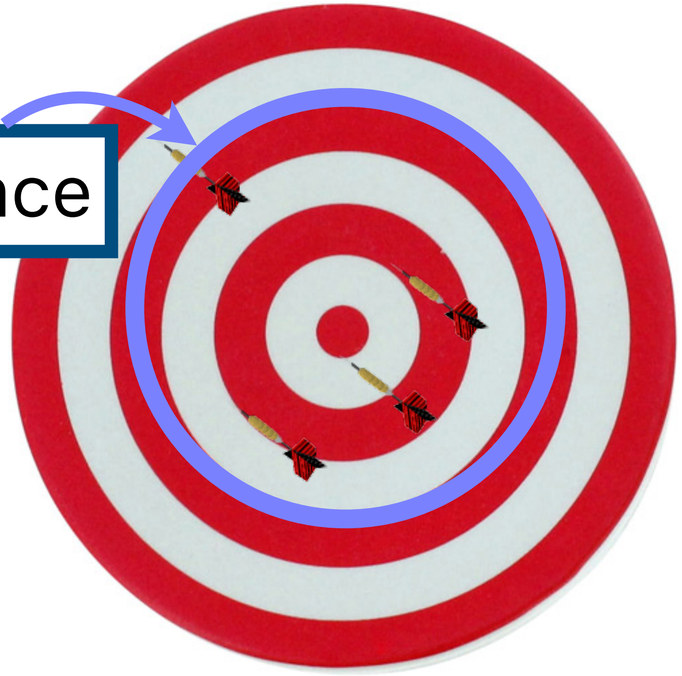
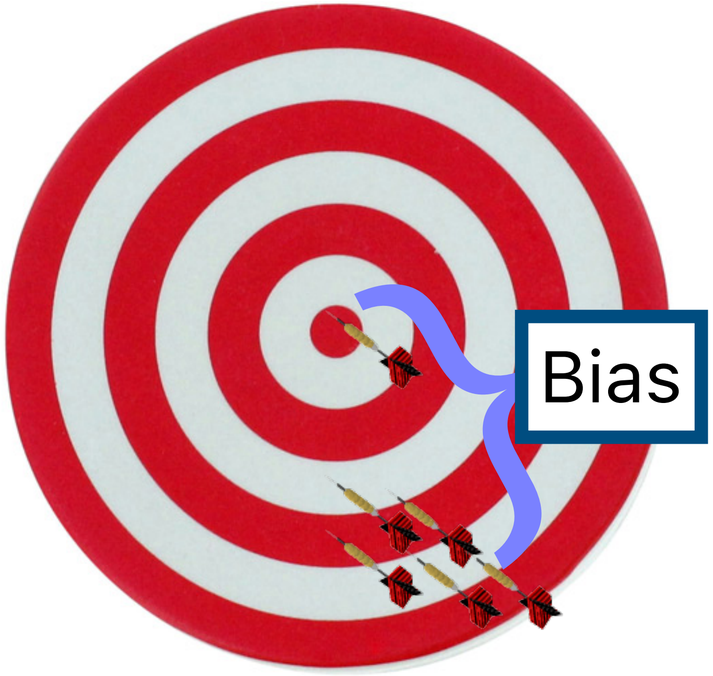




Precision



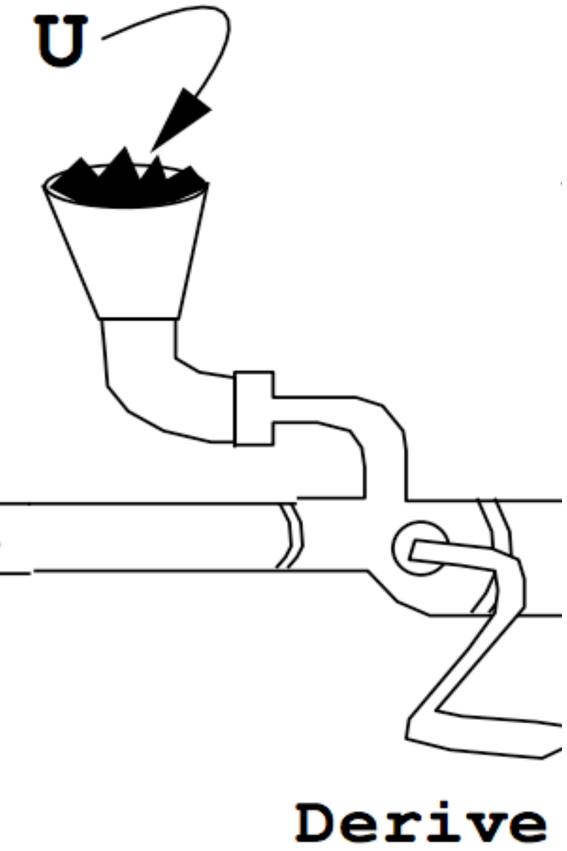
Accuracy

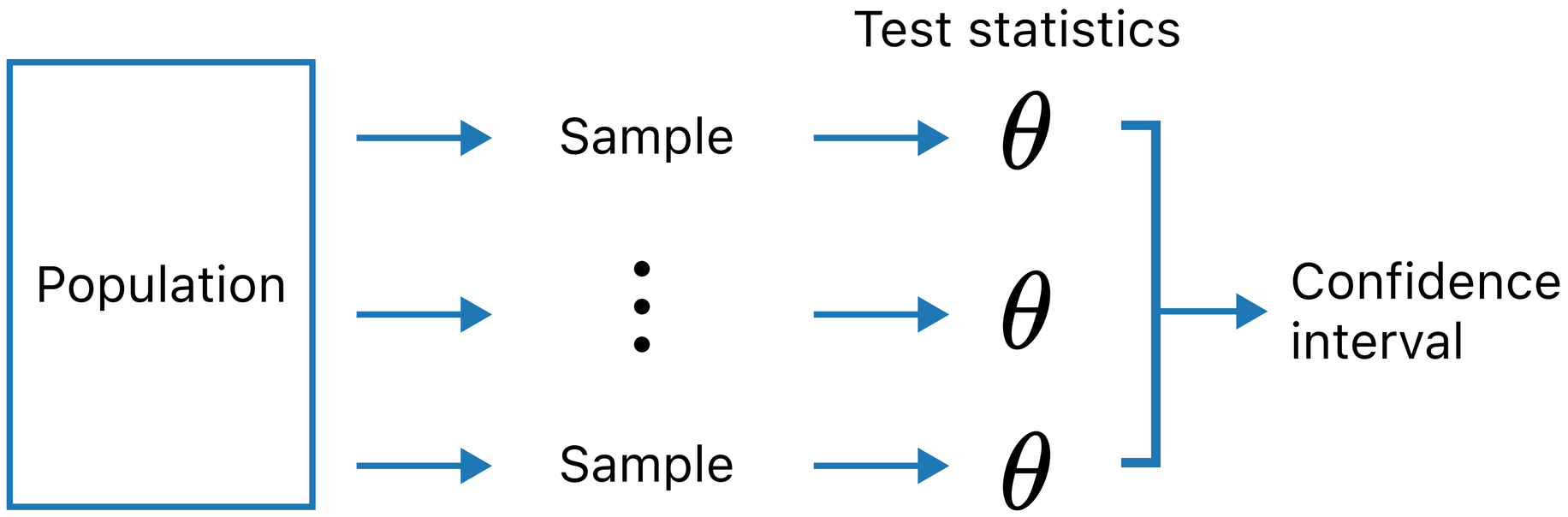
Pang, Wittenbrink, Lodha. Approaches to Uncertainty Visualization, 1997.

Sources and Types of Uncertainty

Model Uncertainty

How does the data fit together?





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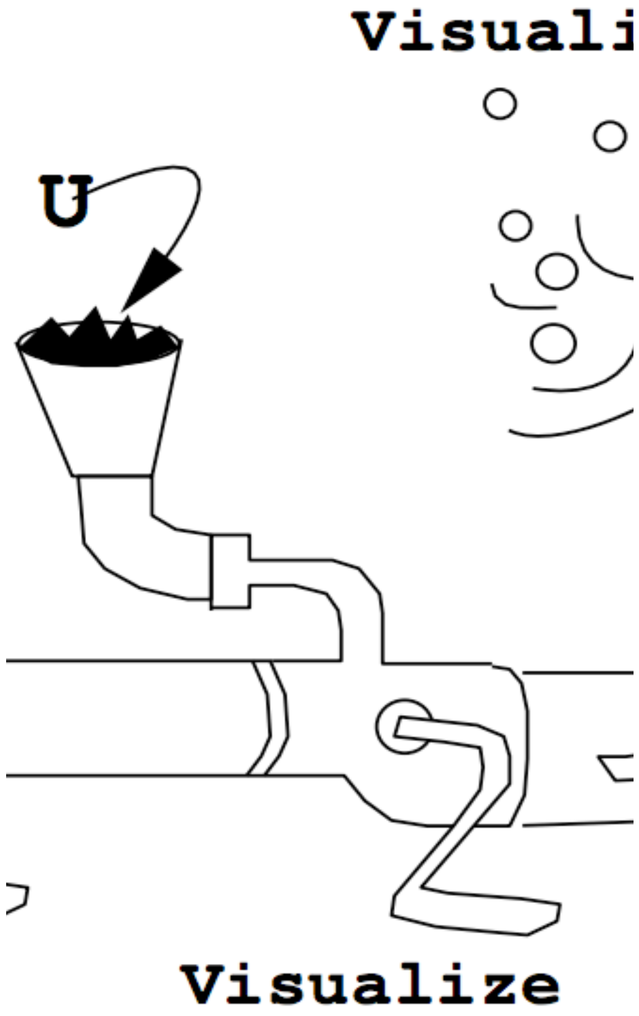
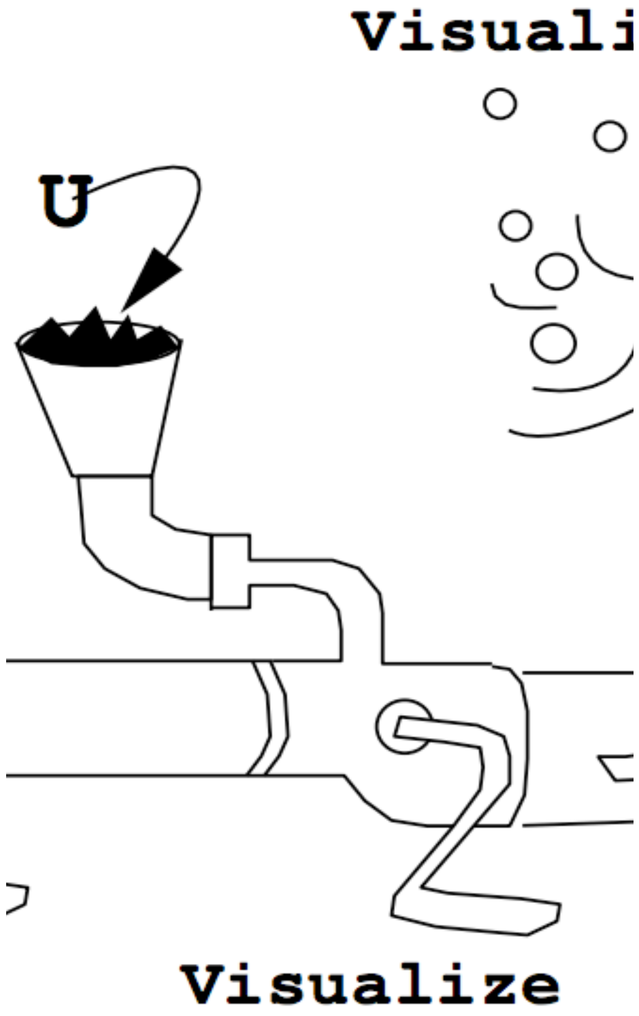


Decision/Forecast Uncertainty
How do I assess the risk or error?

Pang, Wittenbrink, Lodha. Approaches to Uncertainty Visualization, 1997.

Sources and Types of Uncertainty



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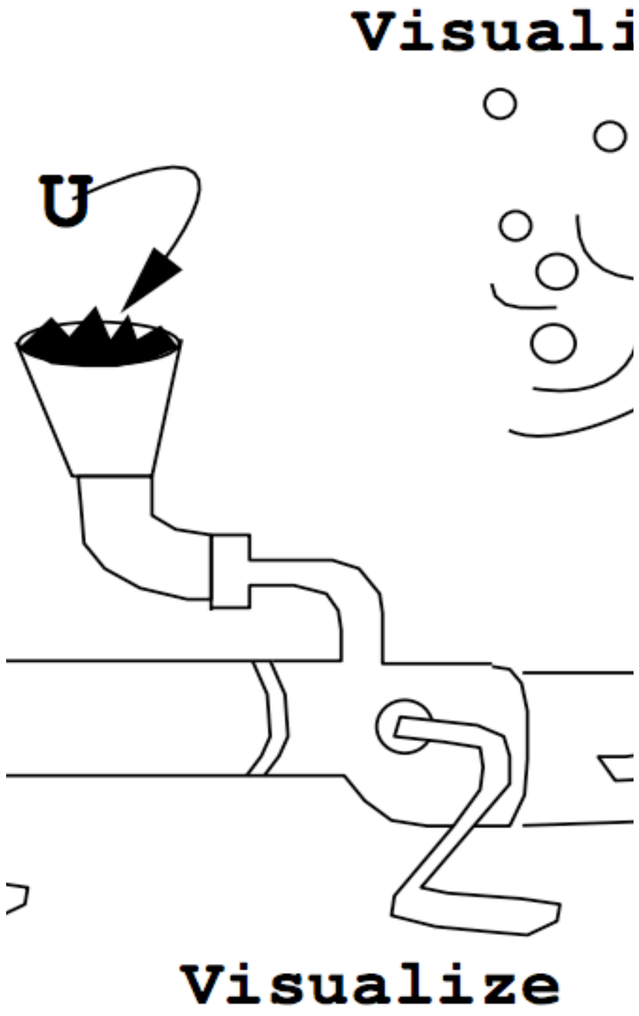

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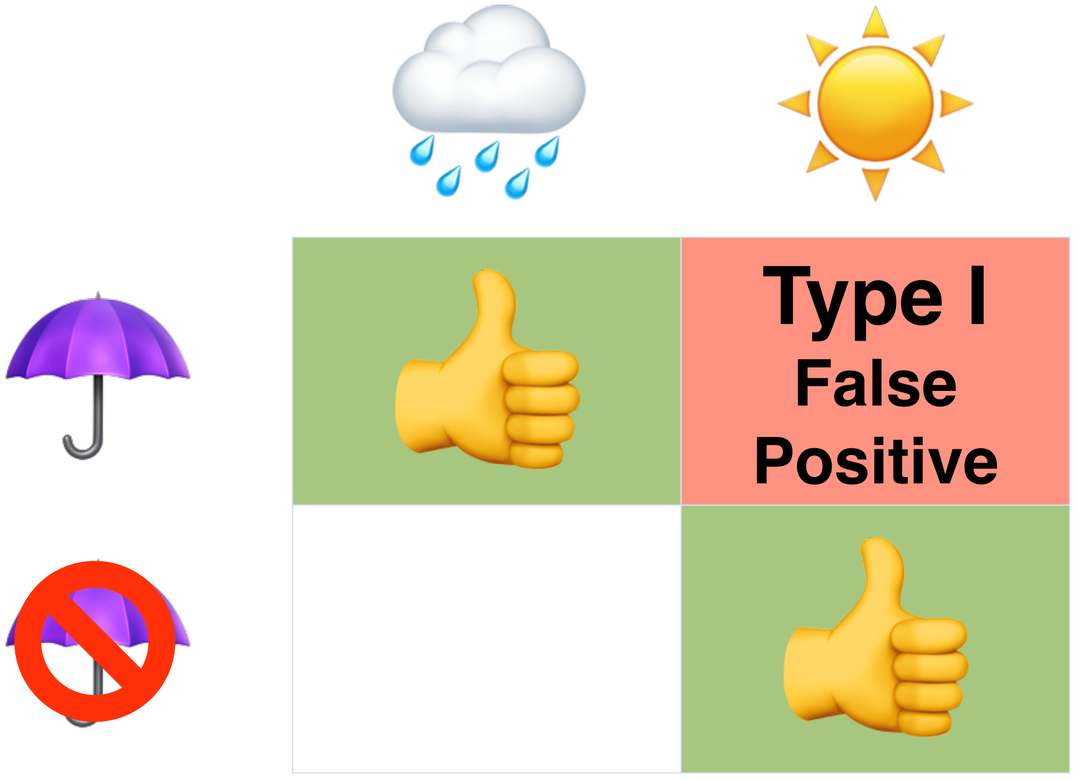

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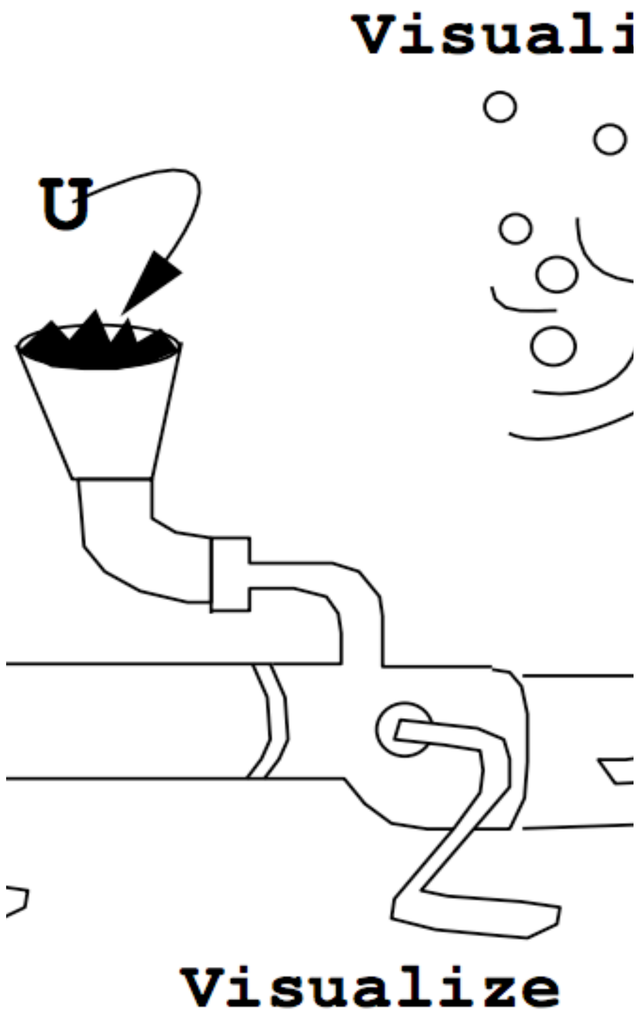

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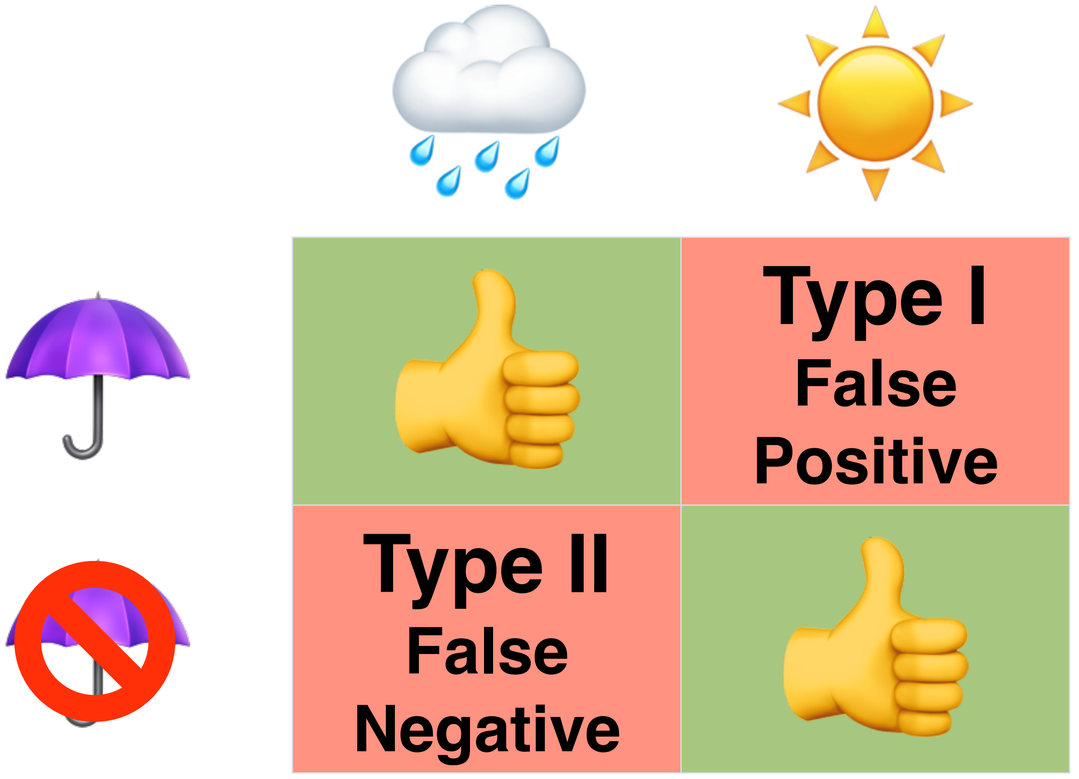


Pang, Wittenbrink, Lodha. Approaches to Uncertainty Visualization, 1997.

Uncertainty

What does it mean?

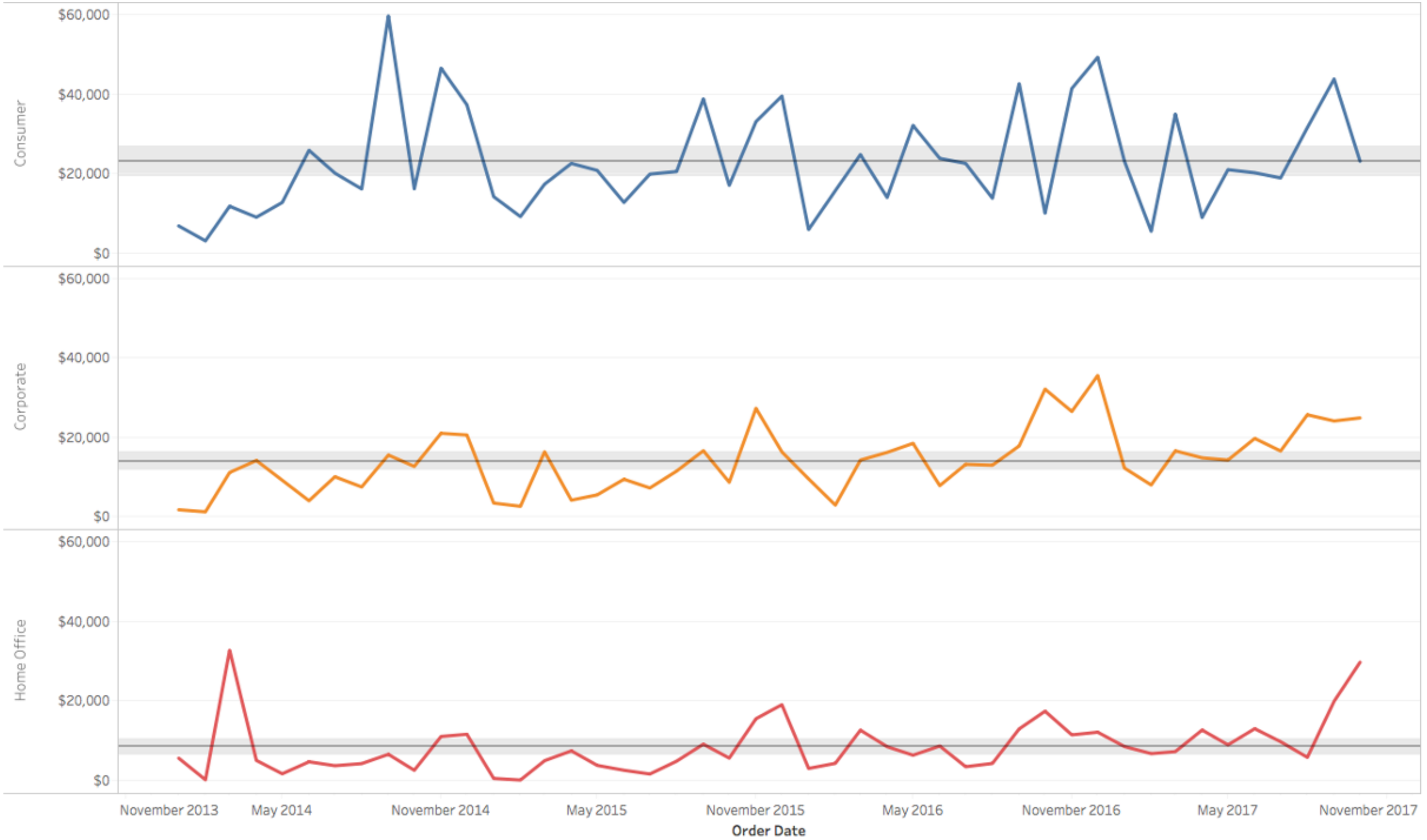
Lots of things!

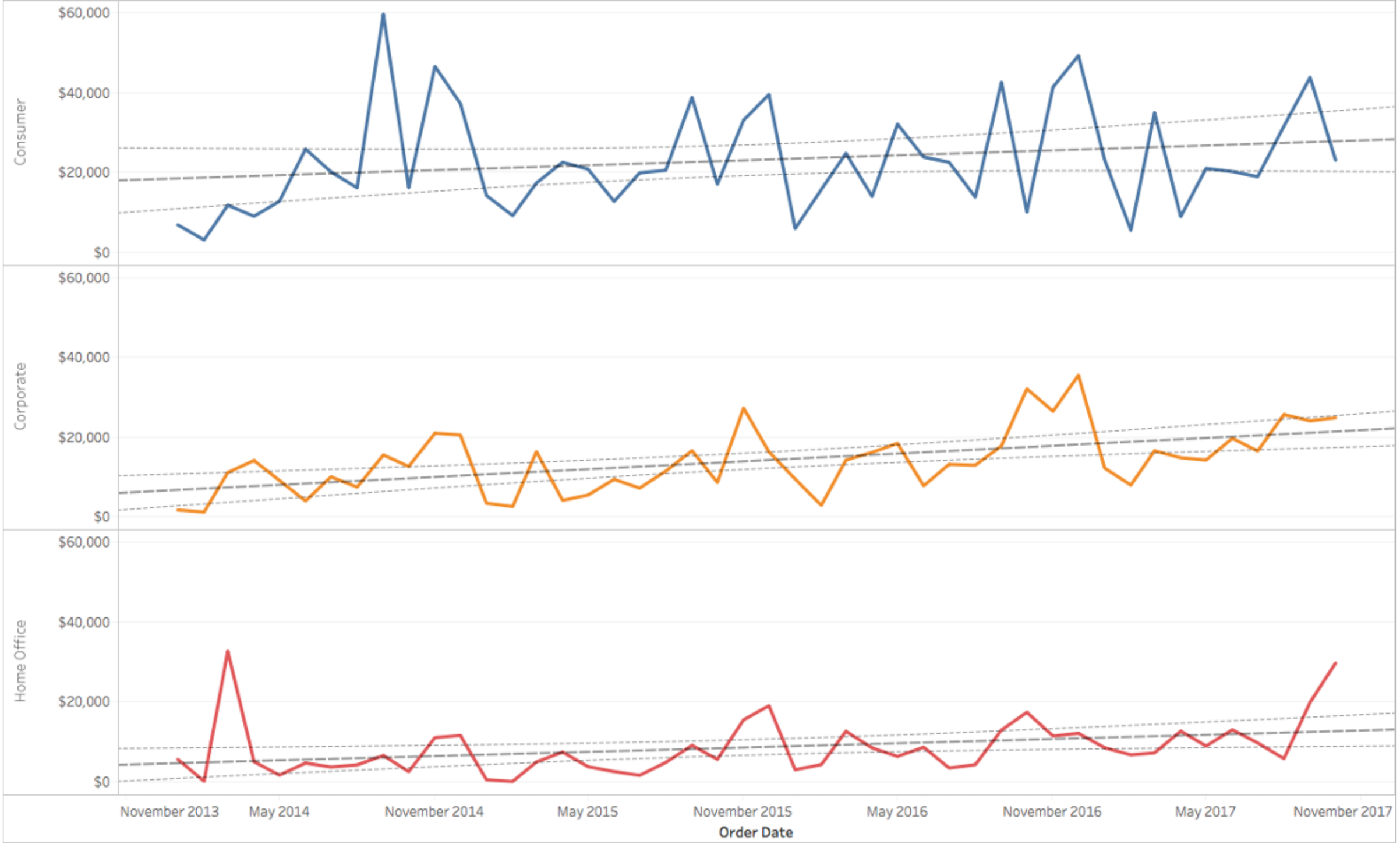
How should I visualize it?

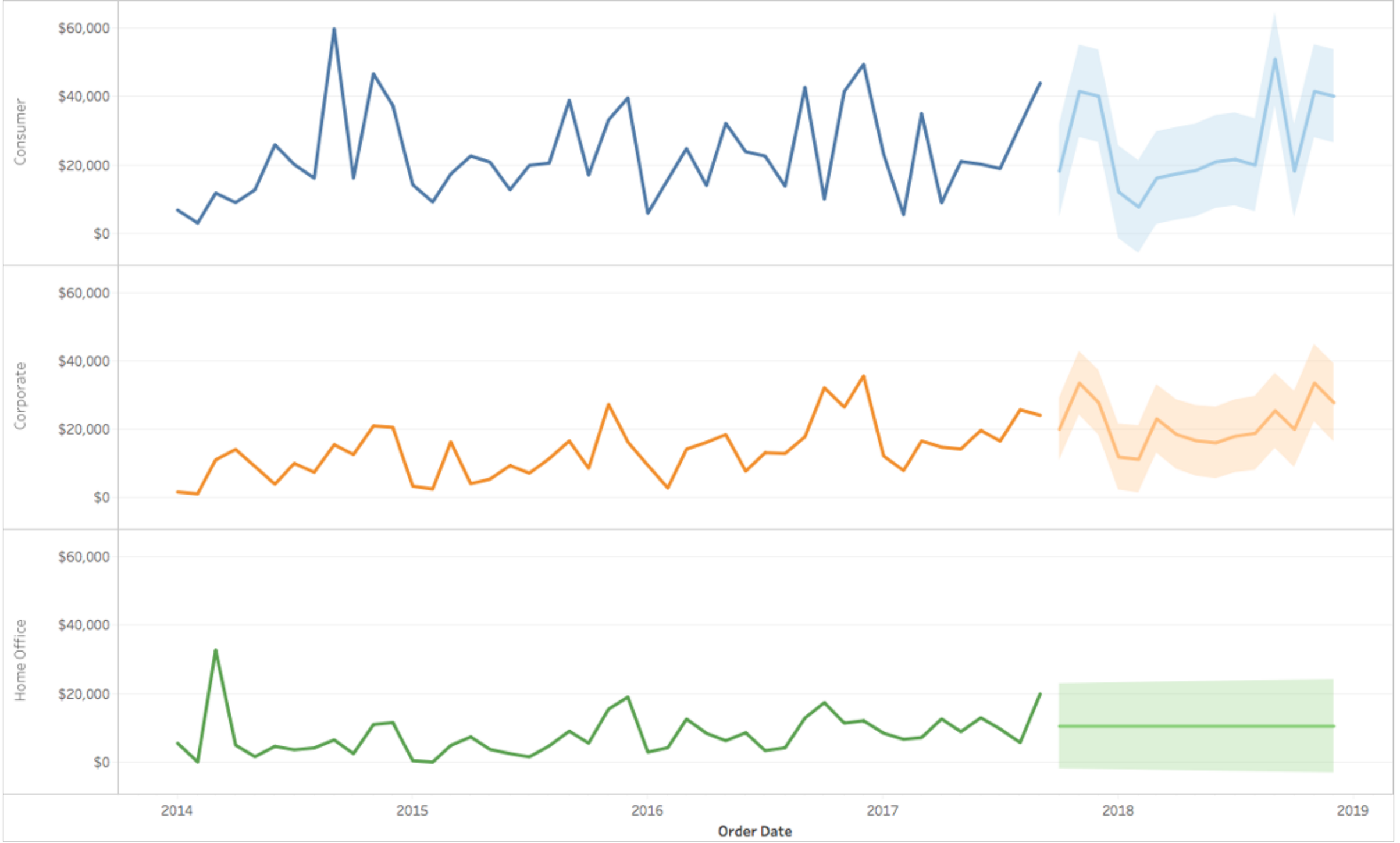
Uncertainty

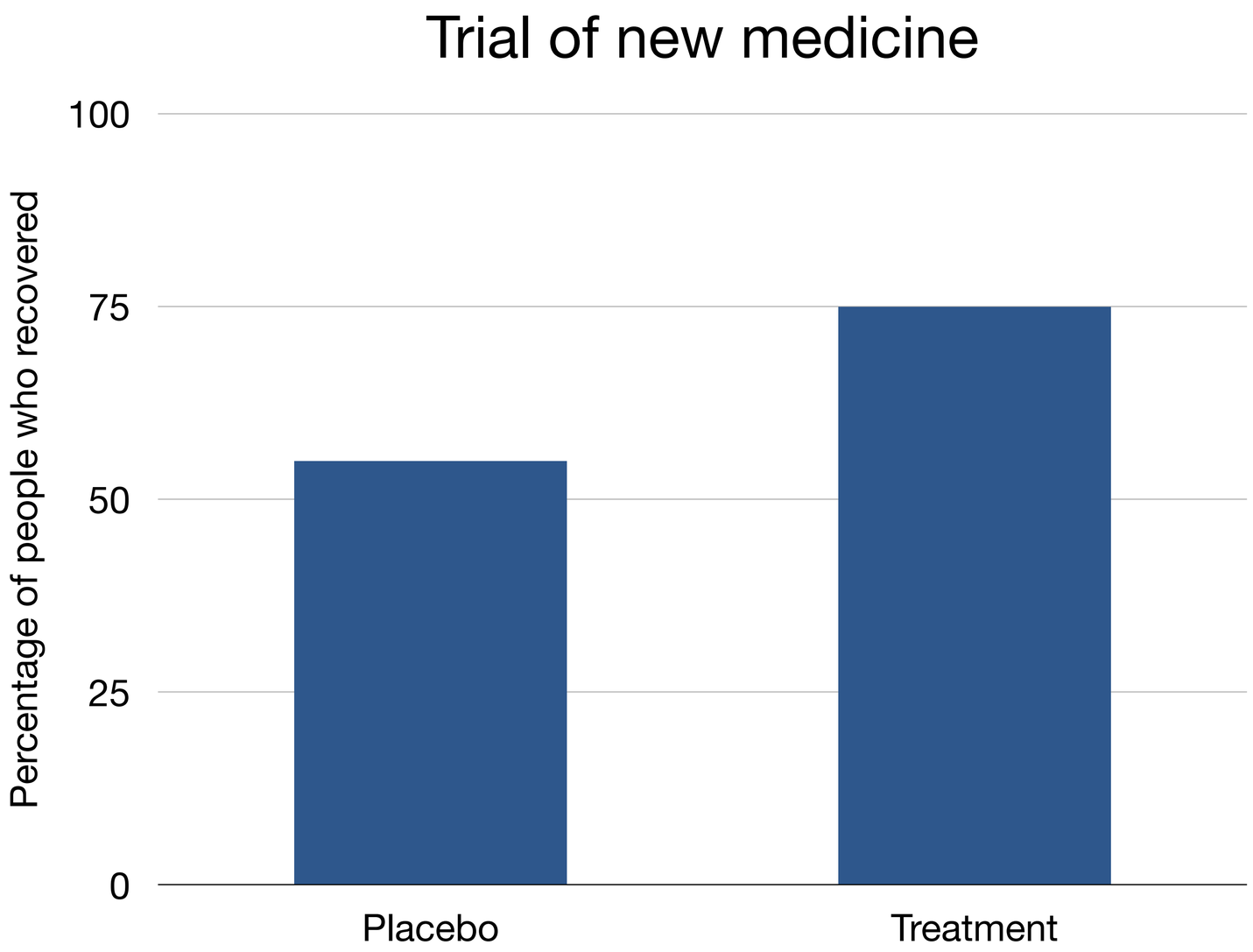
What does it mean?

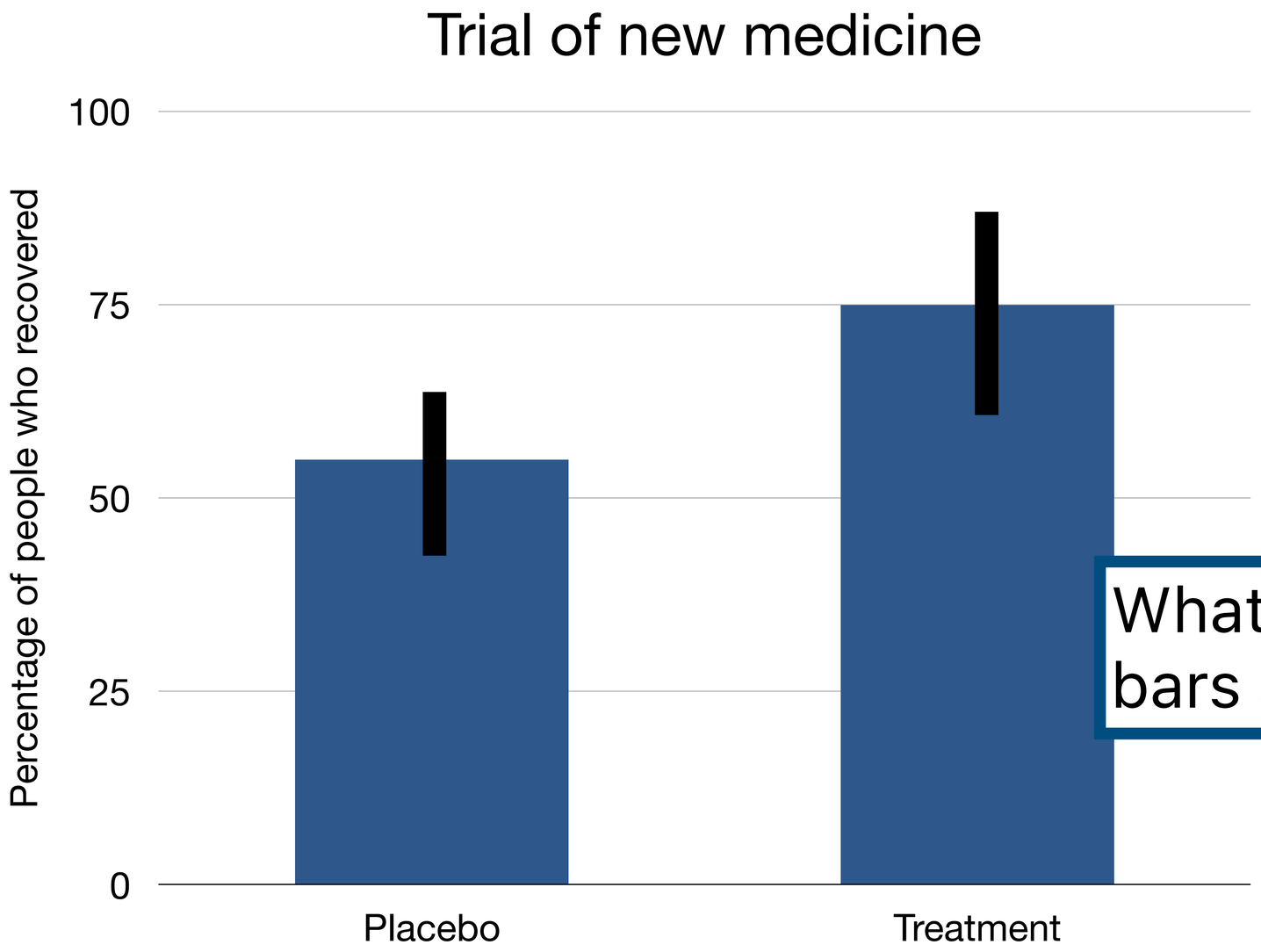
How should I visualize it?


Consumer
$60,000
$40,000
$20,000
$0
Corporate
$60,000
$40,000
$20,000
$0
Home Office
$60,000
$40,000
$20,000
$0
November 2013
May 2014
November 2014
May 2015
November 2015
May 2016
November 2016
May 2017
November 2017
Order Date


Consumer
$60,000
$40,000
$20,000
$0
Corporate
$60,000
$40,000
$20,000
$0
Home Office
$60,000
$40,000
$20,000
$0
November 2013
May 2014
November 2014
May 2015
November 2015
May 2016
November 2016
May 2017
November 2017
Order Date

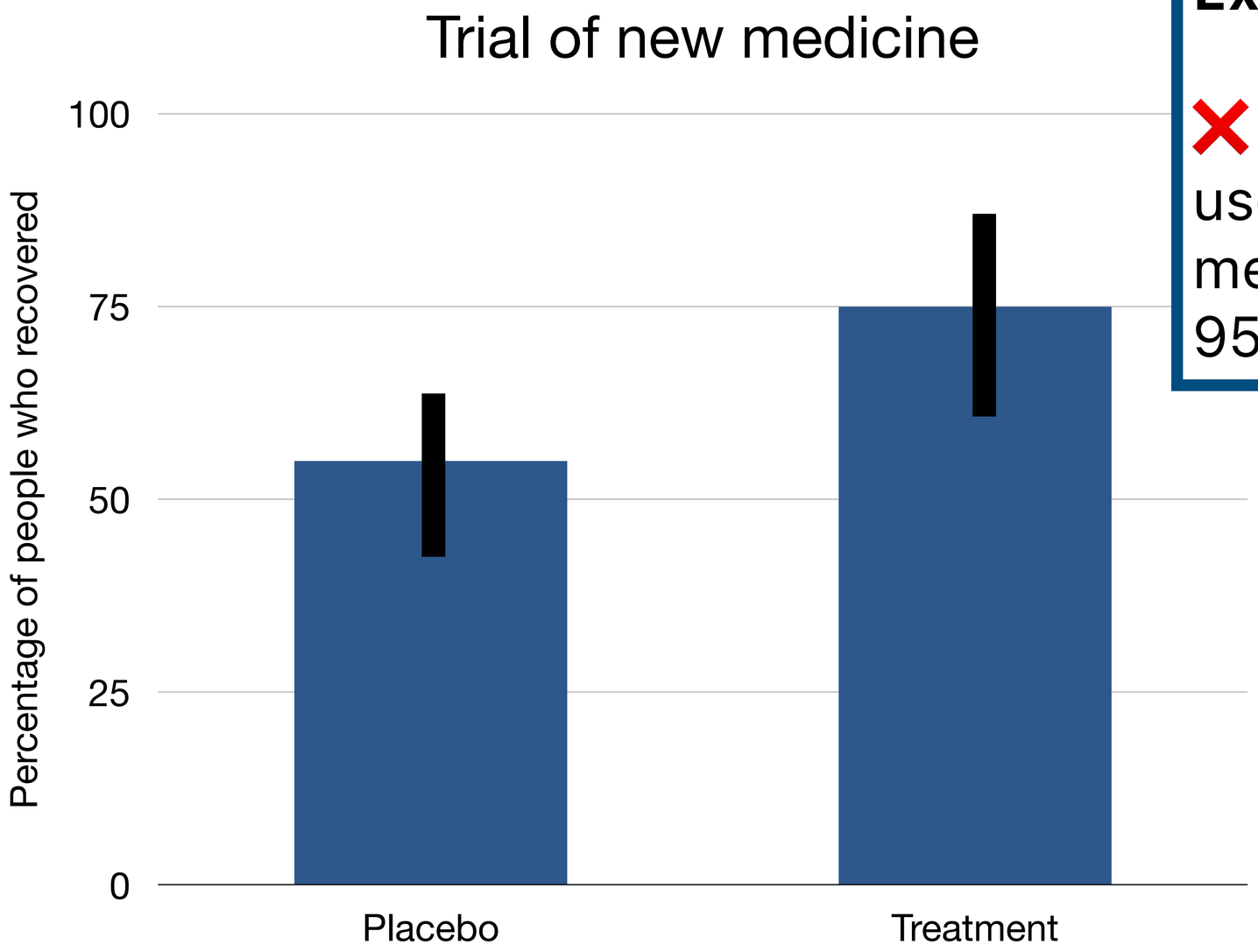

Consumer
$60,000
$40,000
$20,000
$0
Corporate
$60,000
$40,000
$20,000
$0
Home Office
$60,000
$40,000
$20,000
$0
2014
2015
2016
2017
2018
2019
Order Date


Trial of new medicine
Percentage of people who recovered
100
75
50
25
0
Placebo
Treatment



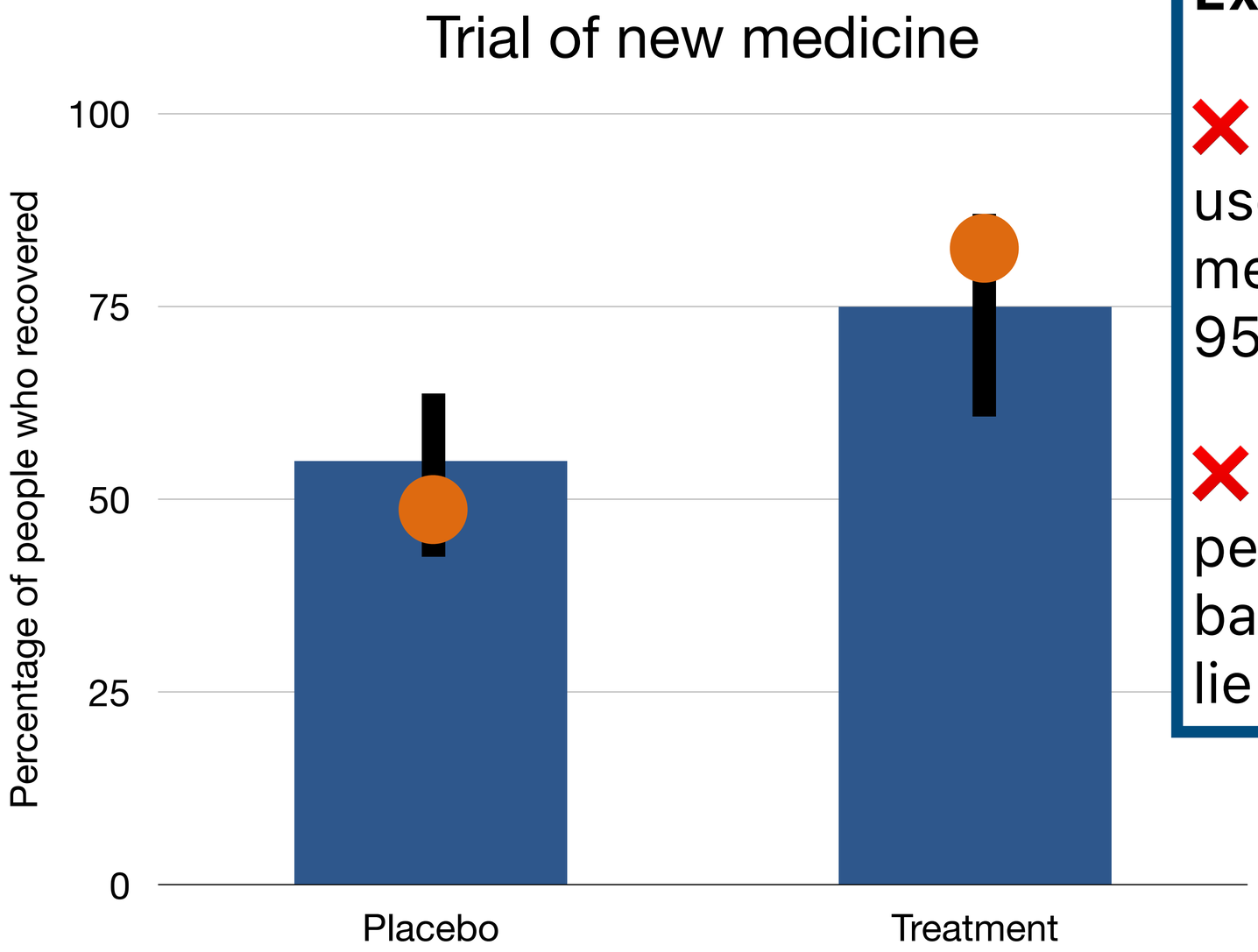
What do you think these error bars are implying?

tryclassbuzz.com
Code: **errorbars**



Expressiveness?

❌ Error bars aren't consistently used to visualize the same measure (standard error, IQR, 95% CI, etc.).

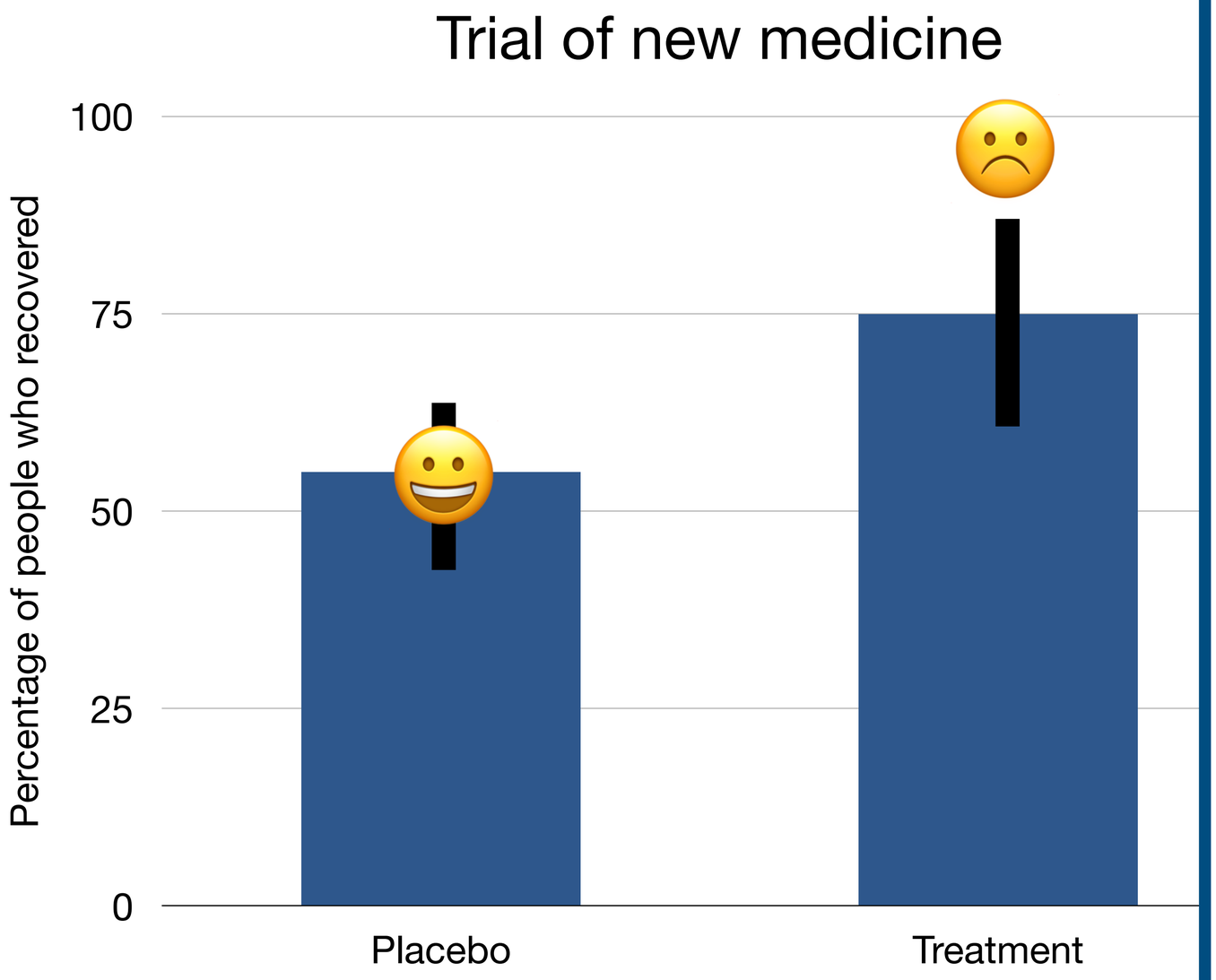


Expressiveness?

❌ Error bars aren't consistently used to visualize the same measure (standard error, IQR, 95% CI, etc.).

❌ Within-the-bar bias: people perceive points falling within the bar as more likely than those that lie outside.

[Newman & Scholl, 2012]
[Correll & Gleicher, 2014]



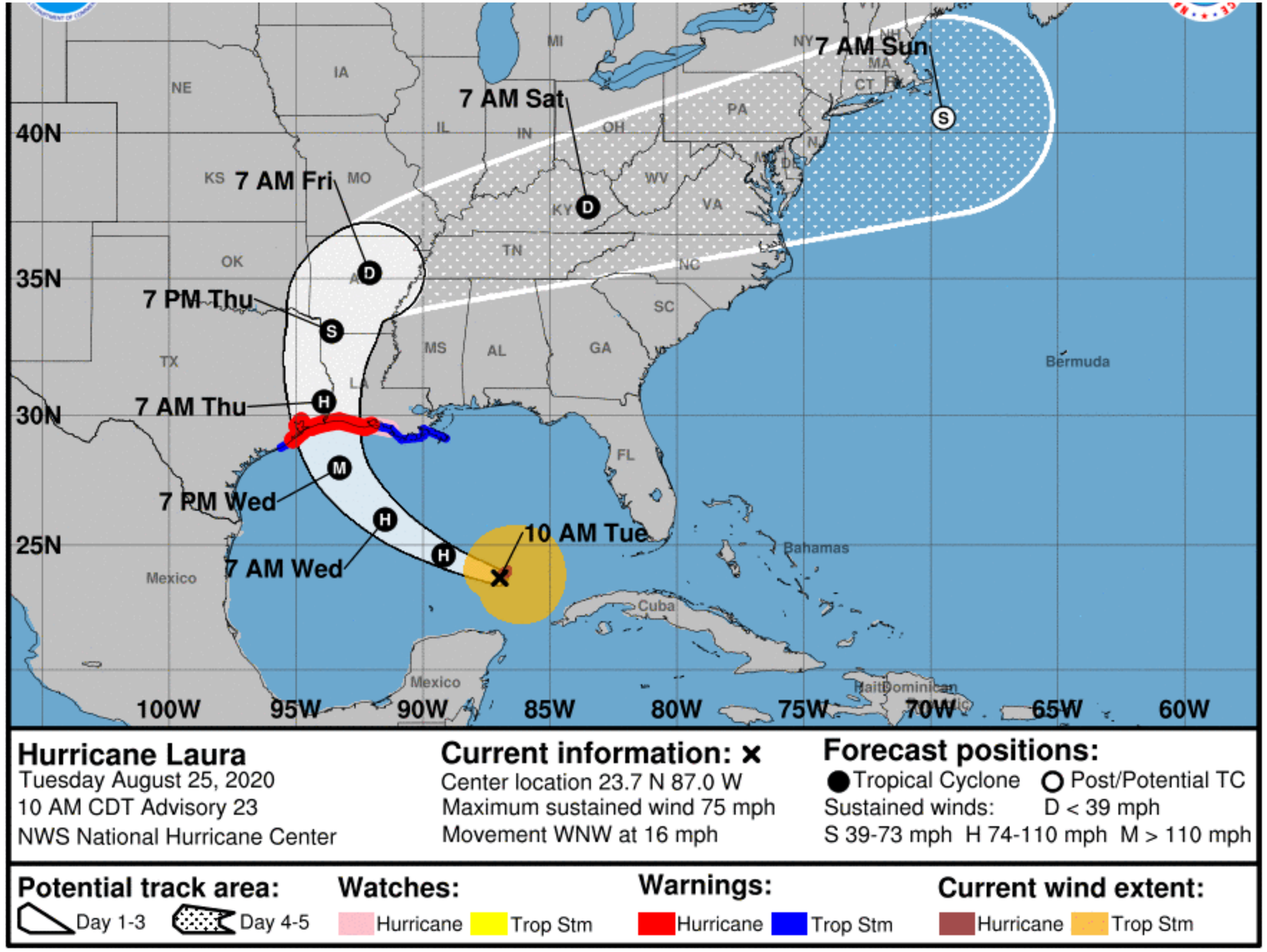
[Newman & Scholl, 2012]
[Correll & Gleicher, 2014]

Expressiveness?

❌ Error bars aren't consistently used to visualize the same measure (standard error, IQR, 95% CI, etc.).

❌ Within-the-bar bias: people perceive points falling within the bar as more likely than those that lie outside.

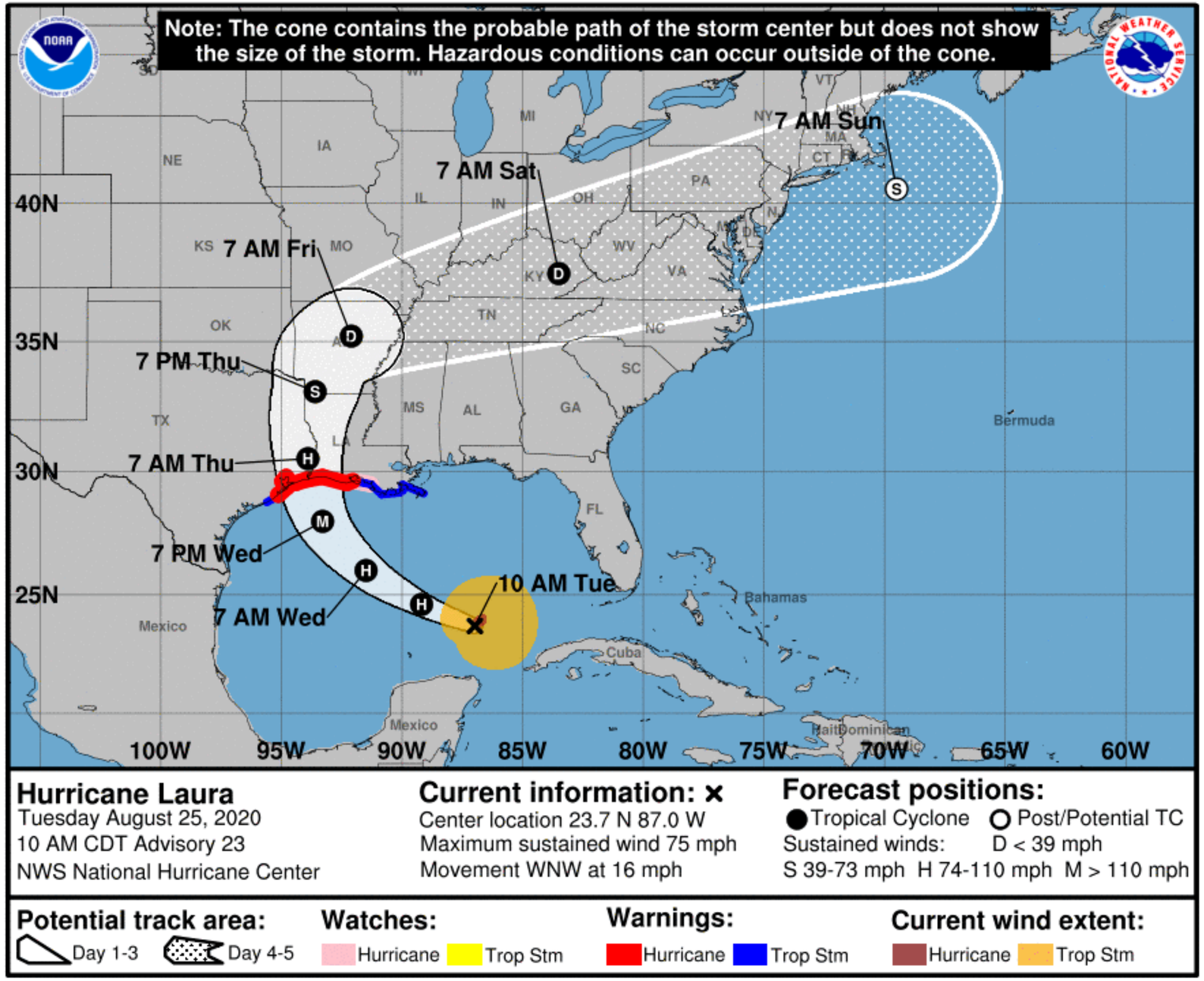
❌ Binary bias: people perceive values to either be in or out of the margins of error.



What is being visualized?

What are the strengths and weaknesses of this visualization?

tryclassbuzz.com
Code: **hurricane**



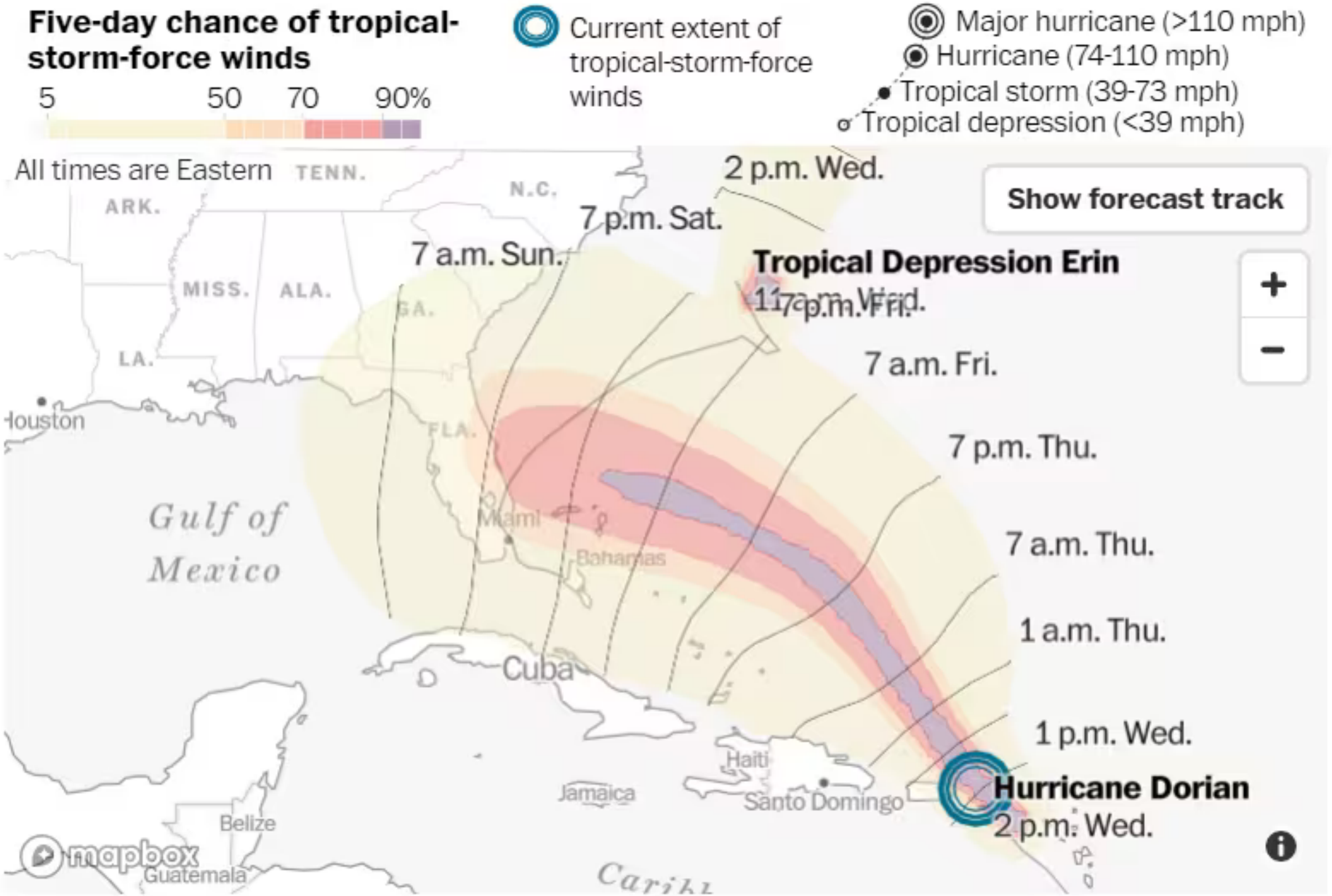
What is being visualized?

What are the strengths and weaknesses of this visualization?


FOX4 HURRICANE IAN
5:00 AM ADVISORY
SAT 2:00 AM
40 MPH
FRI 2:00 AM
90 MPH
THU 2:00 AM
115 MPH
WED 2:00 PM
130 MPH
WED 2:00 AM
140 MPH
FORT MYERS
NAPLES
CURRENT LOCATION: 90 MI SW OF G

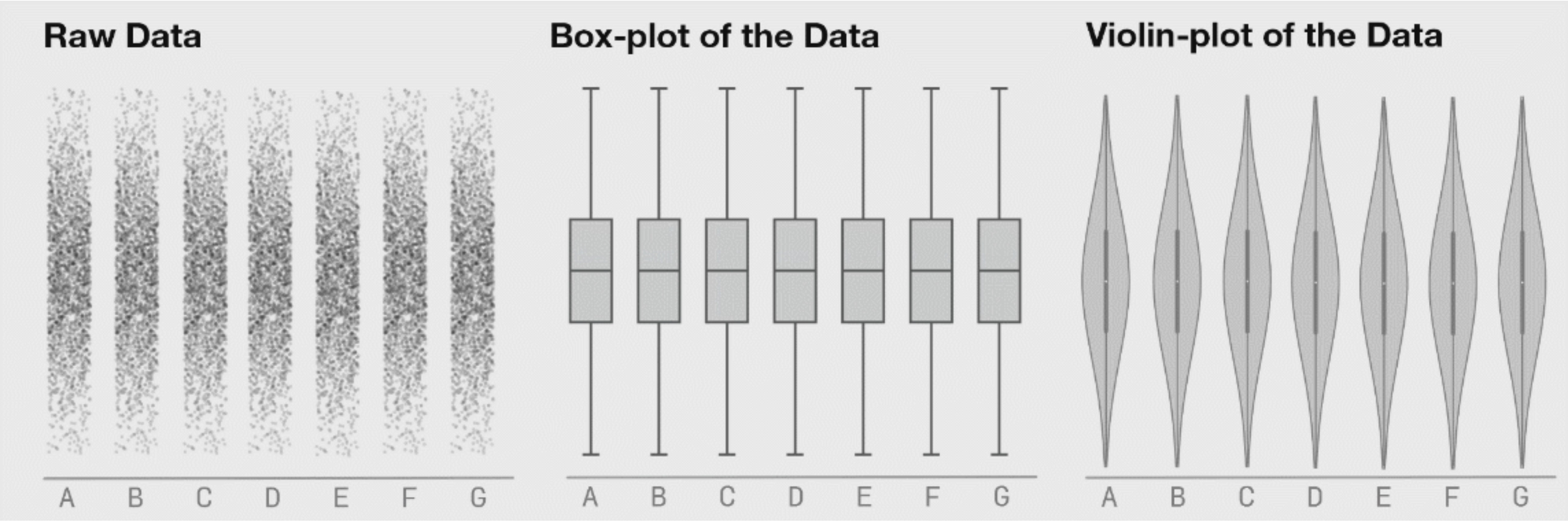

Rapid City
Omaha
St. Louis
Cincinnati
Washington
New York
FIRST WARNING WEATHER
HURRICANE DORIAN
Atlanta
Jacksonville
Wednesday 8:00 AM EDT
75 mph
Tuesday 8:00 AM EDT
125 mph
Monday 8:00 AM EDT
140 mph
Sunday 8:00 AM EDT
130 mph
Saturday 8:00 AM EDT
125 mph
Location: 24.5°N, 69.8°W
Wind: 110 mph
Gusts: 130 mph
Movement: NW at 10 mph
Pressure: 28.70 in


Hurricane Dorian Forecast Track and Intensity
Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.
8 AM Tue
8 AM Sun
8 AM Sat
8 PM Fri
8 AM Fri
8 AM Mon
11 AM Thu
30N
25N
20N
90W
85W
80W
75W
70W
65W
60W
Hurricane Dorian
Thursday August 29, 2019
11 AM AST Advisory 21
NWS National Hurricane Center
Current information:
Center location 21.4 N 67.2 W
Maximum sustained wind 85 mph
Movement NW at 13 mph
Forecast positions:
Tropical Cyclone
Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph
Potential track area:
Day 1-3
Day 4-5
Watches:
Hurricane
Trop Stm
Warnings:
Hurricane
Trop Stm
Current wind extent:
Hurricane
Trop Stm

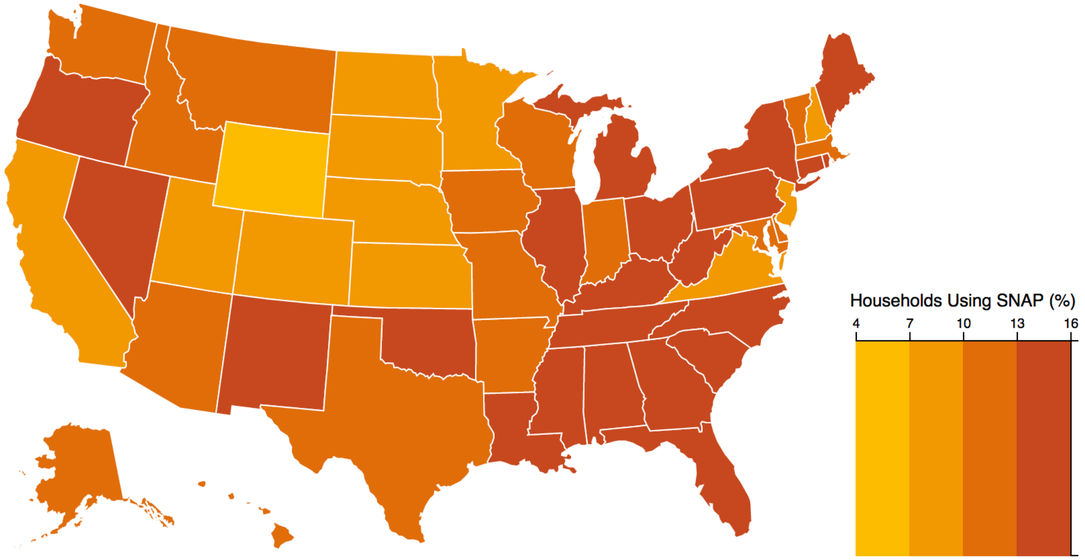


Source: National Weather Service. Note: Impact lines represent the earliest reasonable arrival time of tropical-storm-force winds.

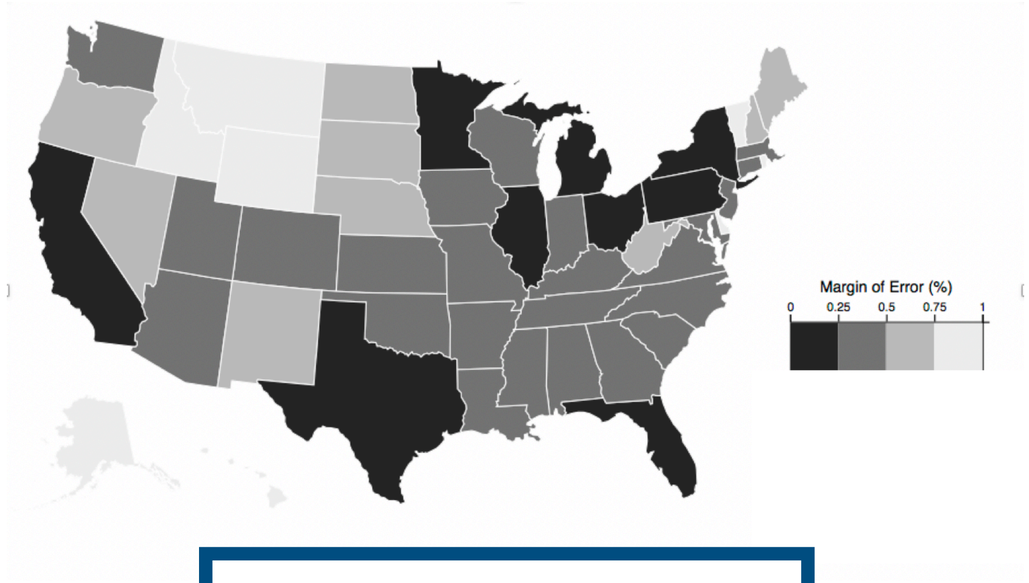
For uncertainty, use **visual variables** instead of visualizing point estimates



For uncertainty, use **visual variables** instead of visualizing point estimates



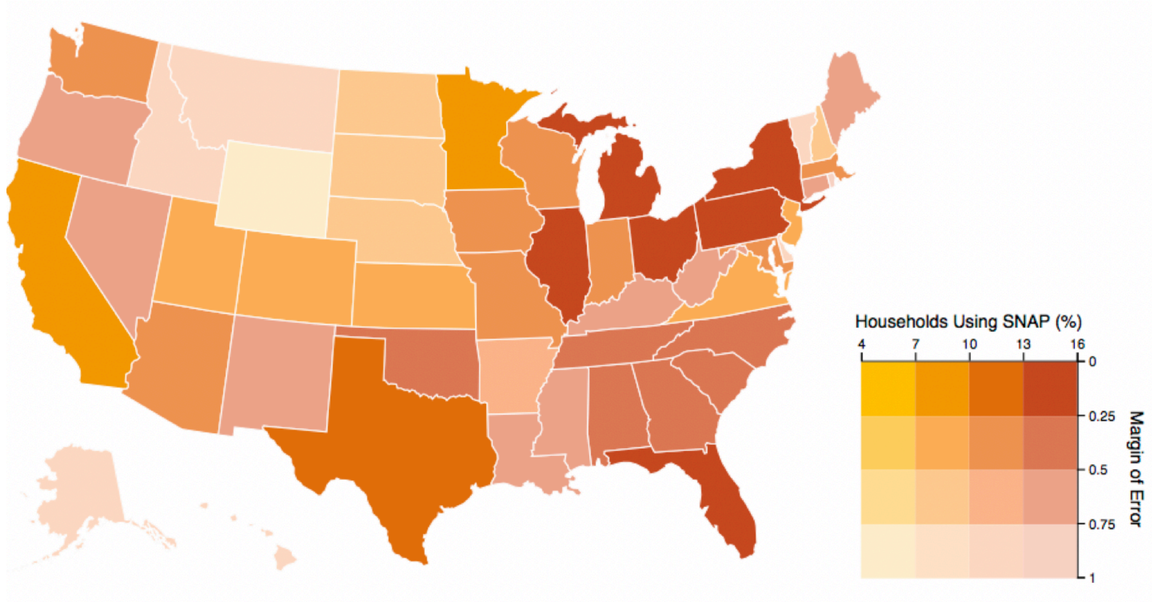
Data Map

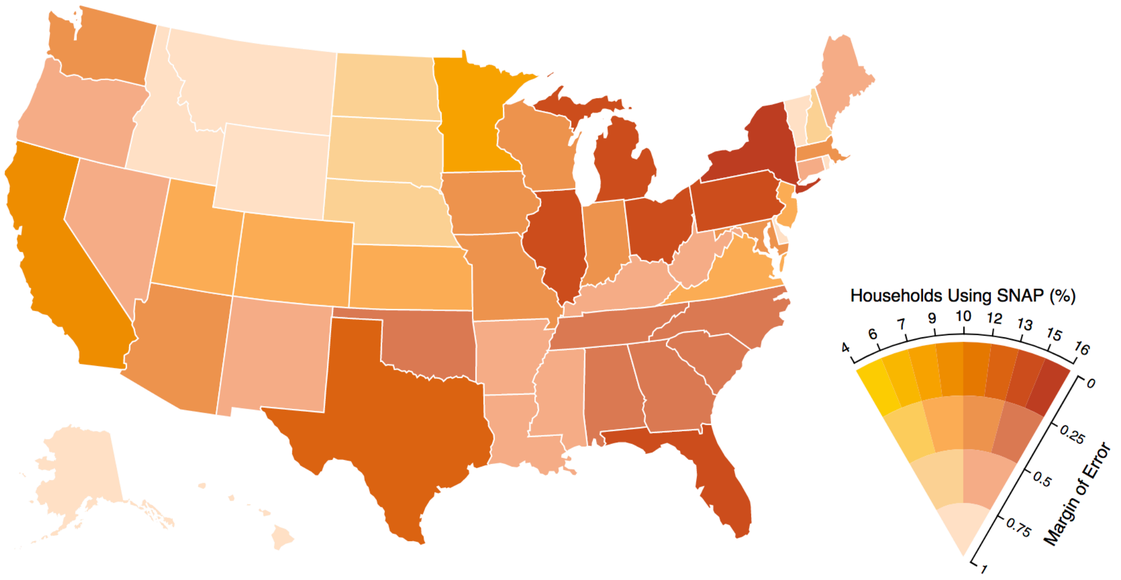


Uncertainty Map

[Correll, Moritz, & Heer, 2018]

For uncertainty, use **visual variables** instead of visualizing point estimates



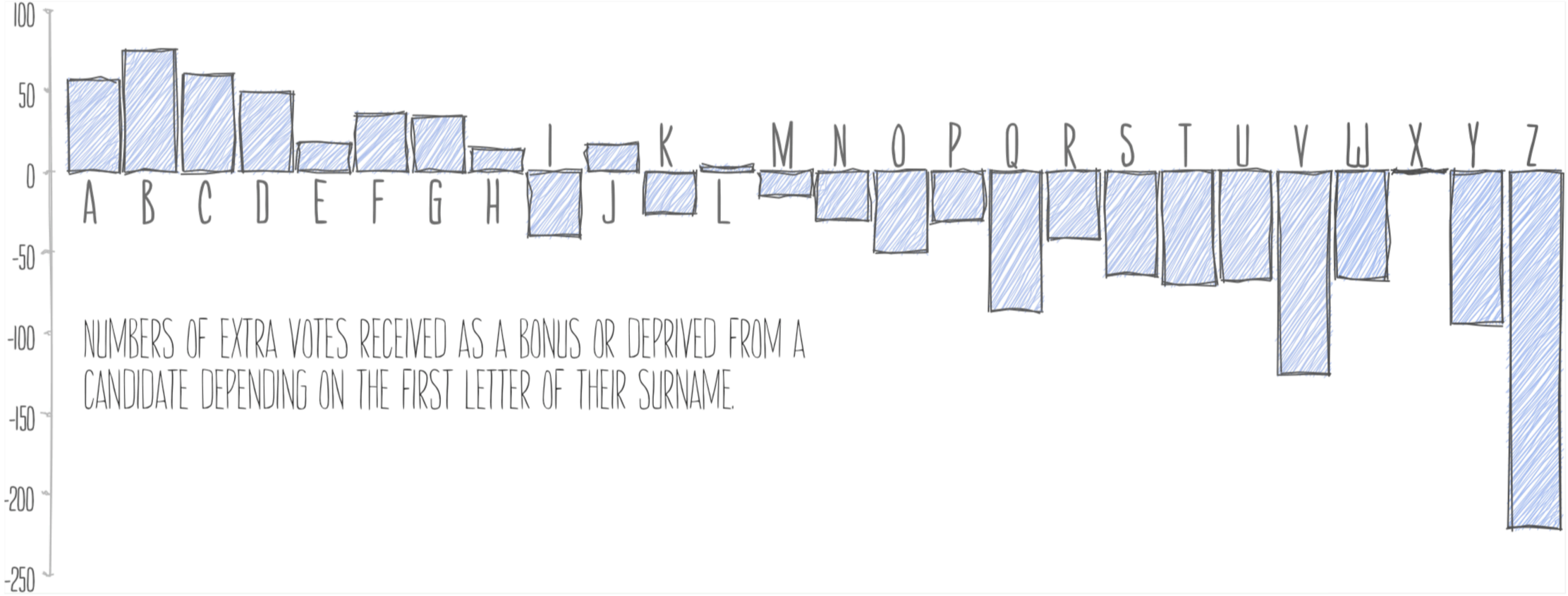


Bivariate Map (Data + Uncertainty)

Value-Suppressing Uncertainty Map

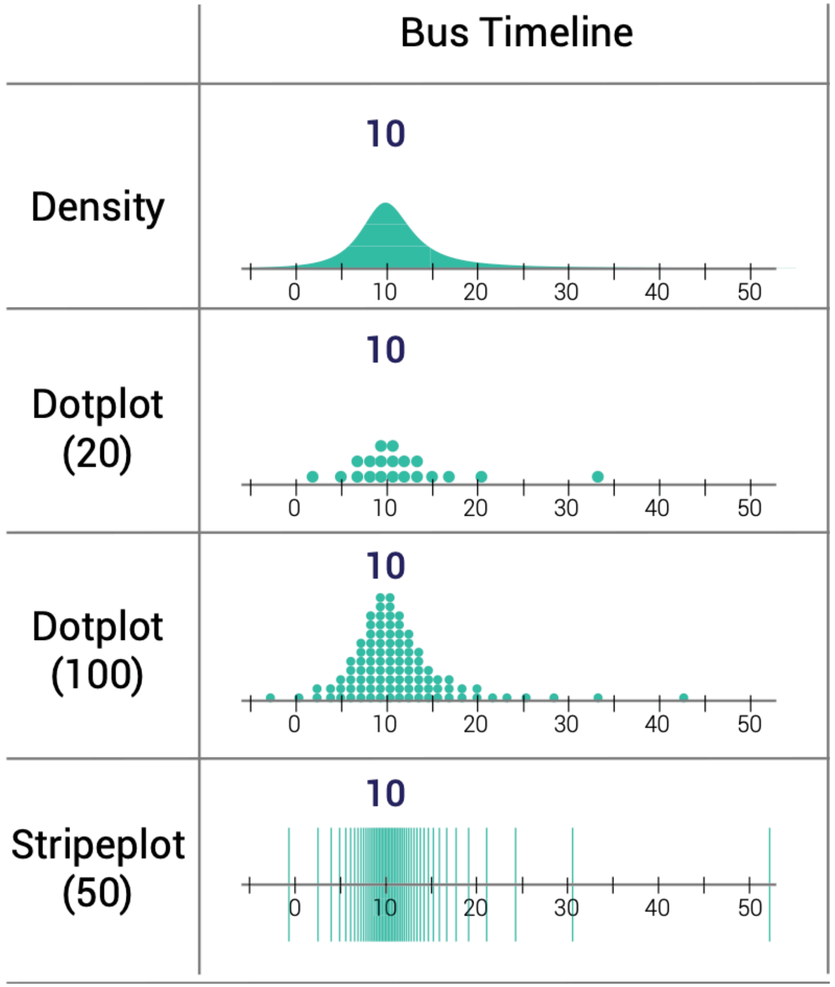
[Correll, Moritz, & Heer, 2018]

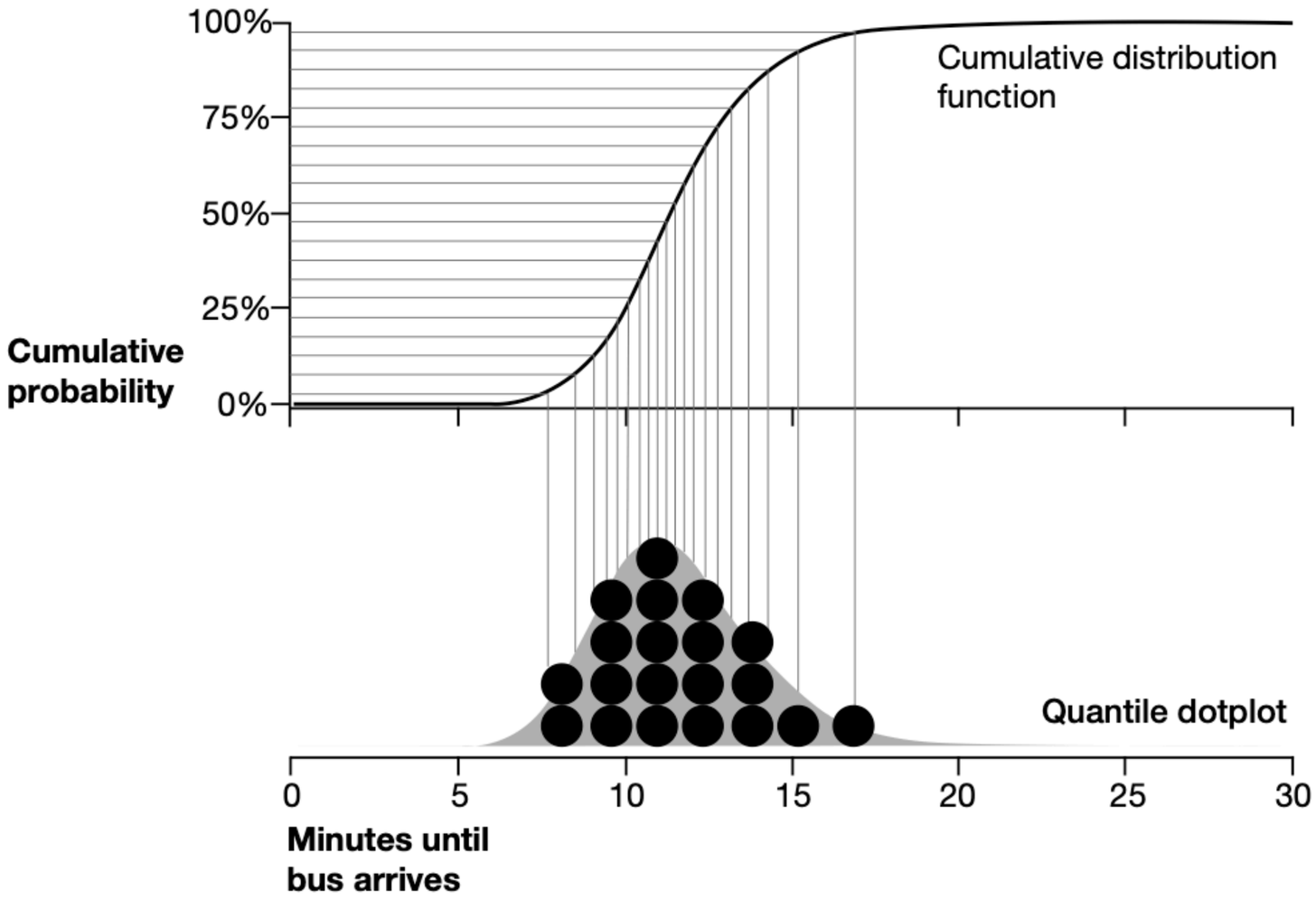
For uncertainty, use **visual variables** instead of visualizing point estimates



[Wood et al., 2012]
[Boukhelifa et al., 2012]

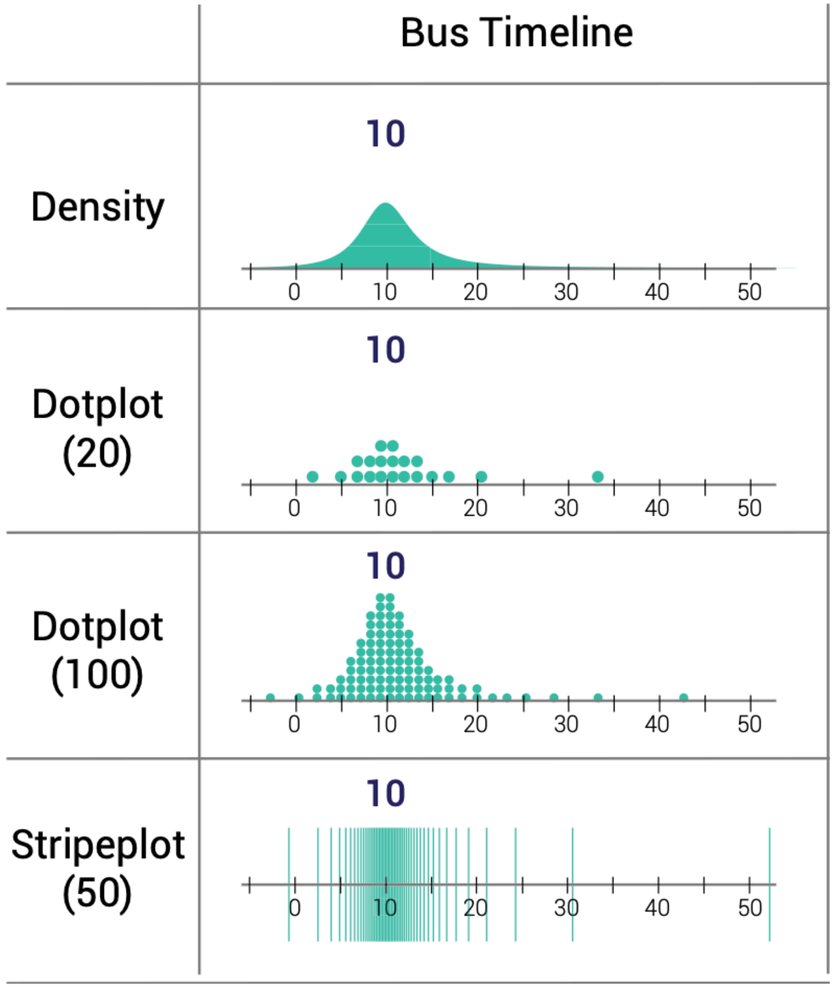
"Set of draws" technique

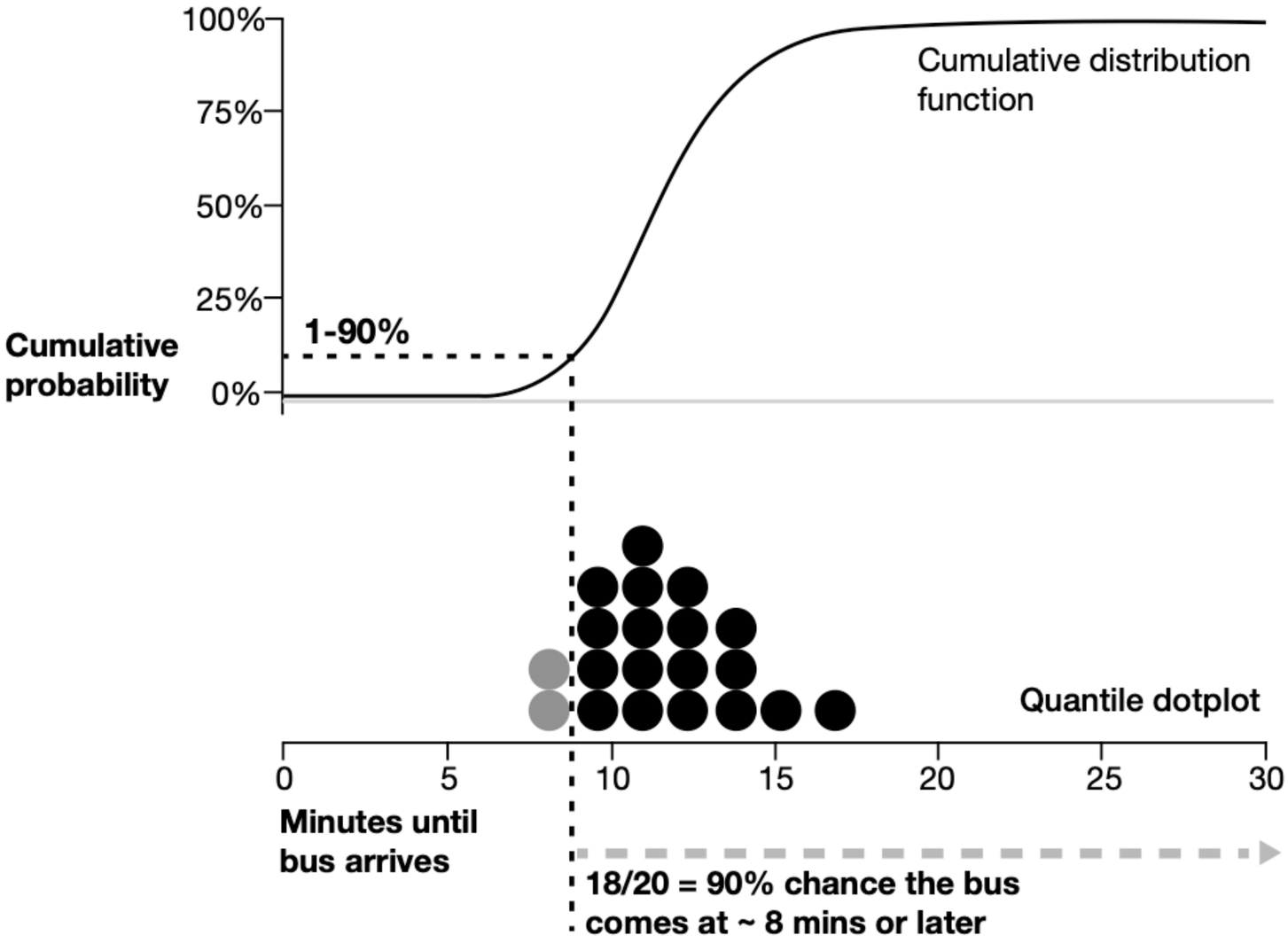




[Kay et al., 2016]

"Set of draws" technique

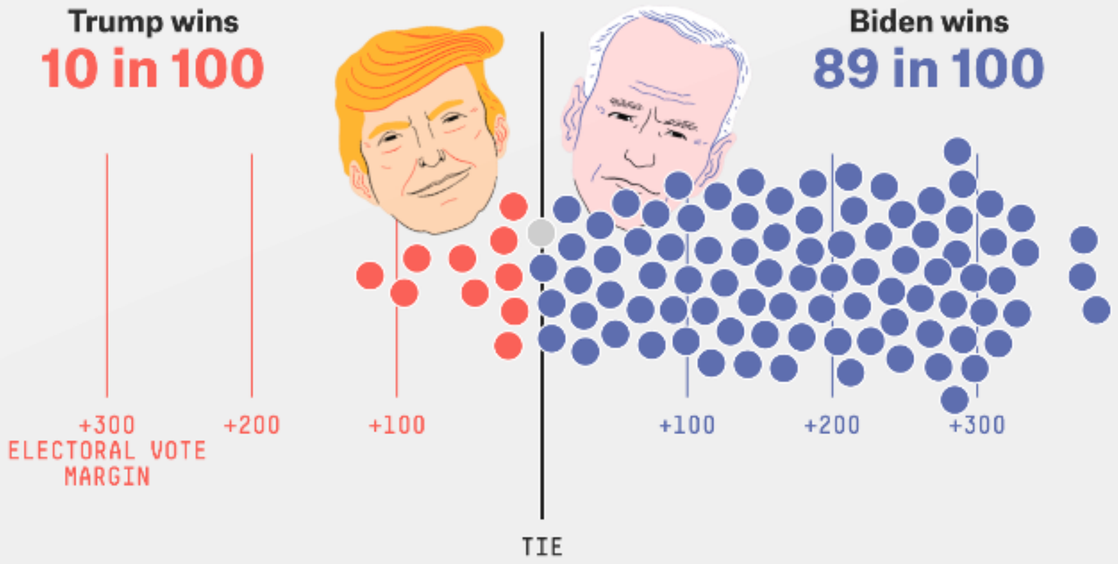




[Kay et al., 2016]

Biden is *favored* to win the election

We simulate the election 40,000 times to see who wins most often. The sample of 100 outcomes below gives you a good idea of the range of scenarios our model thinks is possible.



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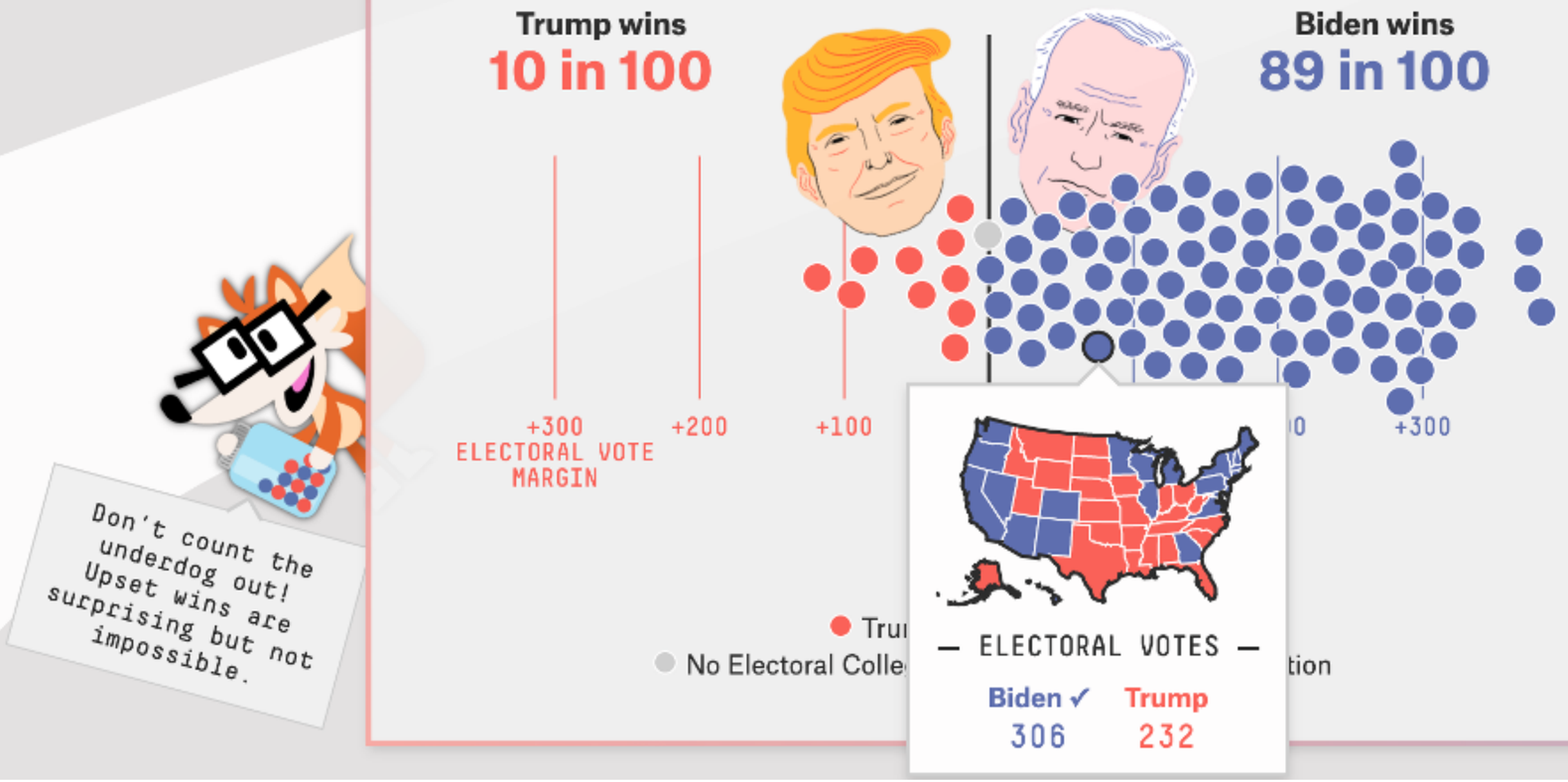

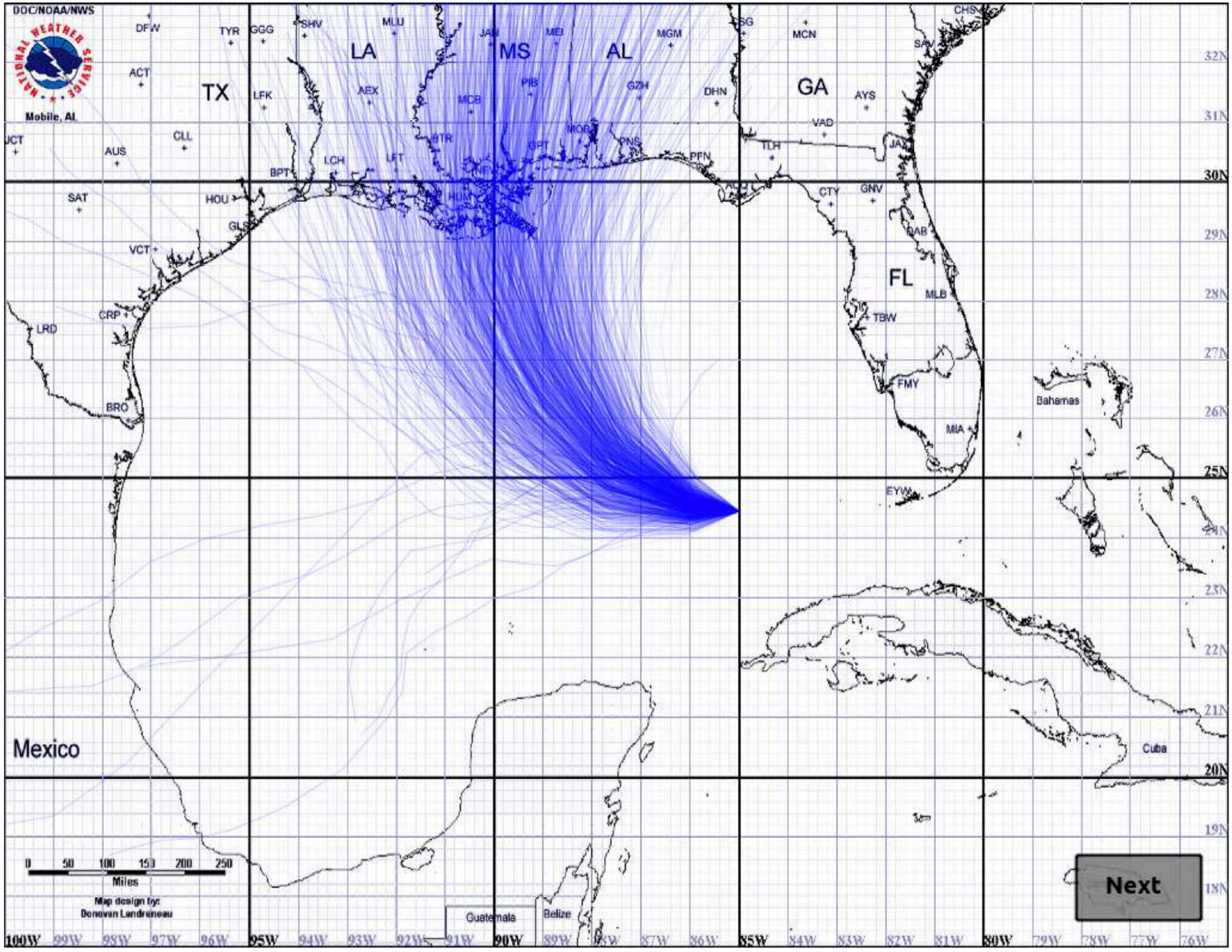
DOC/NOAA/NWS
NATIONAL WEATHER SERVICE
Mobile, AL
LA
MS
AL
TX
GA
FL
Mexico
Bahamas
Cuba
Guatemala
Belize
DFW
TYR
GGG
SHV
MLU
JAN
MEI
MGM
SG
MCN
CHS
SAV
ACT
LFK
AEX
MCB
PIB
GZH
DHN
AYS
VAD
JCT
AUS
CLL
BPT
LCH
LFT
HTR
GPT
MOB
PNS
PFN
TLH
JAX
SAT
HOU
GLS
VCT
CTY
GNV
DAB
MLB
CRP
LRD
TBW
FMY
BRO
MIA
EYW
0 50 100 150 200 250
Miles
Map design by:
Donovan Landreneau
Next
32N
31N
30N
29N
28N
27N
26N
25N
24N
23N
22N
21N
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19N
18N
100W
99W
98W
97W
96W
95W
94W
93W
92W
91W
90W
89W
88W
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
77W
76W

The New York Times

TheUpshot

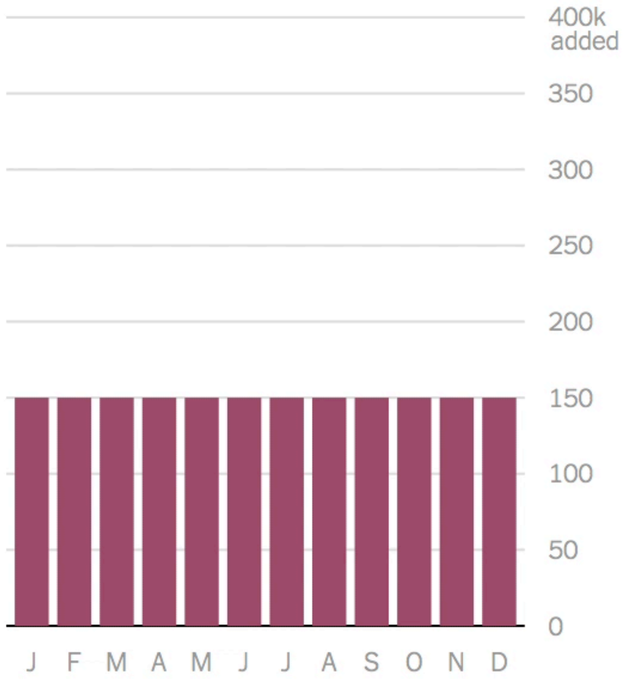
STATISTICAL NOISE

How Not to Be Misled by the Jobs Report

If the economy actually added 150,000 jobs last month, it would be possible to see any of these headlines:

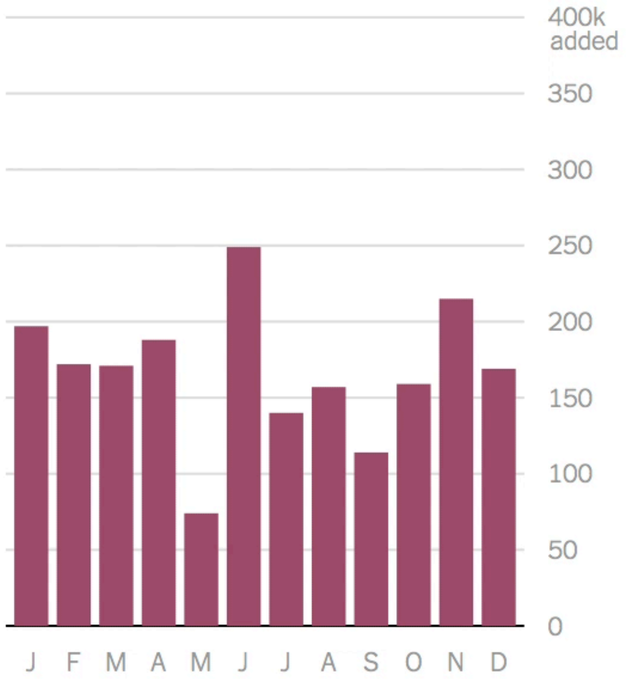
The jobs number is just an estimate, and it comes with uncertainty.

If job growth **were actually steady** over the last 12 months...

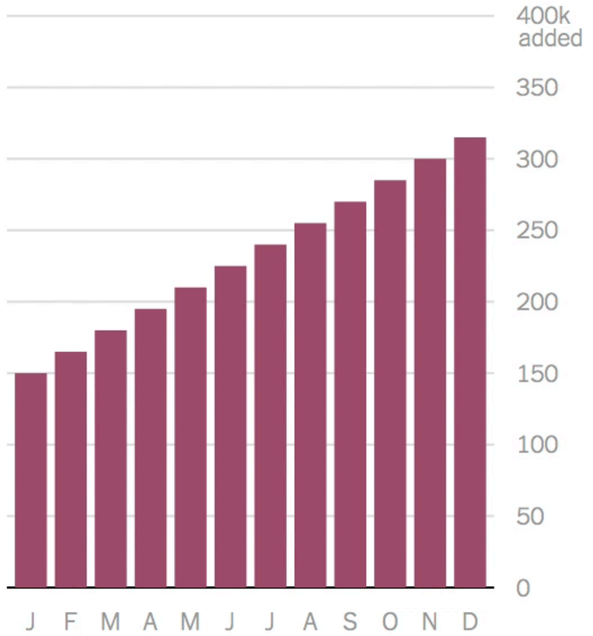


...the jobs report **could look like this**:

Play

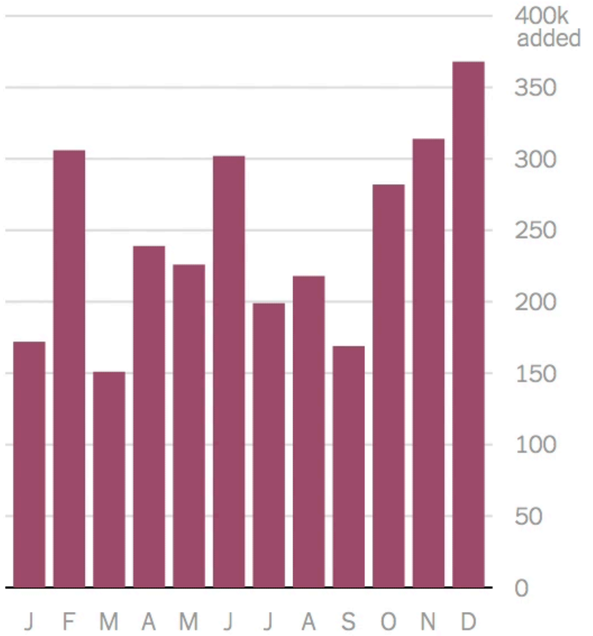


If job growth **had been accelerating**...



...the jobs report **could look like this:**

Play



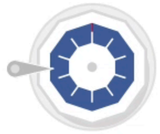
SPIN

Democrats: ?? **Republicans: ??**

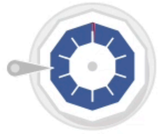
Likely Democratic

R.I.

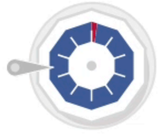
Va.



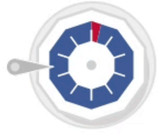
N.J.



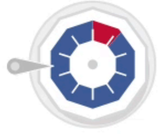
Ill.



Ore.

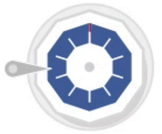


N.H.

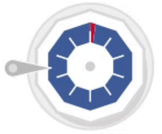


Hawaii

N.M.



Mass.



Del.

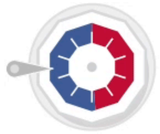
Minn.

Iowa

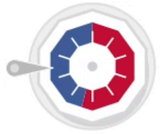
Competitive

Colo.

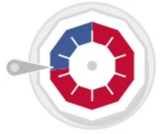
Mich.



Ark.



Ga.



N.C.

Alaska

La.

Ky.

Likely Republican

Ala.

Wyo.

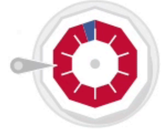
Okla.

Kan.

Tenn.

S.D.

S.C.



Miss.

Okla. (S)

Idaho

Tex.

Me.

S.C. (S)

Neb.

W.Va.

Mont.

Here's a simulation of who could be in and who could be out if the candidates' averages were rounded to the nearest whole number.

If the averages are correct, but rounding is to the nearest whole number:

TRUMP	BUSH	WALKER	PAUL	RUBIO	CRUZ	HUCKABEE	CARSON	CHRISTIE	PERRY	KASICH	SANTORUM	JINDAL	FIORINA	PATAKI	GRAHAM
18.0%	**14.0%**	**11.0%**	**7.0%**	**6.0%**	**6.0%**	**5.0%**	**5.0%**	**3.0%**	**2.0%**	**2.0%**	**2.0%**	**1.0%**	**1.0%**	**1.0%**	**0.0%**

Rounding to fewer decimal places could be welcome news for candidates on the cusp like Mr. Santorum (who has already called the debate rules "a miscarriage"), Mr. Kasich or Mr. Jindal.

Uncertainty

What does it mean?

How should I visualize it?

Building models is necessary to quantify uncertainty.

It is important to communicate the variability in model outcomes.

Dynamic or ensemble displays can help communicate complex models.

Why Authors Sometimes Don't Visualize Uncertainty

A visualization expresses a signal
Authors simplify, crystallize, abstract the complexity of data.

Process validates signal
Authors decide whether process has "low enough" uncertainty.

Uncertainty obfuscates signal
Could distract, or require too much work from the reader.

Hullman, 2019

Uncertainty

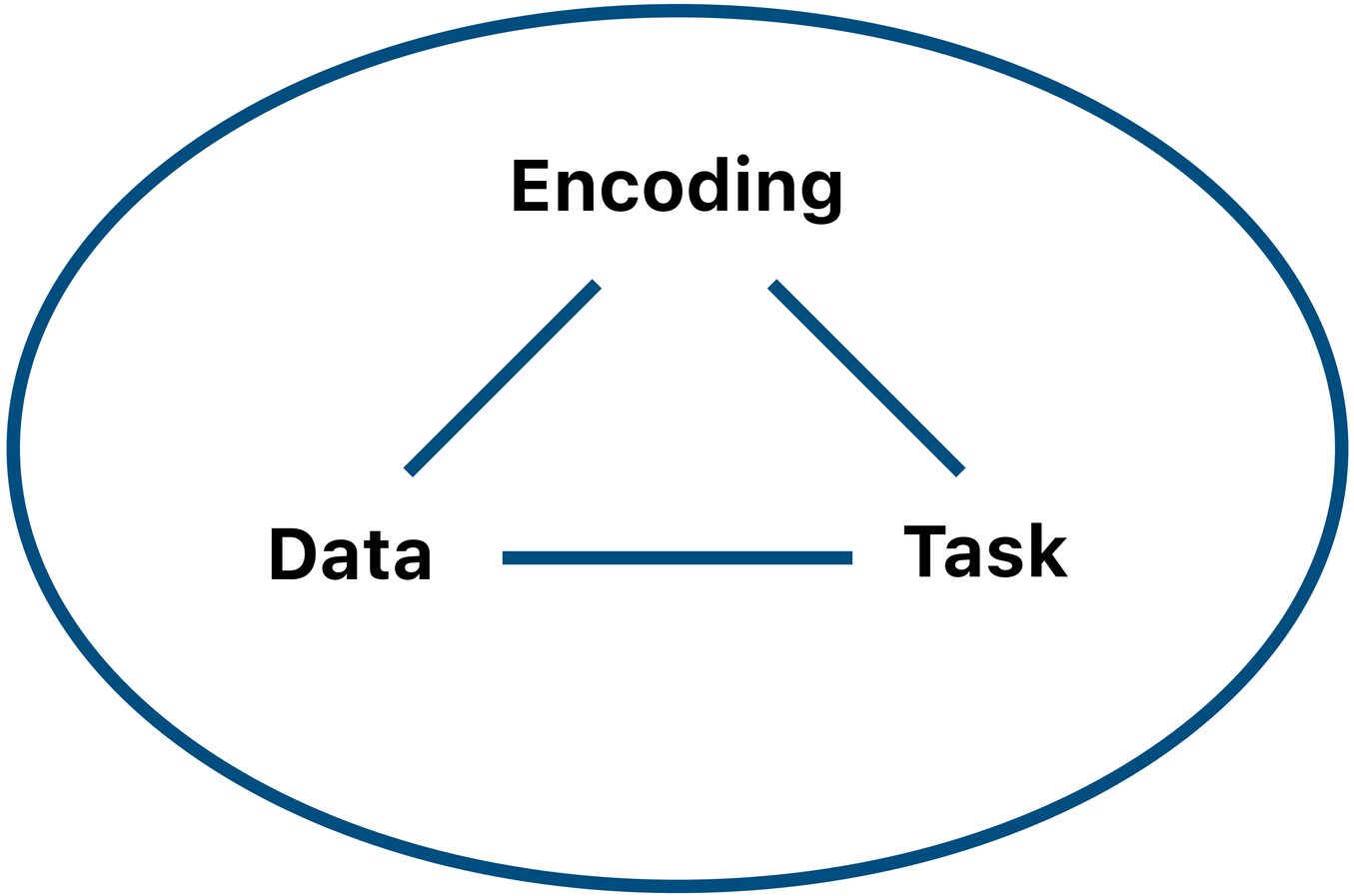
What does it mean?

Lots of things!

How should I visualize it?

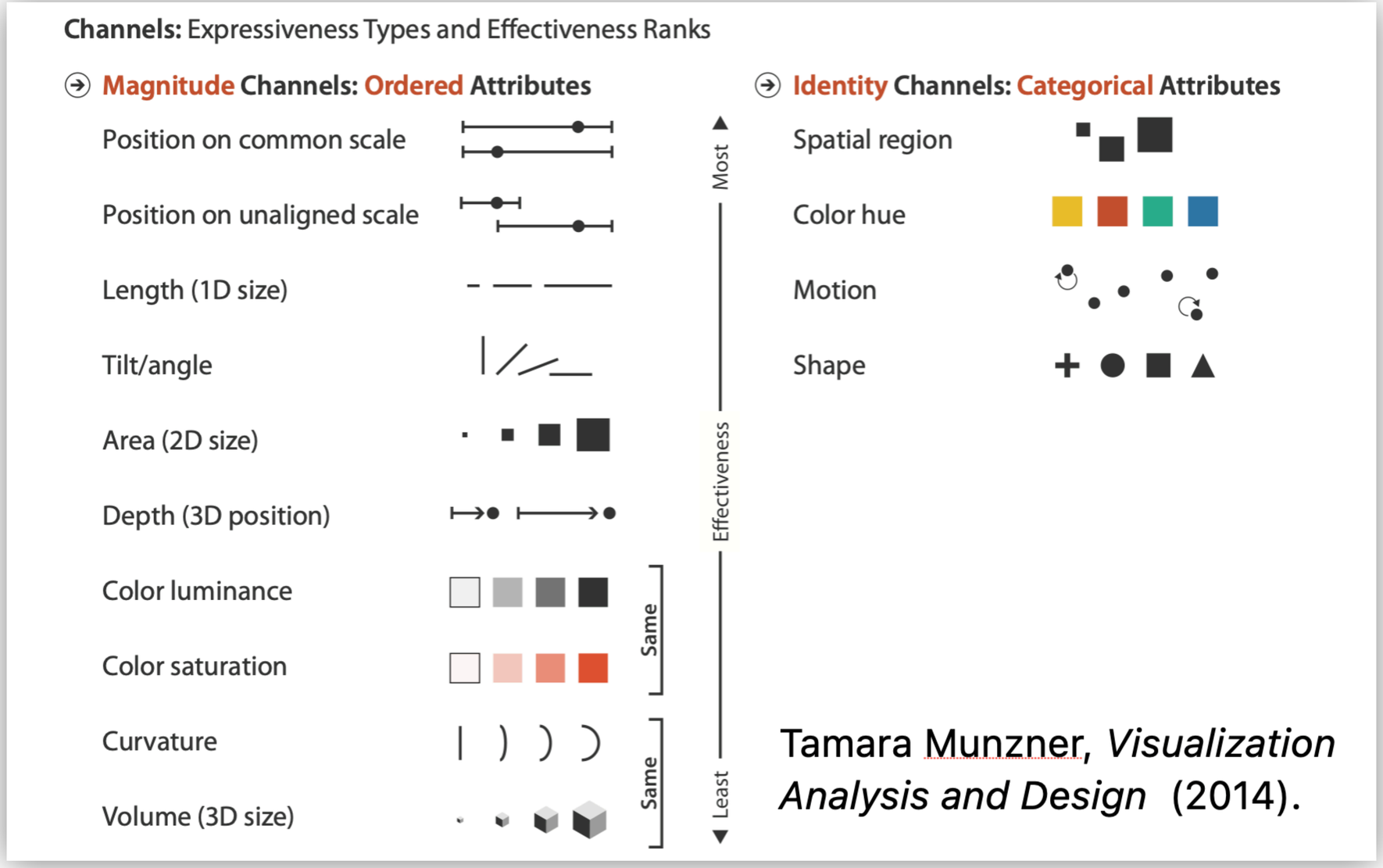
It depends!

Conclusion



Users & Domain

Data and Image Models



Visual Encoding and Dark Patterns

Truncating the y-axis?

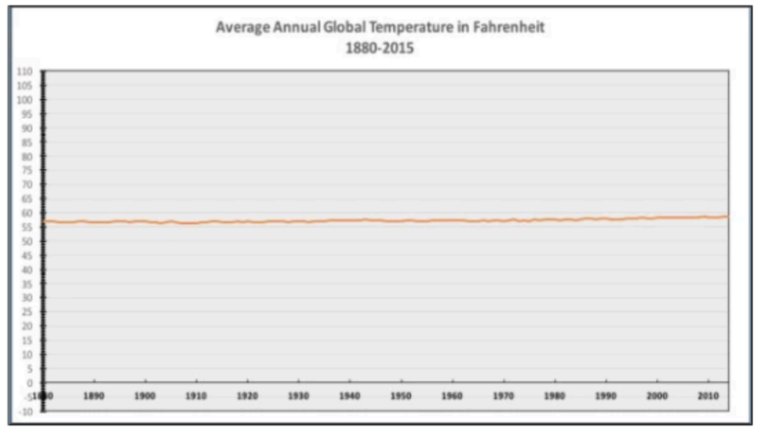
To emphasize Q-interval (vs. Q-ratio)
If the zero value doesn't make much sense.
If it is the norm (e.g., stock charts).

National Review ✓
@NRO

Follow

The only #climatechange chart you need to see. natl.re/wPKpro

(h/t @powerlineUS)

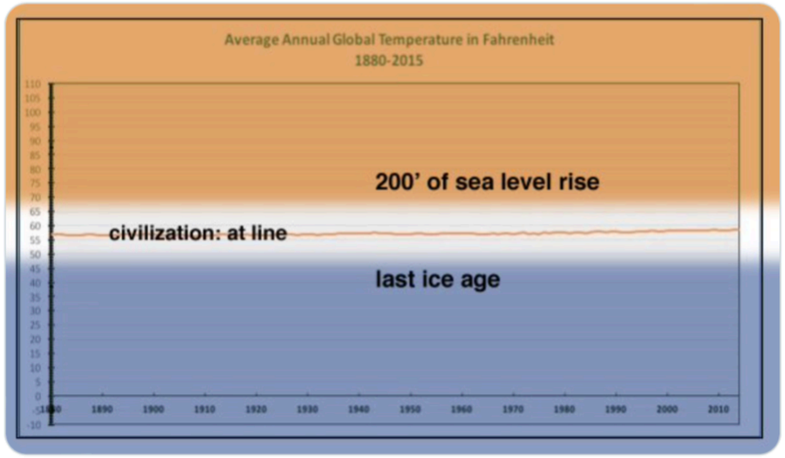


12:36 PM - 14 Dec 2015

City Atlas
@cityatlas

Replying to @NRO

.@NRO @powerlineUS @bradplumer I'm sure someone else has fixed this for you, but here you go. Great idea, thx --



5:28 PM · Dec 14, 2015

78 Retweets **1** Quote Tweet **208** Likes

39

Perception

Graphical Perception Studies

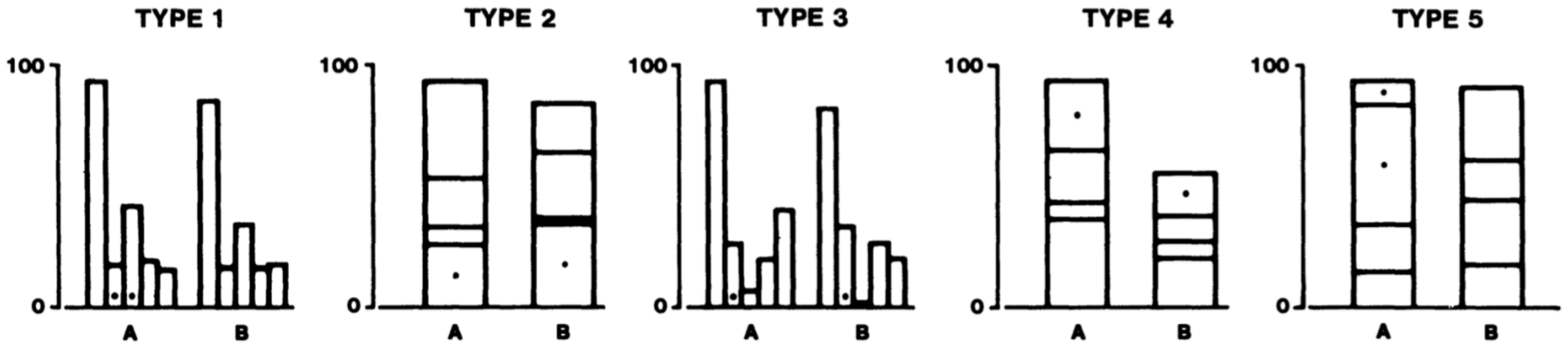


Figure 4. Graphs from position–length experiment.

What proportion is the smaller marked section of the larger?

Cleveland, William S., and Robert McGill. "Graphical perception: Theory, experimentation, and application to the development of graphical methods." 1984

23

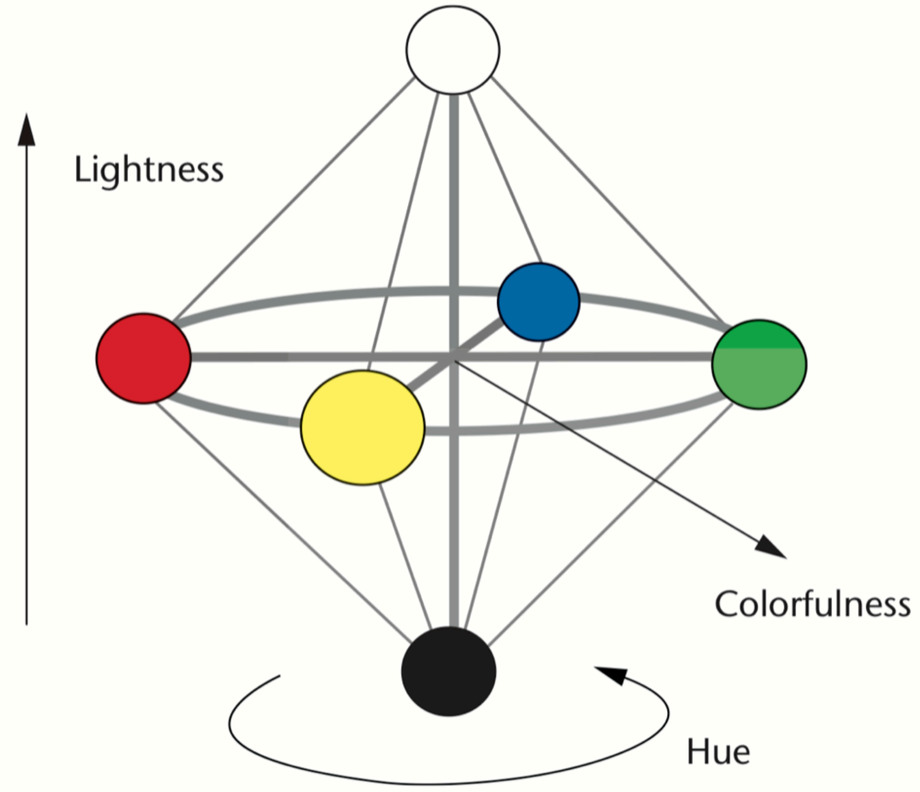
Color

OKLAB Color Space

Oklab is modern version of CIELAB that we recommend

In CSS:

oklch(65% 50% 0)



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JavaScript

Now, let's make our very first data visualization in JS:

`js-lecture/weather02/`

(demo)

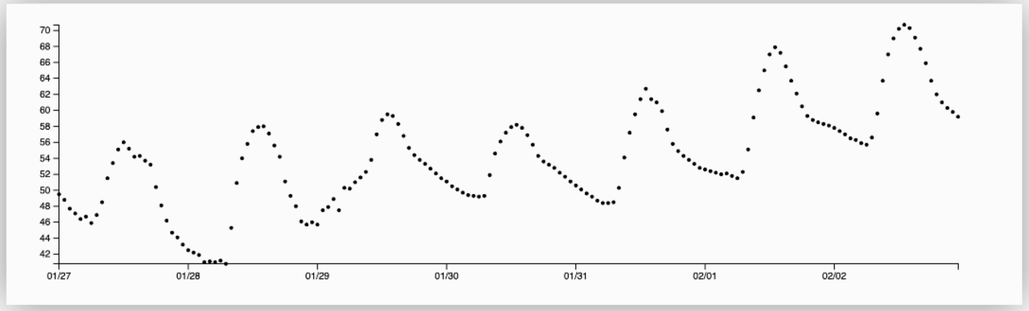
`js-lecture/weather03/`

(demo)

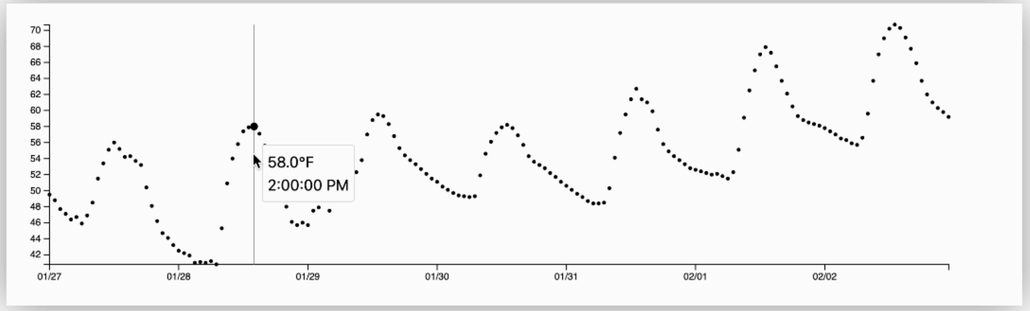
D3

Step 5: Improving our tooltip

Before:



After:



Demo: `d3-lecture/weather05`

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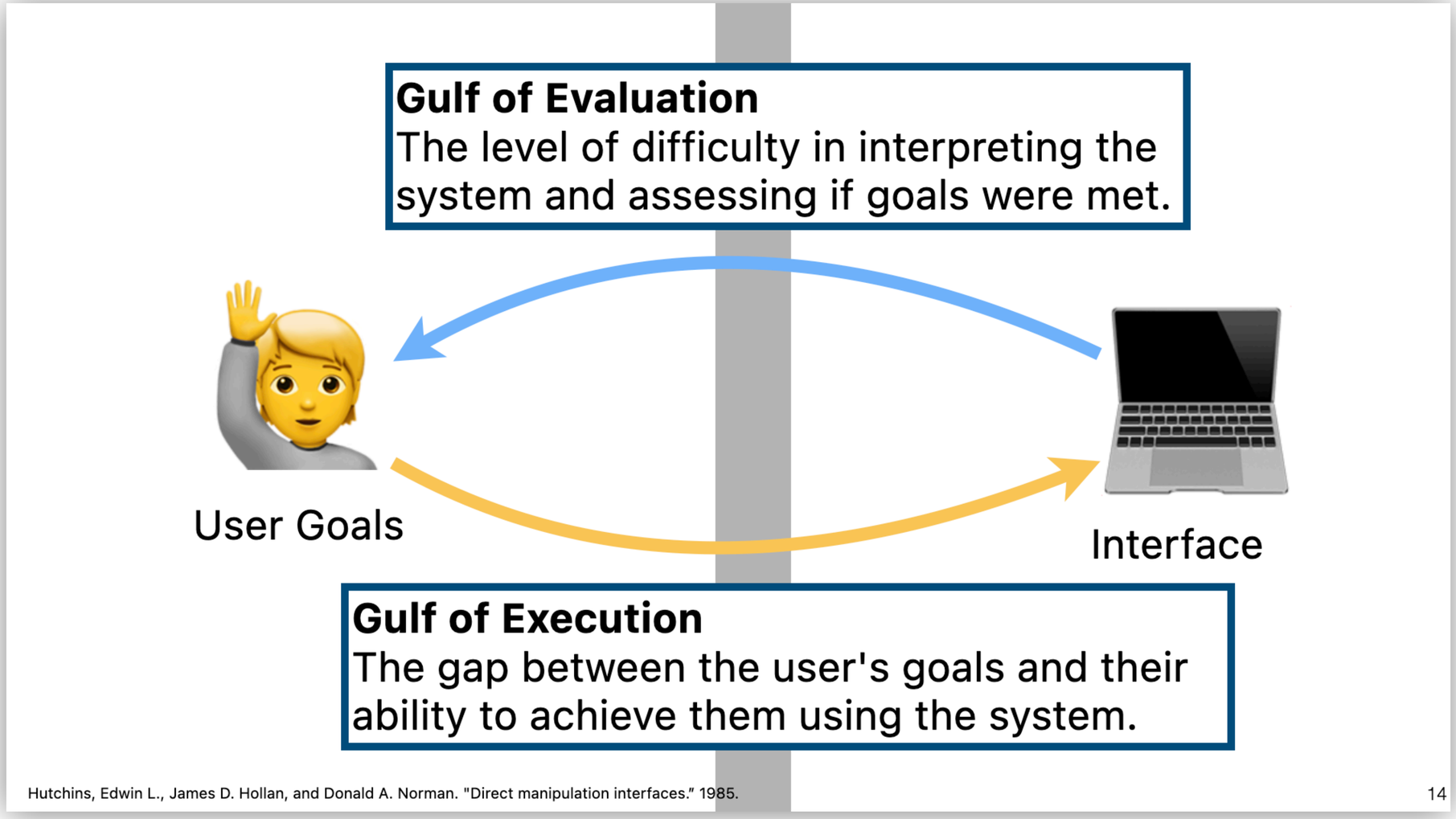
Interaction



Maps

Choropleth

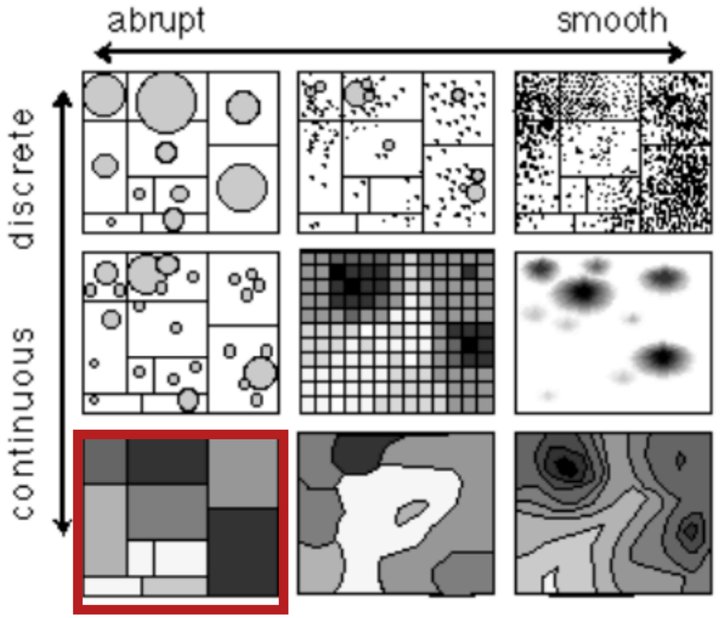
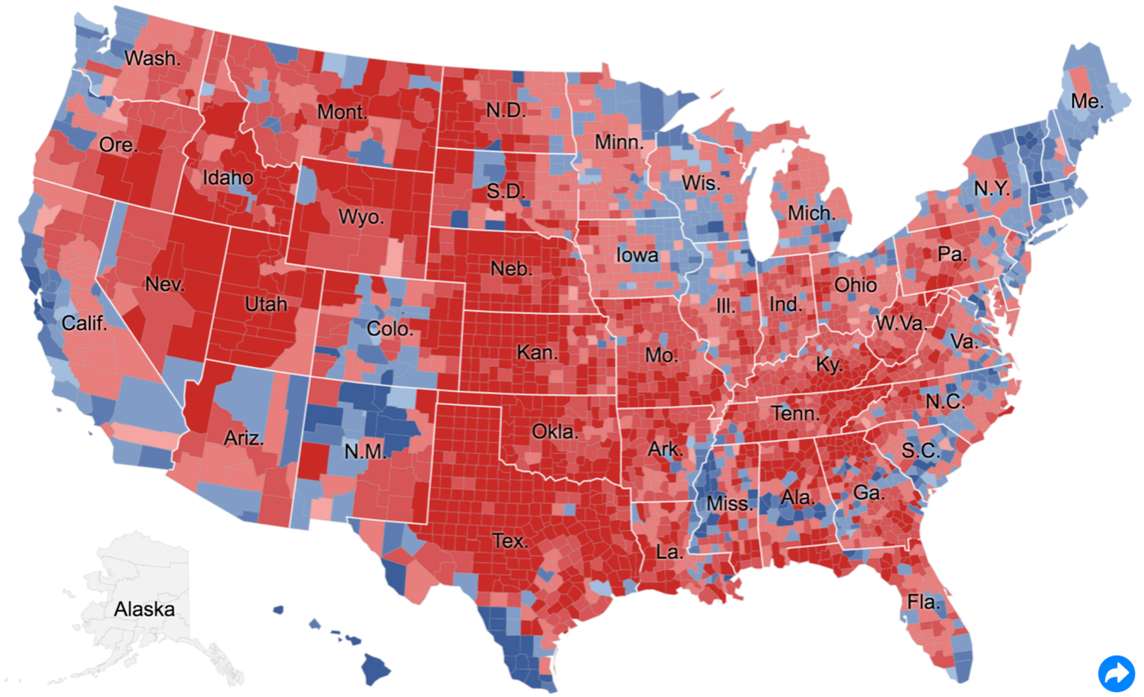


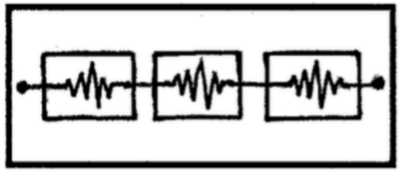
Fig. 9. Possible 2D translations of the 3D data models shown in figure 8.



https://www.nytimes.com/interactive/2016/11/01/upshot/many-ways-to-map-election-results.html

Narrative

Interactive Slideshow



R2
D3

A visual introduction to machine learning

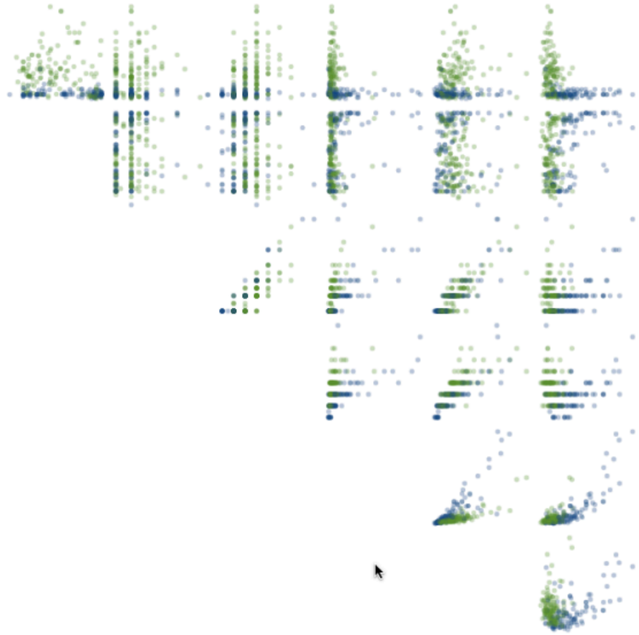
English

In machine learning, computers apply **statistical learning** techniques to automatically identify patterns in data. These techniques can be used to make highly accurate predictions.

Keep scrolling. Using a data set about homes, we will create a machine learning model to distinguish homes in New York from homes in San Francisco.

"Scrolly"-telling

SCROLL



http://www.r2d3.us/visual-intro-to-machine-learning-part-1/

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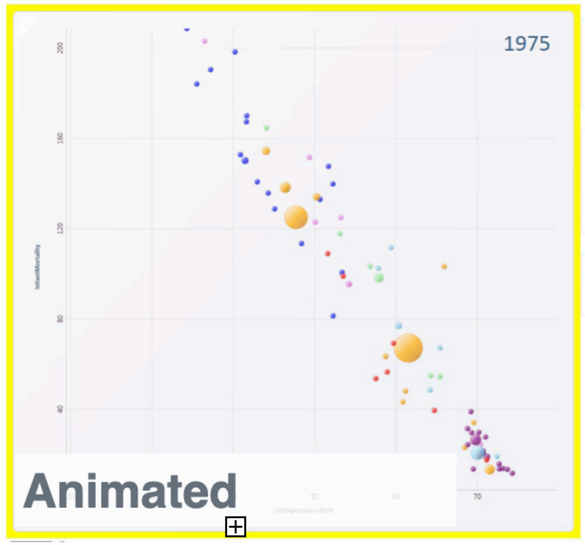
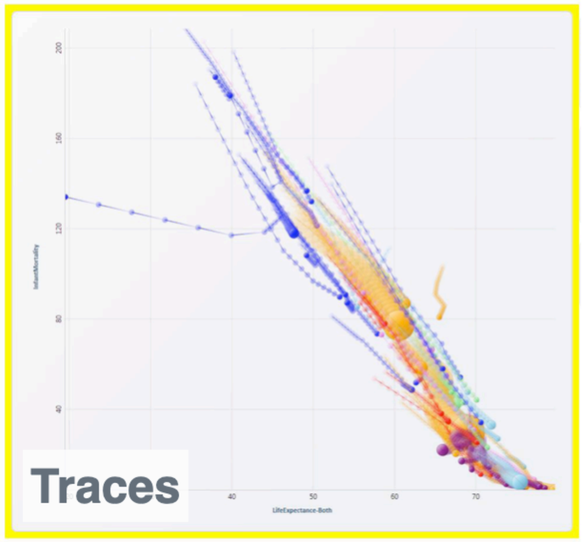
Animation

Study Conclusions

Analysis Task and Presentation Task.
Presentation condition included narration.
Subjects asked comprehension questions.





Which condition would participants:
be more **accurate**, be **faster**, and **prefer**?

tryclassbuzz.com
Code: **anim**

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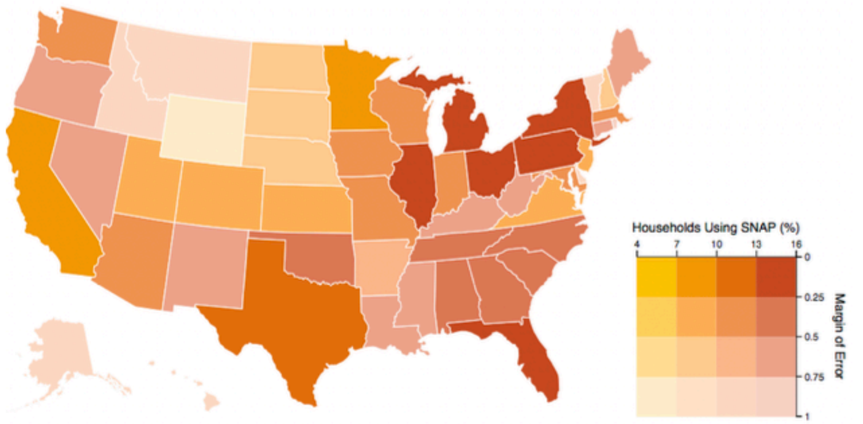
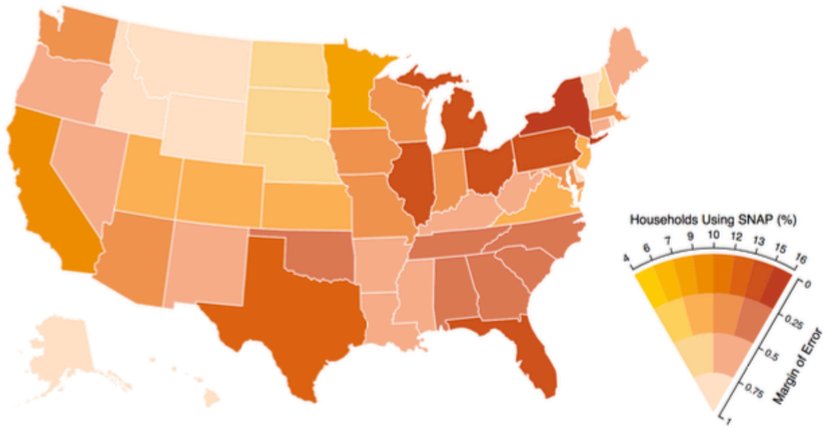
Uncertainty

For uncertainty, use **visual variables** instead of visualizing point estimates





Bivariate Map (Data + Uncertainty)

Value-Suppressing Uncertainty Map

[Correll, Moritz, & Heer, 2018]

Thank You!

TAs: Jacob, Hemanth

As you can see, we're often short on tutors, so consider applying to be a tutor in the future!