

Statistics & Data Science Communication: Tips, Tricks & Thoughts for a New Model of Engagement

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I DON'T UNDERSTAND
HOW MY BRAIN WORKS.

BUT MY BRAIN IS
WHAT I RELY ON
TO UNDERSTAND
HOW THINGS WORK.

IS THAT A PROBLEM?
I'M NOT SURE
HOW TO TELL.

<https://xkcd.com/1163/>

STATISTICAL ERRORS

P values, the 'gold standard' of statistical validity, are not as reliable as many scientists assume.

BY REGINA NUZZO

nature

L'AUTEUR



REGINA NUZZO est journaliste indépendante et professeure de statistiques à l'université Gallaudet de Washington.

La malédiction de la VALEUR-P

L'ESSENTIEL

● La valeur- p désigne la probabilité qu'un résultat statistique ne soit pas le fait du hasard.

Everyone Uses P-Values, But No One Knows What They Are

KEVIN DRUM MARCH 7, 2016 5:01 PM

Mother Jones

I'm probably just wrong. But how about this nickel explanation?

If you're testing a hypothesis with only a limited set of data (for example, proposing that someone is the leader of a presidential race by relying on a survey of only 1,000 people) a p-value is, informally, the probability that the small dataset validated your hypothesis merely by chance.

I suppose that's wrong too in some kind of barely comprehensible way. It always is. But close! And, perhaps, reasonably comprehensible?

"The p-value is the probability that a statistical result is not a coincidence."

34 / POUR LA SCIENCE HORS-SÉRIE N° 98 / Février-Mars 2018

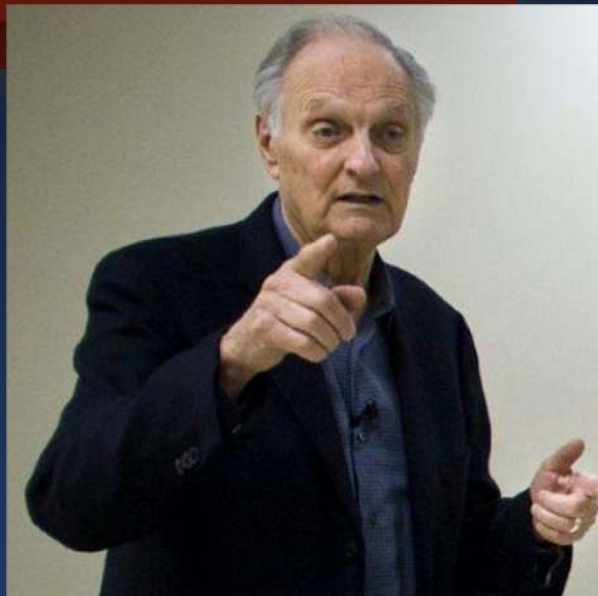
Science communication: a graduate's guide to a growth industry

A centuries-old tradition becomes a necessity in an age of shrinking research budgets

Alan Alda Center
for Communicating Science



AT STONY BROOK UNIVERSITY



“Communication is not something you add on to science; it is the essence of science.”

-Alan Alda

Founding Member of the
Alan Alda Center for Communicating Science

Science Communication Strategies

- ✓ Know your audience
- ✓ Ditch the jargon
- ✗ Don't use too many numbers
- ✗ Be concrete
- ✗ Don't equivocate
- ✗ Tell narratives of discovery

We are unique. We need Human-Centered Quantitative Communication.*

- Risk communication in health behavior
- “Right to explanation” in algorithms and machine learning
- Communication component in the science of team science
- Journalism covering numbers, statistical uncertainty
- Statistics in the courtroom
- ...

*Statistics Communication?
Data Communication?
Ergonomics of Statistics?
Name suggestions welcomed

Numbers

Evidence

Uncertainty

Expectation & Surprise

Numbers

“No one ever made a decision
because of a number.
They need a story.”

-- Daniel Kahneman

Anecdotes → Data → Stories?

The deep history of the number words

Mark Pagel, Andrew Meade

Published 1 January 2018.

**PHILOSOPHICAL TRANSACTIONS
OF THE ROYAL SOCIETY B**

BIOLOGICAL SCIENCES

The New York Times

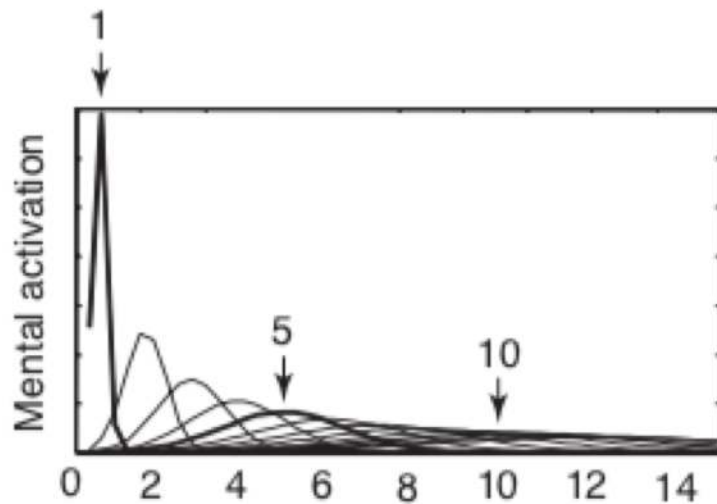
“The sounds that you and I use to say ‘two’ or ‘three’ are the sounds that have been used for tens of thousands of years,” said Mark Pagel, a biologist who studies the evolution of language at the University of Reading.

“It’s not out of the question that you could have been wandering around 15,000 years ago and encountered a few of the last remaining Neanderthals, pointed to yourself and said, ‘one,’ and pointed to them and said, ‘three,’ and those words, in an odd, coarse way, would have been understood.”

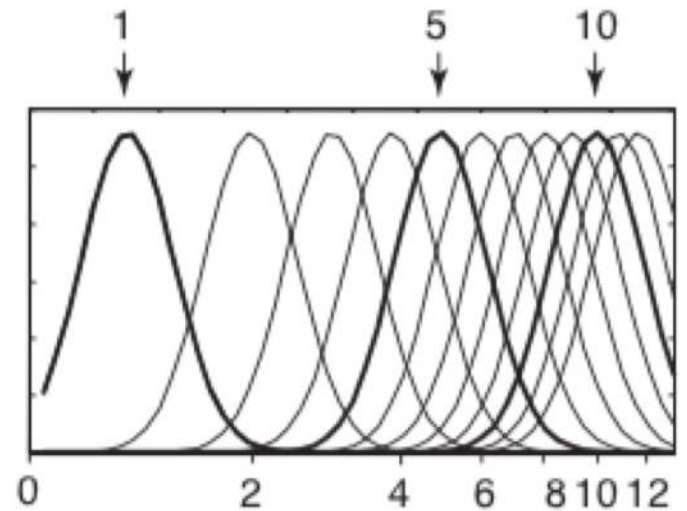
That continuity, Dr. Pagel added, “should astonish us.”

Numerosity on the Log Scale?

(a) Linear model with scalar variability

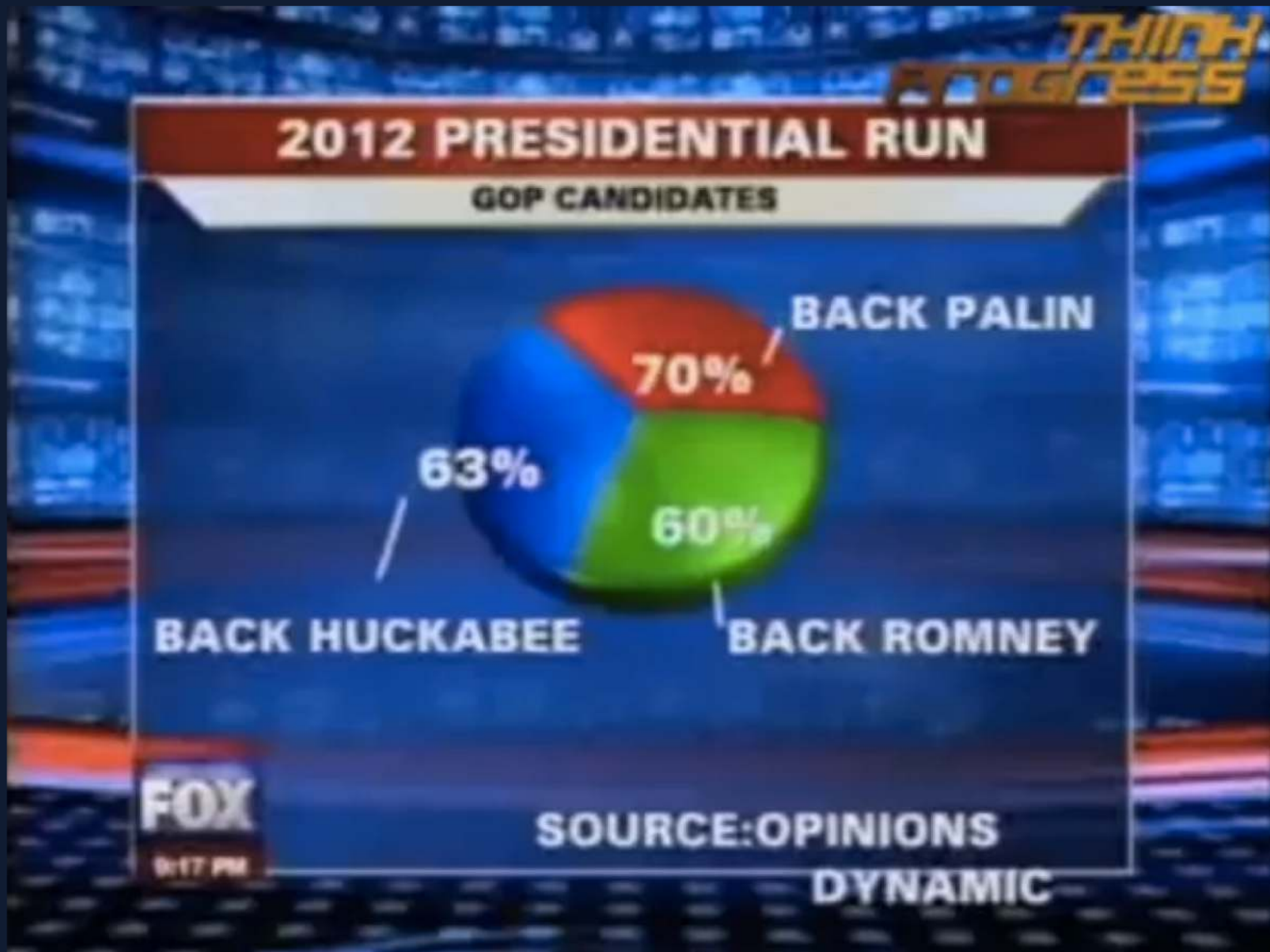


(b) Logarithmic model with fixed variability



TRENDS in Cognitive Sciences

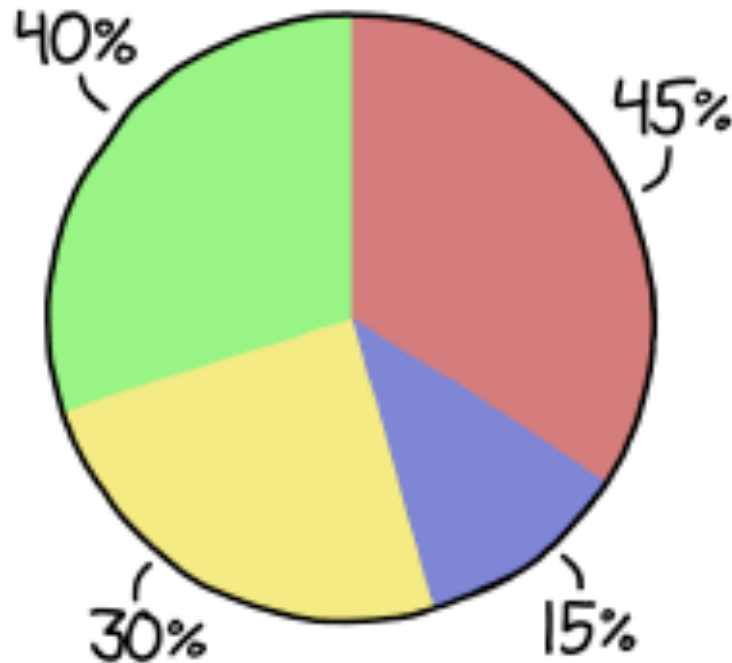
Feigenson, L., Dehaene, S., & Spelke, E. (2004). Core systems of number. *Trends in cognitive sciences*, 8(7), 307-314.



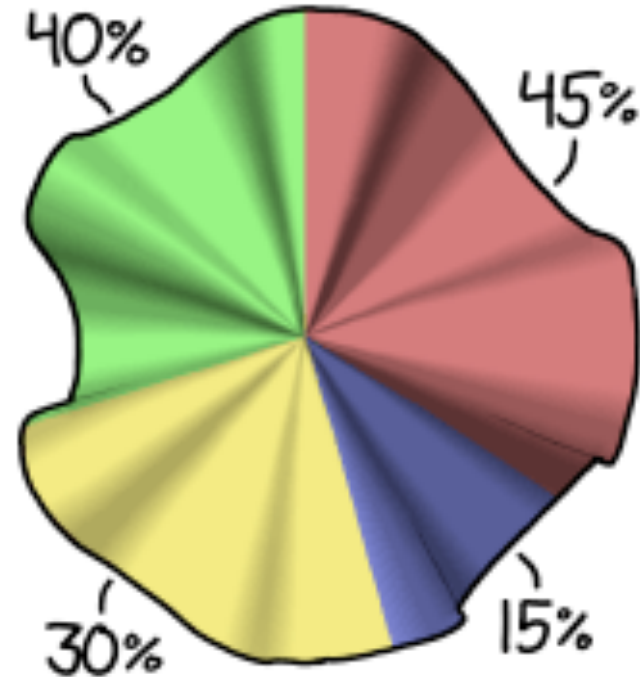
Gigerenzer, G. (1998). Ecological intelligence: An adaptation for frequencies. In *The evolution of mind* (pp. 9-29). Oxford University Press.

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WRONG:



RIGHT:



HOW TO MAKE A PIE CHART IF YOUR
PERCENTAGES DON'T ADD UP TO 100

$$\text{bits of "surprisal"} = -\log_2 p \approx -\frac{\log(p)}{0.3}$$

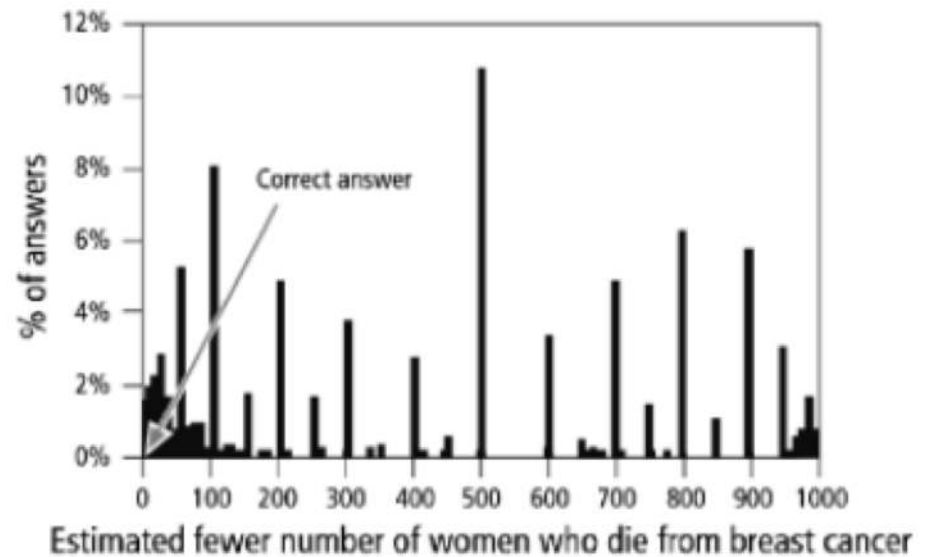
Can we take advantage
of our internal log
scale and love of
natural numbers?

Royal flush	0.0000015	predicting	~ 19 coin flips
Snake eyes	0.028		~ 5
$p = 0.05$			4.3
$p = 0.001$			10
Evidence for Higgs boson			25
Being struck by lightning	0.00000038		18
California Powerball win	0.00000000037		28

“Early detection with mammography reduces the risk of dying from breast cancer by 25%. Assume that 1,000 women aged 40 and older participate regularly in screening. How many fewer would die of breast cancer?”

Three out of 10 of German gynecologists answered: 250 fewer women would die.

(Reality: About one fewer woman would die.)



Gigerenzer, Gerd, et al. "Helping doctors and patients make sense of health statistics." *Psychological science in the public interest* 8.2 (2007): 53-96.

Relative or Absolute Numbers?

Researchers estimate women who are regularly screened are 21% less likely to die of breast cancer.

Researchers estimate that over a 15-year period, the chances of a woman dying of breast cancer if she's not screened are 0.52%. That number will drop to 0.41% with regular screening.

Gigerenzer, Gerd, et al. "Helping doctors and patients make sense of health statistics." Psychological science in the public interest 8.2 (2007): 53-96.

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Percentages or Natural Numbers?

Researchers estimate that over a 15-year period, the chances of a woman dying of breast cancer if she's not screened are 0.52%. That number will drop to 0.41% with regular screening.

Researchers estimate that for every 10,000 women who are not screened, about 52 will die of breast cancer over 15 years, compared to about 41 who will die even if they are screened.

Big Denominators or Tribe-Sized Denominators?

... for every 10,000 women who are not screened, about 52 will die of breast cancer over 15 years, compared to about 41 who will die even if they are screened.

... for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, compared to about 4 who will die even if they are screened.

... for every 10,000 women who are not screened, about 52 will die of breast cancer over 15 years, compared to about 41 who will die even if they are screened.

... for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, compared to about 4 who will die even if they are screened.

... for every 100 women who are not screened, about 0.5 will die of breast cancer over 15 years, compared to about 0.4 who will die even if they are screened.

Varying Denominator or Varying Numerator?

... without regular screening, about one in every 192 women will die of breast cancer over a 15-year period, compared to one in about 244 who do get screening.

... for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, but this number will drop to only about 4 deaths for women who are screened.

Lung Cancer Patients Live Longer With Immune Therapy

By DENISE GRADY APRIL 16, 2018

Odds of survival can greatly improve for people with the most common type of lung cancer if they are given a new drug that activates the immune system along with chemotherapy, a major new study has shown.

paragraph 1 of 23

After a median follow-up of 10.5 months, those in the immunotherapy group were half as likely to die. The median overall survival was 11.3 months in those who did not receive immunotherapy, whereas survival in the immunotherapy group was longer and the median has not yet been reached.

paragraph 17 of 23

The estimated survival at 12 months was 69.2 percent in the group that received immunotherapy, and 49.4 percent in those who did not.

paragraph 19 of 23

ORIGINAL ARTICLE

Pembrolizumab plus Chemotherapy in Metastatic Non–Small-Cell Lung Cancer

L. Gandhi, D. R. ...
F. De Angelis, M. Domir ...
H.G. Bischoff, N. Pele ...
M. Boyer, B. Rubio-Vi ...
J. Yang, H. Ra ...
fo

RESULTS

After a median follow-up of 10.5 months, the estimated rate of overall survival at 12 months was 69.2% (95% confidence interval [CI], 64.1 to 73.8) in the pembrolizumab-combination group versus 49.4% (95% CI, 42.1 to 56.2) in the placebo-combination group (hazard ratio for death, 0.49; 95% CI, 0.38 to 0.64; $P < 0.001$).

The New York Times

The estimated survival at 12 months was 69.2 percent in the group that received immunotherapy, and 49.4 percent in those who did not. paragraph 19 of 23

VS.

For every 100 patients on the regular treatment, about 49 were still alive after one year. That number rose to about 69 for those who had the immunotherapy.

After a median follow-up of 10.5 months, the estimated rate of overall survival at 12 months was 69.2% (95% confidence interval [CI], 64.1 to 73.8) in the pembrolizumab-combination group versus 49.4% (95% CI, 42.1 to 56.2) in the placebo-combination group (hazard ratio for death, 0.49; 95% CI, 0.38 to 0.64; $P < 0.001$).

The median overall survival was not reached in the pembrolizumab-combination group and was 11.3 months (95% CI, 8.7 to 15.1) in the placebo-combination group (hazard ratio for death, 0.49; 95% CI, 0.38 to 0.64; $P < 0.001$) (Fig. 1A). The

PROGRESSION-FREE SURVIVAL

With 410 events of progression or death, the median progression-free survival was 8.8 months (95% CI, 7.6 to 9.2) in the pembrolizumab-combination group and 4.9 months (95% CI, 4.7 to 5.5) in the placebo-combination group (hazard ratio for progression or death, 0.52; 95% CI, 0.43 to 0.64;

After a median follow-up of 10.5 months, those in the immunotherapy group were half as likely to die. The median overall survival was 11.3 months in those who did not receive immunotherapy, whereas survival in the immunotherapy group was longer and the median has not yet been reached.

paragraph 17 of
23

VS.

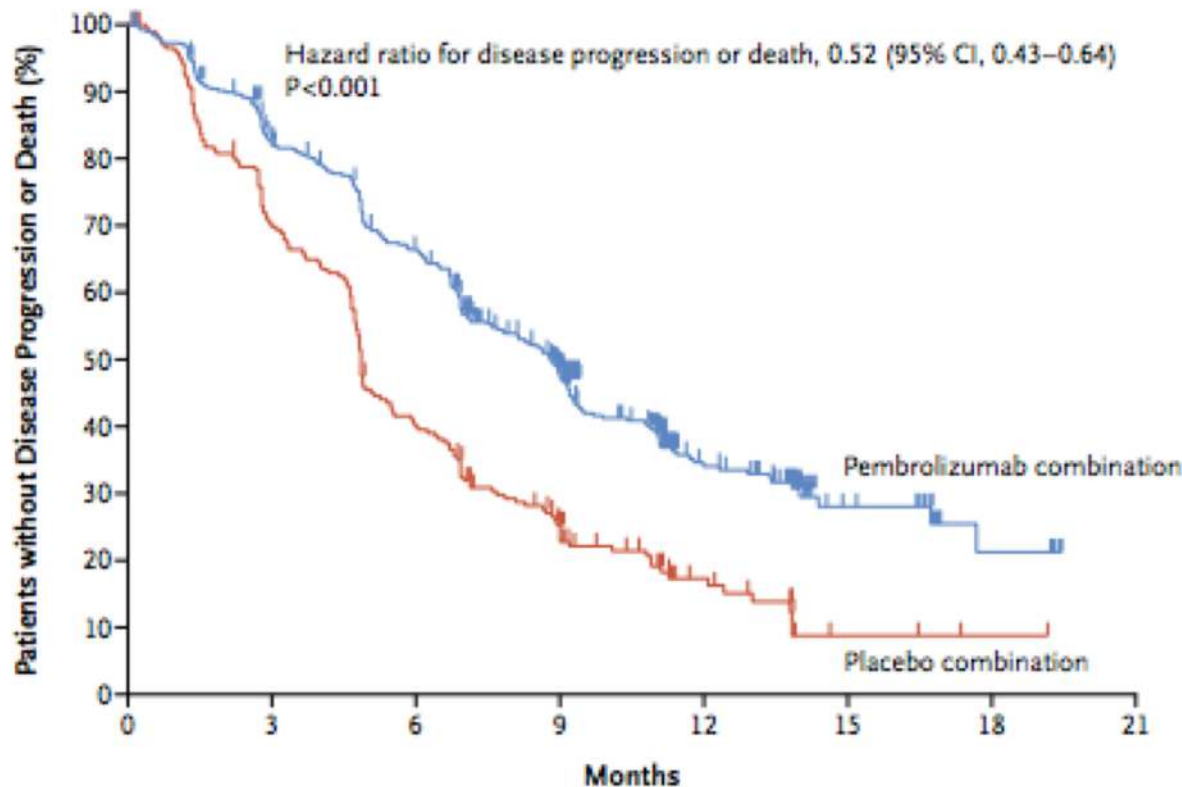
The researchers also looked at how much the cancers in each group progressed. For every 100 patients on the regular treatment, about 50 lived at least five months progression-free; for those on immunotherapy, that number rose to almost nine months.

Open Questions: Positive vs Negative Framing

For every 100 patients on the regular treatment, about 51 died within a year. For those who had the immunotherapy, that number dropped to about 31.

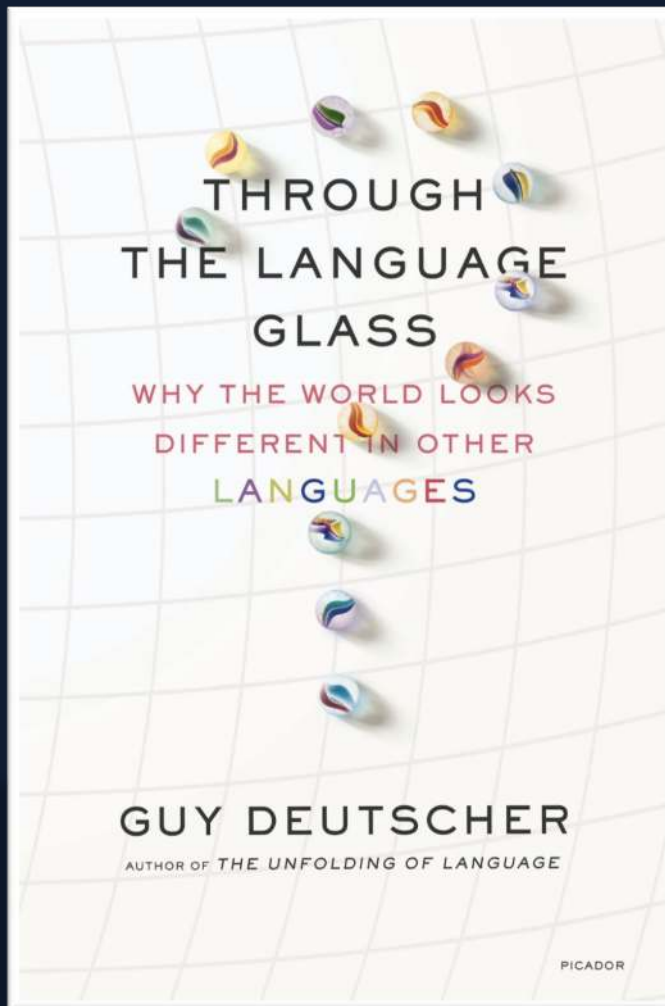
For every 100 patients on the regular treatment, about 49 were still alive after one year. For those who had the immunotherapy, that number rose to about 69.

Open Questions: Where to slice?



For every 100 patients on the regular treatment, about 50 lived at least 5 months progression-free; for those on immunotherapy, that number rose to almost nine months.

Evidence



Evidentiality in verb form:

Direct experience?

Inferred from experience?

Conjecture?

Hearsay?



The Voice of America @VOANews · 2h

.@PressSec Spicer: This was the largest audience to ever witness an inauguration, period.



WH Press Secretary Sean Spicer delivers remarks

179 31 33

MAYBE ELECTION POLLS AREN'T BROKEN AFTER ALL

“Ultimately it would be nice if we could assess polls on their methodologies and inputs and not just on the output,” Cohen says. “But that’s the long game.” And it’s worth keeping in mind when you start clicking on those mid-term election polling results this spring.

Jon Cohen, chief research officer at SurveyMonkey.

That Huge Mediterranean Diet Study Was Flawed. But Was It Wrong?

The New York Times

A highly publicized trial in Spain found that the Mediterranean diet protects against heart disease. Now the original work has been retracted and re-analyzed, with the same result.

By Gina Kolata

June 13, 2018



The idea of a randomized trial is to assign treatments — in this case, diets — to participants with the statistical equivalent of a coin toss. That way, the groups being compared should be equivalent, with no group healthier or sicker, or older or younger, than another on average.

If subjects are not assigned at random, the investigators cannot be sure that the effects they see result from the treatment. And attempts to correct statistically after the fact are fraught with difficulty.

That Huge Mediterranean Diet Study Was Flawed. But Was It Wrong? **The New York Times**

A highly publicized trial in Spain found that the Mediterranean diet protects against heart disease. Now the original work has been retracted and new analysis suggests the diet may be even better.

By Gina Kolata

June 13, 2018

Despite serious problems in the way the study was conducted, their conclusions are the same: A Mediterranean diet can cut the risk of heart attacks and strokes by about 30 percent in those at high risk.

The investigators spent a year working on the re-analysis in collaboration with Dr. Miguel Hernan of the Harvard T.H. Chan School of Public Health.

In the end, they concluded that the original findings were still accurate.

“These people were naïve,” said Donald Berry, a statistician at MD Anderson Cancer Center in Houston. “They were sloppy and didn’t know they were being sloppy.”

Dr. Berry said he wants to believe the results. He loves nuts and has taken to cooking with extra virgin olive oil.

But he remains unconvinced, because the re-analysis did not solve the study’s problems, he said.

Dr. Bradley Efron, a statistics professor at Stanford University, also was skeptical. The revamped results “wouldn’t convince me to be on a Mediterranean diet,” he said.

Mediterranean Diet Study Walks Back Strongest Claim. Here's What Researchers Got Wrong

FORTUNE

By [GLENN FLEISHMAN](#) June 14, 2018

Don't put down the Greek olives and fresh fish just yet, but the widely recommended Mediterranean Diet is short a few nuts.

The New England Journal of Medicine has retracted [the initial version of the landmark](#) study published in 2013, and [published a revised version](#) that no longer makes the broad claim the diet could help everyone who is at a high risk of cardiovascular disease.

The original conclusion was: "Among persons at high cardiovascular risk, a Mediterranean diet supplemented with extra-virgin olive oil or nuts reduced the incidence of major cardiovascular events."

The revised conclusion: "In this study involving persons at high cardiovascular risk, the incidence of major cardiovascular events was lower among those assigned to a Mediterranean diet supplemented with extra-virgin olive oil or nuts than among those assigned to a reduced-fat diet."

Now, it will need to be scoped even further: If you don't live in the Mediterranean, following this diet may or may not help reduce your risks.

The credibility interval of this column is hard to figure | Shad Plank

Daily Press

DECEMBER 18, 2015, 4:01 PM

Reuters/Ipsos pegged his support at 35 percent of Republicans. The poll had a "credibility interval" of 5 percentage points, Reuters said.

The explanation started this way:

"The credibility interval assumes that Y has a binomial distribution conditioned on the parameter θ , i.e., $Y|\theta \sim \text{Bin}(n, \theta)$... Here, ' Y ' is the answer, in this case that a Republican supports Trump, ' n ' is the size of the sample and ' θ ' is the proportion of the population that actually would answer ' Y ' (Trump)."

It gets better, of course: "In effect, $\pi(\theta) \sim \beta(a, b)$ is a useful representation of our prior knowledge about the proportion θ , while β , the posterior distribution is also a beta distribution ($\pi(\theta/y) \sim \beta(y+a, n-y+b)$)."

Exactly.

Uncertainty

Who will win the presidency?



Chance of winning



Hillary Clinton

71.4%

Donald Trump

28.6%



What I Was Wrong About This Year

The New York Times



By David Leonhardt

Dec. 24, 2017

But I've come to realize that I was wrong about a major aspect of probabilities.

But I now think explanation is doomed to fail. For an individual event, people can't resist saying that a probability was "right" if it was above 50 percent and "wrong" if it was below 50 percent. When this happens, those of us who believe in probabilities can't just shake our heads and mutter about white Christmases. We have to communicate more effectively.

Projecting Confidence: How the Probabilistic Horse Race Confuses and Demobilizes the Public

67 Pages • Posted: 12 Feb 2018

[Sean Westwood](#)

Dartmouth College

[Solomon Messing](#)

Pew Research Center - Data Labs

[Yphtach Lelkes](#)

University of Pennsylvania

Date Written: February 2, 2018

A Taxonomy of Uncertainty

1st Order: Aleatory

- “Risk”
- What is random here?
- What is unknowable to us humans?

2nd Order: Epistemic

- “Confidence intervals”
- How uncertain are we about the parameters (or summaries or results)?
- What knowledge do we humans lack?

3rd Order: Ontological

- “Ignorance”
- What are the unknown unknowns?
- What do we need humility around?

"There is a 95% chance that the true percentage of people supporting Romney is between 44 and 50 percent."

-- "Understanding a 'credibility interval,'" AAPOR (2012)

“The researchers judge that based on their models, knowledge of other information, and this batch of data, the odds are 19-to-1 that the true proportion of Romney supporters is between 44 and 50 percent.”

Fox, C. R., & Ülkümen, G. (2017). Comment on Løhre & Teigen (2016). “There is a 60% probability, but I am 70% certain: communicative consequences of external and internal expressions of uncertainty”. *Thinking & Reasoning*, 23(4), 483-491.

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New Ebola Vaccine Gives 100 Percent Protection

By DONALD G. McNEIL Jr. DEC. 22, 2016

In a scientific triumph that will change the way the world fights a terrifying killer, an experimental Ebola vaccine tested on humans in the waning days of the West African epidemic has been shown to provide 100 percent protection against the lethal disease.

The Lancet study was done in 11,841 residents of Guinea last year. Among the 5,837 people who got the vaccine, none came down with Ebola 10 or more days later. There were 23 Ebola cases among the thousands of others not immediately vaccinated.

Paragraph 11 out of 24

THE LANCET

Efficacy and effectiveness of an rVSV-vectored vaccine in preventing Ebola virus disease: final results from the Guinea ring vaccination, open-label, cluster-randomised trial (Ebola Ça Suffit!)

www.thelancet.com Vol 389 February 4, 2017

No cases of Ebola virus disease occurred 10 days or more after randomisation among randomly assigned contacts and contacts of contacts vaccinated in immediate clusters versus 16 cases (7 clusters affected) among all eligible individuals in delayed clusters. Vaccine efficacy was 100% (95% CI 68·9–100·0, $p=0\cdot0045$), and the calculated intraclass correlation coefficient was 0·035. Additionally, we defined 19 non-randomised clusters in which we enumerated 2745 contacts and contacts of contacts, 2006 of whom were eligible and 1677 were immediately

New Ebola Vaccine Gives 100 Percent Protection in Trial

Epistemic:

It's not guaranteed that the vaccine will be 100 percent effective in the real world. Right now, researchers' best guess at a comfortable level of confidence is that it will be at least 69 percent effective.

Aleatory:

If true, that means that for every 100 people who get the vaccine, at least 69 of them will be fully protected against the virus. (It doesn't mean that each person will be 69 percent protected.)

Ontological:

Researchers will have a better estimate of the true efficacy after more studies. It seems certain, however, that ...

There are other important questions around the vaccine. For example ...

First Ebola Vaccine Likely To Stop The Next Outbreak

December 22, 2016 · 6:31 PM ET

Heard on Morning Edition



MICHAEELEEN DOUCLEFF



When Ebola struck West Africa a few years ago, the world was defenseless. There was no cure. No vaccine. And the result was catastrophic: More than 11,000 people died. Nearly 30,000 were infected.

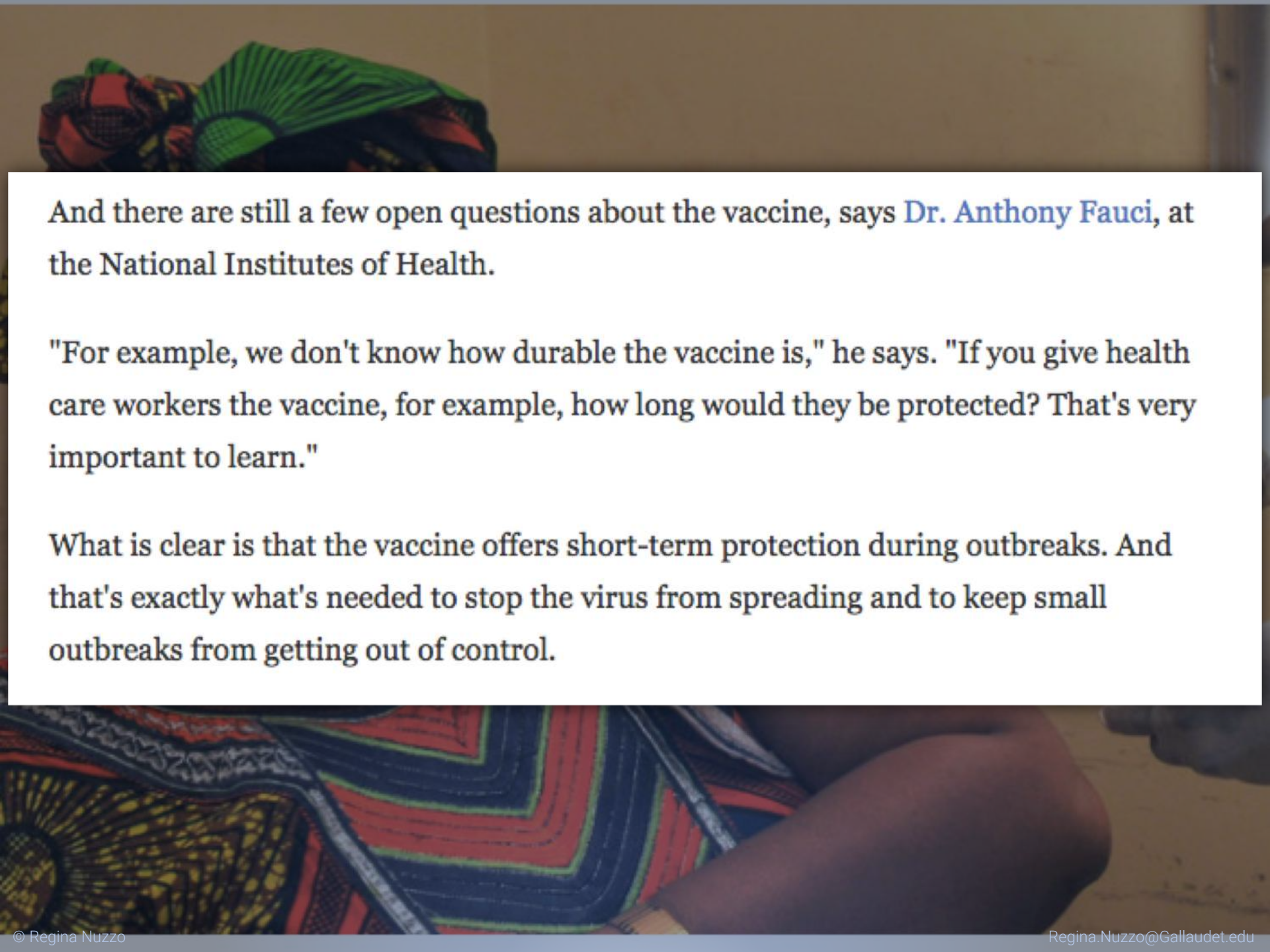
Now it looks like such a large outbreak is unlikely to ever happen again. Ever.

The world now has a potent weapon against Ebola: a vaccine that brings outbreaks to a screeching halt, scientists [report](#) Thursday in *The Lancet*.

"We were able to estimate the efficacy of the vaccine as being 100 percent in a trial," says [Ira Longini](#), a biostatistician at the University of Florida, who helped test the vaccine. "It's very unusual to have a vaccine that protects people perfectly."

Now, no vaccine — or drug for that matter — is *perfect*. The efficacy of the vaccine is clearly high but not "100 percent." That value reflects the fact that they just haven't tested the vaccine on enough people yet. So it is likely to decrease as the vaccine is used over time. In the end, the efficacy is likely to sit somewhere between about 70 percent and 100 percent, Longini says.

By comparison, the flu vaccine last year was about 50 percent effective.

A person wearing a green and red patterned headwrap is visible in the top left corner of the image.

And there are still a few open questions about the vaccine, says [Dr. Anthony Fauci](#), at the National Institutes of Health.

"For example, we don't know how durable the vaccine is," he says. "If you give health care workers the vaccine, for example, how long would they be protected? That's very important to learn."

What is clear is that the vaccine offers short-term protection during outbreaks. And that's exactly what's needed to stop the virus from spreading and to keep small outbreaks from getting out of control.

The Lawfare Podcast, Special Edition: The Kushercast

By Benjamin Wittes Tuesday, May 30, 2017, 9:01 PM

“What do we know?”

“What are the facts in question?”

“How confident are we in what we know?”

“What are the open questions?”

“Is there a path for resolving these questions?”

“If I were [on the Senate intelligence committee],
what should I be doing now?”

Expectation & Surprise

“Organisms only learn when events violate their expectations.”

-- psychologists Robert Rescorla and Allen Wagner (1972)

Context + New Evidence = Updated Knowledge

```
graph TD; A[Context + New Evidence = Updated Knowledge] --> B[How much? What does that mean in human-centered terms?]; A --> C[Compared to what? What would I otherwise expect?];
```

How much?
What does that mean in
human-centered terms?

Compared to what?
What would I
otherwise expect?

$\text{Context} + \text{New Evidence} = \text{Updated Knowledge}$

$\text{Expectation} + \text{Surprise} = \text{Learning}$

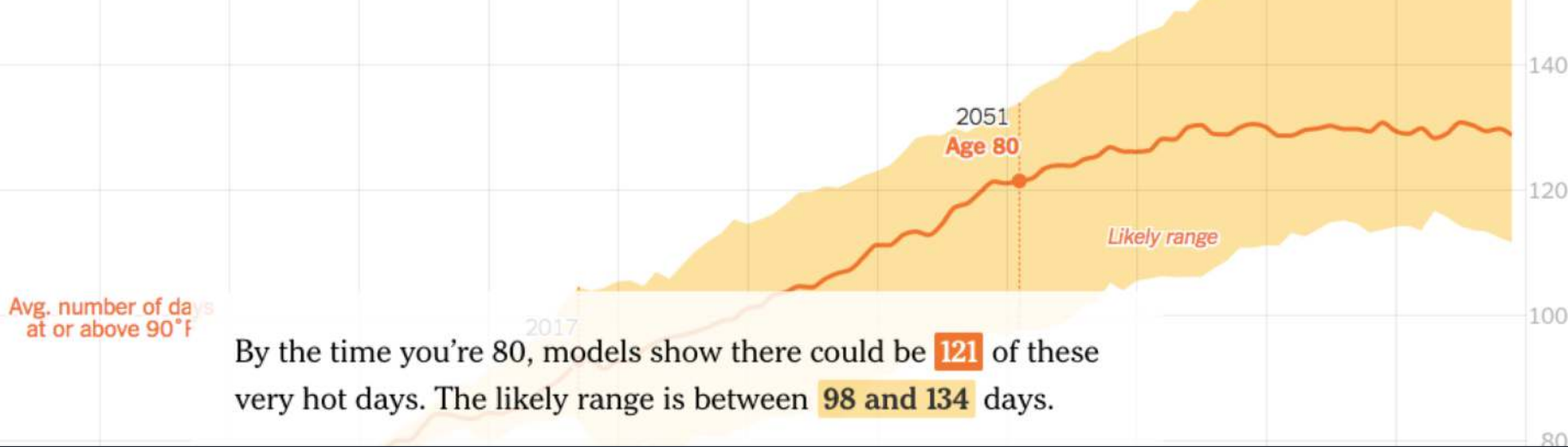


“Mirativity”: Conveying prior expectations through language

What’s more, about twice as many social media users say they mostly *distrust* rather than trust the science posts they see on these sites. This finding is in line with internet users’ very low assessment of the trustworthiness of information more generally that they see on social media.²

Many in the scientific community have worried over how such media influence public impressions of, support for and understanding of science.³ The new Pew Research Center survey finds that while most Americans believe such sources sacrifice realism for

And, just 16% of Americans perceive their family and friends to be accurate sources of science news, far fewer than say general news outlets and most specialty sources get the facts right about science news most of the time. This finding is broadly consistent with a 2016 report that shows that

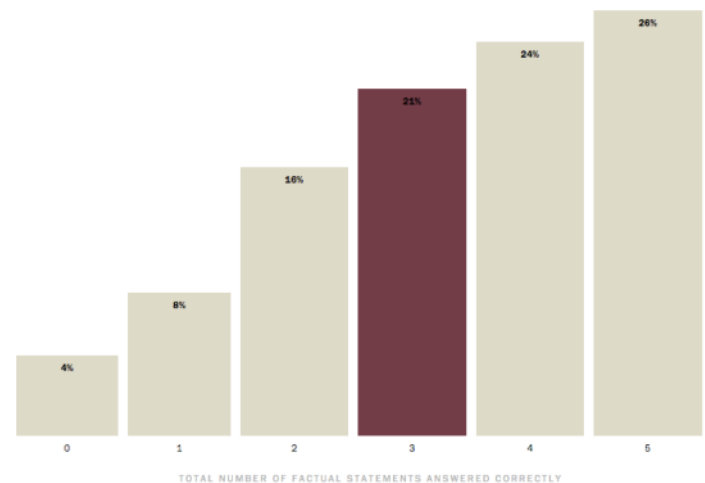


Quiz: How well can you tell factual from opinion statements?



Can you tell the difference between factual and opinion news statements?

You scored better than 28% of the public, below 50% of the public and the same as 21%.

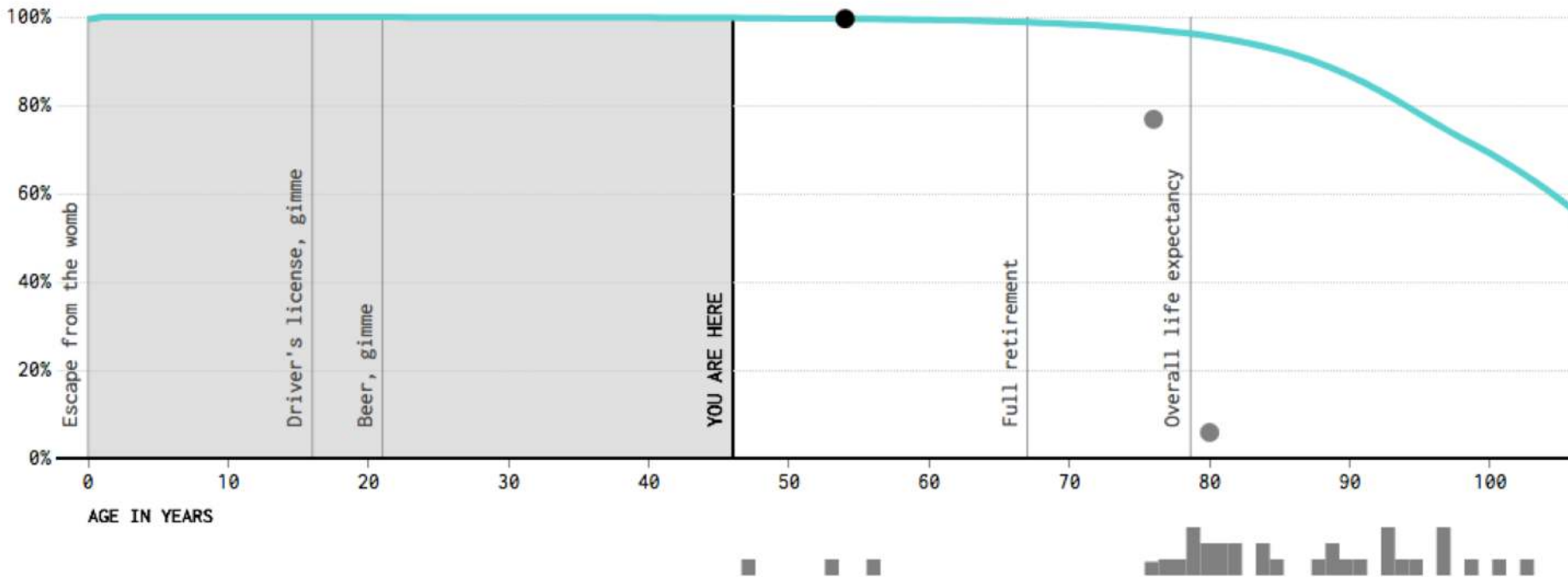


Years You Have Left to Live, Probably



I am female and currently 46 years old.

PROBABILITY OF LIVING TO NEXT YEAR



Probabilities For Years Left to Live

0 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 or more
6%	3%	0%	41%	29%	21%
(2)	(1)	(0)	(14)	(10)	(7)

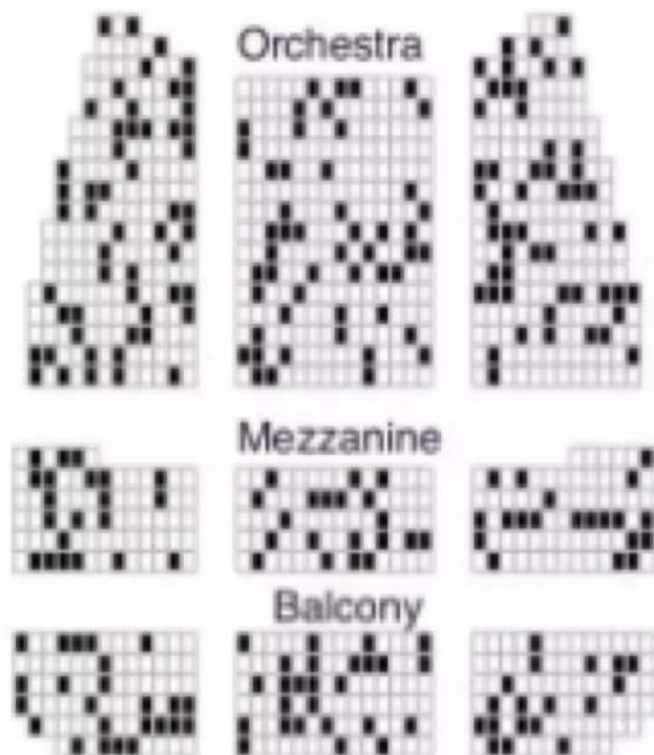
How to better communicate election forecasts – in one simple chart

The Washington Post
Democracy Dies in Darkness

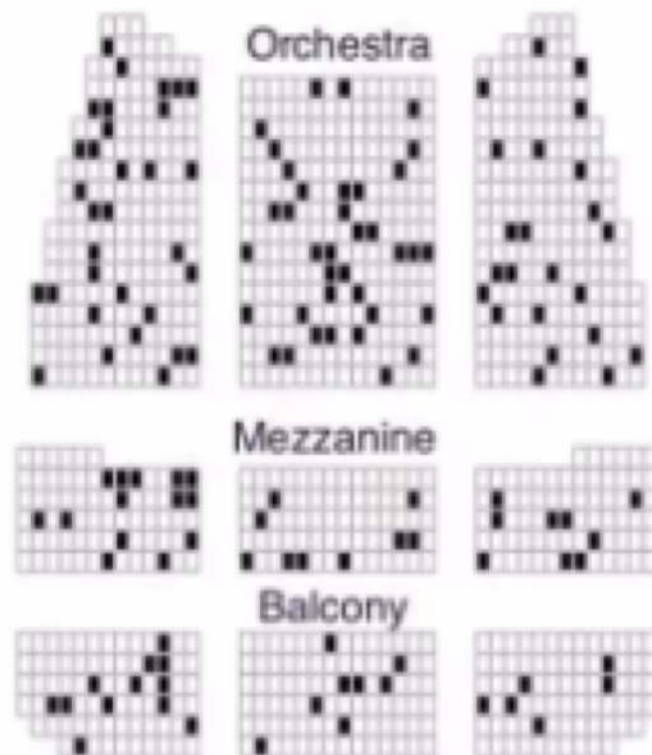
By Justin H. Gross November 29, 2016

FiveThirtyEight: Trump's Chances

NYT Upshot: Trump's Chances



286 cases in 1,000

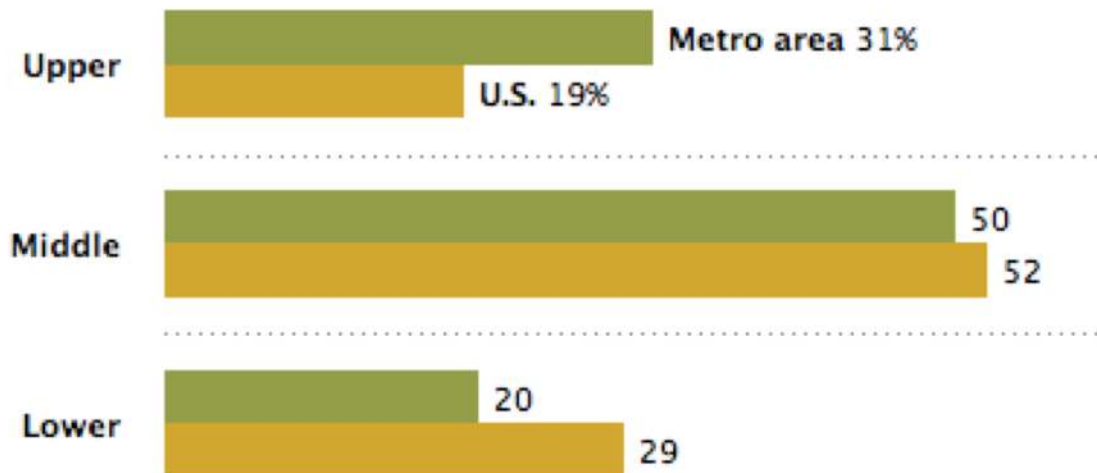


150 cases in 1,000

Based on your household income and the number of people in your household, **YOU** are in the **MIDDLE** income tier, along with **50%** of adults in **WASHINGTON-ARLINGTON-ALEXANDRIA**.

Washington-Arlington-Alexandria

SHARE OF ADULTS IN EACH INCOME TIER IN YOUR METRO AREA AND IN THE U.S.



<http://www.pewresearch.org/fact-tank/2018/09/06/are-you-in-the-american-middle-class/>



I'm gonna choke you,
Nate Silver.

THE DAILY SHOW WITH TREVOR NOAH

**EXCLUSIVE - NATE SILVER
EXTENDED INTERVIEW**

Clip • 11/14/2016



TWENTY QUESTIONS

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Thank
you!

