Communicating Probabilities and Risk

(and weather)

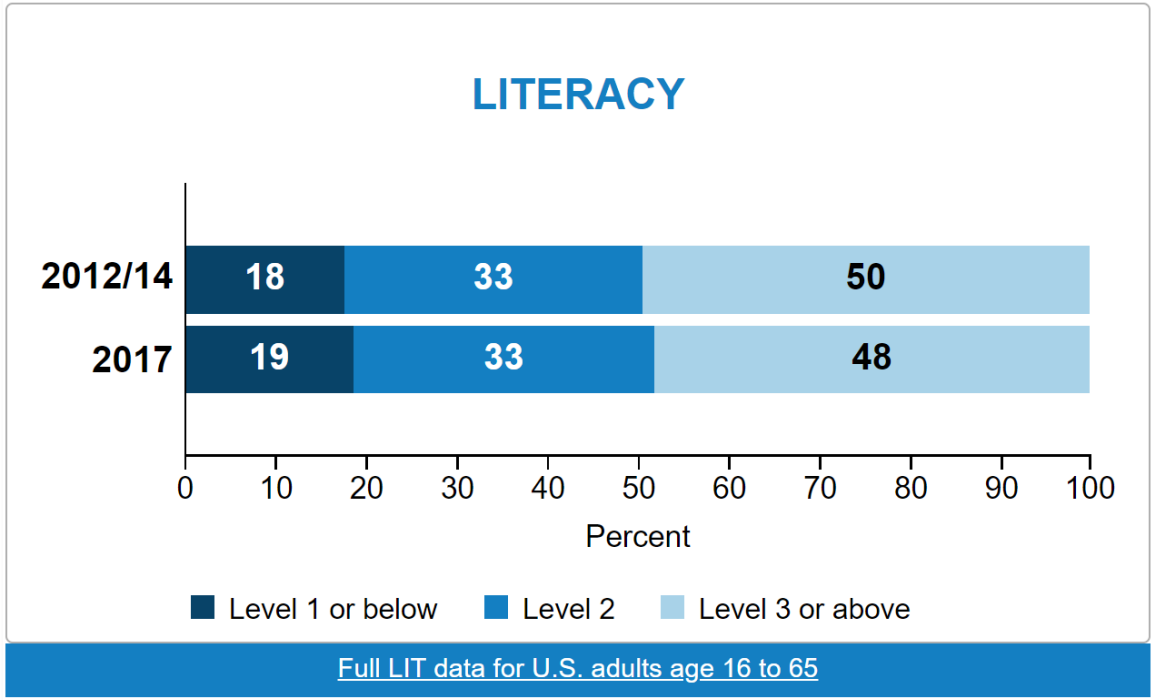
"Medicine is a science of uncertainty and an art of probability."

-- Sir William Osler (1849-1919)

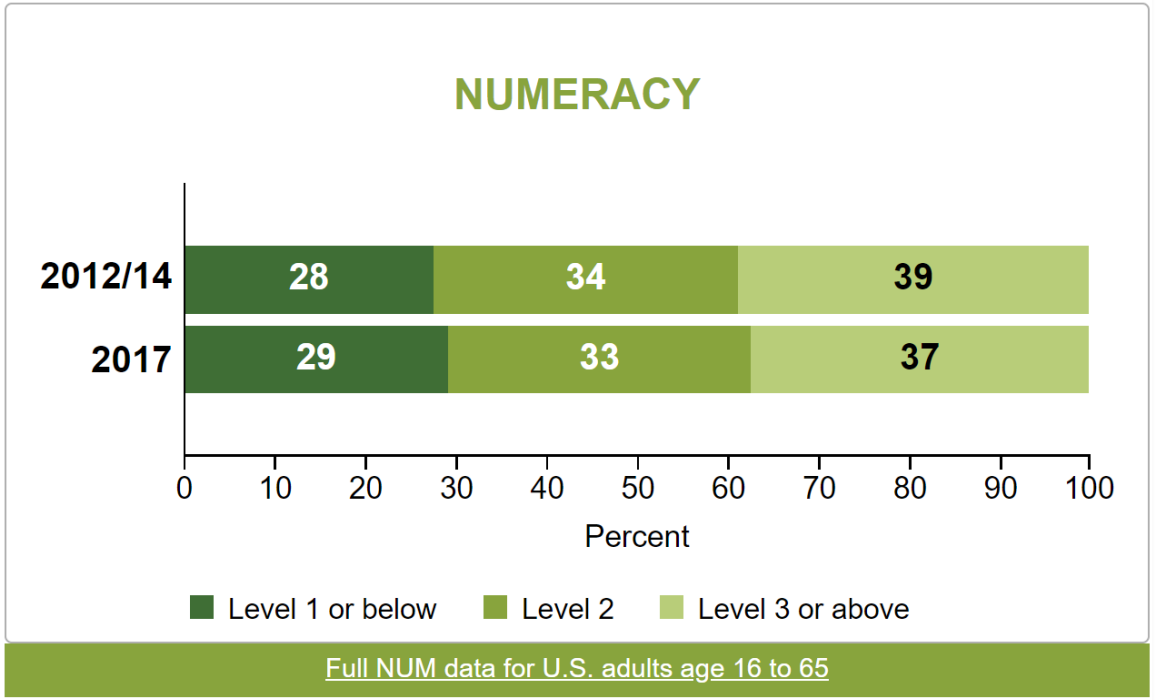
Robbie Berg, NHC Senior Hurricane Specialist
WMO RA-IV Workshop on Hurricane Forecasting and Warning
March 4, 2022

Parallels Between Literacy and Numeracy

Why is it difficult to communicate probabilistic information?



Full LIT data for U.S. adults age 16 to 65



Full NUM data for U.S. adults age 16 to 65

U.S. Department of Education, National Center for Education Statistics
Program for the International Assessment of Adult Competencies (PIAAC)

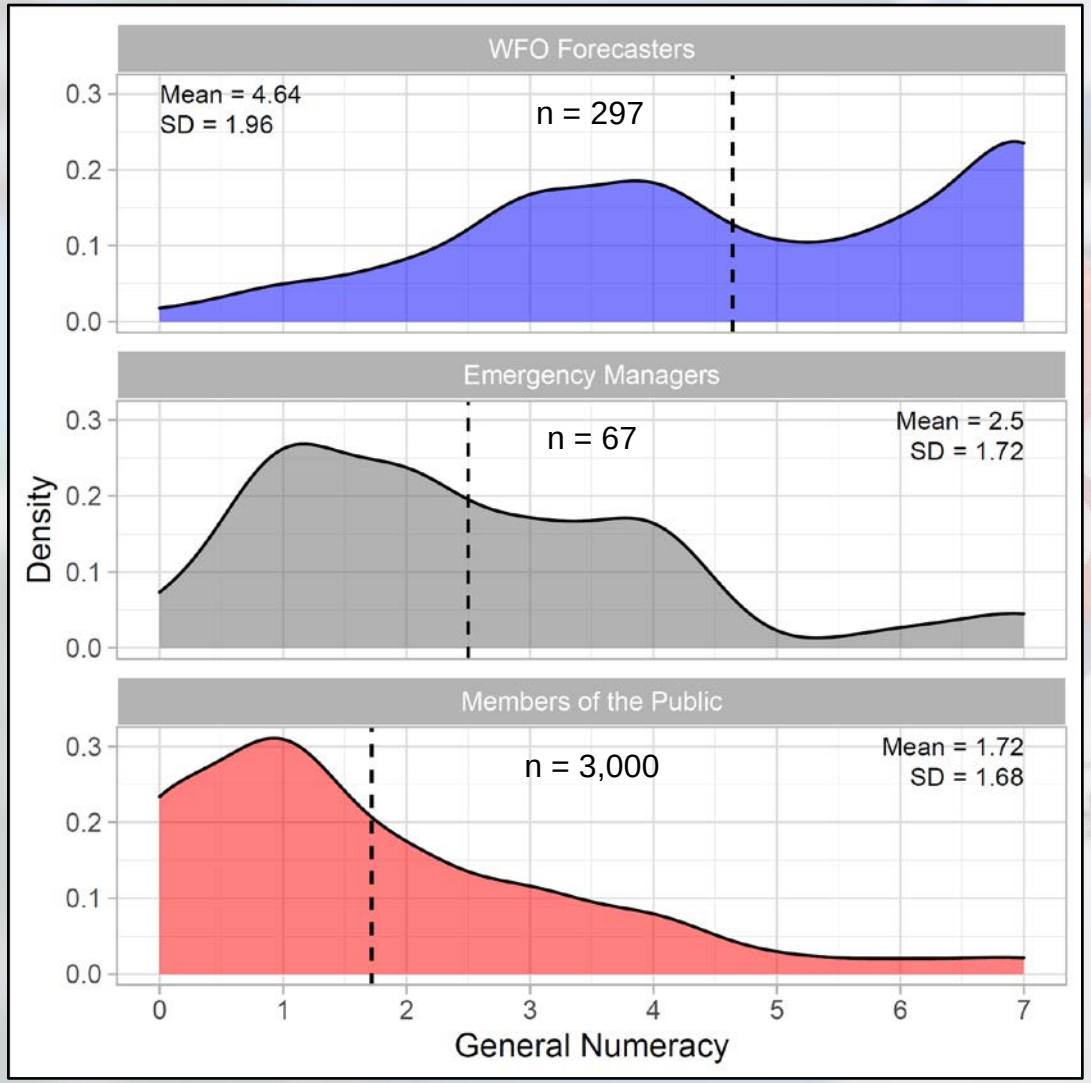
Literacy: the ability to understand, use, and respond appropriately to written texts

Numeracy: the ability to use basic mathematical and computational skills

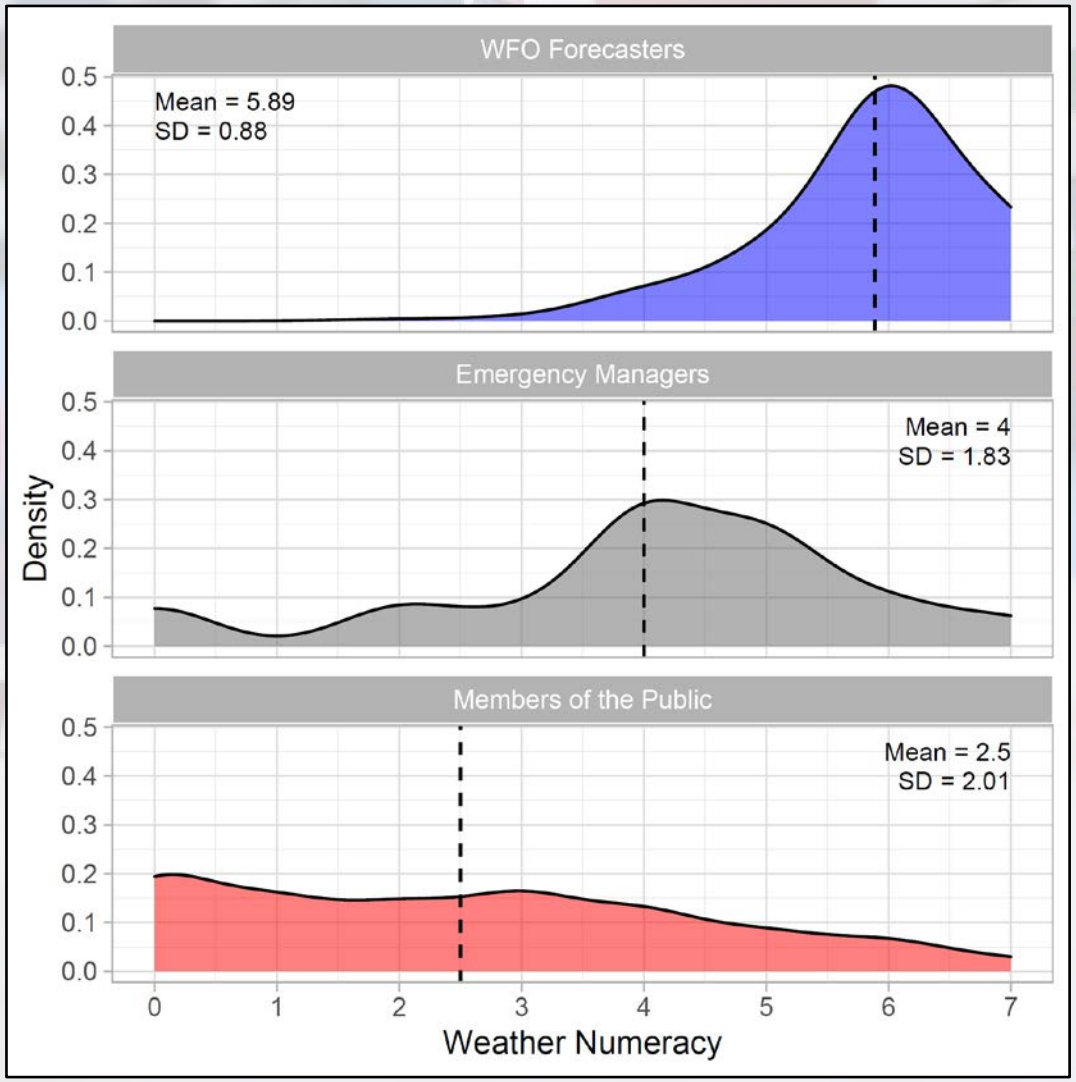
Numeracy Among Forecasters, Emergency Managers, and the Public

"There's a Chance of What?": National Institute for Risk and Resilience at the University of Oklahoma (Ripberger et al.)

General Numeracy



Weather Numeracy



"A 30% Chance of Rain Tomorrow": How Does the Public Understand Probabilistic Weather Forecasts?

Gigerenzer et al. (2005), *Risk Analysis*

Some "interesting" interpretations:

- 3 out of 10 meteorologists believe it will rain
- If you look up at the sky and see 100 clouds, then 30 of them are black
- If we had 100 lives, it would rain in 30 of these tomorrow

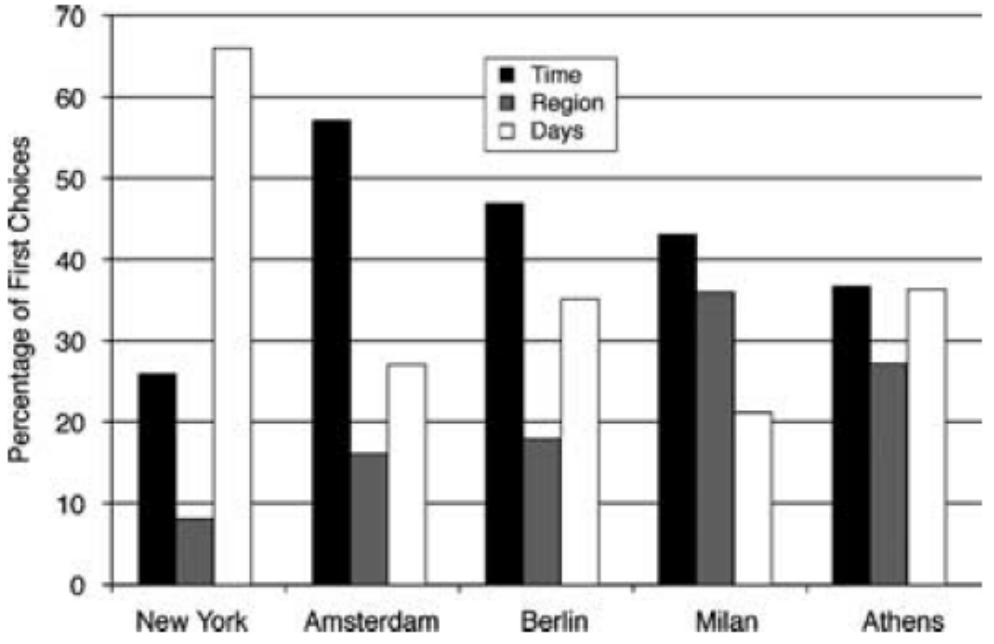


Fig. 1. First choice. People in New York ($n = 103$), Amsterdam ($n = 117$), Berlin ($n = 219$), Milan ($n = 203$), and Athens ($n = 108$) were asked what the statement "There is a 30% chance of rain tomorrow" refers to. The three alternatives were "It will rain tomorrow for 30% of the time," "in 30% of the region," and "on 30% of the days like tomorrow."

If Often Comes Down to Reference Classes…

- There are problems when the reference class is not stated
  - e.g., "There is a 30% chance of rain."
    - 30% of the time? Over what period?
    - 30% of the area? Which area?
    - 30% of the days that are like tomorrow?
    - 30% of meteorologists say so?
- Guide people by being as specific as possible with the reference class of a probability
  - e.g., is it a point or areal probability?
  - *"Misunderstandings can be easily reduced if a statement specifying the intended reference class is added."* – Gigerenzer et al. (2005)


BBC one

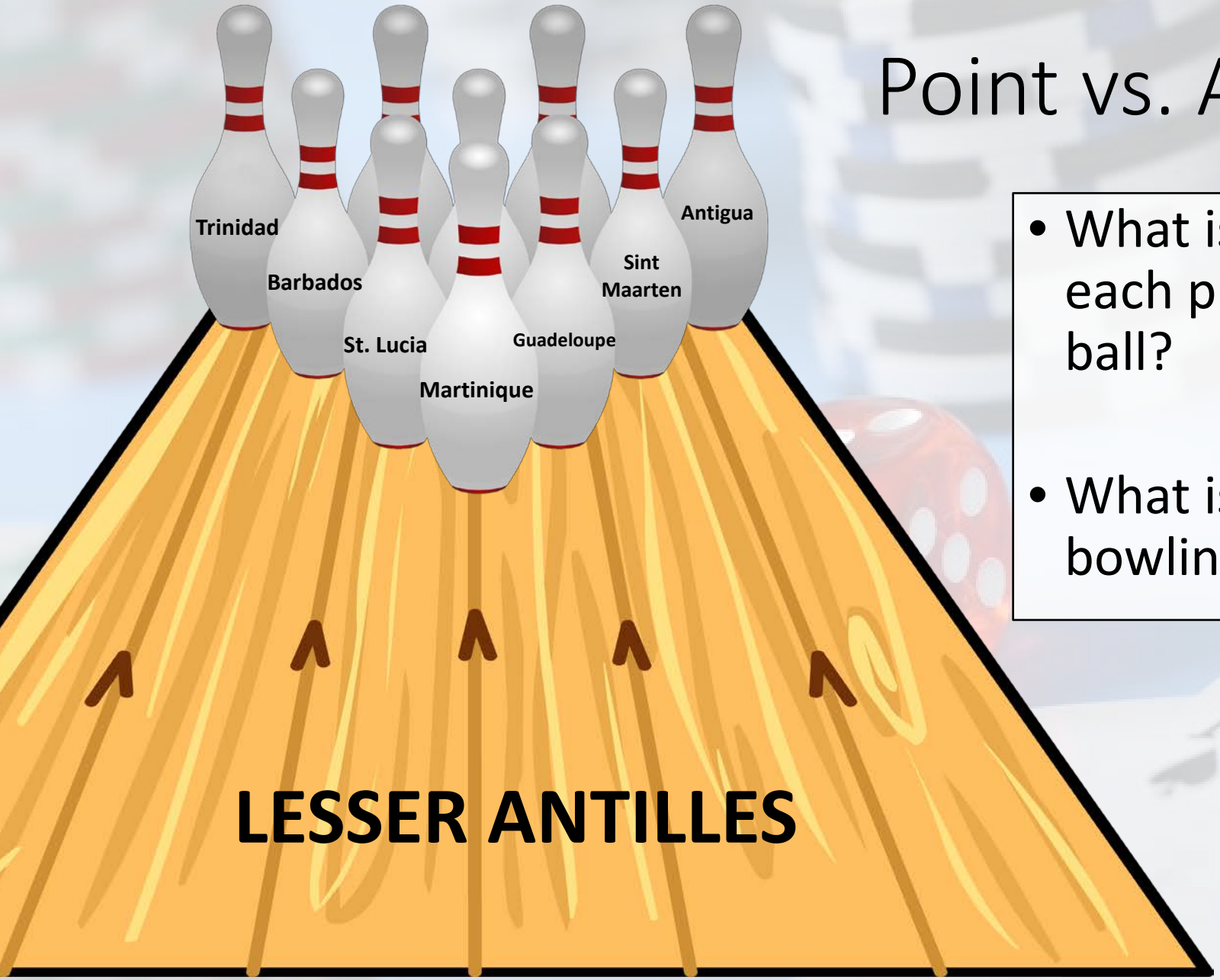
Point vs. Areal Probabilities

- The probability that the dolphins catch ***any fish*** in the bait ball is high.
- The probability that the dolphins catch a ***specific individual fish*** in the bait ball is low.

Even though it's a near certainty that the dolphins will catch at least one fish, the bait ball lowers the probability for each individual fish that it will be the one caught.

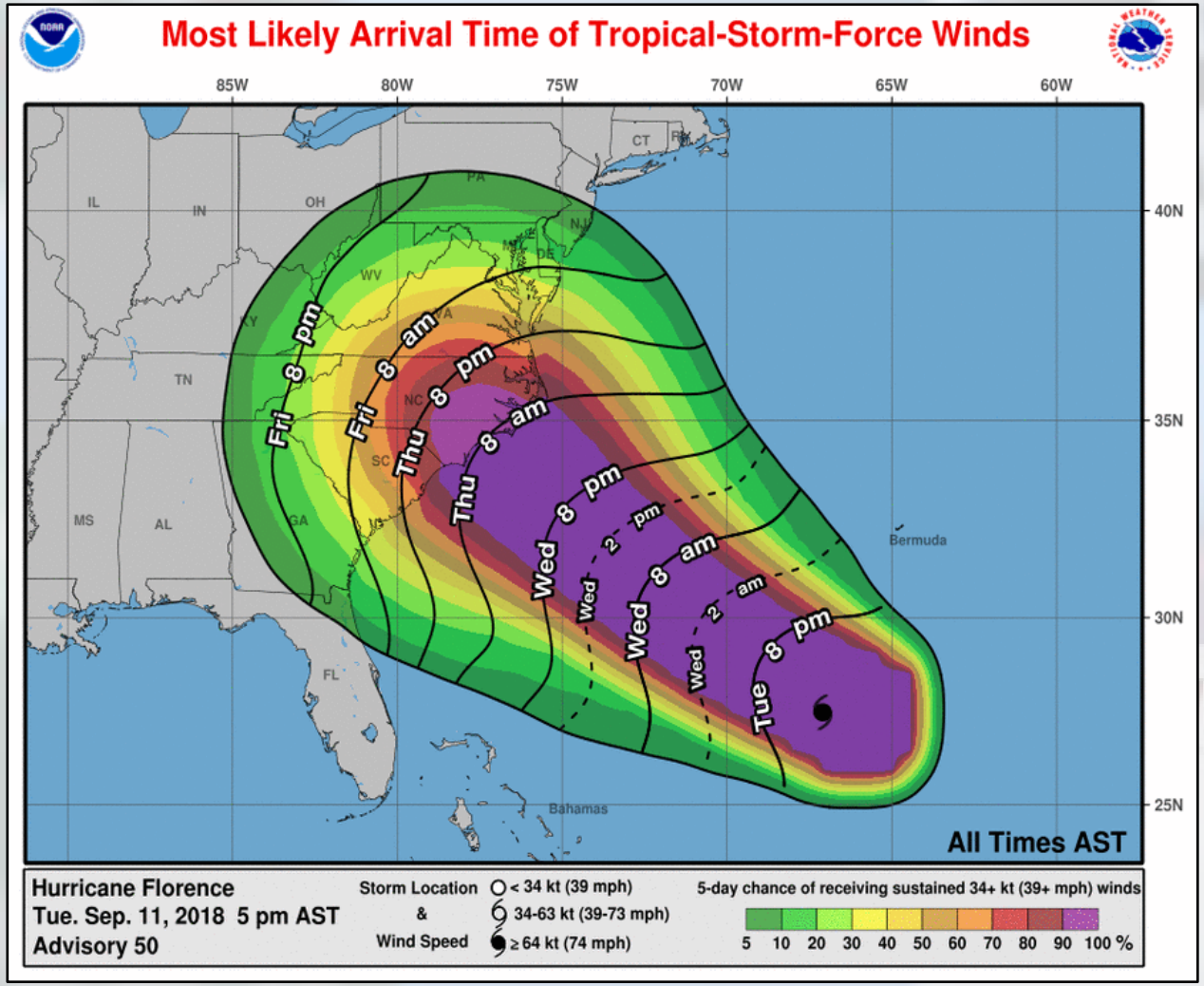

LIVE
JASON BELMONTE
ARSENAL
BALL
HOOK
Lucid
9.5
Defiant Soul
9.0
Reign of Power
8.5
IQ Tour Pearl
7.5
The Wrecker
7.5
Master
NCAAM
4MICH 54 3FLA 38
Men's Basketball Championship
Elite 8 - S
SPORTSCENTER

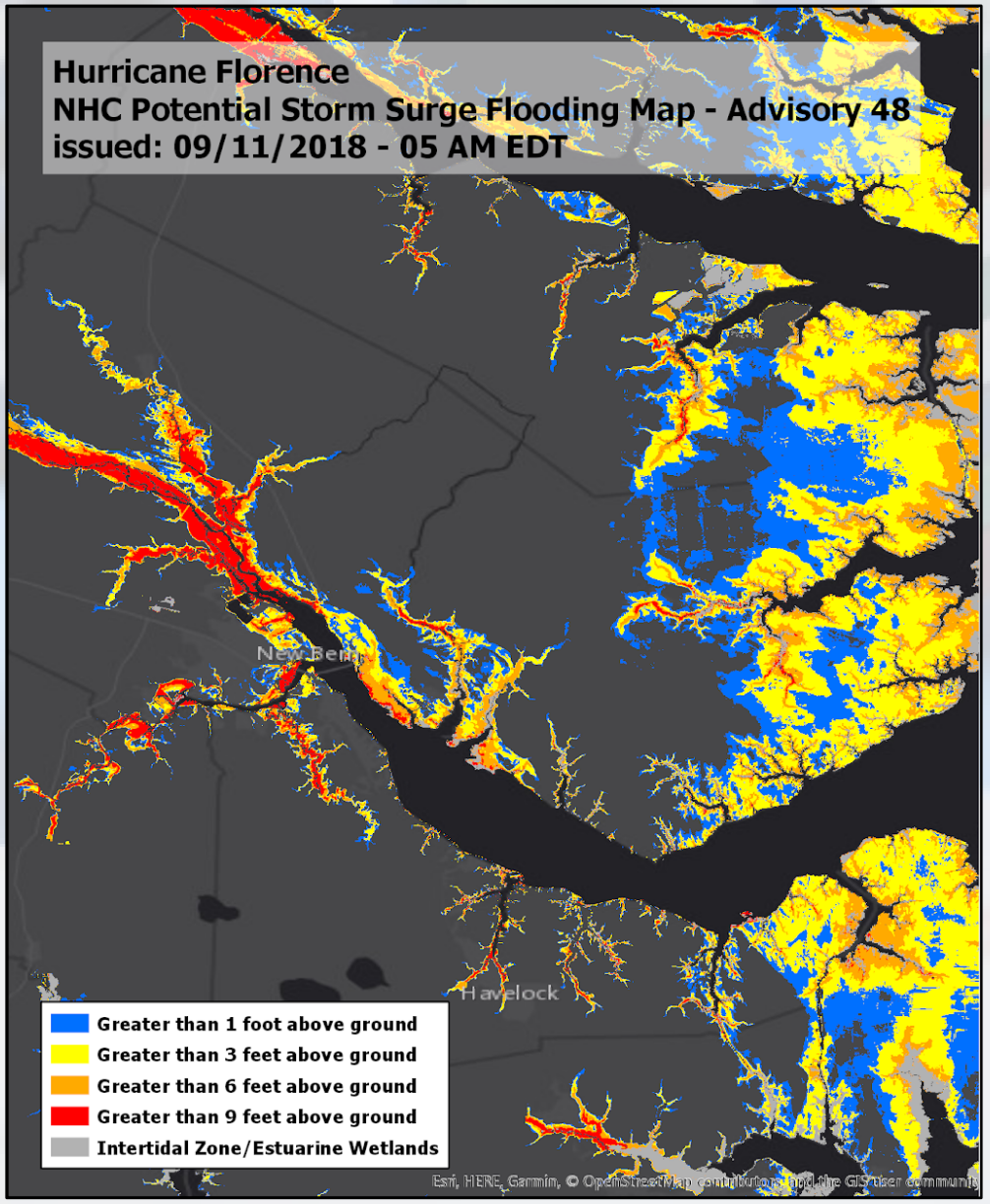
Point vs. Areal Probabilities



- What is the individual probability of each pin being hit by the bowling ball?
- What is the probability that the bowling ball hits any of the pins?

NHC Point Probabilities





Low Probabilities at Long Lead Times

If you get hit by a water balloon, you'll turn into an elephant

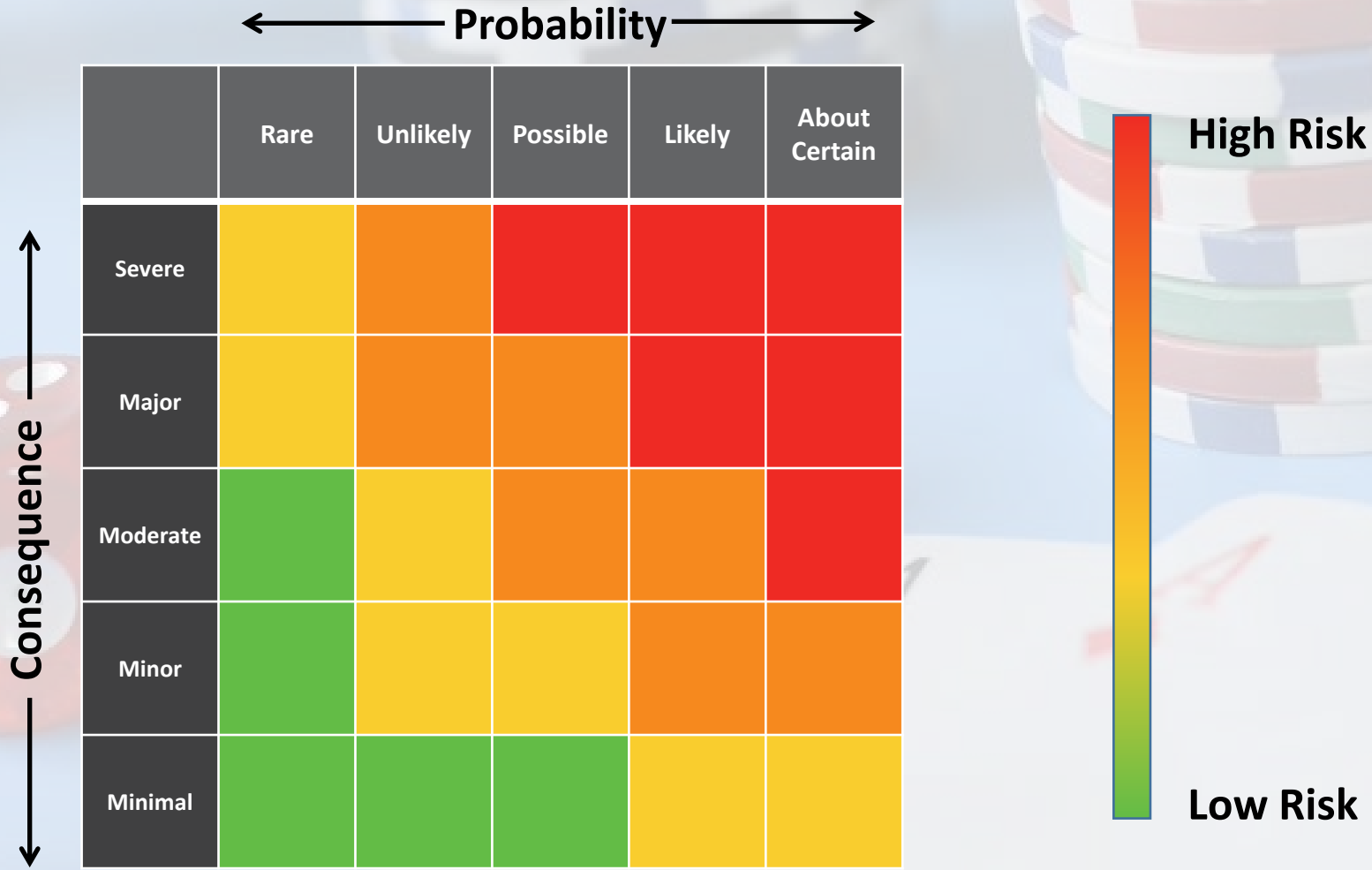
Why Is Risk Communication So Tricky?

Risk, Risk Perception, and Risk Tolerance

- Risk: the potential of gaining or losing something of value

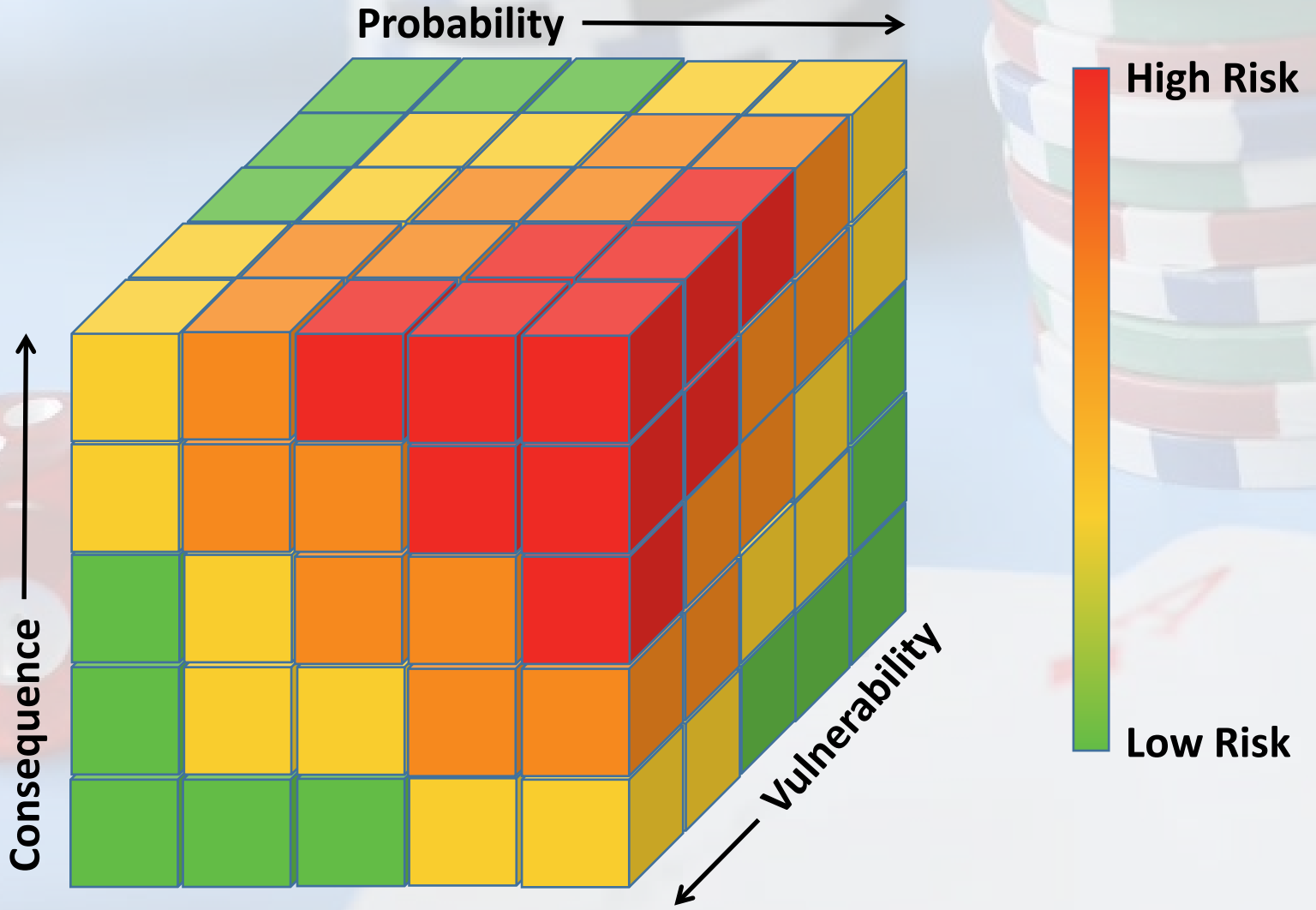
Risk = Probability × Consequence × Vulnerability

Low-Probability, High-Consequence Events
(why low probabilities matter)



Low-Probability, High-Consequence Events

(why low probabilities matter)



Why Is Risk Communication So Tricky?

Risk, Risk Perception, and Risk Tolerance

- Risk: the potential of gaining or losing something of value

  Risk = Probability × Consequence × Vulnerability

- Risk perception: the subjective judgment people make about probability, consequences, or vulnerability, which may vary from person to person

  Actual Risk ≠ Perceived Risk

- Risk tolerance: how willing people are to "take their chances"

Risk Tolerance

Which choice would you make?

A. Receive $100 guaranteed

B. Flip a coin, “heads” you win $200, “tails” you win nothing

Which choice would you make?

A. Flip a coin, “heads” you lose $200, “tails” you lose nothing

B. Lose $100 guaranteed

Risk Tolerance

People tend to be **risk-averse** when they see themselves as ***gaining*** something

Prefer to take the sure thing (receiving $100), rather than gamble (receiving $200 or nothing)

People tend to be **risk-seeking** when they see themselves as ***losing*** something

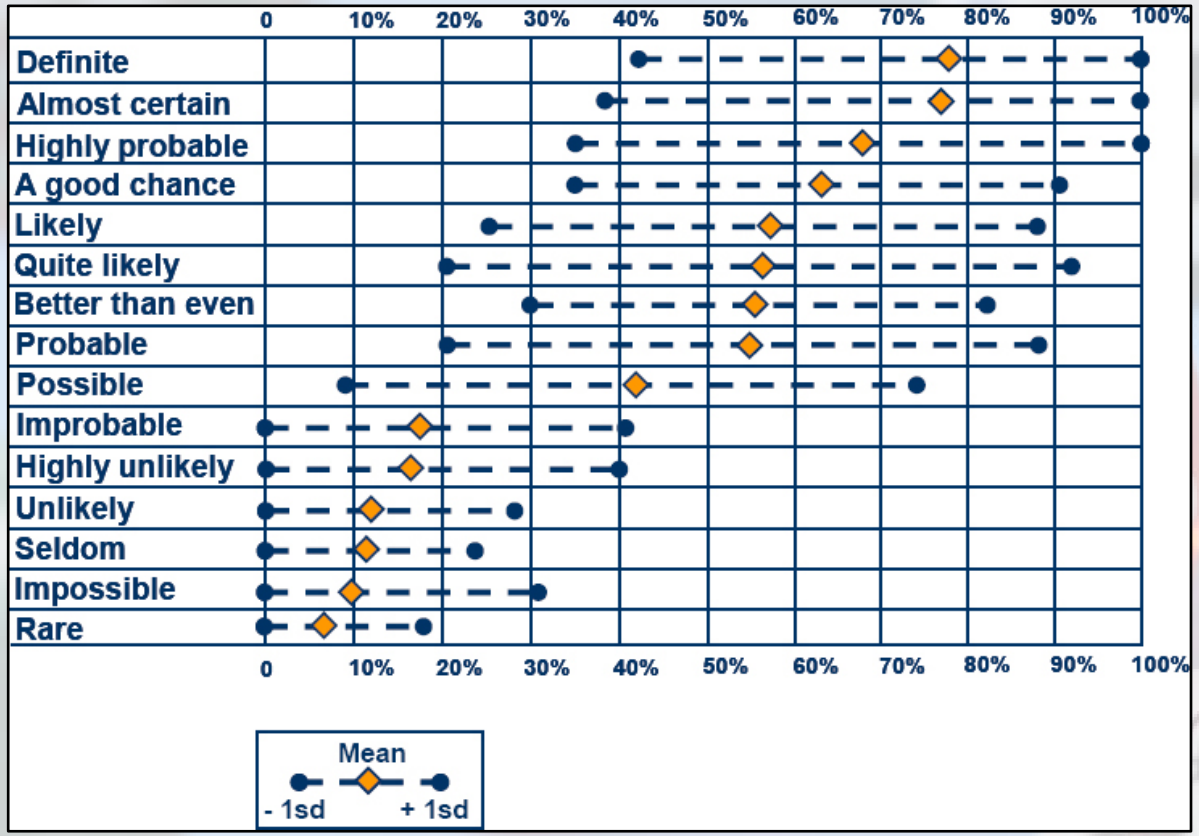
Prefer to gamble (losing $200 or nothing), rather take the sure thing (losing $100)

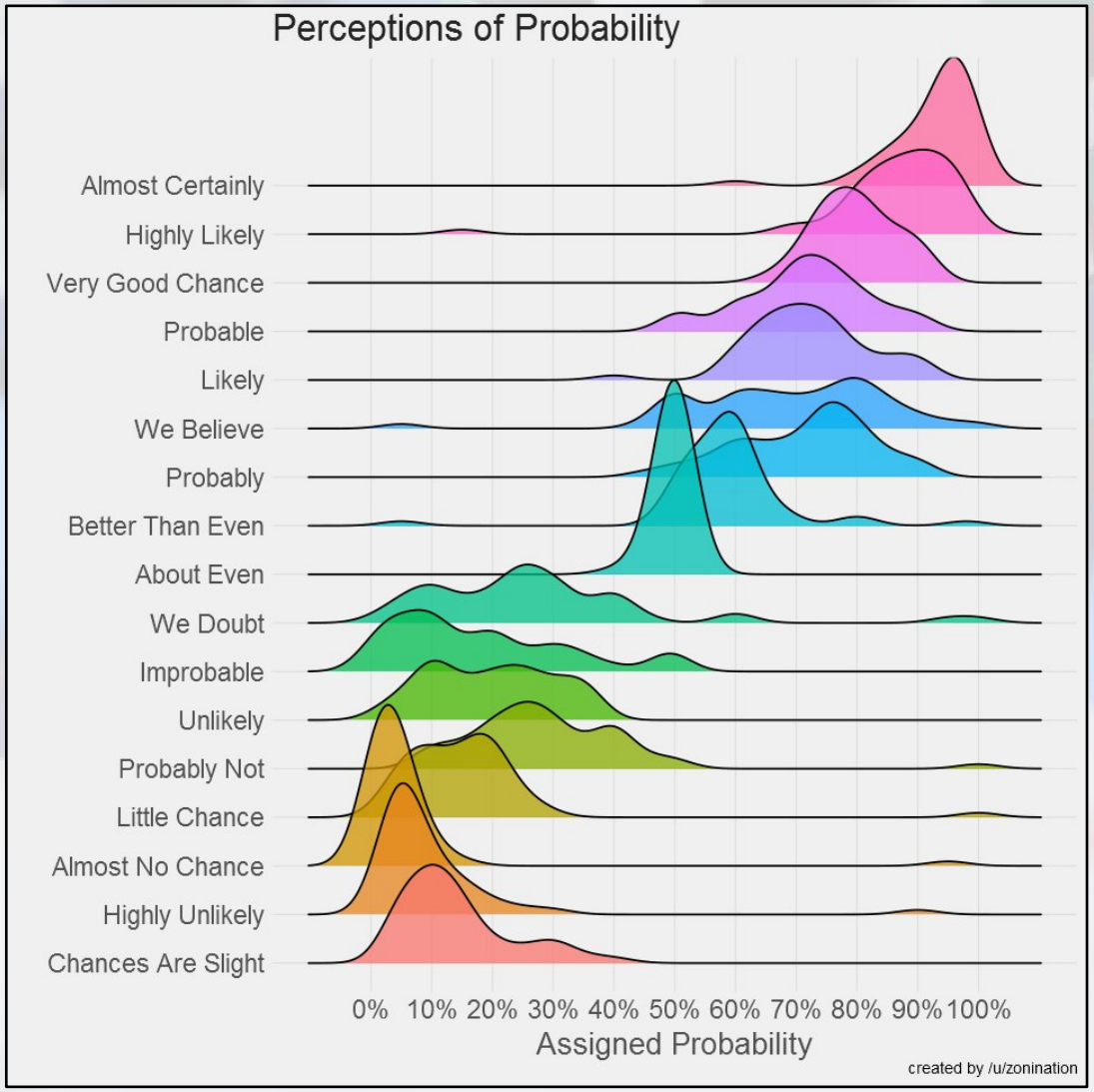
The pain of losing a thing > the pleasure of winning that thing

Risk Tolerance:
Take Your Chances or Better Safe than Sorry?

A Word of Caution About Words

Hillson (2004)





Likely Takeaways

- Be clear in stating the correct reference class for a probability
  - Includes differentiating between point-specific and areal probabilities
- Low probabilities can contribute to high risk
  - Many users have a low risk tolerance, so low probabilities matter
- Use your words carefully!

Recommendations for Communicating Probability Information

(Literature Review by Ripberger et al., OU National Institute for Risk and Resilience)

Use probability information in place of deterministic statements in forecasts

Use probability ranges to emphasize uncertainty when point estimates are not available or appropriate; wide ranges indicate more uncertainty

Include numeric translations next to words/phrases that indicate probability information

If comprehension of probability information is especially important, use numeric probabilities alone or first (before words/phrases)

When using words or phrases to communicate probability information, include rank adjectives (like low, medium, or high) to indicate the magnitude of probability

Use probability (percentage) formats when possible; frequency (fraction) formats can be effective, but the can also generate confusion

When using frequency (fraction) formats, use 1 in X formats in place of X and NX formats

Include information about the reference class when using probability information

Be aware of directionality when using probability information; positive frames can promote comprehension by encouraging people to focus on the events that are most likely to happen whereas negative frames can promote risk aversion by encouraging people to focus on the possibility of negative events, even if they are unlikely

When possible, include probability information in forecast visualizations

Use visualizations to increase comprehension of probability information

Pay attention to the audience