Presenting Only the Worst-Case Scenario in Probabilistic Weather Forecasts: Anchoring Effects

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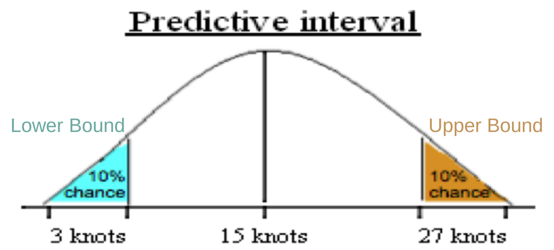
Introduction

Computer models now provide excellent Information about forecast uncertainty[1].
- Example: The 80% predictive interval for wind speed
  - Upper Bound: wind speed at 90th percentile
  - Lower Bound: wind speed at 10th percentile
- Useful to general public because
  - constitutes range of *likely wind speeds*
  - can be adapted to individual risk tolerances.
- However, it is fairly conceptually complex.
  - Perhaps too much information for most people to understand.



Probability Distribution for Wind Speed

- Alternative: present just the worst-case scenario[2]
  - Example: wind speed upper bound
  - (90th percentile- partial uncertainty)
- Potential Problem: ANCHORING[3]
  - Anchoring occurs when a numeric estimate is incorporated into a previously held standard[4].
- The upper bound may lead people to think wind speed will be higher.

Difference between this and prior anchoring studies: An unbiased estimate (deterministic forecast) is also provided.

Experiment 1

Research Question

Will worst case scenario (partial uncertainty information) lead to anchoring?
- Bias understanding of future weather conditions?
- Bias decision-making?

Despite the fact that the deterministic value (an unbiased estimate) is also provided?

Method

Participants acted as weather forecaster making wind speed forecasts in maritime community.

Uncertainty information was manipulated between participants	
Median	The most likely high wind speed for tomorrow is 15 knots.
Upper Bound	The most likely high wind speed for tomorrow is 15 knots; however, there is a 10% chance the high wind speed will be greater than 27 knots.
Lower Bound	The most likely high wind speed for tomorrow is 15 knots; however, there is a 10% chance the high wind speed will be lower than 3 knots.
Full Uncertainty	The most likely high wind speed for tomorrow is 15 knots; however, there is a 10% chance the high wind speed will be greater than 27 knots and a 10% chance that it will be less than 3 knots.
Note: Cover story was manipulated as well, but not reported here because of a confound discovered later.	

Unbiased estimate

WORST CASE SCENARIO: High winds

Participants

278 university students completed a questionnaire in which they took the role of a weather forecaster.

Dependant Variables

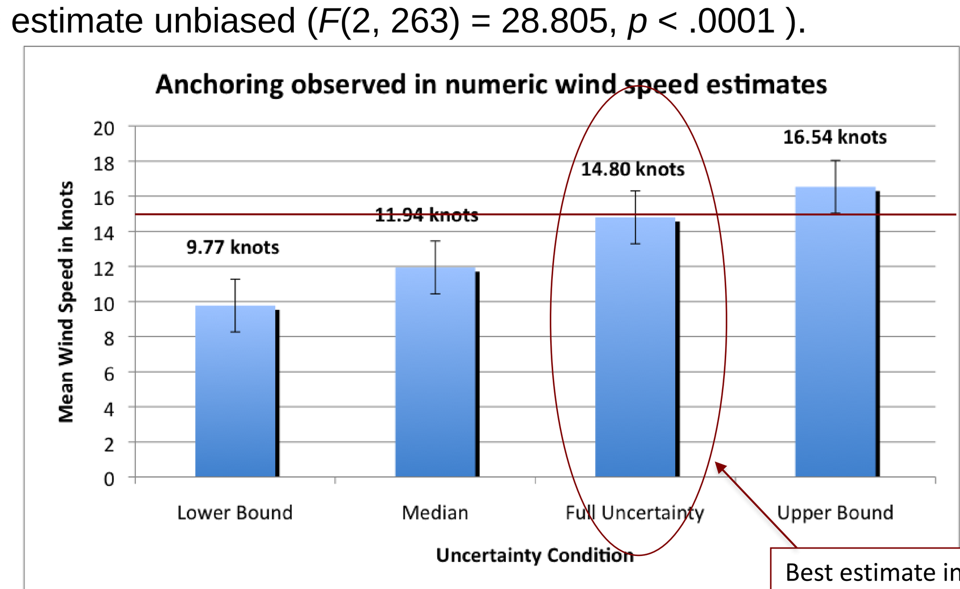
Each participant used one of the forecasts above to make:

- Numeric wind speed estimate
- Binary decision: winds exceed 20 knots (Small Craft Advisory)?
- Rated confidence in their forecast

Results

Numeric Wind Speed Estimate

Anchoring: People estimated higher wind speed when they were given upper bound and lower wind speed when given lower bound. Only in the full uncertainty condition was the estimate unbiased ($F(2, 263) = 28.805$, $p < .0001$).

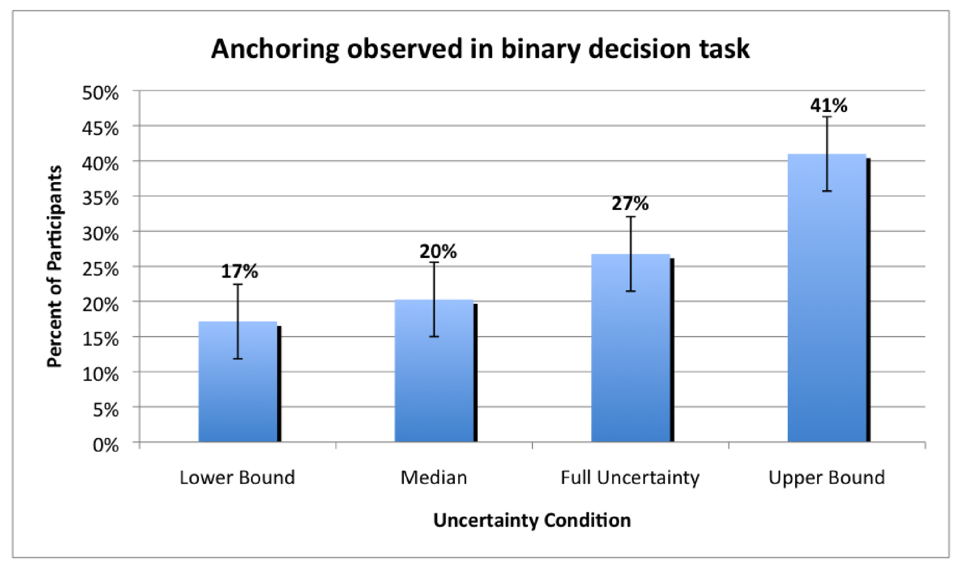


NOTE: All participants had deterministic forecast of 15 knots.

Best estimate in full Uncertainty condition

Binary Decision Task

Anchoring: Those with the upper bound posted advisories significantly more often than participants in both the median (20%, Exp(*B*) = .37, $p = .011$) and the lower bound conditions (17%, Exp(*B*) = .30, $p = .003$).



Confidence Rating: People were MOST confident in Upper Bound. Highest confidence rating in Upper Bound condition. Tukey HSD shows Confidence Rating in Upper Bound significantly different from Median condition ($p = .005$).

Discussion

- Partial uncertainty information leads to anchoring in both understanding of future weather and in the decisions that are based on it.
- People were most confident in forecast in which they were most biased (lower bound)
- Balanced understanding results from full uncertainty information

NOTE: Although an increase in "yes" decisions may be advantageous or not depending on cost/loss considerations of the individual, it should NOT be biased by the format in which the information is presented (anchoring). This effect is thought to be unconscious[5,6] and, as such, may be compounded with strategic bias.

Experiment 2

Research Questions

Will anchoring effect of partial uncertainty information extend to
- other forecast values (temperature)?
- when anchor is less extreme (narrower predictive interval)?
- when reward is dependent on performance?
- when experience with forecast is provided?
- when cost/loss structure is formalized?

Method

Participants (N=104) act as manager of company in charge of treating the roads in the winter to prevent icy conditions-Treatment BEFORE freezing

Cost/Lost Structure

Monthly budget: $36,000
Cost of treating roads 1 day = **$1,000**
Penalty (no treatment temp ≤ 32ºF) = **$6,000**

120 trials each with a different real weather forecast & immediate feedback
Reward: Highest ending budget = **$20** cash prize

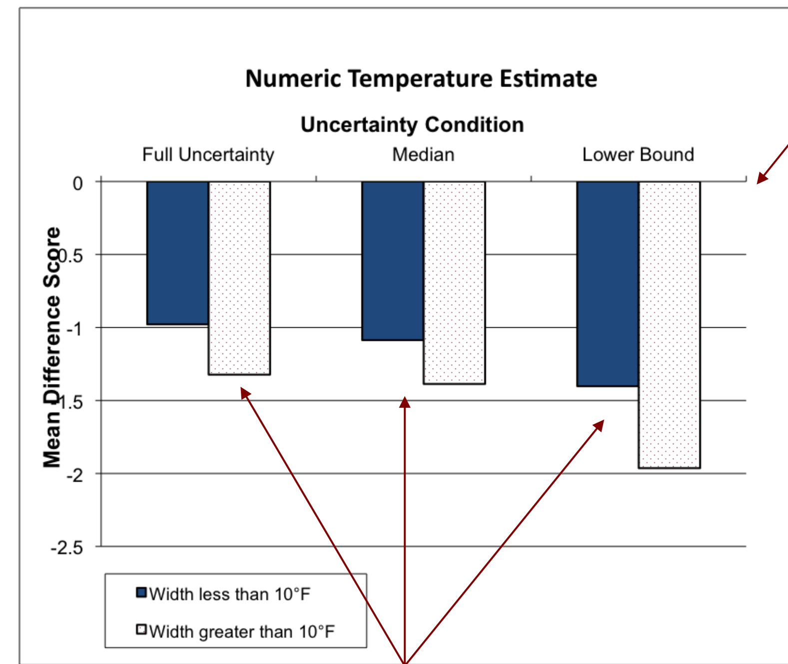
Uncertainty information was manipulated between participants	
Median	The expected night time low temperature is X
Lower Bound	The expected night time low temperature is X; however, there is a 10% chance it will be less than X.
Full Uncertainty	The expected night time low temperature is X; however, there is a 10% chance it will be less than X and a 10% chance it will be greater than X.

Unbiased estimate

WORST CASE SCENARIO: Low Temperature

Dependant Variables:
- Participants made numeric temperature estimate
- Participants made binary road treatment decision

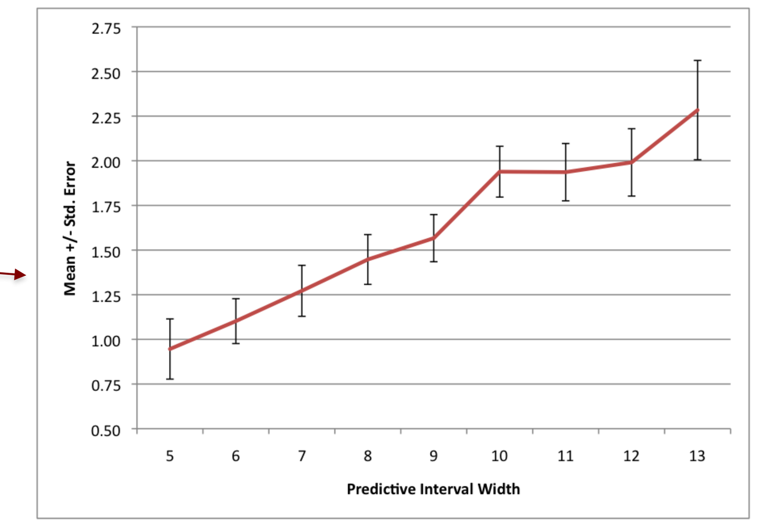
Results



Numeric Temperature Estimate

Anchoring: Difference between numeric temperature estimate and deterministic forecast was largest in the lower bound (worst-case) condition (main effect for uncertainty ($F(2,101)=3.182$, $p=.046$).

Difference between numeric temperature estimate and observation was largest in the lower bound (worst-case) condition (main effect for uncertainty, $F(2,101) = 3.441$, $p=.036$).



Anchoring in temperature estimate increased with width of the predictive interval (distance between the upper and lower bound)

Binary Decision Task

People chose to salt most often in the Lower Bound condition; however, this effect did not reach significance ($F(2,101)=.358$, p=n.s.)

Discussion

- Anchoring was observed with a low value worst-case scenario that reduced temperature estimate accuracy:
  - across multiple different temperature forecasts
  - when participants were motivated to make good decisions
  - when participants had clear cost/loss structure
  - when participants received experience and accurate feedback on every trial
- Anchoring increased with predictive interval width-more extreme anchors lead to more extreme bias.

General Discussion

- Providing partial uncertainty information leads to a bias in understanding future weather conditions that can extend into decision-making.
- People were *most* confident in the forecast in which they were the *most* biased.
- Anchoring bias was observed despite the addition of unbiased estimate on every trial (deterministic forecast) and immediate feed back in Experiment 2 suggesting it is unconscious.
- In real life, may be compounded by strategic biases arising from safety issues.
- Use of "worst-case" may increase false alarms causing people to take unnecessary precautions and erode user trust.
  - e.g. evacuation of a major city, which is often costly (more people died in the evacuation effort prior to Hurricane Rita than died as a direct result of the hurricane[7] and may lead people to begin to ignore the warnings[8]).

We recommend users be provided with full uncertainty information to provide balanced understanding of future weather conditions, to improve decisions and trust in the forecast.

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