Reducing Probabilistic Weather Forecasts to the Worst-Case Scenario: Anchoring Effects

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Outline

- Example of anchoring behavior
- Example of worst-case weather forecast
- Study 1: Demonstrate anchoring behavior in worst-case wind speed forecast
- Study 2: Demonstrate anchoring behavior in worst-case temperature forecast
- Discussion
Anchoring is...

- The effect that occurs when people make numeric estimates that are *unduly* influenced by a previously considered standard (Tversky & Kahneman, 1974)
Demonstration of Anchoring Effect

**GROUP 1**

**QUESTION #1:** Is the percentage of African countries in the United Nations higher or lower than 10%?

**QUESTION #2:** What is the percentage of African countries in the United Nations?

**ANSWER:** 25%

**GROUP 2**

**QUESTION #1:** Is the percentage of African countries in the United Nations higher or lower than 65%?

**QUESTION #2:** What is the percentage of African countries in the United Nations?

**ANSWER:** 45%
Worst-case Weather Forecasts

- Includes:
  - the most likely (best estimate) AND
  - an unlikely outcome (worst-case)

The most likely wind speed for tomorrow is 13 knots, however, there is a 10% chance that it will be 25 knots or greater
Worst-case Weather Forecasts…

- Lead to a biased understanding of wind speed forecasts (Nadav-Greenberg, Joslyn & Taing, 2008)
- Participants’ wind speed estimates are significantly higher when given the worst case wind speed forecast than when given only a single-value wind speed (i.e., anchoring)

\[\text{The most likely wind speed for tomorrow is 13 knots, however, there is a 10\% chance that it will be 25 knots or greater.}\]
Study 1: Paper-based Questionnaire

- Predict the wind speed for the next day
- Decide whether or not to issue a wind speed warning
Procedure

Participants read a paragraph in which they are told that forecast providers base their wind speed forecasts on computer models and that their job is to play the role of a forecast provider and decide what the wind speed will be for the next day and whether to issue a warning based on the prediction below.

**Prediction**
The most likely high wind speed for tomorrow is 13 knots; however, there is a 10% chance that wind speed will 25 knots or greater.

- What is your forecast for the high wind speed tomorrow in the Puget Sound area? ____ knots

- Do you want to issue a wind speed warning for tomorrow? (Issue a warning only if you think wind speeds tomorrow will be equal to or greater than 20 knots). ___ Yes ___ No
## Forecast Formats

<table>
<thead>
<tr>
<th>Deterministic</th>
<th>Single-value deterministic forecast</th>
<th>The most likely high wind speed for tomorrow is 13 knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Bound (Worst-Case)</td>
<td>AND Wind speed at upper bound of the 80% predictive interval</td>
<td>however, there is a 10% chance that the wind speed will be greater than or equal to 25 knots</td>
</tr>
<tr>
<td>Both Bounds</td>
<td>AND Wind speed at lower bound of the 80% predictive interval</td>
<td>and a 10% chance that the wind speed will be equal to or less than 1 knot.</td>
</tr>
</tbody>
</table>
Results

- Participant behavior is consistent with anchoring if:
  - they made significantly higher wind speed estimates when the upper bound was the only form of uncertainty information compared with other forecast formats.

<table>
<thead>
<tr>
<th>Forecast Format</th>
<th>N</th>
<th>% “yes” responses</th>
<th>Mean Wind Speed (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deterministic</td>
<td>90</td>
<td>6%</td>
<td>10.77 (3.19)</td>
</tr>
<tr>
<td>Both Bounds</td>
<td>86</td>
<td>2%</td>
<td>12.49 (2.41)</td>
</tr>
<tr>
<td>Upper Bound (Worst-case)</td>
<td>84</td>
<td>19%</td>
<td>14.77 (3.22)</td>
</tr>
</tbody>
</table>

NOTE: Single-value deterministic wind speed = 13 knots
Conclusions for Study 1

- Participants given the worst-case scenario estimated that wind speeds would be greater than participants in the Deterministic or Both Bound formats
  - Anchoring effect

- Wind speed estimates in the Deterministic format were significantly less than the best estimate
  - Correcting effect

- Presenting both bounds resulted in wind speed estimates that were closer to the best forecast
Study 2

- Addresses 2 main issues:
  - Does the anchoring effect extend beyond single-decision wind speed forecasts?
    - Wind speed forecasts have quite wide predictive intervals (i.e., 10% upper bound much higher than the best estimate)
    - Only hear about wind speeds when an extreme event is expected (unfamiliarity with wind speed forecasts)
  - Explore the nature of the anchoring effect and to distinguish if from the correcting effect
Study 2: Computer-based Simulation

- Predict the nighttime low temperature for the next day
- Decide whether to apply salt brine (Threshold = 32°F)
- 120 trials per participant
- Forecast format was manipulated between participants
Month 1, Day 1

The expected nighttime low temperature for tomorrow is 35°F.

What do you think the temperature will be tomorrow night? _____°F

Do you want to salt the roads?

- YES
- NO

Best estimate
Month 1, Day 1

The expected night time low temperature for tomorrow is 35°F; however, there is a 10% chance that the temperature will be less than or equal to 31°F

What do you think the temperature will be tomorrow night? ______°F

Do you want to salt the roads? YES NO

Best estimate plus the lower bound of the 80% predictive interval
The expected night time low temperature for tomorrow is 35°F; however, there is a 10% chance that the temperature will be less than or equal to 31°F and a 10% chance that the temperature will be equal to or greater than 39°F.

What do you think the temperature will be tomorrow night? ______°F

Do you want to salt the roads?

Yes
No

Best estimate plus the lower and upper bound of the 80% predictive interval
## Participant Data

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Best Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Temperature Estimate</th>
<th>Temperature Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35°F</td>
<td>32°F</td>
<td>38°F</td>
<td>35°F</td>
<td>0°F</td>
</tr>
<tr>
<td>2</td>
<td>39°F</td>
<td>33°F</td>
<td>45°F</td>
<td>38°F</td>
<td>-1°F</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>34°F</td>
<td>30°F</td>
<td>38°F</td>
<td>35°F</td>
<td>1°F</td>
</tr>
</tbody>
</table>

**Temperature Estimate:** Provided by participant

**Temperature Deviation:** Temperature Estimate – Best Estimate
Results

- Participant behavior is consistent with anchoring if:
  - The mean temperature deviation for participants in the Lower Bound format is significantly below that of the other format

<table>
<thead>
<tr>
<th>Forecast Format</th>
<th>N</th>
<th>% Salting</th>
<th>Mean Temperature Deviation (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>31</td>
<td>55%</td>
<td>-1.24 (1.06)</td>
</tr>
<tr>
<td>Both Bounds</td>
<td>34</td>
<td>56%</td>
<td>-1.10 (0.85)</td>
</tr>
<tr>
<td>Lower Bound (Worst-case)</td>
<td>37</td>
<td>58%</td>
<td>-1.58 (0.78)</td>
</tr>
</tbody>
</table>
What is the magnitude of the *anchoring* effect and the *correcting* effect on the temperature deviation?
Hypotheses

- Correcting effect would have the strongest influence on participants’ temperature estimates in the Control format
- Anchoring effect would have the strongest influence on participants’ temperature estimates in the Lower Bound format
- Correcting and Anchoring effects would have the least impact on participants’ temperature estimates in the Both Bounds format
## Trial Data

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Forecast Format</th>
<th>Best Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Half Interval Width</th>
<th>Mean Temperature Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lower Bound</td>
<td>35°F</td>
<td>32°F</td>
<td></td>
<td>3°F</td>
<td>-2.09°F</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>Lower Bound</td>
<td>34°F</td>
<td>30°F</td>
<td></td>
<td>4°F</td>
<td>-1.97°F</td>
</tr>
<tr>
<td>1</td>
<td>Both Bounds</td>
<td>35°F</td>
<td>32°F</td>
<td>38°F</td>
<td>3°F</td>
<td>-1.00°F</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Control</td>
<td>35°F</td>
<td></td>
<td></td>
<td></td>
<td>-1.25°F</td>
</tr>
</tbody>
</table>

- **Dependent Variable**
  - $\text{Temperature Deviation} = \text{Temperature Estimate} - \text{Best Estimate}$

- **Explanatory Variables**
  - Best Estimate $\approx$ Correcting Effect
  - Half Interval Width $\approx$ Anchoring Effect
Single-level Analysis

- Analysis conducted at trial level, NOT at participant level
- Three multiple regression analyses, one for each condition
- Compare regression coefficients for Best Estimate and Half Interval Width across the three conditions
Results: Regression Equations by Format

<table>
<thead>
<tr>
<th>Condition</th>
<th>Regression Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deterministic</td>
<td>$Y_i = 5.90 + (-0.21) \text{ Best Estimate} + (-0.02) \text{ Half Interval Width}_i$</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>$Y_i = 4.66 + (-0.16) \text{ Best Estimate} + (-0.19) \text{ Half Interval Width}_i$</td>
</tr>
<tr>
<td>Both Bounds</td>
<td>$Y_i = 1.81 + (-0.07) \text{ Best Estimate} + (-0.14) \text{ Half Interval Width}_i$</td>
</tr>
</tbody>
</table>

- **Half Interval Width** not significant in the Control format ($p=.79$)

- **Best Estimate** is significantly larger in the **Control** format than in the **Both Bounds** condition ($p=.004$)

- **Half Interval Width** is significantly stronger in the **Lower Bound** format than in the **Both Bounds** format ($p<.001$)
Conclusions for Study 2

- Extended the *anchoring* effect found with Wind Speed to Temperature forecasts
  - *Half Interval Width* had the strongest influence on participants in the worst-case (lower bound) format
- Replicated the *correcting* effect found with Wind Speed forecasts to Temperature forecasts
  - *Best Estimate* had the strongest influence on participants in the Control format
Summary

- To counteract bias expectations in weather forecasts acknowledge and specify the uncertainty
  - Present not only the best estimate, but also the worst-case AND best-case forecasts
QUESTIONS