Probabilistic Tornado Warnings

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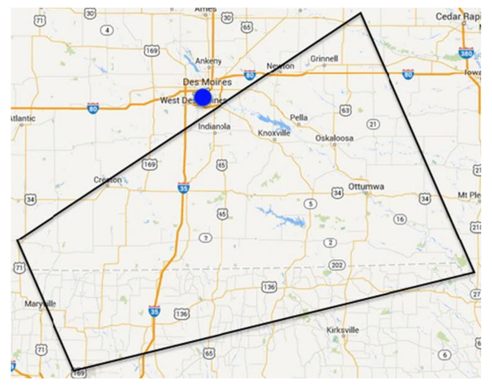
Background and Research Goals

- Current tornado warning polygon is deterministic, implying a tornado *will* occur inside and not outside.
- However, forecasters know that tornado likelihood varies within the polygon.
- Research shows that people have greater trust and make better decisions when an uncertainty estimate, for their location, is provided (Joslyn & LeClerc, 2013).
- We tested whether these advantages extend to graphics showing the likelihood of a tornado at one's own and surrounding locations.

Tornado Warning Polygon



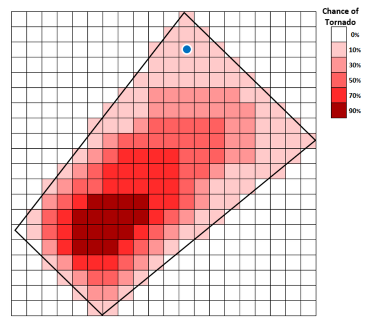
Pilot Study

- Comparing the current deterministic polygon to color coded uncertainty polygons or tables depicting likelihood by location, we found:
  - Improved perceived likelihood
  - But **no** improvement in decision quality: People with probabilistic forecasts were reluctant to shelter when probability of strike was 10% (Qin, et al., 2019)
- What accounts for the lack of improvement in decision quality (contrary to previous research)?

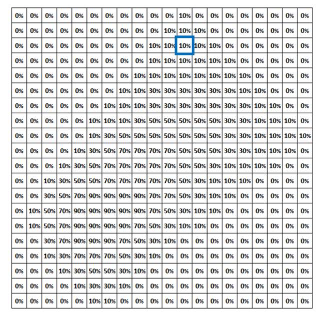
Pilot Study Graphics

Warned Area: 10% probability or higher

Red



Tabular



Current Study Research Questions:

1) Will decision quality improve with probabilistic graphics if the threshold for sheltering is raised from 10% to 30%?

2) Does likelihood information for surrounding areas affect the perception of risk for a specific location and shelter decisions as a result?

Experimental Procedure

- Scenario: *Imagine that you were traveling in the Southeastern US and received tornado warning from a cell phone app. The potential windspeed of the tornado was 86-135 miles per hour.*
- 68 trials in total
- Severity held constant (windspeed 86-135 mph)
- Participants: 232 (47% female) Amazon Mechanical Turkers

Dependent Measures:

Perceived Likelihood — Impossible ... Certain

Perceived Severity — No damage ... Total Destruction

Post Decision Trust — Do Not Trust at All ... Completely Trust

Decision — Shelter (in the bathroom of your hotel room) / Do not shelter

Decisions and Point Structure:

Participants' goal was to end the task with as many points as possible. They started with 25,000 points

- The optimal decision was based on expected value (loss) of not sheltering:
  1000 points x probability of tornado
  Cost of sheltering: 270 points
- Optimal to shelter when likelihood >= 27%
  1000 x .27=270

Decision	Cost	Penalty if Tornado
Take Shelter	270 points	0 points
Not Shelter	0 points	1000 points

Experimental Procedure Continued

Warning was given and polygon included cells at 30% chance of a tornado or higher

Independent variable:

Warning Format:

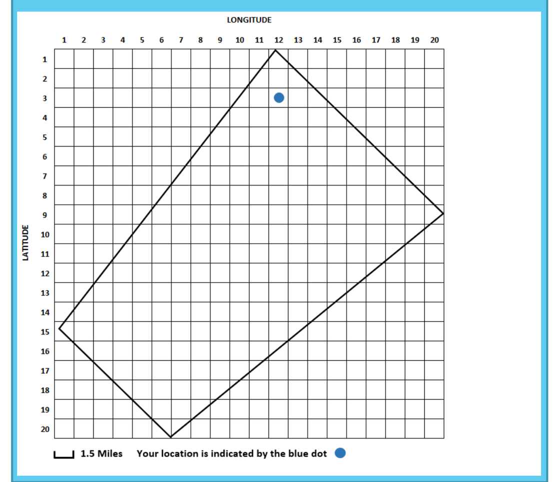
5 Levels Between-Subject

Formats without info on surrounding area/text-based formats

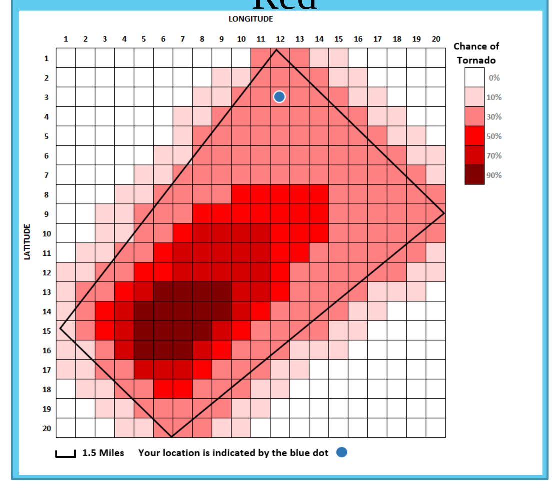
1. Probabilistic Text	2. Deterministic Text
There is a 30% chance that a tornado will hit your location	**Your Location is under Tornado Warning**

Formats with information on surrounding area: Participant location = Blue Dot (or Square)

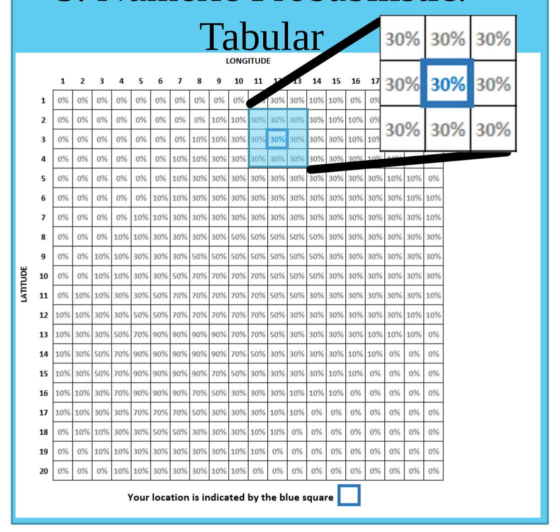
3. Deterministic/Polygon



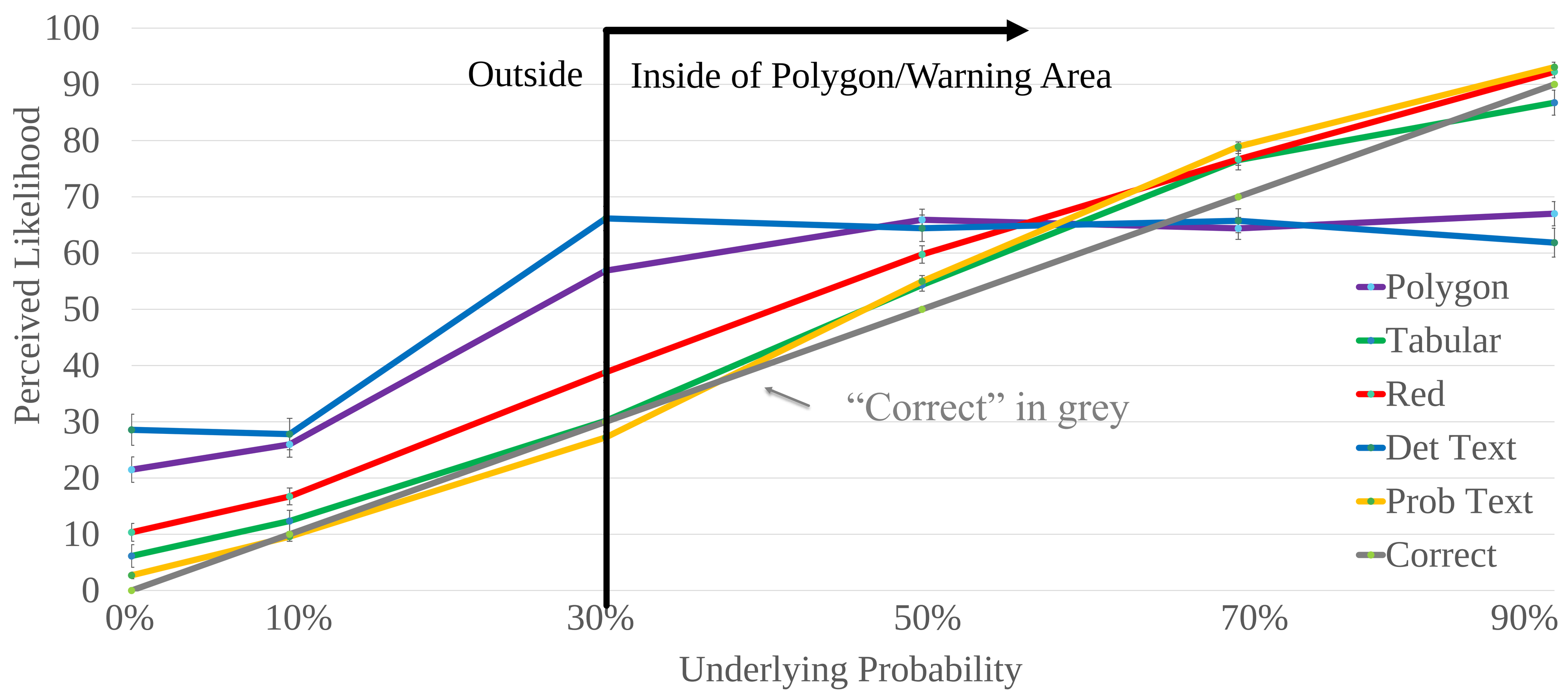
4. Color-Coded Probabilistic: Red



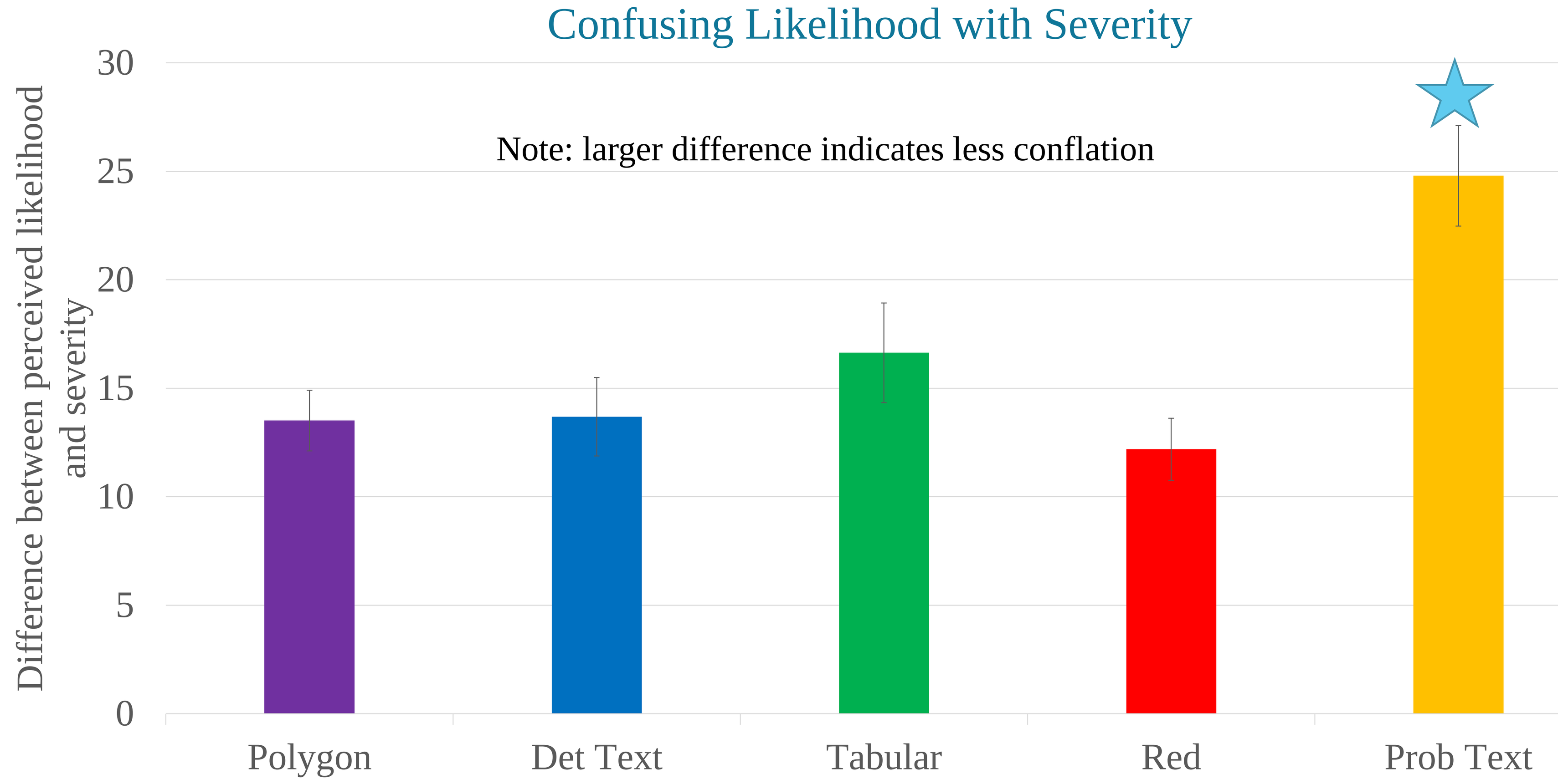
5. Numeric Probabilistic: Tabular



Results



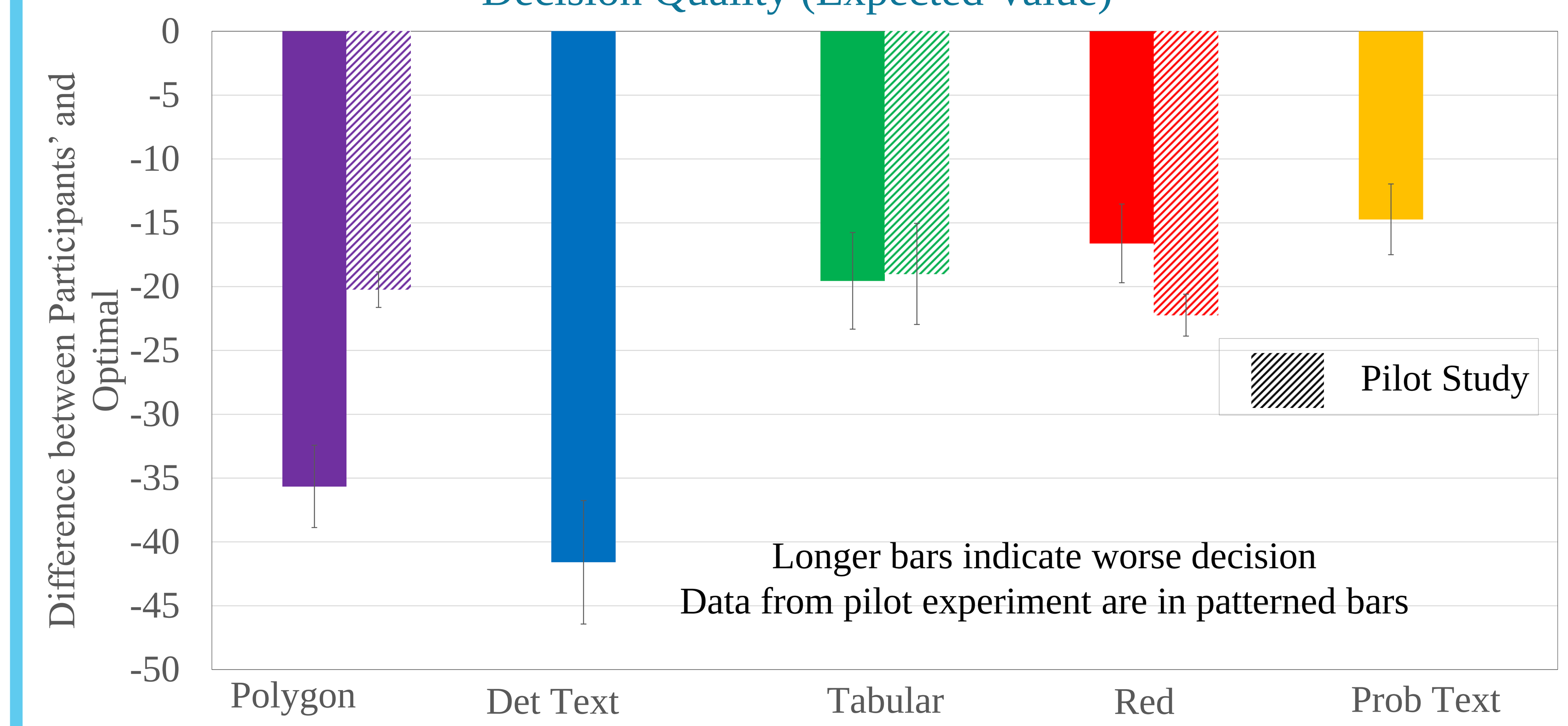
- Probabilistic formats led to most accurate perceived likelihood
- Deterministic formats let to uniform ratings inside the polygon ($F_{(1, 228)} = 24.057$, $p < 0.0001$, $\eta_p^2 = 0.10$)
- Red format led to overestimation especially at lower probability levels ($t(814) = 4.395$, $p = 0.0001$, $\eta_p^2 = 0.02$)



Probabilistic text: least conflation between likelihood and severity information

Red: greatest conflation between likelihood and severity information ($F_{(4,227)} = 7.491$, $p < 0.0001$, $\eta_p^2 = 0.117$)

Results Continued



- Probabilistic conditions (tabular, red and probabilistic text) led to significantly better expected value ($F_{(1,228)} = 49.652$, $p < 0.0001$, $\eta_p^2 = 0.179$)
- Unlike Pilot Study (patterned bars)
- Deterministic text condition did the worst while probabilistic text did the best

Conclusions

- Here, where the warning was issued at 30% chance of a tornado or higher, explicit likelihood information improved participants' sheltering decisions, compared to the deterministic polygon.
  - However, when the optimal decision threshold for decision was low, at 10% in the pilot study, although participants sheltered more often at high likelihood and less at low likelihood than those with the deterministic polygon, there was no improvement in decision quality overall.
  - An interview study conducted among tornado-experienced residents, revealed that at low likelihoods (10%) within the polygon boundary, while people are reluctant to shelter, they take other precautionary actions such as monitoring information and staying close to home.
  - Issuing a tornado warning when there is a 30% chance of a tornado or higher means there is a substantial chance that a tornado would occur outside of the polygon but go unwarned, which has important practical implications.
  - Thus, although moving the warning boundary to 30%, may improve decision quality, it may not be the best option from a practical perspective.
- Color-coding can lead to misunderstandings: Red color-coded likelihood
  - Led to likelihood overestimation
  - Was confused with an expression of severity
- Probabilistic text format, without color or information on surrounding area led to the best understanding:
  - Perceived likelihood closest to the intended values
  - Least conflation between likelihood and severity
  - Highest trust
  - Best decision quality
- Thus, although explicit likelihood can be beneficial, it depends on the situation and how it is presented

References

Ash, K. D., Schumann, R. L., & Bowser, G. C. (2014). Tornado Warning Trade-Offs: Evaluating Choices for Visually Communicating Risk. *Weather, Climate, and Society*, *6*(1), 104–118.

Qin, C., Joslyn, S., Savelli, S., Demuth, J., Morss, R., Ash, K., (2019, November 15th) *Probabilistic Tornado Warning* [Conference Session] Psychonomic Society Annual Meeting 2019, Montreal, Quebec, Canada

This material is based upon work supported by NOAA under Grants NA17OAR4590196 and NA17OAR4590197.

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