Probabilistic Tornado Warnings

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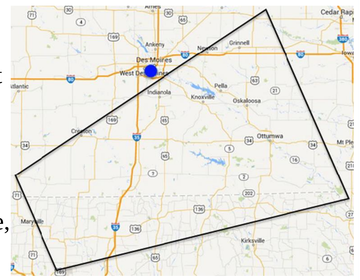
Background and Research Goals

- Current tornado warning polygon is deterministic, implying a tornado *will* occur inside.
- However, forecasters now know that tornado likelihood varies within the polygon.
- Research shows that people have greater trust and make better decisions when a likelihood estimate, for their location, is provided (Joslyn & LeClerc, 2013).
- Will it help for tornados? How should likelihood be conveyed graphically?

Tornado Warning Polygon



Pilot Study

- Color coded and tabular probability information Improved perceived likelihood compared to current deterministic polygon.
- Color-coding led to some misunderstandings
- **No** improvement in decision quality: People with probabilistic warnings were reluctant to shelter at 10% locations within warned are (Qin, et al., 2019)

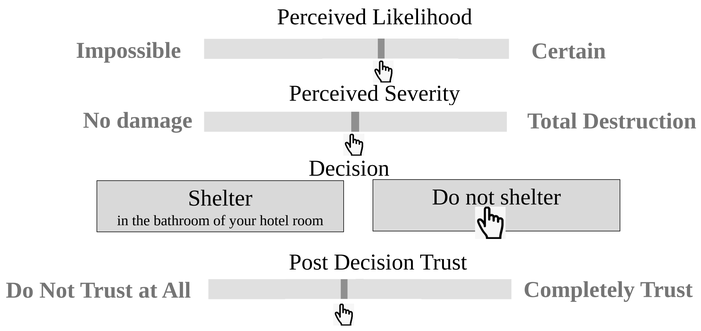
Current Study Research Questions:

1) Will decisions with probabilistic information be superior to the deterministic polygon, if the threshold for sheltering is raised to 30%?
2) Does likelihood information for surrounding areas affect, the perception of risk for a specific location?
3) Do people conflate likelihood with severity in graphic displays?

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 is 86-135 miles per hour.*

Dependent Measures:



- 68 trials in total
- Participants: 232 (47% female) Amazon Mechanical Turkers

Decisions and Point Structure:

Goal: End with as many points as possible. Start with 25,000 points.

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

- Optimal decision is the choice with smallest cost based on expected value:

1000 points x probability of tornado compared to cost of sheltering: 270 points.

- Optimal to shelter when likelihood >= 27% (1000 x .27=270)

Experimental Procedure Continued

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

Warning Format:

Between-Subject

Formats without info on surrounding area/text-based formats

1. Probabilistic Text

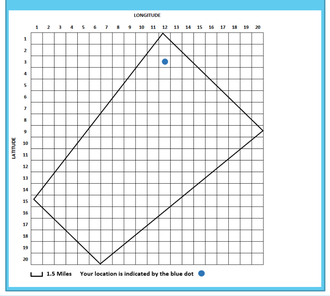
There is a 30% chance that a tornado will hit your location

2. Deterministic Text

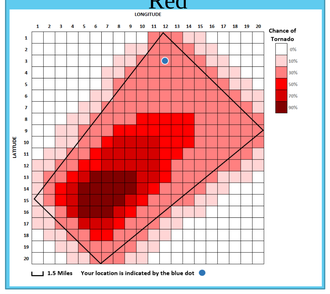
Your Location is under Tornado Warning

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

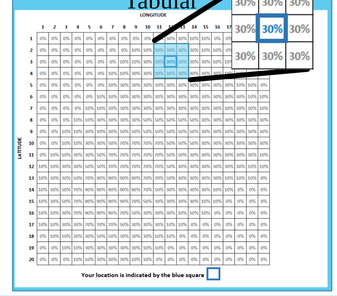
3. Deterministic/Polygon



4. Color-Coded Probabilistic: Red

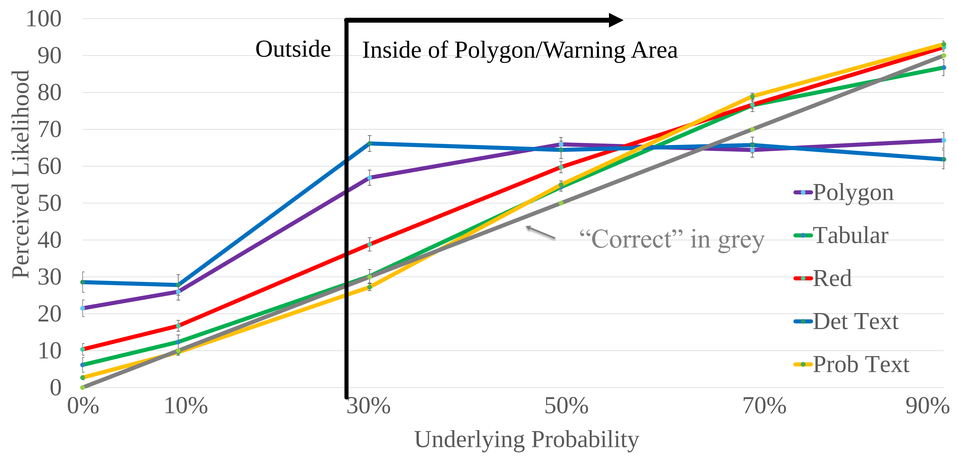


5. Numeric Probabilistic: Tabular



Results

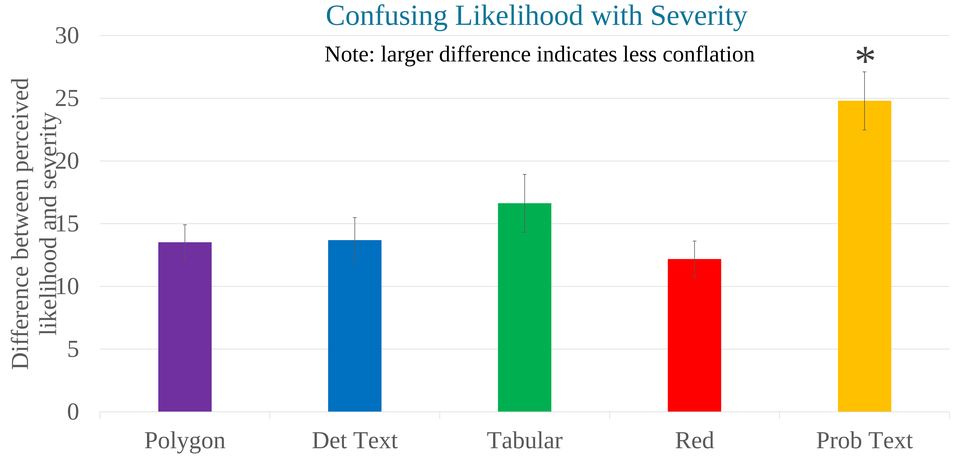
Perceived Likelihood



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

Confusing Likelihood with Severity

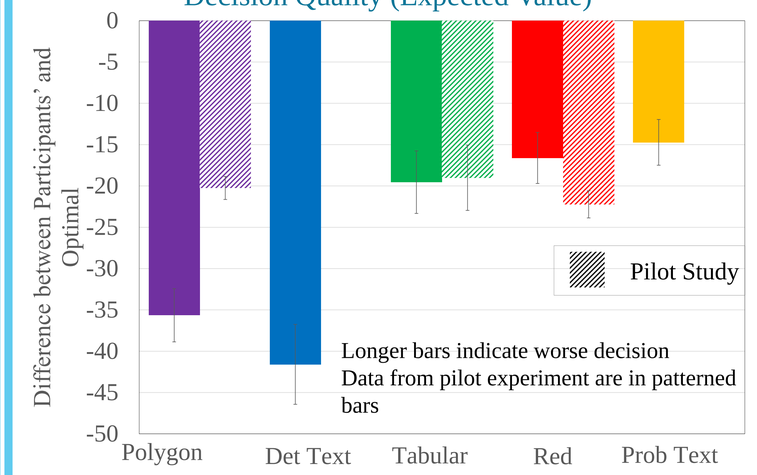
Note: larger difference indicates less conflation



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

Decision Quality (Expected Value)



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

Conclusions

- When 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 was 10% in the pilot study, participants sheltered more at high likelihood and less at low likelihood than those with the deterministic polygon (thought it was over 60%), no improvement in decision quality overall.
  - An interview study conducted among tornado-experienced residents, revealed that at low likelihoods (10%) 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

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