# Determining the Influence of Broadcast Visuals and Messages on the Public's Perceptions and Intent to Shelter in Tornado Warnings

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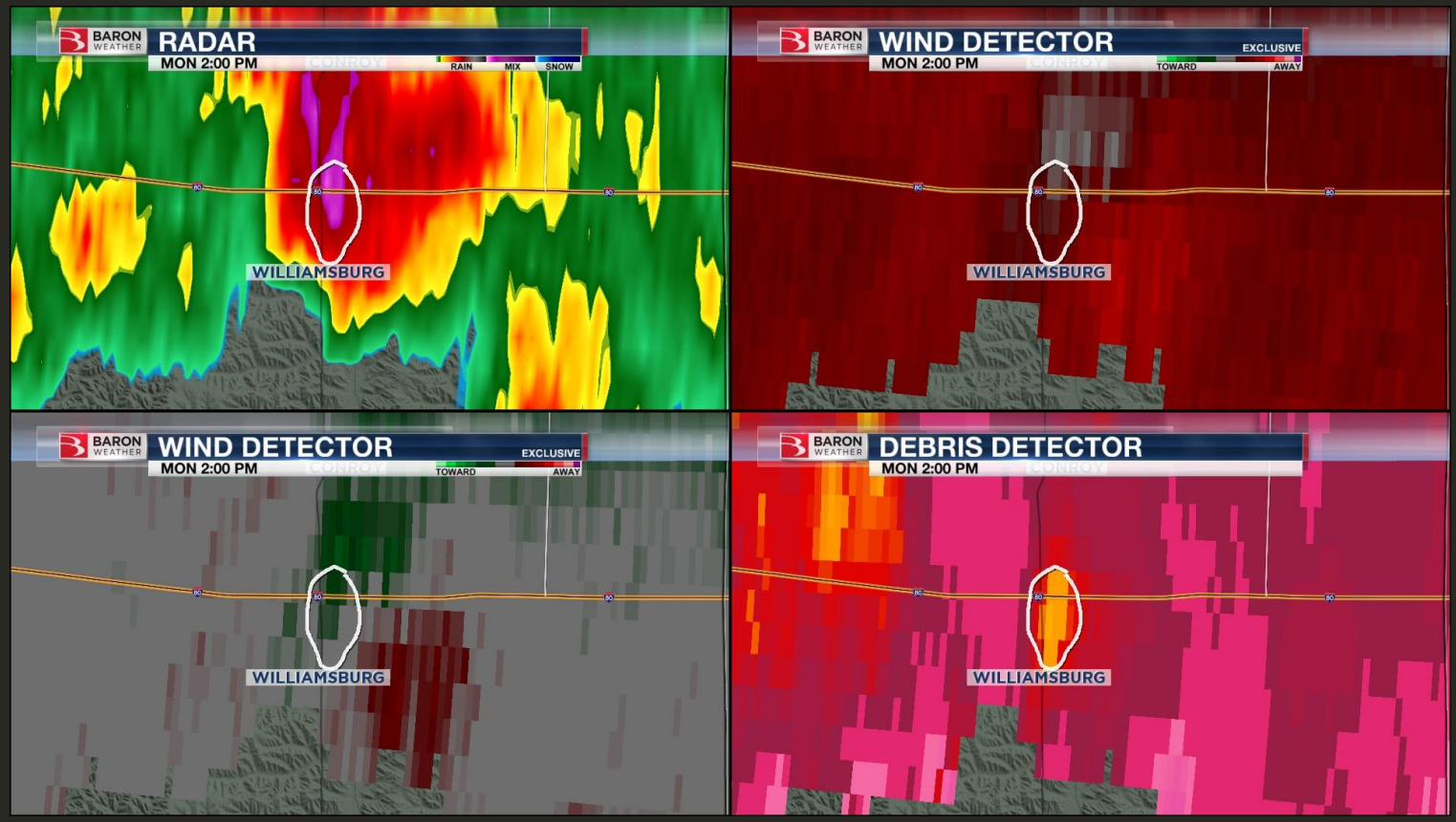
# Background

- For a tornado warning to save lives, it must first be received and ***clearly communicated in a way that is understood*** (Sutton et al., 2021).
- Television is still the most common source for tornado warning information (Stokes & Senkbeil, 2016; Miran et al., 2018).
- What the broadcast meteorologist ***says*** helps the viewers decide if they need to shelter, in real (Sherman-Morris & Brown, 2012) and hypothetical (Sherman-Morris & Lea, 2016) events.
- In one hypothetical situation, the participants' trust in the broadcaster turned into them heeding the broadcaster's advice to seek shelter (Sherman-Morris, 2005).

# Background: Radar

Base Reflectivity




Base Velocity

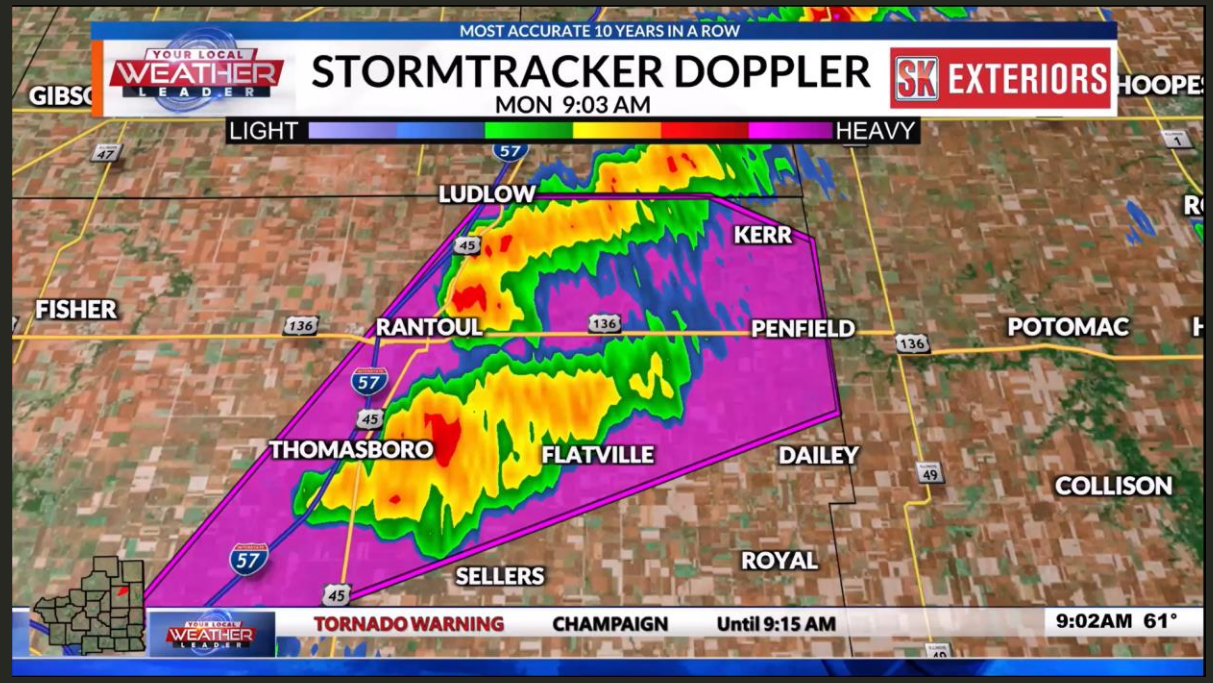
Storm-relative Velocity

Correlation Coefficient

# Background: Radar

- The public needs helps understanding radar because they have incorrectly located tornadoes on base reflectivity (Senkbeil et al., 2022).
- One case study found that using dual-polarization radar reduced injuries in a 2013 Hattiesburg, Mississippi tornado (Cates et al., 2013).

# Background: Mixed Messages

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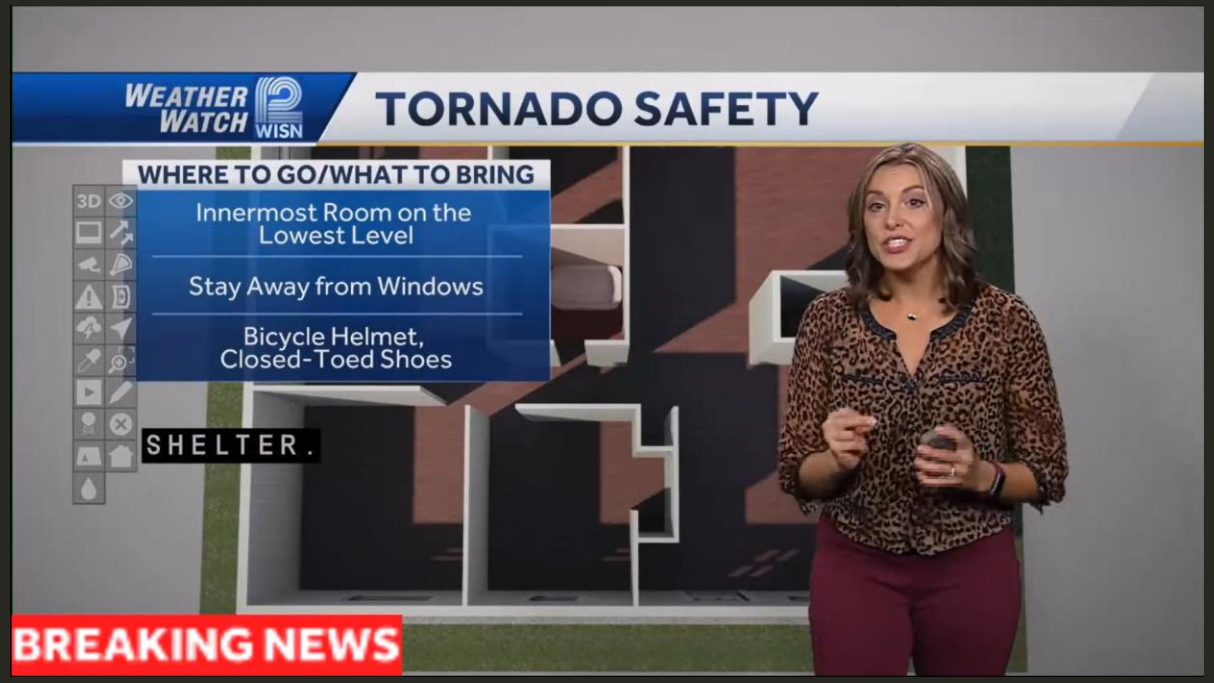



# Background: Mixed Messages


# Background: Mixed Messages

- Messaging inconsistencies limit the ability of the people in the path of the tornado to recognize that they are in the path (Cavanaugh et al., 2013).
- Inconsistent visual information did not influence the integrity of the tornado warning (Weyrich et al., 2019).
- Recent study noted that they were lacking support from their research on whether or not an individual's decision-making or risk perception are harmed by mixed messaging (Williams & Eosco, 2021).

# Background: Tornado Videos

- People try to visually confirm a tornado (Chaney & Weaver, 2010; Sherman-Morris, 2013; Sherman-Morris & Brown, 2012).
- Seeing the tornado in broadcast video made the risk more believable to the participants (Eosco & Scherer, 2015).
- 23% of participants in one study were influenced to shelter after seeing the tornado on video or in person (Stokes & Senkbeil, 2016).

# Research Questions

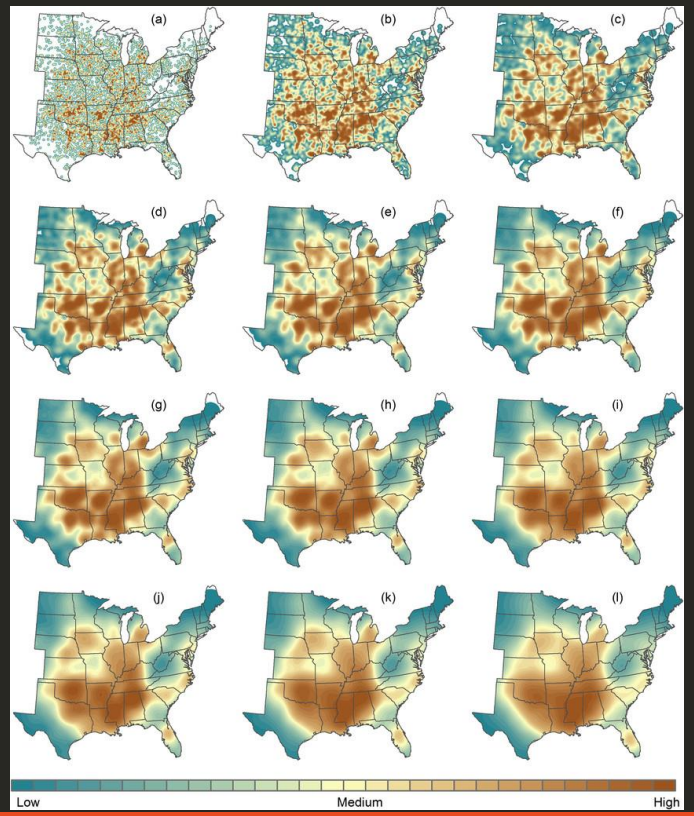
- How do radar product shown, the order in which participants see the tornado video, and the type of call-to-action message the participants are shown affect:
  - Intent to shelter
  - Confidence in that intention
  - Perceived level of danger

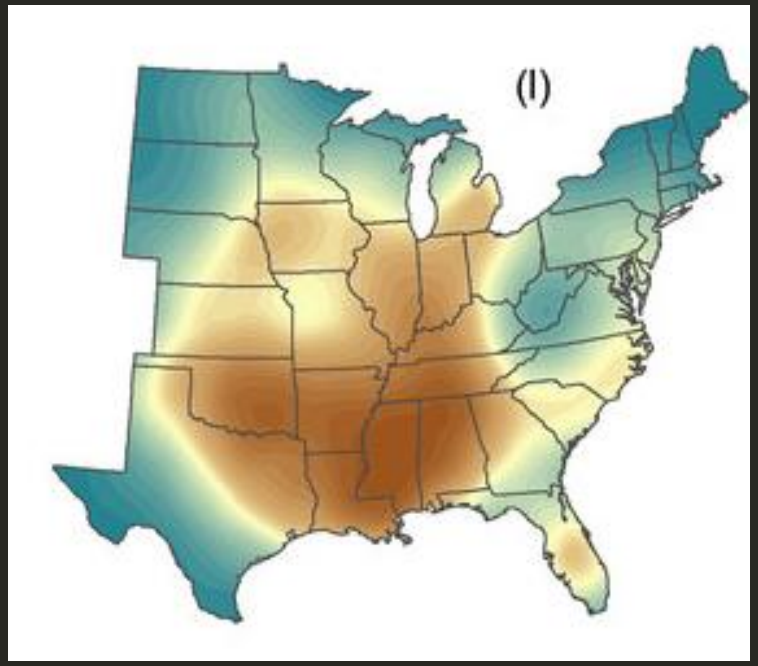
# Hypotheses

- Participants shown correlation coefficient will be more likely to believe that there is a tornado than those shown storm-relative velocity.
- In comparison to participants shown the standard call-to-action, participants shown call-to-action with request for video and call-to-action with viewer-submitted video will be:
  - Less likely to trust the meteorologist
  - Express more confusion, skepticism, or anger
- Participants will be more likely to correctly identify the location of a tornado on the radar product that was explained to them than the one that was not, but most people will correctly locate the tornado on correlation coefficient.

# Methods

- Survey with an experimental design, singling out states with higher tornado densities (Deng et al., 2016).



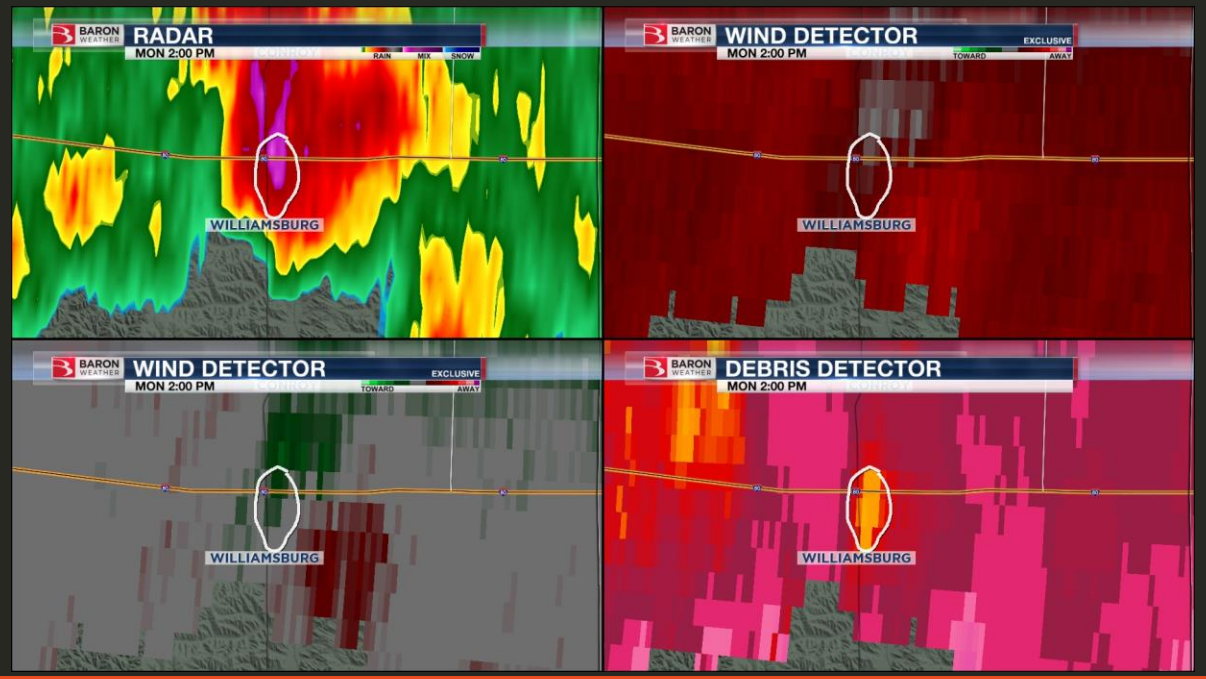



# Methods

- Survey with an experimental design, singling out states with higher tornado densities (Deng et al., 2016).
- Regions (Jay et al., 2018):
  - Southeast: AR, LA, KY, TN, MS, AL, GA, NC, SC (FL excluded)
  - Midwest: MN, IA, MO, WI, IL, MI, IN, OH
  - Great Plains: SD, NE, KS, OK, TX
- Survey created on Qualtrics and distributed on Prolific so that there was representativeness of age and equal number of participants from each region

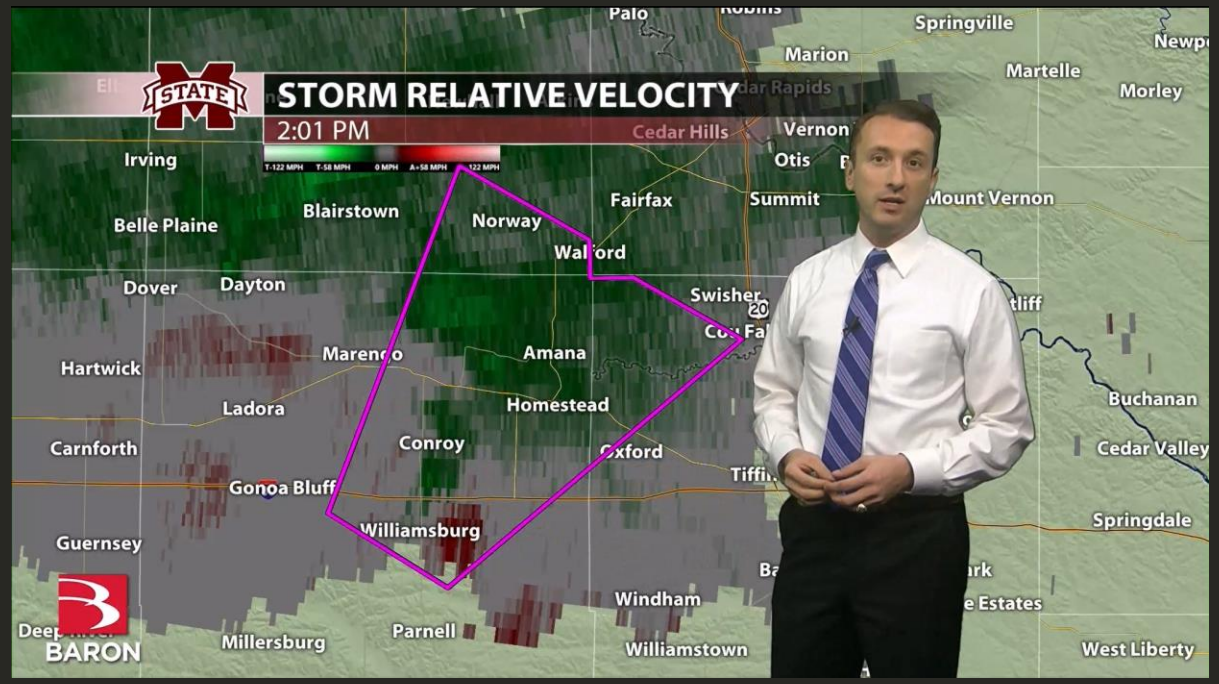
# Methods

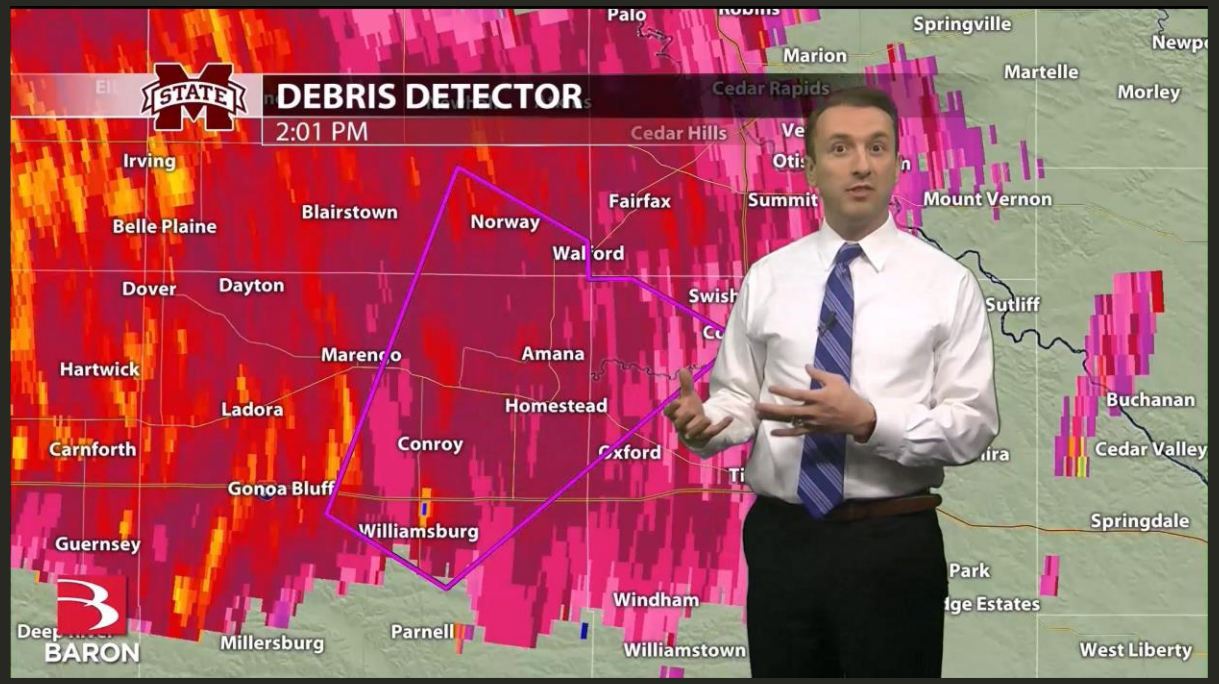
- The event
- EF-1 Williamsburg, Iowa at 2:00 p.m. January 16, 2023
- Caught on IDOT camera and by a viewer in a car as it crossed I-80



# Methods

- Experimental Design: 2 (radar: storm-relative velocity vs. correlation coefficient) × 2 (radar order: tornado video first vs. radar video first) × 3 (call-to-action: standard vs. with request for video vs. with viewer-submitted video)



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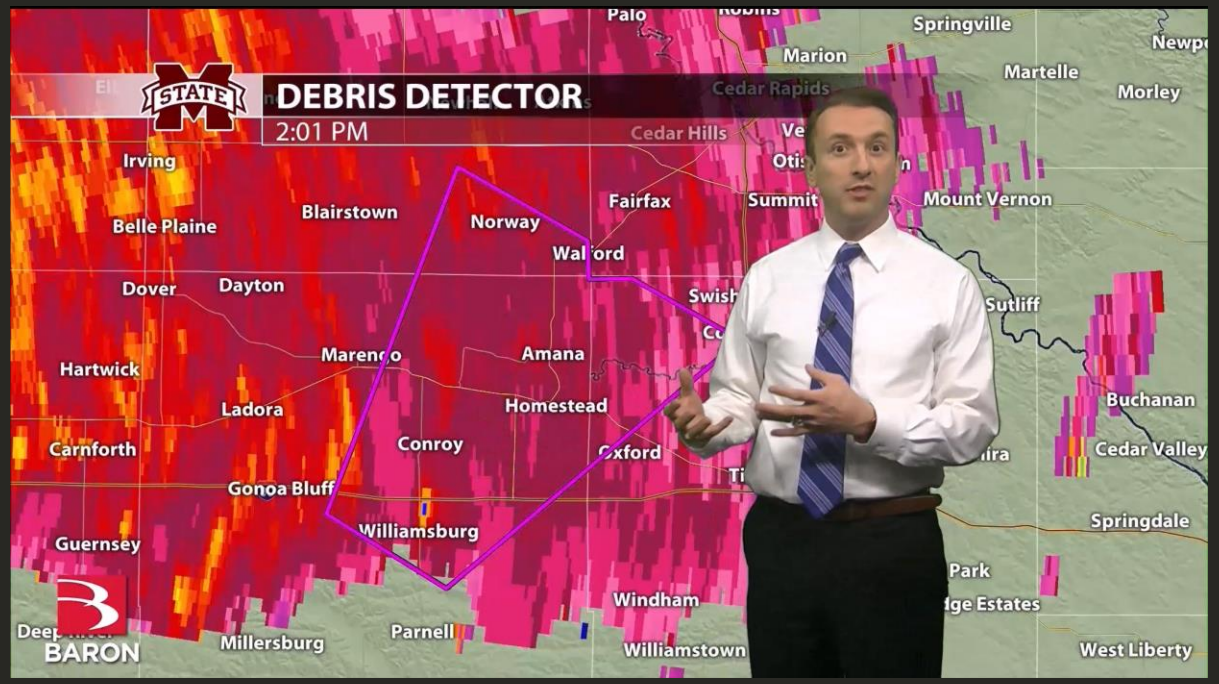

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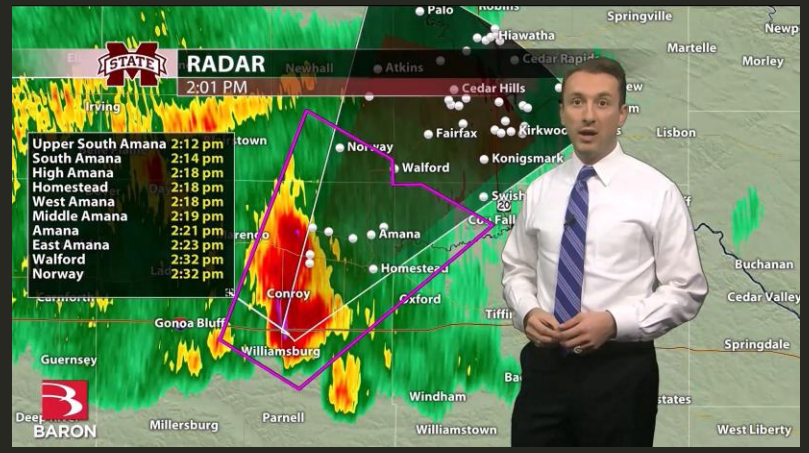
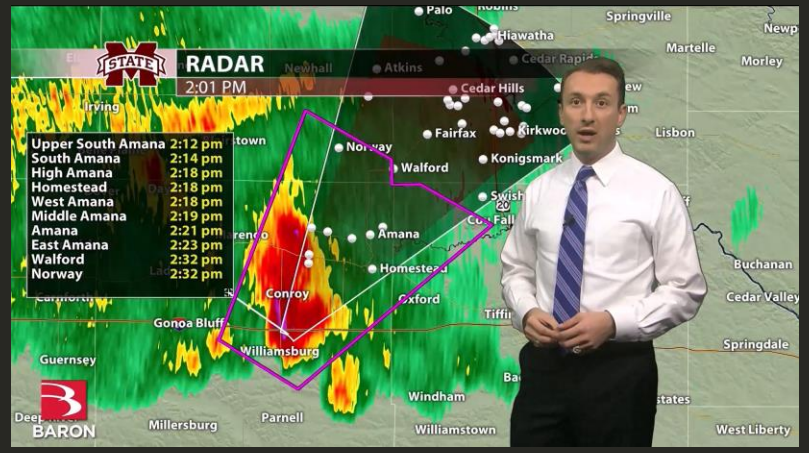
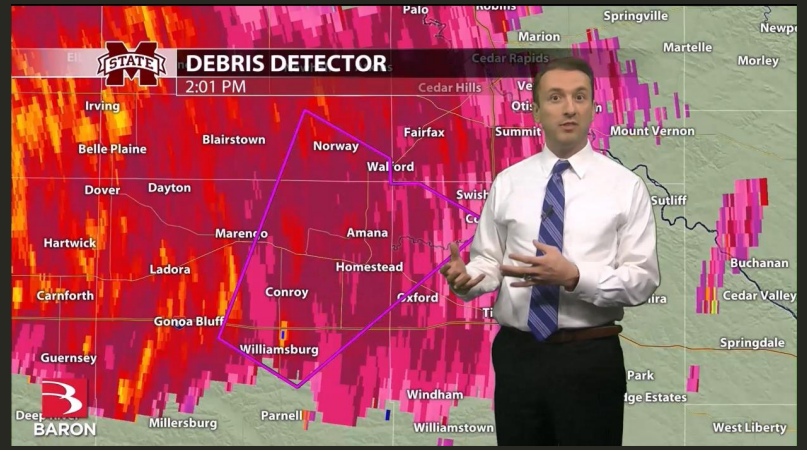


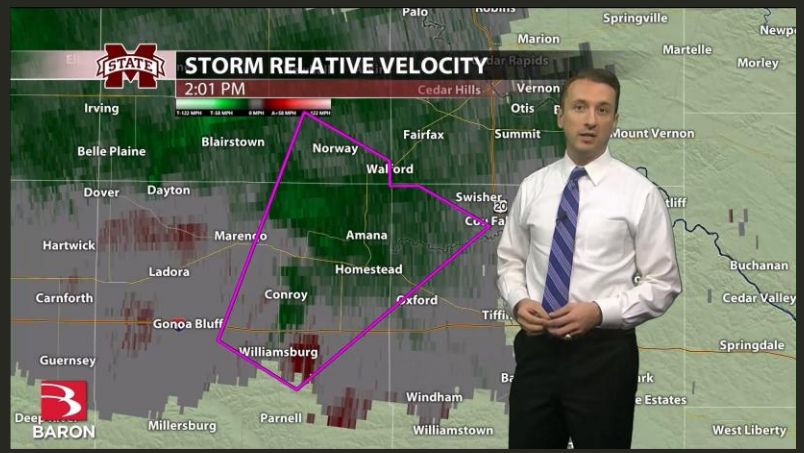

with request for video

# Methods


EAST I-80 CAM
WILLIAMSBURG


DEBRIS DETECTOR
2:01 PM
Springville
Marion
Martelle
Morley
Irving
Belle Plaine
Blairstown
Norway
Fairfax
Summit
Mount Vernon
Dover
Dayton
Hartwick
Amana
Ladora
Homestead
Carnforth
Conroy
Oxford
Buchanan
Cedar Valley
Gonoa Bluff
Williamsburg
Springdale
Guernsey
Windham
Millersburg
Parnell
Williamstown
West Liberty
BARON


Matt Krieger


STORM RELATIVE VELOCITY
2:01 PM
Springville
Marion
Martelle
Morley
Irving
Belle Plaine
Blairstown
Norway
Fairfax
Summit
Mount Vernon
Dover
Dayton
Hartwick
Amana
Ladora
Homestead
Carnforth
Conroy
Oxford
Buchanan
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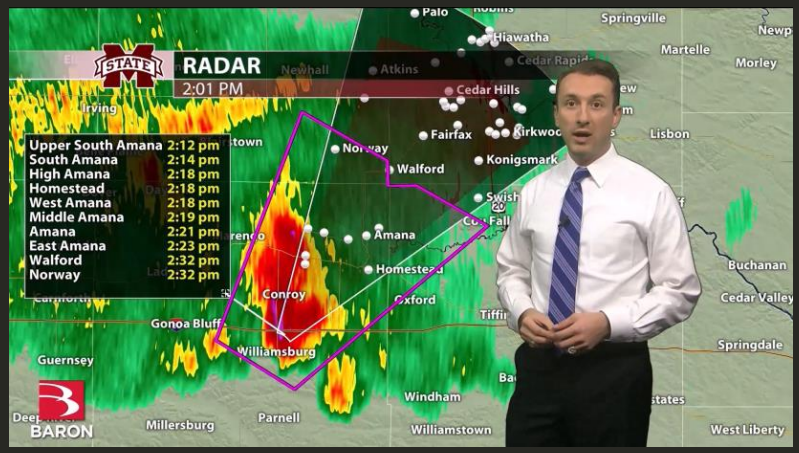
Gonoa Bluff
Williamsburg
Springdale
Guernsey
Windham
Millersburg
Parnell
Williamstown
West Liberty
BARON


EAST I-80 CAM
WILLIAMSBURG

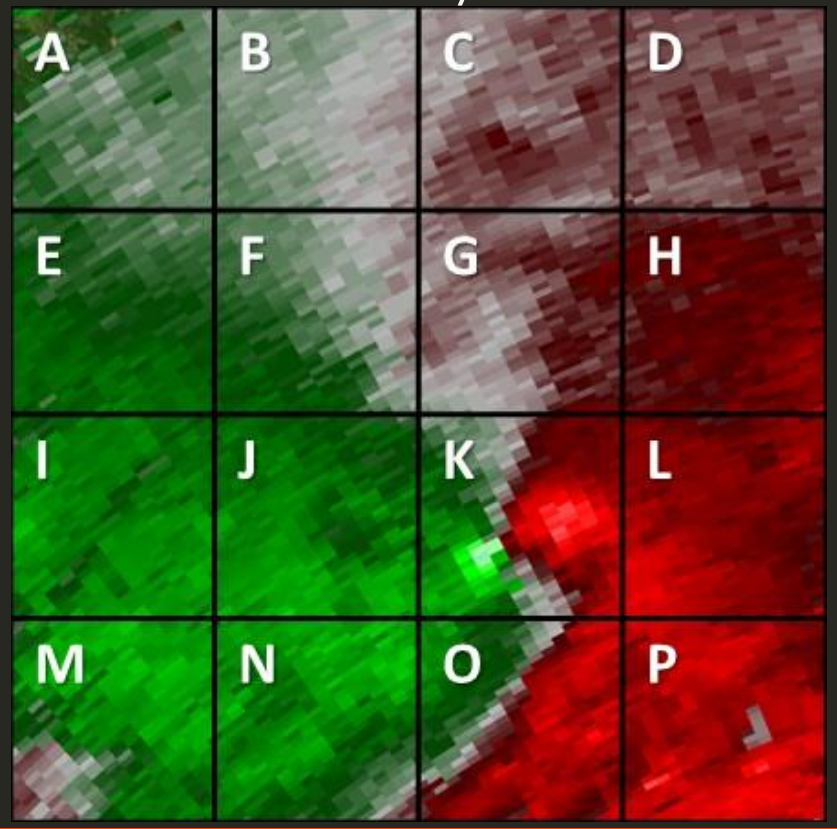

RADAR
2:01 PM
Upper South Amana 2:12 pm
South Amana 2:14 pm
High Amana 2:18 pm
Homestead 2:18 pm
West Amana 2:18 pm
Middle Amana 2:19 pm
Amana 2:21 pm
East Amana 2:23 pm
Walford 2:32 pm
Norway 2:32 pm
Springville
Martelle
Morley
Irving
Fairfax
Lisbon
Walford
Amana
Buchanan
Cedar Valley
Conroy
Oxford
Gonoa Bluff
Williamsburg
Springdale
Guernsey
Windham
Millersburg
Parnell
Williamstown
West Liberty
BARON

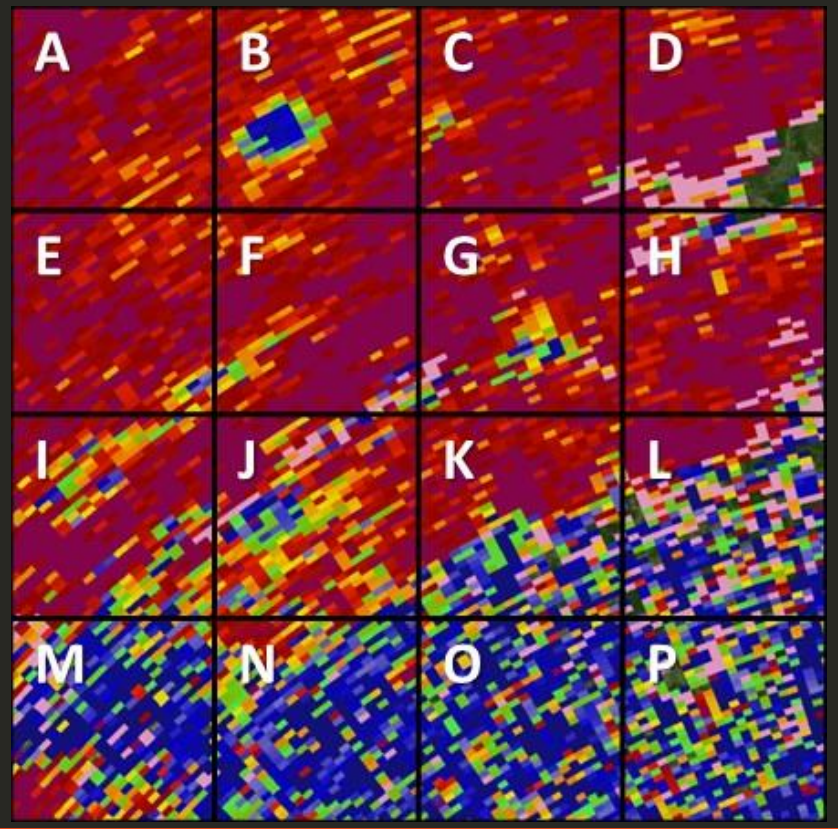
# Methods

- If I were in Homestead, I would shelter immediately.
  - (1 – strongly disagree; 6 – strongly agree)
- I am confident my decision to shelter or not shelter immediately is the best decision.
  - (1 – strongly disagree; 6 – strongly agree)
- What level of danger do you think you would be in if you were in Homestead?
  - (1 – extremely low; 6 – extremely high)
- I believe that is a tornado on the ground.
  - (yes/no/unsure)
- After watching this video, I would rate my trust in this meteorologist as
  - (1 – extremely low; 6 – extremely high)
- I feel like the meteorologist was taking this situation seriously
  - (1 – strongly disagree; 6 – strongly agree)
- The video I just watched made me feel (up to 50 characters):
  - open response

# Methods

- Below is a gridded image of the velocity/debris detector radar product. Which box shows the most likely location of a tornado?



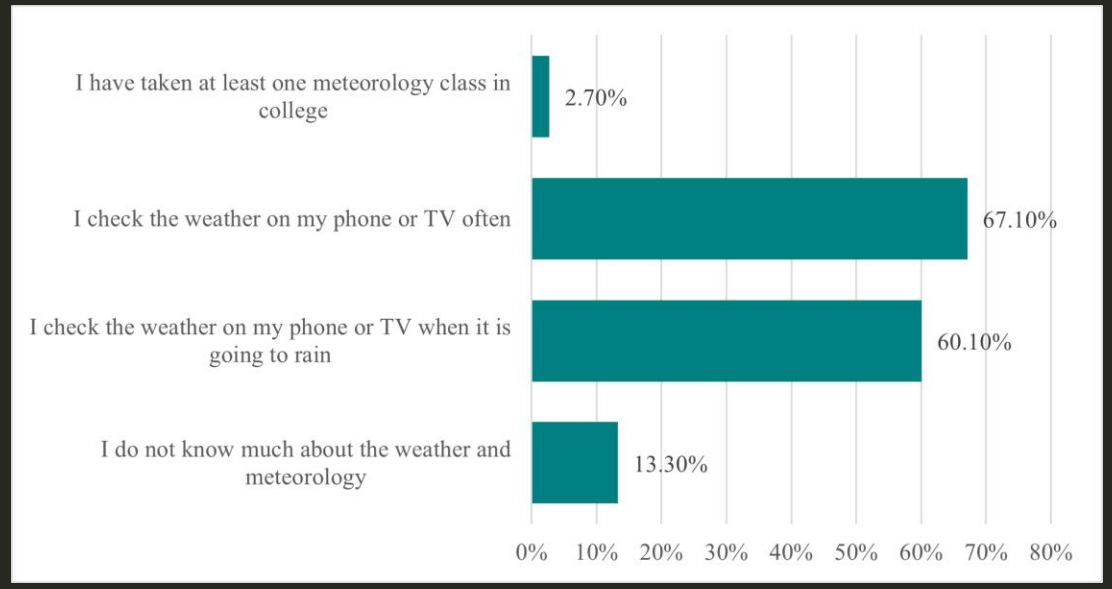



# Results

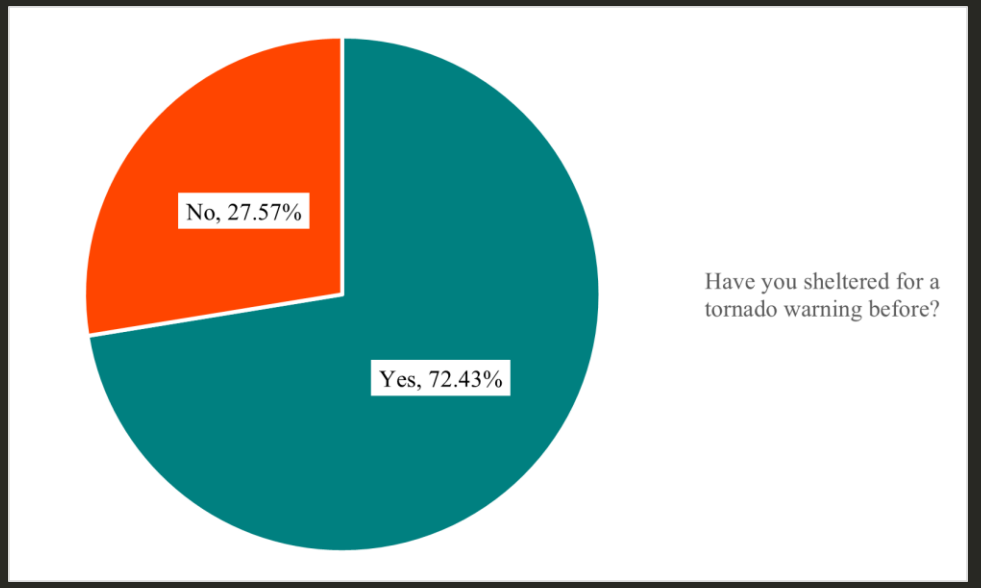
- A total of 301 participants completed the survey.
- The sample was representative of the United States in terms of race, age, and sex.

# Results

General weather knowledge of the sample




Previous shelter experience



# Results

| Hypothetical actions taken if home during a tornado warning | N = 301 |
|---|---|
| Seek more information about the tornado warning | 69.10% |
| Shelter at home | 89.00% |
| Call others | 30.60% |
| Leave your home to shelter somewhere else | 5.60% |
| Go outside to try to see the tornado | 11.00% |
| Nothing | 3.00% |
| Other | 2.30% |

| Prior experience with the aftermath of a tornado | | N = 202 |
|---|---|---|
| I have seen tornado damage firsthand. | 69.30% | 140 |
| I have had damage to my property as a result of a tornado. | 24.80% | 50 |
| My life has been disrupted as a result of a tornado. | 19.80% | 40 |
| People I know have had damage to their property as a result of a tornado. | 72.30% | 146 |
| People I know have had their lives disrupted as a result of a tornado | 50.00% | 101 |

# Results

Factorial ANOVA significance compared with nonparametric analyses

| Relationship | Means | ANOVA p-value | Nonparametric p-value |
|---|---|---|---|
| **Radar order** significant on sheltering question after watching radar video | Radar video first, 4.73<br>Tornado video first, 5.10 | .006 | .035[a] |
| **Radar order** significant on confidence question after watching radar video | Radar video first, 4.99<br>Tornado video first, 5.20 | .049 | .048[a] |
| **Radar order** significant on danger question after watching radar video | Radar video first, 4.54<br>Tornado video first, 4.93 | .002 | .003[a] |
| **Radar order** significant on trusting the meteorologist question after watching radar video | Radar video first, 4.62<br>Tornado video first, 4.93 | .006 | .010[a] |
| **Radar order** significant on understanding of the radar product after the meteorologist explained it | Radar video first, 4.53<br>Tornado video first, 4.96 | .002 | .004[a] |
| **Radar order** significant on sheltering question after watching the tornado video | Radar video first, 4.92<br>Tornado video first, 5.27 | .008 | .013[a] |
| **Shown message** significant on trusting the meteorologist after watching call-to-action video | Standard, 5.38<br>With request, 5.12<br>With viewer video, 5.46 | .011 | .024[b] |
| **Shown message** significant on thinking the meteorologist was taking the situation seriously after watching call-to-action video | Standard, 5.47<br>With request, 5.12<br>With viewer video, 5.43 | .009 | .028[b] |

[a]Results of Mann-Whitney U test
[b]Results of Kruskal-Wallis H test

# Results

Intent to shelter, video order significance

| | Shown Radar First | Shown Tornado First |
|---|---|---|
| Intent to shelter after watching radar video | 4.73 | 5.10 |
| Intent to shelter after watching tornado video | 4.92 | 5.27 |
| Relationship | Tornado video significantly higher than radar video (p = .028) | Tornado video significantly higher than radar video (p = .005) |

# Results

Means for repetitive Likert-scale questions

| | Radar Video | Tornado Video | Call-to-Action Video |
|---|---|---|---|
| **Intent to shelter[a]** | 4.93 | 5.11 | 5.43 |
| **Confidence in decision[b]** | 5.11 | 5.20 | 5.49 |
| **Belief in danger[b]** | 4.75 | 4.85 | 5.26 |
| **Trust in the meteorologist[c]** | 4.80 | 4.91 | 5.32 |
| **Meteorologist took the situation seriously[b]** | 4.99 | 4.97 | 5.34 |

[a]Call-to-action significantly higher than tornado video ($p < 0.001$) and radar video ($p < 0.001$); tornado video significantly higher than radar video ($p < 0.001$)

[b]Call-to-action significantly higher than tornado video ($p < 0.001$) and radar video ($p < 0.001$)

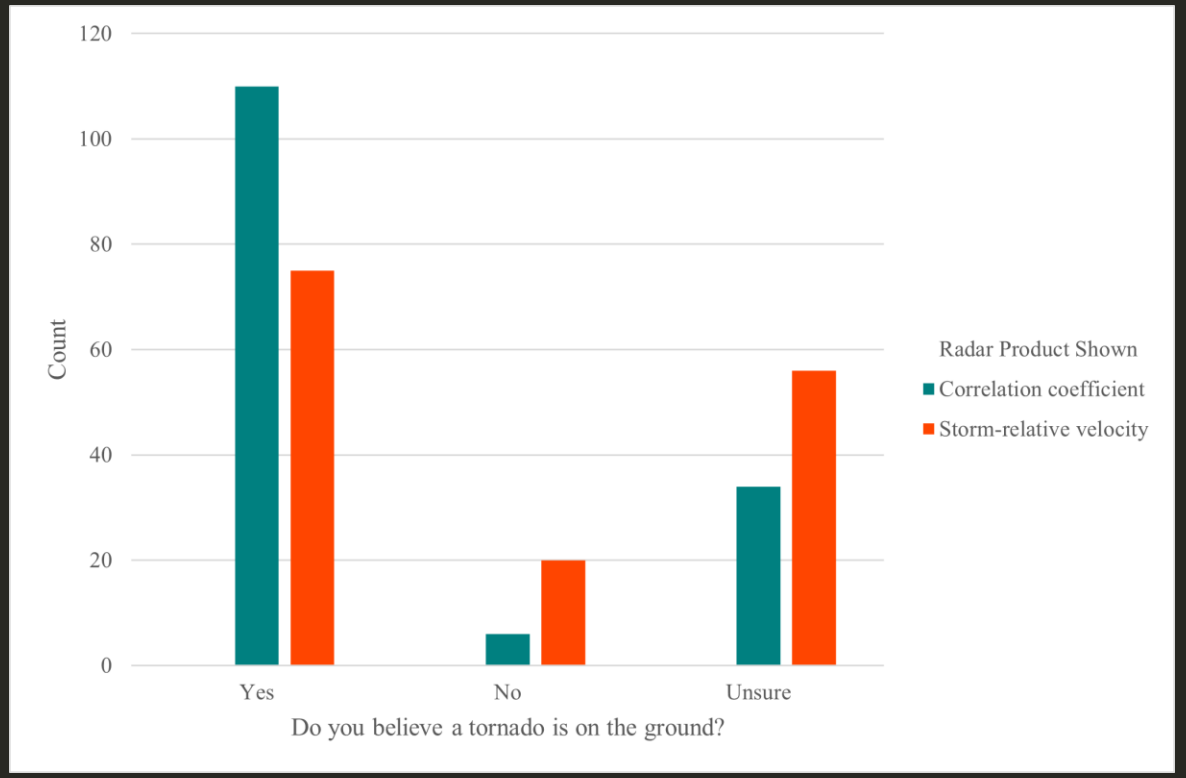
[c]Call-to-action significantly higher than tornado video ($p < 0.001$) and radar video ($p < 0.001$); tornado video significantly higher than radar video ($p = 0.045$)

# Results

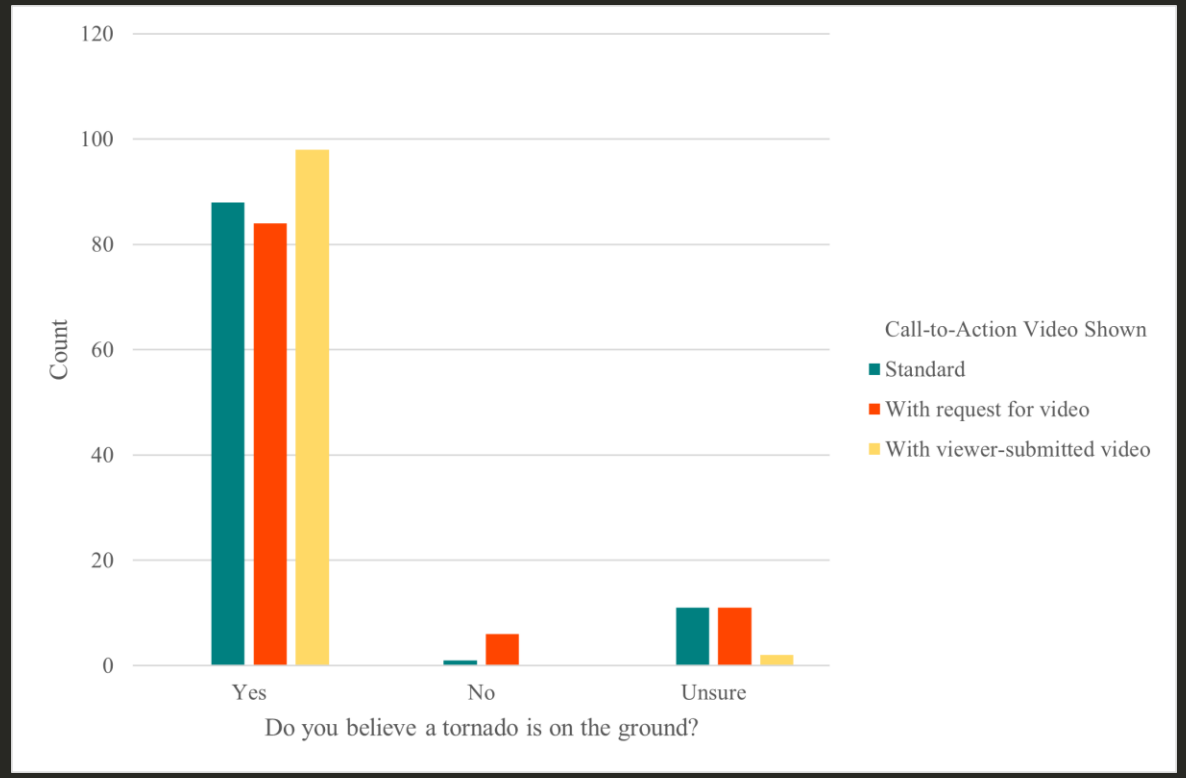
Participants belief in there being a tornado on the ground

| | Yes | No | Unsure |
|---|---|---|---|
| Radar video | 61.5% | 8.6% | 29.9% |
| Tornado video | 82.1% | 5.6% | 12.3% |
| Call-to-action video | 89.7% | 2.0% | 8.3% |

# Results




$p < .001$




$p = .002$

# Results

Feelings described after viewing each video, percentages

| N = 298 | Radar video | Tornado video | Call-to-Action video |
|---|---|---|---|
| Anxious/worried/scared | 30.5% | 41.0% | 45.0% |
| Concerned/cautious | 11.4% | 13.0% | 13.0% |
| Confused/unsure | 11.4% | 3.0% | 0.0% |
| Informed | 17.1% | 12.0% | 8.0% |
| Interested | 6.7% | 2.0% | 3% |
| Neutral/nothing | 4.0% | 3.0% | 1.0% |
| Prepared/calm/secure | 13.8% | 12.0% | 18.0% |
| Skeptical | 5.4% | 7.0% | 2.0% |
| Urgency/alert | 20.8% | 18.0% | 29.0% |
| Other | 4.7% | 9.0% | 3.0% |

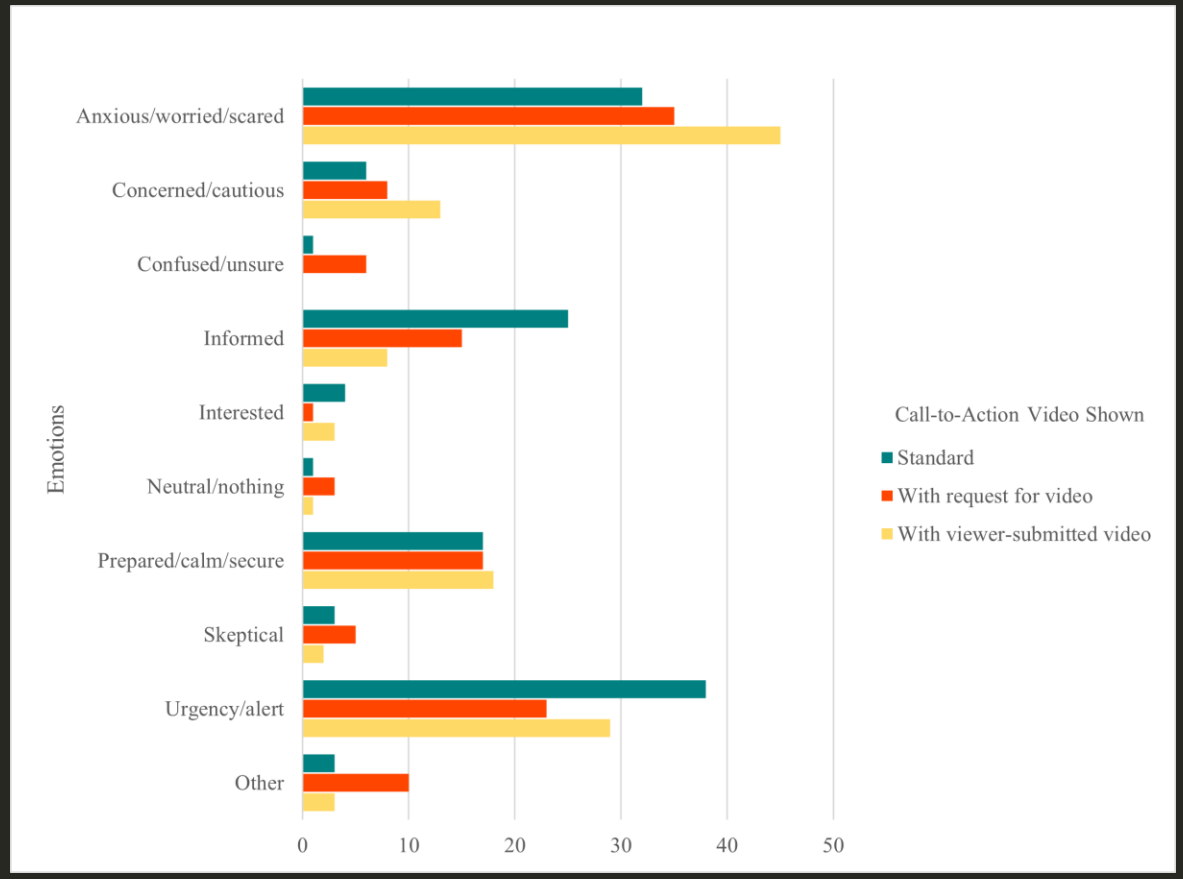
# Results

Significant emotion difference between each of the three videos

| | Cochran's Q p-value | McNemar p-value | Relationship |
|---|---|---|---|
| **Anxious/worried/scared** | .004 | .002 | Tornado video (39.93%) greater than radar video (30.54%) |
| **Confused/unsure** | <.001 | .007<br><br><.001 | Tornado video (5.03%) less than radar video (11.4%)<br>Call-to-action video (2.35%) less than radar video (11.4%) |
| **Interested** | .013 | .017 | Nonsignificant |
| **Neutral/nothing** | .035 | >.017 | Nonsignificant |
| **Prepared/calm/secure** | .008 | .002 | Call-to-action video (17.45%) greater than tornado video (10.07%) |
| **Urgency/alert** | <.001 | .001<br><br>.003 | Tornado video (20.81%) less than call-to-action video (30.20%)<br>Radar video (20.81%) less than call-to-action video (30.20%) |

# Results

Emotions expressed, based on call-to-action message



# Results

- 10 of the 99 participants who were shown the call-to-action message with a request for video used their 50 characters to point out, question, or critique this action
  - "Concerned (but also perplexed by the pic requests)"
  - "I'd have to be outside to take a pic."
  - "Send pictures when I am in a hurry?"
  - "It was weird for him to ask for pictures and videos."
  - "I didn't like that they asked for video or picture"
  - "Annoyed at ask of photos mid tornado."
  - "confused on being told to shelter and send in vids"
  - "slightly mad that the weatherman asked for videos."
  - "I would go to shelter since he said to but not vid"
  - "nervous but the meteorologist also asked for video"

# Results

Correct answers to the gridded questions, based on radar product

| | Shown Correlation Coefficient | Shown Storm-relative Velocity |
|---|---|---|
| Neither Correct | 21.59% | 15.61% |
| Only Velocity Correct | 3.99% | 23.92% |
| Only Correlation Coefficient Correct | 11.63% | 3.65% |
| Both Correct | 12.62% | 6.98% |

# Discussion

- Most people were agreeing to shelter
- Sample extremely weather aware
  - Survey titled "Broadcast Warning Coverage"
  - Target demographic was tornado-prone states
- Participants' intent to shelter on the radar question was significantly higher if they watched the tornado video first
  - Answers went down after viewing radar video
  - Respondents were significantly more confused by the radar video than the tornado video

# Discussion

- Participants were more likely to believe a tornado was on the ground when they were shown correlation coefficient over storm-relative velocity.
- Participants shown call-to-action video with the request for video were significantly less likely to trust the meteorologist and think he was taking the situation seriously than those shown the standard call-to-action or call-to-action with viewer-submitted video
  - Seeing the video a second time outweighed any mixed messaging
  - Risk more believable; what meteorologist says is more important than graphics
- Of the three videos, participants answered highest on the third video they were shown, the call-to-action video

# Discussion

- Participants were significantly more confused by the call-to-action video than by any other
  - Confusion comes from the participants who were shown the call-to-action message with request for video
- Participants were significantly more anxious or scared by the tornado video than the radar video
- At least 30% of the participants felt some level of anxiety, worry, or fear in each of the three videos
- Participants were more likely to answer the gridded radar questions correctly on the radar product that was explained to them
- More people correctly located the tornado on storm-relative velocity, not correlation coefficient

# Key Takeaways

- The participants of this survey intended on sheltering, regardless of any radar product shown, when they saw the tornado video, and which call-to-action video they were shown
- Participants are influenced by seeing the video of the tornado
  - More likely to shelter, perceive danger, feel anxiety than the radar video
- Broadcast meteorologists should continue to explain radar products to the viewers and ***issue call-to-action statements***
- Results of this study found meteorologists asking for video is frowned upon, but not showing the video

# Future Research

- Utilize regional analysis
- Tests other elements of tornado warning coverage, like cross-sectional views of radar products
- Explore other types of warning coverage: tropical, fire, flooding, etc.
- Influence of meteorologists' social media coverage

# Acknowledgements


- Kathleen Sherman-Morris
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- Lindsey Poe
- Andrew Mercer
- All of you ☺

# Questions?

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# Supplemental: Non-parametric analyses

- Mann-Whitney U test
  - Compares two means
- Kruskal-Wallis H test
  - Compares two or more means
- Friedman test
  - Checks for differences between groups
- Wilcoxon test
  - Compares two means between groups
- Cochran's Q test
  - Determines if proportions are signficant
- McNemar test
  - Analyzes pairs; post-hoc for Cochran's Q