Do You See What I See? How Media Choice and Visual Tornado Cues Influence Individual Storm Preparation

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(Manuscript received 4 February 2022, in final form 19 September 2022)

ABSTRACT: When a tornado hits, there is little time to think through mental checklists for needed items. This study attempted to understand what information sources those in the path of tornados utilized for preparation and how those sources influence people to act. Results from the study indicate that television and radio are the top two information sources, and that some visual graphics—gauged via heat maps to understand higher levels of severe weather preparation—were reported as useful. Contrary to meteorological intentions, results showed that participants were less likely to prepare for impending weather when radar displayed tornado locations and intensity. In addition, those who identified as having more interest in weather-related information in the study were significantly more likely to prepare, along with those who fear future tornadoes. Each variable explored is underpinned by the theory of planned behavior and the risk information seeking and processing (RISP) model to better understand behavioral intentions and actions. This study offers two new concepts of general weather that have not previously been explored: interest and general versus specific storm preparation.

SIGNIFICANCE STATEMENT: The purpose of this work is to learn more about how individuals gather information and obtain weather warnings, primarily during tornado events. In particular, the study seeks to understand how individuals view and interpret visual graphics with information about the location and details about the event. Further, results suggest some differences between those who generally prepare for storm season versus those who only prepare for a specific event. Researchers may also be interested to know how weather enthusiasts may differ in their preparatory activities in comparison with nonweather enthusiasts. All of this information will help meteorologists and media professionals to better target their messages during severe weather.

KEYWORDS: Social Science; Forecasting techniques; Communications/decision making

1. Introduction

When a strong thunderstorm, potential hurricane, or winter blizzard is forecast, often televisions, Twitter feeds, and Facebook live posts are focused on maps and weather radar screens. Some individuals view these feeds regularly, even during quiet times. These screens are filled with multicolored graphics and expected wind and precipitation counts. Trained storm spotters head out to gauge the intensity of these storms, reporting back from "in the trenches." These events are highly anticipated broadcasts on local newscasts and media outlets that may preempt other news stories and scheduled television broadcasts. However, some individuals may never see any of them, choosing instead to ignore warnings or rely on other sources for information. Also, with a plethora of media choices available at the touch of a button, confusion may ensue about where to find accurate weather information.

The questions become, then: To what media sources do individuals turn during an impending weather event? Within those forms of media, what kinds of visual cues influence preparatory actions? Specifically, do the visual cues provided by weather forecasters and broadcast meteorologists play a role in influencing preparatory activities? Do these preparatory activities vary between specific and general storms? This study also looks at the role of personal disposition in relation to storm preparation. That is, do individual motivations have an influence on their behaviors? For example, if an individual perceives a storm to be a significant risk to them, are they more likely to prepare? What about those who have a general interest or knowledge about weather-related events? On one hand this could be extreme weather enthusiasm, or on the other hand it could be fear and panic related to impending storms.

This study's survey specifically asks about tornado preparation and includes tornado graphics. This was especially pertinent for the study's sample chosen from the coverage area of the National Weather Service in Memphis, Tennessee, because of recent tornado disasters. In March of 2020, tornados ravaged middle Tennessee in the middle of the night to produce widespread damage and 25 deaths (Reinke et al. 2022). A March 2020 tornado in Jonesboro, Arkansas, demolished a shopping mall, although no fatalities were reported (Samenow 2020). Also, northern Mississippi has suffered multiple strong tornadoes, including one in 2015 that touched down in several northeastern counties, producing millions of dollars in property damage (Clarion Ledger 2022). Although Mississippi, Alabama, Tennessee, and Arkansas are not officially included in what is known as "tornado alley" in the United States, it

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DOI: 10.1175/WCAS-D-22-0017.1

has been called a "bona fide extension of Tornado Alley" by the *Washington Post* because of the South's vulnerable populations (Cappucci 2020).

In addition to exploring media choice and preparatory activities, the paper also offers up two new concepts for study about risk perception and decision-making when severe weather is imminent. First, the authors propose that individuals who have a *general interest in weather* will likely have different views and actions with regard to upcoming weather events than those who do not share that enthusiasm. The second concept proposed is a comparison between those who generally prepare for severe weather each year (i.e., tornado season or hurricane season) versus those who find themselves near a specific severe weather event, perhaps through vacation or an unexpected tornado or hurricane path. Both concepts were examined as part of this work. In all, the overall research question in this paper examines the impact of media choice and visual cues on tornado preparation, along with personal dispositions, such as perceived risk and weather-related interest.

The current theoretical framework focuses on perceived risk and how it influences decision-making, following up on the risk information seeking and processing (RISP) model (Griffin et al. 1999), along with the theory of planned behavior (TPB; Ajzen 1985). Both theoretical components assess decision-making efforts under direct influence, which make them appropriate to use in conjunction with the proposed concepts in the context of tornado preparation.

The findings of this study can be useful for both scholars and practitioners. The extension of the RISP model into storm-related events is a relatively new theoretical application, as well as the two new weather-related concepts. Further, weather forecasters can use these results to fine tune their weather forecasts for different audiences.

2. Literature review

a. Media graphics and disasters

Technology and numeracy have revolutionized the weather-prediction accuracy over the past 25–50 years (Bauer et al. 2015). Meteorologists are able to pinpoint storm direction, timing, and general intensity. Earlier studies have found that graphics, warnings, and radar views are commonly employed in broadcast news (see, e.g., Daniels and Loggins 2007; Landsea and Franklin 2013), along with the projected storm paths, wind speeds, and temperatures (Liu and Xie 2012). In terms of post-disaster news coverage, visual cues have been employed to show the impact area, numbers of casualties, and structural damage (Ash et al. 2014; Moore and Dixon 2012; Wu et al. 2014; Zahran et al. 2013).

Studies that have focused on information gathering during disasters have examined the general sources from which residents gather information, including verbal communication or information provided by emergency management, governmental or rescue personnel (e.g., Perry et al. 2001; Linardi 2016; Landwehr et al. 2016). However, those studies focused on how information is distributed. In today's culture, media consumers can select their own sources, which may not include traditional media or "official" notices—that is, *social media.* Two recent studies have suggested that individuals seek to achieve a level of information sufficiency in times of severe weather, from which they then make decisions about how to prepare (see Armstrong et al. 2020; Armstrong and Towery 2021). The present study looks to more specifically target the sources that individuals choose during tornadoes, when they may have little warning time to prepare.

For those who live in tornado-heavy areas, experts recommend stocking up on batteries, water, and nonperishable food, along with a having a weather radio or broadcast television nearby (Centers for Disease Control and Prevention 2022). As they track tornadoes, viewers may hear and see the roar of the cyclone in a live, standup shot, or, for safety reasons, meteorologists may rely on graphics issued by National Weather Service to tell the story. In particular, visual tornado watch and warning graphics are prevalent on television screens when severe weather hits. As noted by Sattler et al. (2000) findings, these rich, detailed tornado warning graphics may not be perceived or understood by the audience as severe weather professionals would hope (Casteel and Downing 2013).

This may be, in part, because many research participants consuming tornado coverage are not able to identify differences between tornado watches and warnings (Donner et al. 2012) that could impact their preparation responses. Other factors that may influence one's preparation responses include prior tornado experience, knowledge about severe storms, and ability to evacuate or take shelter during tornados (Drost et al. 2016; Demuth et al. 2016). Of the three, past tornado experience could evoke the most emotional response by those who have experienced the wrath of tornados in the past. Demuth et al. (2016) define past tornado experience as the perceptions people hold about the effects of tornadoes. These perceptions are shaped by tornado threats and the actual tornadic event itself, either through the viewers own eyes, or secondhand. As a result, individuals may not respond to generalized tornado watches and warnings in the same manner, despite media messages being uniform.

Another area of study has focused on how media graphics are comprehended by viewers. A study by Sattler et al. (2000) found that weather-related graphics did not contain the necessary instructive preparatory information. The authors suggested that these graphics can lead to unnecessary danger, preventable property damage, or poor decision-making by impacted residents. Researchers have suggested that inclusion of necessary key details is crucial to provide residents with sufficient information to make decisions on evacuation or preparation (Mileti and O'Brien 1992; Mileti and Sorensen 1987; Armstrong et al. 2020). The animation and gesturing of a broadcast meteorologist may also impact comprehension, as a 2015 eye-tracking study of a television weather forecast found that viewers spent more time looking between the weathercaster's eyes and face than looking at the graphics (Drost et al. 2015).

Most recently, the focus of many studies has centered on comprehension of the visual messages during weather events by consumers and their likelihood to take potential life-saving

actions. For example, the "cone of uncertainty" within hurricane predictions has been studied, and researchers found that varying cone designs can often prompt misinterpretation among residents (Millet et al. 2020). Similarly, other scholars (Witt et al. 2020; Boone et al. 2018) argued that interpretations of the graphics varied widely, in terms of potential risk. In a study conducted shortly after Hurricane Michael hit the Gulf Coast in 2018, Armstrong and Towery (2021) found that live video of a hurricane event was a bigger motivator of resident preparedness than either computer "cone of uncertainty" graphics or basic text messages. Bica et al. (2019) suggested that clear and understandable messaging is needed during severe weather, which would allow individuals to assess their situations more meaningfully.

Studies specific to tornado research show lack of knowledge about tornado terminology can be detrimental to effective evacuation (Donner et al. 2012). Particularly, participants had trouble differentiating between tornado watches and warnings (Walters et al. 2020), as evidenced here: "Well I always get confused. I'm thinking the warning is that conditions are favorable, and the watch is one's been … spotted … do I have it reversed?" (Walters et al. 2020, p. 74). The present study focuses on individual comprehension and knowledge of tornado watches and warnings.

Studies that have focused on information gathering during disasters have examined the general sources from which residents gather information, including verbal communication or information provided by emergency management, governmental or rescue personnel (e.g., Perry et al. 2001; Linardi 2016; Landwehr et al. 2016). However, those studies focused on how information is distributed. In today's culture, media consumers can select their own sources, which may not include traditional media or "official" notices. Two recent studies have suggested that individuals seek to achieve a level of information sufficiency in times of severe weather, from which they then make decisions about how to prepare (see Armstrong et al. 2020; Armstrong and Towery 2021). The present study looks to more specifically target the sources that individuals choose during these events.

b. Decision-making during disasters

Scholars have also focused their attention on what factors predict individuals' likelihood to evacuate during times of severe weather. Wachinger et al. (2013) posited that individual trust in official authorities can impact their willingness to evacuate. That is, higher trust in authorities can lead to higher preparation activities, while lower trust levels lead to lower preparation activities (see Wachinger et al. 2013). Sheldon and Antony (2018) suggested that some evacuation decisions are influenced by an optimism bias. These scholars argue that some individuals believe that negative weather outcomes are more likely to affect others before themselves. In effect, individuals can be optimistic that bad outcomes will not happen to them. A 2012 study found that the optimism bias is common in potential storm areas (Donner et al. 2012).

Further, many of the past studies have treated decision-making during severe weather as a decision to evacuate or stay in the area, as the event nears (e.g., Dash and Gladwin 2007). However, recent work has extended the study of outcomes to look at the types of preparatory activities individuals may take before a specific event occurs. These actions include developing a travel kit, securing home and property, creating a disaster plan, gathering water and safety materials, and purchasing disaster-specific preparation items (e.g., Kang et al. 2007; Armstrong et al. 2020). Ripberger et al. (2015) noted that preparation for tornadic events may also include items such as having a safe room in one's home or a nearby storm shelter. Armstrong and colleagues labeled these actions as preparatory activities, which provides a level of safety, even though they do not evacuate the area.

Some scholars suggest that overall interest in severe weather impacts preparation. This could include the occasional weather enthusiast, or it could include the area's dedicated storm chaser. While the actors taking daring excursion into dangerous tornadic events in the movie *Twister* may come to mind, scholars have found many "storm chasers" are not motivated by risk. Xu et al. (2010) found that these storm chasers are mostly motivated by the enjoyment of nature and learning. These findings pair well within the context of this study because this kind of weather interest aids in the preparation—not thrill-seeking—efforts of severe weather. In effect, this interest could be a predisposition that impacts their risk perception and behavioral intention, which is discussed below.

3. Theoretical framework

This study is grounded in previous research in risk, disaster, communication, and message design literature to better understand how community members in urban and rural areas make decisions about evacuations. The theoretical framework chosen for this study is the RISP model and TPB (Griffin et al. 1999; Ajzen 1985). These theories aid in isolating what factors influence community members to make decisions in times of severe weather.

The TPB is an extension of the theory of reasoned action, which focused mainly on people and their decisions around health (Fishbein and Ajzen 1975). However, the consensus is that it can be applied to any range of actions, as long as they are made with free will in mind. The theory argues that intentions correlate with behaviors. These intentions include subjective norms, attitude, and perceived control. Subjective norms are socially accepted behaviors (Ajzen and Albarracín 2007), attitude is how community members think about behaviors (Ajzen and Albarracín 2007), and perceived control is how successfully one thinks he or she can carry out the action (Ajzen 2002).

The creation of the RISP model was born from TPB and the heuristic-systematic model (Griffin et al. 1999). The model analyzes how people are influenced to make decisions when they are under pressure, specifically hazards (Yang et al. 2014). Its expansion led to research surrounding health concerns and seeking information (Kahlor 2010). The RISP model says information seeking and process behavior are influenced by different motivations: accuracy motivation (the need to acquire an adequate amount of information; Eagly and Chaiken 1993),

impression motivation (the achievement of goals through attitudes; Chen and Chaiken 1999), defense motivation (gathering information that is consistent with already held beliefs; Griffin et al. 2004), and information capacity (choosing which information is the most important in making decisions; Yang et al. 2014). The last action to top off the RISP model are people's ability to evaluate the risk in front of them. In addition, previous experience and related value could influence how people search for information (ter Huurne et al. 2009).

The TPB has been applied across the research spectrum. It is effective in explaining why we seek information for potential decisions, including protected sex, mobile telephone use, and low-carbon travel (Albarracín et al. 2001; Cai et al. 2019; Cheon et al. 2012). The RISP model has underpinned much environmental research, too, including community members juxtaposed in flood plains in Belgium (Kellens et al. 2012) and residents' views of climate change (Yang et al. 2015).

Because both TPB and RISP both help to explore influence, intentions, and behaviors, they help understand and explain what forms of media influence those in risky weather situations, as well as subsequent decision-making outcomes. In particular, the study focuses on specific elements of two theories—1) information gathering and 2) risk perception and behavioral intention.

4. Hypotheses and research questions

In this study, we borrow certain aspects of RISP and TPB to predict risk perception and behavioral intention, as it relates to how individuals respond to tornadoes and severe thunderstorms. Specifically for RISP, we focused on how perceived risk and information sufficiency may impact their information gathering. Prior studies have examined perceived risk by asking participants if they believed their home was in a high/low risk for weather damage (see, e.g., Stein et al. 2010). More recent studies have defined risk perception as how concerned they are about a specific storm impacting them (see Sherman-Morris et al. 2020). With the infiltration of weather graphics, the present work will examine what pieces of the graphics are most useful for storm-related information. Further, do those pieces have an impact on an individual's decision-making?

RISP also includes an element of knowledge sufficiency, which scholars define as when an individual feels he/she has enough information to make a decision (e.g., Griffin et al. 2004; Yang et al. 2014) and whether they have the ability to evaluate the potential risk (ter Huurne et al. 2009). Further, scholars have examined the role of media during these evaluations, with several finding that television, radio (both general and weather-specific) and internet are prime sources during weather events (see, e.g., Sherman-Morris et al. 2020; Piotrowski 2015; Armstrong et al. 2020). With the infiltration of weather graphics, the present work will examine what pieces of the graphics are most useful for storm-related information. Further, do those pieces have an impact on an individual's decision-making?

The present work puts forth an overall concept of *general weather interest*, which combines media use with overall knowledge about weather and interest in the topic. Somewhat similar to Stewart's (2009) weather salience idea, this concept is based on one's curiosity and interest in weather as a topic—whether or not a severe event is imminent for them. These individuals seek out meteorological information regularly, perhaps regularly watching The Weather Channel or other specialty weather programming. They frequently search for weather and were informed about their own specific plans if severe weather threatened them. This may fall into the RISP model's concept of individual characteristics—that is, one's interest in weather may influence their risk perception and behavioral intention through their individual predisposition on the issue (see Dunwoody and Griffin 2015).

Research has found that individuals often overestimate their knowledge about severe weather, with residents demonstrating low levels of knowledge about weather-related events or their own location in comparison with the predicted-storm areas (Senkbeil and Schneider 2010; Stein et al. 2010). A recent study by Nunley and Sherman-Morris (2020) found that participants who had visited a specialty weather website and frequently obtained weather information were more knowledgeable about weather-related events than those who did not. This suggests that those who are more connected to weather-related information will likely engage in more preparatory activities. Nunley and Sherman-Morris (2020) deem this as being "weather aware."

With TPB, we argue that one's perceived risk will increase one's likelihood to engage in preparatory action. Researchers have found three reasons community members choose not to follow recommended action during a weather event: overall risk perception, influence from others in a social manner, and access to community resources (Riad et al. 1999; Armstrong and Towery 2021). In related studies, scholars Demuth et al. (2016) and Morss et al. (2016) studied why past experiences with hurricanes influence the way community members think about risk. The study investigated how those who survived hurricanes utilized media warning messages to gauge what they needed to do to stay safe. Both financial loss and damage to property were influential in decision-making (Demuth et al. 2016). A similar study that tested fear-appeal messages found that worry and fear about the potential impact a severe storm can bring can influence decision-making (Morss et al. 2018). Specific to tornadic research, Wallace et al. (2015) suggest that direct experience works in concert with other factors to influence risk perception.

In summary, prior research has suggested that individual decision-making when dealing with severe weather situations is often connected to the following: prior exposure to severe weather, information gathered from friends, neighbors, authorities, and the media, as well as on-site evaluation and availability of resources and fears about future disasters (Collins et al. 2017; Lindell and Perry 2004; Perry et al. 2001; Morss et al. 2018). The RISP model has been tested and applied in multiple health and environmental contexts, although scant work has extended it into severe weather, including a study by Kellens et al. (2012) examined Belgium residents living on flood plains, and views on knowledge of climate change by Yang et al. (2015).

This study also adds the dependent variables of *general storm preparation* versus *specific storm preparation* as a way to better understand individual risk perception and decision-making. Scholars have found that "being prepared" can be different for a variety of people who face impending severe weather (Wang 2018). The authors suggest that there are individuals who consistently prepare each year for tornado season, gathering items and materials, along with making a general safety plan. It is encouraged by meteorologists and emergency managers as a part of the yearly routine (Laska and Morrow 2006). It seems likely that these individuals make this an annual part of their household routine.

Conversely, other residents—perhaps more transient or newer residents—may only prepare if they learn of a specific storm moving in their direction. For travelers or those visiting the area, this includes advanced traveler information systems that alert for severe weather. Travelers are more likely to change their courses by accessing more information sources that are also outlined in this article: radio, television, cellular telephones, and the internet (Khattak et al. 2008). Based on individual preparation needs, these two groups of individuals may act decidedly differently in their risk perception and decision-making.

To summarize, this study looks to compare how individuals prepare for potential tornados—both for a general season of tornado potential and/or for a specific tornadic event that is forecast. In particular, potential predictors of risk perception, fear, and those with a general predisposition of interest in weather may have specific impacts. Based on the literature summarizing media sources employed by individuals during severe weather, comprehension of visual cues and what is lacking, as well as influences of TBP and RISP, the following hypotheses (H1–H3) and research questions (RQ) are put forward:

RQ1: What media sources are participants most likely to rely upon for a storm event?

RQ2: What visual elements on weather graphics are most likely to increase preparatory activities during tornado warnings and watches?

H1: Graphical storm elements are more influential for specific storm preparation than for general storm preparation.

H2: Participants who report general interest in weather will engage in more storm preparation activity, both general and specific.

H3: An individual's fear of future tornadoes will be a significant positive predictor of both general storm preparation and specific storm preparation.

5. Methods

After gaining Institutional Review Board approval, the authors utilized a Qualtrics panel to target desired participants with the service area of the National Weather Service–Memphis, as part of a grant (information withheld for blind review). This panel consisted of U.S. adults who volunteer their time and insights by participating in research activities. Panel participants were compensated by Qualtrics for the panel for participation in a 30-min study, although the researchers are not involved in the compensation process. The total *n* was 679 that met all research criteria and completed the survey. Participants were recruited from the coverage area of the National Weather Service in Memphis, Tennessee, which includes 55 counties across four states.[1] For reference, this included a total potential participant pool of almost 2.7 million people, (U.S. Census Bureau 2020).

Responses were collected from 27 April to 28 May 2021. The sample included 71.2% female participants and 28.8% male participants. The median age was 36–45 years old, and a majority of the sample identified as white (74.2%). Roughly 57% of participants have lived in their communities less than 10 years, and 52.6% of the sample was employed, either full- or part-time, with 72.5% reporting that they live in a single-family home.

a. Study procedure

This study consisted of 40 questions that gauged participants' ideology of weather preparedness, media use, preparatory activities for general tornado seasons and specific weather events, as well as their demographical information. In addition, two graphics labeling tornado warning (Fig. 1) and tornado watch (Fig. 2) information were shown as participants chose the three most important areas. Data were recorded using a heat map within Qualtrics. Heat maps use a row and column clustering structure to plot data points and assess patterns visually (Wilkinson and Friendly 2009). This allows researchers to capture what viewers find important and engaging in a graphic.

After viewing the graphic, manipulation checks were administered to ensure participants were paying attention to the information in the graphics. After the graphics referencing a tornado warning and watch, the manipulation check asked what was depicted in the graphic. Those who could not identify the graphic as a tornado warning/watch were removed from the survey, and their answers discarded.

b. Dependent variables

Dependent variables in this study included participants' perceptions of storm preparation during general severe

[1] Participants lived in counties from Mississippi, Tennessee, Arkansas, and/or Missouri. Counties in Arkansas included Clay (population: 14 551), Crittenden (47 955), Cross (16 419), Greene (45 325), Lee (8857), Mississippi (40 651), Phillips (17 782), Poinsett (23 528), St. Frances (24 994), and Craighead (110 332). Counties in Mississippi included Alcorn (36 953), Benton (16 160), Calhoun (14 361), Chickasaw (17 103), Coahoma (22 124), DeSoto (184 945), Itawamba (23 390), Lafayette (54 019), Lee (85 436), Marshall (35 294), Monroe (35 252), Panola (34 192), Pontotoc (32 174), Prentiss (25 126), Quitman (6792), Tallahatchie (13 809), Tate (28 321), Tippah (22 015), Tishomingo (19 383), Tunica (9632), Union (19 972), and Yalobusha (12 108). Counties in Missouri included Dunklin (29 131) and Pemiscot (15 805). Counties in Tennessee included Benton (16 160), Carroll (28 486), Chester (17 297), Crockett (14 230), Decatur (11 663), Dyer (37 159), Fayette (41 133), Gibson (49 133), Hardeman (25 050), Hardin (25 652), Haywood (17 304), Henderson (28 117), Henry (32 345), Lake (7016), Lauderdale (25 633), McNairy (25 694), Obion (30 069), Shelby (937 166), Tipton (61 599), Weakley (33 328), and Madison (97 984).

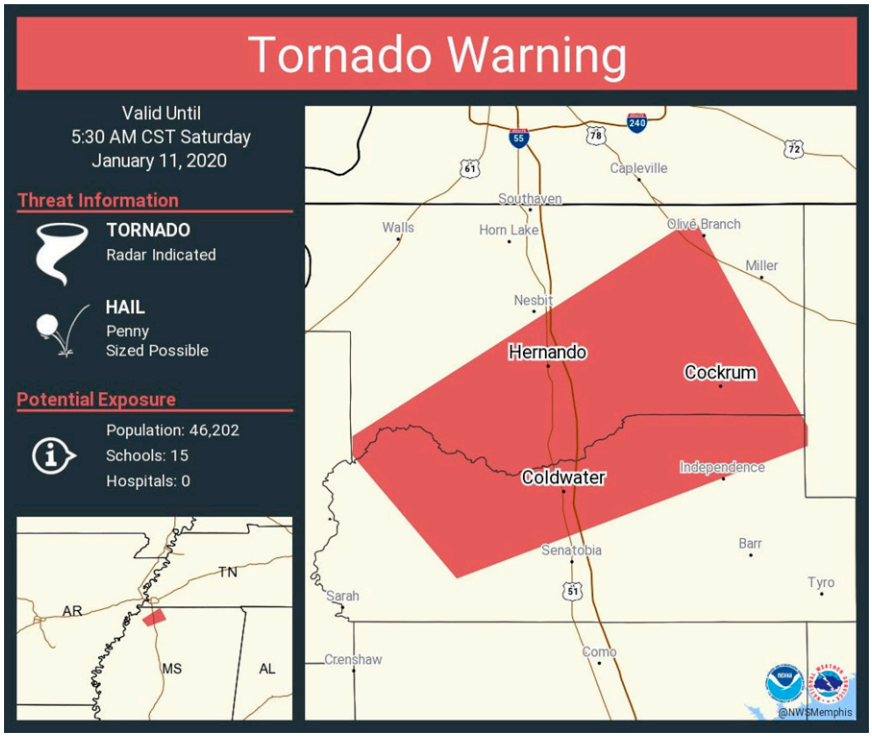

FIG. 1. The hypothetical tornado warning shown to respondents as part of the methods. Participants were asked to click on the three areas of the map that they felt were most important in making storm-related decisions.

weather seasons and participants' perceptions of storm preparation during specific severe weather events. The general storm scale (adapted from Armstrong and Towery 2020) asked participants to rank on a 7-point Likert scale from "never" to "always" which of the following preparatory actions they take before spring storm season each year: obtain gasoline for car, check flashlights, obtain bottled water, keep candles and matches nearby, purchase batteries, purchase canned or dry food, check availability of portable radio, prepare a first aid kit, obtain propane gas tanks, gather wood for window boarding, keep a working flashlight and battery-operated radio in a convenient location, keep a readily available list of emergency telephone numbers, teach (or arrange with) relatives what to do in case of an emergency, attend a first aid course, purchase any kind of insurance against natural disasters, ask someone for information on what to do in case of an emergency, store important objects in a safe place, store emergency food and water supplies, make safe dwelling more comfortable, make some changes to home, and purchase/find a nonelectric can opener [mean $M = 87.4$, standard deviation (SD) = 26.6, and $\alpha = 0.93$].

To create the specific storm scale, the authors consulted four National Weather Service meteorologists located in the mid-South region. Using the general storm preparation list as a start, they offered insight for the specific scale. The final survey questions asked participants to rank on a 7-point Likert scale from "never" to "always" which of the following preparatory actions they take during a specific tornadic event: keep candles and matches nearby, prepare a first aid kit, keep a working flashlight and a battery-operated radio in a convenient location, keep a readily available list of emergency telephone numbers, teach (or arrange with) relatives what to do in case of an emergency, ask someone for information on what to do in case of an emergency, store important objects in a safe place, store emergency food and water supplies, and make some changes to home ($M = 39.9$, SD = 12.7, and $\alpha = 0.87$).

c. *Independent variables*

Several independent variables were utilized in this study. To examine whether an individual's social or economic ideology had an impact on their preparation, opinions on *economic issues* were measured via a 5-point Likert scale, ranging from strongly conservative to strongly liberal ($M = 2.7$; SD = 1.2). A similar scale asked opinions on *social issues* ($M = 2.84$; SD = 1.4). These variables were adapted from Goebbert et al. (2012) who argued that cultural worldviews and political ideology have an impact on perceptions of local weather patterns (see also Morss et al. 2016).

The study employed two informational graphics to look at the influence of visual cues—one for a tornado warning (Fig. 1) and one for a tornado watch (Fig. 2). Using a heat map and researcher-constructed graphics for measurement, participants were asked to click on their perceived top three most important visual cues within each graphic that would be useful in influencing weather-related decisions. On the warning graphic,

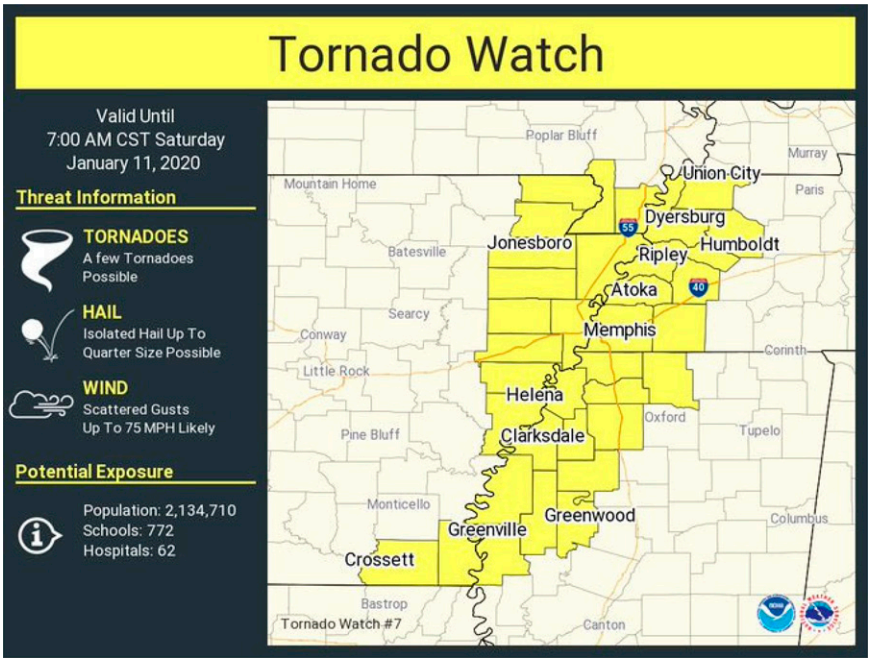

FIG. 2. The hypothetical tornado watch shown to respondents as part of the methods. Participants were asked to click on the three areas of the map that they felt were most important in making storm-related decisions.

percentages for the top three were threat information: tornado, radar indicated (48%); threat information: hail damage (35%); and the map image of the warning area (83%). On the watch graphic, percentages for each of the three were threat information: tornados possible (43%); threat information: hail possible (37%); and map image of the watch area (82%).

To examine one's general weather interest, four variables were constructed. *Weather engagement* included a multiitem question that asked participants how frequently (1–7) they took classes/read books about weather facts, used a weather app on a telephone, actively viewed weather information during an event, watched television programs about severe weather, visited the internet to watch videos about severe weather or read news accounts of the aftermath of weather events (M = 27.6, SD = 7.04, and α = 0.78). Participants were asked how frequently they *searched for information* about weather-related events (flooding, hurricanes, tornados, thunderstorms, and extreme heat (M = 21.4, SD = 7.19, and α = 0.85). Participants self-reported on a 1–7 scale *how informed* they were about safe locations, weather consequences, escape routes, storm shelters, along with how interested they were in weather, how sufficiently informed they felt and if they wanted more information (reversed) (M = 18.7, SD = 6.12, and α = 0.78).

To examine media sources, participants were asked to rank on a 5-point Likert scale from "never" to "always" *how likely they were to receive information for a weather event* from the following: friends/acquaintances, face-to-face interaction with a stranger, telephone call, written notice, and official (such as police), radio, television, newspaper, email, Facebook, Twitter, general social media alerts, other internet, email/text communication from school, or they were able to answer that they typically do not receive them (M = 29.76, SD = 9.96, and α = 0.86). For clarification, smartphone alerts were included in "general social media" alerts because they are often prompted by apps. When we combined these four dimensions together, Cronbach's alpha indicated α = 0.64, which is a bit lower than ideal, but they all load on one factor in principal components factor analysis, which reported an eigenvalue of 2.02% and 50% of the variance. Because of the low alpha, we ran the variables separately within the analyses.

In addition, participants were asked about their overall concern about weather-related events through three variables. Participants were asked to indicate how much *perceived weather risk* they feel each of the following events was to their well-being: flooding, hurricanes, tornados, thunderstorms/lightning, and extreme heat (M = 27.6, SD = 7.04, and α = 0.71). Future fear risk (Wallace et al. 2015) was measured through items asking participants how likely they felt the following would happen within 10 years due to a tornado: their home would be damaged, neighbor's house would be damaged, town would be damaged by tornado, daily activities disrupted, their family or themselves could be injured, a town in the mid-South would be damaged (M = 27.00, SD = 7.23, and α = 0.86). For prior weather experience, participants were asked how frequently within the past five years they had witnessed extreme weather, witnessed storm damage, remained in place during severe weather, taken shelter during an event, or heard a severe storm siren (M = 23.71, SD = 6.18, and α = 0.74).

TABLE 1. Descriptive statistics for media sources during weather events.

Media source (n = 762)	Mean (range 1–5)	SD
Television	3.61	1.29
Radio	2.65	1.28
Friends/acquaintances	2.56	1.21
Facebook	2.44	1.4
General internet	2.43	1.35
Social media alerts	2.33	1.38
Telephone call	2.25	1.29
Email/text from school	1.94	1.31
Do not get notice	1.78	1.11
Email	1.77	1.14
Conversation with stranger	1.66	0.97
Twitter	1.63	1.15
An official	1.60	0.99
Newspaper	1.51	0.98
Written notice	1.39	0.90

6. Results

The first research question focused on the sources that individuals relied upon for information related to a weather event. As noted in Table 1, the top two sources were television (M = 3.61; SD = 1.29) and radio (M = 2.65; SD = 1.28), followed by friends/acquaintances (M = 2.56; SD = 1.21). These are the most important media sources, as asked in RQ1.

The second research question focused on which of the visual graphic cues on the tornado warning and watches were most likely to increase preparatory activities. An analysis of variance was conducted on the six variables—storm damage, hail damage, and radar images for both tornado warnings and watches—with the dependent variables of general storm preparation activities and specific storm preparation activities (not shown here). Only one main effect was found, for hail damage during tornado watches, which yielded an F (1, 672) = 4.56, with p = 0.03, where those who reported hail damage as an important visual cue engaged in less general preparatory activities (M = 86.03) than those who did not report hail damage as an important visual cue (M = 91.51). No main effects were found on specific storm preparation.

To examine the hypotheses, two hierarchical linear regressions were conducted for the two dependent variables (general storm preparation and specific storm preparation), as seen in Table 2. The first block for the general storm preparation regression contained control variables of race, views on social issues, views on economic issues, community type, education, type of home, employment, and gender) and years in community. It accounted for 3.5% (p = 0.008) of the variance and statistically significant variables of views on economic issues (β = 0.112; p = 0.03) and years in the community (β = 0.08; p = 0.01).

The second block contained perceived views of the importance of visual graphic information about storm damage, hail damage, and a radar view in either a watch or warning graphic. It accounted for 1.3% of the variance (p = 0.17; not significant). None of the variables were significant in the general storm preparation block.

The third block examined the influence of those with a general interest in weather information and accounted for the largest variance at 36.7% (p = 0.001). Variables included the frequency of participants' search for weather information (β = 0.14; p = 0.01), individual weather engagement (β = 0.19; p = 0.001), how informed they feel about weather in general (β = 0.24; p = 0.01), and the number of media sources they employ to use to get weather information (β = 0.29; p = 0.01).

The fourth and final block focused on how concerned individuals were about the possibility of severe weather, which accounted for 1.5% of the variance (p = 0.001). This included variables of risk of severe weather, past experience with tornados and their perceived fear that they could experience a tornado in the future, which was a statistically significant positive predictor (β = 0.12; p = 0.001).

The same hierarchical linear regression was conducted using specific storm preparation (see Table 2). Like with general storm preparation, control variables were employed in the first block that accounted for 2.8% of the variance (p = 0.05) of the variance. A statistically significant relationship was found only for views on economic issues (β = 0.115; p = 0.03). The second block contained perceived views of the importance of visual graphic information that accounted for 1.5% of the variance (p = 0.11; not significant) and found one negative statistically significant relationship—radar views during a tornado warning (β = −0.09; p = 0.02).

The third block examined general weather interest and accounted for the largest variance at 33.6% (p = 0.001). All variables in this block were significantly positive predictors of specific storm preparation: frequency of participants' search for weather information (β = 0.13; p = 0.01), individual weather engagement (β = 0.19; p = 0.001), how informed their feel about weather in general (β = 0.25; p = 0.01), and the number of media sources they employ to use to get weather information (β = 0.25; p = 0.01).

The fourth and final block focused on how concerned individuals were about the possibility of severe weather, which accounted for 1.8% of the variance (p = 0.001). This included variables of risk of severe weather, past experience with tornados and their perceived fear that they could experience a tornado in the future, which was a statistically significant positive predictor (β = 0.11; p = 0.001).

From these analyses, we report the following results for our three hypotheses:

H1: Partially supported: the visual graphics were not predictors of general storm preparation, but the radar view graphic during a tornado warning was a positive predictor for specific storm preparation.

H2: Supported: individuals who reported a higher interest or engagement with weather-related information were significantly more likely to prepare for general storms and for a specific weather event, when compared with those reported a low interest.

H3: Supported: an individual who was more fearful of experiencing future tornadoes was more likely to prepare for both general storms and specific events.

TABLE 2. Hierarchical linear regression examining predictors of storm preparation. Here, one and two asterisks indicate $p < 0.05$ and $p < 0.01$, respectively.

Variables	General storm standard final beta	R^2 variance (%)	Specific storm standard final beta	Variance
Block 1: Controls		3.5**		2.8*
Race (white = high)	−0.035		−0.046	
Age	0.039		0.043	
Social issues (liberal = high)	−0.079		−0.097	
Economic issues (liberal = high)	0.112*		0.115*	
Community type (urban = high)	−0.037		−0.029	
Education (college+ = high)	−0.085		−0.061	
Home (single family = high)	0.079*		0.041	
Employment (employed = high)	0.011		0.013	
Gender (female = high)	−0.022		−0.004	
Years in community (10+ = high)	−0.080*		−0.044	
Block 2: Visual views		1.3		1.5
Warn: Storm damage	−0.058		−0.048	
Watch: Storm damage	−0.020		−0.004	
Warn: Hail damage	0.000		0.003	
Watch: Hail damage	−0.015		−0.010	
Warn: Radar view	−0.059		−0.094*	
Watch: Radar view	−0.042		−0.034	
Block 3: Interest block		36.7**		33.6**
Severe weather search	0.098*		0.129**	
Weather engagement	0.193**		0.146**	
Informed weather	0.243**		0.249**	
Media sources	0.287**		0.247**	
Block 4: Weather concern		1.5**		1.8*
Weather risk index	−0.034		−0.025	
Tornado experience	0.045		0.067	
Fear index of tornado	0.116**		0.115**	
Total		43.0**		39.7**

7. Discussion and conclusions

This study used the theoretical framework of risk information seeking and processing and the theory of planned behavior to examine how individuals gather information, make decisions, and engage in general and specific storm preparation activities. In addition to the outlined concepts, two new concepts were introduced and tested within this research—a differentiation between general and specific storm-preparation activities and a broad idea of individuals with a general weather interest.

Participants who held a general interest in weather were strong positive predictors of both those who engage in general and specific storm activities, as were those who were fearful of future tornadoes. Results also indicated that television and radio were the top media choices for participants and that only radar images in a warning graphic held negative predictive power for specific storm activities. Participants who held a general interest in weather were strong positive predictors of both those who engage in general and specific storm activities, as were those who were fearful of future tornadoes.

These findings lend additional support to the importance of risk perception in influencing decision-making, and decision-making and behavioral intention, although not entirely in the predicted direction. That is, perceived risk and concern in this study was limited to the fear that a future tornado may impact the participants' environment. Neither prior experience nor perceived weather risk (which looked at different kinds of weather events) were significant.

However, the findings indicate that the information threshold needed in RISP to help induce decision-making may be influenced by one's general interest in weather. This may be the most noteworthy among these findings, in that we believe this study is among the first to examine the predictive power of interest on behavioral intention. Our results indicated that these individuals were highly predictive of those who prepare for storms. All four dimensions of this concept—media sources, search frequency, engagement and self-reported as informed—were strong predictors of both general and specific storm activity. We ran the dimensions separately because of the low alpha, but these results suggest that across dimensions, these weather-enthusiasts are interested in severe storms and their interests—not necessarily knowledge about storms—drives them to prepare.

The authors argue that this predisposition is likely part of RISP's individual characteristics element that influences information seeking. Similar to Stewart's (2009) "weather salience" concept, although this study did not assess participants' knowledge, using instead self-reports of activity. Further, only 7.9% of the participants reported being employed in either media, weather, or emergency management, so it does not

appear that their interests relate to their jobs. Nonetheless, it appears from these results that individuals with a predisposition of interest in severe weather are influenced to make preparatory decisions differently than those who do not share that predisposition, which supports Stewart (2009) and Stewart et al. (2012). Future research may wish to more explicitly tie this concept directly to the RISP model as well.

Further, it appears this concept can be as influential as perceived risk or prior tornado experience, as those factors that were not significant in this research, which contradicts prior research by Morss et al. (2016), who looked at prior hurricane experience. Perhaps, however, the type of weather event may influence decision-making differently. To be sure, future research needs to dig deeper into the role of general weather interest on decision-making and preparation. In particular, perhaps combined with knowledge, the true nature of this predisposition can be better understood.

Another key finding of this research focuses on the differing results between preparation for general storm season and for a specific tornadic event. The analysis within this study indicates slight differences in the way individuals prepare. Specifically, we found that single family homeowners were more likely to prepare for general storm season, and longtime residents were less likely to prepare for general storm season—those findings were not significant for specific storm preparation. This finding makes sense when thinking about how severe weather events occur. For example, residents within the mid-South know they live in an active area for tornadoes, particularly between November and May (Senkbeil et al. 2021) and coastal regions are aware of annual hurricane seasons, despite their perceived vulnerability to them (Milch et al. 2018). Residents of those areas are encouraged to prepare appropriately at the beginning of each season. Those residents who are more transient, or visiting the area, would not be likely to prepare generally for storm season, but may decide to prepare if a specific event came their way.

We also found a negative relationship between tornado radar maps and specific storm preparation, which was surprising. To clarify, results indicated participants were *less* likely to engage in specific storm preparation activities when radar maps showed potential tornado location and intensity. Perhaps more surprising was the lack of significance for any of the other visual graphics on preparatory activities. We suspect there are two reasons for this lack of results: 1) prior research has indicated that individuals are geographically challenged and unable to find their location on a map (Eve et al. 1994), or 2) it may be the true usefulness of these graphics is somewhat masked by the concept of general weather interest. That is, perhaps the visual graphics are being studied and scrutinized, but the predisposition of general weather interest may have more influence and pulled out any influence in this case. It is important to note, however, that the maps were of a storm that may/may not have been in the participants' home area. Future research may wish to flesh out this idea.

In terms of media use, our results indicated that television and radio were the top choices noted by participants to learn about severe weather. This supports previous work (Piotrowski 2015) in this area, as when a weather event develops, individuals turn to broadcast meteorologists, who often devote coverage time to the event within that area, even preempting regular programming. Similarly, during these events, electrical power and cable systems may be damaged, which is when radios become key communication tools. Particularly noteworthy, our third most used communication source was friends and acquaintances, and internet sources became 4–6. While internet sources have generally appeared higher on the list of media sources, we opted to split up our internet sources to better understand how individuals use them. That split likely accounts for at least part of our differences from prior work.

For media scholars and emergency personnel, it is important to note where individuals are getting their information about severe weather. While the elaborate visual graphics and technical advances in forecasting are important, basic radio is still functioning and perhaps a preferred choice for information among residents. More than 50% of both urban and rural participants noted that they use radio for information at least half the time when learning about severe weather. Communication is needed for all audiences across formats, and often the simple media get overlooked. These results reinforce the need to engage multiple audiences with information.

The study demonstrated significant support for the ideas that ideology and cultural worldviews may impact one's decision-making. Following prior work by Morss et al. (2016) and Goebbert (2012), our results found that those with more liberal views about economic issues were more likely to engage in preparatory actions. We argue that this finding suggests that this may connect to trust in governmental messaging. That is, those who trust the government to have their best interests in mind during a weather event may be more likely to prepare. Those who are more conservative may be less likely to prepare. To be sure, future research is needed to flesh out this idea; however, the results here suggest that ideology is an area ripe for more study.

As with all studies, a few caveats are necessary to discuss. First, this study was conducted into four states in the mid-South region. This is a tornado-heavy area, so generalizations to other kinds of perceived risk to other types of storms should be done with caution. Data were collected outside tornado season in those areas, so it is possible that participants did not have a clear memory of a severe tornado in that area. Also, perhaps visual maps that are directly related to the participants' home region would be more effective than the sample maps used in this study.

Despite these limitations, this study provides some significant knowledge for both scholars and weather practitioners. The results provided an extension of the RISP and TPB, along with findings that suggest individuals with a general interest in weather-related events are more likely to engage in preparation activities. Further, the study offered support for a distinction between those who generally prepare for storm seasons and those who prepare only for specific storm events. In addition, the use of varied media sources for information suggests that meteorologists need

to participate with multiple media platforms to reach the largest audiences.

Acknowledgments. Data for this project were collected as part of a $15,000 Partners grant from the University Corporation for Atmospheric Research to the University of Alabama and the National Weather Service office in Memphis, Tennessee (Subaward SUBAWD002677).

Data availability statement. Data for this project are generally unavailable but can be requested after all reports have been published for the project.

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