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Examining Student Severe Weather Behavior During a Hypothetical Tornado Scenario

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Examining Student Severe Weather Behavior During a Hypothetical Tornado Scenario

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In partial fulfillment of the requirements for the degree of

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To the Department of Geography at the University of North Alabama:

I am submitting herewith a thesis written by C. Martin Leaviit entitled "Examining Student Severe Weather Behavior During a Hypothetical Tornado Scenario." He has successfully defended his research in a public forum. I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Geospatial Science.

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We have read this thesis and recommend its acceptance.

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Acknowledgements

Abstract

Destructive severe weather events are an unfortunate reality of the United States' unique geography. Each spring, the central and southeastern states are subjected to nature's most violent localized storms, tornadoes. The 2011 tornado season received nationwide attention for two events: the April 27 outbreak was responsible for 348 fatalities from 292 confirmed tornadoes across 16 states, while the May 22 Joplin, Missouri, tornado was responsible for an additional 162 fatalities (Storm Prediction Center, 2011; Paul & Stimers, 2012). One of the most devastating single tornadoes of that outbreak was the Tuscaloosa, Alabama, tornado that claimed 64 lives along its 130-km track and ranked as an Enhanced Fujita scale category 4 (EF4).

Urban sprawl in the United States exposes people to more events similar to what occurred in Tuscaloosa as developments increase in area and population size. The National Weather Service (NWS) continues to modernize its warning systems because inadequate warning for at risk populations is a major contributing factor to fatalities and death. However, there is little information available about the public's response to these warnings in seeking adequate shelter.

For this analysis, a survey was constructed to simulate a tornado event, similar to that of the April 27, 2011, tornado. Participants were provided with three levels of warning information (high, medium, and low), while only half were able to view a map of the tornado's progress towards their location. Participants were asked to evaluate the situation by answering a series of questions at multiple intervals of the storm. The collected survey data will be used to analyze risk perception and shelter seeking behavior in relation to available warning information.

I. Introduction

Destructive severe weather events are an unfortunate reality of the United States' unique geography. Each spring, central and southeastern states are subjected to nature's most violent localized storms, tornadoes. Between 800-1,400 tornadoes occur annualy in the United States, making it the most highly active tornado region in the world (Ashley, 2007). Within the context of tornado activity, spring 2011 was abnormaly intense. The number of tornadoes that tracked into metropolitan areas was also an unusual characteristic of the spring 2011 tornado season (Senkbeil *et al*., 2012). The 2011 tornado season received nationwide attention for two events: the April 27 outbreak was responsible for 348 fatalities from 292 confirmed tornadoes across 16 states, while the May 22 Joplin, Missouri, tornado was responsible for an additional 162 fatalities (Storm Prediction Center, 2011; Paul & Stimers, 2012). One of the most devastating single tornadoes of that outbreak was the Tuscaloosa, Alabama, tornado that claimed 64 lives along its 130-km track and ranked as an Enhanced Fujita scale category 4 (EF4). The April 27 Tuscaloosa tornado traveled across residential and business zones of Tuscaloosa's urban area, narrowly missing the University of Alabama and Druid City Hospital Regional Medical Center. The impact of a tornado on such an urban area with college-age residents made it a unique tornadic event.

Urban sprawl in the United States exposes people to more events similar to what occurred in Tuscaloosa as developments increase in area and population size. The National Weather Service (NWS) continues to modernize its warning systems because inadequate warnings for at-risk populations are a major contributing factor to fatalities and deaths (Balluz *et al*., 2000). Understanding of the tornado environment and technological advancements in warning systems has progressed faster than psychological research of risk perception and the cognitive decision-making process during tornado warnings. The implications, regarding human behavior, of forecasting, prediction, and warning system progress are not fully understood. The tornado warning system in the United States has progressed because of data collection, processing, and computing advancements, while the theoretical background has remained somewhat the same. The NWS implemented storm-based warnings (SBWs) in 2007, replacing warnings issued for entire counties, in attempt to provide warnings with finer geographic specificity (Coleman *et al*., 2011; Ash *et al*., 2013). Understanding the relationships between human risk-perception, decision-making, and tornado warning systems is crucial for optimizing future warning systems. Unfortunately, there is little information available about the public's response to these warnings in seeking adequate shelter. More specifically, there is less information available regarding a student population's response to these warnings in taking protective measures.

The personal decision to seek shelter occurs in a narrow window - between a tornado warning's issuance and tornado's possible arrival - often in only a few minutes time. Of the limited studies focused at shelter-seeking behavior, the topic has largely been approached from the context of fatality distribution and shelter location of Oklahoma City, Oklahoma, residents as a result of the 3 May 1999 tornado (Hammer & Schmidlin, 2002); mobile home residents' shelter-seeking options and behavior (Schmidlin *et al*., 2009); and shelter-seeking actions for the 1 March 1997 Arkansas tornadoes (Balluz *et al.*, 2000). Previous research has positively identified education level, basement access, hearing a warning siren, and having a household response plan as factors associated with shelter-seeking behavior (Senkbeil *et* al., 2012). A majority of the previous research has examined the implications of situational factors that dictate the options for someone to shelter rather than cognitive factors which shape how that person processes information and makes decisions.

Following the recent outbreak of April 2011, more research has emerged regarding the effectiveness of warning systems. Ash *et al.* (2013) designed a hypothetical tornado situation to test how visual graphic displays are perceived. Their research importantly addressed the cognitive process that occurs when an individual is exposed to a tornado warning, but focused purely on how visual information impacts protective action decision-making (Ash *et al*., 2013). Sherman-Morris (2010) examined the effectiveness of Mississippi State University's warning system and how students responded following an actual tornado event, however no study has explicitly addressed how the population of a campus body processes the decision to seek shelter. Furthermore, no study has tested tornado warning effectiveness measuring student responses during a hypothetical tornado scenario.

Using the 27 April 2011 event in Tuscaloosa, Alabama as a documented event, a hypothetical tornado scenario was created for a separate town and university in the southeastern United States. The purpose of this research is to examine whether written and visual tornado warning information will influence behavior during a hypothetical tornado scenario. Whereas previous research has examined variables of tornado death and fatality distribution, this research hopes to identify what type, or combination, of warning information, both verbal and visual, influences an indivual's shelter-seeking actions, perception of danger, and understanding of a tornadoes distance from their location. The goal of this study is to contribute to the overall body of tornado victim behavior and perception literature by attempting to understand how different types and amounts of obtainable information may enable an individual to fully process the severity of what is taking place and act accordingly.

II. Literature Review

2.1. Hazard of Severe Weather

Natural hazard research has significant importance: natural disasters killed a reported 30,772 people worldwide in 2011 and caused $366.1 billion in economic damages – the highest ever reported (Guha-Sapir *et al.*, 2011). There is no doubt that future natural hazard events will cause additional property damage, especially as population densities continue to rise (Boruff, 2003). The geographical uniqueness of the United States, specifically the Midwest and Southeastern states, create a situation in which severe weather is the dominant type of natural hazard. The reoccurring collisions between opposing air masses produce some of the most violent weather phenomenon on the planet.

The development and structure of convective storms has intrigued meteorologists and research scientists for decades (Przyblinski, 1995). Convective storms produce a wide variety of weather phenomenon that are worthy of 'severe' classification. Severe weather is considered any meteorological phenomenon capable of causing damage, social disruption, or loss of human life (World Meterological Organization, 2004). Events capable of producing significant damage include hurricanes, blizzards, hail, lightning, thunderstorms, excessive precipitation, and tornadoes. Seasonal, regional, and topographical differences control the distribution, timing, and type of severe weather phenomenon. This creates an environment where the United States' most significant natural hazard threat consistently results from severe weather (Boruff *et al.*, 2003).

2.1.1. Tornadoes. In many locations across the United States, tornadoes are a rite of spring and the dominant type of severe weather phenomenon (Noji, 1997; Balluz *et al.* 2000; Merrel *et al.*, 2005). Not only are tornadoes the most frequent, but they are also nature's most violent localized windstorm, representing a significant hazard to both life and property. The United States experiences approximately 800-1400 tornadoes annually; fortunately only a small percentage of these events result in casualties (Ashley, 2007). While a statistically minimal amount of tornadoes produce casualties, those that do can be devastating. This occurs because the type of destruction common to tornadoes produces a highly concentrated, intense path of destruction (Balluz *et al.*, 2000). Tornadoes have the potential to produce mass-casualties even though a community's infrastructure remains intact (Harris, 1992; Glass *et al.*, 1980). Throughout literature, the term *tornado hazard* has a distinctive meaning in comparison to tornado climatology. Tornado hazards include aspects of tornado climatology, but Boruff (2003) defines the tornado hazard as "any tornado that results in a human fatality, or a human injury, or any amount of reported economic damage" (p. 104).

Tornado research has largely been funded by the federal government through universities, research institutions, federal agencies, and private meteorological companies (Golden & Adams, 2000). Federal funding for tornado research has largely focused on improving the predictive and warning capabilities of operational meteorologists to aid in the protection of life and property. The number of reported tornadoes has significantly increased in recent decades, but many scholars cite advancements in observation, identification, reporting, and documentation as the explanation (Bluestein, 1999, Golden & Adams, 2000; Boruff *et al.*, 2003). It is understood among scholars that while the overall number of tornadoes has increased over the past 100 years, the number of EF2–rated tornadoes has not significantly increased (Grazulis, 2000; Boruff, 2003). There is no debate that tornadoes are capable of immense damage, directing portions of this funded research towards the occurrence of tornado hazards specifically (Boruff, 2003).

2.1.2. Damage. The localized destructive force of tornadoes has the potential to render a landscape unrecognizable. The destruction to homes, businesses, schools, and vegetation is distinctly identifiable, and often remains a visual reminder of a significant event for years to come. With winds exceeding 200 miles per hour, flying debris, and suction vortices, property damage during a tornado has become accepted as an unavoidable reality (Simmons & Sutter, 2011, p. 213). Affected communities and researchers both have directed more attention towards threats to, and loss of, life. For this reason, far less research has been directed towards examining property damage from tornadoes. Even in research involving reported damage, uncertainty surrounds the accuracy of reported damage. Simmons & Sutter (2011) attributed this to National Weather Service (NWS) offices placing little value on accurately report property damage estimates (p. 214). Although official damage reports may not fully represent the damage path, Brooks and Doswell (2001) concluded that the cost of individual tornadoes has not increased through time. While early research discussed monetary property damage estimates with a fairly wide range of uncertainty, contemporary analyses have shown value in using remote sensing to classify damaged and undamaged areas and to estimate monetary losses (Myint *et al.*, 2008). Simmons and Sutter (2011) note that damage estimates provide an alternative source for scaling causalities when damage costs are not the objective of a study (p. 214).

2.1.3. Fatalities. The single worst year for tornado-related deaths remains 1925 when 800 people died (Boruff, 2003; Simmons & Sutter, 2011). Tornadoes killed an average of 260 persons per year (1.8 deaths per million) between 1912 and 1936, but that number declined to 54 deaths per year (0.12 deaths per million) between 1975 and 2000, a 93% decline from 1925 to 2000 (Brooks & Droswell, 2001). Though there is a declining trend in tornado fatalities, researchers consider tornado fatalities unique to other weather-related natural hazard deaths (floods, lightning, and straight line wind events) because a majority of tornado fatalities occur within housing structures (Ashley & Ashley, 2008; Curran *et al.*, 2000; Ashley & Black, 2008; Ashley & Mote 2005; Ashley, 2007). The percentage of tornado casualties occurring in housing structures remains consistent among peer-reviewed analyses: Ashley (2007) found 71.3% from 1985-2005; Simmons & Sutter (2011) reported 73.5% from 1985-2007.

The American Meteorological Society found annual totals of tornado deaths in the 1980s and 1990s to be half of what had been reported earlier, from 1950 to 1970s (Ashley, 2007). The decline over recent decades is largely a result of improvements in detection, warning, public awareness, information delivery and structural building integrity (Sims & Bauman, 1972; Duclos & Ing, 1989).

2.1.4. Vulnerable locations. Although tornado fatalities have declined over the past 50 years, scholars and officials understand that tornado casualties cannot be prevented entirely (Ashley, 2007). Tornadoes possess the power to level a town, and the fact that so many fatalities occur in housing structures has focused research towards identifying what areas are impacted the most. It is well known that mobile homes provide little protection to even the smallest of tornadoes; 43% of tornado fatalities occurred in mobile homes, while 31% in permanent home. More surprising is that less than 7% of the population lived in mobile homes (Simmons & Sutter, 2011, p. 61). Mobile homes are recognized as a large contributor in tornado fatalities. Brooks and Doswell (2002) found the average death rate of mobile home residents to be 20 times higher than in permanent homes.

The most thorough studies of US tornado risk have been conducted by Grazulis (1993, 2001) using a 45-year record to identify a primary risk region in the Great Plains. Boruff (2003) studied damage producing tornadoes over a 50-year span (1950-1999) in the United States to determine trends in hazard occurrences, geographic center of tornado hazard exposure, and hazard density patterns. His research identified that the centroid of tornado occurrence has shifted to the southeast each decade, since 1950 (Boruff, 2003). The southeast also experiences the most *significant* tornadoes (Legates & Biddle, 2008). The explanation for the 'shifting' centroid to the southeast can be attributed to spotting and reporting improvements as well.

2.2. Warning Systems

Currently, the best protection developed against tornadoes is the modern warning system. Warning systems are complex in nature combining sensing technologies, conceptual models, emergency management decision making, warning dissemination technologies, and public education (Brotzge & Donner, 2013). Sorensen (2000) describes warning systems as a system with a dedicated role of detecting potential disasters, relaying collected information to at-risk populations, and empowering persons with decisions about how to take action. The United States may not possess a comprehensive warning system for all hazards, but there is agreement that a single, comprehensive warning system is not appropriate because a single warning concept will not equally fulfill multiple hazard requirements (Mileti & Sorensen, 1990; Sorensen, 2000). More important than an all-encompassing warning system is a well-designed system that provides a predictable and understandable message, unique to each respective hazard for its users. Warning system literature has identified several criteria for effective emergency messages to include: the nature, location, guidance time, and source of a particular hazard (Sorensen, 2000). Particular style aspects for effective message content and trustworthy warning reputation have been identified in the literature as specificity, consistency, accuracy, certainty, and clarity (Sorensen & Mileti 1989; Vogt & Sorensen, 1992; Sorensen, 2000).

2.2.1. Progress of tornado warnings. Since the United States does not have a comprehensive warning system (Sorensen, 2000), it is appropriate to discuss the improvements made specifically to tornado warning systems in the United States. Tornado forecasts were once believed to cause more harm than good (Coleman *et al.*, 2011). The United States Weather Bureau (USWB) once banned tornado forecasting, but lifted this ban in 1938. Before the civilian USWB lifted the ban, the United States Army Signal Corps had handled all warnings since 1887. Much research has chronicled the modernization of the tornado warning system since its beginning in 1948 at Oklahoma's Tinker Air Force Base (Maddox & Crisp, 1999; Doswell *et al.*, 1993, Coleman *et al*., 2011). On 25 March 1948 the first tornado warning was issued by U.S. Air Force officers E. Fawbush and R. Miller at Tinker Air Force Base in Oklahoma City, Oklahoma (Miller & Crisp, 1999b; Maddox & Crisp, 1999). The Tinker Air Force Base tornado warning's success lead to the establishment of the Air Weather Service Severe Weather Warning Center (SWWC), the nation's first severe weather warning program (Brotzge & Donner, 2013). Within the first year of operation in 1951, 102 (65%) of the SWWC's 156 tornado warnings were verified (Miller & Crisp, 1999a). The timely development of weather radar and storm spotter networks are considered two of the most important aspects of the tornado warning program's following growth (Coleman *et al*., 2011). Currently, local NWS Weather Forecast Offices issue tornado warnings, while continually improving the total percentage of verified warnings (Brutzge & Donner, 2013).

For roughly half a century, tornado warning progress only increased the ways in which people could receive information. It was not until 2007 when the NWS made an innovative change to the type of warning information released to the public. Previously, the NWS issued severe thunderstorm and tornado warnings by a county basis. This meant that entire county was issued a warning even if a tornado was suspected to impact only a small portion of the county (Waters *et al.*, 2005; Ash *et al.*, 2013). The NWS now uses storm-based warnings (SBW), where warnings are defined by latitude-longitude coordinates of an easily identifiable shaped feature (Coleman *et al.*, 2011). Storm based warnings allow individuals to see a more geographically specific warning presented as a polygon, or cone, shaped feature surrounding only the areas believed to experience a tornado (Ash *et al.*, 2013). Not only does the storm-based format increase geographic specificity, but Sutter and Erickson (2010) argue these warnings reduce time spent unnecessarily sheltering. Although SBWs allow individuals within a warned area to be targeted with warning messages (Jacks & Ferree, 2007), it has not been proven that being located within a SBW significantly increase shelter seeking and protective action behavior (Nagele & Trainor, 2012). While the effectiveness of SBWs influence on self-preservation efforts through targeted warning messages is still unproven, the dissemination of SBWs via various mediums continues increase (Sherman-Morris, 2010; Ash *et al.*, 2013).

The improvements that tornado warning systems have experienced since the 1970s are impressive, but this progress has stemmed from monitoring, data collection, instrumentation, and data processing improvements; other than the NWS's transition to SBW, no radical theoretical breakthroughs have occurred over the past 30 years (Sorensen, 2000). Meteorologists have started researching ways to enhance the storm-based format by including probabilistic information produced by forecast model outputs (Hoekstra *et al.*, 2011; Stensrud *et al*., 2013; Ash *et al.*, 2013). The effectiveness storm based warnings, both with and without probabilistic information, is unknown. It is optimistic to hope forecasters will one day possess the ability to predict a tornado's exact path and intensity days in advance, allowing for complete evacuation and deployment of emergency management resources (Brotzge & Donner, 2013). Since technology has not empowered meteorologists to that level, it is important to further investigate how the general public interprets the current state of visual and verbal information in storm based warnings and uses such information in their decision-making process.

2.2.2. Warning dissemination. Today, tornado warnings are issued by the National Weather Service when a tornado has been spotted, or when radar indicates a probable tornado. Even in the modern era's progress of warning systems, the American Meteorological Society and other researchers feel the most crucial step in the warning process remains the same – communicating the danger to the public (AMS, 1975; Golden & Adams, 2000; Coleman *et al*., 2011, Brotzge & Donner, 2013). The earliest tornado warnings reached the public via television and radio. Hazards literature clearly indicates that television has served as an important source of information in hazard and disaster warning (Sherman-Morris, 2005, 2010; Hammer & Schmidlin, 2002; Legates & Biddle, 1999; Paul *et al.*, 2003; Schmidlin *et al*., 2009). Research has investigated the importance of television and other mass media during adverse conditions. Loges (1994) examined media dependency, finding the greater a perceived risk, the more important the media becomes as an information source. Television and radio have a storied history as information sources, but the storm siren possibly remains the most iconic medium for distributing warning information. As recently as 2003, research found hearing a siren to be the most effective method of motivating people to take action (Comstock & Mallonee, 2005). Hazard literature suggests tornado sirens serve as both primary and confirmatory warning devices (*Paul et al.*, 2003; Balluz *et al*., 2000; Legates & Biddle, 1999; Sherman-Morris, 2005).

The telephone was revolutionary, but according to warning literature it has not become a primary source for warning information. The percentage of individuals hearing warnings over the phone has been demonstrated in recent studies to remain much lower (9%) than traditional methods such as television, radio, and sirens (Schmidlin *et al.*, 2009; Comstock and Mallonee, 2005). Research shows the internet has replaced television as the most popular pastime (Hein and McClellan, 2005), while providing considerably more information options than the landline. The internet's limitation has previously been the lack of mobile flexibility, but at the beginning of the 21st century the smartphone allowed individuals to be instantaneously and continuously connected to the web in any location (Land & Manner, 2011). The rapid embracement of smart phones, both domestic and worldwide, has provided a personal and mobile platform for issuing information and warnings (Whitney, 2006). The capability of smartphones to utilize mobile data has interested researchers, although the influence of information dissemination through text messages and emails has not yet been supported with clear data (Sherman-Morris, 2010). Smartphones, and other advancing technologies, continue the evolution tornado warnings' most significant aspect: media's role of instantaneously providing information to the public (Golden & Adams, 2000).

Alternative information sources have developed alongside internet and social media growth. Twitter has been introduced to hazard warnings (Sakaki *et al.*, 2010), but extensive research is not yet available on social media's role as an information source in tornado warning systems. University warning systems attempt to utilize the mass availability of cell phones and internet access. Although text messages, email, and instant messages have not been confirmed as effective ways to distribute information, universities have justified such methods in addition to sirens on the assumption students and faculty would be on campus and unable to access television (Sherman-Morris, 2010). Although alternative information sources have been adopted by universities and remain a popular topic of research, Sherman-Morris (2006) noted that local populations develop strong psychological commitments to specific weather stations or forecasters, which may trump newly emerging information sources.

2.2.3. Lead-time. There is little doubt that the overall improvements made in warning information dissemination, forecasting, and ultimately prediction have reduced the number of deaths and injuries over the previous century (White & Haas, 1975; Sorensen 2000, Simmons & Sutter, 2005, 2008; Ashley, 2007). Evidence from NOAA disaster records show a declining trend in tornado related deaths and injuries (NOAA, 1997). Golden and Abrams (2000) attributed the decline to a combination of enhanced detection, longer warning lead-time, coordination with the media, public education efforts.

While forecasters and scholars agree warning systems have progressed, they do not fully understand the implications, for better or worse, of those advances. For instance, there was a 22% probability of tornado detection with a three-minute lead-time in 1978. Probability of detection only increased to 25% with an approximate five-minute lead-time by 1986 (Erickson & Brooks, 2006). Just over a decade later, in 1998 this had advanced to a 65% probability of detection with a thirteen-minute lead-time (Golden & Adams, 2000; Hoekstra *et al.*, 2011). While intuition suggests longer lead-time save lives, meteorologists and social scientists do not clearly understand how the public will respond to increased tornado lead-time (Hoekstra *et al.*, 2010). The public has a reputation of thinking they know more about severe weather than they do (Wong & Yan, 2002), which further supports the need for researchers to understand exactly what the public knows (Hoekstra *et al.*, 2010). If this were known, in combination with ideal lead-lead times, the National Weather Service could issue warnings at the most appropriate time (Hoekstra *et al.*, 2010).

There is no agreement on what the ideal lead-time actually is. While some research has found 30-minute lead-time to be ideal, a recent empirical study showed lead-times up to approximately seventeen- minutes reduce tornado fatalities and injuries (Simmons & Sutter, 2008). In an additional study, Simmons & Sutter (2009) showed six to ten-minute lead-time to reduce fatalities by 46%. While warning lead-time research lacks agreement and availability, it may indicate longer lead-times are not favorable (Ewald & Guyer, 2002; Doswell, 1999; Hoekstra *et al.*, 2010).

The lead-time for the April 27th, 2011 Tuscaloosa tornado was prolonged and accurate regarding the tornado's speed and direction. Well before the tornado touchdown southwest of Tuscaloosa, at approximately 3:43 p.m. CDT (local time), residents of Tuscaloosa and University of Alabama (UA) students had been warned of the threat. Days in advance, meteorologists, local officials, and university administration knew of the severe weather potential. The NWS predicted severe weather to begin around noon for most of central Alabama; UA was included in a tornado watch lasting until 10:00 P.M. CDT local time. The National Weather Service of Jackson, MS, issued the first tornado warning on the supercell, which eventually produced the Tuscaloosa tornado at 3:09 p.m. CDT. Following the official NWS warning, at 3:43 p.m. CDT, the University of Alabama issued a separate tornado-related communication to shelter in place until 4:45 p.m. CDT. The university's warning canceled classes and instructed those on campus to take shelter. At 4:35 p.m. CDT the tornado warning for UA was extended until 5:30 p.m. CDT, and at 4:50 P.M. CDT the UA warning was extended until 5:45 p.m. CDT. The tornado warning for the University of Alabama officially expired at 5:58 p.m. CDT, April 27, 2011. If optimal lead-time actually is around the fifteen-minute mark, an extended lead-time (over 65 minutes) preceding the Tuscaloosa tornado may have had unintended effects. This event is an example of the ongoing optimal lead-time issue and debate; the Tuscaloosa tornado lead-time was twice the length of the highest reported ideal length of time.

2.2.4. False alarms. Variable lead-time is not the only potential imperfection of tornado warnings; recent research addresses false-alarm ratios (FAR). Conventional wisdom attributes over-warning, or false alarms, to a reduction in the public's willingness to respond in the future (Barnes *et al*., 2007). Research supporting this theory, or notion, is limited and often conflicting (Simmons & Sutter, 2009). Breznitz (1984) defines the false alarm effect –also referred to as the *cry wolf effect*– as "credibility loss due to a false alarm," in which "the credibility loss following a false alarm episode has serious ramifications to behavior in a variety of response channels" (p. 11). Turner (1983) found that a threat is considered more credible as it is discussed more frequently, although this research was directed towards earthquake predictions in Los Angeles County (Barnes *et al.,* 2007). Evidence for both the false alarm effect and mobilizing effect were found by Atwood and Major (1998), but this research also addressed earthquake prediction in the New Madrid zone of the United States. Examination of false evacuation warnings for South Carolina residents preceding the near misses of Hurricane Bertha and Fran found the experiences' influence was believed to play no role in the residents' perception of risk (Dow & Cutter, 1998). While Turner (1984), Atwood and Major (1998) examined false alarms of earthquake predictions, and Dow and Cutter (1998) examined the influence of near misses and tornado evacuation, little research has examined how repeat false alarms relate to tornado warning response in the perspective of actual events (Barnes *et al.,* 2007).

Isolated false alarms have been shown to have little effect on appropriate response (Carsell, 2001), and, as recently as 2007, discussion of evidence for the *cry-wolf effect* has not been convincing (Barnes *et al*., 2007). When tornado warnings are issued, a balance exists between the probability of detection (POD) and false alarms. Even with the complexities of issuing tornado warnings, forecasters strive to warn for every tornado with as much lead time as possible, while attempting to limit false alarm warnings (Brotzge & Donner, 2013). Ideally, forecasters would have an FAR of 0.00, but because of uncertainties in forecasting technology and science, officials cannot be 100% accurate; false alarms can only be avoided by never issuing warnings (Barnes *et al.*, 2007). As of 2011, the national tornado POD was 0.75, with an average lead-time of 14.6 minutes, and FAR of 0.74 (NOAA, 2011). Radar advancements and the NWS modernization program has drastically improved current POD, lead-time, and FAR from the POD of 0.48 and average lead time of 7.6 minutes in 1994 (Brotzge & Donner, 2013).

Simmons & Sutter (2009) tested for an impact of false alarms on tornado casualties, not warning response; their findings show higher false alarm rates increases expected fatalities by 12% to 29% and expected injuries by 13% to 32%. Despite their findings, Simmons and Sutter (2009) stress that evidence of false alarms affecting casualties does not imply the existence of a false-alarm problem, but a misinterpretation of FAR and POD dynamics resulting in a FAR higher than ideal. Other research, conducted by Barnes *et al.,* (2007), suggests that perception of over-warning could be alleviated if the National Weather Service warnings were re-categorized to include near misses. While the *cry-wolf effect* idles in a state of speculation, it serves as a large source of concern within the warning community (Barnes *et al.*, 2007).

2.3. The Human Component

2.3.1. Warning response. How the public responds to tornado warnings has received minimal research attention (Golden & Adams, 2000). Thus, many unknowns remain regarding public response to disaster warnings (Mileti, 1988; Sorensen, 2000; Hammer & Schmidlin, 2002). Although "we have little understanding of the relationships among behavioral responses to tornado warnings, locations, warning lead time, warning receipt, and rates of injury and death," there is much to gain from studying these interactions further (Golden & Adams, 2000). Such knowledge has significant utility in planning, preparedness, and delivery of tornado warnings (Hammer & Schmidlin, 2002). Hoekstra *et al*., (2011) also acknowledges that understanding the public's severe weather event perception is critical to optimizing tornado safety. Scholars agree that multiple factors could significantly influence the casting of an individual's response to tornado warnings, including: education level, sex, ethnicity, age, prior tornado experience, number of children, and number of household members (Riad, 1999; Balluz, 2000; Sorensen, 2000; Hoekstra *et al*., 2011). Before an individual can make the decision to take protective action, they must receive, understand, believe, confirm, and personalize the tornado warning (Brotzge & Donner, 2013). Social science's perspective of understanding response to tornado warnings has made far less progress than the science and technology behind tornado forecasting (Hoekstra *et al*., 2011). Of the social science warning response research conducted, little has focused on sheltering decisions; the majority focused on evacuation behavior (Sorenson, 1991; Golden & Adams, 2000).

2.3.2. Risk perception, misunderstanding, and knowledge. The fundamental response to weather warnings is partially controlled by how dangerous an event is perceived by the individual. Hoekstra *et al*., (2010) claims that when an event is perceived as little risk to someone's personal safety they may take less immediate action compared to someone who perceived the threat as enormous. If the general public is overconfident in their understanding of severe weather (Wong & Yan, 2002), could a lack of knowledge influence decisions? Several studies investigate whether the difference between a watch and warning is understood, but many fail to disclose how responses were measured (Sherman-Morris, 2010). Legates and Biddle (1999) reported 90% of respondents to understand the difference. Balluz *et al.* (2000) reported a higher percentage (96%) of respondents knowing the difference. Mitchem (2003) found a much higher percentage (21-30%) of respondents unable to correctly define both a watch and warning; confusing the two was common. When Powell and O'Hair (2008) open-endedly asked respondents to explain the difference between a watch and warning, only 58% correctly did so. This suggests there is a significant difference between providing answer choices and requiring a definition to be provided (Sherman-Morris, 2010).

2.3.3. Risk behavior framework. How a person understands and processes warning information is deeply connected to human psychology and personal experiences (Brotzge & Donner, 2013). Two information-processing systems have been described when discussing decision making in the presence of uncertainty: System 1 and System 2 (Evans, 2008; Kahneman, 2003; Mukjerjee, 2010; Pleskac & Wershbale, 2014). System 1 makes decisions that are automatic, quick, and do not demand computational aptitude, while System 2 makes decisions that are guided, slower, and required computational aptitude (Pleskac & Wershbale, 2014). Furthermore, studies suggest a link between experiences, knowledge, and decision making under risk exist (Hertwig & Pleskac, 2010; Drost, 2013). Individuals will call upon all available recourses when dealing with risk and potential danger. It is common for an individual's knowledge of a risk, and preconceived fear associated with a risk, to weigh heavily in their decision-making process (Drost, 2013). Decisions made under natural hazard risk are similar to decisions made on a daily basis. Uncertainty is caused by a lack of knowledge, but natural hazard risk is also combined with unpredictability created by the natural forces causing such events (Drost, 2013).

The behavior of tornado victims has been characterized into two sets of profiles. Legates and Biddle (1999) provide a thorough evaluation of *cognitive factors* and *situational factors*, crediting these variables as leading contributors to tornado fatalities. Situational factors are demographic or physical aspects, which alter an individual's range of available choices to deal with risk (Tobin & Montz, 1997; Legates & Biddle, 1999; Biddle, 2007). Situational risk factors include lower socioeconomic status, manufactured housing, proximity to tornadoes origin, and also physical limitations such as a disability and older age which influence an individual's ability to react quickly (Gruntfest 1987; Senkbeil *et al.*, 2012). Several studies, including Schmidlin and King's (1995) analysis of 1994 Alabama and Georgia tornadoes, have concluded similar factors to be responsible; fatality groups generally included higher rates older residents, living in mobile homes, with less time to react to an approaching tornado than those surviving the event. Carter *et al.* (1989) also found unanchored structures and non-basement sheltering to contribute to fatalities during his study of the 31 May 1985 outbreak in Ontario, Canada. Cognitive factors are variables that influence risk perception. Cognitive factors include behavioral characteristics, personality and attitudinal traits, parental responsibilities, religious beliefs, and situational knowledge gained from past experiences. The cry wolf effect, false alarm conditioning, and beliefs that a tornado "won't hit here" or "God will protect us" are examples example of a cognitive factors, as are experience-produced cautiousness and overprotectiveness of children (Burnham 1992; Legates & Biddle, 1999; Biddle 2007).

Many decisions involve a balance between risk and expected reward. In these decisions an individual weighs the potential reward against the perceived unlikely risk of a negative outcome. An individual's internal deliberation typically occurs in the early stages of risk-taking activities, and vanishes once a pattern of habitual gratification is formed. For many, the decision-making process is only revisited when high-risk decisions result in a negative outcome (Zuckerman & Kuhlman, 2000). Individuals with certain personality traits, such as sensation seeking and impulsivity, may have a greater likelihood of possessing a risk-taking temperament (Zuckerman 1994, Zuckerman & Kuhlman 2000, Lauriola & Levin, 2000). Barnett and Breakwell (2001) claim that the "psychometric paradigm" has mistakenly attempted to explain the factors that contribute to an individual's perception of risk by developing "personality profiles." This approach successfully identified characteristics as risk perception predictors, but provided little explanation of why individuals differ from each other in their perception. Additional research has been directed at the variability of individual risk perception by attempted to identify the underlying causes through social, cultural, and institutional factors (Turner & Wynne, 1992; Sjöberg, 1995; Barnett & Breakwell, 2001).

While research has had some success at identifying personality characteristics as risk perception predictors, it is important to realize the process of receiving, processing, and understanding risk communication messages to make decisions about shelter seeking action is extremely complex (Ash *et al.*, 2013). Behavioral risk models have identified individual characteristics including personality, prior experience, gender, and self-efficacy as influential factors in the decision-making process (Fishbein, 2008; Lindell & Perry, 2012; Maloney *et al*., 2011; Ash *et al*., 2013). Additional research addressing risk behaviors, personality, and culture, as associated to warning systems, has attempted to explain the density of tornado fatalities at the regional scale. Sims and Baumann (1972) proposed that culturally controlled variables unique to regions were responsible. They suggest that Southerners' religious convictions promote a fatalistic attitude regarding risk and a neglect of the benefits offered by technology and warning systems (Sims & Baumann, 1972). Although theory of Southerners' fatalistic approach towards severe weather exists in literature, it lacks widened support. Biddle (1994) concluded Southerners, and all tornado alley residents, possessed similar warning system access and an equivalent understanding of tornado risk.

A process of analytical reasoning and emotional guidance help form an individual's beliefs and perceptions about a severe weather event and its potentially hazardous consequences. This process occurs from the time a warning is received and a final response is produced (Fishbein, 2008; Lindell & Perry, 2012; Maloney *et al*., 2011; Ash *et al*., 2013). During this process a fundamental step occurs in which an individual must take the threat seriously; essentially, a warning will only be acted upon if an individual perceives the threat as real. Warnings perceived to lack a valid threat would be ignored, while questionable validity can drive *confirmation behavior*, or *normalcy bias*, in which an individual attempts to seek additional sources of information, such as visual confirmation (Drabek & Stevenson, 1971; Perry *et al.*, 1981). If this behavior occurs during a tornadic event, the result is a greatly increased risk of casualty for anyone seeking visual confirmation, because neglecting shelter is required (Biddle, 2007). For many people, their initial reaction upon receiving a warning is disbelief; confirmation behavior seeks to overcome automated feelings of disbelief, and has been identified as part of both the warning process and human nature (Drabek, 1986; Mileti & Fitzpatrick, 1991; Mileti 1999; Biddle, 2007).

Tornado warnings are a form of risk communication that use impending danger and fear of injury as motivators for shelter seeking action (Lundgren & McMakin, 2009; Ash *et al.*, 2013). The significance of a warning is assessed on a variety of factors including past interactions with the hazard type and warning system involved, which is evaluated across personality elements such as ideologies, values, goals, and responsibilities (Biddle, 2007, p. 16).

The message is then reinforced by discerning environmental cues and consulting with both peers and alternative information sources. Biddle (2007) noted that the confirmation process is such a fundamental process that it has been integrated into the planning process by warning authorities through increased lead-time, quality control of message consistency and source credibility.

2.3.4. Visual representations. More recently, a conceptual framework was discussed by Severtson (2013), which accounts for previously mentioned risk factors in the context of environmental maps' influence on risk perception and behavior. Severtson's Integrated Representational and Behavior Framework (IRBF) suggests that individuals form risk behavior via cognitive and emotional interpretations following a visual representation of risk. An individual comprehends and evaluates such visual representations through map or graphic features, personal characteristics, and the conscious and subconscious processes used to assess the information (Severtson, 2013). Individuals also process specific aspects of the hazard itself, how they may handle the consequences of the potential hazard, and the opinions and actions of others in their community (Fishbein, 2008; Lindell and Perry, 2012; Maloney *et al*., 2011; Ash *et al*., 2013).

2.3.5. Hypothetical scenarios and intended actions. Relating risk perception to actual behavior is difficult to facilitate both in real time and in post event analyses because of the dangerous and unstable nature of tornadoes (Ash *et al*., 2013). Human behavior research has produced evidence that suggests intended behavior responses can be used to reasonably predict actual behavior (Fishbein, 2008; Sheeran, 2002; Whitehead, 2005; Wogalter *et al*., 2002; Ash *et al*., 2013). The predictive abilities of intended actions are not proportional to intended behavior. Webb and Sheeran (2006) found that large changes in intended actions generally only lead to small changes in actual behavior. While intended actions are believed to have some predictive value, it is unknown how accurate shelter-seeking intended actions in hypothetical tornado scenarios may translate to actual tornado warning situations (Ash *et* al., 2013; Meyer *et al*., 2013).

Environmental hazards, including tornadoes, can be visually represented through maps, graphs, and charts, although several factors contribute to an individual's ability to understand visual information (Ash *et al*., 2013). Four concepts, described by Pinker (1990), are thought to influence a person's ability to understand information presented in a graphical format: units of perception, Gestalt principles, representation of magnitude, and coordinate systems. Units of perception influence comparison between values assigned to units, Gestalt principles suggest similarity, proximity, and continuity of graphic features affect their interpretation, magnitude assists organization of features into a hierarchy, and coordinate systems aid visual organization in reference frames (Pinker, 1990). It is important to understand a wide variety of combinations among these factors can lead to large differences in how a person interprets maps or other visual representations of risk. Pinker's factors are likely to be useful in the context of hypothetical tornado scenario visual warning representations (Ash *et al*., 2013).

Subconscious processing of visual features occurs prior to cognitive processing of the primary meaning through the influence of preattentive properties (Cleveland & McGill, 1984). Preattentive properties can include, but are not limited to, scale, feature size, color scheme, color saturation, contrast and feature shape. A map viewer's ability to quickly focus their attention on important map features is known as visual salience. Mapmakers are able to increase visual salience, and essentially create a more efficient map, through the use of preattentive properties (Severtson and Vatovec, 2012; Sherman-Morris, 2005; Wogalter *et al*., 2002). While preattentive properties, such as color schemes, shading, shapes, and contrast, increase visual salience, they also have the potential to misrepresent a map's intended message. Adversely, a lack of preattentive properties can cause visual salience issues (Ash *et al*., 2013). The April 2011 tornado outbreak has been a popular topic of recent research. Since the 2011 outbreak, multiple studies have examined misunderstandings related to visual representations of storm-based warnings. Klockow (2011) reported that Alabama residents were unable to determine if they were in danger because static television maps did not provide direction or recognizable features of thunderstorms in relation to their location. Sherman-Morris and Brown (2012) noted that Mississippi residences believed the perimeter of a tornado warning was less likely to experience a tornado than the warning's geographic center.

2.4. Purpose of Current Study

The current theory in literature suggests that providing more information and earlier warning should be implemented in the public severe weather warning process. Since the implications of longer lead-time, multiple information sources, and visual representations of warning information have not been fully explored, this study seeks to better understand how indivuduals respond to various types and levels of warnining information during a severe weather event. The purpose of this research is to examine whether written and visual tornado warning information will influence behavior during a hypothetical tornado scenario. This research examines how three different amounts of written tornado warning information influence shelter-seeking intended behavior, perception of danger, and understanding of proximinty to the using a series intervals during a hypothetical tornado scenario. This research also tests whether the presence of a visual information source, such as a map, influences intended shelter-seeking behavior in the same hypothetical tornado scenario. The experiment consists of a 2x3 factorial design with two visual information options (map/no map) and three levels (high, medium, and low) of written information. The study poses the following research questions: 1) Do shelter-seeking responses differ across each tornado scenario's combination of written and visual warning information? 2) Do individuals perceive the tornado scenario as more dangerous as they are provided with higher levels of information? 3) Does participant perception of the tornado's distance from their location change across written information levels, and do responses become more accurate when visual information is available? Adressing these questions, I propose the following hypotheses:

- H1: Shelter responses will vary according to the amount of information received.
    - H1*a*: Individuals with more written and visual information will be more likely to seek shelter than individuals with low written and no visual information.
    - H1*b***:** Individuals with more written and visual information will be less likely to leave shelter, after it has been sought, than individuals with low written and no visual information.
- H2: Perception of danger will vary according to the amount of information received.
    - H2*a*: Individuals with more written information will perceive a greater amount of danger than individuals with less written information across the 6 intervals.
    - H2*b*: Individuals with visual information will perceive a greater amount of danger than individuals with no visual information across the 6 intervals.
- H3: Participant's estimated tornado distance responses will vary according to the amount of information received.
    - H3*a*: Individuals with more written information will provide a more accurate estimate of tornado distance across intervals.
    - H3*b*: Individuals with visual information will provide a more accurate estimate of tornado distance across intervals.

III. Methods

3.1. Participants

Participants in the main study included a total of 186 students: 183 undergraduates and 3 graduates, 99 males and 87 females, enrolled at a regional university in the Southeast United States. Participants were recruited from (a) classes in lower division geography courses, (b) classes in upper division geography courses, (c) classes in lower division psychology courses, (d) classes in upper division psychology courses, and (e) classes in lower division physics and earth science courses. Participants were offered a modest amount of extra credit for their participants; however, extra credit for participation was up to each instructor's discretion. In all cases, it was stressed that participation was voluntary and that all information would remain confidential and anonymous. There were no negative consequences for refusing to participate.

3.2. Materials

3.2.1. Tornado scenario. The purpose of this study was to examine decision-making and shelter-seeking behavior in severe weather events. In particular, this research examined the role of information in the decision making process. Considering the Southeast's frequent tornado activity and recent experience with large, devastating tornadoes, I decided to focus on tornadoes over all other types of severe weather phenomenon.

To examine decision-making during a tornadic event, a hypothetical scenario was created for this study. The scenario examines how the participant goes through a typical school day as severe weather develops in the area and proceeds towards the local city and university. While the scenario covers nine hours of the day, as weather progressively worsens, participants were only exposed to eight snapshots (i.e., intervals) throughout the day in attempt to eliminate participant fatigue.

Although all participants experienced the same scenario with the same outcome (e.g., local city/university are in the direct path of the tornado), participants received varying types and amounts of information regarding the weather situation. Information provided to participants was meant to replicate information that would be disseminated by trusted weather sources (e.g., the National Weather Service, local television meteorologists) during a severe weather event. Additionally, the number of information sources was limited while still trying to provide a balanced variety of sources.

In this study, participants received a low, medium, or high level of “verbal” or written information regarding the weather. Participants also had the opportunity to receive a visual representation of the storm by either having access or no access to a map. This map visually represented the distance and trajectory of the severe weather event through a series of cone shaped polygons. These polygons represented the estimated location and path of the hypothetical tornado throughout the scenario.

Written/Verbal Information. The first level of information, referred to as *low information,* was intended to replicate the most basic warning information available. If an individual had no access to warning information, it is likely that they could still hear a tornado warning siren. The next level of information, referred to as *medium information*, was intended to replicate a sufficient amount of information. This medium level of information included warning messages from television, radio and university warning system sources. The final level of information, referred to as *high information*, was intended to provide an additional level of detail to the event. This high level of information included all previous warning information while adding graphic descriptions about components of the storm (Appendix B3).

Visual Information. In addition to varying levels of warning information, a component of spatial, visual information was built into the scenario in the form of maps. Maps were included because they are a critical component in weather forecasting and relating potential threats to the public and their specific locations. To eliminate additional information, not intended to be measured, the scenario maps were designed to remain as neutral as possible. Similar to available live radar and forecasting maps, scenario maps showed the local city, university, surrounding communities, and major roads and highways. These maps differed from what is shown during live forecasts because a gray, cone-shaped feature represented the hypothetical tornado. The icon used to represent the tornado showed participants its approximate current location, predicted path, and potential path (Appendix B4). Half of the participant pool was shown maps accompanied with tornado warning information, while the other half only received warning information. The options created using maps and varied levels of information led to six different scenarios, resulting in a 2x3 factorial study design. These six scenarios were coded with the letters A, B, C, D, E, and F (Appendix B1).

The hypothetical tornado event's design was influenced by the Tuscaloosa tornado of April 27, 2011. This tornado was referenced for multiple reasons: its large magnitude, successful forecast and prediction, interaction with a campus population, regional relativity, thorough documentation of the entire event, and known final outcome. University of Alabama students were warned well in advance of the EF-4 April 2011 Tuscaloosa tornado by the National Weather Service and University of Alabama officials. It is uncommon for severe tornadoes to interact with dense urban areas, which is why the event timeline and warning messages of this particular tornado were documented so well. Two historical components of the April 2011 Tuscaloosa tornado were used to create this study's hypothetical tornado scenario: actual, observable tornadic events which were recorded and actual warning messages issued by the University of Alabama, government agencies, and local weather affiliates.

The timeline of events during the April 2011 Tuscaloosa tornado was used to identify public-identifiable landmarks, or checkpoints, along the tornado's path towards and through town. By identifying stages of the tornado's path, the number of intervals presented in the hypothetical scenario was efficiently created to optimize conciseness. Once tornado track landmarks and information were determined, the hypothetical scenario was tailored to meet these metrics within the study university's surrounding area. It was decided that five intervals of the tornado's formation and path would be presented to participants so that the entire event could thoroughly examined without exhausting the participants. Over these five intervals participants were presented the formation of the tornado and its entire path to their location. The tornado origin was approximately 25 miles from campus, and the tornado's final destination was campus itself. These five intervals also attempted to provide relevant and equally spaced windows during the tornado's path. Three additional intervals were included to account for preliminary information available to individuals throughout the day. The three pre-storm intervals replicated information that was available during the morning, mid-day, and early afternoon periods of April 27, 2011.

Using satellite imagery of the 2011 Tuscaloosa tornado in a geographic information system (GIS), the tornado path's selected intervals were established with waypoint identifiers. The tornado track was next overlaid with the study university's local area, where similar landmarks were identified and therefor, local intervals created. A separate map was created for each interval, providing an updated tornado location. Each of these maps was also paired with current information about the tornado as it pertained to the respective interval.

Participants were presented with a single version of the six available tornado scenarios in a paper packet format. All scenario packets were coded with a letter to identify which version of the weather scenario the packet contained. These packets were spiral bound and contained fifteen landscape-formatted slides. The slides within these packets were color-coded: white slides provide instructions and gray slides provide interval information. The first slide contained a brief overview and instructions, which is followed by the first three intervals providing the morning, noon, and early afternoon summaries of preliminary information. After intervals one though three the packets alternate between (white) instructional slides and (grey) interval slides. For scenario packets that did not contain maps, the interval slides only displayed warning information pertaining to that specific scenario. For scenarios containing maps, warning information was placed on the side of each interval's map. Thus they were organized in the following manner:

1. Overview and Instructions
2. Interval 1
3. Interval 2
4. Interval 3
5. Instructions following Intervals 1-3
6. Interval 4
7. Instructions following Interval 4
8. Interval 5
9. Instructions following Interval 5
10. Interval 6
11. Instructions following Interval 6
12. Interval 7
13. Instructions following Interval 7
14. Interval 8
15. Final Instructions following Interval 8

Each time participants reached an instructional (white) slide, they were directed to a web based survey to answer a series of questions related to the interval they just viewed. By providing participants with the scenario in a physical paper packet format, a computer was designated for collecting questionnaire responses. The entire study questionnaire consisted of three sections: the tornado scenario questionnaire, demographic questionnaire, and International Personality Item Pool (IPIP) Questionnaire.

3.2.2. Tornado scenario questionnaire. The tornado scenario questionnaire consists of a total of 71 questions, which were grouped, together in sets of eleven to twelve questions. Participants were asked to answer these question sets (i.e., interval questions) after having been exposed specific intervals in the scenario. Participants were asked to answer the interval questions to determine if and when participants' perception of the weather changed and how their decisions changed as the scenario progressed and new information was introduced.

Although there were a total of eight intervals in the overall weather scenario, participants were only asked to answer the interval questions during six intervals. The first two intervals were meant to "set up" the day's events for participants without discussing specific weather events or phenomenon. As such, participants were not asked to rate the weather situation via interval questions in the first two intervals. After viewing the information in the third interval, participants were asked to answer the first set of interval questions. During the third interval, the severe weather approaching the city is technically described as a "storm" with the potential to cause damage; however, the storm has not yet developed into a tornado. I purposefully described the severe weather as a "storm" at this stage in order to provide a more realistic depiction of a tornadic event. Since this third interval did not outright discuss a tornado, the first set of interval questions was modified to address a severe "storm" rather than a tornado. This set of interval questions was the only set that was different. All other interval questions used the same set of questions posed at different intervals (Appendix C2).

Interval three question set. This set of questions consisted of eleven total questions in mixed format. All of these interval questions were developed for the purposes of this study. The questions in the third interval were used to measure participants' interpretation of the severe weather including perceived personal safety, perceived severity of the weather, and accuracy of the weather information. Participants used a five-point Likert scale ranging from one (v*ery inaccurate*) to five (v*ery accurate*) to rate the first six questions. Participants were then asked to answer two multiple choice questions, one asking participants to choose their immediate shelter plans and the other asking participants to express their general feeling of danger in the current situation (Appendix C1).

Intervals four through eight question sets**.** Participants answered a total of twelve questions in each question set for intervals four through eight. Questions one through eleven, for intervals four through eight question sets, were the same as those used in the interval three question set. The only difference between the interval questions were that in the interval three question set, "tornado" was replaced with "storm" when necessary (question eleven) and an additional question (question twelve) was added to the interval four through eight question set. This final question, which was excluded from the third interval question group alone, asks participants to estimate the tornado's current distance from their current location. Participants were required to answer with a numeric value representing distance in minutes (Appendix C2).

3.2.2. Demographic questionnaire. The twenty-item questionnaire assessed the participant's age, student classification, gender, ethnicity, hometown location, severe weather experience, preferred tornado warning information source, and current residence proximity to campus (Appendix D). These questions consisted of multiple choice, five-point Likert scale, and fill in the blank (text and numeric answer) formats. This questionnaire was designed for this study to establish descriptive, background information about participants and their exposure to severe weather events.

3.2.3. International Personality Item Pool (IPIP) questionnaire. The 31-item question was constructed to assess the participant's personality tendency of risk-taking, harm-avoidance, need for cognition, and quickness (Appendix E). All items in this questionnaire were asked on a 5-point Likert scale ranging from one (v*ery inaccurate*) to five (v*ery accurate*). These four scales were assembled from Ipip.ori.org, an organization that collaborates and makes available advanced measures of personality and individual differences to the public domain.

The questionnaire consisted of four International Personality Item Pool Scales: risk-taking, harm avoidance, need for cognition, and quickness. Each of these scales contained ten items, but because many items overlapped the combined questionnaire only totaled 31 items. According to Jackson (1994), the risk-taking scale is internally reliable with an average Cronbach alpha = 0.78. Cloninger *et al.* (1994) found the harm-avoidance scale, included in the Temperament and Character Inventory (TCI), to be internally reliable with an average Cronbach alpha = 0.78. According to Cacioppo and Petty (1982), the need for cognition scale is internally reliable with an average Cronbach alpha = 0.84. Additionally, Hogan and Hogan (1995) found the quickness scale to be internally reliable with an average Cronbach alpha = 0.82.

3.3. Procedures

3.3.1. Recruitment. Entire classes were targeted as recruitment pools for student participants. Instructors were approached and asked to volunteer class time to allow students to participate in the study. Extra credit was offered as compensation, when instructors chose to do so. Once an instructor agreed to allow students to participate, I visited each class to briefly describe the study. Students were told the name of the study, the expected length of time required to complete the study, and that the research team was interested in how individuals made decisions during severe weather events. Students were also informed that participation was completely voluntary and that all responses were confidential and remained separated from their names, which were therefor anonymous.

3.3.2. Computer lab set-up. Data collection took place in a computer lab with 30 computers connected to the internet. Each computer screen was set to display, in full screen, the first PowerPoint slide of the study, which included the directions and procedures (Appendix A2). The web-based survey was also launched, set to the first page of the survey, and displayed in the background (hidden by the PowerPoint slide). Additionally, scenario packets were placed in a roatating sequence among computers according to the coded letter on each packet. Each scenario packet was paired with a consent form, which included a four-digit participant number, and a corresponding coded scenario letter visible at the top of the form. Participants received only one packet and thus viewed only one scenario.

Students were required to use a participant number in order to participate in the study. Participant numbers were used in order to maintain participant confidentiality by eliminating the need for participants to include any identifying personal information in the online questionnaire. Additionally, I could determine which scenario version a participant completed by associating the participant number with the corresponding coded scenario letter (i.e., A, B, C, D, E, or F). Although I kept a list of names and their corresponding participant numbers, this roster file was saved and stored separately from participant response data. At no time were participants' responses paired with participant names. The participant number and scenario-coded letter were used to create a participant roster, and ensure all scenarios shared an equal *n*.

The consent form gave a brief description of the study and reminded participants that their responses would remain confidential (Appendix A1). The consent form also provided contact information for the principal investigator and the University of North Alabama's Office of Sponsored Projects.

3.3.3. Data collection. As participants arrived to the computer lab for each data collection session, I informed the participants where to sit and asked them not to open his/her scenario packet. After participants had all been seated, I greeted the participants and instructed them to locate the consent form in front of their computer. Participants were then instructed to read through the consent form thoroughly and sign it if they understood its contents and agreed to participate in the study. Next, I provided the participants with an initial overview, which briefly explained the purpose of the study, the study's procedures, and the participants' role in the study. Students were informed that the study would include a hypothetical severe weather scenario and they could withdraw at any point during the study without penalty. Specifically, the overview explained that the purpose of the study was to examine how participants used warning information to make decisions during a severe weather event. The overview explained that the study was composed of three sections: the severe weather scenario with accompanying questionnaire, the demographics questionnaire, and the personality item pool (IPIP) questionnaire.

Students were told that the severe weather scenario was entirely contained in the packets in front of them and that all answer responses would be recorded online via a survey collection website, SurveyMonkey.com. Participants were also informed that this scenario was intended to simulate an entire day, although they would only see eight snapshots. These snapshots were referred to as *intervals* in the study. The scenario packets contain two differently colored pages:

white pages contain survey instructions and grey pages contained scenario interval information. For each interval, there is an accompanying set of questions. Additional instructions were located above and below each group of interval questions on the web-based survey collection site. Participants were also informed that each (grey) interval would be followed by an (white) instructional page in the scenario packet. The instructional pages would direct them to the web-based survey and the instructions after each interval question group would direct them back to the scenario packet's next interval.

The demographic and personality questionnaires were briefly explained to the participants. In particular, participants were aware that these questionnaires were meant to record demographic information, identify participants' previous experience with severe weather, and categorize personality tendencies. These questionnaires followed the severe weather scenario questionnaire and were completely compiled on the web-based survey (Appendices D and E, respectively). This concluded the overview explanation and participants were directed to the survey webpage link through SurveyMonkey.com. The survey requires a participant number to be entered before the participant can continue. Participants were instructed to use the four-digit participant number on their consent form to enter the survey.

Signed consent forms were collected after participants completed their consent forms and entered their four-digit participant number into the survey website. After each survey session, I would organize consent forms by the four-digit participant number. This was used as a reference number to keep track of participants in the study. Since the study was located online it was important to control who participated in the study and verify all collected responses came from the intended research sample. This four-digit reference number was not used to connect participant names with answers, but rather to ensure only valid participant responses were analyzed.

After participants heard the instructions, read the consent form, and entered their participant number into the online survey, participants read through the first third intervals of the severe weather scenario. These first three intervals explained the potential for severe weather and set up the scenario (Appendix B3); thus, participants were not asked to answer the set of interval questions until the third interval. After the third interval, participants were instructed to answer the first set of interval questions (Appendix C1). After completing the first set of interval questions, participants were instructed to view the next slide, which described the next interval in the scenario. Essentially, participants read through a scenario interval and then answered a series of questions regarding the immediate situation; this was followed by another scenario interval describing the developing storm and a set of interval questions. This pattern was repeated until participants finished all eight intervals. Participants were asked not to skip ahead in the packet as I was interested in their decisions at that particular moment in the scenario. At each interval, participants answered the same twelve questions (Appendix C2).

After participants completed reading the interval scenarios and answering the interval questions, they were directed to the demographic and personality questionnaires, which were also posted on the online survey site. Once participants completed these additional questions, they saw a screen informing them that they had completed the study and were free to leave. As participants left the computer lab, I thanked them for their participation and provided them with a debriefing form (Appendix F).

Participants were free to complete the study at their own pace. At least one experimenter was present during each survey session to ensure all participants were able to begin the study and to help answer questions. Participants were encouraged to work though scenario intervals in their intended chronological sequence, but were allowed to navigate through all survey screens by clicking on a next or back button at the bottom of the screen. Participants answered all questions directly on the computer by clicking answers on multiple-choice or Likert-scale formats and also entered numerical values in text boxes. Participants were allowed to change answer responses but questions were coded to accept only one answer. The entire survey was intentionally coded so each question required an answer before participants could proceed to subsequent pages.

IV. Analysis

4.1. Shelter Seeking

I was interested in examining shelter behavior in the six scenario situations, as such participants were asked about their sheltering behavior during each of the six intervals. To determine whether participant choices varied across scenarios, instead of between intervals, I decided to consolidate interval answers for each participant into one shelter behavior response. I coded shelter-seeking behavior based on whether participants (a) never took shelter, (b) took shelter and stayed in shelter, or (c) took shelter and at some point left shelter (Table 1).

Table 1. Shelter-seeking responses were consolidated into three options by researcher by coding as (a) never took shelter, (b) took shelter and stayed in shelter, or (c) took shelter and at some point left shelter. Shelter-seeking responses were collected at all six question groups.

Scenario	**(A) No Shelter**	**(B) Took Shelter**	**(C) Left Shelter**	**Total**
High Info/Map	0	29	2	31
High Info/No Map	1	28	2	31
Med. Info/Map	0	31	0	31
Med. Info/No Map	0	28	3	31
Low Info/Map	3	24	4	31
Low Info/No Map	1	20	10	31
Total	**5**	**160**	**21**	**186**

4.1.1. Kruskal Wallis. A Kruskal-Wallis test was used to determine if shelter-seeking score varied across the six scenarios: low information/map available, low information/no map available, medium information/map available, medium information/no map available, high information/map available, and high information/no map available. Results from the Kruskal-Wallis test indicate a statistically significant difference between scenarios on shelter-seeking behavior, $X^2(5) = 14.769$, $p = 0.011$.

4.1.2. Post hoc analysis. Pairwise comparisons were performed using Dunn's procedure with a Bonferroni correction for multiple comparisons, which acccounted for familywise error. Post hoc analysis revealed statistically significant different shelter-seeking behavior between the low information/no map (M = 2.29) and medium information/map groups (M = 2.00), p = 0.025. A significant difference was also found between low information/no map (M = 2.29) and high information/no map (M = 2.03) groups, p = 0.028. Finally, a significant difference was found between the low information/no map (M = 2.29) and the low information/map (M = 2.03) groups, p = 0.033 (Table 3).

Table 2. Dunn's procedure with a Bonferroni correction was performed. Table displays resulting p-values. Comparisons of shelter-seeking responses among scenario groups are displayed. There were three significantly different (**) scenarios and one marginally different (*) from the low information/no map condition.

** = signficant (p < 0.05); * = marginal sigificance (p < 0.1)

	Low Info No Map	**Low Info Map**	**Med. Info No Map**	**Med. Info Map**	**High Info No Map**
Low Info/Map	0.033**				
Med Info/No Map	0.274	1.000			
Med Info/Map	0.025**	1.000	1.000		
High Info/No Map	0.028**	1.000	1.000	1.000	
High Info/Map	0.089*	1.000	1.000	1.000	1.000

4.2. Perceived Danger

Participants's perception of danger was collected at all six question intervals. Participants were repeatedly (six times) asked whether they currently felt: (a) in no danger at all, (b) slighlty in danger, (c) a moderate amount of danger, or (d) in extreme danger. I was interested in determining whether information level or map availability was related to participants' perceived danger at the interval level (Table 4).

Table 3. Danger perception responses were collected from participants six times throughout the scenario. Responses were coded as (1) in no danger at all, (2) slighlty in danger, (3) a moderate amount of danger, or (4) in extreme danger.

	Danger Perception Question Groups						
Scenario	**1**	**2**	**3**	**4**	**5**	**6**	**Means**
High Info/Map	2.32	2.45	3.00	3.29	3.52	3.68	3.04
High Info/No Map	2.13	2.55	3.03	3.32	3.61	3.58	3.04
Med. Info/Map	2.07	2.61	2.87	3.36	3.55	3.77	3.04
Med. Info/No Map	1.97	2.58	2.97	3.39	3.71	3.81	3.07
Low Info/Map	2.19	2.61	2.52	2.77	3.13	3.48	2.79
Low Info/No Map	2.00	2.57	2.74	2.71	2.71	2.74	2.59

4.2.1. Three-way mixed design ANOVA. As such, a three-way (information X map X interval) mixed-design ANOVA was conducted to compare group ratings of perceived danger.

Between-subjects.

A main effect of information on perceived danger was found to be significant, F = (2, 180) = 7.99, $p < 0.001$. A Bonferroni test on the pairwise comparisons showed that participants with low information (M = 2.69) rated perceived danger lower than individuals with moderate information (M = 3.05) and participants with high information (M = 3.04), both at the $p < 0.01$. There was no significant difference in perceived danger rating between participants with a moderate amount of information and participants with a high amount of information (Figure 1).

Within-subjects.

Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated ($p < 0.001$) as such, the Greenhouse-Geisser corrected degrees of freedom was used to interpret the results.

An examination of the within-subject results revealed statistically significant interactions between information and interval on perceived danger (F (7.51, 675.93) = 10.55, $p < 0.001$) and between map and interval on perceived danger (F (3.76, 675.93) = 3.83, $p < 0.01$). More importantly, an interaction between information, map availability, and interval on perceived danger was also found to be statistically significant, F (7.51, 675.93) = 2.66, $p < 0.01$.

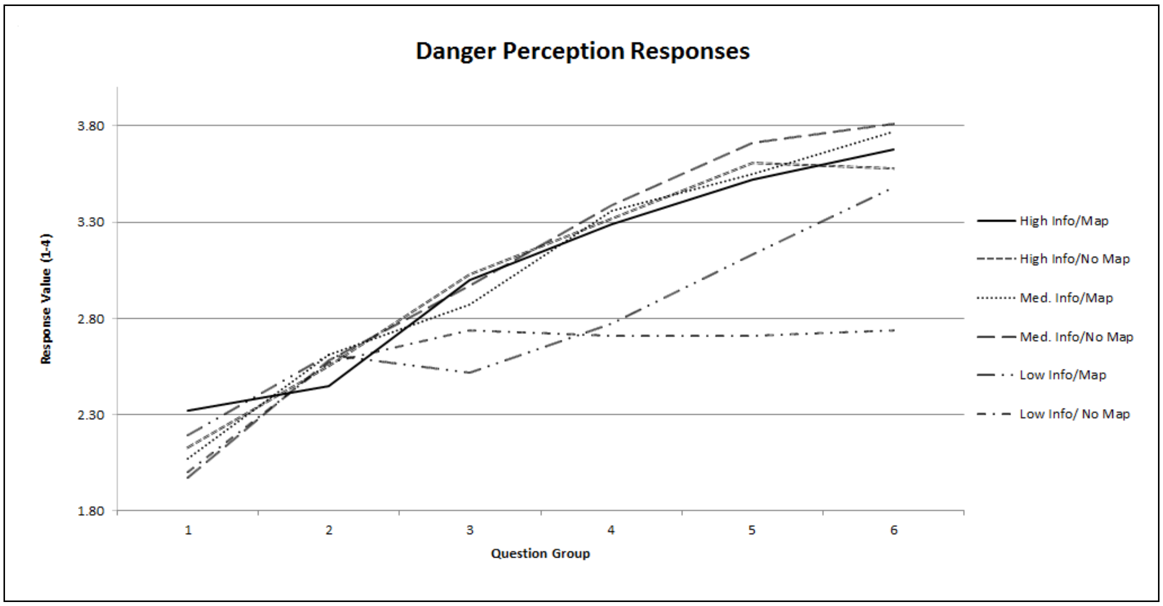


Figure 1. Danger perception responses were collected from participants six times throughout the scenario. Responses were coded as (1) in no danger at all, (2) slighlty in danger, (3) a moderate amount of danger, or (4) in extreme danger.

4.2.2. Two-way ANOVAs. In order to address the significant three-way interaction, two-way ANOVAs were conducted to examine the influence of information and map availability on perceived danger at each interval.

Interval three and interval four. The results from the two-way ANOVAs for interval one and interval two showed no significant main effects (i.e., information, map) or significant interactions on perceived danger.

Interval five. There was no significant main effect of map or interaction of information and map on perceived danger in interval three. However, results did show a significant main effect of information on perceived danger, *F* (2, 180) = 4.31, $p < 0.05$, partial $n^2 = 0.05$. A Bonferroni test on the pairwise comparisons showed that participants in the low information (*M* = 2.63) group rated the situation less dangerous than participants in the high information (*M* = 3.02) group, *SE* = .137 $p < 0.016$. There were no significant difference between the low information and medium information groups or between the medium information and high information groups.

Interval six. As in interval three, the main effect of map on perceived danger and the map and information interaction on perceived danger were not significant. Similar to interval three, the main effect of information on perceived danger was statistically significant, *F* (2, 180) = 13.18, $p < 0.001$, partial $n^2 = .13$. The Bonferroni test on the pairwise comparisons showed that participants in the low information (*M* = 2.74) group rated the situation less dangerous than participants in the moderate information (*M* = 3.37) group (*SE* = 1.35, $p = 0.001$) and from participants in the high information (*M* = 3.31) group (*SE* = 1.35, $p = 0.001$). There were no significant differences between the low information and medium information groups or between the medium information and high information groups.

Interval seven. Although there was not a significant main effect of map on perceived danger (*F* (1, 180) = 0.27, $p = 0.603$, partial *n2* = 0.002), there was a significant main effect of information when participants rated perceived danger, *F* (2, 180) = 19.30, $p < 0.001$, *partial n2* = 0.177. However, this effect was explained by a significant interaction of information and map on perceived danger, *F* (2, 180) = 3.17, $p < 0.05$, partial *n2* = 0.034. The simple effects for the interaction were analyzed and a Bonferroni test on the pairwise comparisons showed that participants who received low information and no map (*M* = 2.71) rated the situation as less dangerous than participants who received a moderate amount of information and no map (*M* = 3.71), *SE* = 0.174, *p* = 0.001.

Additionally, a simple main effect of information on perceived danger was found for the map condition, *F* (2, 90) = 3.24, $p < 0.05$, partial *n2* = 0.067. A Bonferroni test on the pairwise comparisons showed that participants who received low information and a map (M = 3.13) rated the situation marginally less dangerous than participants who received a moderate amount of information and a map (*M* = 3.55), *SE* = 0.183, *p* = 0.074.

Interval eight. There was a main effect of information on perceived danger (*F* (2,180) = 15.12, $p < 0.001$, partial *n2* = 0.144) and a main effect of map on perceived danger, (*F* (1, 180) = 6.35, $p < 0.01$, partial *n2*= 0.034) in the sixth interval. Both effects, however, were explained by a significant interaction between map and information on perceived danger, *F* (2, 180) = 4.99, $p < 0.01$, partial *n2* = 0.053. A Bonferroni test on the pairwise comparisons showed that participants who received low information and no map (*M* = 2.77) rated the situation as less dangerous than individuals in either the moderate amount of information/no map condition (*M* = 3.81), SE = 0.189, p = 0.001) or the high information/no map condition (M = 3.58, SE = .189, p = 0.001). There was no significant difference between participant ratings of the danger between the moderate information/no map and the high information/no map. Although not significant, there is a trend in that the means for medium information appeared to be higher than both low information and high information in most of the intervals.

4.3. Storm Distance

Participants were asked to estimate the distance of the storm/tornado from their current location in minutes during the last five intervals (question groups two through six) (Table 5 and

Figure 2). This data was used to examine the accuracy of participants' storm distance estimates. In order to do so, the actual distance of the storm was determined by referencing the actual Tuscaloosa tornado and its arrival at similar landmarks that were used to create each of the final five hypothetical tornado scenario intervals. Student estimates were subtracted from the actual distance for each of the five intervals thus creating participant residual scores at each interval (Tabel 6 and Figure 3).

Table 4. Storm distance estimates were collected at the final five question groups. These responses were recorded in minutes.

Scenario	2	3	4	5	6	Means
High Info/Map	24.71	15.13	8.74	3.97	1.65	10.84
High Info/No Map	22.94	15.9	7.29	3.16	1.32	10.12
Med. Info/Map	26.94	20.52	9.49	4.94	2.01	12.79
Med. Info/No Map	22.90	15.26	8.42	4.29	2.19	10.61
Low Info/Map	27.55	19.58	12.65	7.19	1.61	13.63
Low Info/ No Map	17.74	11.00	9.00	7.065	6.65	10.29

Table 5. Storm distance residuals were created from differences between estimated responses and known tornado location.These results are shown in minutes.

Scenario	2	3	4	5	6	Means
High Info/Map	4.87	9.99	3.94	2.9	-0.55	4.23
High Info/No Map	6.65	9.12	5.9	3.71	-0.23	5.03
Med. Info/Map	2.65	4.5	3.19	1.94	-0.98	2.26
Med. Info/No Map	6.68	9.76	4.26	2.58	-1.10	4.44
Low Info/Map	2.03	5.44	0.04	-0.32	-0.07	1.42
Low Info/ No Map	11.84	14.02	3.68	-0.19	-5.55	4.76

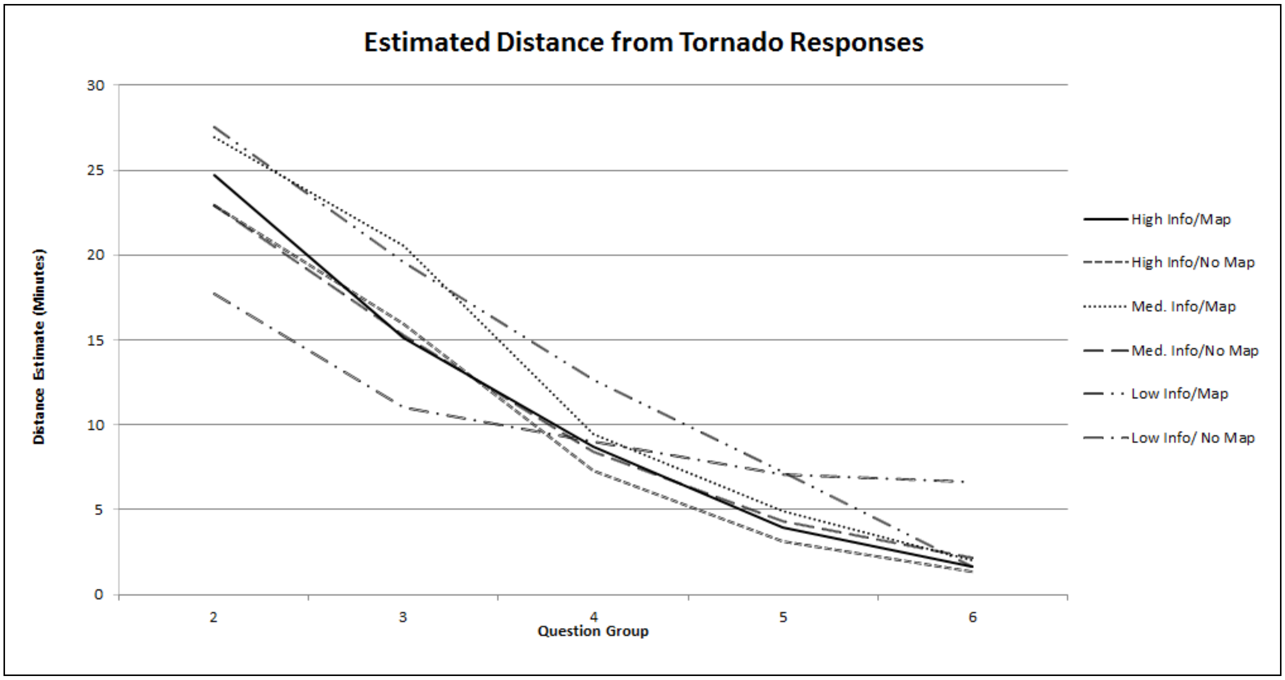


Figure 2. Estimated distance from tornado responses were collected at the final five question groups only. These responses represent the distance that participants believed the tornado was from their location in this hypothetical scenario. Responses were collected in minutes.

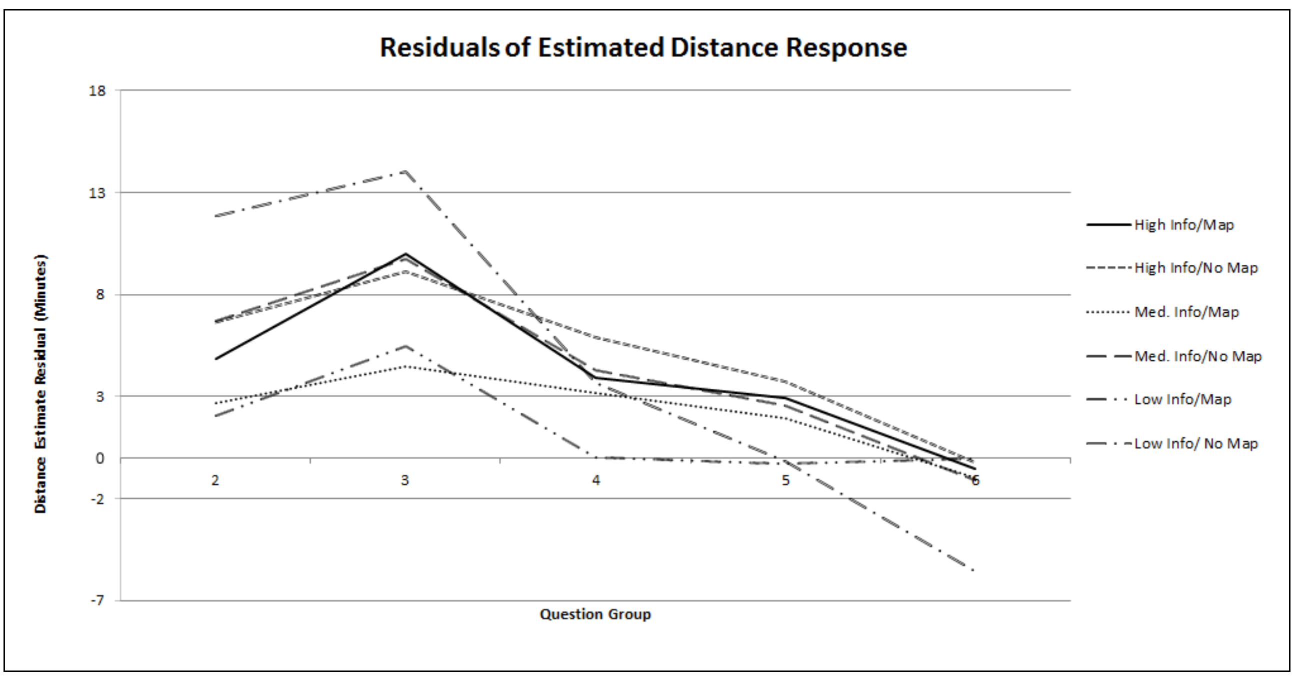


Figure 3. To compare response accuracy to the tornado's actual proximity, residuals were created from the estimated damage responses collected at the final five question groups. The closer a residual value is to zero, the more accurate the corresponding response was.

4.3.1. Three-way mixed design ANOVA. As such, a three-way (information X map X interval) mixed-design ANOVA was conducted to compare group ratings of perceived storm distance. Scenario groups were reduced to 30 participants (n = 30 per cell instead of 31) for this question because of data collection error related to this question allowing students to enter a numberical value.

Between-subjects.

A main effect of map on storm distance residuals was found to be significant, F (1, 180) = 6.519, $p < 0.05$, partial $n^2 = .023$. A comparison of group means showed that participants with an available map ($M = 2.597$) rated storm distance more accurately than individuals with no map available ($M = 4.575$), $SE = .975$, $p = 0.044$ level. There was no significant main effect of information on storm distance residuals; moreover, there was no significant information and map interaction on storm distance residuals.

Within-subjects. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $X^2(9) = 640.998$, $p = 0.001$; as such, the Greenhouse-Geisser corrected degrees of freedom was used to interpret the results.

An examination of the within-subject results revealed no significance in the interaction between information and interval on storm distance. However, both the interaction between map and interval on storm distance residuals (F (1.72, 298.53) = 6.52, $p < 0.01$, partial $n^2 = 0.036$) and between information, map availability, and interval on storm distance residual were found to be statistically significant (F (3.43, 298.53) = 2.96, $p < 0.05$, partial $n^2 = 0.033$)

4.3.2. Two-way ANOVAs. In order to address the significant three-way interaction, two-way ANOVAs were conducted to examine the influence of information and map availability on storm distance residuals at each interval.

Interval two. The main effect of information and the interaction between information and map on storm distance were non-significant. However, a main effect of map on storm distance was statistically significant, F (1, 180) = 5.05, $p < 0.05$, partial $n^2 = .027$. An examination of the means revealed that participants who viewed a map (M = 3.18) more accurately rated the storm's distance than participants who did not view a map (M = 8.39), SE = 2.315, p = .026.

Interval three. There was no main effect of information on storm distance in the third interval. There was a significant main effect of map on storm distance, F (1, 174) = 6.94, $p <$ 0.01, partial $n^2 = 0.038$. Additionally, a significant interaction between information and map on storm distance was found, F (2, 174) = 3.11, $p < 0.05$, $n^2 = 0.035$. The results from a Bonferroni test on the pairwise comparisons showed that participants in the low information/map condition (M = 5.44) rated the storm distance more accurately than individuals in the low information condition that did not receive a map (M = 14.02), SE = 2.57, p = 0.001. The pairwise comparisons also showed that participants in the medium information/map condition (M = 4.50) rated the storm distance more accurately than participants in the medium information/no map condition (M = 9.76), SE = 2.68, p = 0.054. Individuals in the high information group estimated the storm's distance similarly, regardless of whether they had a map or not.

Interval four. Although there was no significant interaction between information and map on storm distance in the fourth interval, there was a significant main effect of information (F (2, 180) = 3.16, $p < 0.05$, partial $n^2 = 0.034$) and a significant main effect of map on storm distance (F (1, 180) = 4.89, $p < 0.05$, partial $\mathrm{n}^2 = 0.026$). An examination of the Bonferroni tests of pairwise comparisons reveal that participants in the low information condition (M = 1.857) rated the storm's distance more accurately than participants in the high information condition (M = 4.664), SE = 1.137, p = 0.044. Additionally, participants who viewed a map (M = 2.39) rated the storm's distance more accurately than individuals in the no map condition (*M* = 4.44), *SE* = .929, *p* = 0.028.

Interval five. The main effect of map on storm distance and the interaction between information and map on storm distance were not significant in the fifth interval. There was a significant main effect of information on storm distance, F (2, 180) = 14.43, $p < 0.001$, partial n^2 = 0.138. A Bonferroni test of the pairwise comparisons revealed that participants in the low information condition (*M* = -.249) rated the storm more accurately than individuals in both the medium information condition (*M* = 2.257, *SE* = .682, *p* = 0.001) and the high information condition (*M* = 3.305, *SE* = .682, *p* = 0.001). There was no significant difference between ratings of storm distance for individuals in the medium information and the high information condition.

Interval six. The main effect of information on storm distance (F (2, 180) = 8.99, $p <$ 0.001, partial n^2 = 0.091) and the main effect of map on storm distance (F (1, 180) = 13.36, $p <$ 0.001, partial n^2 = 0.069) were both significant. Moreover, there was a significant interaction between information and map on storm distance, F (2, 180) = 14.94, $p < 0.001$, n^2 = 0.142. Pairwise comparisons, with a Bonferroni correction, showed that participants in the low information condition that viewed a map (*M* = -.071) rated the storm's distance more accurately than individuals in the low information/no map condition (*M* = -5.56), *SE* = 2.57, *p* = 0.001. Interestingly, participants in the who viewed a moderate or high amount of information rated the storm's distance similarly, regardless of whether they viewed a map or not.

V. Discussion

4.1. Shelter Seeking

The first research question from this study was whether shelter-seeking responses differ across each tornado scenario's combination of written and visual warning information. I hypothesized that shelter responses would vary according to the amount of information received. Specifically, individuals with more written and visual information would be more likely to seek shelter than individuals with less written and no visual information. Furthermore, individuals with more written and visual information would be less likely to leave shelter, after is has been taken, than individuals with less written and no visual information.

Regarding my hypothesis that shelter responses would vary according to the amount of information received, the results indicate a significant difference between scenarios. Using a Kruskal-Wallis test to determine if a variation of responses across the six scenarios, I found a statistically significant difference ($p = 0.011$).

To address both subsections of my hypothesis, pairwise comparisons were performed. To correct for familywise error, Dunn's procedure with a Bonferroni correction for multiple comparisons was performed (Table 3). Post hoc analysis revealed statistically significant different shelter-seeking behavior between the low information/no map ($M = 2.29$) and medium information/map groups ($M = 2.00$), $p = 0.025$. A significant difference was also found between low information/no map ($M = 2.29$) and high information/no map ($M = 2.03$) groups, $p = 0.028$. Finally, a significant difference was found between the low information/no map ($M = 2.29$) and the low information/map ($M = 2.03$) groups, $p = 0.033$.

Looking deeper into these significantly different comparisons I examined the distribution of answers within each of these groups to better understand how each condition's responses varied (Table 1). In the low information/no map condition only twenty individuals took shelter and stayed there, while ten responded that they left shelter after taking it at some point. In the medium information/map condition twenty-eight individuals took shelter and stayed there, while only three responded they left shelter after taking it at some point. In the high information/no map condition twenty-eight individuals took shelter and stayed there, two responded that they left shelter after taking it, and one never took shelter. In the low information/map condition twenty-four took shelter and stayed there, four reported leaving shelter after taking it, and three never took shelter. The low information conditions (map and no map) had the least amount of people taking shelter, and although these two conditions were significantly different from one another, the low information/map condition was not significanlty different than the medium information/map condition, where all thirty-one individuals took shelter.

These findings suggest fewer people sheltered, and remained in shelter, in the low information condition than the medium and high information. This supports my hypothesis that more people would shelter, and remain sheltered, when given more information. These results do not show a significant difference between high and medium information conditions, but a difference in the lowest combination of information (low information/map) and three other conditions (one scenario in each information level). These findings also suggest that significantly more people left shelter in the low information/no map condition than in other information levels. While there was not a significant difference between the low information/map condition and all other scenarios with Dunn's procedure with a Bonferroin correction, we did find a difference with one scenario at each information level.

Human behavior research has produced evidence to suggest intended behavior responses can be used to reasonably predict actual behavior (Fishbein, 2008; Sheeran, 2002; Whitehead, 2005; Wogalter *et al*., 2002; Ash *et al*., 2013). While Webb and Sheeran (2006) found large changes in intended action to only lead to small changes in actual behavior, intended actions are still believed to have some predictive value. Unfortuantly, it is unknown how accurate shelter-seeking intended actions in hypothetical tornado scenarios may translate to actual tornado warning situations (Ash *et* al., 2013; Meyer *et al*., 2013). While I did not find uniform response differences as information increased, I did find the lowest shelter responses to be in the lowest information condition. In the low information/map condition 32.25% of participants responded that they had left their shelter location. This finding shows that the lowest amount of information, low information/no map, resulted in the highest amount of participants leaving sheltered locations. While there was no significant difference between medium and high information groups, there was a significant difference between the most basic level of information and some information. Even within the low information/map condition 77.42% of individuals took, and remained in, shelter compared to the 65.52% in the low information/no map condition. This suggests that individuals receiving any warning information, other than a warning siren, may decide to shelter more often. This is important to note in the context of tornado warnings and warning systems because any information is better than minimal information.

4.2. Perceived Danger

The second research question was whether individuals percieve the tornado scenario as more dangerous as they are provided with higher levels of information. I hypothesized that participants' perception of danger would vary accroding to the amount of information received.

Specifically, individuals with more written information would perceive a greater amount of danger than individuals with less written information acrouss the six intervals. Furthermore, individuals with visual information would perceive a greater amount of danger than indivudials with no visual information across the six intervals.

Regarding my hypothesis about written information specifically, the findings suggest that individuals receiving low information perceived the event as less dangerous than those receiving medium and high levels of information. The overall mean responses of medium ($M = 3.05$) and high ($M=3.04$) information conditions are not significantly different from each other ($p = 1.0$). It is important to remember that these responses increase in relation to how the participant currently felt during the scenario: (1) in no danger at all, (2) slightly in danger, (3) a moderate amount of danger or (4) in extreme danger (Table 4).

A main effect of information on perceived danger was found to be significant at the fourth, fifth, and sixth question groups ($p < 0.001$). At the fourth question group interval, we again see there was a significant difference between the low information group ($M = 2.74$) and medium information group ($M = 3.37$), also the low information group ($M = 2.74$) and high information group ($M = 3.31$). Not only are the medium and high information groups not significantly different from each other at this point, interestingly the medium information response is slightly larger than the high information; this was observed more than once.

At the fifth question group, the file was split by map availability and a one-way ANOVA was conducted between information and perceived danger. I then found that response means in the no map pairwise comparison for low information ($M = 2.71$) to be significantly different from both medium information ($M = 3.71$; $p = .001$) and high information ($M = 3.61$; $p = 0.001$). Once again, I found that the high information group perceived the danger slightly less than the medium group, although both perceived the event significantly more dangerous than the low information group. In the map pairwise comparisons, the low information group (M = 3.13) was only marginally significantly different than medium information (M = 3.55; p = 0.074). Again, the high information group perceived the event slightly less dangerous (M = 3.52) than the medium group at the fifth question group. In both the map and no map pairwise comparisons I noticed the trend of the high information group answering slightly lower than the medium information group.

Another one-way ANOVA between information on perceived danger was conducted at question group six. No main effect of information on percieved danger was found in the map-provided group. In the no map group, I found a main effect of information on percieved danger and that low information responses (M = 2.77) were significantly differenent from medium information (M = 3.81; p = 0.001) and high information (M = 3.58; p = 0.001). There was no significant difference between high and medium responses (p = 0.706), although high information responses perceived the event as slighltly less dangerous than medium information responses.

While the overall hypothesis can be supported by these findings, both aspects of the hypothesis cannot be accepted. The results do not support the hypothesis that individuals with more written information would perceive a greater amount of danger than individuals with less written information acrouss the six intervals. The results do, however, suggest that indivuals with a medium to high amount of information perceive a tornado event as more dangerous than individuals with limited and basic information. The results cannot fully support the hypothesis that, individuals with visual information would perceive a greater amount of danger than indivudials with no visual information across the six intervals. The influence of visual information only appeared in the low information groups. Participants provided with high and medium amounts of warning information were not influenced as strongly by the presence of a map than those with the most basic forms of information.

Information types and levels most certainly influenced responses but not in a uniform manner. Visual information was most influential at the low level of information only. The most interesting result was not only that there was no significant difference high and medium information group responses in the later question groups, but that when the hypothetical tornado was approaching campus the high level of information participants responses shows that they perceived the event as less dangerous than the medium information group. Although this may seem concerning, it actually should be comforting for the National Weather Service, meterologists, and local emergency management officals. In this study, warning the public with as much information as possible did not illicit responses greater than a moderate amount of information. While the predictive abilities of intended actions are not proportional to intended behavior, actual tornado warnings with moderate amounts of information may be more ideal and realisticly possibly than providing high, or abundant, amounts of information. Addressing the initial hypothesis, moderate, or more, information influenced higher perceptions of danger than basic information, although the specific components of this hypothesis were only conditionally accurate

4.3. Storm Distance

The third research question in this study was whether participant perceptions of the tornado's location from their location vary across written information levels, and if responses become more accurate when visual information is available. I hypothesized that participants' estimated torndado distance responses would vary according to the amount of information received. Specifically, individuals with more written information would provide a more accurate estimate of tornado distance across intervals. Furthermore, Individuals with visual information would provide a more accurate estimate of tornado distance across intervals.

Regarding my hypotheses, the results suggest that information level and map availability are both influential on accuracy of storm distance estimation at different intervals. After the fourth interval (question group two), no main effect of information on storm distance was found ($p = 0.725$) but a main effect of map on storm distance ($p = 0.05$) was. Using pairwise comparisons I found that individuals in the map condition rated the storm distance significantly different ($M = 3.18$) than those in the no map condition ($M = 8.39$; $p = 0.026$). At this interval there was no interaction between information and map on storm distance ($p = 0.346$). It is important to understand that these mean values are residuals created form the response difference from the actual tornado's distance in minutes to campus; the closer a mean value is to zero, the more accurate a group responsed. At this interval, individuals in the map condition answered more accurately than those without a map.

In the fifth interval (question group three), no main effect of information level on storm distance ($p = 0.299$) was observed, but a main effect of map availability on storm distance was found ($p < 0.01$). There was a significant interaction between information level and map availability on storm distance response accuracy ($p < 0.05$). The file was split by information level and a one-way ANOVA was conducted on map availability and storm distance. Among low information responses, there was a significant effect of map availability on storm distance ($p < 0.001$). Using pairwise comparisons, I found individuals in the map condition ($M = 5.44$) rated the storm distance significantly more accurate than individuals in the no map condition ($M = 14.02$; $p = 0.001$). Among medium information responses, there was a marginally significant effect of map on storm distance ($p = 0.054$). Using pairwise comparisons, I found individuals in the map condition rated the storm distance ($M = 4.50$) rated the storm distance marginally significantly more accurate than indivudals in the no map condition ($M = 9.76$; $p = 0.054$). Among high information responses, I found no significant effect of map on storm distance ($p = 0.77$). Individuals in the map condition ($M = 9.89$) responded just as accurately as those in the no map condition ($M = 9.12$). At this interval we found map availability to signifcantly effect accuracy in the low information group, marginally effect accuracy in the medium information group, and have no effect in the high information group.

In the sixth interval (question group four), there was a main effect of information on storm distance ($p = 0.05$). Using pairwise comparisons, I found that individuals in the low information condition ($M = 1.86$) reported storm distance significantly more accurately than individuals in the high information condition ($M = 4.46$; $p = 0.044$). There was no significant difference in the accuracy of responses from individuals in the medium information ($M = 3.73$) and the low information conditions ($M = 1.86$; $p = 0.305$) or the high information condition ($M = 4.66$; $p = 1.00$). Also in this interval, there was a main effect of map on storm distance ($p < 0.05$). Using pairwise comparisons, I found that individuals in the map condition ($M = 2.39$) reported the storm distance marginally more accurately than individuals in the no map condition ($M = 4.44$; $p = 0.028$). There was no interaction between information and map on storm distance at this interval ($p = 0.474$). At this interval I found both information level and map availability to influence storm distance response accuracy. Responses were more accurate in the map condition than in the no map condition, which is what is expected, but interestingly, low information responses were more accurate than high information responses. At this interval the findings were opposite of our information level hypothesis, but supported our map availabilty hypothesis.

In the seventh interval (question group five), there was a main effect of information level on storm distance accuracy ($p < .001$). Using pairwise comparisons, I found individuals in the low information condition ($M = -.249$) reported storm distance significantly more accurately than individuals in the medium information ($M = 2.257$; $p = .682$) and the high information condition ($M = 3.305$; $p = .001$). There was no significant difference in reported storm distance accuracy between the medium and high information conditions ($p = 1.00$). There was no significant main effect of map availabilty on storm distance ($p = 0.345$) or a significant relationship between information level and map availability on storm distance ($p = 0.874$) at this interval. For the second consecutive interval I found individuals in the low information condition responded more accurately about the storms distance than individuals in the medium and high information conditions. The results at this interval also are contradictory to my information level hypothesis.

In the eight and final interval (question group six), there was a main effect of information level on storm distance accuracy ($p < 0.001$) and a main effect of map availability on storm distance accuracy ($p < 0.001$). There was also a significant interaction between information level and map availabililty on storm distance ($p < 0.001$). The dataset was split by information and a one-way ANOVA was conducted on map availability and storm distance accuracy. Among low information condition responses a significant effect of map on storm distance was found ($p < 0.001$). Using pairwise comparisons, I found that indivudials in the map condition ($M = -.071$) reported storm distance significantly more accurately than individuals in the no map condition ($M = -5.56$; $p = 0.001$). Among medium information condition responses there was no significant effect of map availability on storm distance response accuracy. Thus, indiviudals in the map condition ($M = -1.104$) did not report storm distance significanlty more accurately than individuals in the no map condition ($M = -.975$; $p = 0.818$). Among high information condition responses there was no significant effect of map availability on storm distance response accuracy. Thus, indiviudals in the map condition (M = -.555) did not report storm distance significanlty more accurately than individuals in the no map condition (M = -.233; p = 0.356). For this interval I found information level to be influential, but in the low information condition so was map availability. Within the low information responses, those within the map condition were significantly more accurate than those in the no map condition. Interestingly, although it is not a significant difference I observed that the low information map condition was more accurate than either of the high information (map and no map) conditions. My map availability hypothesis is supported by the findings in the low information condition, although these findings only raise more questions.

I was surprised to discover the trend of low information responses being more accurate than those of medium and high information responses on more than one instance (question groups 4, 5, and 6). I am unable to fully explain or understand this finding, although my best attempt was developed when examining the overall estimated distance responses before the residuals were created (Table 5 and Figure 6). Examining the low information no map condition I developed the theory that these individuals were aware that a tornado was in their general area, but were unsure about how close it acutally was to them. In my best attempt to explain these results I think this may have been the case because in this scenario the mean response was only 6.65 minutes at the final interval. Whereas in the low information map condition, individuals's mean response was 1.61 minutes at the same point. I believe it is possible that participants in the low information no map condition responded conservatively throughout the entire scenario because they were not provided enough information to realize exactly what was happening around them. As for the low information map condition, I am still unable to fully understand how they repeatedly responded the most accurately of all scenario conditions. I best understand this result as map availability becoming most influential when written information levels are lower. Map availability was not consistently influential throughout all other scenario conditions, but at the most serious moments in the scenario; participants were able to report storm distance accurately with a map, even if they did not have access to much written information.

As for my hypotheses, estimated storm responses most certainly varied according to the amount of information received, but the accuracy related to these information conditions was not as predicted. The two specific components of my hypothesis work against one other. My hypothesis that individuals with visual information will provide a more accurate estimate of tornado distance was supported in the low information condition. The finding in the low information condition does not allow for accepting the other subsection of my hypothesis that individuals with more written information will provide a more accurate estimate. Thus, I must reject the hypothesis that higher levels of written information will produce more accurate storm distance estimates.

VI. Conclusion

The goal of this study was to contribute to the overall body of tornado victim behavior and perception literature by attempting to understand how different types and amounts of obtainable information may enable an individual to fully process the severity of what is taking place and act accordingly. Specifically, this paper examined the effects of written and visual information on individuals' selection of protective action, perception of danger, and estimation of storm distance from their location. Although studies have examined how visual graphics are perceived (Ash *et al*., 2013) and the effectiveness and also how students respons following a tornado event (Sherman-Morris, 2010), little to no research has been done on the effect warning information level and type on these types of decisions and responses in a hypothetical tornado scenario. It was discussed that the decision-making process during stressful events, such as tornadoes, was complex. My findings seem to further support this idea. I found that written information was influential on shelter-seeking decisions and danger perception in some scenarios. I also found mixed influences of written information and map availability regarding storm distance estimates. When a low level of written information was provided, map availability became influential. Although the finding was not significant, in several instances I noticed high information responses rated perception of danger lower than medium information responses. The absence of a significant difference shows that moderate amounts of warning information were just as efficient in relaying the event's seriousness as high, or maximum, information.

The sample population and data collection procedure limit the findings of this study. The participant pool was heavy weighted by geography students; future related studies might consider diversifying their participant recruitment. Lasting effects of the 2011 tornado season could bias the results of any similar tornado-related study in the southeast United States for several more years. Data collection methods in future research may consider isolating participants during the study to eliminate potential interactions between students observing different scenarios. Nevertheless, this research only begins to understand the relationship of warning information on decision-making and tornado perception. Since there was little difference between medium and high information responses, future studies should consider creating a greater difference between these two levels of information. It would be beneficial to discover the level of information at which a decline in responses and perception occur. The information gathered from this study and in future, refined studies could be used to assist agencies and officials issuing warnings in concise, efficient, action-provoking warnings. The National Weather Service, meteorologists, and emergency management officals will be empowered with ability to custom tailor tornado warnings as we better understand how humans process information, perceive risk, and make decisions. More of this type of research is needed because our understanding of risk perception and the cognitive decision-making process is the slowest progressing aspect of tornado warning systems.

References

AMS. (1975). Policy statement of the American Meteorological Society on tornado detection, tracking, and warning. *Bull. Amer. Metero. Soc., 56*, 464-466.

Ash, K. D., Schumann III, R., & Bowser, G. (2013). Tornado Warning Trade-Offs: Evaluating Choics for Visually Communicating Risk. *Weather, Climate, and Society, 6*, 104-118.

Ashley, S. T., & Ashley, W. S. (2008). Flood Fatalities in the United States. *Journal of Applied Meteorology and Cimatology, 47.3*, 805-818.

Ashley, W. S. (2007). Spatial and Temporal Analysis of Tornado Fatalities in the United States: 1880-2005. *Weather and Forecasting, 22*.

Ashley, W. S., & Black, A. (2008). Fatalities associated with nonconvective high-wind events in the United States. *Journal of Applied Meteorology and Climatology, 47.2*, 717-725.

Ashley, W. S., & Mote, T. L. (2004). Derecho hazards in the United States. *Bull. American Meterological Society, 86*, 1577-1592.

Atwood, L., & Major, A. (1998). Exploring the "cry wolf" hypothesis. *Int. J. Mass Emerg. Disasters, 16*, 279-302.

Balluz, L., Schieve, L., Holmes, T., Kiezak, S., & Malilay, J. (2000). Predictors for People's Response to a Tornado Warning: Arkansas, 1 March 1997. *Disasters, 24*(1), 71-77.

Barnes, L., Gruntfest, E., Hayden, M., Schultz, D., & Benight, C. (2007). Flase alarms and close calls: A conceptual model of warning accuracy. *Wea. Forecasting, 22*, 1140-1147.

Barnett, J., & Breakwell, G. (2001). Risk Perception and Experience: Hazarrd Personality Profiles and Individual Differences. *Risk Analysis*, 171-177.

Biddle, M. (1994). *Tornado Hazards, Coping Styles, and Modernizing Warning Systems.* Thesis, Department of Geography, The University of Oklahoma - Norman.

Biddle, M. (2007). *Warning Reception, Response, and Risk Behavior in the 3 May 1999 Oklahoma City Long-track Violent Tornado.* ProQuest.

Bluestein, & Bluestein, H. B. (1999). *Tornado alley: monster storms of the Great Plains.* New York: Oxford University Press.

Boruff, B. J., Easoz, J. A., Jones, S. D., Landry, H. R., Mitchem, J. D., & Cutter, S. L. (2003). Tornado hazars in the United States. *Climate Research, 24*, 103-117.

Bostrom, A., Anselin, L., & Farris, J. (2008). Visualizing seismic risk and uncertainty. *Ann. N.Y. Acad. Sci., 1128*, 29-40.

Breznitz, S. (1984). *Cry Wolf: The Psychology of False Alarms.* Lawrence Earlbam Associates.

Brooks, H., & Doswell, C. (2001). Normalized damage from major tornadoes in the United States. *Weather Forecasting, 16*, 168-176.

Brotzge, J., & Donner, W. (2013, November). The Tornado Warning Process. *Bulletin of the American Meteorological Society*, 1715-1733.

Burnham, M. (1992). Cry Wolf - Repeated Warnings Without Events. *Hydrologic Engineer Center, Univ. of California at Davis*.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of personality and social psychology, 42*(1), 116.

Carter, A., Millson, M., & Allen, D. (1989). Epidemiologic Study of Deaths and Injuries Due to Tornadoes. *American Journal of Epidemiology, 130*, 213-219.

Cleveland, W. S., & McGill, R. (1984). Graphical perception: Theory, experimentation, and application to the development of graphical methods. *J. Amer. Stat. Assoc., 79*, 531-554.

Coleman, T., Knupp, K., Spann, J., Elliot, J., & Peters, B. (2011, October). The History (and Future) of Tornado Warning Dissemination in the United States. *American Meterological Society*, 567-582.

Comstock, R. D., & Mallonee, S. (2005). Comparing results to two severe tornadoes in one Oklahoma community. *Disasters, 29*, 277-287.

Comstock, R., & Mallonee, S. (2005). Comparing Reactions to two severe tornadoes in one Oklahoma community. *Disasters, 29*(3), 277-287.

Curran, E. B., Holle, R. L., & Lopez, R. E. (2000). Lighning casualties and damages in the United States from 1959 to 1994. *Climate, 13*, 3448-3464.

Doswell, C. (1999). Are Warning Lead Times the Most Important Isue in Tornado Events? *WeatherZine, 17*.

Doswell, C., Weiss, S., & Johns, R. (1993). Tornado forecasting: A review. *The Tornado: Its Structure, Dynamics, Oredictions, and Hazards, Geophys. Monogr., 79*, 557-571.

Drabek, T., & Stevenson, S. (1971). When Disaster Strikes. *Journal of Applied Social Psychology, 2*, 187-203.

Drost, R. (2013, January). Memory and Decision Making: Determing Action when the Siren Sound. *Weather, Climate, and Society*, 43-54.

Duclos, P. J., & Ing, R. T. (1989). Injuries and risk factors for injuries from the 29 may 1982 tornado, Marion, Illinois. *Int J Epedmiol, 18*, 213-219.

Evan, J. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology, 59*, 255-278.

Ewald, R., & Guyer, G. (2002). The Ideal Lead Time for Tornado Warnings- A Look From the Customer's Perspective. *Amer. Meteor. Soc.*

Fishbein, M. (2008). A reasoned action approach to health promotion. *Decision Making*, 834-844.

Glass, R. I., Carven, R. B., & Bergman, D. J. (1980). Injuries from the Wichita Falls Tornado: Implications for Prevention. *Science, 207*, 734-8.

Golden, J. H., & Adams, C. R. (2000, May). The Tornado Problem: Forecast, Warning, and Response. *Natural Hazards Review*, 107-118.

Grazulis, T. P. (1993). Significant tornadoes 1691-1991. *Environmental Films*. St. Johnsbury, VT.

Grazulis, T. P. (2001). *The tornado: nature's ultimate windstorm.* Norman: University of Oklahoma Press.

Gruntfest, E. (1987). Warning dissemination and response with short lead times. In *Flood Hazard Management: British and International Perspectives* (Vol. 26, pp. 191-202). Norwich, England: Geo Books.

Guha-Sapir, D., Vos, F., Below, R., & Ponserre, S. (2011). *Annual Disaster Statistical Review 2011: The numbers and trends.* Centre for Research on the Epidemiology of Disasters (CRED). Belguim: Ciaco Imprimerie, Louvain-la-Neuve.

Haimes, Y. Y. (2009). On the complex definition of risk: A systems-based approach. *Risk Analysis, 29*, 1647-1654.

Hammer, B., & Schmidlin, T. (2002). Response to warnings during the 3 May 1999 Oklahoma City tornado: reasons and relative injury rates. *Weather Forecast, 17*, 577-581.

Harris, L. F. (1992). Hospitalized Tornado Victims. *Ala Med, 61*, 12-16.

Hertwig, R., & Pleskac, T. (2010). Decisions from experience: Why small samples. *Cognition, 115*, 225-237.

Hoekstra, S., Butterworth, R., Klockow, K., Brotzge, J., & Erickson, S. (2010). A social perspective of warn on foreceast: ideal tornado warning lead time and the general public's perception of weather risks. *Fifth Symposium on Policy and Socio-economic Research*.

International Personality Item Pool: A Scientific Collaboratory for the Development of

Advanced Measures of Personality Traits and Other Individual Differences (http://ipip.ori.org/). Internet Web Site.

Kahneman, D. (2003). A perspective on judgement and choice: Mapping bounded rationality. *American Psuchologist, 58*, 697-720.

Lane, W., & Manner, C. (2011). The impact of personality traits on smartphone ownership and use. *International Journal of Business and Social Science, 2*(17), 22-28.

Lauriola, M., & Levin, I. (2001). Personality traits and risky decision-making in a controlled experimental task: an exploratory study. *Personality and Individual Differences*, 215-226.

Legates, D., & Biddle, M. (1999). Warning response and risk behavior in the Oak Grove-Birmingham, Alabama, Tornado of 08 April 2008. Quick Response Report #16. *Natural Hazards Research*.

Lindell , M. K., & Perry, R. W. (2012). The protective actoin decision model: Theoretical modifications and additional evidence. *Risk Analysis, 32*, 616-632.

Lundgren, R. E., & McMakin, A. H. (2009). *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks.* IEEE Press.

Maddox, R., & Crisp, C. (14). The Tinker AFB tornadoes of March 1948. *Wea. Forecasting*.

Maddox, R., & Crisp, C. (1999). The Tinker AFB tornadoes of March 1948. *Weather Forecasting, 1999,* 492-499.

Maloney, E. K., Lapinski, M. K., & Witte, K. (2011). Fear appeals and persuasion: A review and update of the extended parallel process model. *Soc. Pers. Psychol. Compass, 5*, 206-219.

Merrel, D., Simmons, K. M., & Sutter, D. (2005). The Determinants of Tornado Casualities and the Benefits of Tornado Shelters. *Land Economics, 81*(1), 87-99.

Meyer, R., Broad, K., Orlove, B., & Petrovic, N. (2013). Dynamic Simulation as an approach to understanding hurricane risk response: Insights from the Stormview Lab. *Risk Analysis, 33*, 1532-1552.

Mileti, D. (1999). *Disasters by design: A reassessment of natural hazards in the United States.* Joseph Henry Press.

Mileti, D., & Fitzpatrick, C. (1991). Communication of public risk: Its theory and its application. *Sociological Practice Review, 2*(1), 20-28.

Mileti, D., & Sorensen, J. (1990). *Communication of emergency public warnings* (Vols. ORNL-6609). Oak Ridge, TN: Oak Ridge National Laboratory.

Miller, R., & Crisp, C. (1999a). Events leading to the establishment of the United States Air Force Severe Weather Warning Center. *Weather Forecasting, 14*, 500-506.

Miller, R., & Crisp, C. (1999b). The first operational tornado forecast twenty million to one. *Weather Forecasting, 14*, 479-483.

Mitchem, J. (2003). An analysis of the September 20, 2002 Indianapolis tornado: public response to a tornado warning and damage assessment difficulties. Quick Response #161.

Mukherjee, K. (2010). A dual system model of preferences under risk. *Psycholigcal Review, 117*, 243-255.

NOAA. (2011). Tornado warnings (nation). *NOAA NWS*, 10 pp, Available online at https://verification.nws.noaa.gov/services/gpra/NWS_GPRA_Metrics.pdf.

Noji, E. K. (1997). *The Public Health Consequences of Disaster.* New York: Oxford University Press.

Paul, B., Brock, V., Csiki, S., & Emerson, L. (2003). Public Response to tornado warnings: a comparative sudy of the May 4 2003 tornadoes in Kansas, Missouri, and Tennessee. Quick Response #165.

Paul, B. K., & Stimers, M. (2012). Exploring probable reasons for record fatalities: the case of 2011 Joplin, Missouri, Tornado. *Natural hazards, 64*(2), 1511-1526.

Perry, R., Lindell, M., & Greene, M. (1982). Crisis Communications: Ethnic Differentials in Interpreting and Acting on Disaster Warnings. *Social Behavior and Personality, 10*, 97-104.

Pinker, S. (1990). A theory of graph comprehension. In R. Freedle, *Artificial Intelligence and the Future of Testing* (pp. 73-126). Lawrence Erlbaum Associates.

Pleskac, T. J., & Wershbale, A. (2014). Making Assessments While Taking Repeated Risks: A pattern of Multiple Response Pathways. *Journal o Experimental Psychology, 143*(1), 142-162.

Przyblinski, R. W. (1995). The Bow Echo: Observations, Numerical Simulations, and Severe Weather Detection Methods. *Wea. Forecasting , 10*, 203-218.

Riad, J. (1999). Predicitng Evacuation in Two Major Disasters: Risk Perception, Social Influence, and Access to Resouces. *Journal of Applied Social Psychology, 29*(5), 918-934.

Sakaki, T., Okazaki, M., & Matsuo, Y. (2010). Earthquake shakes Twitter users: real-time event detection by social sensors. *Proceedings of the 19th international conference on World wide web.* ACM.

Schmidlin, T., & King, P. (1995). Risk Factors for Death in the 27 March 1994 Georgia and Alabama Tornadoes. *Disasters, 19*, 170-177.

Schmidlin, T., Hammer, B., Ono, Y., & King, P. (2009). Tornado shelter-seeking behavior and tornado shelter options among mobile home residents in the United States. *Natural Hazard, 48*, 191-201.

Senkbeil, J. C., Rockman, M. S., & Mason, J. B. (2012). Shelter Seeking Plans of Tuscaloosa Residents for a Future Tornado Event. *Weather, Climate & Society, 4*(3).

Sherman-Morris, K. (2005). Tornadoes, television and trust - a closer look at the influence of the local weathercaster during severe weather. *Env Hazards, 6*, 201-210.

Sherman-Morris, K. (2006). Tornadoes, television, and trust: A closer look at the influence of the local weather foreast during severe weather. *Environmental Hazards*, *6*, 201-210.

Sherman-Morris, K. (2010). Tornado warning dissemination and response at a university campus. *Natural Hazards, 52*, 623-638.

Simmons, K. M., & Sutter, D. (2005). WSR-88D radar, tornado warnings, and tornado casualties. *Wea. Forecasting*, *20*, 301-310.

Simmons, K. M., & Sutter, D. (2011). *Economic and Societal Impacts of Tornadoes.* Boston, MA: American Meteorological Society.

Simmons, K., & Sutter, D. (2008). Tornado warnings, lead times, and tornado casualties: An empirical investigation. *Weather and Forecasting, 23*(2), 246-258.

Simmons, K., & Sutter, D. (2009). False Alarms, Tornado Warnings, and Tornado Casualties. *Weather, Climate, and Society, 1*, 38-53.

Sims, J. H., & Baumann, D. D. (1972). The Tornado Threat: coping styles of the North and South. *Science, 176*, 1386-1392.

Sjöberg , L. (1995). *Explaining risk perception: An empirical evalution of cultural theory.* (Risk Research Reports No. 22). Stockhholm: RHIZIKON: Stockholm School of Economics.

Sorensen, J. (1991). When shall we leave? Factors affecting the timing of evacuation departures. *International Journal of Mass Emergencies and Disasters, 9*(2), 153-165.

Sorensen, J. (2000). Hazard warning systems: review of 20 years of progress. *Natural Hazards Review, 1*(2), 119-125.

Sorensen, J., & Mileti, D. (1989). Warning and evacuation: answering some basic questions. *Industrial Crisis Quarterly, 2*((3-4)), 195-210.

Stensrud, D. J. (2013). Progress and challenges with Warn-on-Forecast. *Atmos. Res., 123*, 2-16.

Sutter, D., & Erickson, S. (2010). The time cost of tornado warnings and the savings with storm-based warnings. *Weather, Climate, and Society, 2*, 103-112.

Tobin, G., & Montz, B. (1997). *Natural Hazards: Explanation and Integration.* New York, NY: Guilford.

Turner, G., & Wynne, B. (1992). Risk Communication. In J. Durant, *Biotechnology in public: A review of recent research* (pp. 109-141). London: Science Museum for the Eurpoean Federation on Biotechnology.

Vogt, B., & Sorensen, J. (1992). *Preparing EBS messages* (Vols. TM-12163). Oak Ridge, TN: Oak Ridge National Library.

Waters, K. R. (2005). Polygon weather warnings - A new approach for the National Weather Service. *21st Int. Conf. on Interactive Information and Processing Systems (IIPS) for Meterology, Oceanography, and Hydrology*. San Diego, CA: American Meteoroligcal Society.

White, G., & Haas, J. (1975). Assessment of research on natural hazards.

Whitney, D. (2006, April). Stations Looking for any edge in a storm. *Television Week, 25*(17), p. 65.

Wong, T., & Yan, Y. (2002). Perceptions of Severe Weather Warnings in Hong Kong. *Meterological Appl., 9*(3), 377-382.

World Meterological Organization. (2004, October). *Workshop On Severe and Extreme Events Forecasting*. Retrieved April 23, 2013

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking.* New York: Cambridge University Press.

Zuckerman, M., & Kuhlman, D. M. (2000). Personality and Risk-Taking Common Biosocial Factors. *Journal of Personality, 68*(6), 999-1029.

Appendices

Appendix A1

Consent Form

You are invited to participate in a research project entitled “Examining Severe Weather Behavior.” The person responsible for this study is Dr. David Brommer of the Department of Geography, who can be reached at (256) 765-6307. You can also contact Dr. Gabriela Carrasco, Dr. Jonathan Fleming, or Martin Leavitt who will be responsible for carrying out the procedures of the study at ReserachUNA@gmail.com.

The purpose of this project is to examine the impact of warning information during a severe weather event. If you decide to participate in this study you will be asked to view a scenario of severe weather approaching your location. During the scenario, you will be asked to evaluate the situation at multiple intervals. **The experimenter does not foresee any risks to you that might result from participation in this research; however you may withdraw from the experiment at any time without penalty.** The total duration of the study will be between 30 and 45 minutes. Depending upon your instructor’s’ policy, students may be awarded credit for participating in this study.

Only Dr. David Brommer, Dr. Gabriela Carrasco, Dr. Jonathan Fleming, and Martin Leavitt will have access to your data. ***However, all data associated with this study will remain strictly confidential and anonymous.*** Neither your name nor any identifiable information will be linked to your answers at any time.

If you have any questions during the study, please feel free to approach the research assistant for help. If you have any questions before or after the study has completed, please feel free to contact Dr. David Brommer, who will answer any questions you have about the study. You can contact Dr. David Brommer at dmbrommer@una.edu or (256) 765-6307. You may also contact the Human Subject’s committee by calling (256) 765-4523 and speaking to Ms. Lynda Coates, the administrative assistant for UNA’s Office of Sponsored Projects.
By signing below you acknowledge that you have read, understood, agreed to the information in this form.

□ I agree I am 19 years of age or older.

<u>Please select one of the following:</u>

□ Yes, I accept these terms and wish to participate in this study.
□ No, I do not wish to participate at this time.

Print Full Name: ____

Sign Full Name: ____

Date: ____________________________

Appendix A2

Directions and Procedures

You will be presented with a severe weather scenario.
This scenario is divided into 8 intervals.

You will be asked to answer questions regarding the situation for intervals 1-3 combined.
Intervals 4,5,6,7, and 8 will have separate groups of questions.

All survey questions will be recorded on SurveyMonkey.com

After you complete the slideshow and interval questions, additional demographic questions will be asked on Survey Monkey.

Please read each page carefully before continuing to the next slide.

You have been provided a scenario packet, which contains all scenario information and survey instructions.
<u>You will be prompted when to use the survey website and when to return to the scenario packet.</u>

Instructions are on **WHITE SLIDES** and **Scenario Information** on **COLORED SLIDES**
Answer all questions to the best of your ability. Keep in mind that **your responses in the study will remain anonymous and confidential.**

If you have any questions please contact a research assistant for help.

Appendix B1

Factoral Design – Six Hypothetical Scenarios

Map Availability	Written Information Level			
		High Information	**Moderate Information**	**Low Information**
	Map	High Information with Map (A)	Moderate Information with Map (C)	Low Information with Map (E)
	No Map	High Information without Map (B)	Moderate Information without Map (D)	Low Information without Map (F)

Appendix B3

Written Warning Information Components for Intervals One through Three

Pre-Tornado Intervals
All Information Levels

1) **8:00a.m.**
   - For the 3rd continuous day, The National Weather Service (NWS) Storm Prediction Center has stated there is a "moderate risk" of severe weather across AL, MS, TN.
   - For the 2nd continuous day, The NWS Storm Prediction Center has stated there is a "high risk" of severe weather.
   - The NWS Storm Prediction Center has issued a Severe Thunderstorm Watch for portions of AL, TN, and MS.
     - The NWS has stated "…This Is A Particularly Dangerous Situation…"

2) **12:00p.m.**
   - The Huntsville NWS has issued a tornado watch for the state of Alabama.
     - The NWS has again stated "…This Is A Particularly Dangerous Situation…"
   - The Huntsville NWS has indicated that the probability for significant weather is greater than 95%.

3) **3:30p.m.**
   - The University of North Alabama has issued a tornado watch for campus.
     - This watch has been issued via Lion Alert
     - Lion Alert watch will last until 4:45p.m.
   - According to the Lion Alert text, classes have ***not*** been suspended
     - Your next class is scheduled for 5:00p.

Appendix B3

Written Warning Information Components for Intervals Four Through Eight

<u>Tornado Intervals</u>

* = Low Information
** = Moderate Information (Includes Low Information)
*** = High Information (Includes Low and Moderate Information)

4) 4:43p.m.

* A **tornado siren** has started sounding, you can hear it from where you are in Wesleyan Hall.

** **TV/Radio:** "A Tornado warning has been issued for Lauderdale county including Sheffield, Tuscumbia, Muscle Shoals, and Florence, AL. A tornado warning has been issued for a severe storm we're tracking south of Cherokee. This storm has the potential to produce high winds, damaging hail, and tornado activity."

** **UNA Lion Alert:** "Tornado Warning has been issued for Lauderdale county, including Florence, AL. University officials are monitoring the situation. Stay inside and monitor the weather."

*** **TV/Radio:** "We are getting reports that there are serious gusts of wind associated with this storm. If you are in or near Cherokee, AL we strongly suggest you stay inside and keep watching the news."

5) 4:47p.m.

* The **tornado siren** continues to sound

** **TV/Radio:** "A tornado has touched down south of Cherokee, AL. Again, a tornado has been spotted 10 miles south of Cherokee, moving northeast at about 50 miles per hour. If you are in or near the path of this tornado we suggest you take cover immediately."

** **UNA Lion Alert:** "A tornado has been spotted southwest of Florence in Cherokee, AL. UNA classes have been cancelled for the rest of the day. Stay inside and prepare to take cover. If you are on campus, do not leave campus. Prepare to take cover in one of UNA's designated shelter areas. A Tornado Warning remains in effect for Florence."

*** **TV/Radio:** "Reports are coming in that a tornado has touched down south of Cherokee, AL. There are reports of downed power lines and damage to buildings in the Cherokee area.

This storm is producing damaging winds, large nickel-sized hail, and heavy rain. This is a strong storm.
If you are in or around the path of this tornado get in doors immediately. If you are indoors, do not attempt to go outside. Take shelter in a basement, a hallway, or the bathtub of a bathroom. Stay away from windows and doors."

6) 5:08p.m.

***** The **tornado siren** has sounded again

** **TV/Radio:** "The tornado that touched down near Cherokee, AL is approaching the Tennessee River near Tuscumbia and is approaching the quad cities quickly. Florence, AL is in the direct path of this tornado. The tornado is expected to be within city limits in a few minutes. People in Tuscumbia, Sheffield, Muscle Shoals and especially Florence should take shelter now."

** **UNA Lion Alert:** "A tornado has been spotted 15 miles from campus moving towards campus. Take shelter now. If you are on campus, do not attempt to leave campus. Take cover immediately in one of UNA's designated shelters. All UNA classes on both campuses have been cancelled for the remainder of the day."

*** **TV/Radio:** "A tornado continues to move from Cherokee towards the quad cities. Reports of downed power lines, uprooted trees, and damage to vehicles and buildings are coming in from those people in the path of the tornado.
If you are in or around the path of this tornado get in doors immediately. If you are indoors, do not attempt to go outside. Take shelter in a basement, a hallway, or the bathtub of a bathroom. Stay away from windows and doors."

7) 5:10p.m.

* The **tornado siren** continues to sound

** **TV/Radio:** "Reports indicate that the tornado is on the outskirts of Florence city limits. It has crossed the Tennessee River near Lauderdale County Rd 204 and is moving directly towards downtown Florence, AL. If you are in Florence, AL or the surrounding area take cover immediately. We expect the tornado to make impact in Florence within minutes."

** **UNA Lion Alert:** "A tornado is approaching Florence, AL. Downtown Florence and UNA's main campus is in the tornado's direct path. If you are on UNA's main campus seek shelter on campus immediately. Do not leave campus. Do not attempt to come on campus."

*** **TV/Radio:** "Downtown Florence, AL, Eliza Coffee Memorial Hospital, and UNA are in the direct path of the tornado. Reports of wind gusts up to 60(?) miles per hour have been

associated with this tornado. Serious damage to buildings and vehicles has been reported. There are reports of downed power lines and uprooted trees throughout this area.
If you are in or around the path of this tornado get in doors immediately. If you are indoors, do not attempt to go outside. Take shelter in a basement, a hallway, or the bathtub of a bathroom. Stay away from windows and doors."

8) 5:13p.m.

* The **tornado siren** continues to sound

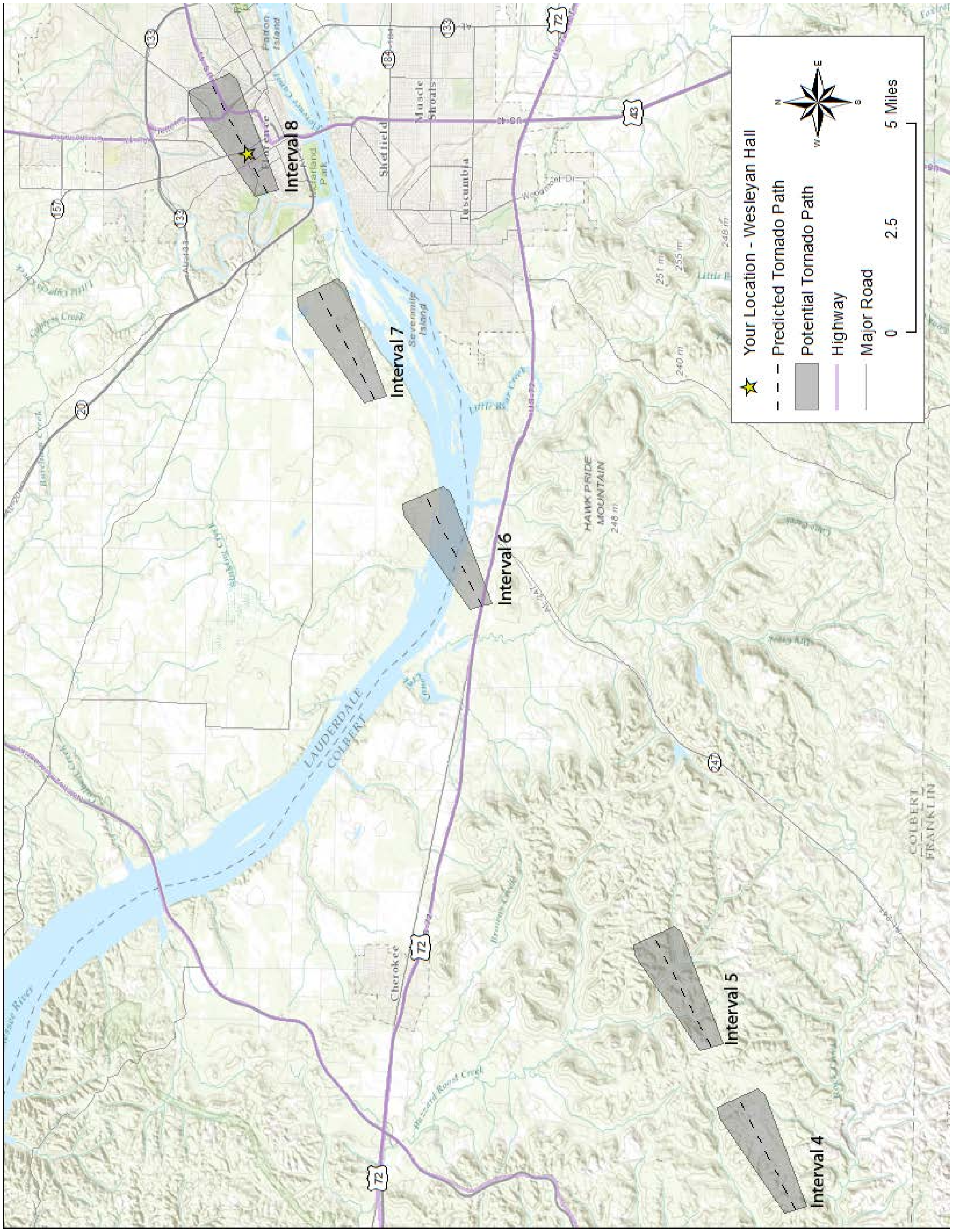
** **TV/Radio:** "Reports are that the tornado is now in downtown Florence. It has just passed Eliza Coffee Memorial Hospital and continues to move in a northwestern direction. It is expected to hit UNA's main campus. Anyone in or near downtown Florence or UNA campus, should be take shelter now."

** **UNA Lion Alert:** "Take shelter immediately. UNA's main campus is directly in the path of a tornado. Stay away from windows and doors and move to the bottom floor of a building immediately. Do not go outside. You will be alerted when it is safe to stop sheltering via UNA Lion Alert"

*** **TV/Radio:** "Reports of damage around McFarland Park indicate that this tornado has the potential to do serious damage. Trees have been uprooted, vehicles and boats have been damaged by large debris, and building structures have partially or fully collapsed. Do not go outside. The tornado, and the storm associated with it, is still moving through Florence. It is not safe to be outside. If you have not done so, please take shelter immediately. Take shelter in a basement, a hallway, or the bathtub of a bathroom. Stay away from windows and doors"

Appendix B4

Tornado Scenario Map



Appendix C1

Question Set following Interval Three

Directions: Please rate the following statements about you, your personality, or your behavior using the following scale.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

1) I feel it is safe to leave Wesleyan Hall.
2) I plan to continue my daily activities unchanged.
3) It is safe to be outside in this weather.
4) I believe the weather at this moment is serious.
5) I plan to monitor the weather.
6) I believe Wesleyan Hall is a safe place to be right now.
7) It is safe to drive in this weather.
8) I plan to seek additional information, about the weather situation.
9) I believe the weather information is accurate.

Directions: Please choose the most accurate response for the following questoins.

10) At this moment __________.
    a. I do not plan to seek shelter
    b. I plan to seek shelter
    c. I have already sough shelter and plan on staying sheltered
    d. I have already sought shelter and plan on leaving the sheltered area soon

11) I currently feel __________.
    a. In no danger at all
    b. Slightly in danger
    c. A moderate amount of danger
    d. In extreme danger

Appendix C2

Question Set for Intervals Four through Eight

Directions: Please rate the following statements about you, your personality, or your behavior using the following scale.

Strongly Disagree — Disagree — Neutral — Agree — Strongly Agree

1) I feel it is safe to leave Wesleyan Hall.
2) I plan to continue my daily activities unchanged.
3) It is safe to be outside in this weather.
4) I believe the weather at this moment is serious.
5) I plan to monitor the weather.
6) I believe Wesleyan Hall is a safe place to be right now.
7) It is safe to drive in this weather.
8) I plan to seek additional information, about the weather situation.
9) I believe the weather information is accurate.

Directions: Please choose the most accurate response for the following questoins.

10) At this moment __________.
    a. I do not plan to seek shelter
    b. I plan to seek shelter
    c. I have already sough shelter and plan on staying sheltered
    d. I have already sought shelter and plan on leaving the sheltered area soon

11) I currently feel __________.
    a. In no danger at all
    b. Slightly in danger
    c. A moderate amount of danger
    d. In extreme danger

12) How far do you think the tornado is from you at this moment?
    (*tornado* replaced with *storm* at interval four)

    Minutes: __________

Appendix D

Demographic Questionnaire

Please answer the following demographic questions to the best of your ability.

1) My current age is: __________ years old

2) I am:
    - o Male
    - o Female

3) I am a:
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
    e. Graduate student

4) I identify with the following ethnicity:
    White (Caucasian)
    Black (African-American, but not Hispanic)
    Hispanic
    Asian
    Other: __________________

5) Do you currently live in the Shoals area all year round?
    - o Yes
    - o No
        - If not, where do you currently live year round?

            City: _______________________

            State: ______________________

6) How long have you lived in your current town?

    Years: _____________ Months: ___________

7) Have you lived in another city/town outside of this area? (e.g. Your hometown)

- o Yes
- o No
  - If so, where did you live?

City: ___________________________________

State: _________________________ Country: ________

8) How long did you live there?

Years: __________________ Months: ________________

9) Do you live on the University of North Alabama Campus?

- o Yes
- o No

10) If you do not live on the University of North Alabama Campus, how far do you live from campus?

Miles: _____________ Minutes (Driving Time): _____________

11) Have you ever been in a tornado warning but not experienced a tornado?

- o Yes
- o No

12) Approximately how many tornado warning have you experienced?

- o 0-10
- o 11-20
- o 21-30
- o 31-40
- o 41-50
- o More than 50

13) Have you ever personally experienced a tornado? (i.e. Has a tornado damaged your property, neighborhood, or nearby areas of town?)

- o Yes
- o No

14) Do you have a designated shelter or severe weather plan in the event of a tornado or other types of severe weather?
   - Yes
   - No

15) What factors, do you believe, will be most important in helping you decide when to seek shelter?
   - Seeing a tornado in person or the raw video of the tornado on the ground near your location
   - The local television meteorologist providing a landmark of where the tornado is that you are familiar with
   - The track of the tornado, as shown on internet, television, or radar, appears to pass over or very near your location
   - Hearing or seeing environmental cues (rain, wind, hail, etc.).
   - A friend or relative informing you (phone call, text, email, etc.).

16) In the event of experiencing a direct tornado, how far ahead (in minutes) of the tornado's arrival do you think you will seek shelter?

   Minutes: __________

17) If a tornado is approaching your location, which source of accurate information would you most likely use regarding the weather?
   - Your smartphone
   - A weather website
   - Social Media (Facebook, Twitter, etc.)
   - A local television station
   - A local radio station
   - The Weather Channel
   - NOAA weather radio
   - The tornado siren in your area
   - A text message or phone call
   - Other, please specify

Appendix E

International Personality Item Pool (IPIP) Questionnaire

Directions: Please rate the following statements about you, your personality, or your behavior using the following scale.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

1) Enjoy being reckless
2) Take risks
3) Seek danger
4) Known how to get around the rules
5) Am willing to try anything once
6) Seek adventure
7) Would never go hang-gliding or bungee-jumping
8) Stick to the rules
9) Avoid dangerous situations
10) Would never go hang gliding or bungee jumping
11) Would never make a high risk investment
12) Do dangerous things
13) Know no limits
14) Let myself go
15) Like to solve complex problems
16) Need things explained only once
17) Can handle a lot of information
18) Love to think up new ways of doing things
19) Love to read challenging material
20) Have difficulty understanding abstract ideas
21) Try to avoid complex people

22) Avoid difficult reading material

23) Avoid philosophical discussions

24) Can handle complex problems

25) Am quick to understand things

26) Catch on to things quickly

27) Am able to find out things by myself

28) Can handle a lot of information

29) Quickly get the idea of things

30) Try to avoid complex people

31) Don’t understand things

Appendix F

Debriefing Form

In this study you viewed a hypothetical tornado scenario and were asked to share your actions regarding the developing event. We were interested in examining whether the amount of warning information provided has any influence on the decision to seek shelter during a serious severe weather event. Also, we were interested in examining whether a specific level of information produced a quicker response than others.

Now that you have completed the study, and know a bit more about what we were doing, we're wondering if you have any questions or comments regarding the study. Not only are we interested in hearing what you think about the study but we welcome any suggestions that you may have to improve the study.

You are welcome to tell the researcher face-to-face or write your comments below.

One more important note, we ask that you not explain the contents of the study to anybody, as other people may be signed up to take the study. We're interested in seeing how people initially respond to these statements without much knowledge of what the study is about.

Thank you for participating.