DISSERTATION

# DEVELOPING A VALID SCALE OF PAST TORNADO EXPERIENCES

Submitted by

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In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2015

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# ABSTRACT

## DEVELOPING A VALID SCALE OF PAST TORNADO EXPERIENCES

People's past experience with a hazard theoretically is a key factor in how they perceive a future risk because experience is a mechanism through which one acquires knowledge about a risk. Despite this, past hazard experience has been conceptualized and measured in wide-ranging and often simplistic ways by researchers, resulting in mixed findings about the relationship between experience and risk perception. Thus, dimensions of past hazard experiences are not validly known, nor is it known how one's experiences relate to their assessment of future risks. Past hazard experience is particularly relevant in the context of weather risks, which are common enough for people to acquire many experiences. This dissertation presents the results of a study to develop a valid scale of past experiences in the context of tornado risks. The scale is developed by, first, conceptualizing and identifying dimensions of past tornado experience, and subsequently by examining the relationship between the different experience dimensions and people's tornado risk perception. Data were collected through two mixed-mode (Web+mail) surveys of the public who reside in tornado-prone areas. An initial set of items to measure people's most memorable tornado experience as well as their experiences with multiple tornado threats were developed and evaluated with the first survey. Additional aspects of people's past tornado experiences were elicited in their own words to identify potentially important ideas that were not captured in the original item set. The item set then was revised and evaluated with the second survey. The second survey also included a scale to measure people's cognitive-affective tornado risk perceptions.

Six latent dimensions of people's past tornado experiences emerged from this study: most-memorable experience-related *risk awareness*, *risk personalization*, *personal intrusive impacts*, and *vicarious troubling impacts*, as well as multiple experiences with *common personal threats and impacts* and *negative emotional responses*. *Risk awareness* captures the event-specific awareness by the respondent and from social cues about the possibility of the hazard occurring and concern about it causing harm. *Risk personalization* captures one's protective and emotional responses as well as direct visual, auditory, and tactile sensory inputs of the hazard. *Personal intrusive impacts* capture unwelcome thoughts, feelings, and disruption caused by the hazard. *Vicarious troubling impacts* capture the tangible property damage and loss incurred by others, disruption to others, and others' verbal accounts of their experiences. *Common personal threats and impacts* capture the amount of experiences one has with official tornado warnings and sirens and with news coverage about tornado events and their impacts. Finally, *negative emotional responses* capture the amount of experience one has fearing and worrying due to tornadoes. Subsequently, these different dimensions were shown to have varying influences on cognitive, affective, and overall tornado risk perception. *Personal intrusive impacts* had a pervasive effect, enhancing each of the risk perception dimensions with especially strong influences on affective and overall risk perception. *Risk awareness* and *risk personalization* influenced cognitive and overall risk perception, but only when combined with the other experience dimensions, suggesting that these experiences may be made more salient when joint with others. Overall, this research theoretically advances how past experience is conceptualized and how it relates to risk perception, and it serves as a foundation for future theoretical and applied research that could leverage and extend this work.

# ACKNOWLEDGEMENTS

It's fair to say that writing the Acknowledgements is both the easiest and hardest part of writing a dissertation because, to me, it's the most important part.

This dissertation is a marker of my being an interdisciplinarian, with a formal background in atmospheric science and now in communication. I have been working at the intersection of these two worlds for some time now, and in that time, I have learned three fundamental truths: (1) it's uncomfortable and downright scary at times, (2) it doesn't necessarily get easier despite all the rhetorical calls for interdisciplinarity, and (3) it requires surrounding yourself with people who are open-minded, supportive, and passionate about paths less-traveled. To that end, there are many people I can truly say I would not be here without, and there are many others who have left indelible impressions, even if they don't know it.

First and foremost, I thank both Craig Trumbo and Rebecca Morss. As my advisor, Craig provided the perfect combination of guidance and freedom as I developed and conducted my research, and he provided the right words of encouragement at just the right times. The word "mentor" seems insufficient to capture all that Rebecca has been for me. She understands the interdisciplinary research questions and challenges in ways that few others do. She has shaped me as a scientist, pushed me to think deeply and thoroughly about problems, and guided me in countless other ways, explicitly and implicitly. Most importantly, she has supported and celebrated me along the way. I admire her as a scientist tremendously, and I cannot thank her enough. I also thank my other committee members—David Most, Lori Peek, Don Zimmerman, and Marilee Long. I am fortunate to have learned so much from each of them and to think of

them as both advisors and colleagues. I truly hope that I can continue to collaborate with and learn from them.

I wouldn't be where I am today without my WAS*IS family. I warmly thank the WAS*IS matriarch, Eve Gruntfest, who knew me (after only one NRC study, albeit it with a rock-star committee) as someone who was interested in societal impacts of weather and who took a chance on me—almost exactly 10 years ago!—to help change the culture from what WAS to what IS. Eve's passion and ways of thinking continue to be an inspiration to me. I also thank Jeff Lazo who hired and supported me during WAS*IS and beyond (including at crucial times).

In that vein of taking a chance on me, I thank John Ogren, Mike Vescio, and Kevin Barjenbruch for offering me the opportunity to participate in the Super Tuesday service assessment, which was transformative for me. John believed that I could do it (and Rebecca and Jeff encouraged me as well), Mike gave me the latitude and support I needed as part of the team, and Kevin was the best field partner and friend I could ever have asked for.

I kindly thank Peter Backlund for valuing and championing integrated research on behalf of me and many others at NCAR. I suspect I will never fully understand all that he did. I especially thank Peter for supporting me personally in so many ways, even when he didn't have to. Beyond the work boundaries, I thank Peter for being a friend and for welcoming me always into his family and his home.

I warmly thank Ann Bostrom and Betty Morrow, both leaders in their research fields and whose knowledge and kindness have had a profound impact on me. I had so much to learn (and I still do!) about research theories and methods when I first had the wonderful opportunities to collaborate with each of them, but they both offered patient, guiding assistance. Also, I found that people were willing to give all sorts of opinions and advice about doing a PhD, but only one

person's words resonated and actually helped me throughout. Thank you, Betty Morrow, for your beautiful and parsimonious advice to take it "one day at a time."

I can't begin to imagine how I would have navigated this journey without my family and my friends (who are also my family). Daniel Nietfeld, you share a passion for weather and how it affects people, you have the ability more than anyone else I know to think deeply about and connect weather research and practice, and your everyday experience as a practitioner saving people's lives leaves me in awe and inspired. Your love, patience (including when you (re)teach me the meteorology I've forgotten), and encouragement have been so important to me. I love you, and I thank you.

Gregory Guibert, saying that I thank you doesn't even do justice to express my gratitude to you for the unwavering friendship, love, and support that you have provided to me in ways big and small. You helped me during the many, many hours of stamping, stuffing, and sealing, and during the momentous mailings. You listened, discussed, and provided endless encouraging words, hikes, hugs, and bubbles (sometimes in emergency form). I don't know how I would have done this without you. Thank you. Alotte.

I warmly thank Sheldon Drobot who believed in me and who especially helped me during those first few critical and, at times, self-doubt-laden steps on this path. His support has meant more to me than he knows. I also thank Jen Henderson and Heather Lazrus for their friendship and for the helpful conversations along the way, as well as Jen and Dane for kindly taking my very final mailing (hundreds of letters!) to the post office when I had to leave town for a conference. My mom, dad, sister, and brother unfailingly provide steady, implicit love and support for me as well as the occasional spirited scientific conversation. I am forever grateful to

them. I also thank my schmoes—Maleek, Fezzik, and Moose—who spent countless hours near (and on) me "helping" while I read, wrote, and thought.

So many people helped with different parts of the dissertation process. I extend a very special thank you to Neil Weinstein whose research, including a seminal paper on past experience, inspired and served as an essential foundation for my work. Neil kindly offered a considerable amount of his time to talk through my initial set of experience items. His content-specific ideas and insight were incredibly helpful, and his overall encouragement and kind words were so meaningful. Thank you also to Robert DeVellis and Jolene Smyth, neither of whom knows me, but who kindly took the time to respond to my emails about scale development and mixed-mode surveys, respectively. I thank Kris Marwitz, Jason Long, Kathy Morgan, and Melissa Miller who helped navigate the unchartered NCAR policy waters for conducting mail surveys with cash incentives. Thank you also to Jenn Boehnert for all her GIS help, and to Zita Toth for helping with the paper survey data entry for the first survey.

Last, but certainly not least, a special thank you to all of the study participants, including the pre-testers and the survey respondents, for sharing your time and most of all for sharing your experiences.

# DEDICATION

On February 14, 2008, just over a week after the Super Tuesday tornado outbreak—so named because it started on Tuesday, February 5, 2008, during the Super Tuesday presidential primary elections—I went into the field for the first time in my life. Fifty-seven people died in that early-season outbreak making it, at that time, the largest number of fatalities in over 20 years. The National Weather Service (NWS) wanted to assess its performance during the event, but they also wanted to better understand the knowledge, perceptions, and decision-making by the people who were affected—thus my participation on the assessment team.

Alongside Kevin Barjenbruch, a NWS colleague turned friend during that time, we spent the next four days traveling throughout parts of Tennessee, Mississippi, and Arkansas, going to the areas where people had died in the outbreak and interviewing survivors, including neighbors and family.

Those four days profoundly affected me. I can still remember every person Kevin and I spoke with. The elderly woman and her son-in-law who went to their storm cellar after he saw the tornado coming, a shelter she could not have gotten into without him because its door was too heavy for her to open. The couple whose son called from Texas to tell them about the tornado, a message they did not get until after they emerged from their shelter. The woman who had her husband carry her to the shelter, and then he, thinking they were not really at risk, returned to the house only to be hit by the tornado.

The people I met during those four days—my experience with their tornado experiences—led me, both directly and indirectly, to this.

To everyone who endured that tornado and everyone who came before and after, I have endeavored to try to understand your experiences, all in the hopes that it will, in some way, eventually help reduce people's risk from tornadoes.

So I try to understand,

What I can't hold in my hand

– Jack Johnson, "Home"

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# CHAPTER 1: INTRODUCTION

It has long been realized that people's risk perception is influenced by more than the objective, technical information about the risk itself. Risk perception also is influenced by various individual, social, and cultural factors as well as by informational and situational factors (Mileti & Sorensen, 1990; Renn, 2008; Slovic, 2010; Wachinger, Renn, Begg, & Kuhlicke, 2013). Among the individual, social, and cultural factors, a commonly measured variable is one's past hazard experience. Researchers have examined experience in countless studies across the domains of health, technological, and natural risks. As Peacock, Brody, and Highfield (2005) note, "the principal reason that experience and communication are often the focus of hazards research is that both are mechanisms through which individuals acquire knowledge … (and) knowledge is and should be important in risk perception" (p. 123).

Despite being frequently included in studies and despite its potentially important role in how people acquire knowledge about a risk, researchers have measured past hazard experience in a variety of ways that range from commonly employed single, simplistic items (e.g., "have you experienced a <hazard>?") to less commonly (and inconsistently) employed summed scales of multiple items. Such wide-ranging approaches to measuring experience suggest that researchers conceptualize it accordingly, and these approaches are inadequate for capturing the conceptual contours of past hazard experience. The corollary of the past hazard experience conceptualization and measurement problem is that there are mixed findings in the literature about the relationship between experience and risk perception. Results of empirical studies run the gamut, showing that past experience increases risk perception, decreases risk perception, or has no relationship. Such inconsistent empirical results can confuse researchers and practitioners

about whether and how past experience plays a role in risk assessment. Thus, more systematically conceptualizing and theorizing about past hazard experience is needed and has been called for by others (Kellens, Terpstra, & De Maeyer, 2013; Lindell, 2012; Peacock et al., 2005; Weinstein, 1989). In other words, there is a need to improve the validity of past hazard experience, including both its content and construct validity (Hayes, 2005; Wimmer & Dominick, 2006).

One domain in which past hazard experience is particularly relevant is that of weather risks. Hazardous weather threats are common enough that they offer people many opportunities to form and accumulate experiences. For example, in 2012, Superstorm Sandy roared up the northeastern seaboard and made landfall in an area that had been affected before, including by Hurricane Irene a year prior. In May 2013, an EF-3 tornado struck a western suburb of Oklahoma City less than two weeks after an EF-5 tornado tore through a southern suburb of the city. The area was hit by an EF-3 tornado again in May 2015. People also experience more common and less extreme examples of hazardous weather, such as driving on slick, snowy roads, or enduring severe thunderstorms. Vicarious experiences gleaned from others and the news media may also contribute to one's past hazard experience, particularly given the information environment in which we currently live (NPR, 2013). For instance, viewers could live stream coverage from the Oklahoma City media of the tornadoes, including of the tornado itself and of the immediate aftermath. Moreover, social media platforms, like Twitter, have been shown to reflect severe weather threats (Ripberger, Jenkins-Smith, Silva, Carlson, & Henderson, 2014); these communications are markers of and potentially drivers of people's experiences.

Theoretically, such weather experiences may influence how people assess future risks. However, the different dimensions of such past experiences are not well known. It also is not

known which dimensions are and are not related to risk perception or in what ways. The research presented here, therefore, is a first step at addressing these research gaps. Specifically, this research begins to develop a valid scale of people's past hazard experiences, focused on the context of tornado risks as discussed below, through two research aims:

(1) First, conceptualize, operationalize, and characterize past tornado experience and its dimensions, and;

(2) Subsequently, characterize the relationship between different past tornado experience dimensions and people's tornado risk perception.

The first research aim relates to improving past experience's content validity, which is the extent to which measurement items represent the universe of possible indicators of a concept. The second research aim relates to construct validity, which involves evaluating theoretically related constructs—here, past experience and risk perception (Hayes, 2005, Wimmer & Dominick, 2006).

This research can provide an important foundation for numerous future risk-related studies that do (or should) incorporate experience as a variable. Moreover, the findings can inform weather forecast and emergency response risk communication which, in turn, could improve people's decision-making and protective responses when hazardous weather is threatening, thereby mitigating harm from these events.

## Study Context: Tornadoes

This research aims to develop a valid scale of past hazard experience with a specific focus on tornadoes as one type of weather hazard. Tornadoes are nature's most violent storm, with wind speeds that can reach 300 mph. With their power and rapid onset, tornadoes pose a

risk—that is, a chance of substantial harm (property loss, injuries, economic disruption, trauma, etc.)—to humans.

Meteorologists tend to emphasize reducing tornado risks through improved observations, understanding, and modeling of the atmosphere (e.g., Lindell & Brooks, 2012; Wurman et al., 2012). These efforts have led to skillful forecasts, including tornado watches and warnings, and a reduction in tornado fatalities over the last several decades (Brooks & Doswell, 2002; Simmons & Sutter, 2005). Accurate and timely forecast information undoubtedly are essential for saving lives and reducing harm from tornadoes. Yet, several recent tornado events have resulted in significant harm and large losses of life despite being very well forecast from a meteorological perspective (NOAA, 2009; 2011a; 2011b; 2014a). This suggests the need to couple atmospheric science efforts with efforts to improve observations, understanding, and modeling of the *people* who are at risk of tornadoes. Such research is increasingly being called for given the potential for this understanding to complement meteorological knowledge in reducing harm caused by tornadoes (Brotzge & Donner, 2013; Lindell & Brooks, 2012; NRC, 2010).

Many studies have been conducted that examine human aspects associated with tornado risks, but most have been post-event assessments, typically of high-impact tornadoes that were either strong or killed many people. These studies have tended to focus on people's warning compliance (whether or when one took shelter) as a function of their warning source(s), warning lead-time received, understanding of tornado watch and warning terminology, location within a warning, proximity to the tornado track, and/or associated demographic characteristics (Balluz , Schieve, Holmes, Kiezak, & Malilay, 2000; Chaney & Weaver, 2010; Chaney, Weaver, Youngblood, & Pitts, 2013; Comstock & Mallonee, 2005; Hammer & Schmidlin 2002; Nagele & Trainor, 2012; Schmidlin & King, 1995; Sherman-Morris, 2010; Silver & Andry, 2014). Other

studies have examined similar variables in relation to intended protective action for a future tornado event (Blanchard Boehm & Cook, 2004; Senkbeil, Rockman, & Mason, 2012; Weinstein, Lyon, Rothman, & Cuite, 2000a), and some recent research has examined the influence of risk communication, including impact-based messages, on intended behaviors (Perreault, Houston, & Wilkins, 2014; Ripberger, Silver, Jenkins-Smith, & James, 2015). Only a few studies have examined people's tornado risk perception and the variables that influence it (Ash, Schumann, & Bowser, 2014; Greening & Dollinger, 1992; Greening, Dollinger, & Pitz, 1996; Mulilis, Duval, & Rogers, 2003). Of these, only the studies by Greening and colleagues (1992; 1996) have given credence to the role of one's past tornado experiences by endeavoring to measure it in ways that are beyond the simplistic approaches described above.[1] Moreover, none of these studies explicitly focused on developing a valid scale to measure people's tornado experiences. The research conducted here, therefore, complements and expands upon these efforts while also contributing to better understanding people's tornado risk perception.

Because tornadoes are extreme, discrete events that likely are also salient and memorable, they are a good phenomenon to study to develop a valid measure of past hazard experience. Although this research is bounded to tornadoes as a contextual starting point, the results can serve as a foundation for more broadly understanding past hazard experience and for examining it in the context of other weather and non-weather risks, in other geographic areas, and over time.

## Study Approach

This study aims to develop a valid scale of people's past tornado experiences by first characterizing different experience dimensions (to improve content validity) and then by

[1] Suls, Rose, Windschitl, & Smith (2013) and Weinstein et al. (2000a) measured experience in more thoughtful ways but not in relation to risk perception.

examining how the different dimensions relate to tornado risk perception (to assess construct validity). These aims are accomplished through two surveys of members of the public who reside in areas at risk of tornadoes. Survey 1 was used to evaluate an initial set of items that were developed to measure people's past tornado experiences and to elicit additional aspects of their experiences in their own words. The set of experience items was revised based on the Survey 1 results, and Survey 2 was used to evaluate the revised measures along with measures of people's tornado risk perception.

Chapter 2 provides a review of the literature, beginning with an explanation of why experience theoretically relates to risk perception. It then summarizes ways that past experience has been measured and how experience has been empirically shown to relate to risk perception. Chapter 3 details the research approach, design, and analysis. It begins with a discussion about scale development in general and as it applies to this study. It then covers the sampling, design, data collection, and data analysis methods for the two public surveys. Following the two research aims, results are provided in Chapter 4 of the scales developed to measure the different dimensions of past tornado experience, based on data from both surveys. Then, in Chapter 5, results are presented of the influence of the different tornado experience dimensions on tornado risk perception, based on data from the second survey. Finally, Chapter 6 includes a discussion of the results, implications for theory and practice, study limitations, and suggestions for future research.

# CHAPTER 2: LITERATURE REVIEW

The notion of past experience permeates many research disciplines and domains.[2] Past experience is relevant to how we cognitively process, store, and retrieve information (Lang, 2000; Middleton & Brown, 2005) and to our schemas and mental models (Fiske & Taylor, 1991; Gentner & Stevens, 1983; Hawkins & Daly, 1988; Howard & Renfrow, 2003; Morgan, Fischhoff, Bostrom, & Atman, 2002). It influences our judgments (Tversky & Kahneman, 1974), how we learn (Bandura, 2009; Durning & Artino, 2012; Kolb, 1984), and how we perceive and behave in situations. Moreover, some research approaches, such as phenomenology, are focused on identifying the essence of human experiences about a phenomenon (Creswell, 2013). In short, experience is woven into people's lives in innumerable implicit and explicit ways.

Because experience is inherent to people's lives, it has been explored across disciplines and circumstances. Commonly, experience is mentioned in empirical studies in a colloquial sense. In other cases, experience is explored intentionally or the importance of its role emerges, but it is not systematically examined as a construct. For instance, past experience has been studied as it pertains to public health (Helweg-Larsen, Harding, & Kleinman, 2008; Karlsson, 2012; Millstein & Halpern-Felsher, 2002), business (Kim, JaeMin, Bonnie, &Jeffrey, 2011), technology and other man-made risks (af Wahlberg, 2012; Bourque, Mileti, Kano, & Wood, 2012; Wood et al., 2012), and various natural hazards, as further discussed below. Others have summarized individuals' past experiences across a range of hazards (Barnett & Breakwell, 2001; Bubeck, Botzen, & Aerts, 2012; Kellens et al., 2013; Wachinger et al., 2013). Although less common, some scholars across various fields have devoted focused attention to experience,

[2] This construct is termed differently throughout the literature, including but not limited to "past experience," "personal experience," "hazard experience," "disaster experience," "risk experience," and, simply, "experience."

treating it as an inherently interesting and important construct and examining it accordingly. For instance, scholars have developed experience scales pertaining to bereavement (Mckiernan, Spreadbury, Carr, & Waller, 2013), spirituality (Currier, Kim, Sandy, & Neimeyer, 2012; Genia, 1997; Underwood & Teresi, 2002), regret (Creyer & Ross, 1999), and health (Bobrovitz, Santana, Kline, Kortbeek, & Stelfox, 2013; Dipietro, Christensen, & Costigan, 2009; Fu, McDaniel, & Rhodes, 2007; Tobin 2011). These studies hint at the far-reaching contexts and ways that experience is considered in research.

This chapter reviews the literature relevant to experience and risk perception. It begins by describing risk perception and explaining, theoretically, why experience influences it. Next, the empirical literature on experience and risk perception for weather risks is summarized. This review will lay the foundation for the two dissertation research aims to (1) conceptualize, operationalize, and characterize past tornado experience and its dimensions, and; (2) characterize the relationship between different past tornado experience dimensions and people's tornado risk perception.

## Experience and Risk Perception Theoretically

Risk, broadly defined, is the possibility of harm (or some other undesirable or adverse effect) due a natural event or human activities (Renn, 2008; Trumbo, 2012). Risk perception, then, is one's awareness of and assessment about a risk. More specifically, risk perception denotes "judgements about events, situations, or activities that could lead to negative consequences" (Renn, 2008, p. 98), judgments that are made through "the process of collecting, selecting, and interpreting signals about uncertain [negative] impacts" of those events

(Wachinger et al., 2013, p. 1049). As Renn notes, "how people … make their [risk] judgments, is influenced by knowledge, values, feelings, and judgments of others" (p. 98).

Experience is a key mechanism by which people recognize that a risk exists and by which they acquire knowledge, values, feelings, and judgments of others about it (Bandura, 2009; Durning & Artino, 2011; Epstein, 1994; Peacock et al., 2005; Renn, 2008; Wachinger et al. 2013). Simply put, experience is informational (Weinstein, 1989). The important role of the "experiential system" as a mode of thought and judgment was discussed by Seymour Epstein (1994) in his cognitive-experiential self theory, which posits how the experiential system works in tandem with a "rational system." In the experiential system, people have schemata that consist primarily of generalizations derived from past experiences. Epstein characterized the experiential system as having multiple features (see Epstein, 1994, Table 1), which he summarized in this way:

> At its lower levels of operation, [the experiential system] is a crude system that automatically, rapidly, effortless, and efficiently processes information. At its higher reaches, and particularly in interaction with the rational system, it is a source of intuitive wisdom and creativity. Although it represents events primarily concretely and imagistically, it is capable of generalization and abstraction through the use of prototypes, metaphors, scripts, and narrative. (p. 715)

A key tenet of the experiential system is its affective basis. It is here that risk perception research by Paul Slovic and colleagues intersects with Epstein's theory to offer one possible mechanism by which experience links to risk perception—the affect heuristic. Experienced images and associations are tagged or "mapped" with affect, which is the underlying good or bad feeling that one experiences as a feeling state. The collection of mapped affective information makes up an "affect pool" for a given person, and "people consult or 'sense' the affect pool in the process of making judgments" (Slovic, Finucane, Peters, & MacGregor, 2004, p. 314). Or, as Epstein describes it, "When a person responds to an emotionally significant event … the

experiential system automatically searches its memory banks for related events, including their emotional accompaniments" (p. 716). Slovic et al. characterize this process as a mental shortcut and thus label the use of affect as a heuristic. Slovic et al. summarize this process of the experiential system informing risk perception in this way: "The experiential system enabled human beings to survive during their long period of evolution and remains today the most natural and common way to respond to risk" (p. 311). "Long before there was probability theory, risk assessment, and decision analysis, there were intuition, instinct, and gut feeling to tell us whether an animal was safe to approach or the water was safe to drink" (p. 313).

Other mechanisms have been suggested as to how experience links to risk perception. One such proffered explanation is the availability heuristic, which refers to the tendency of people to judge the probability of an event (e.g., a hazard) based on the ease with which an occurrence comes to mind (Tversky & Kahneman, 1974). This process often is strongly influenced by one's experiences with past events, including the recency of such events (Boholm, 1998; Greening et al., 1996; Weinstein, 1989). Greening et al. (1996) hypothesized the simulation heuristic as another mechanism that links experience to risk perception. This heuristic refers to the ease with which one is able to conjure up a mental image of an event which, in turn, influences how one judges the probability of the event actually occurring. Greening et al. tested this hypothesis in the context of tornadoes, as discussed later in this chapter. Another possible mechanism offered by Weinstein (1989) is that past experience can enhance the vividness and concreteness of a hazard, which is more powerful than abstract information and can enhance risk judgments. More generally, Viscusi and Zeckhauser (2006) suggested that, "From the standpoint of rational Bayesian learning, one would expect assessed risks to rise after experiencing a natural disaster" (p. 19).

These mechanisms may, and likely do, overlap. Slovic et al. (2004) suggested that the availability heuristic might work because remembered and imagined images are tagged with affect. Vivid and concrete experiences likely also are more cognitively available and may also be tagged with affect (Greening et al., 1996). Affect, memorability, recency, vividness, and concreteness all can be experienced directly by an individual or indirectly, such as through the media or through communicating with friends, family, or others (direct versus indirect experiences are discussed further later in this chapter). Some suggest that events that are experienced directly are more self-relevant and meaningful and thus are processed differently, including more thoroughly, in ways that make them more accessible from memory and therefore more related to risk perception, but this is in need of exploration (Bubeck, Botzen, & Aerts, 2012; Fazio & Zanna, 1981; Kellens et al. 2013; Weinstein, 1989).

The link between experience and risk perception is represented in several risk theories. In accordance with its conceptualized relationship to risk perception, experience is theorized in the models as antecedent to risk perception, which then influence responses. The role of experience in these theories is discussed regardless of the level of analysis as well as the type of response being modeled. Experience is relevant to individual-level theories of protective behavioral responses, including, for example, the Theory of Reasoned Action (Fishbein & Ajzen, 2010) and the Protective Action Decision Model (Lindell & Perry, 2012). The Extended Parallel Process Model, which builds on Protection Motivation Theory by theorizing an emotional response to a risk and risk messages, also notes the role of past experience (Witte, 1994). Although the architects of each of these models acknowledge that past experience is relevant to one's risk perception and thus their risk responses, it is not explicitly included as a core concept of interest. For instance, the Theory of Reasoned Action assumes that people's beliefs (behavioral,

normative, and control) influence their perceptions and attitudes, which then influence their behavioral intentions, which is the immediate precursor to their actual behaviors. Although the model focuses on these determinants, Fishbein and Ajzen note that the first step, people's beliefs, is influenced by several background individual, social, and informational factors, including experience. Specifically, they indicate:

> These beliefs originate in a variety of sources, such as personal experiences, formal education, radio, newspaper, TV, the Internet and other media, and interactions with family and friends. Individual differences (e.g., demographic characteristics, personality) can influence not only the experiences people have and the sources of information to which they are exposed but also the ways they interpret and remember this information. (Fishbein & Ajzen, 2010, p. 20)

One risk model in which experience is explicitly included is the Risk Information Seeking and Processing model, which, as the name suggests, models people's intended risk information seeking (or avoidance) and processing (as heuristic or systematic) (Griffin, Dunwoody, & Neuwirth, 1999). This model theorizes that individual characteristics, including past hazard experience, influence cognitive threat perceptions, which ultimately influence the informational response outcomes. Although the RISP model also includes affect as a concept, the original model did not propose a direct relationship between past hazard experience and affective risk perception, but this direct relationship was found empirically (Griffin, Neuwirth, Dunwoody, & Giese, 2004).

The role of experience is also noted in social and cultural models of risk. For instance, the Social Amplification of Risk Framework denotes how interactions among "informational processes, institutional structures, social-group behavior, and individual responses shape the social experience of a risk" (Kasperson et al., 1998, p. 181). "Signals" arise through direct personal experience with or receipt of information about a risk. These signals are processed by individual and social sources that generate, transmit, and can amplify or attenuate the signal, all

of which lead to social interpretations and responses to a risk (including ripples of secondary and tertiary consequences, e.g., market impacts, loss of credibility and trust).

In summary, in most risk models, the role of experience tends to be implicit or mentioned in passing. Or, experience is lumped with other individual characteristics (e.g., demographic characteristics, political ideology) and, if even measured, is treated only as a variable to be controlled for versus as one that is inherently interesting in its relationship to risk perception and behaviors. This is surprising given that, as discussed above, past experience is a key way that one acquires knowledge, values, feelings, and judgments about a risk. Indeed, some scholars have argued generally for more research to better understand the influences of experience in risk research (Renn & Rohrmann, 2000), and others have more fundamentally noted that although hazard experience as a construct is often studied, it has "hardly been theorized" (Kellens et al., 2013, p. 46; Lindell, 2012). To better theorize past experience and its role in risk perception, a summary of relevant empirical studies is presented next.

## Summary of Empirical Literature on Experience and Risk Perception of Weather Risks

The goals of this literature review are to summarize and critically analyze how past experience has been conceptualized and measured and how it has been shown to relate to risk perception. In this way, it focuses on linking a review of research methods with research outcomes (Randolph, 2009). Because so little past research has examined tornado risk perception, the review was broadened to include studies of other types of weather risks, most of which pertain to floods and hurricanes. Relevant articles were found by searching for a combination of experience (or exposure, which often is used as a proxy for experience), risk

perception, and weather risks.[3] Additional articles with which the author was already familiar also were included. Importantly, risk perception has been conceptualized and measured in a variety of ways, including as perceived likelihood, perceived severity, or the conjoint of these two (e.g., Griffin et al., 1999; Renn, 2008; Weinstein, 2000b; 2003; Witte 1994); as attitudes, sensitivity, and fear (Sjoberg, 2000); as cultural worldviews (Kahan, 2012; Rayner, 1992); and as a dual-mode phenomenon consisting of cognitive and affective systems that operate in parallel (Slovic, 2010). As will be further discussed in Chapter 3, the cognitive-affective conceptualization of risk perception is utilized for this study, but it has not been commonly employed in studies of weather risk. For this reason, and because of the varied and evolving way of thinking about risk perception, articles with any operationalization of it were considered for this review. Such variation in conceptualization and measures of both the independent variable (experience) and dependent variable (risk perception) of interest foreshadow the inevitable conclusion of mixed findings about their relationship. Still, the criteria discussed here for synthesizing the literature were applied to bound the review while not being overly restrictive. Lastly, several studies exist in the weather risk domain that examine how past experience directly affects other dependent variables, especially protective behavioral responses and long-term hazard adjustments or other types of mitigative behaviors. It is beyond the scope of this dissertation to summarize all of the experience measures and related findings from those studies, but experience measures from studies about tornadoes, regardless of whether or not they pertain

[3] One example of a specific search: "((experien* n3 (prior or past or previous or personal or disaster or flood or hurricane or tornado)) and (risk* n5 (perception* or perceiv*)) and (weather haz* or weather disaster* or flood* or tornado* or hurricane*))". Here, "n" is the proximity search syntax for a given database; appropriate proximity syntax was used for the respective databases searched. This same search was conducted replacing "experien*" with "exposur*". Searches were conducted of titles, keywords, and abstracts. Databases searched included multiple EBSCO databases (e.g., Academic Search Premier, Anthropology Plus, Communication and Mass Media Complete, PsycInfo), Web of Science, and PubMed.

to risk perception, are summarized as they inform the conceptual definition of past tornado experience (see Chapter 3).

The next section summarizes and discusses ways experience has been measured in studies of weather risks, and then a brief summary is presented of how experience has been shown to relate (or not) to risk perception.

**Experience Measures**

In Table 1, a synthesis of past experience measures that have been employed across a range of studies of weather risks is provided, offering an immediate illustration of the various ways that this concept has been operationalized. These measures are discussed here.

Although many scholars have measured people's past experiences, most do not explicitly define what it means or how such an item is meant to reflect it, perhaps believing that it is a self-explanatory construct. Interestingly, Weinstein (1989) indicated that personal experience is a "reasonably well-defined concept" (p. 32), but he failed to include a definition. Of the few scholars who do offer conceptual definitions, most characterize experience as consisting of direct and indirect dimensions. Wachinger et al. (2013) succinctly define direct experience as "internal (e.g., experiencing a hazard event with one's own eyes)" and indirect experience as "external (e.g., media and education)" (p. 1052). Others' definitions are consistent although some are elaborated on. For instance Lindell and Hwang (2008) introduce ideas about the occurrence and outcomes of experience with their definition of "people's hazard experience … [as] the recency and frequency of casualties and damage experienced by the respondent him/herself, by members of the immediate or extended family, or by friends, neighbors, or co-workers" (p. 542). Kellens et al. (2011) mirror the first part of this definition and term it "direct personal experience" (p.

Table 1. *Summary of past experience measures from studies of weather risks*

| Experience measure | References |
|---|---|
| Past experience with a weather event (tornado, flood, hurricane, etc.) | Adelekan, 2011; Balluz et al. 2000; Botzen et al., 2009; Drost, 2013; Hoekstra et al., 2011; Kellens et al. 2011; Matyas et al., 2011; Mulilis et al., 2003; Peacock et al. 2005; Ripberger et al., 2015 |
| Others' (family, friends) past experience | Hoekstra et al., 2011; Matyas et al., 2011 |
| Amount of experience, e.g., number of times one has been in a hazard; number of times one performs a protective action (evacuation) | Barnett & Breakwell, 2001; Drost, 2013 Halpern-Felsher et al. 2001; Knocke & Kolivras, 2007; Nagele & Trainor, 2012; Trumbo et al., 2011 |
| Experience with tornado watches or warnings | Perreault et al., 2014 |
| Taken protective action (e.g., shelter from a tornado, evacuation) | Bubeck et al., 2009; Perreault et al., 2014 |
| Fear of dying in the event | Suls et al, 2013 |
| Witness or hear hazard phenomenon | Blanchard-Boehm & Cook, 2004; Greening & Dollinger, 1992; Hoekstra et al., 2011; Perreault et al. 2014; Weinstein et al., 2000a |
| Witness damage or injuries as it occurred | Mishra & Suar (2007); Weinstein et al. (2000a) |
| Proximity to a hazard phenomenon | Blanchard-Boehm & Cook, 2004; Peacock et al., 2005; Perreault et al., 2014; Suls et al. 2013 |
| Personal property damage or other personal or financial loss (amount, number of times had loss, degree of damage to different objects [roof, windows, possessions, etc]) | Blanchard-Boehm & Cook, 2004; Botzen et al., 2009; Comstock & Mallonee, 2005; Greening & Dollinger, 1992; Keller et al, 2006; Lindell & Hwang, 2008; Mishra & Suar, 2007; Peacock et al. 2005; Perreault et al., 2014; Senkbeil et al,. 2012; Suls et al., 2013; Trumbo et al., 2011 |
| Others' property damage or loss | Greening & Dollinger, 1992; Perreault et al., 2014; Trumbo et al., 2011 |
| Physical injuries to oneself | Comstock & Mallonee, 2005; Greening & Dollinger, 1992; Lindell & Hwang, 2008; Mishra & Suar, 2007; Suls et al., 2013 |
| Physical injuries or death of family members, neighbors, or acquaintances | Comstock & Mallonee, 2005; Greening & Dollinger, 1992; Keller et al., 2006; Lindell & Hwang, 2008; Mishra & Suar, 2007; Perreault et al., 2014; Siegrist & Gutscher, 2006; Suls et al., 2013 |
| Emotional impact | Barnett & Breakwell (2001); Morss et al., in review; Terpstra 2011 |
| Perceived severity of impact (also known as threat experience appraisal) | Barnett & Breakwell (2001); Drost, 2013; Grothmann & Reusswig (2006); Morss et al., in review |
| Delayed impacts (lives disrupted, losing electricity, closing workplace, etc.) | Weinstein et al. (2000a) |
| Witness aftermath of hazard (including reminders, e.g., crews cleaning debris) | Siegrist & Gutscher, 2006; Weinstein et al. (2000a) |
| Post-event social interaction (volunteer work, seeing victims, talking with others) | Weinstein et al. (2000a) |
| News coverage of hazard event | Keller et al. (2006) |

1059). Indirect experience is defined as not first-hand but as mediated through someone else (Stapel & Velthuijsen, 1996), and as encountering of a hazard through "social communication" (Kellens et al., 2011), that is, reading or hearing information from experts, news media, public

agencies, or informal networks of friends and family (Blanchard-Boehm & Cook, 2004; Boholm 1997; Lindell & Perry, 2012; Weinstein 1989). Indirect experience is also termed vicarious experience by some scholars (Kellens et al., 2011; Keller et al., 2006; Lindell & Perry, 2012). The direct versus indirect experience conceptualization is apparent in many of the types of experiences listed in Table 1 that are measured as they pertain to the respondents themselves and to others. Zaalberg, Midden, Meijnders, and McCalley (2009) offered a different way of thinking about experience by distinguishing:

> between physical or bodily exposure to a threat, and consecutive subjective or psychological experiences … The extent to which residents are physically exposed to flooding influences, for example, the intensity of subjective experienced emotions (p. 1790).

Their notion of people's "subjective" experiences—or, put differently, how people interpret their experiences—conceivably is an important, and as will be shown below, understudied, aspect of people's past experiences.

Experience commonly has been measured broadly—but vaguely—as whether one (or relevant others) has past experience with a hazard. Although this measure is an attempt to be all-encompassing way to capture one's hazard experience, it suffers in its imprecision and therefore also in its utility. When a respondent answers this type of question, it is unclear what he or she is thinking about and therefore what is being measured. For instance, people might be considering their experience with the event itself (e.g., watching the tornado approach), impacts of the events (e.g., their home being obliterated), or any other number of experiential attributes (e.g., hearing about a major tornado event, like the 2011 Joplin tornado, via news). Often, this is the only experience measure included in a study, exacerbating the problem of not being able to ascertain what people are thinking about when responding. In some instances, this already broad experience measure was rendered even more questionable in its utility due to the researchers'

approach. In one case, the researchers' experience measure was double-barreled in that they asked whether respondents had past experience with "previous tornado events or other severe weather conditions" (Balluz et al., 2000). These two types of weather hazards, tornadoes and severe weather, differ in their intensity, frequency, and possibly other characteristics (e.g., dread), so people's experiences with them and the impact of those experiences may also differ accordingly. In another case, Hoekstra et al. (2011) measured people's prior tornado experience by offering four nominal response options—"no prior experience," "family/friends experienced a tornado," "witnessed a tornado from afar," and "was in a tornado." Here, the problem with the vagueness of what "was in a tornado" means is compounded by the response options being a mix of experience types that are not mutually exclusive. Past experience also has commonly been measured as the number of hazards one has been in but, again, what constitutes that experience is left unspecified. It is conceivable that multiple experiences with a risk could have an important effect on people's risk judgments, but it is unclear what aspects are cumulative, especially given the varying nature of hazards. Weinstein (1989) notes this when he indicates that there are not valid ways of summarizing multiple experiences, such as those of the "many residents of communities along the Gulf of Mexico (who) have lived through half a dozen hurricanes of varying intensities" (p. 37). In summary, the problem with imprecise measures of whether or how much one has past experience with a hazard is the consequent uncertainty about what is being captured. Such measures therefore offer no knowledge about why a relationship between experience and risk perception (or any other dependent variable) may or may not exist.

Several researchers have measured sensory experiences with a hazard, including whether one witnessed or heard the hazard phenomenon itself as well as whether one witnessed damages or injuries as they occurred. Some also have measured experience as whether one lived in the

tornado path, whether one lived in the city where the hazard occurred, or as proximity to the hazard. Others, however, have argued that such measures are geographical, "factual variable(s) of respondents' (hazard) exposure" (Grothmann & Reusswig, 2006, p. 115) that should not be conflated with experience (Botzen et al., 2009; Siegrist & Gutscher, 2006).

Many researchers measure experience as the effects or outcomes of a hazard. Personal property damage and/or other financial loss is the most commonly employed measure of experiential impact—and in fact, it may be the most common way that past experience with weather hazards is measured overall. Not surprisingly, property damage/loss is measured in a variety of ways, most commonly as dichotomously (yes or no, had damage), but also as degree of damage (e.g., none, some, significant, destroyed) and as monetary amount of damage. The other commonly employed measure of impacts is physical injury. Relatedly, Weinstein (1989) noted that degree of harm, which could include factors such as one's time in a hospital, are important aspects of one's experiences. Both property damage and injury commonly are measured as they pertain to the respondent as well as to others the respondent knows (family, friends, neighbors, acquaintances, etc.).

The impacts of people's hazards experiences also have been measured in a variety of other ways, including measures that capture one's subjective interpretation of or meaning attributed to an experience (Lindell & Perry, 2000; Peacock et al., 2005; Zaalberg et al., 2009). Emotional impact is one such type of experience, measured as emotional distress, emotional injury, and positive or negative feelings associated with the experience, all of which link directly to the aforementioned affective mechanism that is posited to link experience to risk perception. Another interpretative measure of experience is the perceived impact or severity of impacts on the respondent. Grothmann and Reusswig (2006) drew on protection motivation theory and

developed a concept related to this that they termed "threat experience appraisal", which measures one's perceived severity of a threat experienced in the past.

In addition to the above types of experience that have been measured in many studies, a few scholars have measured novel aspects of people's experiences. In two recent studies, researchers began to measure experiential aspects of a hazard in the time leading up to and during the event that are beyond the commonly employed sensory measures. Perreault, Houston, & Wilkins (2014) measured whether respondents have experience with tornado watches and warnings as well as whether they have taken shelter because of a tornado. Taking shelter is a type of protective action for rapid-onset hazards, such as tornadoes, but others have measured protective actions, especially experience evacuating, for slower-onset hazards, such as floods and hurricanes (Bubeck et al., 2009). Suls, Rose, Windschitl, and Smith (2013) measured the degree to which respondents felt they might die during the tornado. Although this type of experience likely correlates with emotional impacts, it is more specific in what it captures regarding the content and timing of one's emotional impacts. Weinstein, Lyon, Rothman, and Cuite (2000a) explored multiple new ways of measuring one's experience with the impacts of a tornado, including what they term as "problems later" (life disruption, losing electricity, or having one's workplace closed), "recent reminders" where one witnesses the aftermath of a hazard (damaged areas, crews cleaning, etc.), and different types of "social interaction" following the event (volunteering, having contact with victims, and talking with others). In the flood context, Siegrist and Gutscher (2006) also measured whether people have helped clean up damages caused by a flood, but interestingly they did not classify this as experience (they did measure other types of experience, though). Finally, in a flood-related study, Keller et al. (2006) aimed to measured media-related experience by asking people whether they have seen flooding events on television.

They dropped this item based on pretest data, however, because they found that nearly everyone had this type of experience.

In addition to *what* measures of past experience that researchers have employed, *how* they have used these measures is also of interest. Most researchers measured and used one type of experience in their data analysis, or they measure more than one type of experience but then arbitrarily selected and used only one of them (e.g., Blanchard-Boehm & Cook, 2004; Drost, 2013; Grothmann & Reusswig, 2006; Hoekstra et al., 2011; Kellens et al., 2001; Mulilis et al., 2003). Other researchers measured two or more types of experience and then utilized each measure separately in their data analysis (Peacock et al., 2005; Suls et al., 2013). Only a few researchers measured multiple types of experiences, but in all cases they either averaged or summed them to create an experience scale (Greening & Dollinger, 1992; Greening et al., 1996; Lindell & Hwang, 2008; Mishra & Suar, 2007; Perreault et al., 2014; Trumbo et al., 2011; Weinstein et al., 2000a).[4] Weinstein et al., created multiple summed scales based on the experience dimensions they conceptualized as noted above (problems later, recent reminders, etc.). In none of the studies reviewed, however, did it appear that researchers aimed to broadly conceptualize experience, develop representative items, and then explore what latent dimensions emerged inductively.

In summary, Table 1 and the associated discussion illustrate that past experience has been measured in a variety of ways in the context of weather risks. The vague measure of whether or not one has experience with a hazard is commonly used, as well as measures of sensory experiences (e.g., witnessing the hazard) and impacts associated with experience, particularly property damage and injury. Measures are increasingly being developed and used that begin to

[4] Moreover, the "storm experience" scale created by Perreault et al. (2014) included seven items specific to tornadoes but also three items about experiences with other types of weather hazards.

capture people's interpretation of the experience (e.g., emotional impacts, severity of impacts), but there is room for conceptually exploring more of these experiential aspects. Also, although other aspects of people's experiences are beginning to be considered—including their experiences in the time leading up to and during the event (e.g., with watches and warnings, fear of dying) and other types of impacts (e.g., delayed impacts, witnessing the aftermath, and social interaction)—more can be investigated, especially regarding people's experiences with a hazardous weather threat in the time period leading up to when the event might occur as well as during it. Finally, a more nuanced and less prescribed approach to identifying what are the important dimensions of people's past experiences may help conceptually and theoretically advance understanding of this construct. This leads to the first research question of this study:

$RQ_1$: What are the dimensions of past hazard experience in the context of tornadoes?

**Empirical Relationships between Experience and Risk Perception**

In discussing experience and risk perception, Peacock et al. (2005) smartly noted that "The nature of the experience may also be an important factor shaping risk perceptions … all experience may not be equal with respect to risk perception" (p. 123). Indeed, this idea is supported by the varied findings reported in Table 2, which provides a synthesis of the empirical findings of the relationships between past experience measures and risk perception. The "may not be equal" notion also can be extended to risk perception because, as with experience, it has been measured in a variety of ways. The heterogeneous ways of measuring both concepts and the resultant relationships between them, shown in Table 2, is further discussed here.

Table 2. *Summary of empirical relationships between past experience and risk perception from studies of weather risks*

| Experience measure | Relationship with Risk Perception | References |
|---|---|---|
| Past personal experience with an event | Negative relationship (with higher levels of knowledge as moderator)<br>- RP measured as likelihood of ignoring a tornado warning | Drost, 2013 |
| | Negative relationship<br>- RP measured as probability of a major tornado occurring in respondents' geographic area | Mulilis et al., 2003 |
| | Negative relationship<br>- RP measured as perceived riskiness of hypothetical hurricane scenario | Matyas et al., 2011 |
| | No relationship<br>- RP measured as perception that the area would be affected by a flood | Adelekan, 2011 |
| | No relationship<br>- RP measured as likelihood of 3 consequences (major damage to their homes, injury to self or household members, health problems to self or household members) of floods and hurricanes | Peacock et al. 2005 |
| | Positive relationship<br>- RP measured with 5 cognitive-affective items about floods | Kellens et al., 2011 |
| Amount of experience | Negative relationship<br>- RP measured as chance of *dying* in a lightning storm if at a picnic when a lightning storm strikes | Halpern-Felsher, 2001 |
| Property damage | Positive relationship<br>- RP measured as likelihood of 3 consequences (unable to work, disrupt daily activities, home damage) of hurricanes | Peacock et al., 2005 |
| Involved in cleaning up damages | Positive relationship<br>- RP measured as perceived probability of considerable flood damage in respondent's residential zone | Siegrist & Gustcher, 2006 |
| Emotions associated with an experience | Significant relationship<br>- positive emotions associated with less perceived dread (RP) | Terpstra, 2011 |
| | Inconsistent relationships across studies of how positive emotions relate to perceived consequences and perceived likelihood | Terpstra, 2011 |
| Sum of 2 experience items, one direct and one indirect | Positive relationship<br>- RP measured as perceived riskiness of floods | Keller et al., 2006 |
| (e.g., personal property damage + others harmed from flood) | Positive relationship<br>- RP measured as perceived probability of considerable flood damage in respondent's residential zone | Siegrist & Gustcher, 2006 |

| Experience measure | Relationship with Risk Perception | References |
|---|---|---|
| Sum of 3 experience items: experience with a hazard + experience evacuating + damage | Positive relationship<br>- RP measured as probability of flooding | Botzen et al., 2009 |
| | Positive relationship<br>- RP measured as likelihood of 3 consequences (unable to work, disrupt daily activities, home damage) of hurricanes | Trumbo et al. 2011 |
| | Negative relationship<br>- RP measured as expected flood damage | Botzen et al., 2009 |
| Sum of multiple (4+) experience items capturing direct and indirect experiences (e.g., witnessing event, property damage or other loss, injury, witnessing others' injury/death, and knowing others affected) | Positive relationship (*Greening et al., 1996, later illustrated this relationship was mediated by the simulation heuristic)<br>- RP measured as likelihood of fatality due to tornado | Greening & Dollinger, 1992<br>*Greening et al., 1996 |
| | Positive relationship<br>- RP measured following psychometric paradigm with 9 items about floods | Mishra & Suar, 2007 |
| | Positive relationship<br>- RP measured as likelihood of 3 consequences (major damage to their homes, injury to self or household members, health problems to self or household members) of floods and hurricanes | Lindell & Hwang, 2008 |
| | Positive relationship<br>- RP measured as likelihood of 3 consequences (unable to work, disrupt daily activities, home damage) of hurricanes | Trumbo et al. 2011 |

It is most common for researchers to examine the influence of past hazard experience on risk perception with experience measured in the single, vague way of whether or not one has past experience. Not surprisingly, when experience is measured in this way, the relationship with risk perception is inconsistent, with different studies showing negative, null, and positive relationships. Drost (2013) attempted to explain the negative relationship he found between students' tornado experiences and risk perception by invoking the availability heuristic, specifically as "the possibility of the students discounting the apparent danger and relying on the greater availability of relatively harmless past experiences" (p. 49). In other words, he is assuming that the students' tornado experiences, which 47% reported having, were relatively harmless. Although this assumption may be true, measuring experience more specifically would

inform whether this interpretation is accurate and why. Interestingly, in the one study reported here in which a positive relationship was found between risk perception and people who have past experience, the former was measured in more nuanced ways, with multiple items that captured cognitive and affective aspects (Kellens et al., 2011).

The influence of other single types of experience on risk perception also has been explored. The experience attributes are varied and include the amount of experience, property damage, volunteer clean-up, and emotions experienced. Halpern-Felsher et al. (2001) measured the amount of experience, specifically in the context of experience with lightning storms, and found that people with more experience had lower risk perception. Importantly, though, risk perception was measured as one's perceived chance of *dying* in a lightning storm if at a picnic when a lightning storm strikes. The authors' interpretation was that people's experiences may help calibrate a risk behavior-outcome link in a Bayesian way that might reflect a more accurate objective risk assessment. They note that:

> Once individuals engage in a risk behavior and do not experience the negative outcome, which is most often the case, they may perceive the behavior-outcome link as lower than originally thought, providing lower and perhaps more realistic appraisals regarding their chance of risk. Given this, it is plausible that non- or less-experienced individuals may be overestimating risk, relative to their more experienced counterparts, rather than engagers underestimating their risk. (p. 124)

More generally, this study illustrates the importance of knowing the details of the various risk perception measures used and how they are worded when interpreting the results.

In other studies, Peacock et al. (2005) found that experience with past property damage increased perceptions of the likelihood of hurricane consequences (including damage to one's home). Siegrist and Gutscher (2006) found that experience volunteering to help clean up damages after a flood increased perceptions of the probability of flood damages. In both of these studies, there is correspondence between the nature of the single experience item measured and

the risk perception measure—i.e., experience with damage as it relates to perceptions of possible future damage. Weinstein (1989) discussed considering the correspondence between past experiences and future behaviors, but this notion arguably extends to risk perception as well, especially in cases as these where single, specific aspects of people's experiences are measured.

Terpstra (2011) also measured a single type of past experience, specifically of people's emotions associated with a past flood. He conducted two studies in which he drew on the affect heuristic to assess the hypothesis that if negative affect associated with a past experience increases risk perception, then positive affective associations should decrease it. He examined three aspects of flood-related risk perceptions: dread, perceived consequences, and perceived likelihood. In both studies, he found that people with positive emotions associated with a past flood felt less dread. This result again represents a correspondence between the type of experience and risk perception. There were inconsistent relationships across the two studies in the influence of experience on perceived consequences and likelihood. In the second study, Terpstra also aimed to better understand the emotions people felt by asking the participants who had past flood experience to verbally describe their associated negative and positive feelings with up to three words for each. Fear, powerlessness, and helplessness were the most common negative feelings expressed. These were followed by expressions of damage, casualties, difficulties, worries and stresses, uncertainty, and pity and sadness. The most common positive feeling expressed was that of solidarity (togetherness and unity). These were followed by expressions of care, aid, help, relief, and being impressed by the beauty and force of nature.

Several researchers have measured two or three types of experience that they summed for analysis. Both Botzen et al. (2009) and Trumbo et al. (2011), who respectively studied floods and hurricanes, employed three measures of personal experience: general experience with a

hazard (existence or amount), experience evacuating for that hazard, and property damage due the hazard. Trumbo et al. notes the set was intended to measure "three degrees of hurricane impact" (p. 1912). The three-item experience scales were shown to be associated with greater perceived likelihood of consequences from a hurricane (Trumbo et al.), and greater perceived likelihood of future flooding but lower perceived damages from flooding (Botzen et al.). Botzen et al. explain the unexpected latter result due to the fact that "practically none of the respondents who have experienced a flood or have been evacuated have actually suffered any damage" (p. 12).

Keller et al. (2006) and Siegrist and Gutscher (2006) also employed two items, one measuring personal experience (e.g., property damage) and the other measuring indirect experience (e.g., others harmed). Keller et al. found a positive relationship between these experience measures and perceived riskiness of floods, and they invoked the affect heuristic as the explanatory mechanism by indicating,

> we can assume that people who experienced past flooding events had images that were tagged with affect … Persons who stored images or narratives about floods in their memories perceived the same probability information differently from people without such memories" (p. 636).

Siegrist and Gutscher (2006) showed that people's risk perception is more strongly influenced by their own experiences versus their actual, "objective" flood risk, which they controlled for. They noted that, "apparently, the immediacy and closeness of flooding as a negative experience was crucial" (p. 977), and they invoked the availability heuristic as an explanation.

Only a few researchers have utilized multiple items to measure experience and examine the consequent relationship with risk perception. Lindell and Hwang (2008) and Trumbo et al. (2011) each used 4 measures, Mishra and Suar (2007) used 9, and Greening and colleagues (1992; 1996) used 13. In all cases, the measures were a combination of varying items that

captured both direct and indirect experiences, and they were summed into a scale. A positive relationship with risk perception was found in all of the studies, despite the varying hazard contexts and risk perception measures used. In the research conducted by Greening and colleagues, the authors examined experiences with and judgments about multiple types of risks. They first showed that participants' tornado experiences increased their perceived likelihood of someone like them dying in a future tornado (Greening & Dollinger, 1992). Subsequently, they empirically tested both the availability heuristic and the simulation heuristic as possible mechanisms for the experience-risk perception relationship. They found support for the simulation heuristic, and their interpretation was that "personal experience with a lethal event enhanced one's ability to mentally simulate the risky outcomes for weather disasters, and thereby heightened the adolescents' perceived personal risks" (Greening et al., 1996, p. 36).

As discussed earlier, many researchers have speculated that direct experiences will relate to risk perception differently from indirect experiences, but interestingly, this was not assessed in the studies summarized in Table 2. Even when direct and indirect experiences were measured, in all cases, whether with two or more items, the researchers decided to collapse them into a single scale. Thus, the possible different influences of direct versus indirect experiences could not be ascertained.

The results of the empirical studies reported in Table 2 on balance support a positive relationship, whereby past hazard experience increases risk perception. The negative and null relationships tend to be the studies in which experience is measured simplistically as whether or not respondents have experienced a hazard, although other negative or inconsistent relationships were found as well. Still, the question of how experience relates to risk perception persists because of the inconsistent and arbitrary ways that experience is measured and analyzed. The

varying risk perception measures also are problematic; although most of the measures reported in Table 2 fall within the different ways that risk perception has been conceptualized, in only a couple studies has the increasingly accepted dual-mode, cognitive-affective risk perception approach been examined. This leads to the second research question of this study:

$RQ_2$: How do the emergent dimensions of past tornado experiences relate to people's tornado risk perception, specifically cognitive-affective risk perceptions?

# CHAPTER 3: RESEARCH APPROACH, DESIGN, AND ANALYSIS

This chapter describes the research approach, design, and analysis in three main sections. The first section covers the theoretical and methodological underpinnings of scale development generally and as it applies to this research for explicating past tornado experience. The second section covers the sampling, design, and data collection methods for the two surveys of the public. The final section covers the data analytic procedures for the two research aims to develop the past tornado experience scales and subsequently relate them to risk perception.

## Scale Development

The literature review in the previous chapter illustrates that past weather hazard experience has been measured in various and inconsistent ways. The lack of focused attention on conceptualizing and operationalizing experience as a concept has ramifications for how it has been shown empirically to relate (or not) to risk perception. DeVellis (2012) describes the implications of such measurement problems generally as: "An unfortunate but distressingly common occurrence is the conclusion that some *construct* is unimportant or that some *theory* is inconsistent based on the performance of a *measure* that may not reflect the variable assumed by the investigator" (p. 13, emphasis in original). Accordingly, the first-order goal of this dissertation is to develop a content valid scale of past tornado experiences that identifies what its dimensions are.

The scale development theory and methods employed here largely follow DeVellis (2012). The ideas and steps of scale development are consistent, however, with the communication research text by Chaffee (1991; see also Babbie, 2007) on concept explication, which he describes as "an intellectual process to be applied to any concept one intends to make

the focus of planned research" (p. vii). That intellectual process involves identifying a focal concept, reviewing the literature, analyzing the meaning of the concept, developing a working definition of it, examining how it has been empirically operationalized, and then iterating through the steps again as needed. Indeed, scale development can be thought of as one specific approach to concept explication.

A scale is a collection of items, or measures, combined into a composite score that is "intended to reveal levels of theoretical variables not readily observable by direct means" (DeVellis, 2012, p. 11). Simply put, a scale represents a latent variable. A latent variable is one that is not directly observable (is latent) and is not constant (is variable) across people or contexts. Because it cannot be observed directly, instead it is measured with items that are indicators of the variable as proxies for it. Importantly, the latent variable, therefore, is deemed as the cause of the item score such that "the strength or quantity of the latent variable (i.e., the value of its true score) is presumed to cause an item (or set of items) to take on a certain value" (DeVellis, 2012, p. 19).[5] The direct causal relationship between the latent variable and an item further means that there is a correlation between the item and the latent variable's true score, and that a set of items that correlate with the latent variable also correlate with each other. The true score of the latent variable is immeasurable, so statistical relationships between it and a given item cannot be calculated. However, statistical relationships can be calculated among the items that are all caused by the latent variable. This theoretical assumption is the foundation for statistically evaluating a set of items to determine: (1) what, if any, latent variables underlie them

[5] DeVellis (2012) differentiates a "scale" from an "index", which is another type of multi-item composite score. Whereas a scale consists of conceptually related items whose scores are *determined by* a latent variable, an index consists of items that *determine* the level of some outcome variable. DeVellis uses as an example of an index items that might measure a presidential candidate's appeal. Measures of the candidate's attractiveness, financial resources, family size, and ability to inspire campaign workers might be combined into a score. The score might not be *determined by* a common, underlying variable. Rather, the score might *determine* some other outcome, such as likelihood of a successful presidential campaign.

(primarily determined with common factor analysis); and (2) the extent to which the variance in the observed set of items is due to the latent variable's true score (i.e., is reliable), estimated as the variance that is shared, or common to the latent variable (calculated as Cronbach's alpha). These data analytic procedures are further discussed later in this chapter.

An essential complement to the above foundation for scale development is whether it is content valid, i.e., whether the set of items covers the range of meanings included within the concept (Babbie, 2007; Hayes, 2005; DeVellis, 2012). Implicit in this is the need to define the concept of interest because, as DeVellis (2012) notes, content validity and the definition are "intimately linked" such that "a scale's content should reflect the conceptual definition applicable *to that scale"* (p. 60, emphasis in original). The remainder of this section, therefore, provides a detailed definition of past tornado experiences to establish its conceptual contours specific to this study. Subsequently, the measures are presented that were developed to operationalize the concept as defined.

**Past Tornado Experiences: Conceptual Definition**

The following conceptual definition was created, drawing from the literature review (Chapter 2) and from personal knowledge, to guide the scale development:

> Past tornado experience consists of the perceptions one acquires about the conditions associated with or impacts of a prior tornado event. Such perceptions are gained by (a) the occurrence of a tornado threat (something that might happen; a hazard) and/or event (a threat manifested) (b) directly by oneself or indirectly through others (c) at different points along the temporal continuum of the threat and event. Past tornado experience can

be of varying impact and (d) can occur at any point in one's life, from the distant past to more recently, and (e) can occur more than one time.

Elaborating on parts of the above definition:

Experience is defined as one's perceptions to differentiate it from a factual understanding of a phenomenon. Per (a), because experience is acquired by the occurrence of a threat and/or event, it differs from knowledge formally acquired through education or training. Per (b), direct experience is that which is acquired through one's own, unmediated participation in the threat and/or event. Indirect experience is that which is mediated by reading, viewing, or hearing information about conditions or impacts from others, including personal networks of family, friends, co-workers, and other acquaintances and other sources such as community leaders, news media, and experts from governmental, non-governmental, and private sector agencies. For example, seeing a tornado in person is a direct experience because it is unmediated, whereas seeing a tornado on television or via the Internet or hearing about it from someone else is indirect because it is mediated. Per (c), tornado experiences can occur before, during, or after the threat and/or event. Because hazardous weather events, including tornadoes, have some predictive skill, people can acquire experiences before an event has occurred when it is threatening, including the time during which there are forecasts (outlooks, watches, etc.) for an event. Experience can also be acquired while an event is occurring, including the time during which there is a warning or any visual, auditory, or tactile sensory input indicative of the event conditions (e.g., sirens, funnel, tornado, greenish clouds, hail, heavy rain, thunder, lightning, "sticky"/humid atmosphere) or impacts (e.g., seeing debris). Finally, experience can occur after the event. As with the traditional disaster management cycle

(with the phases of mitigation, preparedness, response, and recovery), the before, during, and after stages can overlap (e.g., Lindell, 2011).

**Past Tornado Experiences: Operationalization and Measurement Construction**

The operationalization of past tornado experiences was an iterative process that tacked between the above conceptual definition and the development of the items, many of which were based on experience measures employed in other studies (Chapter 2), as well as other related literature. These are discussed further below. In addition, the author's personal research experience conducting interviews with tornado survivors, including relatives and neighbors of those killed, following the 2008 Super Tuesday tornado outbreak (NOAA, 2009) also informed the item development.

One's past tornado experiences can come in many forms. For this initial effort at developing a valid experience scale, items were developed to measure two "classes" of past tornado experiences. The first class is one's most memorable tornado experience, which goes to part (d) of the definition that experience can occur at any point in one's life. Such an experience is, by nature, memorable and conceivably is vivid and concrete, making it relevant for scale development. Indeed, Lave and Lave (1991) found when eliciting people's mental models of floods that the salient experience participants discussed was their most memorable flood experience—which tended to be the largest or most destructive flood—rather than the most recent flood experience. The second class are the multiple tornado experiences one has, which goes to part (e) of the definition that experiences can occur more than one time. This was an attempt to investigate whether the quantity of people's experiences has a quality of its own and to identify which attributes are important in aggregate. For each of these two classes of past

tornado experiences, items were developed that aimed to address and measure experiential aspects pertaining to parts (a) through (c) of the definition. A synthesis of these items is provided here, but the full set of items and their related references are provided in Appendix A.

To gather data on one's most memorable experience, the survey question was structured with the follow instruction and explanation:

> Please think about your most memorable tornado experience. That experience may have happened to you personally, or you may have learned about the experiences of another person (or other people). It may have been a time when a tornado actually occurred or when there was just the possibility a tornado might occur. It may have occurred a long time ago or more recently.

Questions about the factual characteristics of that experience were developed to measure to whom it happened, whether a tornado occurred, and when it happened. On Survey 2, if the memorable experience happened to other(s), an additional question measured the approximate physical distance between them and the survey respondent. The rest of the most memorable experience measures were structured as a statement, and the respondent was asked as it pertained to his or her most memorable experience to report how true each statement was on a four-point scale with response options of "not at all," "a little," "somewhat," and "a great deal"; a "not applicable" option also was provided.[6]

Items were developed to capture the tornado threat before it manifested as well as when the tornado event materialized, per part (a) of the definition. Respective examples include, "I was concerned about the threat of tornadoes that day" and "I saw the tornado or funnel cloud firsthand." Items also were created to measure direct, unmediated experiences as well as indirect experiences through mediated information from others, per part (b) of the definition. Respective examples include "I had damage to my property (e.g., home, trees, car)" and "People I know had

[6] Four response options were used to capture variability in responses while having options that the respondent could discriminate meaningfully and not having a neutral middle category (DeVellis, 2012; Dillman, Smyth, & Christian, 2009). Similar four-item response options have been used in other experience scales (see, e.g., DiPietro et al., 2008).

damage to their property (e.g., home, trees, car)." Lastly, items were developed to capture experiences across the time leading up to, during, and after the tornado threat, per part (c) of the definition. Respective examples include "The air felt unusual that day (e.g., humid, calm, electric)," "I tried to get to my loved ones to be with them (or they tried to get to me)," and "I saw scenes of the aftermath firsthand (e.g., damaged areas, downed trees, people injured)." The measures of experiences leading up to and during the event expand upon the limited ways these aspects have been previously measured, as discussed in Chapter 2.

Theoretical literature on fear responses to media entertainment (Valkenburg & Buijzen, 2008) was used to guide development of some of the items intended to denote experiences gleaned indirectly through the (non-entertainment) media (Appendix A). For example, the item "There was news coverage (on radio, TV, or online) about the threat of tornadoes that day" is a media-induced experience that occurs via a negative information transfer pathway, which is when viewers hear information about a danger or threat of danger. Another example, which represents a mediated experience during an event, is the item "I heard or saw live news coverage (on radio, TV, or online) of the tornado as it was happening," which in an experience that is gleaned via the observational learning pathway where one vicariously observes the results of a danger to victims.

Experience items also were informed by and expanded upon some of the novel measures discussed in Chapter 2 (see Table 2, Appendix A). For instance, items were included that measure fearing for one's life (following Suls et al., 2013) as well as fearing for loved ones. Following Weinstein et al. (2000a), items were designed to measure multiple unmediated sensory experiences during the event (i.e., seeing firsthand the tornado, seeing other storm scenes, hearing storms sounds) as well as items designed to capture different types of post-event

"social interaction" experiences, such as talking about the experience and volunteering. Other items to measure experiences in the aftermath of a tornado were designed following the revised Impact of Event Scale (IES) (Horowitz, Wildner, & Alvarez, 1979; Christianson & Marren, 2013; Weiss & Marmar, 1997). Specifically, experiences pertaining to the intrusion dimension were measured, drawing from items such as "I had trouble staying asleep and/or had dreams about it" and "I thought about it when I didn't mean to."

To gather data on one's multiple tornado experiences—specifically, the amount of experience they have with different aspects—a survey question was structured with the following text:

> People can have multiple experiences with tornadoes over the course of their lifetime. Please think about all of your experiences with tornadoes, and indicate how much experience you have with each of the statements listed below.

Respondents then were provided with a set of statements and asked to indicate how much experience they have on a four-point scale with response options of "no experience," "a little experience," "some experience," and "a great deal of experience." This experience question was designed following other studies where multiple experience scales were developed, including multiple experiences with combat (Guyker et al., 2013) and spirituality (Underwood & Teresi, 2002). The items mirrored those that were developed to measure one's most memorable tornado experience (Appendix A). Examples include, "I have been threatened by a tornado," "I have taken shelter from a tornado," and "I have seen news coverage about the aftermath of a tornado."

The most memorable and multiple tornado experience items were designed to cover the different parts of the conceptual definition—i.e., the threat and event, unmediated and mediated experiences, and the periods before, during, and after the event. Each of those parts is a continuum, however, thus some of the items developed do not necessarily capture one thing. For

instance, the item "People talked to me about what they experienced" may capture both a mediated and unmediated experience. Moreover, the items overlap in the ways and degrees to which they capture the different parts of the definition. In other words, the conceptual definition provided an important framework for bounding and developing the past tornado experience items, but how the items ultimately cluster were identified through an exploratory analysis of the underlying latent variables that cause them and not a priori based on the definition.

## Survey Methods

This section describes the methods used for the two public surveys that provided the data for this research. The survey development is described first, followed by the sampling approach, and then the mixed-mode survey design and implementation, all of which pertain to both surveys, with any differences noted. The fielding, sample, and data preparation details specific to Survey 1 are then discussed, followed by the details of Survey 2. Finally, the sample characteristics of the two surveys are summarized.

All aspects of the survey research were approved by Colorado State University's Research Integrity & Compliance Review Office (CSU RICRO) and by the National Center for Atmospheric Research's Human Subjects Committee (NCAR HSC).

### Survey Development

Here, the development of Surveys 1 and 2, respectively provided in Appendices B and C, is briefly discussed. Survey 1 was used to evaluate the initial set of experience items that were developed and to elicit additional aspects of their experiences in their own words. Survey 2 was used to evaluate the revised set of tornado experience measures, based on the Survey 1 results,

and to evaluate how the final experience dimensions influence tornado risk perception. All survey questions discussed pertain to both surveys unless otherwise indicated.

The surveys began with questions about people's past tornado experiences, first pertaining to their most memorable tornado experiences and then to their multiple experiences, as described in detail above. On Survey 1, after asking people to think about to whom the most memorable experience happened, whether a tornado occurred, and when it happened, a two-part open-ended question asked respondents to describe the experience with a focus on what they remember most clearly and their feelings about it as well as how the experience has changed how they think about future tornado risks. This was the only open-ended question on the survey, and it was to elicit people's experiences in their own words. These qualitative data were analyzed to identify important experiential aspects that were not captured in the items developed for the first survey. Accordingly, a handful of items were added to the second survey, as discussed in Chapter 4. This open-ended question was not included on Survey 2. As also discussed in Chapter 4, several of the experience items were dropped from Survey 2 based on the data analysis from Survey 1.

Next, data were collected on tornado risk perception. As discussed in the literature review, risk perception has been conceptualized and measured in various ways. Through the work of Paul Slovic and colleagues who connected their classic psychometric paradigm research (Fischhoff, Slovic, Lichtenstein, Read, & Combs,1978) with Epstein's (1994), individual-level risk perception increasingly is considered as a dual-mode phenomenon consisting of a logical, slower cognitive system and an intuitive, faster affective system that operate in parallel (Slovic, 2010). Trumbo et al. (in review) built on this work and on the affect-focused research by Västfjäll, Peters, and Slovic (2008) to develop and evaluate a cognitive-affective scale for

hurricane risk perception. The scale was applied here to measure tornado risk perception. Example items include "I can control being physically harmed by a tornado" and "Thinking about the possibility of a tornado makes me feel dread." To the author's knowledge, this is the first study that has measured people's dual-mode, cognitive-affective risk perceptions in the context of tornadoes.

Another question asked about respondents' sheltering options if a tornado threatens. Then demographic data were gathered on age, gender, zip code, length of residence in areas at risk of tornadoes, household size including number of children in the home, dwelling type, education, employment status, race, ethnicity, and income. The final two survey questions gathered data on dispositional optimism using the Life Orientation Test-Revised (Scheier, Carver, & Bridges, 1994), and on locus of control using the Internal Control Index (Duttweiler, 1984). Dispositional optimism and locus of control are stable personality traits that can influence how one evaluates a risk, thus they are included as covariates. Dispositional optimism is one's global outlook that he or she will have more positive than negative events in life (Burke, Joyner, Czech, & Wilson, 2000). It is a reflection of a general positive attitude. Persons high in dispositional optimism are thought to have lower risk perception and vice versa (Radcliff & Klein, 2002). Indeed, Trumbo et al. (in review) have shown this relationship in the natural hazard context of hurricanes. Locus of control refers to whether one considers the occurrence of events and outcomes to be influenced by one's own actions (internal orientation) or as largely influenced by outside forces, such as other people or chance (external orientation) (Rotter,1966). Persons with an internal control orientation are thought to have lower risk perception and vice versa (Kallmen, 2000; Nordgren, van der Pligt, & van Harrevel, 2007). This relationship, too, has been supported in the hurricane context by Trumbo et al. (in review).

All questions that were newly developed for this survey followed recommended guidelines for content, structure, and visual formatting (Dillman, Smyth, & Christian, 2009). The risk perception, dispositional optimism, and locus of control questions replicated past work. The demographic questions replicated those on the American Community Survey. Prior to fielding, the surveys were pretested in person using think-aloud cognitive interviews with volunteers (five people across the two surveys) who had previously lived in the geographic sampling area (Dillman et al., 2009). The pretests helped identify problems with question wording, content, response options, and order. For instance, based on feedback from one volunteer who was young when their most memorable experience happened and from another volunteer who spoke of protecting her child, one survey item was changed from "I tried to get my family to safety" to "I tried to take action to protect myself or my loved ones (or someone tried to protect me)." Each pretest volunteer was paid $50 for his or her time.

A simple readability assessment was done prior to fielding the surveys, and both were shown to be readable with Flesch-Kincaid grade levels of 6.3-6.9.

**Sampling Approach**

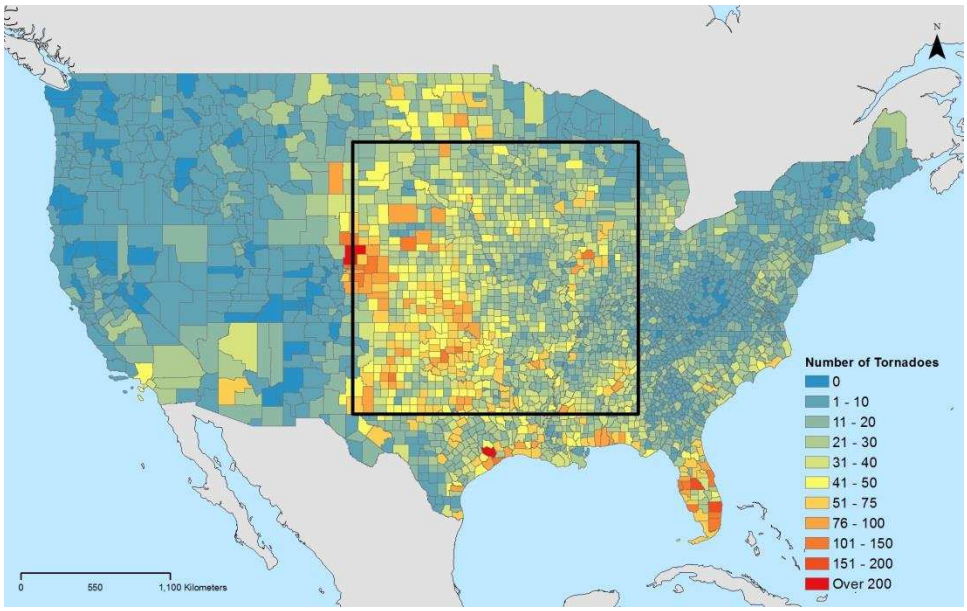
Because of the study focus on tornado risks, the target population was people in the United States who reside in areas where tornadoes occur. To identify the specific tornado-affected area for the study, tornado occurrence data from the National Weather Service's Storm Prediction Center were mapped using Geographic Information System software. Data were from the period from 1950 through 2012, which is the latest year that data were available at the time of the sample area selection. Tornadoes of all intensities, from (E)F0 through (E)F5 strength,

were included.[7] Weak tornadoes occur more commonly than do strong ones, and they occur more commonly occur in areas where strong tornadoes are rare (Ashley, 2007, Figure 6), which affects the geographic distribution of tornado occurrence. Weak tornadoes were included so as not to impart any meteorologically based biases. They also were included so as not to make assumptions about individuals' tornado experiences based on event magnitude, because people's experiences with an EF0 tornado may be profound and have an influence their tornado risk perception. Thus, areas where weak tornadoes are more prevalent were included in the geographic sampling decision-making.

The distribution of tornado frequency, mapped at the county level to match the geographic scale for sampling, is shown in Figure 1. Counties with fewer tornadoes are shown in greater detail to aid decision-making about sampling the lower-end frequency areas. Using this map, the rectangular bounding box comprising the sample area was selected (Figure 1a) such that it captured (1) the high frequency of tornadoes in eastern Colorado, (2) the bulls-eyes in Alabama and Illinois, (3) tornado activity in the south without getting too close to the coast where tornadoes may be influenced by, and potentially conflated with, hurricanes, and (4) tornado activity in the north without also capturing too much low-frequency area or crossing international borders. All counties that were 100% inside this box were selected for sampling (Figure 1b), resulting in 1242 counties in 20 states (AL, AR, CO, IA, IL, IN, KS, KY, LA, MI, MN, MO, MI, NE, NM, OK, SD, TN, TX, WI). Although large, this sample area provides considerable variability in tornado frequency, especially with its east and north borders that capture active tornado areas as well as less active areas in-between bulls-eyes, thereby hopefully providing heterogeneity in the experiences of people sampled.

[7] The Fujita-scale (F-scale) of tornado damage intensity was replaced with the Enhanced-Fujita scale (EF-scale) and made operational in 2007.

(a)




(b)

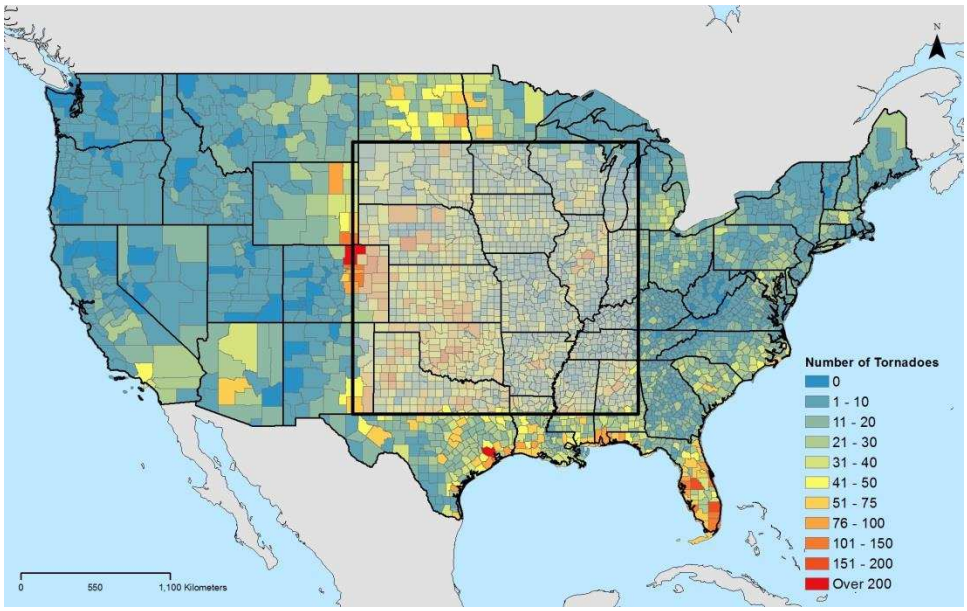



*Figure 1.* Sample area of the study based on (a) frequency of tornado occurrence data (1950-2012) mapped by county and bounding box, and (b) counties fully inside the bounding box, colored in grey, to identify final sampling area.

Both surveys were implemented using a mixed-mode approach, discussed further in the next section, which involved contacting people by postal mail. This approach leverages the address-based sampling (ABS) frame from the U.S. Postal Service's Delivery Sequence File

(DSF). This frame is a list of all U.S. addresses that receive mail delivery from the U.S. Post Office along with accompanying information that differentiates business and residential addresses (Dillman et al., 2009). This frame provides nearly complete coverage of U.S. households, including addresses without any phone and those with cell phones only. For both surveys, random address-based samples from throughout the sample area were purchased from Survey Sampling International (SSI).[8] Details of the samples for Surveys 1 and 2 are discussed further in the respective sections below.

**Mixed-Mode Survey Design and Implementation**

Internet-based surveys, where respondents are invited via e-mail to respond to a Web survey, are appealing for their cost savings and the ability to collect data within a shorter period of time as compared to mail surveys. Significant challenges associated with Internet-based surveys exist, however, including low coverage, lack of a complete sampling frame, ethical considerations, and poor response rates (Couper, 2000; Manfreda, Bosnjak, Berzelak, Haas, & Vehovar, 2008; Smyth, Dillman, Christian, & O'Neill, 2010). Regarding coverage, despite increasing broadband Internet penetration only 62% of adults living in rural areas had broadband access at home as of May 2013 (Pew Research Center, 2013).[9] In addition to the coverage problem posed by Internet-based surveys, no complete sampling frame of e-mail addresses exists for sampling Internet users. Moreover, without a preexisting relationship with the e-mail recipient, it is considered unethical to e-mail people with a survey request because Internet access is not considered a public utility in the same way as landline telephones or addresses. For

[8] SSI supplements the DSF with data from other commercial database and consequently boasts coverage of approximately 95% of households (SSI, 2014).
[9] Rural areas tend to be defined as people living in counties that do not contain any portion of a metropolitan statistical area (MSA). Much of the target area falls outside an MSA and therefore is considered rural.

these reasons, conducting an exclusively Internet-based survey for this research could potentially exclude a substantial proportion of the target population, thereby introducing coverage error.[10] Still, because of the positives that Web surveys potentially offer in cost savings and shorter data collection times, research is continually being conducted to assess and improve its viability. In particular, research is being conducted on mixed-mode surveys in which the Web mode is combined with another mode, such as mail or phone, to reach people (Converse, Wolfe, Huang, & Oswald, 2008; Messer & Dillman, 2011; Millar & Dillman, 2011; Smyth et al., 2010).

One mixed-mode approach is with a mailed (postal) letter that includes a request for recipients to respond by Web but with a paper survey mailed later for people who either cannot or prefer not to respond via the Web. This mixed-mode approach has been shown as successful when using the aforementioned ABS to draw the sample and when following the Dillman Tailored Design method with multiple contacts, including a prenotice letter, survey invitation letter, reminder postcard, and final contact with replacement survey. This approach helps reduce coverage and nonresponse error, and it also allows for providing a cash incentive with the initial invitation letter.[12] The mixed-mode survey approach, when using ABS sampling and following these other research-based survey guidelines, has produced overall response rates between 43-55% (Messer & Dillman, 2011; Smyth et al., 2010). Moreover, Smyth et al. (2010) showed that this approach is effective even in small towns and rural communities, of which the sample area for the research conducted here is largely comprised. Because this mixed-mode approach allows for quicker Web responses but also reaches people without Internet access and because it produced strong response rates even in rural areas, it is followed here for both surveys.

[10] Coverage error occurs when not all members of a survey population have an equal or known chance of being sampled for survey participation, and when those who are excluded differ from those who are included (Dillman et al., 2009). Coverage error is considered a significant threat to inference from Web surveys (Couper, 2000). Nonresponse error is when a significant number of people who have important different characteristics from the rest of the sample do not respond (Dillman et al., 2009),

The online survey company QuestionPro (www.questionpro.com) was used for the Web survey. Specifically, the Corporate edition was used because two key features it offers are: (1) unique respondent access codes, which control survey responses by restricting access to only those who are invited, and (2) custom survey Web addresses, which can be made topic-specific and simple, which is especially important when respondents must manually type in a Web address. For Survey 1, the Web address used was "tornadoes.questionpro.com," and for Survey 2, it was "twisters.questionpro.com." The author managed all programming, testing, and data collection of the Web survey.

The mail and Web surveys were designed following guidelines for mixed-mode surveys (Dillman et al., 2009; Smyth et al., 2010). Survey questions were asked in the same order. Also, because different visual presentations and layouts can lead to different survey results (Dillman et al., 2009), these aspects were designed to be similar across modes (e.g., with similar sponsor logos; one-column question format; and question typeface, shading, structure) (Figure 2). To emulate the manner in which the mail survey respondents could complete the survey, Web survey respondents were not required to answer questions, and they were allowed to stop the survey and return to complete it at later time (Dillman et al., 2009).

## Mail

NCAR Colorado State University

**Your Thoughts and Opinions about Tornadoes**

The purpose of this survey is to learn your thoughts and opinions about tornadoes, including your experiences with them. You do not need any special knowledge about tornadoes or weather forecasts to answer the questions.

Your responses will be used to better understand how people perceive and respond to tornadoes. This research will help improve weather forecasts in ways that can help protect people's lives, so your responses are very important. This survey is for academic research purposes only.

Completing this survey is voluntary. All of your responses will remain anonymous. None of your answers will be linked back to you, so please respond as best as you can.

The survey should take you about 15-20 minutes to complete. Thank you in advance for your responses!

**Q1. Please think about your most memorable tornado experience. That experience may have happened to you personally, or you may have learned about the experiences of another person (or other people). It may have been a time when a tornado actually occurred or when there was just the possibility a tornado might occur. It may have occurred a long time ago or more recently.**

**a. Did that tornado experience happen to you personally, did you learn about others' experiences, or both?** *Please select ONE option.*
- ○ It happened to me personally.
- ○ It happened to other(s), and I learned about it.
- ○ Both – it happened to me personally, and it happened to other(s).

**b. Did a tornado actually occur during that experience, or was there just the possibility of a tornado?** *Please select ONE option.*
- ○ A tornado actually occurred.
- ○ There was the possibility of a tornado, but one did not occur.

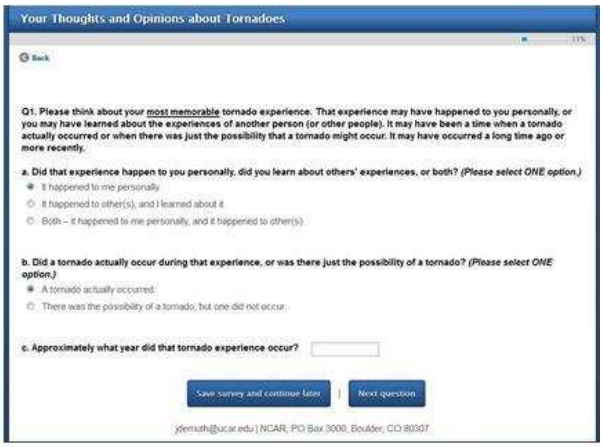
**c. Approximately what year did that tornado experience occur?** _____

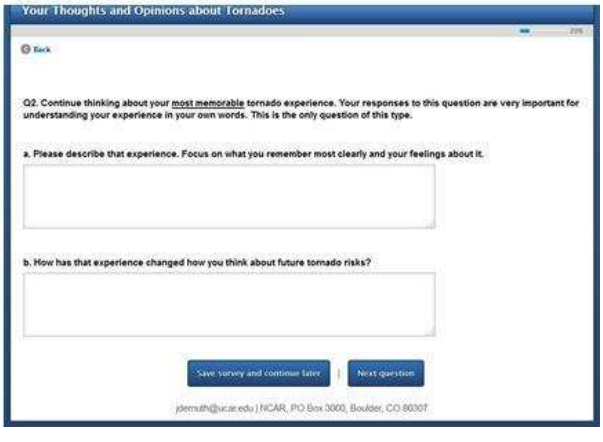
**Q2. Continue thinking about your most memorable tornado experience. Your responses to this question are very important for understanding your experience in your own words. This is the only question of this type.**

**a. Please describe that experience. Focus on what you remember most clearly and your feelings about it.**

**b. How has that experience changed how you think about future tornado risks?**

## Web

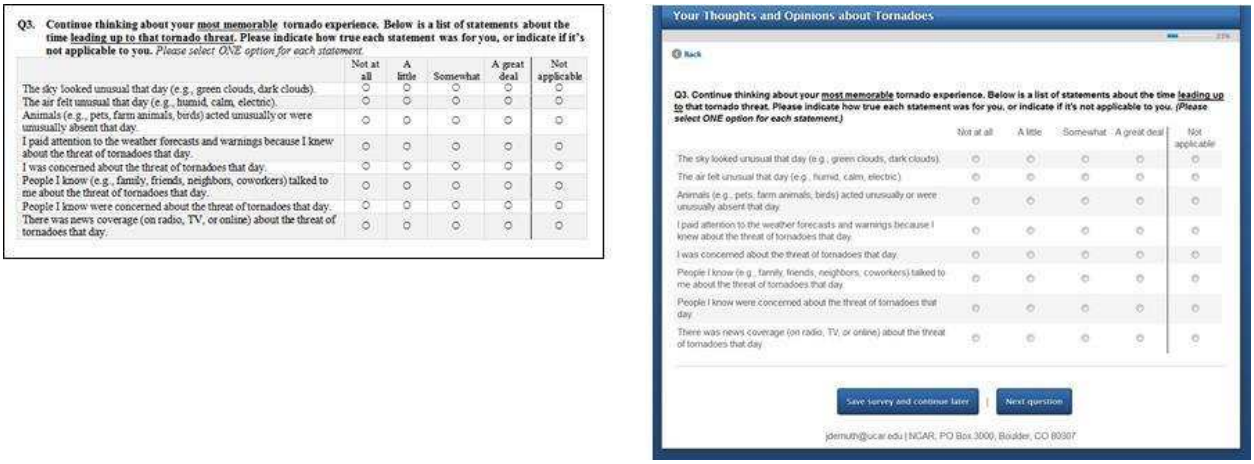



*Figure 2.* Design of mail and Web surveys. Images shown are from Survey 1.

The survey implementation followed research-based guidelines for surveys in general as well as additional guidelines specific to mixed-mode surveys (Dillman et al., 2009; Smyth et al., 2010). Up to four mailings were sent to each survey invitee. First, a prenotice letter was sent to inform recipients that they would receive a survey request in a few days along with the importance of their responses. A few days later, a survey invitation letter was sent with brief information about the survey and its sponsors; survey instructions, including that the adult who had the most recent birthday should complete the survey (to randomize respondents); the address of the Web survey and a unique five-digit access code; a $2 bill cash incentive; information about sending a paper survey in the future; and CSU RICRO and NCAR HSC contact information. One week later, a postcard was sent to thank those who had responded. A postcard also was sent to remind non-respondents and provide the survey instructions, Web address, and access code again. Approximately two weeks later, a final mailing was sent to non-respondents that included a paper survey and a stamped, addressed return envelope. Web survey instructions and access information also were provided for those who still wished to respond via that mode. The only two changes in content between the Survey 1 and 2 mailings were (a) the survey Web

address, and (b) revised text instructing Web respondents to type the Webpage address into the address bar of their Internet browser and not into a search engine like Google. The latter change was driven by feedback from a few Survey 1 respondents that revealed their confusion and problems with accessing the Web survey because they were searching for it.

All mailings were sent to "<city or town> Area Resident" per guidance that it is inadvisable to use one's name when relying on within-household random selection processes as employed here and because names are not available with many of the records from the U.S. Postal Services DSF (Smyth et al., 2010). All mailings were personally signed with a blue ballpoint pen to personalize them (versus using an electronic signature), and all mailings were sent with first-class stamps, both features that have been shown to increase response rates.

Images of the mailings for Surveys 1 and 2 are provided in Appendix D along with specifications for each of the mailings.

**Survey 1: Fielding, Sample Size, and Data Preparation**

An ABS of 650 households was randomly selected from within the sample area for Survey 1. This sample size was based on a target of 300 completed survey responses, with an estimated 50% response rate, and an estimated 6-8% of letters being undeliverable that would reduce the functional sample (Smyth et al., 2010; Jeff Lazo, personal communication). The target of 300 completed surveys was a conservative desired sample size for scale development, which relies heavily on factor analysis (further discussed later in this chapter). The estimated sample size for factor analysis assumed wide communalities, several items, and multiple factors (MacCallum, Widaman, Zhang, & Hong, 1999, Table 1).

The 650 randomly selected addresses were from 346 of the counties (27.9%) within the target area (Figure 3). The county with the most addresses (6.3%) was Cook County, Illinois, where Chicago is located and that has a population of 5.2 million (ACS 2014). The second (3.2%) and third (2.5%) most addresses, respectively, were from Dallas and Tarrant counties, where Dallas and Fort Worth are located and that have populations of 2.5 and 1.9 million (ACS 2014). The rest of the sampled counties had less than 10 addresses each, and most (71.7%) had only 1 address. Thus, as expected, the random sample of households from the sample area is correlated with population size.

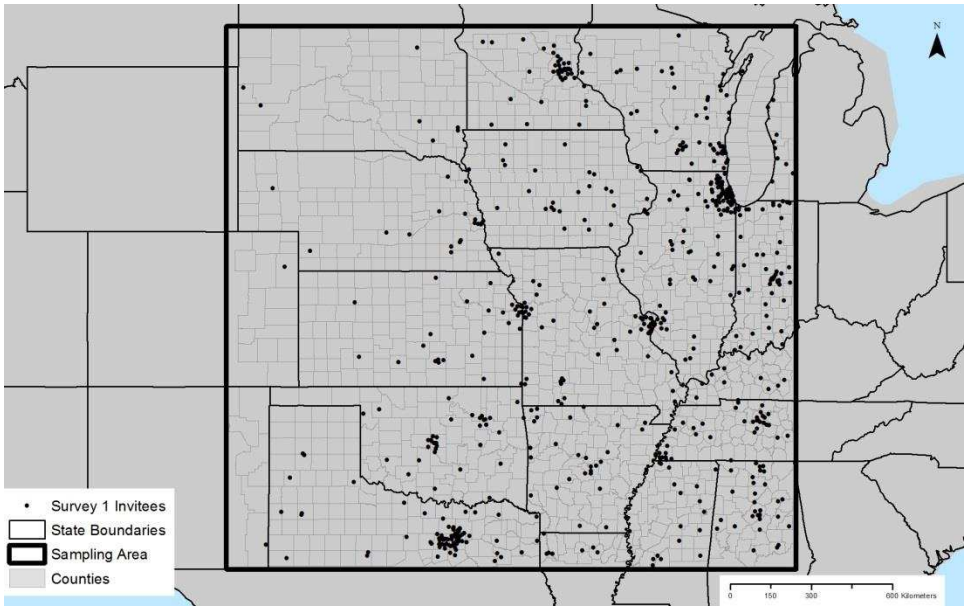



*Figure 3.* Location within the sample area of the 650 randomly sampled addresses for Survey 1.

Survey 1 was fielded beginning on April 1, 2014, with the prenotice letter sent that day. The subsequent mailings were sent following the timeline discussed in the previous section; the exact mailing dates are provided in the Survey 1 mailing images (Appendix D). The final returned mail survey was postmarked June 12, 2014, approximately 10 weeks after the initial

mailing. However, the bulk of the surveys (all but five of them) were received by May 14, 2014, i.e., within six weeks.

Of the 650 household invitations, 56 (8.6%) were undeliverable, leaving a functional sample size of 594. Of this, eight people requested they be withdrawn from the survey for various reasons including that they, e.g., had never been in a tornado, felt they were too old to participate, or simply did not wish to participate. As shown in Table 3, the final response rate was 27.9%, with 19.0% from the Web and 8.9% from mail. This response rate is considerably lower than that from Smyth et al. (2010), whose mixed-mode approach this survey was modeled after. Reasons for the difference are unclear. However, the 27.9% response rate is within the range of, and in some cases greater than, other weather-related surveys that have followed the Dillman method (Arlikatti, Lindell, Prater, & Zhang, 2006; Huang et al., 2012, and references therein). The proportion of responses by mode is similar to that from Smyth et al. ($\chi^2(1, 478) = 2.13$, $p = 0.14$), with 68.1% from the Web and 31.9% from mail.

Table 3. *Survey 1 response rates*

| | Survey 1 | Smyth et al. (2010)[a] |
|---|---|---|
| Functional sample size[b] | 594 | 566 |
| Withdrawals | 8 | not reported |
| Web completes and partials[c] | 113 | 232 |
| Mail completes and partials | 53 | 80 |
| Total completes | 166 | 312 |
| Response by Web (%) | 19.0% | 41.0% |
| Response by mail (%) | 8.9% | 14.1% |
| Total response rate (%) | 27.9% | 55.1% |
| Proportion of responses by Web | 68.1% | 74.4% |
| Proportion of responses by mail | 31.9% | 25.6% |

[a] Data from Table I
[b] Undeliverables subtracted from sample size
[c] The response rates reported here include completes and partials for comparison with those reported in Smyth et al. (2010)

To prepare the data, the Web survey data were downloaded, a codebook was developed, and the mail survey data were entered following it.[11] Unanswered items or questions were left as missing data. Ambiguous responses, i.e., where two answers were marked, were reconciled by comparing with other items when possible or else coded as the more conservative answer (typically, non-agreement).

Of the 166 total responses, 22 surveys were classified as incomplete because the respondent either quit the survey partway through or skipped multiple questions. Nineteen of the incompletes were Web surveys. Of those, six people quit at the open-ended question (Q2) without answering it. Although the wording explicitly indicated that this question was important and that it was the only question of this type, both guidelines from Dillman et al. (2009), this was the most common drop-off point. The other three incompletes were mail surveys: one person seemingly missed a page, another wrote only an open-ended response, and the other answered only the first and last few questions. Of all the incompletes with responses to the risk target question, a majority (63.2%) indicated that the tornado experience happened to others and they heard about it; these people tended to drop off earlier in the survey than those who indicated the experience happened to them personally. For the quantitative analysis, all of the incompletes were omitted, leaving a final sample size of $N = 144$ with 94 from the Web and 50 from mail (24.2% completed survey response rate). For the qualitative analysis, all responses were used, but 21 of the 166 people provided no data, leaving a qualitative sample size of $N = 145$.

Although 144 cases were considered "complete" for the quantitative analysis, some cases had missing data. Because Survey 1 served as the first effort toward the scale development of

[11] A summer student assistant, Zita Toth, did the paper survey data entry for Survey 1. She was provided with the Web survey data file, codebook, and instructions.

past tornado experience, it was important to retain as much of the experience-related data as possible while utilizing reasonable imputation approaches.

For Q1, which asked about the most memorable tornado experience characteristics, no data were missing about to whom the experience happened (Q1a). Data from other survey questions in conjunction with data from Q2—respondents' descriptions about their most memorable experience—were used to impute the 1 missing case about whether or not the tornado occurred (Q1b) and 4 of the 10 missing cases about what year the experience occurred (Q1c). For instance, one respondent for whom the year of experience was missing indicated that a tornado occurred and wrote as the description "Woodward, OK, I was a small child, building flattened, debris everywhere." The respondent was 72 when he completed the survey, so he was born in 1942. An Internet search immediately found the April 9, 1947, Woodward, OK, tornado, which is consistent with his being a small child when it occurred, so this was imputed as the year.[12] The six cases for which the year of experience could not be reasonably inferred were left as missing data; accordingly, analyses between the memorable experience dimensions and year of occurrence are of reduced sample size.

The multi-item questions about respondents' tornado experiences (Q3-Q6) were those used for scale development. Because scale development relies heavily on factor analysis, described further below, missing cases were imputed for all items from these questions. According to Harrell (2001), when less than 5% of data are missing for a variable, "it doesn't matter very much how you impute missings … for continuous variables imputing missings with the median nonmissing value is adequate; for categorical predictors the most frequent category can be used" (p. 49). The maximum proportion of missing data for the experience variables was 3.5%, which was from one item only. The vast majority of the variables (92.3%) had less than

[12] See, for example, http://www.srh.noaa.gov/oun/?n=events-19470409

2% of their data missing, and more than half of the variables had no missing data. Therefore, following Harrell, missing data were imputed with the mode. For the most memorable experience questions (Q3-Q5), missing data were imputed conditioned on the risk target, i.e., to whom the experience happened (Q1a). For the multiple experience question (Q6), the imputed value was the mode for the full dataset. No other data were imputed from Survey 1.

**Survey 2: Fielding, Sample Size, and Data Preparation**

An ABS of 900 households was randomly selected from within the sample area for Survey 2. This sample size was based on a target of 200 completed survey responses, given the 24.2% completed survey response rate and the 8.6% undeliverable rate from the Survey 1 sample, discussed above. The targeted 200 completed surveys was a judicious sample size estimate for factor analysis based on the Survey 1 results (discussed in Chapter 4), which showed wide communalities and a larger item-to-factor ratio than estimated for Survey 1 (MacCallum et al., 1999, Table 1). This sample size also is more than the needed sample of 175 for a hierarchical multiple linear regression model to predict risk perception with 80% power with up to 6 experience variables that have small effects over a base model of up to 10 control variables (e.g., dispositional optimism, locus of control, sheltering options, and demographic variables).[13]

The 900 randomly selected addresses were from 448 of the counties (36.1%) within the target area (Figure 4). Again, the sample correlates with population size, with 6.6%, 3.2%, and 2.4% of addresses coming from the Chicago and Dallas-Fort Worth areas, respectively. The rest of the sampled counties had 16 or less addresses each, and most (72.3%) had only 1 address each.

[13] Sample size calculator for hierarchical multiple regression from http://www.danielsoper.com/statcalc3/calc.aspx?id=16

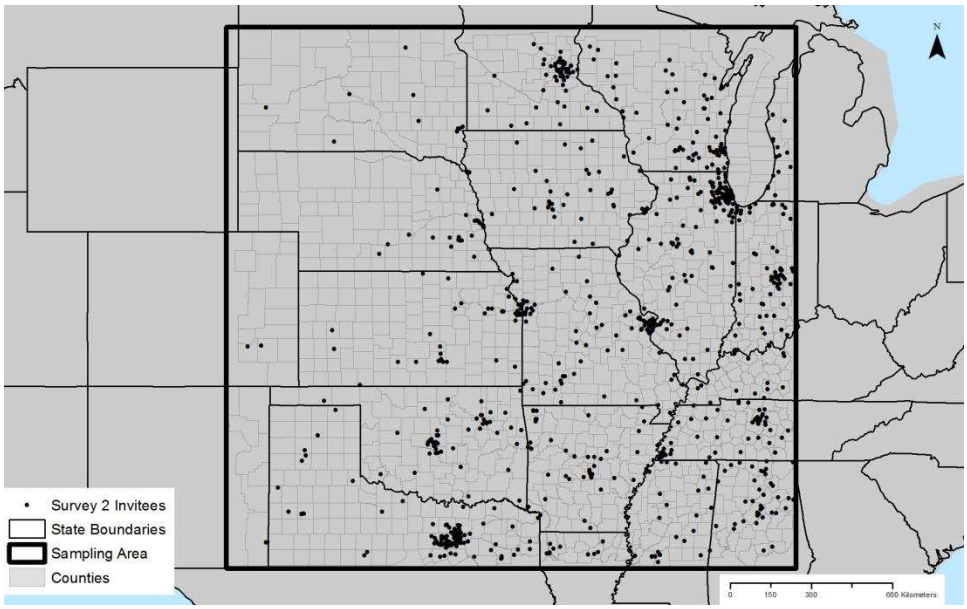



*Figure 4.* Location within the sample area of the 900 randomly sampled addresses for Survey 2.

Survey 2 was fielded beginning on October 9, 2014, with the prenotice letter sent that day. Again, the subsequent mailings were sent following the timeline discussed above; the exact mailing dates are provided in the Survey 2 mailing images (Appendix D). The final returned mail survey was postmarked February 17, 2015, more than 18 weeks after the initial mailing. As with Survey 1, the bulk of the surveys (all but 15 of them) were received within six weeks, i.e., before November 20, 2014; this was the goal as Thanksgiving was the following week.

Of the 900 household invitations, 72 (8.0%) were undeliverable, leaving a functional sample size of 828. Of this, 10 people requested they be withdrawn from the survey for various reasons including that they, e.g., are blind, do not have accurate knowledge or experience of a tornado, or simply did not wish to participate. As shown in Table 4, the final response rate was 25.4%, with 14.6% from the Web and 9.8% from mail. Again, this response rate is considerably lower than that from Smyth et al. (2010)—and it also is slightly lower than that for Survey 1 (Table 3)—but, as with Survey 1, it is within the range of other surveys that have followed the Dillman method. The proportion of responses by mode, unlike in Survey 1, is significantly

different from that from Smyth et al. ($\chi^2(1, 522) = 16.06$, $p < 0.01$), with 57.6% from the Web and 42.4% from mail. Moreover, there is a significant difference in responses by mode between Surveys 1 and 2 ($\chi^2(1, 376) = 4.31$, $p = 0.04$); although a majority of responses to Survey 2 still were via the Web, the distribution shifted toward being more even by mode.

Table 4. *Survey 2 response rates*

| | Survey 2 | Smyth et al. (2010)[a] |
|---|---|---|
| Functional sample size[b] | 828 | 566 |
| Withdrawals | 10 | not reported |
| Web completes and partials[c] | 121 | 232 |
| Mail completes and partials | 89 | 80 |
| Total completes | 210 | 312 |
| Response by Web (%) | 14.6% | 41.0% |
| Response by mail (%) | 9.8% | 14.1% |
| Total response rate (%) | 25.4% | 55.1% |
| Proportion of responses by Web | 57.6% | 74.4% |
| Proportion of responses by mail | 42.4% | 25.6% |

[a] Data from Table I
[b] Undeliverables subtracted from sample size
[c] The response rates reported here include completes and partials for comparison with those reported in Smyth et al. (2010)

The data were prepared by downloading the Web survey data, developing a codebook, and using it to enter the mail survey data.[14] As with Survey 1, unanswered items or questions were left as missing data, and ambiguous responses were reconciled by comparing with other items when possible or else coded as the more conservative answer (typically, non-agreement).

Of the 210 total responses, 26 surveys were classified as incomplete because the respondent either quit the survey partway through or skipped multiple questions. Eighteen of the incompletes were Web surveys; there was no common drop-off point, but most respondents quit within the first half of the survey. The other eight incompletes were mail surveys: five people seemingly missed a page, two people answered most of the survey but only a few of the

[14] The author did the paper survey data entry for Survey 2.

demographic questions, and one person only provided a lengthy written comment at the end. Of all the incompletes with responses to the risk target question, an equal portion (40.0%) indicated that the tornado experience happened to them personally as those who indicated it happened to others, meaning the risk target did not have an influence on survey completion. All of the incompletes were omitted for the analysis, leaving a final sample size of $N = 184$ with 103 from the Web and 81 from mail (22.2% completed survey response rate).

Although 184 cases were considered "complete", some cases had missing data. Imputation methods were applied to retain as much of the data as possible for the experience scale development as well as for the analysis relating experience and risk perception. For Q1, which asked about the most memorable tornado experience characteristics, four cases had missing data about to whom the experience happened (Q1a). These respondents answered all of the other memorable experience survey questions, so those data were assessed for hints to impute the risk target. Two respondents answered "not applicable" to most of the items, thus it was inferred that the experience happened to others and was imputed as such. The other two respondents answered most of the experience items that pertained to their unmediated sensory, protective action, and emotional responses as these being "somewhat" or "a great deal" applicable to them. Moreover, they did not answer "not applicable" to any of the experience items. Thus, the risk target for these two was imputed as the experience happened to both them personally and to others.

All of the other sub-questions from Q1 had missing data, some substantially so. Respondents who indicated that the most memorable experience happened to others were asked approximately how far away they were (Q1ai), but 25.4% of these data are missing. After imputing one case using open-ended data from the "additional comments" at the end of the

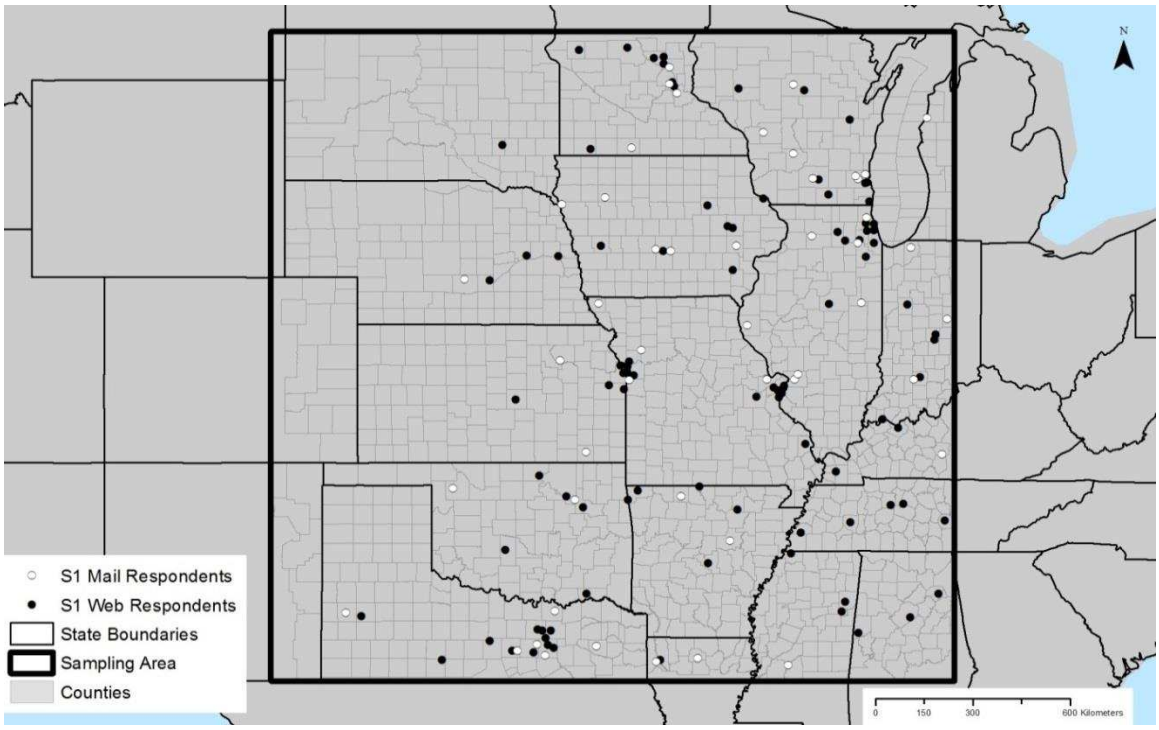
survey, 3.8% of the data are missing about whether or not the tornado occurred (Q1b). Finally, 16.8% of the data are missing about the year the tornado experience occurred (Q1c). The other survey data did not provide insight for imputing the data for these questions, therefore they were left as missing. Accordingly, analyses between the memorable experience dimensions and these questions are of reduced sample size.

Most of the remainder of the survey had less than 5% of the data missing by variable, thus the data were imputed with the mode (Harrell, 2001). As in Survey 1, the most memorable experience items (Q2-3) were imputed with the mode conditioned on the risk target, i.e., to whom the experience happened (Q1a). All other survey questions that were imputed used the mode for the full dataset. For the demographic variables, four had no missing data: age, gender, residency type, and education. Residence length was imputed with the mode or with the respondent's age if it was lower. Missing data for household size, number of children in the home, employment, and ethnicity were cross-checked with other demographic data and imputed with the mode. For instance, in the one case with missing employment data, the respondent was 41 years old and the sole resident, so it was reasonable to impute with the modal response of full-time employment. Also, in five of the cases with missing ethnicity data, respondents reported their race as "White" so the modal response of "Not of Hispanic, Latino, or Spanish origin" was imputed. In one case, neither race nor ethnicity was reported, so these data were left blank; they are the only instance with these data left missing. Finally, 7% of the cases have data missing for income. Because more than 5% of missing data requires more rigorous imputation techniques, these data were not used in the analysis.

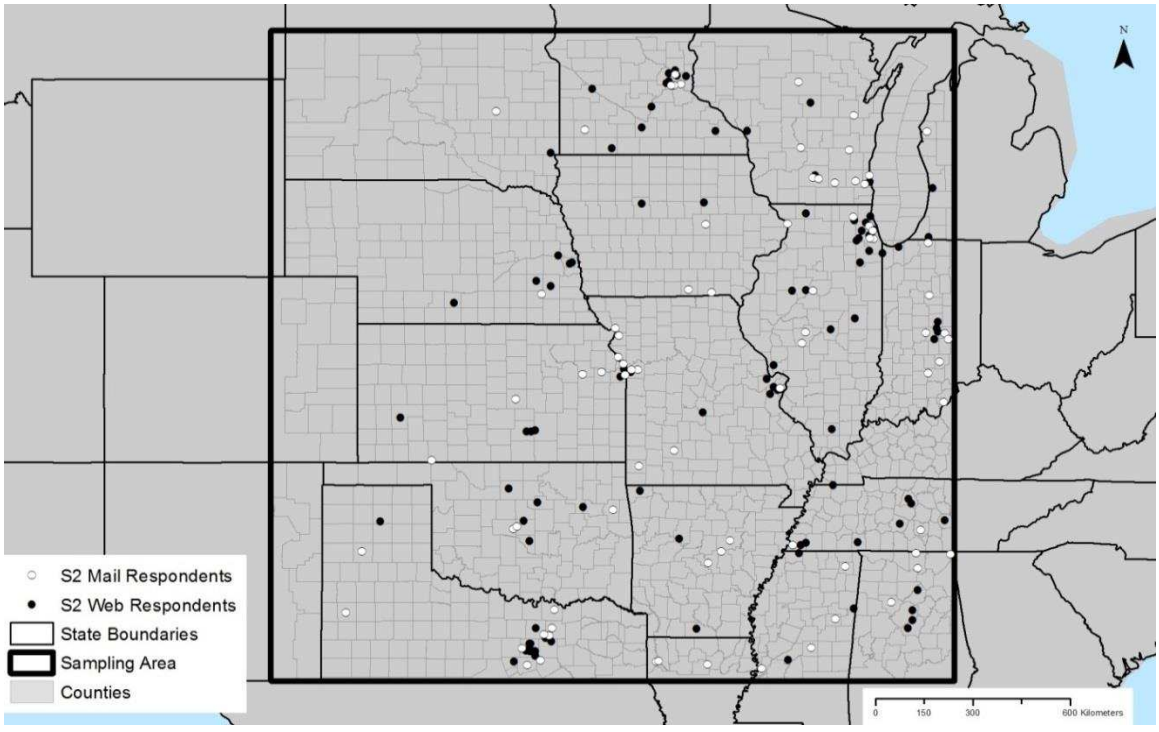
**Survey 1 and 2: Sample Characteristics**

The final samples for Surveys 1 and 2 are very similar to each other demographically. Complete demographic data for both surveys is provided in Appendix E. In summary, the overall demographic is older with a median age in the mid-50s, a median household size of 2 people with 0 children, a median residence length in the sample area of 45 years or more, and a modal employment status as full time (50–57%) but with the second most common status as retired (29–32%). For Survey 1, exactly half of the respondents were male and half were female, and Survey 2 had slightly fewer males than half. More than three-quarters of respondents live in a single-family, detached home, 4-5% live in a mobile home, and the rest live in an attached home with one or more units. About one-third of respondents had completed some college, technical school, or associate's degree as their highest degree, about one-fourth completed a bachelor's degree, and the rest completed more or less schooling. The vast majority of the sample is White (87-89%) and not of Hispanic, Latino, or Spanish origin (90-93%). The income distribution is shifted toward being slightly wealthier on Survey 1 with median as the sixth bin ($75,000-99,999) whereas it is the fifth bin ($50,000-$74,999) on Survey 2.

The geographic distribution of the Survey 1 and Survey 2 respondents by response mode is shown in Figure 5.




(a)




(b)

*Figure 5.* Location of the (a) *N* = 144 respondents to Survey 1 and (b) *N* = 184 respondents to Survey 2.

## Data Analysis

### Experience Dimensionality Analysis

Multiple assessments were used across multiple steps to identify the latent dimensions of past tornado experience. The assessments, briefly described here, are primarily drawn from DeVellis (2012). As discussed earlier in this chapter, however, Chaffee (1991) and Babbie (2007) discuss methods consistent with those of DeVellis in their communication research texts on concept explication and measurement.

Common factor analysis (hereafter referred to simply as factor analysis) is essential in scale development, as it is the technique used to empirically determine if and how many latent variables (or factors) underlie a set of items, and consequently to help define the substantive meaning of those factors. Therefore, a series of exploratory factor analyses were conducted to iteratively evaluate the experience items in Surveys 1 and 2. The most memorable experience items and the multiple experience items were factor analyzed separately because they are conceptually distinct and they were measured with different response options.

The factor analyses were employed with a principal axis factoring extraction and an oblique (Promax) rotation. An oblique rotation allows the resultant factors to be correlated with each other, which the experience dimensions conceivably may be. The initial factor analysis for each class of experiences (most memorable experiences and multiple experiences) was checked to ensure the data met the assumptions of factor analysis, i.e., with Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy values greater than 0.5, and with a significant Bartlett's test of sphericity (Child, 2006).

With these criteria met, the number of factors to extract was determined next. This "can be a knotty issue" (DeVellis, 2012, p. 127) as there are several traditional techniques (e.g., scree

test, amount of variance explained) and, increasingly, several new techniques (e.g., parallel analysis; see O'Connor, 2000; Courtney, 2013) for choosing the number of factors. Selecting and interpreting from among these various techniques is made more complicated, DeVellis (2012) notes, in exploratory common factor analysis where the researcher is interested in factors that are parsimonious and meaningful rather than ones that are statistically exhaustive. Inevitably, selecting the number of factors to extract involves some degree of subjectivity and interpretation. In the present study, the number of factors to extract was based primarily on the scree plot, percent of variance explained, and interpretability of the results.

Once the number of factors to extract was determined, an iterative process to eliminate items was employed by examining a combination of each item's factor loadings, communality, and corrected item-scale correlation. Communality values, which are output as part of the factor analysis results, are the sum of an item's squared factor loadings, thus they represent the variance in that item that is accounted for by the common factors (Child, 2006). The corrected item-scale correlation (also known as the corrected item-total correlation) is the correlation between a given item and all other scale items, excluding itself. Items with low communalities and low corrected item-scale correlations are indicators that an item should be excluded (DeVellis, 2012). Here, the iterative process of dropping items was based first on those with factor loadings less than 0.4 (Garson, 2012; Hatcher, 1994), then on items with low communalities and/or item-scale correlations (DeVellis, 2012), and, if necessary, on items that did not load cleanly, i.e., that had a secondary loading greater than 0.3. The final factor solution was evaluated for face validity and meaning.

Cronbach's alpha was calculated for the items that each factor comprises as an indicator of the reliability (i.e., the proportion of the observed score that is attributable to the true score of

the latent variable). Summed scales of the items in each factor then were created for subsequent analyses. All of the quantitative scale development data analyses were done in SPSS v.22.

The qualitative data from the open-ended question on Survey 1 that asked people to describe their most memorable experience were analyzed to identify important aspects that were not represented in the existing set of items. These data were analyzed following a data analysis spiral (Creswell, 2013) that involves reading through the complete dataset; identifying and coding emergent concepts that are relevant to people's experiences; memoing about their context and meaning; comparing the codes against each other to identify repeated ideas as well as to refine, aggregate, or parse them; and comparing the codes against the existing set of experience survey items. The qualitative analysis was done in Atlas.ti v.6.2.28.

**Risk Perception Dimensionality and Regression Analyses**

The construct validity of the emergent past tornado experience dimensions was assessed by evaluating their theoretical relationship with tornado risk perception. First, common factor analysis was conducted with the set of items drawn from Trumbo et al. (in review) that were intended to measure cognitive and affective tornado risk perceptions. As with the analysis of the experience data, the factor analyses were employed with a principal axis factoring extraction and an oblique (Promax) rotation; KMO and Barlett's tests were assessed; the scree plot and variance explained per factor were used to determine the number of factors to extract; and an iterative process was conducted to eliminate items based first on those with the factor loadings less than 0.4 and then on items with low communalities and/or item-scale correlations. The final factors were evaluated for face validity and meaning, Cronbach's alpha was calculated, and summed scales of the items each factor comprised were created.

Hierarchical linear regression analysis was used to evaluate how the different types of past tornado experiences relate to people's tornado risk perception after controlling for other variables that relate to risk perception. The hierarchical models regressed risk perception onto (a) a base set of control variables, including demographic variables, dispositional optimism, and locus of control (discussed further in Chapter 5), (b) followed by the set of most memorable tornado experience dimensions and multiple experience dimensions derived from the scale development. Additional analyses were conducted as needed to more deeply investigate some of the results.

# CHAPTER 4: RESULTS OF DIMENSIONS OF PAST TORNADO EXPERIENCES

The items that were developed to measure two classes of experiences are evaluated and the dimensionality results are presented in this chapter, first for the most memorable tornado experience, and then for multiple tornado experiences.

## Most Memorable Tornado Experience

### Experience Characteristics

Data on respondents' most memorable tornado experience, as described in Chapter 3, were gathered first with questions about to whom the experience happened (the risk target), whether or not a tornado actually occurred, and what year the experience happened. The distribution of these characteristics for Surveys 1 and 2, shown in Table 5, illustrates the variability of these experiences. Although a majority of respondents indicated the experience happened to them, either alone or to others also, approximately 40% of respondents indicated the experience happened to others. For most respondents' experience, a tornado actually occurred, with more reports of occurrence in Survey 2 than in Survey 1, but 12-20% of respondents reported that their most memorable experience was one in which a tornado was possible but did not materialize. There also was considerable variability in how many years ago respondents' most memorable experience happened. The most common response, but still representing a minority, was that the experience happened within the last 1-2 years. However, the distribution was strongly right-skewed with the average experience happening 17-20 years ago and maxima of 64-74 years ago.

Table 5. *Comparison of most memorable experience characteristics between Surveys 1 and 2*

| Most memorable experience characteristics | Survey 1 | Survey 2 | Statistical comparison |
|---|---|---|---|
| Risk target: % | | | |
| (Self) It happened to me personally | 30.6% | 29.3% | $\chi^2(2, 328) = 0.50$, $p = 0.78$ |
| (Others) It happened to others, and I learned about it | 41.0% | 38.6% | |
| (Both) It happened to me personally, and it happened to others | 28.5% | 32.1% | |
| Tornado occurrence: % | | | |
| A tornado actually occurred | 79.9% | 87.6% | $\chi^2(2, 321) = 3.53$, $p = 0.06$ |
| There was the possibility, but a tornado did not occur | 20.1% | 12.4% | |
| Years ago tornado experience happened: M(SD); range | 19.9 (19.2); 0–74 | 16.5 (17.8); 0–64 | $t(289) = 1.59$, p = 0.11 |

Bivariate analyses of the most memorable characteristics provide a more nuanced picture of respondents' experiences. The distribution of tornado occurrence versus possibility is approximately 80-20 for each of the risk targets in Survey 1($\chi^2(2, 144) = 0.28$, $p = 0.87$). There is a significant difference in the proportional distribution in Survey 2, however, primarily because 97% of the people who indicated that the experience happened to both themselves and to others reported that a tornado actually occurred ($\chi^2(2, 144) = 6.57$, $p = 0.04$). Survey 1 respondents to whom the most memorable experience happened personally reported that it occurred significantly longer ago on average ($M = 24.6$ years) than experiences that happened to others ($M = 14.5$ years) ($F(2, 135) = 4.10$, $p = 0.02$). This significant difference might be expected given that personal experiences are thought to be more vivid and therefore more memorable than experiences that happen to others, as discussed in Chapter 2. However, in Survey 2, neither this nor other significant differences are seen in how long ago the experience occurred based on the risk target ($F(2, 150) = 0.73$, $p = 0.48$). Lastly, in Survey 1, there was no significant difference in how long ago the experience was for a tornado that actually occurred versus one that threatened but did not occur ($t(136) = 0.59$, $p = 0.56$). In Survey 2, however,

tornadoes that actually occurred happened significantly longer ago on average ($M$ = 17.5 years) than tornados that threatened but did not occur ($M$ = 10.0 years) ($t(30.9) = 2.60$, $p = 0.01$). Overall, these bivariate analyses with the Survey 1 and Survey 2 data show that there does not appear to be a systematic pattern in what constitutes one's most memorable experience based on to whom the experience happened, whether a tornado occurred, or when it occurred. This suggests that one's most memorable experience can represent a range of attributes.

The wide-ranging attributes that make up people's most memorable experiences are further supported by the Survey 1 respondents' open-ended descriptions of it—where they were asked what they remember most clearly about the experience and their feelings about it—coupled with their classification of the experience characteristics in response to the closed-ended questions. This variability emerges especially when looking at the experience descriptions across the three risk targets, i.e., to whom the experience happened.

Of the respondents who indicated that the experience happened to them personally, some described it solely as it pertained to themselves. However, most respondents also mentioned impacts to others. This was true for respondents whose experience included a direct hit by the tornado such that they endured property damage or injury, as was the case for this respondent:

> Did not know whether I would live through it or not. Could feel the air being sucked out of the house. Sounded like a train and then things hitting the front of the house first and then the back of the house. After it passed it was really quiet. Electricity was off. Could not see all the damage until morning. Parts of the neighborhood I had grown up in were unrecognizable and were never the same again. [63036] [15]

Many respondents who indicated the tornado happened to them personally but who did not experience a direct hit from a tornado also tended to primarily describe the event as it pertained to them, but they too discussed impacts to others, as per these two quotes:

[15] The five-digit number is the unique access code given to each survey invitee to track their responses. They are reported as an anonymous reference for the quotes.

> My three children were young at the time and I was scared for our safety. I knew the safest thing I could do was to hide the four of us in the closet under the stairs because we didn't have a basement. The kids recall it from time to time so I know they sensed my heightened awareness; I tried to make it fun for them so they wouldn't be afraid. Five tornados hit the city that day (Nashville, TN) so we were thankful to escape harm, but sad for those whose lives were changed in an instance. [13132]
>
> I was eight years old, the sirens where going off, the sky was very dark and we had just experienced large hail. We were in the basement and I was under a table with my brother and our dog. The hail ended and my dad and the neighbors went outside, my dad said they watched the tornado approach our neighborhood. Just before it would have hit our homes the tornado lifted up traveled about a mile or two, dropped down on the other side of the river and devastated Fridley, MN. I still remember seeing a neighborhood that was gone except for one home with only four walls of the bathroom still standing, the door was open and you could see the toilet and bath tub. That was all that was left of that neighborhood. [72808]

As these two quotes illustrate, even if respondents did not suffer a direct hit, those who indicated the experience happened to them personally often experienced many other aspects of the tornado event—e.g., fear, taking action to protect oneself and one's children, sadness for people others who were affected, environmental and social cues, and observing scenes of the aftermath. The latter quote also is an example of someone whose most memorable experience was a long time ago, in this case, 49 years prior.

The reverse of respondents classifying their experience as happening to them but discussing impacts to others also is true. Many respondents indicated the event happened to others, but described ways that they too had experienced the event. In some cases, it seems the *type* of experiences the respondent had compared to others may have influenced their designation that it happened to others. For instance, in the quote below, the respondent describes experiencing a number of environmental cues and taking shelter as the storm approached, but she distinguishes these types of experience from others who suffered a direct hit and damage from the tornado.

> I could see the dark clouds in the distance. It was very humid. The radio was giving a warning and updates and I was watching out the windows. The wind started picking up and really blowing the trees. Leaves were flying by. I pulled my grill inside from my deck, it was blowing so hard. As the dark clouds grew nearer, I debated whether to go to the basement...but then I could not see what was happening. Then the hail came and I went to the basement. As it passed, the radio was saying that a funnel cloud had touched down in a nearby suburb and lifted big trees up knocking out power. Roofs were damaged and cars parked in driveways were crushed by the big trees. I was thankful not to live in that neighborhood. Relief, that my neighborhood was not damaged, and everyone was OK. [30096]

For others, the *degree* of their experience compared to others seemed to influence their classifying that the event happened to others, as illustrated by this quote in which the respondent describes suffering property damage but that it was minor relative to impacts incurred by others:

> My whole family (my husband, my son, my daughter and me) was in the basement listening closely to the television until the power went out, then we tuned into our battery operated radio. We could hear the wind blow like the train sound everyone speaks of. We could hear hail falling on the roof. My husband, the curious one, went up the stairs and looked out the front door and he said the tree branches were touching the ground with the wind that was blowing and we have very tall, old oak trees! I yelled for him to get back downstairs and we all huddled in the bathroom of the basement which has no windows and I feel is the best room to be in. When it was all over, we went outside to assess the damage. We had hail damage on our camper, vehicles and the roofs of the house and shed and one of the dog pens was all twisted up. A huge tree branch broke off of one of our oak trees, but no major damage to anything which we were thankful for. We talked to some of our neighbors who were outside and witnessed the tornado. They said it stayed above our homes on our street hanging in the sky until it reached the next street to us, where it took out many homes, trailers and a row of trees along a creek! Very scary stuff to know we were that close and very thankful no one was seriously injured! [42616]

There were several respondents, however, who reported that the experience happened to others and described it as such, with little or no reference to themselves. Their quotes represented a wide range of contexts, including respondents who saw new coverage on television, who saw neighborhoods devastated in the aftermath of a tornado (these experiences were remembered both as a child and as an adult), and who relayed stories they had heard from others. Stories from others included those told secondhand, as in this quote:

> A friend's relative was in a mobile home when the tornado struck, lifting their mobile home off the ground, dropped down and exploded. They covered themselves with a mattress in the bathtub, and walked away with scratches and bruises. [78843]

In addition, many stories were about friends or family members who had had a range of experiences, some severe, as in this quote:

> A tornado struck my grandfather's assisted living home in Bells, TN, and the nursing home next door. The damage to the assisted living home was minor and my grandfather was not injured. It continued on its path and destroyed my first cousin's home, lifting the home and carrying it and my first cousin about 100 yards. She survived and was found naked walking along a highway dazed but with no broken bones or severe injuries. The force of wind stripped her of her pajamas (it was at night, she was in bed asleep when it struck). The tornado continued on its path and severely damaged the community store in Fruitvale, TN. I and my father and grandparents have many memories from that old store. It was originally built by my great grandfather. It housed the Fruitvale post office for many decades, my grandfather was post master there for many years. [51025]

The experience descriptions from respondents who indicated that the tornado happened both to them personally and to others mirrored many of those above. Many described the experience primarily as it pertained to themselves but then classified it more broadly as having happened to others as well, and some were opposite, focusing primarily on what happened to others. Some described their personal experience relative to others in ways that, again, often pertained to the types and degree of experiences. Interestingly, a few respondents explicitly described an event they watched on television but characterized themselves as having experienced it as well, as in this quote:

> I watched that tornado on TV as it approached Tuscaloosa on a local TV station. It was so much larger than anything I'd ever seen personally combined with news feeds of the masses of tornadoes that occurred that day...it was awe-filling. Many, many areas of our state were hit that day. So much destruction...It was like a war zone! [68366]

This respondent lives approximately 60 miles west of Tuscaloosa, and in response to other survey questions, she reported experiencing unmediated aspects associated with that event. Still,

although her experience was not solely vicarious, the mediated aspects clearly left an indelible impression.

Respondents' descriptions of their memorable experiences in which a tornado was possible but did not actually occur reveal that, in most cases, they nevertheless experienced severe weather conditions, as indicated by these quotes:

> The possibility of a tornado was very real and I had to drive home earlier from work because my wife was by herself at home and was really scared. I experienced some trouble on my way back home because a severe storm was underway and the streets were flooded and to top things off, I drove a small car at that time and I could really feel the wind moving my car a lot! [29785]

> The experience was not at all frightening and most of my memories involve being outside and watching the intense storm. Although we were outside, secure shelter was immediately accessible and our safety never felt jeopardized. A tornado warning was in effect and local tornado sirens were sounding. Although some ominous swirling in the clouds was seen, no tornado was observed. Intermittent precipitation ranging from a light mist to large heavy drops to hail was experienced. I can also remember that the sky had, for a very long time, a somewhat unsettling green coloration. The clouds seemed to glow with a very dark green from within, while the external surface texture of the clouds could be seen almost as a silhouette in front of the glow. [74978]

> Wind gusts were rattling the back door while my husband and I were in the basement under the stairs and the feeling that we were going to have the door go flying and first time I felt we might have a tornado hit the house. We lost power and it was completely dark. [99481]

Overall, the quantitative and qualitative data reveal that what characterizes people's most memorable tornado experiences is varied. The data also provide support for the conceptual definition that captures different experiential attributes and their spectra, and by extension, it supports the types of items that were developed to measure them. These items are evaluated next.

**Item Descriptives**

Thirty-nine items were developed for Survey 1 to measure one's most memorable tornado experience (Appendix A). As further discussed below, several items were dropped based

on the scale development analysis, and six new items were developed for Survey 2 based on the qualitative analysis. All items and their complete wording are provided in Table 6. Respondents were asked to indicate the extent to which each item was true for them as it pertained to their most memorable experience, and they were provided with four response options (from "not at all" to a "a great deal") as well as a "not applicable" option. Regardless of to whom the experience happened, respondents to both surveys did not appear to reliably differentiate between the "not at all" and "not applicable" options, thus "not applicable" was recoded to "not at all".

For each item, summary statistics and *t*-tests to compare the Survey 1 and 2 means are provided in Table 6. Most items have good variance across the response options, but some items are skewed toward a lack of experience. For instance, approximately two-thirds of respondents on both surveys had no experience with unusual animal behavior. However, some respondents who did have this type of experience relayed these stories when describing their most memorable experience. One respondent noted, "Growing up in Kansas, I was no stranger to the eerie quiet and complete lack of noise from birds, dogs, anything…" [53251], and another described, "I noticed the cows on their knees circled around the calves like a wagon train preparing for attack. I had never seen that when I lived on the farm in MO." [61467] Although these experiences are rare, clearly they can resonate for those who do have them.

Table 6. *Most memorable experience item wordings and item comparison between Surveys 1 and 2*

| Item | Survey 1 *M(SD)* | Survey 2 *M(SD)* | *t*-test comparison |
|---|---|---|---|
| Retained in Surveys 1 and 2 | | | |
| I paid attention to the weather forecasts and warnings because I knew about the threat of tornadoes that day | 2.60 (1.26) | 2.78 (1.23) | $t(326) = -1.34$, $p = 0.18$ |
| I was concerned about the threat of tornadoes that day | 2.35 (1.24) | 2.49 (1.24) | $t(326) = -1.03$, $p = 0.30$ |
| People I know (e.g., family, friends, neighbors, coworkers) talked to me about the threat of tornadoes that day[a] | 2.10 (1.20) | 2.14 (1.19) | $t(326) = -0.28$, $p = 0.78$ |
| People I know were concerned about the threat of tornadoes that day | 2.30 (1.23) | 2.42 (1.16) | $t(326) = -0.90$, $p = 0.37$ |
| There was news coverage (on radio, TV, or online) about the threat of tornadoes that day | 2.73 (1.30) | 2.96 (1.18) | $t(291.0)^b = -1.68$, $p = 0.09$ |
| I tried to take action to protect myself or my loved ones (or someone tried to protect me) | 2.95 (1.26) | 2.59 (1.28) | $t(326) = 2.58$, $p = 0.01$ |
| I tried to get to my loved ones to be with them (or they tried to get to me) | 2.56 (1.35) | 2.24 (1.32) | $t(326) = 2.13$, $p = 0.03$ |
| I feared for my loved ones (e.g., family, friends, pets) | 2.83 (1.21) | 2.40 (1.19) | $t(326) = 3.27$, $p < 0.01$ |
| I worried about my home | 2.53 (1.13) | 2.41 (1.16) | $t(326) = 0.9$, $p = 0.37$ |
| I saw scenes of the storm firsthand (e.g., the tornado, debris flying, trees bending or breaking, heavy rain or hail)[c] | 2.40 (1.32) | 2.64 (1.31) | $t(326) = -1.68$, $p = 0.09$ |
| I heard sounds of the storm firsthand (e.g., sirens, the tornado, glass breaking, heavy rain or hail) | 2.64 (1.36) | 2.83 (1.33) | $t(326) = -1.25$, $p = 0.21$ |
| I felt sensations of the storm firsthand (e.g., pressure, strong winds)[+] | n/a | 2.69 (1.24) | n/a |
| I was shaken up | 2.47 (1.10) | 2.09 (1.03) | $t(298.3)^b = 3.19$, $p < 0.01$ |
| I had trouble staying asleep and/or had dreams about it | 1.38 (0.75) | 1.36 (0.76) | $t(326) = 0.13$, $p = 0.90$ |
| I had waves of strong feelings about it | 1.79 (1.02) | 1.63 (0.94) | $t(326) = 1.53$, $p = 0.13$ |
| I thought about it when I didn't mean to | 1.54 (0.84) | 1.54 (0.86) | $t(326) = 0.04$, $p = 0.97$ |
| Pictures about it popped into my mind | 1.72 (0.97) | 1.73 (0.95) | $t(326) = -0.12$, $p = 0.90$ |
| My life was disrupted afterward | 1.39 (0.86) | 1.37 (0.72) | $t(326) = 0.22$, $p = 0.83$ |
| People I know had damage to their property (e.g., home, trees, car) | 2.54 (1.22) | 2.83 (1.21) | $t(326) = -2.11$, $p = 0.04$ |
| People I know lost irreplaceable items (e.g., photographs, heirlooms) | 1.69 (1.14) | 2.04 (1.28) | $t(320.8)^b = -2.61$, $p = 0.01$ |
| The lives of people I know were disrupted afterward | 2.17 (1.19) | 2.25 (1.26) | $t(326) = -0.61$, $p = 0.54$ |
| People talked to me about what they experienced | 2.48 (1.08) | 2.53 (1.10) | $t(326) = -0.44$, $p = 0.66$ |
| I saw scenes of the aftermath firsthand (e.g., damaged areas, downed trees, people injured, debris) | 2.88 (1.18) | 3.16 (1.12) | $t(326) = -2.26$, $p = 0.02$ |
| People I know were shaken up[+] | n/a | 2.60 (1.17) | n/a |
| I was shocked by the devastation and loss[+] | n/a | 2.88 (1.16) | n/a |
| | | | |

| Item | Survey 1 *M(SD)* | Survey 2 *M(SD)* | *t*-test comparison |
|---|---|---|---|
| Retained from Survey 1 (as *threat environmental cues)*, dropped in Survey 2 | | | |
| The sky looked unusual that day (e.g., green clouds, dark clouds) | 2.69 (1.25) | 2.78 (1.21) | $t(326) = -0.69$, $p = 0.49$ |
| The air felt unusual that day (e.g., humid, calm, electric) | 2.56 (1.18) | 2.53 (1.13) | $t(326) = 0.28$, $p = 0.78$ |
| Animals (e.g., pets, farm animals, birds) acted unusually or were unusually absent that day | 1.64 (1.04) | 1.74 (1.09) | $t(326) = -0.84$, $p = 0.40$ |
| Dropped in Survey1 yet retained for Survey 2, but dropped again | | | |
| I was physically injured | 1.06 (0.33) | 1.03 (0.27) | $t(326) = 0.69$, $p = 0.49$ |
| People I know were physically injured | 1.27 (0.71) | 1.43 (0.92) | $t(325.9)^{b} = -1.83$, $p = 0.07$ |
| I had damage to my property (e.g., home, trees, car) | 1.66 (1.03) | 1.82 (1.00) | $t(326) = -1.43$, $p = 0.15$ |
| I feared for my life | 2.15 (1.16) | 1.97 (1.05) | $t(291.8)^{b} = 1.44$, $p = 0.15$ |
| I talked to others about what I experienced | 2.23 (1.13) | 2.26 (1.04) | $t(326) = -0.22$, $p = 0.83$ |
| Dropped in Survey 1, and not retained for Survey 2 | | | |
| I saw the tornado or funnel cloud firsthand | 1.61 (1.14) | n/a | n/a |
| I heard or saw live news coverage (on radio, TV, or online) of the tornado as it was happening | 2.13 (1.28) | n/a | n/a |
| I lost irreplaceable items (e.g., photographs, heirlooms) | 1.10 (0.48) | n/a | n/a |
| I thought about moving away | 1.16 (0.55) | n/a | n/a |
| I saw news coverage of the aftermath (e.g., people who were affected, images of damage, images of the tornado) | 3.01 (1.17) | n/a | n/a |
| I volunteered to help others after the tornado | 1.62 (0.96) | n/a | n/a |
| Others volunteered to help me or my loved ones | 1.44 (0.98) | n/a | n/a |
| Looking back, I took action to protect myself or my loved ones from the tornado threat that was unnecessary | 1.44 (0.91) | n/a | n/a |
| Looking back, responding to the tornado threat was an inconvenience | 1.29 (0.75) | n/a | n/a |
| Added after Survey 1, dropped in Survey 2 | | | |
| I had a bad sense about the weather (e.g., that something was wrong, different, didn't feel right). | n/a | 2.21 (1.19) | n/a |
| The storm happened suddenly. | n/a | 2.77 (1.15) | n/a |
| At times, I couldn't tell what was happening (e.g., couldn't see or hear anything). | n/a | 2.03 (1.14) | n/a |

[+] Item added to Survey 2 based on qualitative analysis of Survey 1 open-ended response

[a] Parentheticals with examples were not repeated for items within a question, but they were repeated at first use across questions.

[b] Levene's test for equality of variances is significant, thus *t*-test statistics are reported for equal variances not assumed

[c] Item changed slightly from Survey 1 to Survey 2. In Survey 1, it read "I saw *other* scenes of the storm…" because another item asked about seeing the tornado or funnel cloud firsthand. That item was dropped from Survey 1 and not included on Survey 2, so seeing a tornado was wrapped into this item for Survey 2.

Three items that have been commonly employed in other studies were not common experiences for either survey sample in this study. Only five Survey 1 and three Survey 2 respondents had been physically injured, and only 15-22% of respondents indicated someone they knew had been physically injured. Personal property damage was relatively more common but was experienced by only 35-47% of respondents. Most of the past studies that included these measures of injury and damage were conducted following a tornado event in an area where people were affected, thus these experiences likely were more prevalent among those samples than in the present study. Survey 1 respondents also reported little experience with losing irreplaceable items, witnessing the tornado or funnel cloud firsthand, and volunteerism (being helped or helping others).

Interestingly, negative experiences associated with taking protective responses also were not common among Survey 1 respondents (these items were not asked on Survey 2). Even after removing the respondents for whom these items were not applicable, the majority indicated that it was not at all the case that they took unnecessary action (57%) or that responding to a tornado threat that did not occur was an inconvenience (67%). Further analysis focused only on respondents who indicated that the experience happened to them personally (with or without others); for this subset of people, there were no significant differences between cases where a tornado threatened and cases were a tornado actually occurred in reports of taking unnecessary action ($t(72) = 0.41$, $p = 0.69$) or of being inconvenienced ($t(74) = -1.05$, $p = 0.30$). In the weather forecast and emergency response communities, such negative experiences are thought to be associated with false alarms, overwarning, or both, and there is general concern that they reduce future risk assessment and behavioral responses. However, these results suggest that, at least in this context where people are reporting about a memorable experience, there is little

reason to be concerned about negative experiences associated with taking protective responses, even when the weather threat does not manifest.

## Experience Dimensionality

As detailed in Chapter 3, exploratory common factor analysis (hereafter, factor analysis) and item-scale correlations were used to determine the number of factors to extract and to assess and eliminate specific items. These results are discussed for Survey 1 first, and then the Survey 1 qualitative analysis to develop new items for Survey 2 is presented. The quantitative analysis of the Survey 2 data follows. The final most memorable experience dimensions and their interpretations are presented last.

### *Survey 1 Dimensionality Results.*

The initial factor analysis of the 39 most memorable experience items from Survey 1 met the required assumptions (KMO = 0.79; Bartlett's Test of Sphericity, $\chi^2(741) = 3199.4$, $p < 0.01$). A 5-factor solution was suggested by the scree plot and variance explained. Fourteen items were dropped based on iterative evaluations of factor loadings, communalities, and item-scale correlations, leaving 25 items loading onto 5 factors with 66.2% total variance explained. The items and their factor loadings are provided in Table 7 (see Appendix F for communalities and item-scale correlations). The variance explained for each of the five emergent factors also is reported, as are the Cronbach's alpha statistics, which indicate very good internal consistency of the dimensions.

Table 7. *Factor analysis results of most memorable experiences from Survey 1*

| | *Threat environmental cues* | *Risk awareness* | *Risk personalization* | *Personal intrusive impacts* | *Vicarious troubling impacts* |
|---|---|---|---|---|---|
| I paid attention to the weather forecasts and warnings because I knew about the threat… | 0.14 | 0.81 | 0.02 | 0.02 | -0.05 |
| I was concerned about the threat… | 0.07 | 0.83 | 0.02 | 0.03 | -0.04 |
| People I know talked to me about the threat… | -0.04 | 0.78 | 0.07 | -0.09 | 0.10 |
| People I know were concerned about the threat… | -0.08 | 0.90 | 0.00 | -0.01 | 0.03 |
| There was news coverage about the threat… | 0.01 | 0.89 | -0.06 | 0.00 | 0.00 |
| I tried to take action to protect myself or my loved ones *(or vice versa)* | 0.02 | 0.01 | 0.74 | -0.11 | -0.02 |
| I tried to get to my loved ones to be with them *(or vice versa)* | 0.00 | -0.10 | 0.77 | 0.04 | -0.18 |
| I feared for my loved ones | -0.17 | 0.13 | 0.58 | 0.11 | 0.03 |
| I worried about my home | 0.02 | 0.15 | 0.57 | 0.24 | -0.02 |
| I saw scenes of the storm firsthand | 0.07 | 0.00 | 0.60 | -0.05 | 0.03 |
| I heard sounds of the storm firsthand | -0.03 | 0.00 | 0.71 | -0.12 | 0.16 |
| I was shaken up | -0.02 | -0.16 | 0.27 | 0.58 | 0.00 |
| I had trouble staying asleep and/or had dreams about it | 0.02 | -0.04 | -0.03 | 0.66 | -0.03 |
| I had waves of strong feelings about it | -0.06 | 0.08 | 0.04 | 0.80 | -0.02 |
| I thought about it when I didn't mean to | 0.02 | 0.04 | -0.17 | 0.96 | -0.06 |
| Pictures about it popped into my mind | 0.00 | 0.02 | 0.03 | 0.76 | 0.01 |
| My life was disrupted afterward | 0.08 | -0.12 | -0.04 | 0.56 | 0.29 |
| People I know had damage to their property | 0.00 | -0.01 | 0.13 | -0.13 | 0.81 |
| People I know lost irreplaceable items | 0.03 | 0.04 | -0.13 | 0.00 | 0.71 |
| The lives of people I know were disrupted afterward | -0.09 | 0.10 | -0.19 | 0.11 | 0.92 |
| People talked to me about what they experienced | 0.03 | -0.04 | 0.13 | -0.01 | 0.70 |
| I saw scenes of the aftermath firsthand | 0.10 | -0.12 | 0.24 | 0.07 | 0.44 |
| The sky looked unusual that day | 0.69 | 0.12 | 0.04 | 0.11 | -0.05 |
| The air felt unusual that day | 0.96 | -0.06 | -0.04 | -0.05 | 0.05 |
| Animals acted unusually or were unusually absent that day | 0.47 | 0.06 | 0.02 | -0.06 | 0.00 |
| Variance explained (66.2%) | 6.2% | 25.2% | 9.4% | 17.4% | 8.0% |
| Cronbach's α | 0.75 | 0.93 | 0.83 | 0.87 | 0.85 |

*Note:* Factor loadings in black text indicate the primary loading, and other loadings are in grey text.

The 14 items that were dropped from the Survey 1 most memorable experience dimensionality analysis are provided in Table 6. The items that measure personal injury, injury to others, and personal property damage were not commonly experienced by the survey respondents, as discussed above, and this lack of variance may have contributed to their being dropped in the analysis. Because these items are commonly employed in other studies, they were included on Survey 2 to re-assess their performance, even though they were dropped from the Survey 1 data analysis. Two other items—i.e., the measures of respondents' experiences with fearing for their life and with talking to others about their experience—were dropped from the analysis because they loaded onto two factors, but these also were included on Survey 2 to re-assess their performance. The remaining nine items that were dropped from the analysis were not included on Survey 2. They include the aforementioned less common experiences associated with volunteering and negative experiences with protective responses, two items that measure unmediated and mediated observations of the tornado, and three items that measure different types of impacts.

The five latent factors that emerged were interpretable, representing most memorable experiences pertaining to: (1) *risk awareness*, (2) *risk personalization*, (3) *personal intrusive impacts*, (4) *vicarious troubling impacts*, and (5) *threat environmental cues*. The first four factors also emerged from the Survey 2 analysis, thus are further discussed in that section below. The fifth factor, which is interpreted as representing environmental cues of the threat, consists of items that capture direct sensory inputs that are atypical and are associated with a tornado threat, i.e., unusual aspects of the sky (visual), air (tactile), and animal behavior (which can be visual, auditory, or both). These items were worded to represent the threat of a tornado, that is, the time either before the tornado formed or before it arrived at the respondent's location. In this way,

these items differ from environmental cues that occur during the event (e.g., hearing sounds of the storm). The "Animals acted unusually…" item, although it had an adequate factor loading (Table 7), had low communality and item-scale correlation values (Appendix F). The item was retained, however, so that the environmental cues factor had more than two items. Moreover, as discussed above, most respondents did not have experience with unusual animal behavior, but the qualitative data suggest it was salient for those who did. Retaining it therefore allowed this less common but potentially important type of experience to be captured and for it to be re-assessed on Survey 2.

***Survey 1 New Item Development.***

Following the quantitative dimensionality analysis of the Survey 1 items, respondents' open-ended descriptions of what they remember most clearly and their feelings about their most memorable experience were analyzed inductively, as described in Chapter 3, to identify important aspects that were not represented in the original item set. Six new survey items were developed based on the qualitative analysis; the full wording of each is provided in Table 6.

The first item added was "I had a bad sense about the weather… . " This item captures a negative affective feeling often associated with sensory experiences, as indicated by these two quotes:

> We were at our lake home (no basement). 5 married children and 16 grandchildren. The wind shifted on the lake, which I knew was not a good sign… [88280].

> I remember it was in January. The temperature was about 70 and here in WI it's never that warm in January. It was around 3:00 pm. I was driving home from work and noticed the sky looked stormy and it was really warm. Things just didn't feel right… [71411]

This new item also supplements the three existing items that measured environmental cues of the threat (i.e., pertaining to the sky, air, and animals), which emerged as a dimension of one's most memorable experience as discussed above.

The second item added was "I felt sensations of the storm firsthand… ." One way this was described was as "I could feel the pressure in my head" [16887]. Others described the sensations as it pertained to their home including such as, "The house began to shake and I saw our windows flexing in and out" [37412]; "Could feel the air being sucked out of the house" [63036]; and even anthropomorphically as "The posters on the inside of my son's bedroom door were pulled under the door into the hallway. The house felt like it was breathing." [61467]. All of these descriptions came from instances in which a tornado actually occurred. But respondents who reported that tornado was possible but did not occur also described feeling sensations of the storm, as in this quote:

> I experienced some trouble on my way back home because a severe storm was underway and the streets were flooded and to top things off, I drove a small car at that time and I could really feel the wind moving my car a lot! [29785]

This new item also supplements the other items that capture firsthand sensory experiences during the event (e.g., seeing scenes and hearing sounds of the storm firsthand).

The third and fourth items added also supplement the existing items that aimed to measure different sensory aspects of the experience. One item was, "The storm happened suddenly." In all cases, the suddenness that respondents discussed represented a transition from a non- (or less) threatening situation to a more threatening one. For some, this transition scenario was from no storm to a sudden storm, as was the case for this person, "It was a beautiful day when all of a sudden a storm rolled in, producing tornadoes throughout the area" [77209] and for this person, "It was early evening about 6 p.m. and I went outside, because the rain and thunder

were coming on quickly." [32060] Others described the transition scenario as one in which a storm was happening but then rapidly worsened, as was the case for these two people:

> I remember laying in bed listening to the heavy rain and hail on the roof, then all of a sudden it got quiet for like 10 mins, then I could hear things flying around and glass breaking, it all happened so fast. [84450]

> Driving home and was heading into the direction of the storm. Sirens were going off, tornado warnings were in force, and winds were extremely strong with no rain yet. Small debris was flying in the air and being carried across the top of the roof tops of the neighborhood. When we parked the truck in the driveway, we knew we had to get shelter ASAP. The winds were so strong that it was difficulty to open the doors of the truck. We had to put our body weight on the doors in order to just get them open enough to get out. The experience was certainly scary as the winds gained strength in such a short period of time. [22829]

As indicated by all of these quotes, there are different ways that the rapid-onset nature of tornadoes can manifest. It seems that, for some people, being caught off-guard by such suddenness is an important part of their experience.

The fourth new item, "At times, I couldn't tell what was happening… ," aimed to capture an uncertain sensory experience, either due to confusion or lack of information. Ways that respondents discuss this type of experience included as follows:

> I got the dog and ran for cover in the hallway and piled blankets on top of us. Within seconds the windows rattled and I could feel the pressure in my head. The electricity went off so I had no idea what was going on. When I came out I didn't know if the house would still be standing around me. [16887]

> I was driving back from Peru State College in October when a tornado was less than a mile away from me. It was dark and raining and I could not tell which direction it was coming or going. [71371]

> I was shopping with friends at the mall. There was an announcement that everyone needed to take shelter immediately. We went into the area that they directed and waited. I just remember it was so loud inside the building that we couldn't hear that there was anything going on outside. We just assumed that it was another warning and nothing happened. Until we went outside. There had been a small tornado that had touched down and done some minor damage in the parking lot. [59349]

As these quotes indicate, not being able to tell what is happening can be fearful, disorienting, or simply confusing, all of which can be a vivid part of one's experience.

The last two new items supplemented the suite of existing items that measure impacts. One item was "People I know were shaken up." There was only a little qualitative evidence for this idea, as per this quote:

> The after effects, leveled homes and barren lands. Debris everywhere and just general chaos. Walking in the vicinity with possessions being trampled was very alarming. But thankful no one was seriously hurt, but emotions were clearly distraught." [82636]

This item was added, though, based on this evidence but also to have an item that parallels the existing one that measures being personally shaken up, especially because such intangibles were shown by the quantitative analysis to be important experiential measures. The other, and final, new item was "I was shocked by the devastation and loss," an idea that was conveyed by several respondents. Some respondents explicitly noted their shock, as did this person, "Shock at the utter devastation and loss of everything material" [40020] and this person, "I remember going outside after the tornado being amazed at the damage even though the tornado did not touch down were we were." [86381] For others, the amazement was implicit from their comments, such as from this respondent:

> I remember driving through neighborhoods where there were no houses, just driveways and sidewalks leading to nowhere. The trees were all cut off at the top and looked like a huge saw had come through and sliced them all off at the same height and left no branches. [24711]

Another example, discussed earlier, conveys the memorable shock of someone whose experience occurred several decades ago.

> I still remember seeing a neighborhood that was gone except for one home with only four walls of the bathroom still standing, the door was open and you could see the toilet and bath tub. That was all that was left of that neighborhood. [72808]

***Survey 2 Dimensionality Results.***

Thirty-six most memorable experience items were evaluated on Survey 2, consisting of the 25 items (making up 5 factors) that were retained by the dimensionality analysis from Survey 1, the 5 items that were dropped from the dimensionality analysis but were kept for Survey 2 to re-assess their performance, and the 6 items that were newly developed based on the Survey 1 qualitative analysis.

The initial factor analysis of the 36 items met the required assumptions (KMO = 0.88; Bartlett's Test of Sphericity, $\chi^2(630) = 4100.0$, $p < 0.01$). A 4-factor solution was suggested by the scree plot and variance explained. Eleven items were dropped based on iterative evaluations of factor loadings, communalities, and item-scale correlations, leaving 25 items loading onto 4 factors with 65.0% total variance explained. The items and their factor loadings are provided in Table 8 (see Appendix F for communalities and item-scale correlations).

The 11 items that were dropped from the dimensionality analysis of the Survey 2 most memorable experiences are provided in Table 6. Five of the 11 items were those that were dropped from the Survey 1 dimensionality analysis but that were included on Survey 2 to re-assess their performance. That these items were again dropped implies that these results are valid. Three of the 11 dropped items were those that were newly developed for Survey 2 based on the qualitative analysis, including having a bad sense about the weather, the storm happening suddenly, and at times not being able to tell what was happening. Finally, the three items that made up the *threat environmental cues* factor in Survey 1 were dropped in the Survey 2 analysis. It is interesting that that these were dropped despite having added the item about having a bad sense about the weather, which was thought to capture a complementary aspect of one's threat-

Table 8. *Factor analysis results of most memorable experiences from Survey 2*

| | *Risk awareness* | *Risk personalization* | *Personal intrusive impacts* | *Vicarious troubling impacts* |
|---|---|---|---|---|
| I paid attention to the weather forecasts and warnings because I knew about the threat… | 0.77 | 0.07 | -0.07 | 0.00 |
| I was concerned about the threat… | 0.82 | 0.05 | 0.01 | 0.01 |
| People I know talked to me about the threat… | 0.81 | -0.04 | 0.07 | -0.08 |
| People I know were concerned about the threat… | 0.89 | -0.08 | -0.01 | -0.03 |
| There was news coverage about the threat… | 0.74 | 0.01 | -0.09 | 0.03 |
| I tried to take action to protect myself or my loved ones (or vice versa) | 0.17 | 0.62 | 0.02 | 0.05 |
| I tried to get to my loved ones to be with them (or vice versa) | 0.19 | 0.52 | 0.08 | 0.02 |
| I feared for my loved ones | 0.10 | 0.49 | 0.15 | 0.08 |
| I worried about my home | 0.13 | 0.57 | -0.01 | 0.03 |
| I saw scenes of the storm firsthand | -0.17 | 0.79 | -0.02 | 0.00 |
| I heard sounds of the storm firsthand | -0.07 | 0.88 | -0.04 | -0.09 |
| I felt sensations of the storm firsthand[+] | -0.05 | 0.83 | -0.06 | -0.04 |
| I was shaken up | 0.01 | 0.19 | 0.60 | 0.04 |
| I had trouble staying asleep and/or had dreams about it | -0.06 | -0.02 | 0.69 | 0.05 |
| I had waves of strong feelings about it | 0.02 | -0.06 | 0.77 | 0.01 |
| I thought about it when I didn't mean to | 0.03 | -0.12 | 0.95 | -0.02 |
| Pictures about it popped into my mind | -0.08 | 0.11 | 0.82 | -0.08 |
| My life was disrupted afterward | 0.00 | -0.02 | 0.70 | 0.06 |
| People I know had damage to their property | -0.04 | 0.12 | -0.12 | 0.88 |
| People I know lost irreplaceable items | -0.08 | -0.10 | -0.04 | 0.84 |
| The lives of people I know were disrupted afterward | 0.09 | -0.27 | 0.05 | 0.95 |
| People talked to me about what they experienced | 0.09 | 0.19 | 0.09 | 0.49 |
| I saw scenes of the aftermath firsthand | -0.09 | 0.23 | -0.06 | 0.65 |
| People I know were shaken up[+] | 0.01 | 0.04 | 0.12 | 0.68 |
| I was shocked by the devastation and loss[+] | -0.02 | -0.01 | 0.08 | 0.63 |
| Variance explained (65.0%) | 7.6% | 8.5% | 16.6% | 32.3% |
| Cronbach's α | 0.90 | 0.87 | 0.89 | 0.90 |

*Note:* Factor loadings in black text indicate the primary loading, and other loadings are in grey text.
[+]Item added to Survey 2 based on qualitative analysis of Survey 1 open-ended response.

related environmental cues. This factor did account for the smallest amount of variance in the Survey 1 results, however (Table 7).

The four latent factors that emerged were interpretable and, importantly, they are consistent with the Survey 1 results, with the factors representing: (1) *risk awareness*, (2) *risk personalization*, (3) *personal intrusive impacts*, and (4) *vicarious troubling impacts*. The only

difference in these factors between Survey 1 and Survey 2 is that three of the six items that were newly developed based on the Survey 1 qualitative analysis were retained. "I felt sensations of the storm" loaded onto the *risk personalization* dimension. Also, "People I know were shaken up" and "I was shocked by the devastation and loss" both loaded onto the *vicarious troubling impacts* dimension. There was no change between the surveys in the set of items loading onto either the *risk awareness* dimension or the *personal intrusive impacts* dimension. The dimensions and the items they comprise are summarized across the two surveys in Table 9. The Survey 2 results are considered the final set of most memorable experience dimensions and items for the present study. The interpretation and statistical summary of them is discussed next.

***Final Dimensions of Most Memorable Experience.***

Four final, interpretable factors emerged following the scale development and analysis from Surveys 1 and 2. The first factor consists of five items that capture the most memorable event-specific awareness of the tornado risk—i.e., of the possibility of the hazard occurring and concern about it causing harm—by the respondent as well as threat-related social cues from known others and the news media.[16] Therefore, this experience dimension is interpreted as "*risk awareness*" regarding a specific event (versus general awareness that a type of risk exists).

The next factor consists of seven items that captures one's responses—including both protective actions (e.g., trying to get to loved ones) and emotional responses (fear, worry)—as well as direct visual, auditory, and tactile sensory information during the event. Collectively, these items are indicators of one's recognition that they *personally* are risk of a tornado versus recognizing a more uncertain tornado risk (at some time or for some place, which is captured

[16] Note that some researchers, like Lindell and Perry (2012), distinguish social cues from forecast and warning information transmitted from an official source.

Table 9. *Summary of most memorable experience dimensions and items from Surveys 1 and 2*

| Latent dimension | Item | Survey 1 | Survey 2 |
|---|---|---|---|
| *Threat environmental cues*[a] | The sky looked unusual that day | x | |
| | The air felt unusual that day | x | |
| | Animals acted unusually or were unusually absent that day | x | |
| *Risk awareness* | I paid attention to the weather forecasts and warnings because I knew about the threat of tornadoes that day | x | x |
| | I was concerned about the threat of tornadoes that day | x | x |
| | People I know talked to me about the threat of tornadoes that day | x | x |
| | People I know were concerned about the threat of tornadoes that day | x | x |
| | There was news coverage about the threat of tornadoes that day | x | x |
| *Risk personalization* | I tried to take action to protect myself or my loved ones (or vice versa) | x | x |
| | I tried to get to my loved ones to be with them (or vice versa) | x | x |
| | I feared for my loved ones | x | x |
| | I worried about my home | x | x |
| | I saw scenes of the storm firsthand[b] | x | x |
| | I heard sounds of the storm firsthand | x | x |
| | I felt sensations of the storm firsthand[+] | | x |
| *Personal intrusive impacts* | I was shaken up | x | x |
| | I had trouble staying asleep and/or had dreams about it | x | x |
| | I had waves of strong feelings about it | x | x |
| | I thought about it when I didn't mean to | x | x |
| | Pictures about it popped into my mind | x | x |
| | My life was disrupted afterward | x | x |
| *Vicarious troubling impacts* | People I know had damage to their property | x | x |
| | People I know lost irreplaceable items | x | x |
| | The lives of people I know were disrupted afterward | x | x |
| | People talked to me about what they experienced | x | x |
| | I saw scenes of the aftermath firsthand | x | x |
| | People I know were shaken up[+] | | x |
| | I was shocked by the devastation and loss[+] | | x |

[+] Item added to Survey 2 based on qualitative analysis of Survey 1 open-ended response.
[a] This dimension only emerged in Survey 1 and therefore is not among the final dimensions of most memorable tornado experiences.
[b] Item changed slightly from Survey 1 to Survey 2. In Survey 1, it read "I saw *other* scenes of the storm…"because another item asked about seeing the tornado or funnel cloud firsthand. That item was dropped from Survey 1 and not included on Survey 2, so seeing a tornado was wrapped into this item for Survey 2.

by the prior dimension). Therefore, this experience dimension is interpreted as "*risk personalization*." The similar notion of one personalizing a formal (natural or man-made) hazard *warning* as an important step in warning response emerged in the hazards literature decades ago

based on work done by Dennis Mileti and John Sorensen (Mileti & Sorensen, 1991; Sorensen, 2000). However, Mileti and Sorensen describe warning personalization simply as one believing that he or she is the target of the warning (versus thinking the warning does not apply to them or feeling an optimism bias that "it can't happen to me," Mileti & Sorensen, 1991, pp. 5-2). Although personalizing a warning is important for behavioral response, one may not receive a formal warning for a tornado, which is a rapid-onset hazard, either because a warning may not be in effect or because the information was not received. Moreover, even if one receives and personalizes a tornado warning, most people who are warned about a tornado do not suffer a direct hit from one because there can be overspray of the information such that it reaches people who are not officially within the warning, and because tornadoes are spatially localized hazards (Coleman, Knupp, Spann, Elliott, & Peters, 2011). Therefore, personalizing one's risk of being directly hit by a hazard such as a tornado is important, and the items that make up this dimension illustrate what constitutes this process.

The next factor consists of six items that capture ways one is personally affected by an experience. Four of the items (trouble sleeping, waves of feelings, thinking about it when not meaning to, and pictures popping into the mind) were drawn from the intrusion subscale of the Impacts of Event Scale-Revised (Christianson & Marren, 2013; Weiss & Marmar, 1997). The other two items (shaken up, life disrupted) were designed as additional measures of intrusiveness. Therefore, this experience dimension is interpreted as "*personal intrusive impacts*." This dimension and all of the items it comprises interestingly capture intangible personal impacts. By comparison, measures of tangible personal impacts—such as personal injury and property damage—were not retained based on the dimensionality analysis. As noted above, only three of the Survey 2 respondents had been physically injured. Additional analysis

shows that those three respondents reported a level of *personal intrusive impacts* (using summed scale of the items, discussed further below) that was more than twice the average for respondents who had not been injured ($M$ = 20.0 vs. $M$ = 9.6, $t(182) = -4.41$, $p < 0.01$). Forty-seven percent of the Survey 2 respondents had suffered some degree of property damage. They too reported an average *personal intrusive impacts* level that was greater than respondents who had not suffered damage, although the mean difference is not as large as in the injury comparison ($M$ = 10.9 vs. $M$ = 8.7, $t(182) = -3.63$, $p < 0.01$). Collectively, these results suggest that the personal intrusive impacts dimension captures the effect of these types of tangible impacts for those who have experienced them, even though it does not explicitly include such measures, but the dimension is a more encompassing and therefore a potentially more useful scale for measuring personal impacts of tornado experiences. This is particularly noteworthy given that the tangible measures of impacts are what are often used by researchers, which suggests that those studies are measuring respondents' personal impacts in limited ways.

The last factor comprises seven items. It includes items that capture others' tangible impacts (property damage and loss), others' intangible disruptive impacts (life disruption, being shaken up), and others' verbal accounts of their experience. The dimension also consists of items that capture respondents' unmediated experiences with the impacts (seeing scenes of the aftermath, shock by the devastation and loss), which likely pertain to impacts suffered by others even if they also pertain to respondents themselves. Importantly, although many (and perhaps all) of the items are about indirect experiences, the respondent still personally experiences these aspects in some way by hearing about or witnessing them. This dimension therefore is interpreted as "*vicarious troubling impacts.*" As specified in most of the items, the "others" that contribute to these vicarious experiences are people the respondent knows. Moreover, most

respondents—including those who indicated that the experience happened to other people—lived near where the event occurred, implying that one's community attachment may also influence the one's vicarious experience.[17] This dimension differs from the previous one which captures impacts that are solely personal (although, as discussed below, these two dimensions are strongly correlated).

The Cronbach's alpha statistics, reported in Table 8, indicate there is excellent internal consistency of the items that make up each of the four most memorable experience dimensions, with values between 0.87-0.90. Items were summed to create the respective scales for use in subsequent analyses; the scale summary statistics are provided in Table 10. There is good variability in all scales except for the personal intrusive impacts scale, which is positively skewed, indicating that more people score lower on the scale, and vice versa.

Table 10. *Scale summary statistics for the four most memorable experience dimensions*

| | *Risk awareness* | *Risk personalization* | *Personal intrusive impacts* | *Vicarious troubling impacts* |
|---|---|---|---|---|
| Mean | 12.8 | 17.8 | 9.7 | 18.3 |
| Median | 13.0 | 18.0 | 8.0 | 19.0 |
| Mode | 20 | 7 | 6 | 28 |
| Standard deviation | 5.1 | 6.6 | 4.3 | 6.6 |
| Variance | 25.7 | 44.0 | 18.2 | 43.0 |
| Skewness | -0.2 | -0.2 | 1.4 | -0.1 |
| Kurtosis | -1.2 | -1.2 | 1.4 | -1.2 |
| Minimum | 5 | 7 | 6 | 7 |
| Maximum | 20 | 28 | 24 | 28 |

Bivariate analyses were conducted between the most memorable experience dimensions and the tornado occurrence and date of the experience characteristics discussed at the beginning

[17] This sub-question was added to Survey 2 to gather data on how far away the respondent was from the "other" person that they reported the experience happened to (see Appendix C, Q1a). Fifty percent of respondents were within 15 miles, 75% were within 30 miles, and all were within 300 miles.

of this chapter. Analyses were not conducted for the risk target because of the results presented earlier showing that there was overlap in how respondents conceptualized to whom the experience happened.

Analyses with the tornado occurrence variable reveal there is no significant difference based on whether or not a tornado occurred in *risk awareness* ($t(175) = 0.01$, $p = 0.99$) or in *risk personalization* ($t(175) = 1.4$, $p = 0.15$). This may be expected for *risk awareness*, as it is common for a tornado threat to be raised without the event occurring. That there is no difference for *risk personalization* suggests that people can get to the point of engaging in protective and emotional responses and that there may be sensory inputs, all without a tornado actually occurring. This is supported by the earlier qualitative reports from respondents who stated that even when a tornado did not occur, other hazardous weather conditions did occur. Other analyses revealed that when a tornado occurred, respondents reported significantly higher *personal intrusive impacts* ($t(175) = 2.3$, $p = 0.02$) and *vicarious troubling impacts* ($t(175) = 4.9$, $p < 0.01$) compared to when a tornado threatened but did not materialize. In other words, not surprisingly, impacts tend to be greater when a tornado occurs, but there can be impacts in the ways measured here even when a tornado does not.

Correlations between the most memorable experience dimensions and how many years ago the experience happened reveal two significant relationships. First, the *risk awareness* values decreased overall the longer ago the experience occurred ($r(151) = -0.33$, $p < 0.01$). Recalling that the items this dimension comprises measure one's own awareness of and concern about the threat of tornadoes as well as related social cues from others, these experiences may be less vivid and therefore less memorable over time. These experiences also tend to be common for people who live in tornado-prone areas, which could muddle memories of a specific event. Next, there is

a positive relationship between *personal intrusive impacts* and when the experience occurred ($r(151) = 0.22$, $p < 0.01$). This reveals that many of the respondents with stronger personal impacts experienced their memorable tornado event long ago, which suggests that the experience is vivid and memorable. No significant relationships exist between when the experience occurred and *risk personalization* ($r(151) = -0.07$, $p = 0.40$) or *vicarious troubling impacts* ($r(151) = 0.05$, $p = 0.54$).

Gender differences among the most memorable experience dimensions were explored, but none were found (*risk awareness:* $t(182) = -0.01$, $p = 0.99$; *risk personalization:* $t(182) = -1.2$, $p = 0.24$; *personal intrusive impacts:* $t(182) = -1.2$, $p = 0.24$; *vicarious troubling impacts:* $t(182) = 0.01$, $p = 0.99$).

## Multiple Tornado Experiences

### Item Descriptives

People can have more than one experience with a tornado threat or event. Thus, as described in Chapter 3, several items were developed to measure the amount of multiple experiences respondents have with tornadoes. Seventeen items were developed for Survey 1 and, for each, respondents were asked to indicate how much experience they had on a four-point scale (ranging from “no experience” to “a great deal of experience”). The items and their complete wording are provided in Table 11.

Table 11. *Multiple experience item wordings and item comparison between Surveys 1 and 2*

| Item | Survey 1 *M(SD)* | Survey 2 *M(SD)* | *t*-test comparison |
|---|---|---|---|
| Retained in Surveys 1 and 2 | | | |
| I have been under a tornado warning | 3.44 (0.68) | 3.47 (0.69) | $t(326) = -0.37$, $p = 0.71$ |
| I have heard tornado sirens (not as a test) firsthand[a] | 3.36 (0.83) | 3.29 (0.88) | $t(326) = 0.71$, $p = 0.48$ |
| I have heard or watched live news coverage (on radio, TV, or online) of a tornado as it was happening | 3.15 (0.88) | 3.28 (0.88) | $t(326) = -1.35$, $p = 0.18$ |
| I have seen news coverage about the aftermath of a tornado (e.g., people who were affected, damage, images of the tornado) | 3.49 (0.65) | 3.64 (0.61) | $t(298.4)^b = -2.11$, $p = 0.04$ |
| I have feared for my life due to a tornado | 1.94 (0.97) | 2.15 (0.99) | $t(326) = -1.91$, $p = 0.06$ |
| I have feared for my loved ones due to a tornado | 2.36 (1.06) | 2.51 (1.00) | $t(326) = -1.26$, $p = 0.21$ |
| I have worried about my home due to a tornado | 2.48 (0.98) | 2.47 (1.01) | $t(326) = 0.06$, $p = 0.95$ |
| Dropped in S1, yet retained for S2 but dropped | | | |
| I have dreams about tornadoes. | 1.31 (0.65) | 1.46 (0.80) | $t(325.2)^b = -1.87$, $p = 0.06$ |
| I think about moving to where tornadoes aren't as threatening. | 1.22 (0.52) | 1.34 (0.70) | $t(325.3)^b = -1.78$, $p = 0.08$ |
| Dropped in S1, not retained for S2 | | | |
| I have been threatened by a tornado | 2.61 (0.91) | n/a | n/a |
| I have seen a tornado or funnel cloud firsthand | 2.35 (1.17) | n/a | n/a |
| I have taken shelter from a tornado. | 2.91 (1.00) | n/a | n/a |
| I have left my home to flee from a tornado. | 1.42 (0.81) | n/a | n/a |
| I have had property damage (e.g., home, trees, car) due to a tornado. | 1.83 (0.98) | n/a | n/a |
| I have seen the aftermath of a tornado firsthand (e.g., damaged areas, downed trees, people injured). | 2.98 (0.94) | n/a | n/a |
| I have volunteered to help others who were affected by a tornado. | 1.78 (0.92) | n/a | n/a |
| I have taken action to protect myself or my loved ones from a tornado threat that was unnecessary. | 2.11 (1.00) | n/a | n/a |
| I have been inconvenienced by responding to a tornado threat. | 1.77 (0.91) | n/a | n/a |
| I have been warned about a tornado that did not occur. | 2.83 (0.91) | n/a | n/a |

[a] Parenthetical "(not as a test)" added from Survey 1 to Survey 2 based on pretest.
[b] Levene's test for equality of variances is significant, thus *t*-test statistics are reported for equal variances not assumed.

Summary statistics and *t*-tests to compare the Survey 1 and 2 means also are provided in Table 11. Most items have good variance, but there are some items with which most respondents reported having a lot of experience. Nearly all respondents had frequently been under a tornado warning, with more than half from each survey reporting they had a great deal of experience; only four Survey 2 respondents reported they had never been under a warning, and none from Survey 1 did. More than half of respondents from each survey also had a great deal of experience hearing sirens and seeing news coverage about the aftermath of a tornado. Similarly, 44-50% had a great deal of experience hearing or watching live news coverage as a tornado was happening. In contrast, a few items were infrequently experienced. Many respondents reported they had no experience fleeing from a tornado (74%), suffering personal property damage (50%), or volunteering to help others after a tornado (49%).

Most Survey 1 respondents reported they had little or no experience with negative experiences associated with taking unnecessary protective action (66%) or being inconvenienced by responding to a tornado threat that did not occur (79%). This is especially interesting given that, in contrast, most respondents reported they had some or a great deal of experience (65%) with a false alarm, i.e., being warned about a tornado that did not occur. Crosstab analyses further show that, of the 95 respondents who had any amount of experience (a little, some, or a great deal) with taking unnecessary protective action, 74% of them reported little or no inconvenience. Similarly, 78% of the 132 respondents who had experienced a false alarm reported little or no inconvenience. These results, coupled with the related most memorable experience results discussed above, further support that there is little reason to be concerned that people have negative perceptions associated with false alarms (whether they took protective

action or not). These results may be specific to those who were motivated to complete the survey, however.

## Experience Dimensionality

Again, exploratory factor analysis and item-scale correlations were used to determine the number of multiple experience factors and evaluate the items. In contrast to the most memorable experience results, here, the Survey 1 and Survey 2 results are presented together because the results are consistent between the two and because there are fewer results to present (i.e., no data on characteristics and no qualitative data).

### *Amount of Multiple Tornado Experiences.*

The initial factor analysis of the 17 multiple experience items from Survey 1 met the required assumptions (KMO = 0.88; Bartlett's Test of Sphericity, $\chi^2(136) = 1165.1$, $p < 0.01$). A 2-factor solution was suggested by the scree plot and variance explained. Ten items were dropped based on iterative evaluations of factor loadings, communalities, and item-scale correlations, leaving 7 items loading onto 2 factors with 74.2% total variance explained. The items and their factor loadings are provided in Table 12 (see Appendix F for communalities and item-scale correlations) along with the variance explained for each factor.

The 10 items that were dropped from the Survey 1 dimensionality analysis are provided in Table 11. They include the more frequently experienced items of being threatened by a tornado, seeing a tornado or funnel cloud firsthand, taking shelter, and seeing tornado aftermath first. Also dropped were the aforementioned less frequently experienced items of fleeing from a tornado, personal property damage, and volunteering, as well as the negative perception and

response experiences of taking unnecessary action, being inconvenienced, and being warned about a tornado that did not occur (false alarm).

Only the seven items that were retained by the Survey 1 dimensionality analysis were retained for Survey 2. The initial factor analysis met the required assumptions (KMO = 0.81; Bartlett's Test of Sphericity, $\chi^2(21) = 683.4$, $p < 0.01$), and a 2-factor solution again was suggested. The seven items loaded cleanly onto the two factors, and none needed to be dropped based on the communalities or item-scale correlations (Appendix F). The results, provided in Table 12, replicate those from Survey 1.

Table 12. *Factor analysis results of amount of multiple experiences from Surveys 1 and 2*

| | Survey 1 | | Survey 2 | |
|---|---|---|---|---|
| | *Common personal threat and impact experiences* | *Negative emotional responses* | *Common personal threat and impact experiences* | *Negative emotional responses* |
| I have been under a tornado warning | 0.89 | -0.05 | 0.84 | 0.04 |
| I have heard tornado sirens (not as a test) firsthand | 0.82 | -0.05 | 0.77 | -0.06 |
| I have heard or watched live news coverage on radio TV or online of a tornado as it was happening | 0.59 | 0.15 | 0.66 | 0.08 |
| I have seen news coverage about the aftermath of a tornado | 0.70 | 0.11 | 0.65 | -0.02 |
| I have feared for my life due to a tornado | 0.00 | 0.83 | -0.06 | 0.90 |
| I have feared for my loved ones due to a tornado | -0.05 | 0.96 | -0.02 | 0.91 |
| I have worried about my home due to a tornado | 0.14 | 0.66 | 0.12 | 0.75 |
| Variance explained (Survey 1: 74.2%; Survey 2: 73.3%) | 58.3% | 15.9% | 18.5% | 54.8% |
| Cronbach's α | 0.85 | 0.87 | 0.82 | 0.90 |

The two factors that emerged from the Survey 1 and 2 dimensionality analyses of the multiple experience items were interpretable. The first factor consists of four items. Two items represent the amount of personal experience one has with two types of official warning information about tornado threats: being under a tornado warning and hearing tornado sirens

firsthand. These two forms of communication—which often co-occur, as most municipalities' policies are to sound sirens when a tornado warning is in effect—have existed for decades in tornado-prone areas.[18] The other two items represent experience with tornado-related news information. One item, hearing or watching live news coverage as a tornado is happening, likely captures the information-seeking that occurs when one is under a tornado warning or hears sirens (i.e., is personally threatened), as well as more general information-seeking. The final item captures experience with seeing news coverage of the aftermath of a tornado. Together, these four items are interpreted as "*common personal threat and impact experiences.*"

The second factor consists of three items that capture the amount of experience a respondent has fearing for their own life, fearing for loved ones, and worrying about their home due to a tornado. The latter two items are the same as those that represented negative emotional responses as part of the most memorable experience dimension of *risk personalization.* This dimension therefore is interpreted as "*negative emotional responses.*"

The Cronbach's alpha statistics (Table 12) indicate there is excellent internal consistency of the items that make up the two multiple experience dimensions, with values between 0.82-0.90. Items were summed to create the respective scales for use in subsequent analyses; the scale summary statistics are provided in Table 13. The *common experiences* scale is negatively skewed, indicating that more people score higher on the scale. The *negative emotional responses* scale is more normally distributed.

[18] Note, however, that many municipalities sound sirens for other types of hazardous weather in addition to tornadoes.

Table 13. *Scale summary statistics for the two multiple experience dimensions*

| | *Common personal threat and impact experiences* | *Negative emotional responses* |
|---|---|---|
| Mean | 13.7 | 7.1 |
| Median | 14.0 | 7.0 |
| Mode | 16 | 6 |
| Standard deviation | 2.5 | 2.7 |
| Variance | 6.2 | 7.4 |
| Skewness | -1.2 | 0.2 |
| Kurtosis | 1.4 | -0.8 |
| Minimum | 4 | 3 |
| Maximum | 16 | 12 |

Correlations were explored between the multiple experience dimensions and the demographic characteristics of age, as it conceivably relates to the amount of experiences one can have, and gender. Surprisingly, no relationship was found with age (*common experiences*: $r(182) = -0.04$, $p = 0.60$; *negative emotional experiences*: $r(182) = -0.03$, $p = 0.65$). Men reported having slightly more of the *common experiences* than women ($M = 14.2$ vs. 13.6, $t(182) = 2.52$, $p = 0.01$), but there were no gender differences in the amount of *negative emotional experiences* ($t(182) = -0.11$, $p = 0.91$).

## Relationships among Types of Past Tornado Experiences

Four dimensions of a most memorable tornado experience and two dimensions of multiple tornado experiences emerged from the dimensionality analysis of the Survey 1 and 2 data. Correlations among the resultant summed scales (Table 14) were examined to understand the relationship among these dimensions. Nearly all of the dimensions are significantly and strongly correlated with the others, but some interesting sub-patterns emerged.

First, *risk personalization* is consistently strongly correlated with each of the other dimensions. This suggests that by the time one personalizes their risk in the ways captured by

Table 14. *Correlations among all pairs of experience variables*

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| 1. *Risk awareness* | | | | | | |
| 2. *Risk personalization* | 0.41*** | | | | | |
| 3. *Personal intrusive impacts* | 0.03 | 0.38*** | | | | |
| 4. *Vicarious troubling impacts* | 0.13* | 0.41*** | 0.52*** | | | |
| 5. *Common personal threat and impact experiences* | 0.29*** | 0.40*** | 0.20*** | 0.37*** | | |
| 6. *Negative emotional responses* | 0.28*** | 0.53*** | 0.49*** | 0.46*** | 0.50*** | |
| 7. I am experienced with tornadoes | 0.27*** | 0.45*** | 0.09 | 0.32*** | 0.49*** | 0.33*** |

***p < 0.01; **p < 0.05; *p < 0.1

this dimension, they are more likely to have the intangible personal impacts in the ways captured by the intrusiveness dimension as well as to experience impacts vicariously through proximate and known others. Being aware of the risk on a given day may have aided how one personalized their risk, but personalizing one's risk may also influence how one recalls being aware of the tornado risk on that given day; both of these causal processes may be at play.

Second, the relationship between *personal intrusive impacts* and *vicarious troubling impacts* is among the strongest correlations ($r(182) = 0.52$, $p < 0.01$). It is unclear whether this relationship is simply associative—i.e., that respondents who personally experience and are affected by a tornado event also vicariously learn of that experience with family and friends who also were affected—or whether it is causal, further supporting the idea that experiences that happen to others are personally experienced by the respondent (to the degree of causal intrusive impacts) through the vicarious process of hearing or learning about them. Indeed, the relationship likely is both for most respondents. Regardless, the relationship suggests that experiences with memorable hazards such as tornadoes are not solely individual, rather the experience is shared with others.

Third, consistently strong relationships exist between *negative emotional responses* and each of the other dimensions. Not surprisingly, this shows that respondents who have

experiences particularly with *risk personalization, personal intrusive impacts,* and *vicarious troubling impacts* consider themselves as having more negative emotional experience. It also shows that the more experiences respondents have with the *common personal threat and impact experiences,* the more negative emotional experiences they are likely to feel.

Finally, part of Trumbo et al.'s (in review) hurricane risk perception scale is a single item that measures one's self-reported experience. It was included on the surveys for the tornado context as "I am experienced with tornadoes," measured on a 5-point scale from "strongly disagree" to "strongly agree." The item was analyzed here in conjunction with the other experience dimensions to assess how an explicit self-report of experience relates to the emergent experience dimensions (Table 14). Strong correlations exist between the item and each dimension, except for *personal intrusive impacts*. Although the reason for this lack of relationship is unclear, it suggests that people who have experienced a memorable tornado event and then endured intrusive thoughts and feelings about it for some period of time afterward may not consider those aspects as part of the experience. In contrast, especially strong relationships exist between the self-report experience item and *risk personalization* and *common experiences,* suggesting that these types and amount of experiences are key ways that people think about their experiences.

# CHAPTER 5: TORNADO EXPERIENCES AND RISK PERCEPTION RESULTS

This chapter presents the results of the second research aim of this study, which is to investigate the relationship between the different emergent dimensions of people's tornado experiences and their tornado risk perceptions as a way to evaluate the construct validity of the scales. It begins by presenting the dimensions of tornado risk perception as measured in this study. Next, the experience-risk perception relationships are explored.

## Tornado Risk Perception

Risk perception has been conceptualized and measured in various ways, but increasingly, it is considered as a dual-mode phenomenon consisting of cognitive and affective systems that operate in parallel (see Chapter 2). As described in Chapter 3, Trumbo et al.'s (in review) recently developed cognitive-affective scale for hurricane risk perception was applied here to measure tornado risk perception. The article by Trumbo et al. details the development of the hurricane risk perception scale, including items that were dropped from the final scales. Because a scale to measure tornado risk perception has not yet been developed to the author's knowledge, all 20 of the items—including those retained in and dropped from the final hurricane risk perception scales—were tested here to explore whether there are differences in risk perception dimensions for the tornado context. The questions and items from Trumbo et al. were employed verbatim but with the word "hurricane" replaced with "tornado." One item, "I am experienced with tornadoes," was included on the survey, but it was omitted from the dimensionality analysis because, had it been retained in one of the risk perception dimensions, it would have been endogenous in the subsequent analyses between risk perception and the experience dimensions.

This self-reported experience item was used for other analyses, however (see Chapter 4). The complete wording of the remaining 19 risk perception items is provided in Table 15. Respondents were asked the extent to which they disagree or agree with each item, and they were provided with five response options (from "strongly disagree" to "strongly agree"). The positive affect items as well as three additional items were reversed coded (Table 15) so that higher response values reflect greater risk perception. Summary statistics for each item also are provided in Table 15.

Following Trumbo et al., the cognitive and affective items were factor analyzed together. The initial factor analysis of the 19 risk perception items met the required assumptions (KMO = 0.72; Bartlett's Test of Sphericity, $\chi^2(171) = 1405.1$, $p < 0.01$). A 4-factor solution was suggested by the scree plot and variance explained. Five items, all intended to measure cognitive aspects of risk perception, were dropped based on an iterative evaluation of factor loadings, communalities, and item-scale correlations (Table 15). All of the items that were intended to measure positive and negative affect loaded cleanly but, following Trumbo et al., the poorest performing item for each was dropped to achieve an equal number of items per factor. The final set of 12 items load onto 4 factors and explain 72.2% of the total variance. The factor loadings of each item are provided in Table 15 (see Appendix F for communalities and item-scale correlations) along with the variance explained per factor.

Table 15. *Item wordings, summary statistics, and factor analysis results of cognitive-affective tornado risk perception items*

| | Item summary statistics | Factor analysis results | | | |
|---|---|---|---|---|---|
| | *M(SD)* | *Negative affect* | *(lack of) Positive affect* | *Cognitive threat* | *(lack of) Cognitive knowledge* |
| Thinking about the possibility of a tornado makes me feel dread. | 2.77 (1.11) | 0.83 | 0.02 | 0.08 | -0.03 |
| … fearful. | 3.10 (1.16) | 0.97 | 0.01 | -0.06 | 0.04 |
| … worried. | 3.28 (1.10) | 0.83 | -0.02 | -0.02 | 0.01 |
| … courageous. *(reversed)* | 3.61 (0.90) | -0.08 | 0.67 | 0.12 | 0.06 |
| … exhilarated. *(reversed)* | 3.70 (1.05) | 0.02 | 0.94 | 0.00 | -0.01 |
| … alive. *(reversed)* | 3.72 (1.01) | 0.06 | 0.89 | -0.06 | -0.04 |
| … depressed. | 2.14 (0.96) | Item dropped | | | |
| … capable. *(reversed)* | 3.52 (1.05) | Item dropped | | | |
| I think that tornadoes may cause catastrophic destruction | 4.35 (0.72) | -0.07 | 0.09 | 0.64 | -0.17 |
| I think that tornadoes may cause widespread death | 3.84 (0.91) | -0.05 | 0.03 | 0.88 | 0.15 |
| I think that tornadoes pose great financial threat | 4.08 (0.82) | 0.18 | -0.07 | 0.44 | -0.05 |
| I am knowledgeable about tornadoes *(reversed)* | 2.27 (0.90) | -0.06 | 0.11 | -0.27 | 0.54 |
| I think tornadoes are hard to prepare for | 3.11 (1.14) | 0.15 | 0.01 | 0.16 | 0.42 |
| I think it is difficult to understand tornado forecast information | 2.42 (0.93) | -0.01 | -0.05 | 0.01 | 0.83 |
| I can control being physically harmed by a tornado *(reversed)* | 3.03 (1.08) | Item dropped | | | |
| I think tornadoes are very unpredictable | 3.77 (0.97) | Item dropped | | | |
| I think that the threat from tornadoes is increasing | 3.36 (1.00) | Item dropped | | | |
| I can control the amount of personal property damage from a tornado. *(reversed)* | 4.02 (0.98) | Item dropped | | | |
| I think that tornado damages extend to future generations | 3.70 (0.88) | Item dropped | | | |
| Variance explained (72.2%) | n/a | 24.6 | 20.2 | 15.1 | 12.3 |
| Cronbach's α | n/a | 0.91 | 0.86 | 0.67 | 0.57 |

*Note:* Factor loadings in black text indicate the primary loading, and other loadings are in grey text.

The four tornado risk perception factors that emerged and the items they comprise exactly match the hurricane risk perception results from Trumbo et al. (in review), thus they are interpreted accordingly. The first two factors represent "*negative affect*" and "*positive affect*" as they respectively capture the negative and (lack of) positive emotions respondents feel when

thinking about the possibility of a tornado. The other two factors were interpreted as "*cognitive threat*" and "*cognitive knowledge*" as they respectively represent the potential threat (as magnitude of consequences) of tornadoes and (lack of) knowing about the nature of tornadoes (Trumbo et al, in review). The Cronbach's alpha statistics indicate there is excellent internal consistency of the items that make up the affective dimensions and moderate to good internal consistency of the items that make up the cognitive dimensions (Table 15).

Following Trumbo et al., the *negative* and *positive affect* dimensions were combined into one summed scale to represent overall *affective risk perception*, and the same was done for the *cognitive threat* and *knowledge* dimensions to create an overall *cognitive risk perception* scale. In addition, all 12 items were summed to create an *omnibus risk perception* scale. The summary statistics for these three scales are provided in Table 16. All of the risk perception dimensions have a near-normal distribution; the *affective* and *cognitive* scales are slightly negatively skewed, meaning that more respondents had higher scores, representing greater risk perception. The Cronbach's alpha statistics indicate good internal consistency of the *affective* and *omnibus* scales, but weaker reliability among the *cognitive* items; all values are similar to those reported by Trumbo et al. The summed risk perception scales are used in the subsequent regression analyses.

Table 16. *Scale summary statistics for tornado risk perception*

| | *Affective risk perception* | *Cognitive risk perception* | *Omnibus risk perception* |
|---|---|---|---|
| Mean | 20.1 | 20.2 | 40.3 |
| Median | 20.0 | 20.0 | 40 |
| Mode | 20 | 18 | 40 |
| Standard deviation | 2.9 | 4.1 | 5.5 |
| Variance | 8.7 | 16.8 | 30.5 |
| Skewness | -0.1 | -0.1 | 0.0 |
| Kurtosis | -0.2 | 0.7 | 0.7 |
| Minimum | 12 | 7 | 21 |
| Maximum | 27 | 30 | 57 |
| Cronbach's α | 0.72 | 0.51 | 0.67 |

## Regression Analysis

Hierarchical regression was used to investigate how the set of experience dimensions relates to the different risk perception dimensions derived above after controlling for a base set of demographics and other individual traits. This section begins with a brief description of the set of control variables that are included, and then the regression results are discussed.

As discussed in Chapters 1 and 2, very few studies have examined people's risk perception in the context of tornadoes. Consequently, there is limited knowledge of how even demographic variables, which are readily collected and commonly included as independent variables in social and behavioral research studies, are related to tornado risk perception. This study therefore includes a small set of covariates consisting of demographic and other individual characteristics, most of which have been shown to relate to risk perception in the context of other natural hazards, including weather hazards (especially hurricanes) (e.g., Kellens et al., 2013; Lindell & Hwang, 2008; Peacock et al. 2005; Trumbo et al., 2011). Age, gender (females = 1; males = 0), household size, education (recoded as years of schooling), and race (White = 1; non-White = 0) were included in the analysis because older adults, females, persons in larger households, persons with less education, and non-whites have been shown, on balance, to have

higher risk perception across many natural hazards. Sheltering location also was included as a covariate (recoded as basement, storm cellar, or safe room = 1; all others = 0) as it is conceivable that whether or not one has a safe place to shelter may influence how ones perceives risks from tornadoes. Finally, as discussed in Chapter 3, the two personality traits of dispositional optimism (higher values = greater optimism) (Scheier, Carver, & Bridges, 1994) and locus of control (higher values = internal orientation) were included as covariates (Duttweiler, 1984). Higher dispositional optimism and internal locus of control both are thought to be associated with lower risk perception. Correlations among all of the risk perception dimensions, covariates, and experience dimensions are provided in Table 17. These results will be discussed below in conjunction with the regression results.

The hierarchical regression results are presented in Table 18. Three regressions are presented, one each for the affective, cognitive, and omnibus risk perception scales as dependent variables. For all of the regressions, the set of eight control variables discussed above was entered as Block 1, and then the six experience dimensions—the four most memorable plus the two multiple experience dimensions—were added as Block 2. Again, the motivation for conducting hierarchical regressions was to examine how the set of experience variables influenced risk perception after controlling for demographics, dispositional optimism, and locus of control. Thus, the model change statistic is reported (i.e., the squared setwise semipartial correlation, as $\Delta R^2$) along with its corresponding null hypothesis test (i.e., the $\Delta F$), and only the final model coefficients for the covariates are shown.

Some relationships between tornado risk perception and the demographic and personality characteristics were consistent with previous research in other contexts. Females had greater risk perception, specifically greater *affective risk perception* and *omnibus risk perception* (Table 17),

although only the strong relationship with affective risk perception held when controlling for other variables. People who are more dispositionally optimistic had lower *affective, cognitive,* and *omnibus* risk perceptions (Table 17), but this relationship only persisted for overall risk perception when controlling for other variables. Also, people whose locus of control is internally-oriented had lower *cognitive risk perception*, but not when controlling for other variables. In contrast with past research results, Whites had greater *affective* and *omnibus* risk perception, and there was no influence on risk perception due to age, household size, or education (Table 17, Table 18). Finally, although not examined in previous studies, respondents who did not have a basement, storm cellar, or safe room in which to shelter from a tornado had greater *cognitive risk perception,* including when controlling for other variables. Also, overall risk perception was higher among these people.

The set of experience variables significantly contributed, beyond the set of covariates, to explaining the variance in each of the types of risk perception (Table 18). The influence of the different types of tornado experiences on risk perception is discussed further.

*Personal intrusive impacts* had a consistent and positive relationship with all of the risk perception dimensions and especially strong relationships with *affective* and *omnibus* risk perception. Thus, if a past tornado experience caused one to have unwelcome thoughts, feelings, and disruption, as captured by this dimension, it was related to (a) more negative and less positive feelings when considering the possibility of a future tornado, (b) more thoughts about the potential threat and nature of tornadoes, and (c) greater risk perception overall. These relationships held regardless of whether they were bivariate (Table 17) or when controlling for other variables (Table 18). In comparison, *vicarious troubling impacts*—which capture others' impacts that are both tangible (e.g., property loss) and intangible (e.g., life disruption) as well as

others' stories of their experiences—and multiple experiences with *negative emotional responses* (i.e., fear and worry) each were strongly correlated with *affective* and *omnibus risk perception*, but these relationships were weaker when controlling for other variables. As discussed in Chapter 4, *personal intrusive impacts* were strongly correlated with these two experience dimensions. To better understand these results, supplementary hierarchical regressions of *affective* and *omnibus risk perception* were conducted with *personal intrusive impacts* added separately in its own block after the other five experience dimensions (Appendix G). The regressions show that *vicarious troubling impacts* and *negative emotional responses* both were strongly related to each risk perception dimension until *personal intrusive impacts* was added. Together, these results imply that *personal intrusive impacts* (in the way measured here) capture some aspects of these other experience dimensions and that, when analyzed together, *vicarious troubling impacts* and *negative emotional experiences* are relatively less important.[19]

*Risk awareness*, which captures awareness by the respondent as well as from social cues about the possibility of and concern about a tornado threat, increased *cognitive risk perception*, i.e., increased thoughts about the potential threat and nature of tornadoes. *Risk awareness* also enhanced overall risk perception. In contrast, *risk personalization*, which captures one's protective and emotional responses as well as firsthand sensory inputs of the storm, surprisingly decreased people's *cognitive* and *omnibus* tornado risk perceptions. Both of these experience dimensions were shown to have these influences on risk perception only when controlling for other variables (Table 17, Table 18). Again, supplementary hierarchical regressions were conducted with *risk awareness* and *risk personalization* entered individually, in counterbalanced orders, then together, and then with all other experience dimensions (Appendix G). The results

[19] Note that the variance inflation factors are all less than or equal to 2.0 suggesting that multicollinearity is not a problem.

show that these experience dimensions both became influential only when they were combined with the other tornado experience dimensions. Similarly, *common personal threat and impact experiences*—which captures the amount of experience one has with two types of official threat information (warnings and sirens) as well as news about tornado threats and aftermath—was shown to decrease overall risk perception, but again only when controlling for other variables (Table 17, Table 18).

Table 17. *Correlations among all pairs of regression variables*

| | Risk perception dimensions | | | Covariates | | | | | | | | Experience dimensions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. |
| 1. *Affective risk perception* | | | | | | | | | | | | | | | | |
| 2. *Cognitive risk perception* | .21*** | | | | | | | | | | | | | | | |
| 3. *Omnibus risk perception* | .85*** | .69*** | | | | | | | | | | | | | | |
| 4. Age | .11 | .07 | .12 | | | | | | | | | | | | | |
| 5. Gender (female = 1)[a] | .25*** | .00 | .19*** | -.03 | | | | | | | | | | | | |
| 6. Household size | -.04 | -.03 | -.05 | -.26*** | -.01 | | | | | | | | | | | |
| 7. Education | -.08 | -.09 | -.11 | -.09 | -.06 | .08 | | | | | | | | | | |
| 8. Race (White = 1) | .24*** | -.02 | .17** | .22*** | .03 | .01 | -.03 | | | | | | | | | |
| 9. Shelter location (basement, cellar, safe room = 1) | -.09 | -.18*** | -.16** | -.04 | -.03 | .07 | .10 | .09 | | | | | | | | |
| 10. Dispositional optimism | -.17** | -.16** | -.21*** | .16** | -.06 | -.05 | .36*** | -.01 | .21*** | | | | | | | |
| 11. Locus of control | -.05 | -.13* | -.11 | -.05 | -.26*** | .07 | .18*** | -.10 | .06 | .25*** | | | | | | |
| 12. *Risk awareness* | .05 | .03 | .05 | -.19 | .00 | .02 | .03 | -.14* | -.09 | -.06 | .04 | | | | | |
| 13. *Risk personalization* | .07 | -.10 | .00 | -.06 | -.09 | .14* | .08 | .02 | -.13* | -.10 | .15** | .41*** | | | | |
| 14. *Personal intrusive impacts* | .34*** | .17** | .34*** | .08 | .09 | .15** | .00 | .03 | -.11 | -.21*** | -.04 | .03 | .38*** | | | |
| 15. *Vicarious troubling impacts* | .19*** | .10 | .19*** | .04 | .00 | .17** | .00 | .10 | -.04 | .00 | .07 | .13* | .41*** | .52*** | | |
| 16. *Common personal threat and impact experiences* | .00 | -.12** | -.07 | -.04 | -.18*** | .09 | .07 | .01 | .12* | -.03 | .21*** | .29*** | .40*** | .20*** | .37*** | |
| 17. *Negative emotional responses* | .21*** | .02 | .17** | -.03 | .01 | .15** | -.02 | -.05 | -.07 | -.25*** | .05 | .28*** | .53*** | .49*** | .46*** | .50*** |

[a] Reporting eta for nominal by interval data, and reporting phi for nominal by nominal data

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

Table 18. *Hierarchical regression of risk perception regressed onto covariates (Block 1) and experience dimensions (Block 2)*

| Independent variable | *Affective Risk Perception* | | | | | | *Cognitive Risk Perception* | | | | | | *Omnibus Risk Perception* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ |
| Block 1: Control variables (demographic characteristics, dispositional optimism, and locus of control) | | | | | | | | | | | | | | | | | | |
| Age (years) | 0.01 | 0.02 | 0.04 | 0.60 | 0.55 | 0.00 | 0.01 | 0.01 | 0.06 | 0.80 | 0.42 | 0.00 | 0.02 | 0.03 | 0.07 | 0.91 | 0.36 | 0.00 |
| Gender (female =1, male = 0) | 1.71 | 0.57 | 0.21 | 2.98 | 0.00 | 0.05 | -0.50 | 0.45 | -0.09 | -1.12 | 0.26 | 0.01 | 1.21 | 0.78 | 0.11 | 1.56 | 0.12 | 0.01 |
| Household size (number) | -0.24 | 0.20 | -0.08 | -1.19 | 0.24 | 0.01 | -0.02 | 0.15 | -0.01 | -0.14 | 0.89 | 0.00 | -0.26 | 0.27 | -0.07 | -0.96 | 0.34 | 0.01 |
| Education (years) | -0.04 | 0.14 | -0.02 | -0.25 | 0.80 | 0.00 | 0.01 | 0.11 | 0.00 | 0.06 | 0.95 | 0.00 | -0.03 | 0.19 | -0.01 | -0.15 | 0.88 | 0.00 |
| Race (white = 1, all others = 0) | 3.29 | 0.92 | 0.25 | 3.58 | 0.00 | 0.07 | -0.22 | 0.71 | -0.02 | -0.30 | 0.76 | 0.00 | 3.07 | 1.24 | 0.17 | 2.47 | 0.01 | 0.03 |
| Shelter location (basement, storm cellar, safe room = 1, others = 0) | -0.26 | 0.59 | -0.03 | -0.44 | 0.66 | 0.00 | -0.78 | 0.46 | -0.13 | -1.69 | 0.09 | 0.02 | -1.04 | 0.80 | -0.09 | -1.30 | 0.20 | 0.01 |
| Dispositional optimism (higher = optimistic) | -0.10 | 0.09 | -0.09 | -1.17 | 0.24 | 0.01 | -0.09 | 0.07 | -0.12 | -1.39 | 0.17 | 0.01 | -0.20 | 0.12 | -0.13 | -1.66 | 0.10 | 0.02 |
| Locus of control (higher = internal) | 0.07 | 0.05 | 0.10 | 1.36 | 0.18 | 0.01 | -0.03 | 0.04 | -0.06 | -0.72 | 0.47 | 0.00 | 0.04 | 0.07 | 0.04 | 0.59 | 0.55 | 0.00 |
| Block 2: Experience dimensions | | | | | | | | | | | | | | | | | | |
| *(memorable) Risk awareness* | 0.09 | 0.06 | 0.11 | 1.43 | 0.15 | 0.01 | 0.08 | 0.05 | 0.14 | 1.66 | 0.10 | 0.02 | 0.17 | 0.08 | 0.15 | 2.01 | 0.05 | 0.02 |
| *(memorable) Risk personalization* | -0.08 | 0.05 | -0.13 | -1.46 | 0.15 | 0.01 | -0.11 | 0.04 | -0.24 | -2.51 | 0.01 | 0.04 | -0.19 | 0.07 | -0.22 | -2.52 | 0.01 | 0.04 |
| *(memorable) Personal intrusive impacts* | 0.27 | 0.08 | 0.29 | 3.30 | 0.00 | 0.06 | 0.12 | 0.07 | 0.17 | 1.85 | 0.07 | 0.02 | 0.39 | 0.11 | 0.30 | 3.50 | 0.00 | 0.07 |
| *(memorable) Vicarious troubling impacts* | 0.02 | 0.05 | 0.03 | 0.39 | 0.70 | 0.00 | 0.06 | 0.04 | 0.14 | 1.48 | 0.14 | 0.01 | 0.08 | 0.07 | 0.10 | 1.14 | 0.26 | 0.01 |
| *(multiple) Common personal threat and impact experiences* | -0.16 | 0.14 | -0.09 | -1.13 | 0.26 | 0.01 | -0.17 | 0.11 | -0.14 | -1.56 | 0.12 | 0.01 | -0.32 | 0.19 | -0.15 | -1.73 | 0.09 | 0.02 |
| *(multiple) Negative emotional responses* | 0.21 | 0.14 | 0.14 | 1.45 | 0.15 | 0.01 | 0.00 | 0.11 | 0.00 | 0.03 | 0.98 | 0.00 | 0.21 | 0.19 | 0.10 | 1.09 | 0.28 | 0.01 |
| $\Delta R^2$ with experience variables | 0.10 | | | | | | 0.08 | | | | | | 0.13 | | | | | |
| $\Delta F$ with experience variables; for all models, F(6,169) | $4.0^{***}$ | | | | | | $2.5^{**}$ | | | | | | $4.8^{***}$ | | | | | |
| Final model F | $4.4^{***}$ | | | | | | $2.0^{**}$ | | | | | | $4.2^{***}$ | | | | | |
| Final model adj $R^2$ | 0.21 | | | | | | 0.07 | | | | | | 0.20 | | | | | |

$^{***}p < 0.01$; $^{**}p < 0.05$

# CHAPTER 6: DISCUSSION AND SUMMARY

Extreme weather events, such as tornadoes, can cause significant harm to the people who are threatened by them. Understanding how people judge these types of risks is important for knowing how to prevent or reduce harm from future events. One's past experiences with such hazards (or threats of them) is informational—that is, they are ways that people can develop knowledge and feelings about a risk—thus understanding people's experiences is theoretically important for understanding their risk perception. Yet, this knowledge has been hamstrung by the "need [for hazard experience] to be more carefully conceptualized and consistently measured" (Lindell, 2012, p. 408).

This study endeavored to build this knowledge in the context of tornadoes through investigating two research questions to (1) identify the dimensions of past hazard experience by more fully conceptualizing it than has been done to date, developing measures to represent those conceptual contours, and analyzing the data to allow latent dimensions to emerge; and (2) subsequently explore how the resulting experience dimensions relate to cognitive and affective dimensions of risk perception. This work was done through a careful review of the extant literature on studies of risk perception of weather hazards and additional studies in which tornado experiences were measured, followed by two surveys of the public who reside in tornado-prone areas of the United States. The result is set of items that capture six dimensions of people's past tornado experiences and which are shown to have varying relationships with cognitive-affective tornado risk perceptions. This study, therefore, offers the most comprehensive experience scale developed to date coupled with a more nuanced assessment of how experiences influence risk

perception. In doing so, it also lays a foundation for future work, including scale improvement and theoretical and practical applications.

In this concluding chapter, interpretations of the results are discussed, followed by implications for theory and practice. Limitations of this study then are presented, and lastly, a conclusion. Ideas for future research are woven into each of these sections.

## Discussion of Results

Several results emerged from this research that are important for better understanding and thinking further about people's past tornado experiences.

First, six latent dimensions of people's past tornado experiences emerged from this work: most-memorable experience-related *risk awareness, risk personalization, personal intrusive impacts*, and *vicarious troubling impacts*, as well as multiple experiences with *common personal threats and impacts* and *negative emotional responses*. These dimensions provide a more resolved picture of the conceptual landscape of people's experiences than has been measured by others, at least in the context of weather hazards. The emergent dimensions add to the literature not just in their breadth, however, but also in the nature of what they comprise. The dimensions capture experiences across the temporal spectrum of the hazard, including leading up to and during the event, which have been less commonly measured, as well as the after the event. Half of the dimensions that emerged represent experiences that are primarily unmediated *(risk personalization, personal intrusive impacts, negative emotional responses),* whereas the other half capture both unmediated and mediated experiential aspects *(risk awareness, vicarious troubling impacts, common personal threat and impact experiences*). Also, implications and

interpretations of people's experiences are captured in many of the dimensions, and *personal intrusive impacts* completely consists of these types of experiences, as further discussed below.

Next, the different experience dimensions have varying relationships with the *cognitive* and *affective* dimensions of risk perception and with risk perception overall. The most memorable experience dimensions of *risk awareness* and *risk personalization* influenced cognitive and overall risk perceptions, but only when they were included with the other experience dimensions. This suggests there is something about the joint influence of these variables that makes them salient and therefore important. There was no difference in *risk awareness* depending on whether a tornado threatened or occurred, and there was a negative correlation with when the memorable experience happened (Chapter 4). Thus, it seems that *risk awareness*—on its own—may not be distinguishable or vivid enough to be cognitively available for influencing people's risk perception, but it becomes so when combined with other memorable experiential dimensions. *Risk personalization*, when included with the other experience dimensions, surprisingly decreased cognitive and overall risk perception. Although the reasons for these results are unclear, it is possible that taking protective action to protect oneself (and/or others) and witnessing, hearing, and feeling sensations of a tornadic storm may make people think they have a clear, concrete sense of what a tornado event entails, therefore making them think they better understand the nature and threat of tornadoes. This result may reflect an experience-cognitive risk "calibration", akin to the calibrated link that Halpern-Felsher et al. (2001) discussed where experience with lightning decreased one's perceived lightning risks (Chapter 2). Alternatively, these results may hint at the gambler's fallacy cognitive bias, whereby people think that a future probability is altered by past events (e.g., lightning does not strike the same place twice) (Tversky & Kahneman, 1971). In other words, some people may think that

their future tornado risk is lower based on a past experience that was threatening enough that they personalized it in the ways captured here. Future research should explore the mechanisms underlying this negative relationship between *risk personalization* and risk perception to better understand it. Moreover, research should further investigate the synergistic role of multiple dimensions of experience, as for *risk awareness* and *risk personalization*, in influencing risk perception and other dependent variables.

Only one dimension, the most memorable experience dimension of *personal intrusive impacts*, influenced all of the risk perception scales. *Personal intrusive impacts* consist of items that capture unwelcome thoughts, feelings, and disruption, thus representing the intangible impacts people endure and their interpretations of their experience. This dimension increased affective, cognitive, and overall risk perception. It had an especially strong relationship with *affective risk perception*, meaning that one's negative thoughts and emotions associated with a past tornado can induce negative (or less positive) emotions regarding the possibility of a future tornado. This result illustrates the correspondence between a past experience and a future outcome that Weinstein (1989) suggested may be important. That being said, *personal intrusive impacts* also enhanced people's *cognitive risk perception*, that is, their thoughts about the nature of tornadoes and severe tangible consequences of them (destruction, death, financial). In other words, this experience dimension links past intangible impacts to the possibility of future tangible ones, likely because it indirectly captures such tangible outcomes (e.g., personal injury and property damage) for those who have experienced them (Chapter 4). Taken together, the results imply that the intrusive (and at times, subconscious) ways that a tornado experience affects someone for some period of time following the experience is powerful, plausibly because it is uncontrolled, upsetting, and lasting, and therefore is made more vivid and memorable.

The meaning and importance of the *personal intrusive impacts* dimension is further shown when considered in conjunction with the *vicarious troubling impacts* dimension, the two of which were strongly correlated. Although intangible personal impacts may partly be caused by the respondents' own unmediated experiences, the experiences of relevant and proximate others likely also has an influence on the intangible effects that one feels. This idea is supported by how respondents classified to whom their most memorable experience happened and their qualitative descriptions of that experience. Commonly, people who reported that the event happened to them also described impacts to others and vice versa. In many cases, even people who experienced direct, tangible impacts from a tornado appeared to consider themselves less affected relative to others and thus classified the experience accordingly. Methodologically, this suggests that a closed-ended question asking to whom a memorable experience happened is not meaningful in this type of context. The interwoven relationship between one's own experiences and those of others is further illustrated by the risk perception regression results showing that *vicarious impacts* was influential until *personal impacts* was introduced, suggesting that the latter captured aspects of the former and beyond. Theoretically and practically, this implies that people's tornado experiences are not solely individual, rather they also represent a collective which, in turn, appears to affect how people process a hazard and how they think about future risks.

The collection of results associated with *personal intrusive impacts* has several implications for thinking about past experience. First, it is interesting to note that this dimension was not correlated with the item that explicitly measures one's experience, i.e., "I am experienced with tornadoes," from Trumbo et al.'s risk perception scale (see Chapter 4). This implies that the myriad studies that have used this type of vague, all-encompassing item in attempt to measure people's hazard experiences may not be capturing some of the most

important aspects of it. Second, and more importantly, the dimension illustrates the intangible and interpretive aspects of one's experience (or what Zaalberg et al., 2009, referred to as "subjective or psychological experiences"). Although the other experience dimensions include some of these types of items, *personal intrusive impacts* is the only dimension that completely consists of them. It also is the only dimension that enhances all of the risk perception dimensions, strongly so for affective and overall risk perception. This suggests that future work could explore refining the conceptualization and measurement of experience in a way that focuses more fully on these perceptual and interpretive attributes. Moreover, the results suggest that if personal impacts are measured in this way, they can account for tangible experiences as well as for both direct and indirect experiences in a meaningful way.

Finally, the regression results showed that neither of the two multiple experience dimensions emerged as strong predictors of risk perception when controlling for other variables, despite strong correlations between amount of *negative emotional responses* and affective and overall risk perception. Although this likely is due to the stronger influence of the most memorable experience dimensions, it implies that such experiences may be more important than an accumulation of experiences for some people.

## Implications for Theory

The study conducted here theoretically advances how past experience is conceptualized and how it relates to risk perception, and it serves as a foundation for future theoretical research that could leverage and extend this work.

First, although the six latent experience dimensions that emerged in this study replicated across two independent samples of the public who reside in tornado-prone areas of the United

States, the validity of these results should continue to be assessed. For instance, the content and construct validity of shortened scales could be evaluated. Also, external validity could be assessed with other populations affected by tornadoes (e.g., the southeastern U.S.); for other weather risks, including other rapid-onset hazards (flash floods) and slower-onset hazards (hurricanes, winter storms); and over time. Moreover, although the most memorable experience-related dimension of *threat environmental cues* did not emerge in the second survey, it should be explored whether this dimension is an important aspect of people's experiences for other types of weather risks (e.g., rough surf before a hurricane landfall) or for specific situations (e.g., when tornadoes threatened but do not occur). The applicability of these experience scales to non-weather risks—including other natural hazards (e.g., earthquakes, wildfires), public health risks, and technical and environmental risks—also could be evaluated, although they likely would have to be modified in part for these very different risk contexts.

Next, this study only examined risk perception as the dependent variable. The experience dimensions derived here may influence other dependent variables, including self and response efficacy, information seeking and processing behaviors, protective and mitigative responses, and emotional responses. For instance, it is conceivable that people with greater *personal intrusive impacts* may have lower self and/or response efficacy (a belief in one's ability to perform some action, and that taking some action will be effective in reducing a risk, respectively; Witte, 1994), or that having more *common personal threat and impact experiences* may affect how frequently one seeks tornado forecast information and from which source(s). Drawing on risk theories—such as the Theory of Reasoned Action, Protective Action Decision Model, and Risk Information Seeking and Processing model, and Extended Parallel Process Model—the influence of experience on these variables could be evaluated directly or mediated through other variables,

including risk perception. Notably, though, the broader literature that empirically assesses the relationship of experience on these other variables should be examined.

Relatedly, this study examined only cognitive-affective risk perception as the dependent variable. Future work could investigate and compare these findings with risk perception as conceptualized and measured in other ways, including as the commonly employed perceived likelihood and severity of a threat (Renn, 2008; Weinstein, 2000b; 2003; Witte, 1994), but also as less common ways, such as attitudes (Sjoberg, 2000) or preoccupation (Weinstein et al., 2000a). Moreover, other aspects of people's experientially influenced tornado-related risk perception could be explored. For instance, on the first survey of the study presented here, after respondents described their most memorable experience in their own words, they were asked to explain how that experience changed how they think about future tornado risks. Because these data were gathered on Survey 1, they were not able to be used to help interpret the Survey 2 analyses between specific experience and risk perception dimensions, but they did provide general insights. One idea that emerged repeatedly from respondents' comments was that their experience prompted them to take forecasts of the threat more seriously and/or to heed them. In a case study of a community hit by a tornado and then threatened again a few days later, Silver and Andry (2014) similarly found that people were more aware of and tuned in to the threat after the initial experience. This notion of vigilance may be an aspect of risk perception that is particularly relevant in the context of weather risks and could be further explored, including what types of experiences might influence it.

Weinstein (1989) argued that studies of personal experience "will be most informative if they include measurements of the variables thought to mediate the effects of experience" (p. 47). Indeed, mediation studies should build on the nearly 20-year-old work by Greening et al. (1996)

to empirically examine the theorized heuristics that link experience and risk perception (versus inferring the link as most scholars have done), including the affect, availability, and simulation heuristics. Finally, moderators of experience could be examined to better understand under what conditions the dimensions might relate to risk perception (or other dependent variables). For instance, differences in the experience-risk perception relationship could be explored based on gender, age, or housing type (or shelter options). Experience as a moderator itself also could be examined. For instance, Trumbo et al. (2011) note the "likely importance of experience in moderating optimistic bias" (p. 1908), but this relationship has yet to be explored. Findings from such moderation studies could feasibly inform risk communication that is tailored to certain groups.

## Implications for Practice

Although the research conducted here was more foundational and theoretical in nature, it does offer ideas for practical implications, namely for risk communication (Wachinger et al., 2013). The weather forecast community has been known to invoke the role of experience—typically an iconic, and therefore presumably memorable, past event—in its forecasts (which are a form of risk communication) to influence protective behavior, especially in the hurricane risk context. During Hurricane Katrina, the National Weather Service inland hurricane warning began in this way:

> HURRICANE KATRINA...A MOST POWERFUL HURRICANE WITH UNPRECEDENTED STRENGTH...RIVALING THE INTENSITY OF HURRICANE CAMILLE OF 1969.[20] (NOAA, 2006, p. 18)

[20] The warning text is reproduced in the original all-caps and ellipse-heavy format that is still used in National Weather Service products.

More recently, during Hurricane Sandy, a National Weather Service forecaster issued a "personal plea" to his constituents that included the following message: "If you are reluctant to evacuate, and you know someone who rode out the '62 storm on the barrier islands, ask them if they would do it again" (NOAA, 2013, p. 26). Although these messages seemingly are intended to induce affect and availability and, in the latter example, recognize the role of vicarious experiences, the effect of such experience-oriented risk communication is unknown, and ideally it should be tested in a controlled setting prior to implementation.

Building on the theoretical implications discussed above, if mechanisms for linking experience and risk perception are tested (e.g., showing the role of the affect and/or availability heuristic or the simulation heuristic), this knowledge could be used to inform the design and testing of risk communication. Such research could be conducted to evaluate the effect of (a) different risk communication content (b) on risk perception as well as behavioral responses, including both long-term hazard adjustment behaviors and shorter-term protective response behaviors (c) for people with varying degrees of the experience dimensions derived here (including for people who consider themselves as having no experiences).

For instance, Keller et al. (2006) conducted a study in which they experimentally manipulated affect by showing images of flooded homes and showed that people who saw the negative-affect laden images reported greater risk perception of living in a place like that shown. In another study aimed at "mimicking flooding experience", Zaalberg and Midden (2013) experimentally exposed participants to either an interactive three-dimensional flood simulation—which was meant to mimic a direct flood experience—or a non-interactive, two-dimensional simulation. The former was shown to incite stronger evacuation intentions and slightly stronger intentions to purchase flood insurance. In both cases, the researchers could have enhanced their

study by testing whether and how the effect differed for people who actually had past flood experience (which neither study included), and, in turn, this knowledge could inform how to tailor risk communication for different populations accordingly.

Drawing on the work by Zaalberg and Midden, in the tornado context, risk communication to mimic a direct experience could be designed that aims imbue the types of *personal intrusive impacts* that were found here to enhance people's risk perception. Furthermore, risk communication interventions could be tailored to specific dimensions of experience. For instance, if, as pondered above, *risk personalization* reduces risk perception due to the gamblers' fallacy, risk messages could be developed to try to correct this bias. Clearly, these types of risk communication, especially the former, have ethical implications that would need to be carefully considered before testing. It also would be critical to evaluate whether, in response to such messages, some people (e.g., those who are especially high on the *personal intrusive impacts* scale) engage in maladaptive emotional response behaviors as the EPPM theorizes (Witte, 1994). Such experience-oriented risk communication may be most beneficial if it includes content that enhances self and response efficacy. Moreover, because tornadoes are rapid-onset hazards, leaving limited time for people to assess their risk and engage in protective behavior, risk communication that exploits one's experience may be best used in an educational context or during the outlook (i.e., longer lead-time) phase of the event, versus when the hazard is threatening or imminent.

## Study Limitations

A number of limitations of this study are worth noting. First, limitations exist regarding the survey sample. The 25-28% response rates to the two surveys were commensurate with other

weather-related surveys that have followed the Dillman Tailored Design Method, but they were lower than other efforts that employed this mixed-mode, Web+mail survey design (see Chapter 3). Although the mixed-mode survey design was intended to speed data collection (via Web) while also providing a response mode (mail) for people who either could not or did not want to respond online, some respondents reported confusion when trying to respond via the Web (e.g., trying to use a search engine to locate the Web survey rather than typing in the survey Web address), which may have reduced their inclination to respond even by mail. Moreover, the "Heartbleed" software bug that made vulnerable the OpenSSL encryption program used by many websites—including QuestionPro and specifically including Survey 1 of this study for which the SSL security feature was purposely enabled (see Appendix D)—made nationwide news in early April 2014, which was right in the middle of the Survey 1 fielding period (Pew Research Center, 2014). It is plausible that this security breach may have reduced people's willingness to respond to a Web survey at an unfamiliar Web address. These two problems coupled with the significantly greater proportion of the mail responses to Survey 2 suggest it is possible that response rates may have been better with mail as the sole mode. Relatedly, the sample sizes of 144 and 184 completed responses to Surveys 1 and 2, respectively, are marginal in being sufficient for the factor analysis (based on the number of dimensions, measures, and communalities per MacCallum et al., 1999). Although the experience dimensionality results were stable across surveys (excepting the dropped *threat environmental cues* dimension) future work with a larger sample to test the stability of these results would further support the validity of the findings. Also, it was not possible to conduct comparisons of the sample against census data because of the very large geographic area covered by this survey, but the sample from both surveys likely is older on average (median age in the mid-50s) and over-represents retirees

compared to the target population. Finally, non-response bias must be considered as plausible such that respondents likely are those who had at least one tornado experience that was "sufficient" enough to motivate their replying to the survey. In other words, the results likely do not represent the "lower bounds" of people's tornado experiences or their relationships with risk perception.

Next, the survey data were cross-sectional in nature. Thus, although data were collected about *past* memorable and multiple experiences and these were theorized to influence risk perception about *future* tornado events, caution is warranted when inferring this causal relationship. Also, Weinstein (1989) discusses the importance of controlling for pre-experience differences in preparedness when measuring people's experiences because they can influence the outcomes of experience. He notes that "Lack of preparedness cannot produce a [natural hazard, like a tornado], but it can increase the damage experienced" (p. 36). Some pre-experience preparedness factors—such as people's sheltering options and access to tornado forecast information—conceivably could have influenced their experiences. However, no attempt was made to measure these factors given the nature of the way experiences were measured here—i.e., as most memorable experience that could have happened long ago and multiple experiences—because of the high likelihood of inaccurate recall. Additional research to measure people's future tornado experiences could control for these types of variables, especially if longitudinal studies were conducted.

Finally, although an attempt was made to conceptually define past tornado experience broadly and to develop items to measure it accordingly, other ways of measuring experience can and should be explored. For instance, capturing one's most recent experience (and, therefore its dimensions and relationship with risk perception) would complement the most memorable and

multiple experiences measured here. Also, here, multiple experiences were conceptualized as multiple events occurring at different times. However, in some scenarios, multiple events—and therefore, multiple experiences—can be embedded within "one" longer-duration event. The 2013 flooding that occurred along the Colorado Front Range is one example of this, in which multiple flash flood and flood threats occurred, in some cases in the same geographic areas (NOAA, 2014b). In May 2013 and then again in May 2015, Oklahoma City and nearby communities endured severe weather outbreaks in which the same areas were repeatedly threatened by tornadoes, severe thunderstorms, and flash flooding, all within the course of a few hours (NOAA 2014a; NOAA, 2015). It may be important to characterize people's multiple experiences in these types of events and to understand how they can influence evolving risk perceptions and behaviors within that event as well as for future events.

Also, other experiential aspects may be important to capture in the phase leading up to an event, such as experiences with evacuating (including negative associated experiences, e.g., getting stuck in traffic), purchasing supplies, and preparing a home. These experiences tend to be less relevant for tornadoes given their rapid-onset nature, but they likely are important aspects of people's experiences with slower-onset hazards, such as hurricanes and winter storms. In addition, items that measure the lack of an experience could be expounded upon beyond the couple of "false alarm"-related items included here. Dillon and colleagues (Dillon, Tinsley, & Cronin, 2011; Dillon, Tinsley, & Burns, 2014) have conceptualized prior experience "near-misses" as events where a negative outcome could have happened due to a hazard but did not. Similarly, Baker (1991) coined the idea of a "false experience" in the context of hurricanes as those in which people were "on the fringes of a bad storm or experienced a lesser hurricane" (p. 302). Baker termed this as "false" not to diminish people's experiences but rather as a way of

suggesting that these people may believe they have experienced the equivalent of other, more severe conditions, which is misleading and can falsely affect their future risk perception and decision-making. Finally, a recent study by Lazrus et al. (2015) found that people who have limited direct experience with a certain type of hazard (here, flash floods) draw on analogies to other hazards in assessing the risk, sometimes in inaccurate ways. As these studies imply, a lack of experience is still experience, and better understanding the contours and implications of near-misses, false experiences, and analogues to experience would complement the research conducted here.

## Conclusion

Think back to an experience you had with a hazardous weather event, tornadic or otherwise. Think about what you knew, saw, heard, felt, and did. Think about others who were a part of that experience. Think about the timeframe over which all of those observations, emotions, and actions occurred. And think about how that experience from then affects you now.

We all have experiences with past weather hazards. When we reflect on them, we realize just how inadequate most of the common ways of measuring those experiences are—regardless of whether those measures are whether you have experienced a tornado, whether you saw a funnel cloud or the tornado, or the degree of property damage you or others had. These measures cannot begin to capture the breadth and depth of what people experience—whether it is noticing "eerie quiet and complete lack of noise from birds, dogs, anything" [53251], or the sensation that "the house felt like it was breathing" [61467], or witnessing the devastating aftermath "where there were no houses, just driveways and sidewalks leading to nowhere" [24711].

The six dimensions that emerged in this study—memorable experience *risk awareness*, *risk personalization*, *personal intrusive impacts*, and *vicarious troubling impacts*, as well as multiple experiences with *common personal threat and impacts, and negative emotional responses*—better capture and identify the conceptual contours of people's past tornado experiences. However, they are but a first attempt at explicating this concept and developing a scale that is content and construct valid.

Chaffee (1991) described concept explication as an iterative, ongoing process, and he noted that "For some scholars this can last a lifetime; rarely does it end with the completion of a single study" (p. 7). How very true.

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# APPENDIX A: PAST TORNADO EXPERIENCES MEASUREMENT CONSTRUCTION

Table 19. *Summary of the Survey 1 experience measures and their link to related literature*

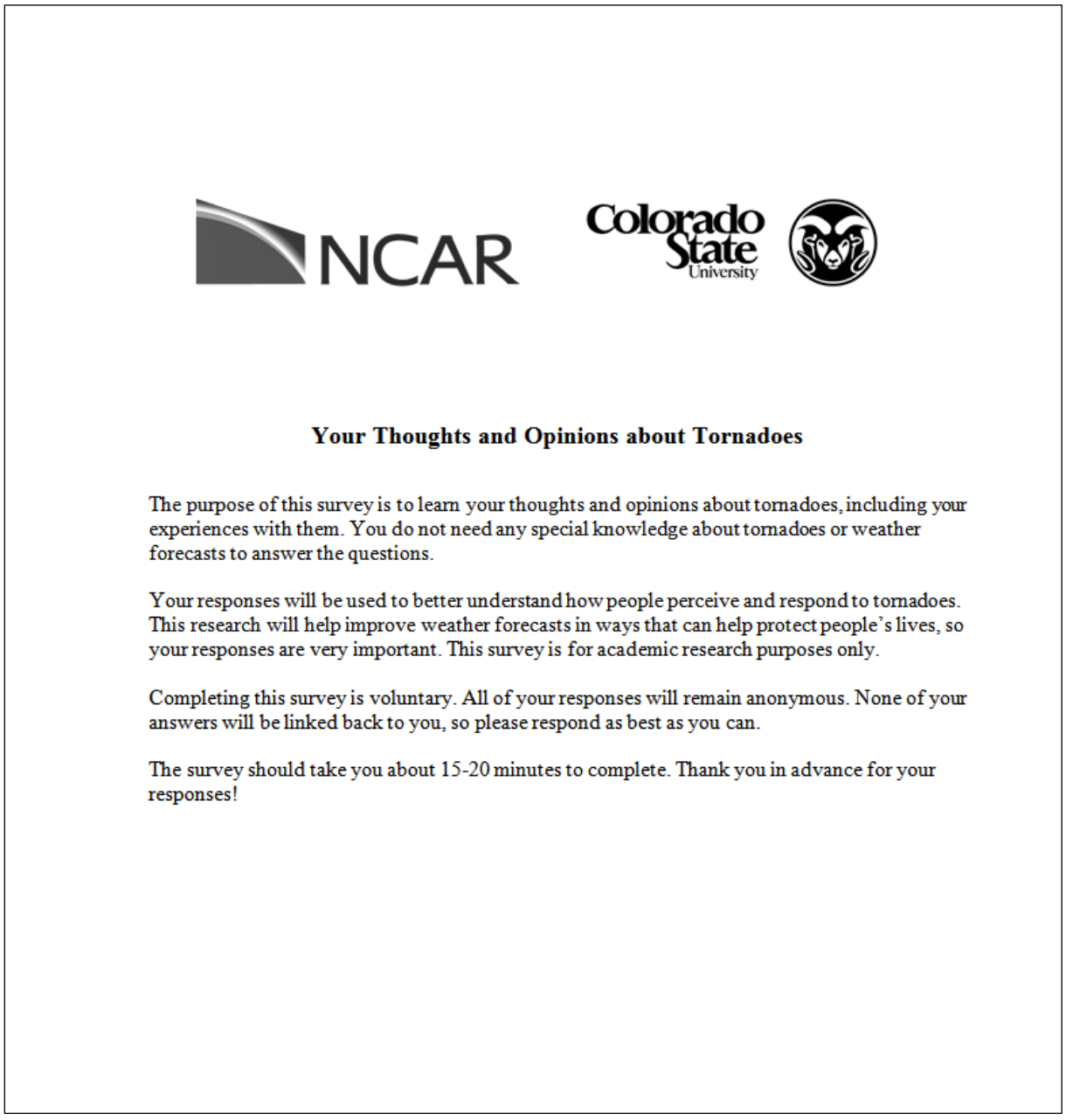
| Survey question | Concepts | Dimensions and measures | Related references and notes |
|---|---|---|---|
| Q1. | Most memorable tornado experience | Experience details<br>• Risk target – personal, others, or both<br>• Tornado occurrence vs. threat<br>• Year experience occurred | |
| Q2.<br>a.<br>b. | Most memorable tornado experience | Experience description *(open-ended)*<br>• Clearest recollections and feelings about it<br>• Change in thinking about future tornado risks | |
| Q3. | Most memorable tornado experience | Experiences <u>leading up to</u> the tornado threat *(how true each experience was: not at all, a little, somewhat, a great deal, not applicable)*<br>a) Sky<br>b) Air<br>c) Animals<br>d) Attended to weather forecasts<br>e) Concerned about tor threat<br>f) People talked about the tornado threat<br>g) People were concerned about the tornado threat<br>h) News coverage about the tornado threat | • Item (h) can relate to mediated "negative information transfer" pathway described by Valkenburg and Buijzen (2008) |

| Survey question | Concepts | Dimensions and measures | Related references and notes |
|---|---|---|---|
| Q4. | Most memorable tornado experience | Experiences <u>during</u> the tornado threat *(how true each experience was: not at all, a little, somewhat, a great deal, not applicable)*<br>a) Action to protect self or loved ones<br>b) Tried to get to loved ones to be with them (or vice versa)<br>c) Feared for life<br>d) Feared for loved ones<br>e) Worried about home<br>f) Saw tornado or funnel firsthand<br>g) Saw other scenes from storm firsthand<br>h) Heard sounds from storm firsthand<br>i) Heard or saw live news coverage as tor happened<br>j) Property damage<br>k) Physically injured<br>l) Lost irreplaceable items<br>m) People I know had property damage<br>n) People I know were physically injured<br>o) People I know lost irreplaceable items | • Item (c) mirrored after Suls et al. (2013) fear of dying<br>• Items (f-h) is mirrored after Weinstein et al.'s (2000a) "watched impact index" items (pg. 354)<br>  ○ Item (f) is measured frequently in other studies (Table 1)<br>• Item (i) can relate to mediated "observational learning" pathway in Valkenburg and Buijzen (2008)<br>• Item (j) is measured frequently in other studies (Table 1)<br>• Item (k) is measured frequently in other studies (Table 1) |
| Q5. | Most memorable tornado experience | Experiences <u>after</u> the tornado threat *(how true each experience was: not at all, a little, somewhat, a great deal, not applicable)*<br>a) Shaken up<br>b) Moving away<br>c) Trouble staying asleep / had dreams<br>d) Waves of strong feelings<br>e) Thought about it when didn't mean to<br>f) Pictures popped into mind<br>g) Life was disrupted<br>h) Lives of people I know were disrupted<br>i) Talked to others about experience<br>j) People talked to me about experiences<br>k) Saw scenes of aftermath firsthand<br>l) Saw news coverage of the aftermath<br>m) Volunteered to help others<br>n) Others volunteered to help me<br>o) Took unnecessary protective action<br>p) Responding was inconvenience | • Items (c-f) are from Impact of Events Scale-Revised "intrusion" dimension (Horowitz et al., 1979; Christianson & Marren, 2013)<br>  ○ Item (g) designed to capture another type of intrusion<br>  ○ Weinstein et al. (2000a) used some of these items as well<br>• Items (i-j) designed to follow Weinstein et al. (2000a) measures of talking about an experience<br>• Item (k) follows Siegrist & Gutscher (2006) and Weinstein et al. (2000a)<br>• Item (l) follows Valkenburg and Buijzen's (2008) "negative info transfer" pathway<br>• Items (m-n) designed to measure volunteer acts following Weinstein et al. (2000a) |

| Survey question | Concepts | Dimensions and measures | Related references and notes |
|---|---|---|---|
| Q6. | Multiple tornado experiences | Amount of experience *(how much experience: no experience, a little experience, some experience, a great deal of experience)*<br>a) Threatened by tornado<br>b) Under tornado warning<br>c) Seen tornado or funnel cloud firsthand<br>d) Heard sirens firsthand<br>e) Taken shelter<br>f) Left home to flee<br>g) Feared for life<br>h) Feared for loved ones<br>i) Worried about home<br>j) Had property damage<br>k) Heard or watched live news coverage<br>l) Seen aftermath of tor firsthand<br>m) Seen news coverage of tor aftermath<br>n) Have volunteered to help others affected<br>o) Taken unnecessary protective action<br>p) Been inconvenienced<br>q) Been warned of a tornado that didn't occur | • This question follows Guyker et al. (2013)'s approach to scale development through measuring the frequency of experiencing different events (their study measured combat experience). The specific items are a subset of those used in Q3-5 |

# APPENDIX B: SURVEY 1

The complete Survey 1 is provided, reproduced here as the paper survey that was sent to participants who requested it and with the final mailing (see Figure 9). The paper survey was 8.5 x 11", 4-page, 2-sided, black-and-white, stapled along the left-hand side.



**Your Thoughts and Opinions about Tornadoes**

The purpose of this survey is to learn your thoughts and opinions about tornadoes, including your experiences with them. You do not need any special knowledge about tornadoes or weather forecasts to answer the questions.

Your responses will be used to better understand how people perceive and respond to tornadoes. This research will help improve weather forecasts in ways that can help protect people's lives, so your responses are very important. This survey is for academic research purposes only.

Completing this survey is voluntary. All of your responses will remain anonymous. None of your answers will be linked back to you, so please respond as best as you can.

The survey should take you about 15-20 minutes to complete. Thank you in advance for your responses!

**Q1. Please think about your <u>most memorable</u> tornado experience. That experience may have happened to you personally, or you may have learned about the experiences of another person (or other people). It may have been a time when a tornado actually occurred or when there was just the possibility a tornado might occur. It may have occurred a long time ago or more recently.**

**a. Did that tornado experience happen to you personally, did you learn about others' experiences, or both?** *Please select ONE option.*

- ○ It happened to me personally.
- ○ It happened to other(s), and I learned about it.
- ○ Both – it happened to me personally, and it happened to other(s).

**b. Did a tornado actually occur during that experience, or was there just the possibility of a tornado?** *Please select ONE option.*

- ○ A tornado actually occurred.
- ○ There was the possibility of a tornado, but one did not occur.

**c. Approximately what year did that tornado experience occur?** _____

**Q2. Continue thinking about your <u>most memorable</u> tornado experience. Your responses to this question are very important for understanding your experience in your own words. This is the only question of this type.**

**a. Please describe that experience. Focus on what you remember most clearly and your feelings about it.**

**b. How has that experience changed how you think about future tornado risks?**

**Q3. Continue thinking about your most memorable tornado experience. Below is a list of statements about the time leading up to that tornado threat. Please indicate how true each statement was for you, or indicate if it's not applicable to you.** *Please select ONE option for each statement.*

| | Not at all | A little | Somewhat | A great deal | Not applicable |
|---|---|---|---|---|---|
| The sky looked unusual that day (e.g., green clouds, dark clouds). | ○ | ○ | ○ | ○ | ○ |
| The air felt unusual that day (e.g., humid, calm, electric). | ○ | ○ | ○ | ○ | ○ |
| Animals (e.g., pets, farm animals, birds) acted unusually or were unusually absent that day. | ○ | ○ | ○ | ○ | ○ |
| I paid attention to the weather forecasts and warnings because I knew about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| I was concerned about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| People I know (e.g., family, friends, neighbors, coworkers) talked to me about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| People I know were concerned about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| There was news coverage (on radio, TV, or online) about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |

**Q4. Continue thinking about your most memorable tornado experience. Below is a list of statements about the time during that tornado threat. Please indicate how true each statement was for you, or indicate if it's not applicable to you.** *Please select ONE option for each statement.*

| | Not at all | A little | Somewhat | A great deal | Not applicable |
|---|---|---|---|---|---|
| I tried to take action to protect myself or my loved ones (or someone tried to protect me). | ○ | ○ | ○ | ○ | ○ |
| I tried to get to my loved ones to be with them (or they tried to get to me). | ○ | ○ | ○ | ○ | ○ |
| I feared for my life. | ○ | ○ | ○ | ○ | ○ |
| I feared for my loved ones (e.g., family, friends, pets). | ○ | ○ | ○ | ○ | ○ |
| I worried about my home. | ○ | ○ | ○ | ○ | ○ |
| I saw the tornado or funnel cloud firsthand. | ○ | ○ | ○ | ○ | ○ |
| I saw other scenes of the storm firsthand (e.g., debris flying, trees bending or breaking, heavy rain or hail). | ○ | ○ | ○ | ○ | ○ |
| I heard sounds of the storm firsthand (e.g., sirens, the tornado, glass breaking, heavy rain or hail). | ○ | ○ | ○ | ○ | ○ |
| I heard or saw live news coverage (on radio, TV, or online) of the tornado as it was happening. | ○ | ○ | ○ | ○ | ○ |
| I had damage to my property (e.g., home, trees, car). | ○ | ○ | ○ | ○ | ○ |
| I was physically injured. | ○ | ○ | ○ | ○ | ○ |
| I lost irreplaceable items (e.g., photographs, heirlooms). | ○ | ○ | ○ | ○ | ○ |
| People I know (e.g., family, friends, neighbors, coworkers) had damage to their property (e.g., home, trees, car). | ○ | ○ | ○ | ○ | ○ |
| People I know were physically injured. | ○ | ○ | ○ | ○ | ○ |
| People I know lost irreplaceable items (e.g., photographs, heirlooms). | ○ | ○ | ○ | ○ | ○ |

**Q5. Continue thinking about your most memorable tornado experience. Below is a list of statements about the time after that tornado threat. Please indicate how true each statement was for you, or indicate if it's not applicable to you.** *Please select ONE option for each statement.*

| | Not at all | A little | Somewhat | A great deal | Not applicable |
|---|---|---|---|---|---|
| I was shaken up. | ○ | ○ | ○ | ○ | ○ |
| I thought about moving away. | ○ | ○ | ○ | ○ | ○ |
| I had trouble staying asleep and/or had dreams about it. | ○ | ○ | ○ | ○ | ○ |
| I had waves of strong feelings about it. | ○ | ○ | ○ | ○ | ○ |
| I thought about it when I didn't mean to. | ○ | ○ | ○ | ○ | ○ |
| Pictures about it popped into my mind. | ○ | ○ | ○ | ○ | ○ |
| My life was disrupted afterward. | ○ | ○ | ○ | ○ | ○ |
| The lives of people I know were disrupted afterward. | ○ | ○ | ○ | ○ | ○ |
| I talked to others about what I experienced. | ○ | ○ | ○ | ○ | ○ |
| People talked to me about what they experienced. | ○ | ○ | ○ | ○ | ○ |
| I saw scenes of the aftermath firsthand (e.g., damaged areas, downed trees, people injured). | ○ | ○ | ○ | ○ | ○ |
| I saw news coverage of the aftermath (e.g., people who were affected, images of damage, images of the tornado). | ○ | ○ | ○ | ○ | ○ |
| I volunteered to help others after the tornado. | ○ | ○ | ○ | ○ | ○ |
| Others volunteered to help me or my loved ones after the tornado. | ○ | ○ | ○ | ○ | ○ |
| Looking back, I took action to protect myself or my loved ones from the tornado threat that was unnecessary. | ○ | ○ | ○ | ○ | ○ |
| Looking back, responding to the tornado threat was an inconvenience. | ○ | ○ | ○ | ○ | ○ |

**Q6. People can have multiple experiences with tornadoes over the course of their lifetime. Please think about all of your experiences with tornadoes, and indicate how much experience you have with each of the statements listed below.** *Please select ONE option for each statement.*

| | No experience | A little experience | Some experience | A great deal of experience |
|---|---|---|---|---|
| I have been threatened by a tornado. | ○ | ○ | ○ | ○ |
| I have been under a tornado warning. | ○ | ○ | ○ | ○ |
| I have seen a tornado or funnel cloud firsthand. | ○ | ○ | ○ | ○ |
| I have heard tornado sirens firsthand. | ○ | ○ | ○ | ○ |
| I have taken shelter from a tornado. | ○ | ○ | ○ | ○ |
| I have left my home to flee from a tornado. | ○ | ○ | ○ | ○ |
| I have feared for my life due to a tornado. | ○ | ○ | ○ | ○ |
| I have feared for my loved ones due to a tornado. | ○ | ○ | ○ | ○ |
| I have worried about my home due to a tornado. | ○ | ○ | ○ | ○ |
| I have had property damage (e.g., home, trees, car) due to a tornado. | ○ | ○ | ○ | ○ |
| I have heard or watched live news coverage (on radio, TV, or online) of a tornado as it was happening. | ○ | ○ | ○ | ○ |
| I have seen the aftermath of a tornado firsthand (e.g., damaged areas, downed trees, people injured). | ○ | ○ | ○ | ○ |
| I have seen news coverage about the aftermath of a tornado (e.g., people who were affected, damage, images of the tornado). | ○ | ○ | ○ | ○ |
| I have volunteered to help others who were affected by a tornado. | ○ | ○ | ○ | ○ |
| I have taken action to protect myself or my loved ones from a tornado threat that was unnecessary. | ○ | ○ | ○ | ○ |
| I have been inconvenienced by responding to a tornado threat. | ○ | ○ | ○ | ○ |
| I have been warned about a tornado that did not occur. | ○ | ○ | ○ | ○ |

**Q7. Continue thinking about all of your tornado experiences. Based on all of those experiences, please indicate how frequently you think about or do each of the statements below.** *Please select ONE option for each.*

| | Never | Rarely | Sometimes | Often |
|---|---|---|---|---|
| I get nervous during tornado season. | ○ | ○ | ○ | ○ |
| I pay extra attention to weather forecasts during tornado season. | ○ | ○ | ○ | ○ |
| I think about future tornadoes that might strike. | ○ | ○ | ○ | ○ |
| I watch the weather for possible tornado activity. | ○ | ○ | ○ | ○ |
| I notice when dark clouds approach. | ○ | ○ | ○ | ○ |
| I look for places where I can take shelter during bad weather. | ○ | ○ | ○ | ○ |
| I think about past tornadoes that have threatened me. | ○ | ○ | ○ | ○ |
| I have dreams about tornadoes. | ○ | ○ | ○ | ○ |
| I think about moving to where tornadoes aren't as threatening. | ○ | ○ | ○ | ○ |

**Q8. Approximately what is the closest (in miles) that you have ever been to a tornado?**

○ _____ miles
○ Not applicable

**Q9. On a scale from 0% to 100%, where 0% = "no chance" and 100% = "certain", please indicate how likely you think it is that sometime in the next 10 years…**

**a. …a tornado will hit your city or town.** _____ (percent chance)

**b. …a tornado will damage your home.** _____ (percent chance)

**c. …you will be personally injured by a tornado.** _____ (percent chance)

**Q10. People understand tornadoes in different ways. In thinking about tornadoes generally, how strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| I am knowledgeable about tornadoes. | ○ | ○ | ○ | ○ | ○ |
| I am experienced with tornadoes. | ○ | ○ | ○ | ○ | ○ |
| I can control being physically harmed by a tornado. | ○ | ○ | ○ | ○ | ○ |
| I think that the threat from tornadoes is increasing. | ○ | ○ | ○ | ○ | ○ |
| I think that tornado damages extend to future generations. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes may cause catastrophic destruction. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes may cause widespread death. | ○ | ○ | ○ | ○ | ○ |
| I think tornadoes are hard to prepare for. | ○ | ○ | ○ | ○ | ○ |
| I think it is difficult to understand tornado forecast information. | ○ | ○ | ○ | ○ | ○ |
| I think tornadoes are very unpredictable. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes pose great financial threat. | ○ | ○ | ○ | ○ | ○ |
| I can control the amount of personal property damage from a tornado. | ○ | ○ | ○ | ○ | ○ |

**Q11. People have different kinds of emotional responses to the threat of a tornado. In thinking about the possibility of you being in a tornado, how strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| **Thinking about the possibility of a tornado….** | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| …makes me feel dread. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel fearful. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel worried. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel depressed. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel courageous. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel exhilarated. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel alive. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel capable. | ○ | ○ | ○ | ○ | ○ |

**Q12. In which of the following places would you most likely take shelter if you were threatened by a tornado while you were at home?** *Please select ONE option.*

- ○ Basement, storm cellar, or safe room
- ○ Closet, hallway, bathroom, or other interior room above ground
- ○ Someone else's home, public shelter, business, etc.
- ○ I would get in my car and drive away
- ○ I would not take shelter or drive away
- ○ Other (please describe) _____

**Q13. How frequently do you use the following to receive forecast and warning information when a tornado threatens?** *Please select ONE option for each.*

| | Never / Not applicable | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| Television (e.g., TV meteorologists, news media, emergency broadcast system crawlers) | ○ | ○ | ○ | ○ | ○ |
| Commercial radio (e.g., emergency broadcast system alerts, news media) | ○ | ○ | ○ | ○ | ○ |
| Websites (e.g., weather forecasting sites, news media sites, Facebook) | ○ | ○ | ○ | ○ | ○ |
| Cell phone (e.g., weather app, text alerts) | ○ | ○ | ○ | ○ | ○ |
| Landline phone (e.g., reverse-911) | ○ | ○ | ○ | ○ | ○ |
| Sirens | ○ | ○ | ○ | ○ | ○ |
| NOAA Weather Radio | ○ | ○ | ○ | ○ | ○ |
| Family, friends, others | ○ | ○ | ○ | ○ | ○ |

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## About You and Your Household

The remaining survey questions are about you and your household. All of your responses will remain anonymous. Your answers will be grouped with other people's responses and will not be reported in any way that can be linked to you.

**Q14. What is your age (in years)?** _____

**Q15. What is your gender?**

- ○ Male
- ○ Female

**Q16. What is your home 5-digit zip code?** _____

**Q17. Approximately how long (in years) have you lived anywhere in the dark grey boxed area shown on the map below?** _____

**Q18. How many people live or stay in your household, including yourself?** _____

a. **Of those people, how many are younger than 18?** _____

**Q19. Which of the following best describes the building that you live in?** *Please select ONE option.*

- ○ A mobile home
- ○ A one-family house, detached from any other house
- ○ A one-family house, attached to one or more house(s)
- ○ A building with two or more apartments
- ○ A boat, RV, van, etc.

**Q20. What is the highest degree or level of school that you have completed?** *Please select ONE option.*

- ○ Did not complete high school
- ○ High school diploma or GED equivalent
- ○ Some college, technical school, or associate's degree
- ○ Bachelor's degree (e.g., BA, BS)
- ○ Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
- ○ Professional degree or doctorate (e.g., MD, DDS, DVM, LLB, JD, PhD, EdD)

**Q21. What is your present employment status?** *Please select ALL that apply to you.*

- ☐ Employed full time
- ☐ Employed part time
- ☐ In Armed Forces
- ☐ Retired
- ☐ Homemaker
- ☐ Student
- ☐ Unemployed

**Q22. What is your race?** *Please select ALL that apply to you.*

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other (please describe) _____

**Q23. Are you of Hispanic, Latino, or Spanish origin?** *Please select ALL that apply to you.*

- ☐ No, not of Hispanic, Latino, or Spanish origin
- ☐ Yes, Mexican, Mexican American, Chicano
- ☐ Yes, Puerto Rican
- ☐ Yes, Cuban
- ☐ Yes, another Hispanic, Latino, or Spanish origin
- ☐ Other (please describe) _____

**Q24. What was your total household income for 2013 before taxes?** *Please select ONE option.*

- ○ Less than $15,000
- ○ $15,000 - $24,999
- ○ $25,000 - $34,999
- ○ $35,000 - $49,999
- ○ $50,000 - $74,999
- ○ $75,000 - $99,999
- ○ $100,000 - $149,999
- ○ $150,000 - $199,999
- ○ $200,000 or more

**Q25. How strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| In uncertain times, I usually expect the best. | ○ | ○ | ○ | ○ | ○ |
| It's easy for me to relax. | ○ | ○ | ○ | ○ | ○ |
| If something can go wrong for me, it will. | ○ | ○ | ○ | ○ | ○ |
| I'm always optimistic about my future. | ○ | ○ | ○ | ○ | ○ |
| I enjoy my friends a lot. | ○ | ○ | ○ | ○ | ○ |
| It's important for me to keep busy. | ○ | ○ | ○ | ○ | ○ |
| I hardly ever expect things to go my way. | ○ | ○ | ○ | ○ | ○ |
| I don't get upset too easily. | ○ | ○ | ○ | ○ | ○ |
| I rarely count on good things happening to me. | ○ | ○ | ○ | ○ | ○ |
| Overall, I expect more good things to happen to me than bad. | ○ | ○ | ○ | ○ | ○ |

**Q26. Please read each statement. Where there is a blank, indicate what your normal or usual attitude, feeling, or behavior would be.** *Please select ONE option for each statement.*

| | Rarely (Less than 10% of the time) | Occasionally (About 30% of the time) | Sometimes (About half the time) | Frequently (About 70% of the time) | Usually (More than 90% of the time) |
|---|---|---|---|---|---|
| I ____ like jobs where I can make decisions and be responsible for my own work. | ○ | ○ | ○ | ○ | ○ |
| I ____ enjoy being in a position of leadership. | ○ | ○ | ○ | ○ | ○ |
| I ____ need someone else to praise my work before I am satisfied with what I've done. | ○ | ○ | ○ | ○ | ○ |
| I am ____ sure enough of my opinions to try to influence others. | ○ | ○ | ○ | ○ | ○ |
| When something is going to affect me, I ____ learn as much about it as I can. | ○ | ○ | ○ | ○ | ○ |
| I ____ stick to my opinions when someone disagrees with me. | ○ | ○ | ○ | ○ | ○ |
| I ____ get discouraged when doing something that takes a long time to achieve results. | ○ | ○ | ○ | ○ | ○ |
| When part of a group, I ____ prefer to let other people make all the decisions. | ○ | ○ | ○ | ○ | ○ |
| I ____ prefer situations where I can depend on someone else's ability rather than just my own. | ○ | ○ | ○ | ○ | ○ |
| Having someone important tell me I did a good job is ____ more important to me than feeling I've done a good job. | ○ | ○ | ○ | ○ | ○ |

**If you have any additional thoughts to share, please write them below.**

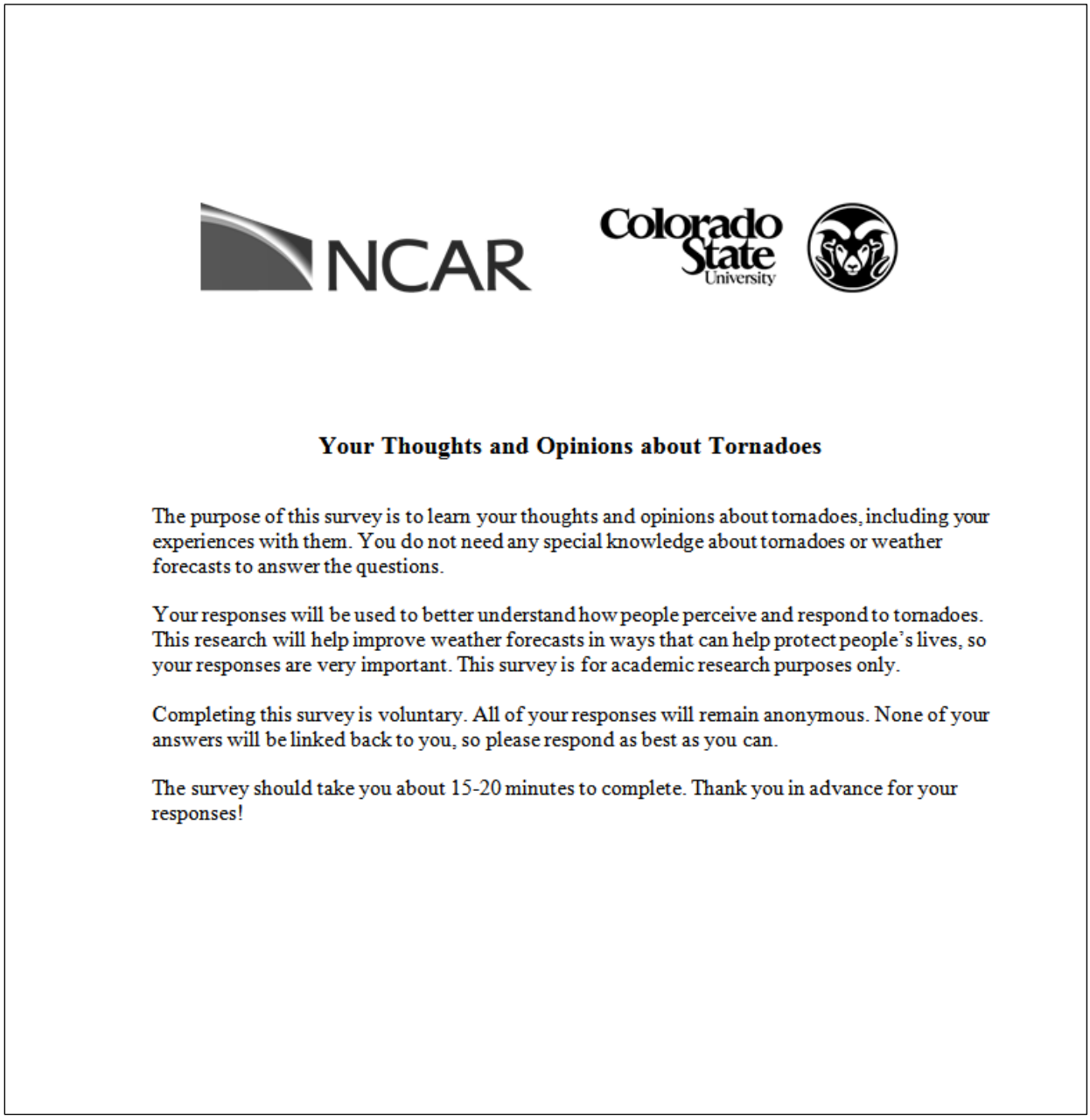
**Thank you for taking the time to complete this survey!**

Julie Demuth | National Center for Atmospheric Research | P.O. Box 3000 | Boulder, CO 80307

Access code (for tracking purposes only so that you are not contacted again): «RESPID»

# APPENDIX C: SURVEY 2

The complete Survey 2 is provided, reproduced here as the paper survey that was sent to participants who requested it and with the fourth and final mailing (see Figure 13). The paper survey was 8.5 x 11", 4-page, 2-sided, black-and-white, stapled along the left-hand side.



NCAR Colorado State University

**Your Thoughts and Opinions about Tornadoes**

The purpose of this survey is to learn your thoughts and opinions about tornadoes, including your experiences with them. You do not need any special knowledge about tornadoes or weather forecasts to answer the questions.

Your responses will be used to better understand how people perceive and respond to tornadoes. This research will help improve weather forecasts in ways that can help protect people's lives, so your responses are very important. This survey is for academic research purposes only.

Completing this survey is voluntary. All of your responses will remain anonymous. None of your answers will be linked back to you, so please respond as best as you can.

The survey should take you about 15-20 minutes to complete. Thank you in advance for your responses!

**Q1. Please think about your <u>most memorable</u> tornado experience. That experience may have happened to you personally, or you may have learned about the experiences of another person (or other people). It may have been a time when a tornado actually occurred or when there was just the possibility a tornado might occur. It may have occurred a long time ago or more recently.**

**a. Did that tornado experience happen to you personally, did you learn about others' experiences, or both?** *Please select ONE option.*

- ○ It happened to me personally.
- ○ It happened to other(s), and I learned about it.
  - ➔ If yes, approximately how far away (in miles) were you from them? _____
- ○ Both – it happened to me personally, and it happened to other(s).

**b. Did a tornado actually occur during that experience, or was there just the possibility of a tornado?** *Please select ONE option.*

- ○ A tornado actually occurred.
- ○ There was the possibility of a tornado, but one did not occur.

**c. Approximately what year did that tornado experience occur?** _____

**Q2. Continue thinking about your <u>most memorable</u> tornado experience. Below is a list of statements about <u>that experience</u>. Please indicate how true each statement was for you, or indicate if it's not applicable to you.** *Please select ONE option for each statement.*

| | Not at all | A little | Somewhat | A great deal | Not applicable |
|---|---|---|---|---|---|
| The sky looked unusual that day (e.g., green clouds, dark clouds). | ○ | ○ | ○ | ○ | ○ |
| The air felt unusual that day (e.g., humid, calm, electric). | ○ | ○ | ○ | ○ | ○ |
| Animals (e.g., pets, farm animals, birds) acted unusually or were unusually absent that day. | ○ | ○ | ○ | ○ | ○ |
| I had a bad sense about the weather (e.g., that something was wrong, different, didn't feel right). | ○ | ○ | ○ | ○ | ○ |
| I paid attention to the weather forecasts and warnings because I knew about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| I was concerned about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| People I know (e.g., family, friends, neighbors, coworkers) talked to me about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| People I know were concerned about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| There was news coverage (on radio, TV, or online) about the threat of tornadoes that day. | ○ | ○ | ○ | ○ | ○ |
| I tried to take action to protect myself or my loved ones (or someone tried to protect me). | ○ | ○ | ○ | ○ | ○ |
| I tried to get to my loved ones to be with them (or they tried to get to me). | ○ | ○ | ○ | ○ | ○ |
| I feared for my life. | ○ | ○ | ○ | ○ | ○ |
| I feared for my loved ones (e.g., family, friends, pets). | ○ | ○ | ○ | ○ | ○ |
| I worried about my home. | ○ | ○ | ○ | ○ | ○ |
| I saw scenes of the storm firsthand (e.g., the tornado, debris flying, trees bending or breaking, heavy rain or hail). | ○ | ○ | ○ | ○ | ○ |
| I heard sounds of the storm firsthand (e.g., sirens, the tornado, glass breaking, heavy rain or hail). | ○ | ○ | ○ | ○ | ○ |
| I felt sensations of the storm firsthand (e.g., pressure, strong winds). | ○ | ○ | ○ | ○ | ○ |
| The storm happened suddenly. | ○ | ○ | ○ | ○ | ○ |
| At times, I couldn't tell what was happening (e.g., couldn't see or hear anything). | ○ | ○ | ○ | ○ | ○ |

**Q3. Continue thinking about your most memorable tornado experience. Below is a list of more statements about that experience. Please indicate how true each statement was for you, or indicate if it's not applicable to you.** *Please select ONE option for each statement.*

| | Not at all | A little | Somewhat | A great deal | Not applicable |
|---|---|---|---|---|---|
| I had damage to my property (e.g., home, trees, car). | ○ | ○ | ○ | ○ | ○ |
| I was physically injured. | ○ | ○ | ○ | ○ | ○ |
| People I know (e.g., family, friends, neighbors, coworkers) had damage to their property (e.g., home, trees, car). | ○ | ○ | ○ | ○ | ○ |
| People I know were physically injured. | ○ | ○ | ○ | ○ | ○ |
| People I know lost irreplaceable items (e.g., photographs, heirlooms). | ○ | ○ | ○ | ○ | ○ |
| I was shaken up. | ○ | ○ | ○ | ○ | ○ |
| People I know were shaken up. | ○ | ○ | ○ | ○ | ○ |
| I had trouble staying asleep and/or had dreams about it. | ○ | ○ | ○ | ○ | ○ |
| I had waves of strong feelings about it. | ○ | ○ | ○ | ○ | ○ |
| I thought about it when I didn't mean to. | ○ | ○ | ○ | ○ | ○ |
| Pictures about it popped into my mind. | ○ | ○ | ○ | ○ | ○ |
| My life was disrupted afterward. | ○ | ○ | ○ | ○ | ○ |
| The lives of people I know were disrupted afterward. | ○ | ○ | ○ | ○ | ○ |
| I talked to others about what I experienced. | ○ | ○ | ○ | ○ | ○ |
| People talked to me about what they experienced. | ○ | ○ | ○ | ○ | ○ |
| I saw scenes of the aftermath firsthand (e.g., damaged areas, downed trees, people injured, debris). | ○ | ○ | ○ | ○ | ○ |
| I was shocked by the devastation and loss. | ○ | ○ | ○ | ○ | ○ |

**Q4. People can have multiple experiences with tornadoes over the course of their lifetime. Please think about all of your experiences with tornadoes, and indicate how much experience you have with each of the statements listed below.** *Please select ONE option for each statement.*

| | No experience | A little experience | Some experience | A great deal of experience |
|---|---|---|---|---|
| I have been under a tornado warning. | ○ | ○ | ○ | ○ |
| I have heard tornado sirens (not as a test) firsthand. | ○ | ○ | ○ | ○ |
| I have feared for my life due to a tornado. | ○ | ○ | ○ | ○ |
| I have feared for my loved ones due to a tornado. | ○ | ○ | ○ | ○ |
| I have worried about my home due to a tornado. | ○ | ○ | ○ | ○ |
| I have heard or watched live news coverage (on radio, TV, or online) of a tornado as it was happening. | ○ | ○ | ○ | ○ |
| I have seen news coverage about the aftermath of a tornado (e.g., people who were affected, damage, images of the tornado). | ○ | ○ | ○ | ○ |

**Q5. Continue thinking about all of your tornado experiences. Based on all of those experiences, please indicate how frequently you think about or do each of the statements below.** *Please select ONE option for each.*

| | Never | Rarely | Sometimes | Often |
|---|---|---|---|---|
| I get nervous during tornado season. | ○ | ○ | ○ | ○ |
| I pay extra attention to weather forecasts during tornado season. | ○ | ○ | ○ | ○ |
| I think about future tornadoes that might strike. | ○ | ○ | ○ | ○ |
| I watch the weather for possible tornado activity. | ○ | ○ | ○ | ○ |
| I notice when dark clouds approach. | ○ | ○ | ○ | ○ |
| I look for places where I can take shelter during bad weather. | ○ | ○ | ○ | ○ |
| I think about past tornadoes that have threatened me. | ○ | ○ | ○ | ○ |
| I have dreams about tornadoes. | ○ | ○ | ○ | ○ |
| I think about moving to where tornadoes aren't as threatening. | ○ | ○ | ○ | ○ |

**Q6. Approximately what is the closest (in miles) that you have ever been to a tornado?**

- ○ _____ miles
- ○ Not applicable

**Q7. On a scale from 0% to 100%, where 0% = "no chance" and 100% = "certain", please indicate how likely you think it is that sometime in the next 10 years…**

**a. …a tornado will hit your city or town.** _____ (percent chance)

**b. …a tornado will damage your home.** _____ (percent chance)

**c. …you will be personally injured by a tornado.** _____ (percent chance)

**Q8. People <u>understand</u> tornadoes in different ways. In thinking about tornadoes generally, how strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| I am knowledgeable about tornadoes. | ○ | ○ | ○ | ○ | ○ |
| I am experienced with tornadoes. | ○ | ○ | ○ | ○ | ○ |
| I can control being physically harmed by a tornado. | ○ | ○ | ○ | ○ | ○ |
| I think that the threat from tornadoes is increasing. | ○ | ○ | ○ | ○ | ○ |
| I think that tornado damages extend to future generations. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes may cause catastrophic destruction. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes may cause widespread death. | ○ | ○ | ○ | ○ | ○ |
| I think tornadoes are hard to prepare for. | ○ | ○ | ○ | ○ | ○ |
| I think it is difficult to understand tornado forecast information. | ○ | ○ | ○ | ○ | ○ |
| I think tornadoes are very unpredictable. | ○ | ○ | ○ | ○ | ○ |
| I think that tornadoes pose great financial threat. | ○ | ○ | ○ | ○ | ○ |
| I can control the amount of personal property damage from a tornado. | ○ | ○ | ○ | ○ | ○ |

**Q9. People have different kinds of <u>emotional responses</u> to the threat of a tornado. In thinking about the possibility of you being in a tornado, how strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| **Thinking about the possibility of a tornado….** | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| …makes me feel dread. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel fearful. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel worried. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel depressed. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel courageous. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel exhilarated. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel alive. | ○ | ○ | ○ | ○ | ○ |
| …makes me feel capable. | ○ | ○ | ○ | ○ | ○ |

**Q10. In which of the following places would you most likely take shelter if you were threatened by a tornado while you were at home?** *Please select ONE option.*

- ○ Basement, storm cellar, or safe room
- ○ Closet, hallway, bathroom, or other interior room above ground
- ○ Someone else's home, public shelter, business, etc.
- ○ would get in my car and drive away
- ○ I would not take shelter or drive away
- ○ Other (please describe) _____

**Q11. How frequently do you use the following to receive forecast and warning information when a tornado threatens?** *Please select ONE option for each.*

| | Never / Not applicable | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| Television (e.g., TV meteorologists, news media, emergency broadcast system crawlers) | ○ | ○ | ○ | ○ | ○ |
| Commercial radio (e.g., emergency broadcast system alerts, news media) | ○ | ○ | ○ | ○ | ○ |
| Websites (e.g., weather forecasting sites, news media sites, Facebook) | ○ | ○ | ○ | ○ | ○ |
| Cell phone (e.g., weather app, text alerts) | ○ | ○ | ○ | ○ | ○ |
| Landline phone (e.g., reverse-911) | ○ | ○ | ○ | ○ | ○ |
| Sirens | ○ | ○ | ○ | ○ | ○ |
| NOAA Weather Radio | ○ | ○ | ○ | ○ | ○ |
| Family, friends, others | ○ | ○ | ○ | ○ | ○ |

**Q12. How strongly do you agree or disagree that you would do each of the following actions if you were threatened by a tornado while you were at home?** *Please select ONE option for each.*

| | Strongly disagree | Disagree | Agree | Strongly agree |
|---|---|---|---|---|
| I would get in my car and drive away. | ○ | ○ | ○ | ○ |
| I would take shelter in the best place available to me (e.g., basement, bathroom, hallway, storm cellar). | ○ | ○ | ○ | ○ |
| I would seek additional information about the threat. | ○ | ○ | ○ | ○ |
| I would try to get to loved ones to be with them. | ○ | ○ | ○ | ○ |
| I would look outside to see what was happening. | ○ | ○ | ○ | ○ |
| I would do nothing. | ○ | ○ | ○ | ○ |

**Q13. Please indicate whether or not you have done each of the following actions to prepare for a tornado threat.** *Please select ONE option for each.*

| | Yes | No |
|---|---|---|
| I have a disaster supply kit. | ○ | ○ |
| I have a plan for where to take shelter from a tornado. | ○ | ○ |
| I have a designated safe room to take shelter in. | ○ | ○ |
| I have a family disaster plan (i.e., what to do during and after a tornado). | ○ | ○ |
| I have a way to receive emergency weather alerts (e.g., by cell phone, from NOAA weather radio). | ○ | ○ |
| I (and my family) practice drills of what to do when a tornado threatens. | ○ | ○ |
| I know how to shut off the utilities (e.g., gas) in my home if needed. | ○ | ○ |

## About You and Your Household

The remaining survey questions are about you and your household. All of your responses will remain anonymous. Your answers will be grouped with other people's responses and will not be reported in any way that can be linked to you.

**Q14. What is your age (in years)? _____**

**Q15. What is your gender?**
- ○ Male
- ○ Female

**Q16. What is your home 5-digit zip code? _____**

**Q17. Approximately how long (in years) have you lived anywhere in the dark grey boxed area shown on the map below? _____**


**Q18. How many people live or stay in your household, including yourself? _____**
- **a. Of those people, how many are younger than 18? _____**

**Q19. Which of the following best describes the building that you live in?** *Please select ONE option.*
- ○ A mobile home
- ○ A one-family house, detached from any other house
- ○ A one-family house, attached to one or more house(s)
- ○ A building with two or more apartments
- ○ A boat, RV, van, etc.

**Q20. What is the highest degree or level of school that you have completed?** *Please select ONE option.*
- ○ Did not complete high school
- ○ High school diploma or GED equivalent
- ○ Some college, technical school, or associate's degree
- ○ Bachelor's degree (e.g., BA, BS)
- ○ Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
- ○ Professional degree or doctorate (e.g., MD, DDS, DVM, LLB, JD, PhD, EdD)

**Q21. What is your present employment status?** *Please select ALL that apply to you.*

- ☐ Employed full time
- ☐ Employed part time
- ☐ In Armed Forces
- ☐ Retired
- ☐ Homemaker
- ☐ Student
- ☐ Unemployed

**Q22. What is your race?** *Please select ALL that apply to you.*

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other (please describe) _____

**Q23. Are you of Hispanic, Latino, or Spanish origin?** *Please select ALL that apply to you.*

- ☐ No, not of Hispanic, Latino, or Spanish origin
- ☐ Yes, Mexican, Mexican American, Chicano
- ☐ Yes, Puerto Rican
- ☐ Yes, Cuban
- ☐ Yes, another Hispanic, Latino, or Spanish origin
- ☐ Other (please describe) _____

**Q24. What was your total household income for 2013 before taxes?** *Please select ONE option.*

- ○ Less than $15,000
- ○ $15,000 - $24,999
- ○ $25,000 - $34,999
- ○ $35,000 - $49,999
- ○ $50,000 - $74,999
- ○ $75,000 - $99,999
- ○ $100,000 - $149,999
- ○ $150,000 - $199,999
- ○ $200,000 or more

**Q25. How strongly do you disagree or agree with the following statements?** *Please select ONE option for each statement.*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| In uncertain times, I usually expect the best. | ○ | ○ | ○ | ○ | ○ |
| It's easy for me to relax. | ○ | ○ | ○ | ○ | ○ |
| If something can go wrong for me, it will. | ○ | ○ | ○ | ○ | ○ |
| I'm always optimistic about my future. | ○ | ○ | ○ | ○ | ○ |
| I enjoy my friends a lot. | ○ | ○ | ○ | ○ | ○ |
| It's important for me to keep busy. | ○ | ○ | ○ | ○ | ○ |
| I hardly ever expect things to go my way. | ○ | ○ | ○ | ○ | ○ |
| I don't get upset too easily. | ○ | ○ | ○ | ○ | ○ |
| I rarely count on good things happening to me. | ○ | ○ | ○ | ○ | ○ |
| Overall, I expect more good things to happen to me than bad. | ○ | ○ | ○ | ○ | ○ |

**Q26. Please read each statement. Where there is a blank, indicate what your normal or usual attitude, feeling, or behavior would be.** *Please select ONE option for each statement.*

| | Rarely (Less than 10% of the time) | Occasionally (About 30% of the time) | Sometimes (About half the time) | Frequently (About 70% of the time) | Usually (More than 90% of the time) |
|---|---|---|---|---|---|
| I ____ like jobs where I can make decisions and be responsible for my own work. | ○ | ○ | ○ | ○ | ○ |
| I ____ enjoy being in a position of leadership. | ○ | ○ | ○ | ○ | ○ |
| I ____ need someone else to praise my work before I am satisfied with what I've done. | ○ | ○ | ○ | ○ | ○ |
| I am ____ sure enough of my opinions to try to influence others. | ○ | ○ | ○ | ○ | ○ |
| When something is going to affect me, I ____ learn as much about it as I can. | ○ | ○ | ○ | ○ | ○ |
| I ____ stick to my opinions when someone disagrees with me. | ○ | ○ | ○ | ○ | ○ |
| I ____ get discouraged when doing something that takes a long time to achieve results. | ○ | ○ | ○ | ○ | ○ |
| When part of a group, I ____ prefer to let other people make all the decisions. | ○ | ○ | ○ | ○ | ○ |
| I ____ prefer situations where I can depend on someone else's ability rather than just my own. | ○ | ○ | ○ | ○ | ○ |
| Having someone important tell me I did a good job is ____ more important to me than feeling I've done a good job. | ○ | ○ | ○ | ○ | ○ |

**If you have any additional thoughts to share, please write them below.**

**Thank you for taking the time to complete this survey!**

Julie Demuth | National Center for Atmospheric Research | P.O. Box 3000 | Boulder, CO 80307

Access code (for tracking purposes only so that you are not contacted again): «RESPID»

APPENDIX D: SURVEY MAILINGS

## Survey 1 Mailings

April 1, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE» «ZIP»

Dear «DEAR_CITY» Area Resident,

I am writing to ask for your help with an important study about tornadoes that is being conducted by Colorado State University (CSU) and the National Center for Atmospheric Research (NCAR). In the next few days, you will receive another letter asking you to participate in this research project by responding to a short survey about your thoughts and opinions about tornadoes.

I am writing in advance because many people like to know ahead of time that they will be asked to fill out a survey. This research can only be successful with the generous help of people like you.

To say thanks, in the next letter you will receive a small token of appreciation with the request to participate in the study. I hope you will take 15-20 minutes of your time to help and to voice your thoughts and opinions about tornadoes.

Best Wishes,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

*Figure 6.* Survey 1 first mailing (prenotice letter).
Specifications: 8.5 x 11" 1-page, 1-sided, full-color, z-folded letter mailed in #10 black-and-white envelope

April 4, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE» «ZIP»

Dear «DEAR_CITY» Area Resident,

I am writing to ask for your help in understanding your thoughts about tornadoes. The best way to learn about this topic is by asking different people who live in tornado-prone areas to share their thoughts. Your address is one of a small number that has been randomly selected to help in this study. This research is being conducted by Colorado State University (CSU) and the National Center for Atmospheric Research (NCAR).

To make sure we hear from different types of people who live in the area, please have the adult (age 18 or older) in your household who has had **the most recent birthday** be the one to complete the survey.

It would be best if you can complete the survey on the Internet so that the results can be summarized more quickly and accurately. Taking the survey online is easy. Just type the webpage address below into your Internet browser, and then type in your access code to begin the survey.

Webpage address: https://tornadoes.questionpro.com
Your access code: «RESPID»

I realize that some households do not have Internet access. If you do not, I will send a paper survey to all households that I have not heard from in about 2 ½ weeks. If you would like one sooner, please contact me by telephone at 303-497-8112.

The survey should only take about 15-20 minutes to complete. Completing this survey is voluntary. By completing this survey, you are consenting as a participant. Your answers will be grouped with other people's responses, and none of your answers will be linked back to you, so please respond as best as you can.

If you have questions about this survey, or if you have trouble responding on the Internet, please contact me (phone and email below). If you have questions about your rights as a study participant, contact Janell Barker, CSU Human Research Administrator, at 970-491-1655, or Michael Thompson, NCAR Human Subjects Committee chair, at 303-497-1500. Additional details about this project are provided on the next page.

You will be helping a great deal by taking a few minutes to share your thoughts and opinions about tornadoes. A small token of appreciation is enclosed as a way of saying thank you. I look forward to receiving your responses to the survey.

Thank you,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

(a)

**TITLE OF STUDY:** "Developing a tornado experience scale"

**PRINCIPAL INVESTIGATOR:** Craig Trumbo, PhD, Professor and Faculty Advisor, Department of Journalism and Technical Communication (970-491-2077; craig.trumbo@colostate.edu), 1785 Campus Delivery Colorado State University, Fort Collins, CO 80526. Co-investigator: Julie Demuth, PhD candidate, Department of Journalism and Technical Communication (303-497-8112; julie.demuth@colostate.edu).

**WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH?** We are seeking participation from a random selection of people who live in counties throughout the central United States where tornadoes occur.

**WHO IS DOING THE STUDY?** The study is being conducted by researchers in the Department of Journalism and Technical Communication at Colorado State University and the National Center for Atmospheric Research in Boulder, CO.

**WHAT IS THE PURPOSE OF THIS STUDY?** This study has two main purposes. First, it is designed to gather information about people's past experiences with tornadoes and about their tornado risk perceptions. Second, the results of this project will be useful for those who create and issue tornado warning and response messages.

**WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?** We will ask a group of 650 people living throughout the central United States to complete an at-home survey either online or by mail.

**WHAT WILL I BE ASKED TO DO?** You will be asked to respond to a survey either online or by mail; it should take 15-20 minutes to complete. No sensitive will be asked. Questions will involve your experiences with tornadoes, your thoughts about tornadoes, and your socio-demographic and household characteristics.

**ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY?** There are no reasons why you should not take part in this study.

**WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?** There are no foreseeable risks or discomforts to you from participating in this research study.

**ARE THERE ANY BENEFITS FROM TAKING PART IN THIS STUDY?** There are no direct benefits to you from participating in this research study. We hope that the results of the study will provide more general benefits to people who live in tornado-prone areas. The information we will gather will hopefully be of use to weather forecasters and emergency managers who provide tornado warning and response information.

**DO I HAVE TO TAKE PART IN THE STUDY?** Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

**WHAT WILL IT COST ME TO PARTICIPATE?** There are no costs to you for joining this study.

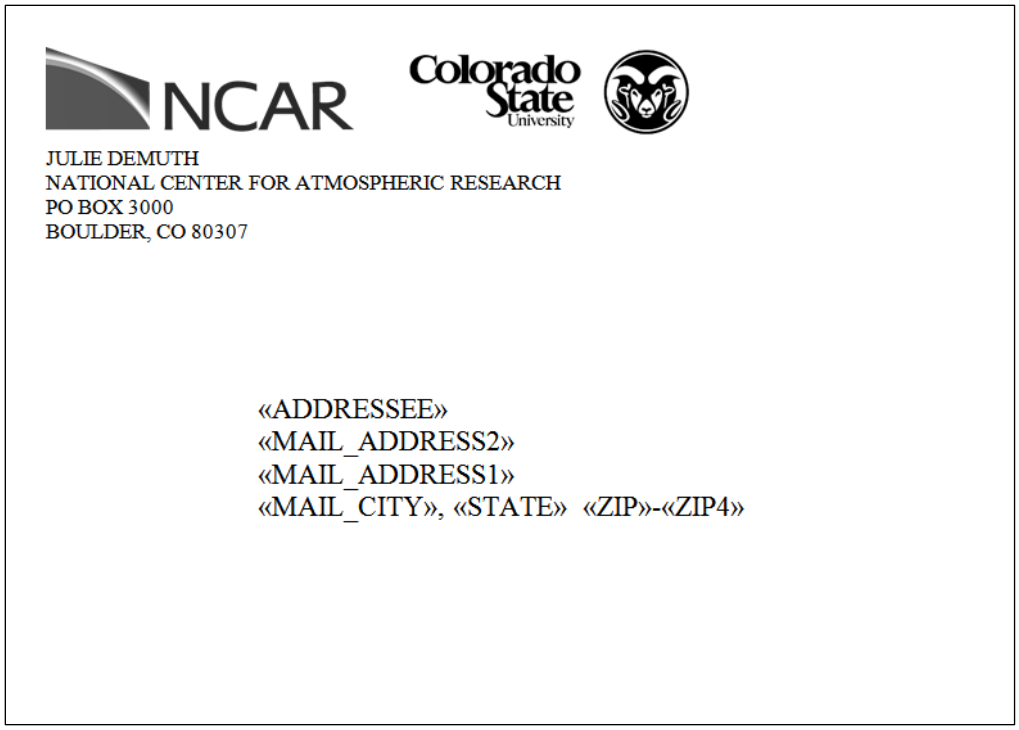
**WHO WILL SEE THE INFORMATION THAT I GIVE?** Your information will be combined with information from other people who take part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be identified in these written materials. We may publish the results of this study; however, we will keep any identifying information you provide private.

**WILL I RECEIVE ANY COMPENSATION FOR TAKING PART IN THIS STUDY?** This survey will include a $2 cash payment.

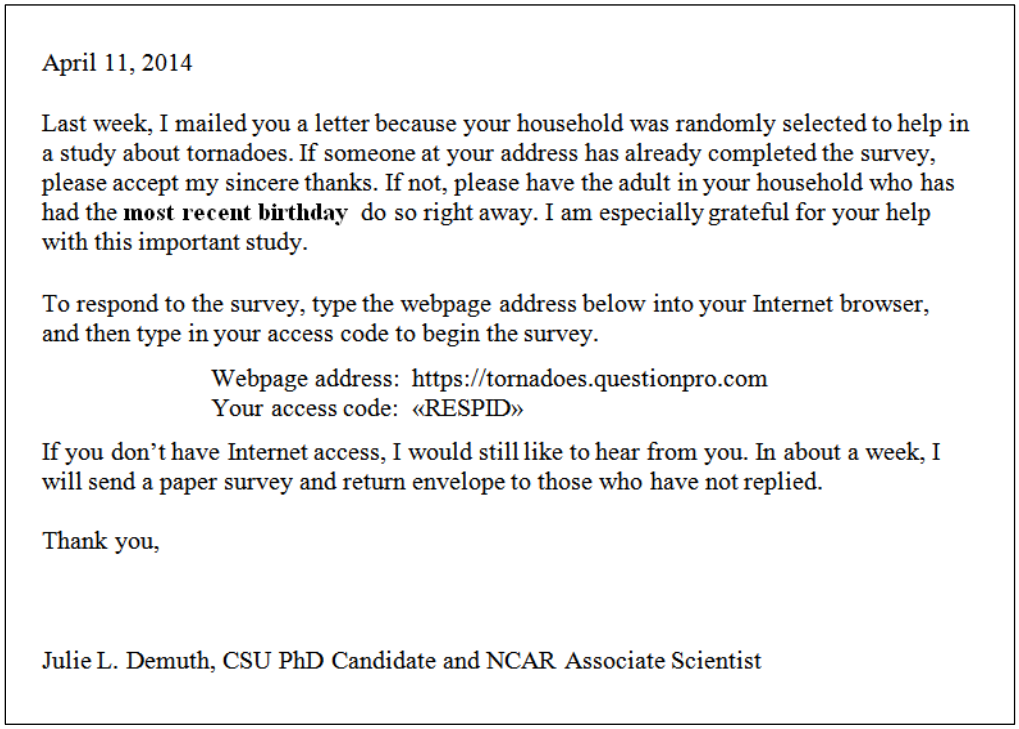
**WHAT IF I HAVE QUESTIONS?** Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind. You can contact the investigator, Craig Trumbo at 970-491-2077 or ctrumbo@colostate.edu. If you have any questions about your rights as a volunteer in this research, contact Janell Barker, CSU Human Research Administrator, at 970-491-1655, or Michael Thompson, NCAR Human Subjects Committee chair, at 303-497-1500.

(b)

*Figure 7*. (a) Front and (b) back of the Survey 1 second mailing (survey letter). Specifications: 8.5 x 11" 1-page, 2-sided, full-color, z-folded letter with $2 bill tucked in top fold, mailed in #10 black-and-white envelope

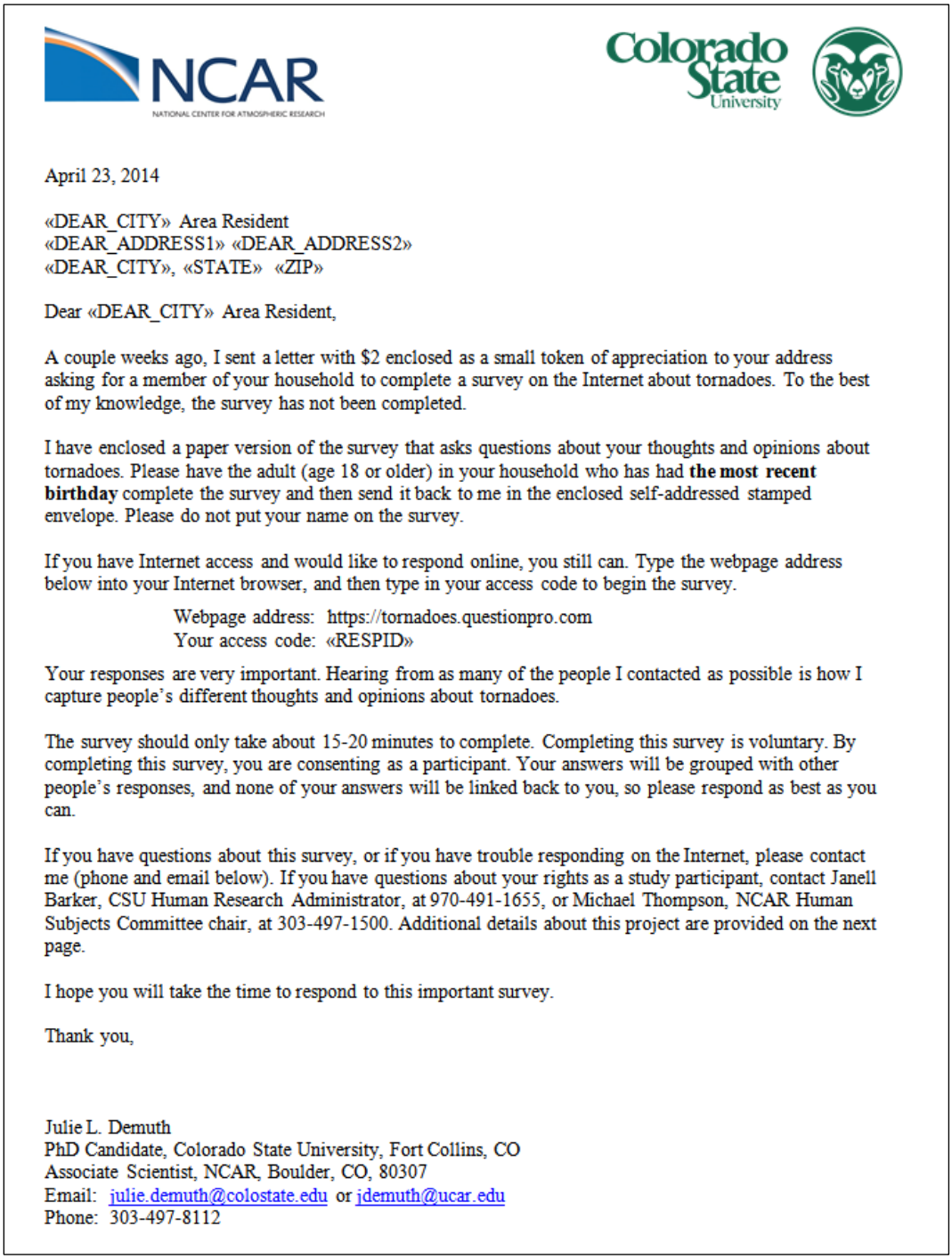



(a)




(b)

*Figure 8.* (a) Front and (b) back of the Survey 1 third mailing (postcard). Specifications: 6 x 4.25", 2-sided, black-and-white postcard



April 23, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE» «ZIP»

Dear «DEAR_CITY» Area Resident,

A couple weeks ago, I sent a letter with $2 enclosed as a small token of appreciation to your address asking for a member of your household to complete a survey on the Internet about tornadoes. To the best of my knowledge, the survey has not been completed.

I have enclosed a paper version of the survey that asks questions about your thoughts and opinions about tornadoes. Please have the adult (age 18 or older) in your household who has had **the most recent birthday** complete the survey and then send it back to me in the enclosed self-addressed stamped envelope. Please do not put your name on the survey.

If you have Internet access and would like to respond online, you still can. Type the webpage address below into your Internet browser, and then type in your access code to begin the survey.

Webpage address: https://tornadoes.questionpro.com
Your access code: «RESPID»

Your responses are very important. Hearing from as many of the people I contacted as possible is how I capture people's different thoughts and opinions about tornadoes.

The survey should only take about 15-20 minutes to complete. Completing this survey is voluntary. By completing this survey, you are consenting as a participant. Your answers will be grouped with other people's responses, and none of your answers will be linked back to you, so please respond as best as you can.

If you have questions about this survey, or if you have trouble responding on the Internet, please contact me (phone and email below). If you have questions about your rights as a study participant, contact Janell Barker, CSU Human Research Administrator, at 970-491-1655, or Michael Thompson, NCAR Human Subjects Committee chair, at 303-497-1500. Additional details about this project are provided on the next page.

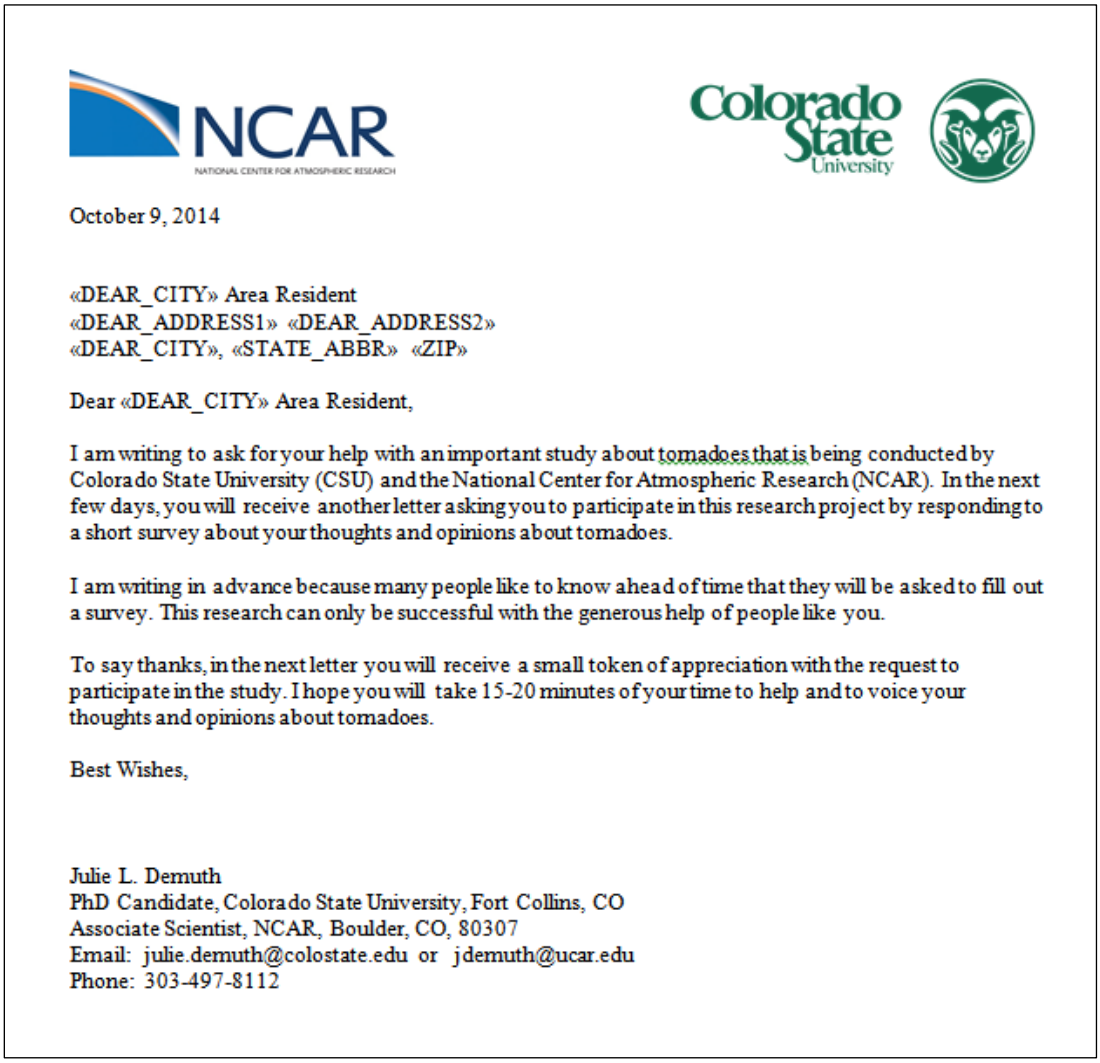
I hope you will take the time to respond to this important survey.

Thank you,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

*Figure 9.* Front of the Survey 1 final mailing (back is same as that in the second mailing). Specifications: 8.5 x 11" 1-page, 2-sided, full-color, z-folded letter with paper survey (Appendix B) and #9 return envelope tucked into top fold, mailed in #10 black-and-white envelope

**Survey 2 Mailings**



October 9, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE_ABBR» «ZIP»

Dear «DEAR_CITY» Area Resident,

I am writing to ask for your help with an important study about tornadoes that is being conducted by Colorado State University (CSU) and the National Center for Atmospheric Research (NCAR). In the next few days, you will receive another letter asking you to participate in this research project by responding to a short survey about your thoughts and opinions about tornadoes.

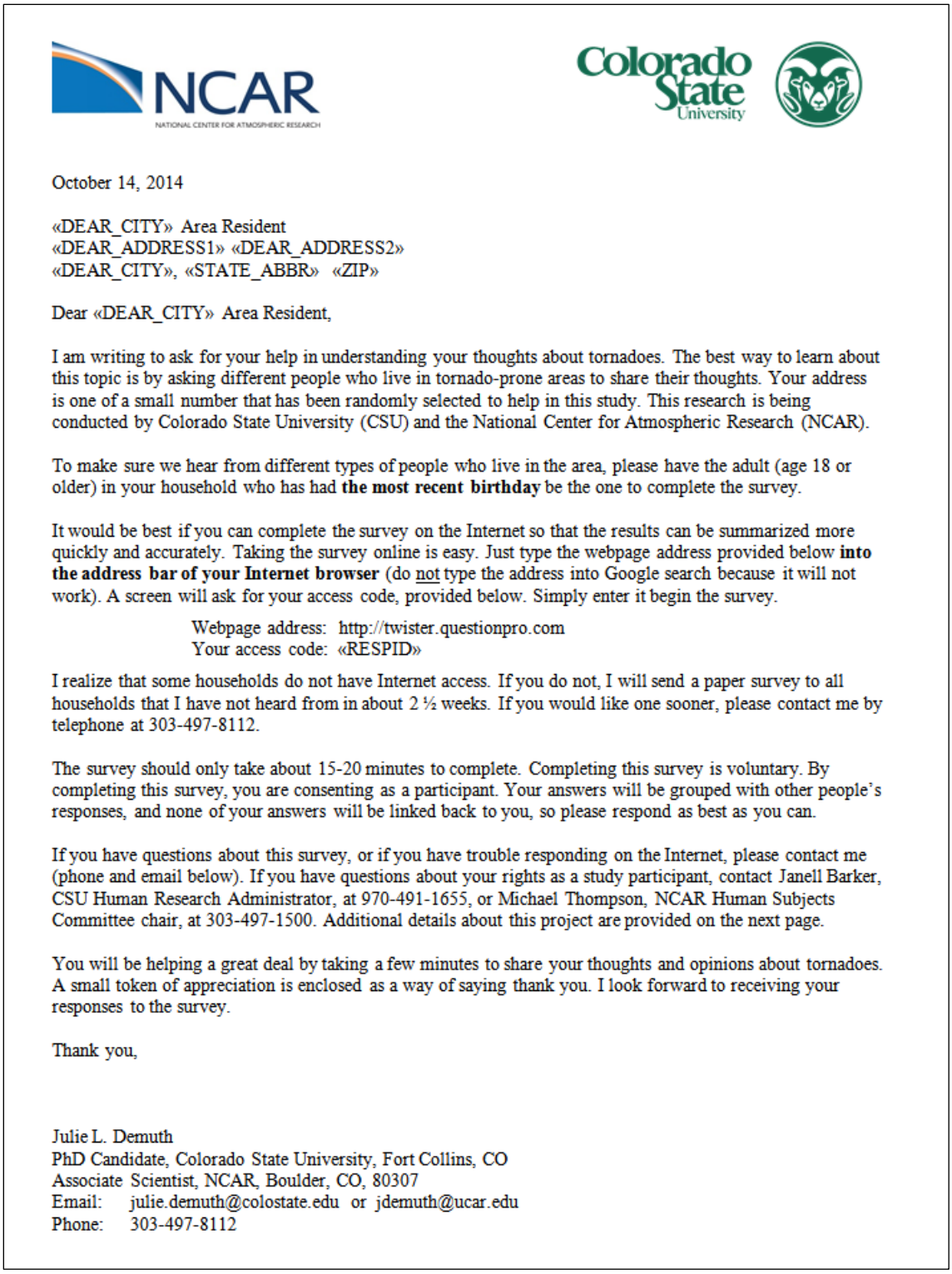
I am writing in advance because many people like to know ahead of time that they will be asked to fill out a survey. This research can only be successful with the generous help of people like you.

To say thanks, in the next letter you will receive a small token of appreciation with the request to participate in the study. I hope you will take 15-20 minutes of your time to help and to voice your thoughts and opinions about tornadoes.

Best Wishes,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

*Figure 10.* Survey 2 first mailing (prenotice letter).
Specifications: 8.5 x 11" 1-page, 1-sided, full-color, z-folded letter mailed in #10 black-and-white envelope



October 14, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE_ABBR» «ZIP»

Dear «DEAR_CITY» Area Resident,

I am writing to ask for your help in understanding your thoughts about tornadoes. The best way to learn about this topic is by asking different people who live in tornado-prone areas to share their thoughts. Your address is one of a small number that has been randomly selected to help in this study. This research is being conducted by Colorado State University (CSU) and the National Center for Atmospheric Research (NCAR).

To make sure we hear from different types of people who live in the area, please have the adult (age 18 or older) in your household who has had **the most recent birthday** be the one to complete the survey.

It would be best if you can complete the survey on the Internet so that the results can be summarized more quickly and accurately. Taking the survey online is easy. Just type the webpage address provided below **into the address bar of your Internet browser** (do not type the address into Google search because it will not work). A screen will ask for your access code, provided below. Simply enter it begin the survey.

Webpage address: http://twister.questionpro.com
Your access code: «RESPID»

I realize that some households do not have Internet access. If you do not, I will send a paper survey to all households that I have not heard from in about 2 ½ weeks. If you would like one sooner, please contact me by telephone at 303-497-8112.

The survey should only take about 15-20 minutes to complete. Completing this survey is voluntary. By completing this survey, you are consenting as a participant. Your answers will be grouped with other people's responses, and none of your answers will be linked back to you, so please respond as best as you can.

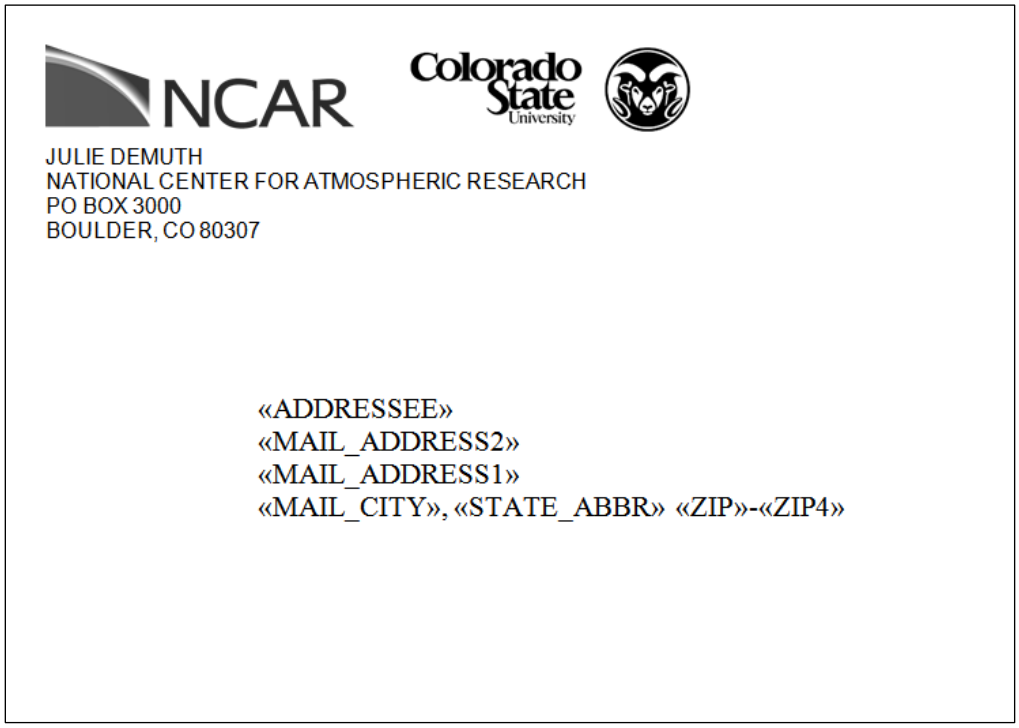
If you have questions about this survey, or if you have trouble responding on the Internet, please contact me (phone and email below). If you have questions about your rights as a study participant, contact Janell Barker, CSU Human Research Administrator, at 970-491-1655, or Michael Thompson, NCAR Human Subjects Committee chair, at 303-497-1500. Additional details about this project are provided on the next page.

You will be helping a great deal by taking a few minutes to share your thoughts and opinions about tornadoes. A small token of appreciation is enclosed as a way of saying thank you. I look forward to receiving your responses to the survey.

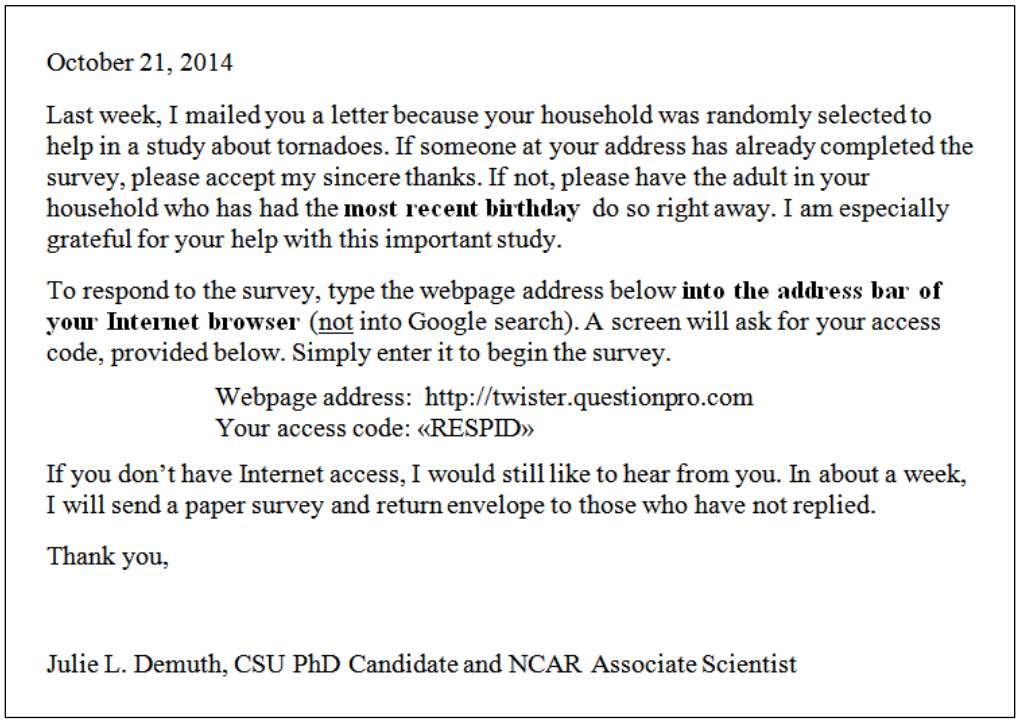
Thank you,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

*Figure 11.* Front of the Survey 2 second mailing (survey letter).
Back of this survey letter is the same as in Survey 1.
Specifications: 8.5 x 11" 1-page, 2-sided, full-color, z-folded letter with $2 bill tucked in top fold, mailed in #10 black-and-white envelope

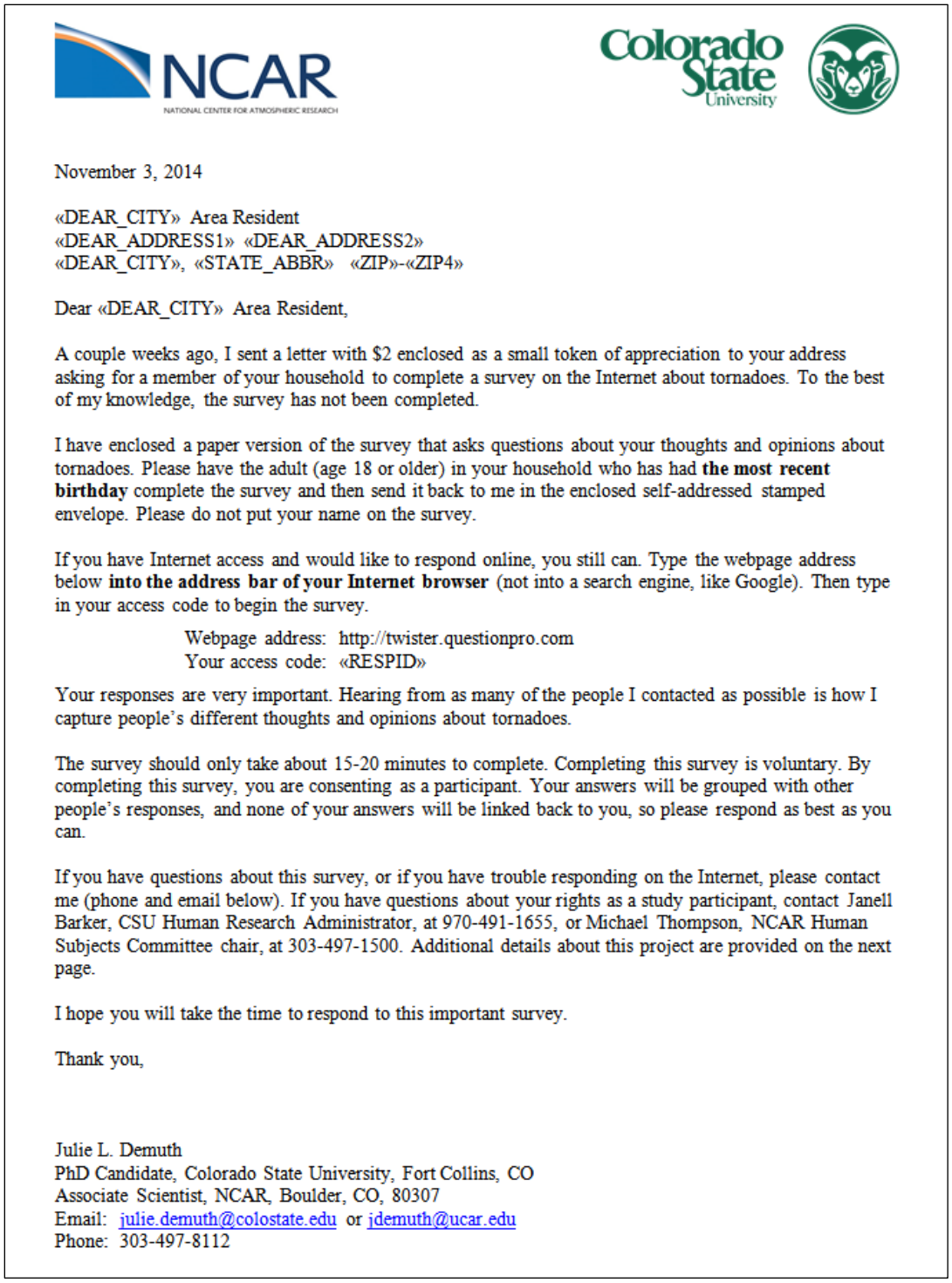



(a)




(b)

*Figure 12.* (a) Front and (b) back of the Survey 2 third mailing (postcard). Specifications: 6 x 4.25", 2-sided, black-and-white postcard



November 3, 2014

«DEAR_CITY» Area Resident
«DEAR_ADDRESS1» «DEAR_ADDRESS2»
«DEAR_CITY», «STATE_ABBR» «ZIP»-«ZIP4»

Dear «DEAR_CITY» Area Resident,

A couple weeks ago, I sent a letter with $2 enclosed as a small token of appreciation to your address asking for a member of your household to complete a survey on the Internet about tornadoes. To the best of my knowledge, the survey has not been completed.

I have enclosed a paper version of the survey that asks questions about your thoughts and opinions about tornadoes. Please have the adult (age 18 or older) in your household who has had **the most recent birthday** complete the survey and then send it back to me in the enclosed self-addressed stamped envelope. Please do not put your name on the survey.

If you have Internet access and would like to respond online, you still can. Type the webpage address below **into the address bar of your Internet browser** (not into a search engine, like Google). Then type in your access code to begin the survey.

Webpage address: http://twister.questionpro.com
Your access code: «RESPID»

Your responses are very important. Hearing from as many of the people I contacted as possible is how I capture people's different thoughts and opinions about tornadoes.

The survey should only take about 15-20 minutes to complete. Completing this survey is voluntary. By completing this survey, you are consenting as a participant. Your answers will be grouped with other people's responses, and none of your answers will be linked back to you, so please respond as best as you can.

If you have questions about this survey, or if you have trouble responding on the Internet, please contact me (phone and email below). If you have questions about your rights as a study participant, contact Janell Barker, CSU Human Research Administrator, at 970-491-1655, or Michael Thompson, NCAR Human Subjects Committee chair, at 303-497-1500. Additional details about this project are provided on the next page.

I hope you will take the time to respond to this important survey.

Thank you,

Julie L. Demuth
PhD Candidate, Colorado State University, Fort Collins, CO
Associate Scientist, NCAR, Boulder, CO, 80307
Email: julie.demuth@colostate.edu or jdemuth@ucar.edu
Phone: 303-497-8112

*Figure 13.* Front of the Survey 2 final mailing (back is the same as that in the second mailing). Specifications: 8.5 x 11" 1-page, 2-sided, full-color, z-folded letter with paper survey (Appendix C) and #9 return envelope tucked into top fold, mailed in #10 black-and-white envelope

# APPENDIX E: SURVEY 1 AND 2 SAMPLE CHARACTERISTICS

Table 20. *Demographic characteristics of the Survey 1 and Survey 2 samples*

| Demographic characteristic | Survey 1 sample[a] | Survey 2 sample[a] |
|---|---|---|
| Age: median (range) | 54 years (20–93 years) | 55 years (18–91 years) |
| Gender: % male | 50.0% | 46.2% |
| Length of residence in sample area: median (range) | 45 years (2–93 years) | 49 years (1–82 years) |
| Household size: median (range) | 2 people (1–7 people) | 2 people (1–11 people) |
| Number of children: median (range) | 0 people (0–5 people) | 0 people (0–8 people) |
| Dwelling type: | | |
| One-family home, detached | 75.7% | 77.7% |
| One-family home, attached to 1 or more home | 6.9% | 7.1% |
| Building with 2 or more apartments | 11.8% | 10.9% |
| Mobile home | 4.9% | 4.3% |
| Education: | | |
| Did not complete high school | 0.7% | 1.6% |
| High school diploma or GED equivalent | 16.7% | 17.4% |
| Some college, technical school, or associates degree | 35.4% | 39.1% |
| Bachelor's degree | 27.8% | 25.0% |
| Master's degree | 12.5% | 15.8% |
| Professional degree or doctorate | 6.3% | 1.1% |
| Employment status: | | |
| Full time | 56.9% | 49.5% |
| Part time | 6.9% | 10.3% |
| Retired | 28.5% | 32.1% |
| Homemaker | 10.4% | 6.5% |
| Other[b] | 4.2% | 8.1% |
| Race | | |
| White | 86.8% | 88.6% |
| Black or African American | 9.0% | 4.3% |
| Other[c] | 4.2% | 6.5% |
| Ethnicity | | |
| Not of Hispanic, Latino, or Spanish origin | 88.9% | 92.9% |
| Of Hispanic, Latino, or Spanish origin | 3.5% | 4.3% |
| Income | | |
| Less than 15,000 | 2.8% | 3.3% |
| 15,000–24,999 | 6.9% | 6.5% |
| 25,000–34,999 | 8.3% | 10.3% |
| 35,000–49,999 | 12.5% | 19.6% |
| 50,000–74,999 | 17.4% | 19.0% |
| 75,000–99,999 | 16.0% | 13.6% |
| 100,000–149,999 | 16.7% | 10.9% |
| 150,000–199,999 | 5.6% | 3.8% |
| 200,000 or more | 6.3% | 6.0% |

[a] Excluding missing data
[b] In Armed Forces, Student, or Unemployed
[c] American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, or Other

APPENDIX F: SCALE COMMUNALITIES AND ITEM-SCALE CORRELATIONS

## Most Memorable Experiences

Table 21. *Most memorable experience item communalities and corrected item-scale correlations*

| | Survey 1 | | Survey 2 | |
|---|---|---|---|---|
| | Communality | Corrected item-scale correlation | Communality | Corrected item-scale correlation |
| I paid attention to the weather forecasts and warnings because I knew about the threat… | 0.75 | 0.45 | 0.64 | 0.41 |
| I was concerned about the threat… | 0.73 | 0.45 | 0.71 | 0.49 |
| People I know talked to me about the threat… | 0.64 | 0.43 | 0.62 | 0.38 |
| People I know were concerned about the threat… | 0.77 | 0.42 | 0.72 | 0.38 |
| There was news coverage about the threat… | 0.78 | 0.39 | 0.56 | 0.37 |
| I tried to take action to protect myself or my loved ones *(or vice versa)* | 0.50 | 0.46 | 0.55 | 0.63 |
| I tried to get to my loved ones to be with them *(or vice versa)* | 0.53 | 0.39 | 0.45 | 0.58 |
| I feared for my loved ones | 0.41 | 0.48 | 0.43 | 0.60 |
| I worried about my home | 0.53 | 0.62 | 0.42 | 0.53 |
| I saw scenes of the storm firsthand | 0.38 | 0.44 | 0.52 | 0.50 |
| I heard sounds of the storm firsthand | 0.53 | 0.51 | 0.65 | 0.54 |
| I felt sensations of the storm firsthand | n/a | n/a | 0.60 | 0.55 |
| I was shaken up | 0.53 | 0.40 | 0.53 | 0.56 |
| I had trouble staying asleep and/or had dreams about it | 0.41 | 0.30 | 0.50 | 0.42 |
| I had waves of strong feelings about it | 0.66 | 0.46 | 0.58 | 0.46 |
| I thought about it when I didn't mean to | 0.79 | 0.37 | 0.81 | 0.49 |
| Pictures about it popped into my mind | 0.60 | 0.43 | 0.68 | 0.49 |
| My life was disrupted afterward | 0.53 | 0.43 | 0.52 | 0.46 |
| People I know had damage to their property | 0.66 | 0.51 | 0.75 | 0.62 |
| People I know lost irreplaceable items | 0.46 | 0.36 | 0.60 | 0.44 |
| The lives of people I know were disrupted afterward | 0.86 | 0.46 | 0.83 | 0.54 |
| People talked to me about what they experienced | 0.56 | 0.50 | 0.46 | 0.62 |
| I saw scenes of the aftermath firsthand | 0.39 | 0.45 | 0.53 | 0.57 |
| People I know were shaken up | | | 0.59 | 0.60 |
| I was shocked by the devastation and loss | | | 0.45 | 0.49 |
| The sky looked unusual that day | 0.60 | 0.43 | n/a | n/a |
| The air felt unusual that day | 0.87 | 0.33 | n/a | n/a |
| Animals acted unusually or were unusually absent that day | 0.23 | 0.21 | n/a | n/a |

## Multiple Experiences

Table 22. *Multiple experience item communalities and corrected item-scale correlations*

| | Survey 1 | | Survey 2 | |
|---|---|---|---|---|
| | Communality | Corrected item-scale correlation | Communality | Corrected item-scale correlation |
| I have been under a tornado warning | 0.74 | 0.67 | 0.74 | 0.69 |
| I have heard tornado sirens (not as a test) firsthand | 0.63 | 0.62 | 0.55 | 0.54 |
| I have heard or watched live news coverage on radio TV or online of a tornado as it was happening | 0.48 | 0.61 | 0.50 | 0.59 |
| I have seen news coverage about the aftermath of a tornado | 0.59 | 0.67 | 0.42 | 0.51 |
| I have feared for my life due to a tornado | 0.68 | 0.68 | 0.75 | 0.66 |
| I have feared for my loved ones due to a tornado | 0.86 | 0.72 | 0.81 | 0.70 |
| I have worried about my home due to a tornado | 0.57 | 0.67 | 0.68 | 0.72 |

## Tornado Risk Perceptions

Table 23. *Risk perception item communalities and corrected item-scale correlations*

| | Communality | Corrected item-scale correlation |
|---|---|---|
| Thinking about the possibility of a tornado makes me feel … dread. | 0.72 | 0.54 |
| … fearful. | 0.94 | 0.56 |
| … worried. | 0.69 | 0.49 |
| … courageous. *(reversed)* | 0.44 | 0.25 |
| … exhilarated. *(reversed)* | 0.88 | 0.27 |
| … alive. *(reversed)* | 0.82 | 0.26 |
| I think that tornadoes may cause catastrophic destruction | 0.41 | 0.11 |
| I think that tornadoes may cause widespread death | 0.80 | 0.27 |
| I think that tornadoes pose great financial threat | 0.26 | 0.20 |
| I am knowledgeable about tornadoes *(reversed)* | 0.35 | 0.09 |
| I think tornadoes are hard to prepare for | 0.27 | 0.37 |
| I think it is difficult to understand tornado forecast information | 0.69 | 0.26 |

## APPENDIX G: SUPPLEMENTARY HIERARCHICAL REGRESSIONS

Table 24. *Hierarchical regression of affective risk perception with personal intrusive impacts entered separately*

| Independent variable[a] | *Affective Risk Perception – Model 1* | | | | | | *Affective Risk Perception – Model 2* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ |
| *(memorable) Risk awareness* | 0.06 | 0.06 | 0.07 | 0.94 | 0.35 | 0.01 | 0.09 | 0.06 | 0.11 | 1.43 | 0.15 | 0.01 |
| *(memorable) Risk personalization* | -0.05 | 0.06 | -0.08 | -0.91 | 0.36 | 0.01 | -0.08 | 0.05 | -0.13 | -1.46 | 0.15 | 0.01 |
| *(memorable) Vicarious troubling impacts* | 0.09 | 0.05 | 0.14 | 1.72 | 0.09 | 0.02 | 0.02 | 0.05 | 0.03 | 0.39 | 0.70 | 0.00 |
| *(multiple) Common personal threat and impact experiences* | -0.20 | 0.14 | -0.12 | -1.40 | 0.16 | 0.01 | -0.16 | 0.14 | -0.09 | -1.13 | 0.26 | 0.01 |
| *(multiple) Negative emotional responses* | 0.32 | 0.14 | 0.21 | 2.25 | 0.03 | 0.03 | 0.21 | 0.14 | 0.14 | 1.45 | 0.15 | 0.01 |
| *(memorable) Personal intrusive impacts* | | | | | | | 0.27 | 0.08 | 0.29 | 3.30 | 0.00 | 0.06 |
| $\Delta R^2$ | n/a | | | | | | 0.05 | | | | | |
| $\Delta F$; for all models, F(1,169) | n/a | | | | | | $10.9^{***}$ | | | | | |
| Final model F | n/a | | | | | | $4.4^{***}$ | | | | | |
| Final model adj $R^2$ | n/a | | | | | | 0.21 | | | | | |

[a] Covariates (demographic characteristics, dispositional optimism, locus of control) are controlled for but not shown

Table 25. *Hierarchical regression of omnibus risk perception with personal intrusive impacts entered separately*

| Independent variable | *Omnibus Risk Perception – Model 1* | | | | | | *Omnibus Risk Perception – Model 2* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ |
| *(memorable) Risk awareness* | 0.13 | 0.09 | 0.12 | 1.47 | 0.14 | 0.01 | 0.17 | 0.08 | 0.15 | 2.01 | 0.05 | 0.02 |
| *(memorable) Risk personalization* | -0.14 | 0.08 | -0.17 | -1.92 | 0.06 | 0.02 | -0.19 | 0.07 | -0.22 | -2.52 | 0.01 | 0.04 |
| *(memorable) Vicarious troubling impacts* | 0.18 | 0.07 | 0.21 | 2.58 | 0.01 | 0.04 | 0.08 | 0.07 | 0.10 | 1.14 | 0.26 | 0.01 |
| *(multiple) Common personal threat and impact experiences* | -0.39 | 0.19 | -0.17 | -2.00 | 0.05 | 0.02 | -0.32 | 0.19 | -0.15 | -1.73 | 0.09 | 0.02 |
| *(multiple) Negative emotional responses* | 0.37 | 0.19 | 0.18 | 1.93 | 0.06 | 0.02 | 0.21 | 0.19 | 0.10 | 1.09 | 0.28 | 0.01 |
| *(memorable) Personal intrusive impacts* | | | | | | | 0.39 | 0.11 | 0.30 | 3.50 | 0.00 | 0.07 |
| $\Delta R^2$ | n/a | | | | | | 0.05 | | | | | |
| $\Delta F$; for all models, F(1,169) | n/a | | | | | | $12.2^{***}$ | | | | | |
| Final model F | n/a | | | | | | $4.2^{***}$ | | | | | |
| Final model adj $R^2$ | n/a | | | | | | 0.20 | | | | | |

[a] Covariates (demographic characteristics, dispositional optimism, locus of control) are controlled for but not shown

Table 26. *Hierarchical regression of cognitive risk perception with risk awareness and risk personalization entered separately*

| Independent variable[a] | *Cognitive Risk Perception – Model 1a* | | | | | | *Cognitive Risk Perception – Model 1b* | | | | | | *Cognitive Risk Perception – Model 2* | | | | | | *Cognitive Risk Perception – Model 3* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ |
| *(memorable) Risk awareness* | .02 | .04 | .03 | .35 | .73 | .00 | | | | | | | .05 | .05 | .09 | 1.09 | .28 | .00 | .08 | .05 | .14 | 1.66 | .10 | .02 |
| *(memorable) Risk personalization* | | | | | | | -.05 | .03 | -.12 | -1.56 | .12 | .01 | -.07 | .04 | -.16 | -1.87 | .06 | .02 | -.11 | .04 | -.24 | -2.51 | .01 | .04 |
| *(memorable) Personal intrusive impacts* | | | | | | | | | | | | | | | | | | | .12 | .06 | .17 | 1.85 | .07 | .02 |
| *(memorable) Vicarious troubling impacts* | | | | | | | | | | | | | | | | | | | .06 | .04 | .14 | 1.48 | .14 | .01 |
| *(multiple) Common personal threat and impact experiences* | | | | | | | | | | | | | | | | | | | -.17 | .11 | -.14 | -1.56 | .12 | .01 |
| *(multiple) Negative emotional responses* | | | | | | | | | | | | | | | | | | | .00 | .11 | .00 | 0.03 | .98 | .00 |
| $\Delta R^2$ | n/a | | | | | | n/a | | | | | | Model 1a: 0.02<br>Model 1b: 0.01 | | | | | | 0.06 | | | | | |
| $\Delta F$ | n/a | | | | | | n/a | | | | | | Model 1a: $3.5^{*}_{(1, 173)}$<br>Model 1b: $1.2_{(1, 173)}$ | | | | | | $2.8^{**}_{(4, 169)}$ | | | | | |
| Final model F | n/a | | | | | | n/a | | | | | | n/a | | | | | | 2.0** | | | | | |
| Final model adj $R^2$ | n/a | | | | | | n/a | | | | | | n/a | | | | | | 0.07 | | | | | |

[a] Covariates (demographic characteristics, dispositional optimism, locus of control) are controlled for but not shown

Table 27. *Hierarchical regression of omnibus risk perception with risk awareness and risk personalization entered separately*

| Independent variable[a] | *Omnibus Risk Perception – Model 1a* | | | | | | *Omnibus Risk Perception – Model 1b* | | | | | | *Omnibus Risk Perception – Model 2* | | | | | | *Omnibus Risk Perception – Model 3* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ | B | Std err | β | t | p | $\eta_p^2$ |
| *(memorable) Risk awareness* | .08 | .08 | .08 | 1.04 | .30 | .01 | -.01 | .06 | -.01 | -.19 | .85 | .00 | .11 | .09 | .10 | 1.23 | .22 | .01 | .17 | .08 | .15 | 2.01 | .05 | .02 |
| *(memorable) Risk personalization* | | | | | | | | | | | | | -.05 | .07 | -.05 | -0.68 | .50 | .00 | -.19 | .07 | -.22 | -2.52 | .01 | .04 |
| *(memorable) Personal intrusive impacts* | | | | | | | | | | | | | | | | | | | .39 | .11 | .30 | 3.50 | .00 | .07 |
| *(memorable) Vicarious troubling impacts* | | | | | | | | | | | | | | | | | | | .08 | .07 | .10 | 1.14 | .26 | .01 |
| *(multiple) Common personal threat and impact experiences* | | | | | | | | | | | | | | | | | | | -.32 | .19 | -.15 | -1.73 | .09 | .02 |
| *(multiple) Negative emotional responses* | | | | | | | | | | | | | | | | | | | .21 | .19 | .10 | 1.09 | .28 | .01 |
| $\Delta R^2$ | n/a | | | | | | n/a | | | | | | Model 1a: 0.00<br>Model 1b: 0.01 | | | | | | 0.12 | | | | | |
| $\Delta F$ | n/a | | | | | | n/a | | | | | | Model 1a: $0.5_{(1, 173)}$<br>Model 1b: $1.5_{(1, 173)}$ | | | | | | $6.8^{***}_{(4, 169)}$ | | | | | |
| Final model F | n/a | | | | | | n/a | | | | | | n/a | | | | | | 4.2** | | | | | |
| Final model adj $R^2$ | n/a | | | | | | n/a | | | | | | n/a | | | | | | 0.20 | | | | | |

[a] Covariates (demographic characteristics, dispositional optimism, locus of control) are controlled for but not shown