Personality and Social Psychology Bulletin
39(5) 691–702

DOI: 10.1177/0146167213477457
pspb.sagepub.com

Optimism Following a Tornado Disaster

Jerry Suls[1], Jason P. Rose[2], Paul D. Windschitl[1], and Andrew R. Smith[3]

Abstract

Effects of exposure to a severe weather disaster on perceived future vulnerability were assessed in college students, local residents contacted through random-digit dialing, and community residents of affected versus unaffected neighborhoods. Students and community residents reported being less vulnerable than their peers at 1 month, 6 months, and 1 year after the disaster. In Studies 1 and 2, absolute risk estimates were more optimistic with time, whereas comparative vulnerability was stable. Residents of affected neighborhoods (Study 3), surprisingly, reported less comparative vulnerability and lower "gut-level" numerical likelihood estimates at 6 months, but later their estimates resembled the unaffected residents. Likelihood estimates (10%-12%), however, exceeded the 1% risk calculated by storm experts, and gut-level versus statistical-level estimates were more optimistic. Although people believed they had approximately a 1-in-10 chance of injury from future tornadoes (i.e., an overestimate), they thought their risk was lower than peers.

Keywords

risk perception, unrealistic optimism, natural disaster, absolute and comparative risk, social comparison

Received March 25, 2012; revision accepted December 26, 2012

> Hannah Miller knew the Mulders (both killed by a F-5 tornado), who lived a few doors east of her now-destroyed home . . . Miller lives alone, but her son and daughter-in-law were visiting when the warning went out . . . He said, "Time to go in the basement." Miller said, "I never go in the basement. He had a hard time getting me to."
>
> —Excerpt from an interview taken just days after an F-5 tornado struck and destroyed the town of Parkersburg, Iowa (*Gazette*, Wednesday, May 28, 2008, p. 1A)

Unrealistic comparative optimism refers to the common tendency for people to think they are less at risk of threats, such as illness, injury, or disaster, than are their peers (Dunning, Heath, & Suls, 2004; Weinstein, 1980; Weinstein & Klein, 1995). This belief is considered "unrealistic" because everyone cannot be less vulnerable. There is evidence that cognitive and motivational mechanisms are sources of the bias (Chambers & Windschitl, 2004; Guenther & Alicke, 2010; Taylor & Brown, 1988). This article considers whether optimism persists even after a disaster happens close-by. Was Hannah Miller, who seemed unaffected by the deaths of her neighbors in an earlier tornado, an oddity? A second question is whether temporal or physical proximity to a natural disaster influences the trajectory of vulnerability beliefs. Three naturalistic field studies followed residents of a small Midwestern city, which had a tornado of F-2 force touchdown one evening causing significant injuries, displacement of residents, and millions of dollars in damage.

Prior Studies

Despite the attention paid to the psychology of stress and trauma (e.g., Lazarus & Folkman, 1984; Seary, Holman, & Silver, 2010) and to unrealistic optimism (e.g., Weinstein, 1980), little is known about the trajectory of comparative vulnerability beliefs following a natural disaster. We found only five previous naturalistic studies. First, after the Chernobyl nuclear reaction accident, Dolinski, Gromski, and Zawisza (1987) surveyed a sample of Polish high school students who had not experienced consequences of the disaster. These students reported feeling more vulnerable than other classmates to radiation-induced illness in the following year.

[1]University of Iowa, Iowa City, USA
[2]University of Toledo, OH, USA
[3]Appalachian State University, Boone, NC, USA

Corresponding Author:
Jerry Suls, Department of Psychology, University of Iowa, E11 Seashore Hall, Iowa City, IA 52242, USA.
Email: jerry-suls@uiowa.edu

Second, Burger and Palmer (1992) surveyed college students, who resided near the Loma Prieta earthquake but had not been directly affected. Shortly after the disaster, the students were not optimistic about avoiding harm from earthquakes in the future; in fact, they felt more vulnerable than their peers. After 3 months, however, they reported feeling less vulnerable to an earthquake than their peers. Burger and Palmer concluded, "out of sight out of mind effect makes living in earthquake country easier" (p. 43).

Third, Helweg-Larsen (1999) collected ratings of comparative invulnerability from a sample of students attending the University of California, Los Angeles (UCLA) after the Northridge, California, earthquake (near Los Angeles). Responses were collected 1 week after the disaster and then periodically for up to 16 months later. In contrast to Burger and Palmer, Helweg-Larsen found no evidence of unrealistic optimism—her participants rated their level of risk as comparable with other undergraduates 1 week post-earthquake and over the next 16 months. Helweg-Larsen also inquired about the participants' experience of personal injury or damage caused by the Northridge earthquake or of anyone with whom they were well-acquainted. Both direct and indirect experiences were modestly associated with lower optimism, suggesting that physical proximity and experiences with the event tempered optimism about future invulnerability. These associations did not vary, however, as a function of time since the earthquake. People did *not* return to optimism; they were not optimistic at the start of the study.

Fourth, research conducted by Weinstein, Lyon, Rothman, and Cuite (2000a, 2000b) is most relevant because they studied responses to tornado disasters. They inquired about perceived vulnerability to harm from a future tornado for residents of three communities struck by tornadoes and three matched, control communities. An inclusion criterion was that respondents in the three affected communities had not incurred any damage or injury in the tornado. Participants were interviewed about 2 to 4 weeks after the disaster. Although the residents of affected towns were less optimistic than the controls, they still reported their personal risk was lower than other peoples'. Fourteen months later, the researchers interviewed the residents of the three affected communities again. Although comparative risk at follow-up was not reported (Weinstein et al., 2000b), Helweg-Larsen (1999) cites a personal communication from Weinstein (November 26, 1996) indicating there was no change 14 months later. In sum, residents' optimism was affected by their physical proximity to the disaster—residents of affected towns were less optimistic than residents of unaffected towns. However, the passage of time since the tornado had no effect, as the residents at both time points felt they were less likely to be harmed by a future earthquake than their peers.

Fifth, one other study is indirectly relevant. Li et al. (2010) conducted a door-to-door survey with residents living in an area of China that experienced an earthquake 1 to 1.5 months earlier and with residents of a nondisaster area (control community). Participants were asked to estimate their comparative risk with respect to catching a serious infectious disease (another negative event). Those in the devastated area were less optimistic than participants in the nondisaster area. However, those living in the disaster area still judged their risk to be lower than 70% of their peers. A second study collected surveys from two new samples of disaster area residents at 4 and 11 months post-earthquake and compared them with the ratings of the Study 1 participants who had been surveyed 4 to 6 weeks after the earthquake. The sample tested 11 months later was more optimistic that they would not become ill than those surveyed at 4 to 6 weeks or 4 months. As in Burger and Palmer (1992), optimism rebounded although it should be kept in mind that optimism was assessed about future illness and not an earthquake. With that caveat, even those living in the disaster area perceived their risk to be lower than that of peers, as had Weinstein et al.'s (2000a) participants.

To summarize, there is empirical inconsistency about the trajectory of comparative optimism and the effects of physical and temporal proximity to a disaster. The Polish students, who did not have direct physical experience with the nuclear event, felt vulnerable for a year after Chernobyl (perhaps for fear of delayed effects of the explosion). Students residing near the Loma Linda earthquake, who also had no direct physical experience with the earthquake, only felt vulnerable for a few months. Residents of three Midwestern towns damaged by tornadoes were less optimistic than residents of control communities but still thought they were at less comparative risk (vs. peers) and this belief persisted for more than a year. Students near the Prieta quake were less optimistic immediately afterward and remained so for more than 16 months. The difference in results reported by Helweg-Larsen (1999) and Burger and Palmer (1992), who studied responses to earthquakes, is striking. Helweg-Larsen suggested the difference could be attributed to the ambiguity of Burger and Palmer's risk questions, which referred to harm from a "future disaster," and not specifically about earthquakes. She argued that soon after the Loma Prieta, the students probably were still focused on the earthquake so their optimism was tempered in answering about comparative risk; months later, the earthquake was probably less salient so they may have focused on other disasters, such as storms or flood—leading to more optimism. Helweg-Larsen's (1999) study was not vulnerable to this criticism because she restricted her surveys to risk of harm from a future earthquake. Li et al. (2010) found some indirect evidence that optimism increased with time, but even a few weeks after an earthquake, residents were optimistic about their own chances. The differences among the studies may be, in part, a consequence of the different ways in which vulnerability has been measured. A discussion of these measures and their conceptual implications follows.

Measurement of Vulnerability

Direct and Indirect Comparison Measures

How researchers assess personal beliefs about invulnerability may be important for drawing conclusions. Dolinski et al. (1987) and Burger and Palmer's (1992) respondents made separate risk estimates for self and peers. (The absolute rating for peers was subtracted from the absolute rating for self to obtain an indirect comparative index; hence, a negative score represented comparative optimism, a positive score represented comparative pessimism.) Helweg-Larsen (1999) and Li et al. (2010) had participants make a direct comparison (i.e., "less than others" to "greater than others"). Weinstein et al. (2000a) requested participants to make a direct comparative rating and absolute ratings ("almost zero" to "very high") for personal risk and other risk. Direct and indirect comparisons are sometimes treated as equivalent, but this may not be the case because they engage different judgment processes (Chambers & Windschitl, 2004; Helweg-Larsen & Shepperd, 2001; Klein & Zajac, 2009; Ranby, Aiken, Gerend, & Erchull, 2010; Rose, Suls, & Windschitl, 2011). Some researchers (Otten & Van der Pligt, 1996) consider the indirect comparison index to be a more accurate representation of people's true beliefs because concerns about self-presentation should be less salient. Reporting that one is at less risk than others on a direct measure may appear self-aggrandizing; making separate judgments for self and others allows respondents to feel more comfortable about giving themselves favorable status. This is consistent with a trend for indirect comparison measures to show more consistent evidence for unrealistic optimism (i.e., the self is less at risk) than direct comparison (Chambers, Windschitl, & Suls, 2003; Kruger & Burrus, 2004; Rose, Endo, Windschitl, & Suls, 2008; for reviews, see Chambers & Windschitl, 2004; Helweg-Larsen & Shepperd, 2001). However, the use of direct versus indirect measures cannot fully account for differences in unrealistic optimism described in the preceding studies. Burger and Palmer found a return to optimism with an indirect measure; Weinstein et al. did not find a rebound (but, keep in mind, even the residents of the affected communities leaned toward optimism).

Response Scales and Numerical Likelihood. Perceived vulnerability has been operationalized in several ways, which may tap into different ways people think about their risk. Traditionally, optimism has been measured with verbal rating scales, but vulnerability also may be assessed with numeric scales (i.e., 0%-100% likely) that avoid the ambiguity and subjective meaning associated with verbal labels and are not comparative. Another option is that people can be instructed to respond to numeric scales in terms of statistical probability *or* "gut/hunch" estimates (Windschitl & Wells, 1996). The former instructions prompt respondents to make judgments from a "statistical or scientific" perspective, which may engage deliberative, rule-based thinking. In contrast, instructions to rely on "gut feelings," tend to engage associationistic, intuitive-based thinking (Sloman, 1996). Responding to verbal (vs. numerical) scales also is more likely to tap into intuitive thinking (Windschitl & Wells, 1996). In those cases, when people believe their predictions are somewhat arbitrary, they guess optimistically, that is, in a way that suggests things will turn out all right. This is most likely when they judge based on their "gut feelings" (Windschitl, Smith, Rose, & Krizan, 2010).

Current Research

The preceding review suggests that the trajectory of perceived invulnerability may differ depending on whether beliefs are assessed with verbal versus numeric scales and whether absolute versus comparative vulnerability is the focus. Responses to verbal and intuitive/gut measures may encourage optimistic thinking because they are more susceptible to subjective appraisal, whereas statistical measures might facilitate a more evenhanded perspective. Moreover, as time passes and experience with the prior disaster is less salient, verbal and "gut-level" judgments about future risk may encourage a return to or maintenance of an optimistic outlook; statistical-level measures may force the individual to make estimates more grounded in reality. Based on prior evidence, it is also predicted that optimism should be more likely found on indirect than on direct comparative ratings of vulnerability. Whether verbal direct comparative, absolute, and indirect comparative vulnerability differ in their temporal trajectories since the disaster was an empirical question.

The current research had two primary aims: (a) to study how different operationalizations of vulnerability may be associated with different trends as the time since the tornado passed and (b) to systematically examine the roles of physical and temporal proximity to a tornado disaster on judgments of future vulnerability. Several different measures of perceived vulnerability were collected. In Study 1, student participants estimated their perceived vulnerability at 1 and 6 months post-tornado disaster. The main variables were verbal scales about comparative and absolute vulnerability. Study 2 represented a replication and extension with community residents, who were recruited via random-digit dialing at 6 and 12 months post-tornado. Besides verbal scales, similar to those used in Study 1, numerical likelihood estimates were added to the Study 2 protocol. Study 3 involved door-to-door recruitment of community residents, who lived in affected versus unaffected areas of the city—surveyed at 6 and 12 months post-tornado. As in Study 2, the neighborhood surveys included verbal scales concerning comparative and absolute vulnerability, as well as numerical likelihood estimates.

Study 1

Overview

In April 2006, a F-2 tornado with winds speeds of 150 mph left a path of destruction 4.5 miles long and one third of a mile wide in the downtown area of a small city and home of a state university with a population of approximately 65,000 permanent residents and 26,000 students. There were extensive injuries and damage, with estimates of damage of US$10 million to businesses, tens of millions to private residences and to the university (The Gazette Staff, 2006). One month later, undergraduates leaving two large classes at the end of lecture were recruited to complete surveys about their experiences with the tornado and beliefs about future tornado risk. Six months later, those who had agreed to be recontacted completed a follow-up survey.

Method

Participants. Students in one psychology and one nursing class at a large Midwestern university were recruited while leaving their classrooms. All participants were asked to fill out a paper-and-pencil survey concerning their reactions and experiences following the recent tornadoes. Time 1 responses ($N = 269$) were collected approximately 1 month post-tornado. Of the original 269 participants, 48% ($n = 129$) expressed interest in being recontacted for a follow-up survey and provided an email address. Six months after the initial survey (or 7 months post-tornado), they were contacted for a second (online) survey. Fifty-three percent ($n = 68$) completed the follow-up, which was the sample used in all of the main analyses.

Dependent Measures

Vulnerability beliefs. The survey at Times 1 and 2 requested three vulnerability estimates about harm from a future tornado. The direct index of comparative optimism inquired about how likely the participant would be injured in a tornado before age 50 compared with the average student (−3 = *much less likely than the average student*, +3 = *much more likely than the average student*). There were also 2 items inquiring about absolute likelihood—an estimate for the self and an estimate for the average university student about the likelihood of being injured by a tornado before the age of 50 (1 = *extremely unlikely*, 7 = *extremely likely*). The absolute peer rating was subtracted from the absolute self-rating to obtain an indirect comparative risk index (with negative scores indicating self at less risk and positive scores indicating self at greater risk).

Tornado experiences. The Time 1 survey also inquired about experiences associated with the recent tornado that might affect beliefs in vulnerability. First, participants indicated the extent of personal damage caused by the tornado (0 = *none*, 4 = *complete damage*; for example, to roof, windows, possessions, carpeting, automobile), which were aggregated into an overall "damage index" ($\alpha = .72$; $M = .34$, $SD = 0.60$). Second, participants were asked about injuries that resulted from the tornado (i.e., personal, family/friend, saw someone injured, acquainted with someone who was injured), which were dummy-coded into two categories: *had experience with self- or other injury* (1) or *not* (0). Twenty-four percent of the final sample ($n = 16$) had or knew someone who was injured in the tornado. Third, participants indicated their physical proximity to the tornado when it touched down in terms of blocks or miles. These responses were later transformed into miles or fractions of a mile (e.g., 8 blocks equal 1 mile; $M = 2.28$, $SD = 6.05$). Fourth, participants rated their fears about dying during the tornado (1 = *not at all*, 7 = *absolutely;* $M = 2.10$, $SD = 1.59$) as an additional indicator of their physical proximity to the tornado.

Results and Discussion

Attrition Analyses. Attrition analyses were conducted to assess whether the Time 2 sample ($n = 68$) differed from the larger sample that responded only at Time 1. Those who provided T1 data were comparable in age ($M = 20.63$, $SD = 3.70$) to participants who provided T1 and T2 data ($M = 20.85$, $SD = 2.66$), $t(262) = -.44$, $p > .60$. The proportion of females also was comparable in both samples (71% vs. 74%), $\chi^2(1, n = 269) = .14$, $p > .10$. The final sample consisted of 50 female and 18 male students. The vast majority of participants were Caucasian (59); 3 others identified themselves as Asian, 2 as Hispanic, and 4 did not provide information about ethnicity. Responses to the vulnerability estimates at Time 1 were compared between those who only completed the Time 1 measures and those who also completed the follow-up. No significant differences were found (all ts < 1; ps > .10). In sum, the participants who only completed the initial survey did not differ from those participants completing both T1 and T2 surveys, in terms of demographics or responses to the main dependent measures. The results reported below pertain only to those who responded to the Times 1 and 2 surveys.

Vulnerability Perceptions and Changes Over Time

Direct comparative ratings. A major question was whether vulnerability perceptions shifted with time since the tornado (1-7 months) and whether the magnitude of mean-level change varied across different types of vulnerability measures. In terms of direct comparative risk, at Time 1 ($M = -.32$, $SD = .87$) and Time 2 ($M = -.19$, $SD = 1.20$), participants were generally comparatively optimistic about invulnerability to future tornado injuries, as indicated by one-sample t tests comparing the mean values to the midpoint of the scale ("0"), $t(67) = -3.06$, $p < .01$ and $t(67) = -1.89$, $p = .06$. Although comparative optimism was somewhat reduced at Time 2, the difference was not statistically significant, $F(1, 67) = 1.43$, $p > .20$ (see Table 1).

Table 1. Mean-Level Shifts and Rank-Order Stability of Vulnerability Perceptions for Future Tornado Injury Across Time in Study 1 (n = 68).

Variable	Time 1		Time 2		Correlation (Times 1 and 2)
	M	*SD*	*M*	*SD*	
Direct comparative	−0.32***	0.87	−0.19*	1.20	.43***
Absolute self	1.71	1.25	1.41	1.28	.43**
Absolute other	2.04	1.19	1.91	1.32	.28**
Indirect comparative	−0.36**	1.20	−0.49***	0.84	.20

Note: Direct comparative estimates were made on 7-point scales (−3 = *much less likely than the average student*, +3 = *much more likely than the average student*). Absolute estimates were made on 7-point scales (1 = *extremely unlikely*, 7 = *extremely likely*). Means in the "indirect comparison" row were computed by subtracting absolute other estimates from absolute self-estimates. Values in the direct and indirect comparison rows that significantly differ from "0" are marked with asterisks (*p < .10. **p < .05. ***p < .01).

Absolute self and other ratings. For estimates of absolute personal vulnerability about future tornado injury, the mean was 1.71 (SD = 1.25) at Time 1 and 1.41 (SD = 1.28) at Time 2, suggesting participants tended to report higher absolute risks immediately after the tornado, $F(1, 67) = 3.22$, $p = .08$. However, because the response scale ranged from 1 = *extremely unlikely* to 7 = *extremely likely*, absolute vulnerability for the self was very low 1 to 6 months following the tornado. The estimates for the average student were somewhat higher: Time 1 M = 2.04 (SD = 1.2) and Time 2 M = 1.91 (SD = 1.32), which did not differ, $F(1, 66) = .53$, $p > .47$. Comparison of the absolute estimates for the self versus the average student (i.e., indirect comparative index) indicated that respondents believed they were less likely to be injured in a future tornado than the average student at Time 1 (M = −.36, SD = 1.20), $t(66) = -2.44$, $p < .02$, and Time 2 (M = −.49, SD = .84), $t(67) = -4.78$, $p < .01$; these values did not differ, $F(1, 66) = .69$, $p > .41$. In summary, 1 month after the disaster, participants were quite optimistic that they would not suffer injury in a future tornado and they remained optimistic 6 months post-tornado.

Rank-order stability. An alternative measure of belief vulnerability change, using correlational analyses, was computed as an index of whether the relative rankings of perceived vulnerability were consistent across time (Shepperd, Helweg-Larsen, & Ortega, 2003; Watson, 2004).[1] Shepperd et al. (2003) found considerable consistency for comparative vulnerability across a range of events.

Rank-order stability was moderate across direct comparative estimates for tornado injury (see Table 1), but somewhat lower for absolute other risk estimates and the indirect comparative index. The greater instability of absolute other and indirect measures may stem from the difficulties in making judgments about the "average" person, for whom one has less information (Moore, 2007; Rose, 2010; Windschitl, Rose, Stalkfleet, & Smith, 2008).

Experience With the Tornado and Vulnerability Estimates. Experience with injury (self or acquaintance) was positively correlated with estimated vulnerability of others at Times 1 (r = .25) and 2 (r = .23; see Table 2). Damage from the tornado was unrelated to vulnerability estimates. Closer proximity to the tornado was negatively related to unrealistic comparative optimism at Time 2: One was less optimistic the closer one had been to the places where the tornado touched down (−.30, $p < .05$). The trend was similar at Time 1 but nonsignificant. Other people were judged to be more vulnerable the closer the participant had been to the tornado's touchdown ($r = .26$, $p < .05$), but only at Time 1. The closer to the disaster at Time 1, the more vulnerable participants felt on the indirect comparative index ($r = -.25$, $p < .05$). Fear of dying at Time 1 was most consistently related to higher vulnerability across all indicators, but only the direct comparative and absolute self-ratings were statistically significant by conventional standards, rs = .25 and .29, ps < .05. Regression analyses were also conducted using Time 1 variables to predict Time 2 variables, but these results were uniformly weak and nonsignificant.

Study 2

College students were comparatively optimistic about future injury from tornados, but perhaps they anticipated relocating after graduation to another area of the country where tornadoes are rare. In Study 2, relatively permanent residents of the small Midwestern city, where the tornado touched down and of an adjoining community, were contacted via random-digit dialing and asked to answer a short survey regarding the recent tornadoes. The questions were virtually identical to those used in Study 1, with the exception of adding numeric vulnerability measures (on 0%-100% scales) with instructions to make gut-level and statistical-level probability estimates. The inclusion of direct comparative, absolute verbal, and absolute numeric scales was expected to produce a more complete picture of whether changes in optimism differ depending on the type of risk judgment.

Method

Recruiting and Participants. A call center affiliated with a state university recruited community residents of the small city and an adjoining community. Six months after the tornadoes, a commercially available random-digit dialing list of residents was used by nine different professional interviewers who made a total of 2,183 calls. Each number was attempted at least 10 times if it was a working number. Of these, 756 were nonworking numbers, for 640 calls no one could be reached, 320 of those who answered declined to be interviewed, 129 were businesses and therefore not relevant, 65 people answered who were ineligible (i.e., minors), and 21 did not speak or understand English.

Table 2. Zero-Order Correlations Between Tornado Experiences and Vulnerability Perceptions in Study 1.

	Injuries		Damage		Proximity		Fears of dying	
Variable	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Direct	−.01	−.04	−.17	−.00	−.19	−.30**	.29**	.13
Absolute self	.16	.15	.12	.06	.01	−.03	.25**	.19
Absolute other	.25**	.23*	−.04	.12	.26**	.05	.22*	−.05
Indirect	−.07	−.14	.17	−.11	−.25**	−.13	.24*	.12

Note: For the analyses involving "*injuries*" to self or others (0 = *no*, 1 = *yes*), the "*damage*" index (0 = *none*, 4 = *complete damage*), and "*fears of dying*" (1 = *not at all*, 7 = *absolutely*), positive correlations indicate that more tornado-related experiences were associated with greater perceived vulnerability. For "*proximity*" to the path of the tornado (in blocks), high *negative* correlations indicate that participants closer to the tornado reported more vulnerability.
*$p < .10$. **$p < .05$.

A total of 252 community residents completed Time 1 interviews about "Perceptions of negative life events." All respondents were recontacted 1 year after the tornado. Eighty-five percent (n = 213) of the original participants completed the Time 2 interview.

Dependent Measures

Vulnerability perceptions. Participants answered five different vulnerability questions at Times 1 and 2. Respondents were asked a direct comparative question: How likely he/she was to be injured by a tornado in the next 10 years, compared with the average Iowan (−2 = *much less likely than the average Iowan* to +2 = *much more likely than the average Iowan*). Respondents were asked two separate questions to assess absolute verbal estimates: How likely he/she and the average Iowan were to be injured by a tornado in the next 10 years (1 = *extremely unlikely*, 5 = *extremely likely*). Finally, these were followed by 2 items requesting absolute estimates made on numeric scales: How likely from a "statistical or scientific point of view" they would be to experience a tornado injury in the next 10 years and from a "personal or gut-level point of view" (0%-100% likely).

Tornado experiences. As in Study 1, respondents were queried at Time 1 about property damage (0 = *none*, 4 = *complete damage*) to roof, windows, possessions, carpeting, and car (α = .80; mean across the 5 items = 1.18, SD = .49), injury to self and others (coded as 1 if "yes;" 12%, n = 26; 0 if none, 88%, n = 187), to what degree they thought they might die in the tornado (1 = *not at all*, 7 = *absolutely;* M = 1.35, SD = 1.00), and their physical proximity to the tornado (in miles) when it touched down (M = 4.35, SD = 15.79).

Demographic information. With the exception of age (participants had to be at least 18 years of age to participate so this was asked initially), all demographics were collected after all of the other questions. Interviewers inquired about (a) years residing in the small city and adjoining community, (b) years residing in the same location, (c) ethnicity, (d) type of housing (i.e., apartment, house), (e) any children under 18 living in the residence, (f) marital status (i.e., married, divorced, widowed; marriage-like relationship), and (g) job status (i.e., employed [part- or full-time], retired, unemployed).

Results and Discussion

Attrition Analyses. Demographic information for the Time 1 sample and those who also were reinterviewed at Time 2 are presented in Table 3. The subset of respondents who participated only at Time 1 did not differ in age (M = 48.8; SD = 13.62) from those who also completed the second interview (M = 52.38; SD = 15.37), t (243) = –1.3, p = .20. There was no difference in the proportion of women who participated in the follow-up (65.7%) versus only at Time 1 (61.5%), chi-square (1, n = 252) = .255, p = .61. Finally, with the exception of the direct comparative estimates, Time 1 responses to vulnerability measures for those who completed both interviewers did not differ from those who completed the first interview (ts < 1, ps > .10). The results described below are based on the 213 participants who were interviewed at both time points.

Vulnerability Perceptions and Changes Over Time

Direct comparative ratings. At Time 1 (M = −.67, SD = .87) and Time 2 (M = −.57, SD = .86), participants were more optimistic that they would avoid tornado injury in the future than the average Iowan, as indicated by one-sample t tests comparing the mean values to the midpoint of the scale ("0"), $t(211) = −11.19$, $p < .01$ and $t(211) = −9.58$, $p < .01$. There was a marginally significant difference between the Times 1 and 2 direct comparative indices, $F(1, 210) = 3.02$, $p = .08$ (see Table 4), with the sample reporting being slightly less optimistic a year later.

Absolute self and other ratings. Consistent with the findings in Study 1, the absolute rating of personal risk at Time 2 (M = 1.75, SD = 0.88) was lower than at Time 1 (M = 1.89, SD = 0.92), $F(1, 211) = 4.29$, $p < .05$. Recall that absolute risk was estimated on a 1- to 5-point scale (1 = *very unlikely*, 5 = *very likely*), so personal risk was perceived to be lower as the tornado disaster faded from memory. Absolute risk estimates for "the average person" were higher than the self-estimates, but they did not differ across the two time points (Time 1 M = 2.03, SD = 0.98; Time 2 M = 1.99, SD = 0.95); $F(1, 209) = .44$, $p > .10$. On the indirect comparative index—calculated by subtracting the absolute other risk rating from

Table 3. Demographics for Study 2.

Variable	Time 1 Full Sample (n = 252) M (SD) or frequency%	Times 1 Time 2 Responders (n = 213) M (SD) or frequency%
Age	51.85 (15.15)	52.38 (15.38)
Gender		
Male	88 (35%)	73 (34.3)
Female	164 (65%)	140 (65.7)
Ethnicity		
Asian American	4 (1.6%)	3 (2.4%)
African American	6 (2.4%)	6 (2.9%)
Caucasian	217 (87.2%)	184 (87.6%)
Hispanic	6 (2.4%)	2 (1.0%)
Native American	5 (2.0%)	5 (2.3%)
Other	11 (4.4%)	10 (4.8%)
Marital status		
Married	155 (61.5%)	133 (62.4%)
In a relationship	16 (6.4%)	13 (6.1%)
Never married	24 (9.5%)	20 (9.4%)
Divorced	35 (13.9%)	29 (13.6%)
Widowed	22 (8.7%)	18 (8.5%)
Children below 18		
Yes	75 (29.8%)	62 (29.1%)
No	177 (70.2%)	151 (70.9%)
Employment status		
Employed (full or part)	165 (65.5%)	135 (63.4%)
Unemployed	27 (10.7%)	22 (10.3%)
Retired	60 (23.8%)	56 (26.3%)
Residence type		
House	198 (78.6%)	171 (80.2%)
Apartment	23 (9.1%)	18 (8.5%)
Other	31 (12.3%)	24 (11.3%)

Table 4. Mean-Level Shifts and Rank-Order Stability of Vulnerability Perceptions Across Time in Study 2 (n = 212).

Variable	Time 1		Time 2		Correlation (Times 1 and 2)
	M	*SD*	*M*	*SD*	
Direct comparative	−0.67***	0.87	−0.57***	0.86	.45***
Absolute self	1.89	0.92	1.75	0.88	.43***
Absolute other	2.03	0.98	1.99	0.95	.53**
Indirect comparative	−0.14**	0.98	−0.25***	0.84	.34**
Statistical probability	13.34	18.03	13.56	17.90	.44***
Gut probability	11.00	18.23	10.18	17.37	.48***

Notes: Rows 1 to 4 are explained in Table 1. Probability estimates were made on 101-point scales (0%-100% likely).
**p < .05. ***p < .01.

the absolute self-rating—personal risk was judged to be lower than for the average peer at Time 1 (M = −.14, SD = .98), $t(211) = −2.04$, $p < .05$, and Time 2 (M = −.25, SD = .84), $t(210) = −4.28$, $p < .01$; these values did not differ, $F(1, 209) = 2.48$, $p > .10$.

Absolute numerical estimates. Likelihood estimates made from a "statistical or scientific" perspective did not differ between Time 1 (M = 13.34, SD = 18.03) and Time 2 (M = 13.56, SD = 17.90), $F(1, 209) = .03$, $p > .10$; nor did estimates based on "personal/gut-level" perspective at Time 1 (M = 11.00, SD = 18.23) and Time 2 (M = 10.18, SD = 17.37), $F(1, 211) < 1$, p >.10. The "statistical or scientific" estimates were, however, higher than those based on "gut-level/personal" estimates at Time 1, $t(211) = 2.49$, $p < .02$, and Time 2, $t(210) = 5.67$, $p < .01$. On average, residents thought there was a little more than a 1-in-10 chance they would be harmed by a future tornado. This is an *overestimate* based on data from the National Severe Storms Laboratory (2008) that the probability of a tornado striking the respondent's area in a given year is less than 1%: "Since 1980, there have been 729 injuries and 26 deaths attributable to tornadoes." (http://www.crh.noaa/images/dmx/dmx/IowaToClimatologyFinal-2008.pdf). Discussion of the apparent overestimation of risk will be considered following the presentation of Study 3's results.

Rank-order stability. For comparative and absolute self-risk, rank-order stabilities across Times 1 and 2 were of moderate magnitude (see Table 4). For absolute other risk, stability tended to be higher than in Study 1; stability of statistical- and gut-level estimates were moderate in size.

Did Experience With the Tornado Influence Vulnerability? Having experienced injury or damage or knowing someone who did were unrelated to vulnerability judgments (see Table 5). Proximity/injury to the tornado was modestly correlated with some of the vulnerability indices in Study 1, but there were no appreciable or significant correlations in the telephone sample. However, fear about dying showed more associations with future vulnerability, especially with gut-level and statistical assessments of likelihood.

Study 3

Both college students (Study 1) and community residents (Study 2) seemed confirmed in their beliefs about comparative invulnerability to a future tornado. These beliefs shifted little with time since the disaster, but the nature of the experience (e.g., fear of dying) with the tornado moderated vulnerability. In Study 3, we tried to directly assess the role of tornado impact/experience on the trajectory of optimism. Our expectation was that living in close proximity to and regularly seeing the damage left by the tornadoes should increase beliefs about vulnerability. To test this idea, community residents were surveyed in areas of the city that had been in the path of the tornadoes and incurred damage and in comparable areas that had been unaffected. Although some neighborhoods partly recovered within a few months, there was still much damage to buildings, trees, and other vegetation clearly evident more than 16 months after the tornado.

Table 5. Zero-Order Correlations Between Tornado Experiences and Vulnerability Perceptions in Study 2.

	Injuries		Damage		Proximity		Fears of dying	
Variable	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Direct	−.04	−.04	.07	.12*	.09	.04	.12*	.14**
Absolute self	.03	.07	.11*	.07	−.03	−.10*	.12*	.24***
Absolute other	.03	.04	.05	−.05	−.10	−.12*	.22***	.21***
Indirect	−.01	.02	.06	.14**	.08	.01	−.10	.02
Gut level	−.10	−.07	.05	−.07	−.03	−.04	.26***	.37***
Stat level	−.12	−.03	.07	−.05	−.04	−.02	.19***	.29***

Note: For the analyses involving "*injuries*" to self or others (0 = *no*, 1 = *yes*), the "*damage*" index (0 = *none*, 4 = *complete damage*), and "*fears of dying*" (1 = *not at all*, 7 = *absolutely*), positive correlations indicate that more tornado-related experiences were associated with greater perceived vulnerability. For "*proximity*" to the path of the tornado (in blocks), high *negative* correlations indicate that participants closer to the tornado reported more vulnerability.
*$p < .10$. **$p < .05$. ***$p < .01$.

Method

Participants and Procedure. Neighborhoods were chosen that had been in the tornadoes' paths versus comparable areas that had not by referring to detailed maps of the tornado path (found at www.ic.gov.org) and matched to population tracts within the community based on the 2000 U.S. Census (http://www.census.gov/). Using these selection criteria, we identified tornado-affected and nonaffected areas of the city, which matched on population size (average number of people across selected tracts was 3,878 vs. 3,214), median income (average median income across selected tracts was US$55,672 vs. US$56,374), and demographics (e.g., percentage of minority citizens across selected tracts was 7.51% vs. 7.53%).

Approximately 6 months after the tornado, a team of research assistants went door-to-door in the selected neighborhoods to recruit participants for a study about "reactions to the tornadoes in April 2006." Participants were offered US$10 gift cards good at local shops as reimbursement; only one person per household was permitted to participate. Once someone agreed, research assistants left the questionnaire with them to complete while the assistants continued on to new houses. Approximately 15 to 25 min later, research assistants returned to pick up the completed questionnaire packet and to give participants a gift certificate. A total of 210 residences were approached. In all, 122 nonstudent community residents agreed and completed Time 1 surveys (58%). Six months later, participants were sent a follow-up questionnaire in the mail and were further prompted via email and/or phone to encourage survey completion. Those participants who returned Time 2 questionnaires via mail were sent an additional gift card. Fifty-four (or 44%) of the original participants completed surveys at Time 2. The results reported below are based on a sample size of 54, with 20 from affected and 34 from nonaffected areas.

Dependent Measures

Vulnerability perceptions. Study 3 used the same direct comparative, absolute self (verbal), absolute other (verbal), absolute (numerical) "personal or gut-level," and absolute (numerical) "statistical or scientific" items as Study 2. These were queried at Times 1 and 2.

Tornado experiences. The Time 1 survey also included the same measures of "tornado experience" used in Study 2: questions about damage, injury to self and/or others, anxiety about dying during the tornado, and proximity to the tornadoes (in miles) when they struck.

Results and Discussion

Attrition Analyses. Participants who only completed surveys at Time 1 were comparable in age ($M = 52.69$, $SD = 17.8$) with those who completed Times 1 and 2 measures ($M = 51.04$, $SD = 15.37$), $t(119) = .60$, $p > .10$. A higher proportion of females tended to complete surveys at Times 1 and 2 (74%) than at Time 1 (58% female), $\chi^2(1, n = 122) = 3.20$, $p = .07$). Time 1 responses to the vulnerability measures did not differ between those who completed both surveys versus those who completed only the first (ts < 1.70, ps > .09). The results described below are based on participants who completed both surveys.

Experiences Across Affected Versus Affected Areas. The tornado experience variables (e.g., injury and anxiety about dying) were analyzed to validate our classification of affected and unaffected neighborhoods. Residents of affected areas reported a higher level of damage ($M = .83$, $SD = .94$) than those living in nonaffected areas ($M = .08$, $SD = .30$), $t(52) = 4.36$, $p < .01$. In addition, knowing someone or personally being injured was more common in affected (21%) than in nonaffected areas (6%), $\chi^2(1, n = 52) = 2.66$, $p = .10$. Third, participants residing in affected areas recalled having experienced more anxiety about dying during the tornado ($M = 2.10$, $SD = 1.59$) than participants in nonaffected areas ($M = 1.39$, $SD = 0.83$), $t(51) = 2.12$, $p < .04$. Fourth, participants living in affected neighborhoods reported being somewhat closer to the tornado (in miles) when it touched down ($M = 0.93$, $SD = 2.63$) than did participants

Table 6. Mean-Level Shifts and Rank-Order Stability of Vulnerability Perceptions As a Function of Area and Time in Study 3.

	Affected areas (n = 20)			Nonaffected areas (n = 34)		
	Time 1	Time 2		Time 1	Time 2	
Variable	M (SD)	M (SD)	r	M (SD)	M (SD)	r
Direct comparison	−1.00*** (1.30)	−0.40*** (0.88)	.14	−0.58*** (1.25)	−0.70*** (1.18)	.45***
Absolute self	2.33 (1.37)	2.22 (1.22)	.34	2.15 (1.25)	2.32 (1.22)	.58***
Absolute other	2.83 (1.46)	2.85 (1.40)	.34	2.38 (1.41)	2.85 (1.46)	.48***
Indirect comparison	−0.50*** (0.71)	−0.67*** (0.97)	.00	−0.24** (0.61)	−0.53*** (1.33)	.48***
Stat probability	13.50 (19.38)	14.73 (17.01)	.40	14.95 (14.70)	22.64 (17.14)	.80***
Gut probability	7.80 (16.54)	15.88 (23.31)	.66***	12.82 (10.45)	10.45 (15.19)	.62***

Note: Direct comparative estimates were made on 5-point scales (−2 = *much less likely than the average Iowan*, +2 = *much more likely than the average Iowan*). Absolute estimates were made on 5-point scales (1 = *extremely unlikely*, 5 = *extremely likely*). Means in the "indirect comparison" column were created by subtracting absolute other estimates from absolute self-estimates. Values in the direct and indirect comparison columns that significantly differ from "0" indicated with asterisk (**p < .05. ***p < .01). Probability estimates were made on 101-point scales (0%-100% likely). Values in the "r" columns are the correlations between Times 1 and 2 responses (**p < .05. ***p < .01).

in nonaffected neighborhoods (M = 1.53, SD = 1.79), although this difference did not approach statistical significance, $t(41) = -.89$, $p > .10$. In general, however, the affected versus unaffected classification of neighborhoods appeared to be valid.

Vulnerability Perceptions and Changes Over Time

Direct comparative ratings. Estimates for each type of vulnerability index were submitted to 2 (time) × 2 (affected/nonaffected areas) mixed ANOVAs, with time treated as a within-participant factor. All means and SDs are displayed in Table 6. For direct comparisons, no significant main effects for time, $F(1, 51) = 2.78$, $p = .10$, nor area, $F(1, 51) = .83$, $p > .10$, were evident, but there was a significant interaction, $F(1, 51) = 6.31$, $p < .02$. Residents of affected neighborhoods were more comparatively optimistic at Time 1 ($M = -1.00$, $SD = 1.30$) than at Time 2 ($M = -.40$, $SD = .88$), $t(19) = 1.83$, $p < .08$. However, residents of nonaffected areas were comparably optimistic at Time 1 ($M = -.58$, $SD = 1.25$) and Time 2 ($M = -.70$, $SD = 1.18$), $t(32) = 1.16$, $p > .10$. Those living in a visibly damaged area were less optimistic 12 months later, whereas residents of nonaffected areas showed no appreciable change. Notably, residents in both types of neighborhoods believed they were less vulnerable to a future tornado than were others at both time points; all four means were significantly different from the midpoint of the scale (all ts > 2, ps ≤ .05).

Absolute (verbal) ratings. For absolute self (verbal) estimates, there were no significant main effects or interactions (all Fs < .60, ps > .40). Participants in affected and nonaffected areas made very low vulnerability estimates about future tornado injury at Time 1 ($M = 2.33$, $SD = 1.37$ and $M = 2.15$, $SD = 1.25$ for affected and unaffected areas, respectively) and Time 2 ($M = 2.22$, $SD = 1.22$ and $M = 2.32$, $SD = 1.22$ for affected and nonaffected areas, respectively). Absolute other (verbal) estimates of vulnerability showed no significant main or interaction effects (all Fs < 1.50, ps > .20). Residents rated the average person's risk as low at Time 1 ($M = 2.83$, $SD = 1.46$ and $M = 2.38$, $SD = 1.41$ for affected and nonaffected areas, respectively) and Time 2 ($M = 2.85$, $SD = 1.40$ and $M = 2.85$, $SD = 1.46$ for affected and nonaffected areas, respectively). For the indirect comparative estimates (absolute self-rating minus absolute other rating), negative scores indicate that participants perceived themselves to be at lower risk than the average person: participants in affected areas at Time 1 ($M = -.50$, $SD = .71$), $t(17) = -3.00$, $p < .01$, and at Time 2 ($M = -.67$, $SD = .97$), $t(19) = -3.12$, $p < .01$, and for participants in nonaffected areas at Time 1 ($M = -.24$, $SD = .61$), $t(33) = -2.26$, $p < .05$, and Time 2 ($M = -.53$, $SD = 1.33$), $t(33) = -2.32$, $p < .05$.

Numerical estimates. Estimates of numerical likelihood based on "gut-level" or "statistical" perspectives were submitted to a 2 (Time) × 2 (judgment type: gut vs. statistical) × 2 (affected/nonaffected neighborhood) mixed ANOVA, with the first two as within-participant factors. There was a significant main effect of judgment type, $F(1, 50) = 4.95$, $p < .03$, whereby estimates of likelihood were higher when judging risk from a "statistical or scientific" perspective ($M = 14.10$, $SD = 17.02$) than from a "personal or gut-level" perspective ($M = 11.45$, $SD = 16.29$). There were no other main effects or two-way interactions (Fs < 2.85, ps > .10). However, there was a significant three-way interaction, $F(1, 51) = 6.43$, $p < .01$. To dissect the interaction, separate analyses were conducted for the two judgment types.

For estimates made from a "statistical or scientific" perspective, there were no main or interaction effects for time or area (Fs < 1, ps > .10). Residents of affected areas estimated their risk at 13.5% (SD = 19.38) at Time 1 and 14.73% (SD = 17.01) at Time 2. Estimates of residents of unaffected areas were comparable, 14.95% (SD = 22.64) at Time 1 and 14.70% (SD = 17.14) at Time 2. "Personal or gut-level" estimates also showed no effects of time or area (Fs < 2, ps > .10), but there was a significant Time × Area interaction, $F(1, 51) = 5.73$, $p < .05$. The nature of the interaction was the same one found for direct comparative vulnerability. At Time 1, residents of affected areas made *lower* gut-level estimates about future tornado injury at Time 1 ($M = 7.80\%$, $SD = 16.54$) but higher estimates at Time 2 ($M = 15.88\%$, $SD = 23.31$), $F(1, 19) = 4.72$, $p < .05$. However, residents of nonaffected areas provided generally similar estimates at both Time 1 ($M = 12.82\%$, $SD = 10.45$) and Time 2 ($M = 10.45\%$, $SD = 15.19$), $F(1, 32) = .94$, $p > .10$. Thus, while persons living in areas where the tornado inflicted damage tended to become somewhat less optimistic over time, residents of nonaffected areas felt about the same over the course of the year. Overall, as in Study 2, participants overestimated the numerical likelihood of future tornado injury by 8% to 16% relative to expert calculations (National Severe Storm Laboratory, 2008).

Rank-order stability. Generally, stability was lower among the residents of affected areas (see Table 6). For direct comparative ratings, rank-order stability was moderate for those living in nonaffected areas but appreciably lower for residents of affected areas. Rank-order stability for the absolute (verbal) self-ratings was higher among the residents of unaffected areas than those from affected areas, as was true of the absolute (verbal) other ratings for nonaffected and affected. The largest difference in stability was for the indirect comparative index for unaffected versus and affected neighborhoods. Numerical "statistical" estimates of vulnerability were very stable among the nonaffected residents, but appreciably lower in the affected residents. For "gut-level" estimates, likelihood was high for unaffected and affected residents.

General Discussion

Despite having experienced a tornado disaster, students and community residents reported they were less likely than their peers to experience a future tornado injury in terms of direct and indirect comparative indices at 1 month, 6 months, or 1 year after the disaster. Unrealistic comparative optimism was "alive and well," even in a community that experienced a significant disaster.

Relation to Extant Research on the Trajectory of Perceived Vulnerability

The results are closest to Weinstein et al. (2000a, 2000b), who also assessed reactions to tornado. Although Burger and Palmer (1992) and Li et al. (2010) found short-lived pessimism after (earthquake) disaster, only Dolinska, Gromski, and Zawisza (1987; nuclear reactor accident) and Helweg-Larsen (1999; earthquake) found persistent pessimism. Even when differences in perceived vulnerability emerged in the present research, estimates always were in the optimistic range (e.g., Weinstein, 1980). Such optimism may bolster subjective well-being—but also might discourage emergency preparedness—an important question for future researchers.

Why Dolinska et al. (1987) and Helweg-Larsen (1999) found persistent pessimism remains unclear, whereas we found considerable optimism. However, the severity, damage, and threat posed by nuclear disasters (e.g., radioactive debris can travel long distances, seep into the ground, contaminate vegetation, farm animals, and the water supply) and by earthquakes (e.g., which can create havoc over large areas) differ from tornadoes for which catastrophic injury and damage may only occur in the specific area where the tornado touched down. Future research is needed to assess whether optimism or pessimism are distinctively connected to specific types of disasters based on severity and the possible range over which damage can be sustained.

Two results suggested changes in perceived vulnerability as time passed since the disaster. In the college and the community telephone samples, absolute personal risk estimates became more optimistic, whereas comparative vulnerability remained the same. In addition, residents of affected neighborhoods, within 6 months of the disaster, reported feeling less comparatively vulnerable and made lower "gut-level" numerical estimates. Twelve months post-tornado, however, their estimates were somewhat less optimistic and resembled those of residents of unaffected neighborhoods.

The initial optimism of the people living in communities with daily reminders of the tornado seems counterintuitive. Perhaps, however, the "gambler's fallacy" was operating (Tversky & Kahneman, 1971, 1974) with affected residents thinking "lightning doesn't strike twice in the same place." Or these residents may have been relieved they had "dodged a bullet." Heightened defensiveness in the face of visible damage for an extended period also may have prompted evaluation of the future more positively (Rothman, Klein, & Weinstein, 1996).

The initially lower perceived vulnerability of people in the affected neighborhoods (at Time 1) seems contradictory to the finding that anxiety, fear of death, and familiarity with damage or injury was associated with greater vulnerability. It may be important to distinguish between how people felt during the tornado event versus later thoughts and feelings (e.g., lightening doesn't strike twice in the same place). In any case, support providers and emergency workers should be prepared to find more optimism among survivors, who experienced "a close call," than might be expected on an intuitive basis.

Statistical- Versus Gut-Based Numerical Estimates

The numerical likelihood ratings are striking because the absolute likelihood of experiencing injury of a future tornado actually is very low (less than 1%) National Severe Storms Laboratory (2008). Although the likelihood estimates suggest risk was overestimated, these need to be considered in context. First, storm experts have access to information about the absolute frequencies of past tornadoes, but most laypeople do not. It is not uncommon, however, for people to make likelihood estimates that greatly exceed the actual risks (Lichtenstein, Slovic, Fischoff, Layman, & Combs, 1978; Windschitl, 2002). For example, respondents asked how many cigarette smokers out of a hundred will get lung cancer predict about 43 when actually the risk is between 5% and 10% (see Viscusi, 1990; see also Weinstein, 1998). Likelihood estimates are flexibly used and interpreted because they are affected by affect and context (e.g., Slovic & Peters, 2006; Windschitl, 2002; Zikmund-Fisher, Fagerlin, & Uber, 2010). People also have difficulty generating risk estimates in terms of percentages. For example, estimates of 50% are frequent, but further inquiry suggests some respondents mean "the outcome might or might not happen," (p. 135) or are trying to communicate that "they don't know" (Weinstein, 1998). In any case, a chance of 1 in 10 may seem small. Thus, respondents, strictly speaking, overestimated risk, based on expert calculations, but the likelihood of future injury from a tornado still may have seemed low to them.

In addition, estimates made on a statistical basis were higher than gut-level basis, which is consistent with other research findings of people guessing more optimistically, particularly when judging on the basis of their "gut" (Windschitl et al., 2010). However, our results do not show that "statistical"-level thinking led to somewhat more accurate estimates as they were somewhat further from the experts' tornado injury calculations.

Limitations and Conclusion

These results reinforce the need to distinguish among different measures of perceived vulnerability. Perceptions of absolute vulnerability became more optimistic as the tornado receded further in the past, whereas direct and indirect comparative estimates and numerical likelihood estimates showed little change over time. Rank-order stability of the direct comparative estimates and absolute self-estimates was higher than that for peers or indirect comparative estimates perhaps because of the difficulties assessing the vulnerability of unspecified peers (Moore, 2007; Rose, 2010; Windschitl et al., 2008).

Although the study methods permitted an assessment of possible changes in perceived vulnerability as a function of time after a tornado disaster, we lacked a measure of vulnerability prior to the tornado. There also was some attrition; however, comparison of baseline attributes with the final samples showed no substantive differences.

It is surprising and somewhat comforting to find comparative optimism within months of a tornado disaster. People thought there was approximately a 10% chance they would be injured in a future tornado (an overestimate), but they also were confirmed in the belief that their risk was lower than that of other people. Although Hannah Miller, with whom we introduced this article, initially seemed like a special case, she appears to represent "the norm," and a challenge to emergency preparedness.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The authors acknowledge the support of NSF Grant BCS-SGE 0634901, Shirley Huck of the Iowa State University Call Center, and the team of energetic and diligent undergraduate research assistants who assisted with Study 3.

Note

1. Mean-level change and rank-order stability can be independent. With the passage of time, the samples might perceive themselves to be at less risk in terms of mean levels, but rank-order stability could be high if people shift in similar increments and do not overlap. Alternatively, mean-level change could show no evidence of change, but rank-order stability might drop and indicate that people are changing their rankings.

References

Burger, J. M., & Palmer, M. L. (1992). Changes in and generalization of unrealistic optimism following experiences with stressful events: Reactions to the 1989 California earthquake. *Personality and Social Psychology Bulletin*, *14*, 264-270.

Chambers, J., & Windschitl, P. D. (2004). Biases in social comparative judgments: The role of nonmotivated factors in above-average and comparative-optimism effects. *Psychological Bulletin*, *130*, 813-838.

Chambers, J., Windschitl, P. D., & Suls, J. (2003). Egocentrism, event frequency, and comparative optimism: When what happens frequently is "more likely to happen to me." *Personality and Social Psychology Bulletin*, *29*, 1343-1356.

Dolinski, D., Gromski, W., & Zawisza, E. (1987). Unrealistic pessimism. *Journal of Social Psychology*, *127*, 511-516.

Dunning, D., Heath, S., & Suls, J. (2004). Flawed self-assessments: Implications for health, education and the workplace. *Psychological Science in the Public Interest*, *5*, 69-106.

The Gazette Staff. (2006). *Taken by storm*. Cedar Rapids, IA: Gazette Communications.

Guenther, C. L., & Alicke, M. (2010). Deconstructing the better-than-average effect. *Journal of Personality and Social Psychology*, *99*, 755-770.

Helweg-Larsen, M. (1999). (The lack of) optimistic biases in response to the 1994 Northridge Earthquake: The role of personal experience. *Basic and Applied Social Psychology*, *21*, 119-129.

Helweg-Larsen, M., & Shepperd, J. A. (2001). Do moderators of the optimistic bias affect personal or target risk estimates? *Personality and Social Psychology Review*, *5*, 74-95.

Klein, W. M., & Zajac, L. E. (2009). Imagining a rosy future: The psychology of optimism. In K. D. Markman, W. M. Klein, &

J. A. Suhr (Eds.), *Handbook of imagination and mental simulation* (pp. 313-330). New York, NY: Psychology Press.

Kruger, J., & Burrus, J. (2004). Egocentrism and focalism in unrealistic optimism (and pessimism). *Journal of Experimental Social Psychology*, *40*, 332-340.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York, NY: Springer.

Li, S., Li, J.-Z., Chen, Y.-W., Bai, X.-W., Ren, X.-P., Zheng, R., & Lu, H. (2010). Can overconfidence be debiased by low-probability/high-consequence events? *Risk Analysis*, *30*, 699-707.

Lichtenstein, S., Slovic, P., Fischoff, B., Layman, B., & Combs, B. (1978). Judged frequency of lethal events. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 551-578.

Moore, D. A. (2007). Not so above average after all: When people believe they are worse than average and its implications for theories of bias in social comparison. *Organizational Behavior and Human Decision Processes*, *102*, 42-58.

National Severe Storms Laboratory. (2008). Available from http://www.nssl.noaa.gov/research/tornadoes/

Otten, W., & Van der Pligt, J. (1996). Context effects in the measurement of comparative optimism in probability judgments. *Journal of Social & Clinical Psychology*, *15*, 80-101.

Ranby, K. W., Aiken, L. S., Gerend, M. A., & Erchull, M. J. (2010). Perceived susceptibility measures are not interchangeable: Absolute, direct comparative, and indirect comparative risk. *Health Psychology*, *29*, 20-28.

Rose, J. P. (2010). Are direct or indirect measures of comparative risk better predictors of concern and behavioral intentions? *Psychology & Health*, *25*, 149-165.

Rose, J. P., Endo, Y., Windschitl, P. D., & Suls, J. (2008). Cultural differences in unrealistic optimism and pessimism: The role of egocentrism and direct vs. indirect comparison measures. *Personality and Social Psychology Bulletin*, *34*, 1236-1248.

Rose, J. P., Suls, J., & Windschitl, P. D. (2011). When and why people are comparatively optimistic about future health risk: The role of direct and indirect comparison measures. *Psychology, Health & Medicine*, *169*, 475-483.

Rothman, A. J., Klein, W. M., & Weinstein, N. D. (1996). Absolute and relative biases in estimations of personal risk. *Journal of Applied Social Psychology*, *26*, 1213-1236.

Seary, M. D., Holman, E. A., & Silver, R. C. (2010). Whatever does not kill us: Cumulative lifetime adversity, vulnerability, and resilience. *Journal of Personality and Social Psychology*, *99*, 1025-1041.

Shepperd, J. A., Helweg-Larsen, M., & Ortega, L. (2003). Are comparison risk judgments consistent across time and events? *Personality and Social Psychology Bulletin*, *29*, 1169-1180.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3-22.

Slovic, P., & Peters, E. (2006). Risk perception and affect. *Current Directions in Psychological Science*, *15*, 322-325.

Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, *103*, 193-210.

Tversky, A., & Kahneman, D. (1971). Belief in the law of small numbers. *Psychological Bulletin*, *76*, 105-110.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*, 1124-1131.

U.S. Census. (2000). *2002 economic census: Geographic area series schedule*. Retrieved from www.census.gov/prod/2001pubs/mso-01icdp.pdf

Viscusi, W. K. (1990). Do smokers underestimate risks? *Journal of Political Economy*, *98*, 1253-1269.

Watson, D. (2004). Stability versus change, dependability versus error: Issues in the assessment of personality over time. *Journal of Research in Personality*, *38*, 319-350.

Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, *39*, 806-820.

Weinstein, N. D. (1998). Accuracy of smokers' risk perceptions. *Annals of Behavioral Medicine*, *20*, 135-140.

Weinstein, N. D., & Klein, W. M. (1995). Resistance of personal risk perceptions to debiasing interventions. *Health Psychology*, *14*, 132-140.

Weinstein, N. D., Lyon, J. E., Rothman, A. J., & Cuite, C. L. (2000a). Changes in perceived vulnerability following natural disaster. *Journal of Social & Clinical Psychology*, *19*, 372-395.

Weinstein, N. D., Lyon, J. E., Rothman, A. J., & Cuite, C. L. (2000b). Preoccupation and affect as predictors of protective action following natural disaster. *British Journal of Health Psychology*, *5*, 351-363.

Windschitl, P. D (2002). Judging the accuracy of a likelihood judgment: The case of smoking risk. *Journal of Behavioral Decision Making*, *15*, 19-35.

Windschitl, P. D., Rose, J. P., Stalkfleet, M., & Smith, A. R. (2008). Are people excessive or judicious in their egocentrism? A modeling approach to understanding bias and accuracy in people's optimism. *Journal of Personality and Social Psychology*, *95*, 253-273.

Windschitl, P. D., Smith, A. R., Rose, J. P., & Krizan, Z. (2010). The desirability bias in predictions: Going optimistic without leaving realism. *Organizational Behavior and Human Decision Processes*, *111*, 33-47.

Windschitl, P. D., & Wells, G. (1996). Measuring psychological uncertainty: Verbal versus numeric methods. *Journal of Experimental Psychology: Applied*, *2*, 343-364.

Zikmund-Fisher, B., Fagerlin, A., & Uber, P. (2010). Risky feelings: Why a 6% risk of cancer does not feel like 6%? *Patient Education and Counseling*, *81*, S87-S93.