Flood Risk Literacy: Communication and Implications for Protective Action

Madhuri Ramasubramanian[1,2], Jinan N. Allan[1,2], Rocio Garcia Retamero[3], Hank Jenkins-Smith[1,4], Edward T. Cokely[1,2]
[1]National Institute for Risk & Resilience, University of Oklahoma, [2]Department of Psychology, University of Oklahoma,
[3]Department of Experimental Psychology, Universidad de Granada, [4]Department of Political Science, University of Oklahoma

Flooding is among the costliest natural disasters in the United States. Research indicates that flood risk perceptions and knowledge often shape flood-related decision making; however, relatively less is known about specific individual differences in flood risk literacy. The current study presents data from 630 participants who completed a flood risk communication experiment and a general decision-making inventory (e.g., numeracy, risk perceptions, knowledge). Structural equation modeling revealed that both numeracy and flood knowledge partially explain differences in vulnerability, including effects on risk comprehension, weather risk perceptions, and decision quality (i.e., taking protective action). Limitations and implications for enhancing flood risk literacy are discussed.

INTRODUCTION

On average, each flooding event in the US results in $4.3 billion in damages (NOAA, 2019). However, recent floods caused by Hurricane Katrina and Hurricane Harvey were some of the costliest natural disasters in US history, leading to more than 1,000 deaths, along with estimated economic losses of $125 billion and $160 billion, respectively, (Knabb et al., 2006; see also Blake & Zelinksy, 2018). Research indicates that disaster recovery is also complicated by personal financial losses resulting from damage to uninsured property (Shultz & Galea, 2017). For instance, during Hurricane Harvey, only 15% of eligible homes in Harris County, Texas, were insured by the National Flood Insurance Program (NFIP). What factors shape these and other flood-related decision vulnerabilities among at-risk US residents?

Research suggests one cause of flood decision vulnerability may include misconceptions about terms such as the "100-year floodplain," among organizations and laypeople (Ludy & Kondolf, 2012). The 100-year floodplain is defined as a flood event that statistically has a 1% chance of occurring in any given year. Although 1% may seem modest, over the course of a 30-year mortgage this translates into a term risk of about 26% (1 in 4 odds of catastrophic loss; Holmes & Dinicola, 2010). Additionally, mechanisms related to purchasing flood insurance may often be communicated in ways that cause confusion (Botzen & Bergh, 2012). For example, more than 30% of Americans erroneously believe that homeowner's or renter's insurance covers flood damage (Insurance Information Institute, 2018). Recent evidence further suggests that individual differences in specific psychological factors (e.g., risk perceptions, knowledge) may help explain differences in insurance purchasing and related protective action decisions (Petrolia, Landry & Coble, 2013).

Numeracy and Risk Literacy

Tests of statistical numeracy (i.e., practical probabilistic and inductive reasoning), including the Berlin Numeracy Tests, tend to be the single strongest predictors of general decision making skill, including individual differences in *risk literacy*--defined as the ability to interpret and evaluate risk (Cokely et al., 2018; see RiskLiteracy.org). Evidence on the robust relationships between statistical numeracy as measured by the Berlin Numeracy Test and decision quality, vulnerability, and other outcomes, has been documented in over one hundred studies involving more than 50,000 diverse adult residents from 165 countries (Cokely et al., 2018). Research suggests the relationship may be especially robust when predicting realistic and naturalistic decision making (e.g. ignoring heart attacks, consumer decisions, hazard warning interpretations; Cokely et al., 2012; Peters et al., 2010; Petrova et al., 2016). Theoretically, solving statistical numeracy problems involves evaluating and integrating probabilistic information under conditions of complexity and uncertainty and thus may provide relatively representative tests of common risk evaluation and real-world decision making, as experienced in doctors' offices, during financial transactions, or during natural disasters (Cokely et al., 2018; Peters et al., 2007; Schwartz et al., 1997).

Research, including systematic reviews of data from more than 27,000 residents from North America and Europe further demonstrate simple visual aids can be used to compensate for decision vulnerabilities associated with lower levels of numeracy (Garcia-Retamero & Cokely, 2017). For instance, in a nationally representative study, accuracy of judgements about medical treatments increased from 20% to 80% for less numerate individuals, when visual aids were used (e.g., icon arrays and bar graphs; Garcia-Retamero & Galesic, 2010). The benefits of this transparent risk communication effectively eliminated differences between those who were more numerate and those who were not, provided that the low numerate individuals were moderately graph literate. The benefits of visual aids and numeracy are explained by Skilled Decision Theory, which posits that numeracy and visual aids shape decision quality via a predictable cascade of heuristic deliberation, confidence assessment, risk comprehension, and affective calibration. As such, decision making tends to be influenced by one's risk literacy as it shapes one's ability to acquire, evaluate, and integrate information about risk. This allows decision makers to accurately "feel" the weight of risks associated with different decisions, even if they cannot precisely complete a formal economic decision analysis

(Cokely et al., 2009; 2012; 2018; Peters, 2012).

Recent advances in risk literacy research, including prediction of decision vulnerabilities and development of user-friendly decision aids have been used in research on weather risk literacy, including topics concerning climate change and extreme weather. For instance, research on Weather Risk Literacy suggests that numeracy as well as hazard knowledge and warning awareness can predict potentially deadly misunderstandings of tornado risks (e.g., tall buildings protect people from tornados; Allan et al., 2017a). Moreover, while there are many factors that may influence weather decision making, a recent experiment by Grounds and Joslyn (2018) observed that numeracy was the only robust predictor, as well as the single best predictor, of one's ability to understand probabilistic winter weather information and related protective action decision making.

Risk Perceptions, Knowledge and Protective Action

A landmark study by Fischhoff et al., (1978) developed a psychometric paradigm to measure risk perceptions and demonstrated that most people perceive risks on two orthogonal factors: dread risks and unknown risks. Another measure of psychometric risk perception is the Industrial Strength Risk Perception Measure (Kahan, 2011; 2015). This measure asks, "*On a scale of 0 (No risk) to 10 (Extreme risk) how much risk do you think each of the following poses to human health, safety and/or prosperity*?" This measure can be used across domains (e.g., technologies, activities, natural hazards), with much initial research focusing on climate change and political ideology (Kahan, 2015).

Using these different risk perception techniques, the relationship between risk perceptions and behavior has been studied in various domains (e.g., Sitkin & Weingart, 1995; Brewer et al., 2004). For example, risk perceptions can have a profound impact on preparing for and taking protective action during natural hazard events (e.g., hurricanes; Demuth et al., 2016). Further, risk perceptions of climate change and nuclear energy can also impact support for government policies (Goebbert et al., 2012; Whitfield et al., 2009).

With regard to floods, risk perceptions have been tied to increased (i) willingness to pay for insurance, (ii) coping appraisals, and (iii) protective action (Botzen & Bergh, 2012; Bubeck, Botzen & Aerts, 2012). However, those with increased risk perceptions are also more likely to be vulnerable to overpayment (e.g., predatory insurance; Johnson et al., 1993).

In addition to risk perceptions, domain specific knowledge and previous experience with natural hazards also influence protective behaviors (e.g., Allan et al., 2017a; Ripberger et al., 2015). Based on natural hazard response research, the Protective Action Decision Model (PADM) posits that protective actions and decisions depend on three processes: reception, attention, and comprehension (Lindell & Perry, 2012). As such, this model supports the notion that (i) knowledge about the risks of a natural hazard and (ii) awareness of the risk are necessary to support protective action (Allan et al., 2017a; 2017b; Ripberger et al., under review). Consistent with the model, prior experience with a hazard also tends to influence protective behavior (Siegrist & Gutscher, 2006). Evidence within the domain of floods further suggests that the protective action decision model can appropriately be applied to flood preparedness decisions (Terpstra & Lindell, 2011; 2012).

Finally, previous research also established a predictive relationship between domain specific knowledge and risk perception. This suggests that increased knowledge can actually attenuate natural hazard risk perceptions (Sjoberg & Drottz-Sjoberg, 1991). Taken together, there is some evidence linking risk perceptions, previous experience, knowledge, and protective behaviors. However, the current study presents the first investigation of the intersection of all of these factors, with respect to floods. Specifically, our objective was to refine a detailed risk communication paradigm (e.g., icon array visual aid) to empower decision making and protective behavior during floods that result from a storm surge. In accord with Skilled Decision Theory, we also intended to estimate the role of individual differences such as numeracy, risk perceptions and prior knowledge on the comprehension of risk information and associated decision quality and vulnerability indicators.

METHOD

Participants

A sample of 630 participants recruited from Amazon's Mechanical Turk completed the study. There were 169 males (26.8%) and 461 females (73.2%). The average age of the participants was 41.2 years (SD = 13.3), with 511 participants (81.1%) indicating that they had completed at least high school and some college. Additionally, roughly a quarter of the sample (154 participants) reported that they had experienced storm surge flooding before.

Design and Procedure

To provide a test of how visual aids improve flood decision making, a between-subjects experiment was conducted. Participants were first asked to complete assessments of statistical numeracy, prior flood knowledge, and risk perceptions. They were then randomly assigned to three conditions (control, text only, and text with visual aid; see Figure 1). The risk communication information consisted of (i) a definition of a storm surge, (ii) causes, (iii) damages and (iv) long and short-term preparation methods. Based on input from subject matter experts, and following standards for representative design (Dhami et al., 2004) the risk information was adapted from resources from the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), and the United States

Geological Survey (USGS).

After reading the information, participants were asked to further read about "the Thompsons", a hypothetical family who were faced with the prospect of buying flood insurance for their home. Following this, participants were assessed on their comprehension of the risk information presented, as well as decision quality. Finally, participants completed other demographic assessments.

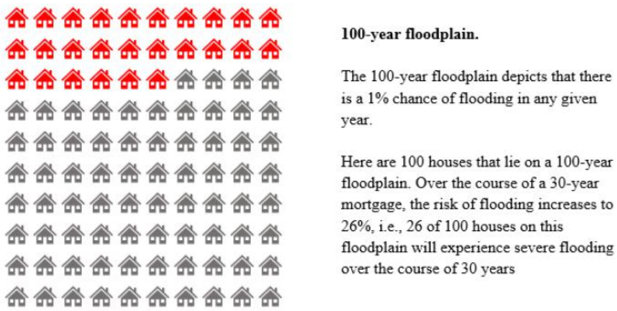

Figure 1. The visual aid presented to Condition 3.

Materials

In accord with best psychometric practices, factor analysis and Item Response Theory (IRT) was conducted on three newly created scales: (i) prior flood knowledge, (ii) comprehension of risk information and (iii) decision quality. Items were generated with expert input, following resources from FEMA, NOAA, and the USGS. Items were retained based on item discriminability and difficulty.

Prior Flood Knowledge. In order to assess prior flood knowledge, a pool of 11 items were developed. Items were asked on a 4-point Likert scale (Strongly Disagree, Disagree, Agree, Strongly Agree). After unidimensionality analysis and IRT, 8 items were retained, including items such as, "*Most people can safely outrun a storm surge in their car, when it is imminent in their city"* (False). The new prior knowledge scale met reliability standards (α=0.73).

Comprehension. To assess comprehension of the risk information presented, 7 items were retained with varying levels of difficulty. Items were similarly assessed on a 4-point Likert scale, and it met reliability standards (α=0.72). An example item is, "*Generally, it is sufficient to just purchase homeowner's/renter's insurance for your property*" (False).

Decision Quality. In order to assess decision quality, 7 items were retained. These were measured with a 7-point Likert scale (Strongly Disagree to Strongly Agree), for example, "*Most experts recommend that the Thompsons should follow the advice of their local real estate agents*." The new decision quality scale met reliability standards (α=0.74).

Numeracy. To assess statistical numeracy, we used the Berlin Numeracy Test (see RiskLiteracy.org).
Following best-practice recommendations, we used the BNT-S form, which includes three items taken from Schwartz et al., (1997), and provides increased sensitivity among less skilled and less educated individuals (i.e., non-college graduates, older-adults, etc.; Cokely et al., 2012; 2018). An example item is, *"Imagine we are throwing a five-sided die 50 times… out of 50 throws what proportion will result in an odd number?"*

Risk Perceptions. Risk perceptions were measured using the Industrial Strength Risk Perception Measurement (Kahan, 2015). Twenty everyday risks were provided to the participants (Table 1). They were asked to respond to the question: "*On a scale of 0 (No risk) to 10 (Extreme risk) how much risk do you think each of the following poses to human health, safety and/or prosperity?*"

RESULTS

Factor Analysis of Risk Perceptions

Prior research has posited that risk perceptions may be domain specific (i.e., related risks are perceived similarly; see Weber et al., 2002). Using the ltm package in R (Rizopoulos, 2006), Exploratory Factor Analysis provided a solution, with five distinct factors, namely: weather, technology, cybersecurity, vices, and manmade risks (Table 1). Given this multidimensional fit, we only use the first factor's latent trait (i.e., weather risks) in the following analyses.

Table 1. *Factor Analysis*

Risk Perceptions			**Factor**		
	1	**2**	**3**	**4**	**5**
Tornadoes	**0.86**				
Earthquakes	**0.82**				
Floods	**0.73**				
Hurricanes	**0.87**				
Genetically Modified Organisms (GMOs)		**0.63**			
Vaccines		**0.83**			
Private use of drones (UAVs)		**0.50**			
Cellular Phones		**0.73**			
Driverless Cars		**0.53**			
Commercial Airplane Travel		**0.62**			
Computer Hacking (Domestic)			**0.86**		
Computer Hacking (Foreign)			**0.90**		
Social Network Data Breach			**0.40**		
Alcohol Consumption				**0.43**	
Sexually Transmitted Diseases				**0.64**	
Smoking				**0.68**	
Unprotected Sex				**0.68**	
Fracking					**0.57**
Global Climate Change					**0.82**
Proportional Variance	**0.14**	**0.14**	**0.10**	**0.10**	**0.06**
Cumulative Variance	**0.14**	**0.28**	**0.38**	**0.48**	**0.54**

Structural Equation Model

To estimate the direct and indirect effects of individual differences on decision quality, we constructed and tested a

Structural Equation Model (SEM) based on predictions of framework for skilled decision making, as described in Skilled Decision Theory (Cokely et al., 2018). Using MPlus, our identified model demonstrated excellent fit, $\chi^2(9) = 8.92$, $p = .44$, with CFI = 1.00, TLI = 1.00, SRMR = 0.03, RMSEA = 0.00 with 90% C.I (0.00-0.05). As seen in Figure 2, results reveal that risk communication format (decision aid condition) directly impacted comprehension, such that participants who received a risk communication (text only or text with visual aid) demonstrated better comprehension of flood risks, than those who did not receive a decision aid (i.e., control). Numeracy also positively and directly shaped prior flood knowledge and risk information comprehension. This indicates that participants with higher numeracy were more likely to have acquired more previous knowledge about relevant risks, and also more effectively interpreted information presented in the risk communication, independent of the influence of decision aids.

A weak negative relationship between flood knowledge and weather risk perceptions was also observed, consistent with previous research, such that higher knowledge about storm surge flooding led to less extreme risk perceptions about weather risks. Moreover, previous flood experience was weakly related to weather risk perceptions: Individuals who had previously experienced flooding tended to perceive weather risks as greater (see Factor 1 in Table 1). Finally, prior flood knowledge had a direct and indirect effect on increasing decision quality, mediated by comprehension (e.g., more knowledgeable people were better able to understand the risk communication, independent of the influence of numeracy or available decision aids).

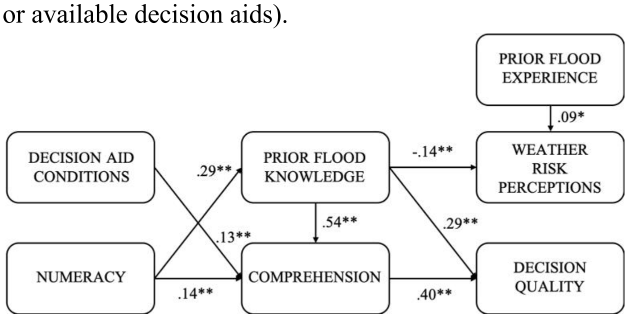

Figure 2. Structural Equation Model.

DISCUSSION

The present research illustrates flood decision quality (i.e., decisions about buying flood insurance, floodproofing, etc.) is significantly predicted by prior knowledge of floods and comprehension of the risk information provided. In accord with Skilled Decision Theory, the relationship between numeracy, risk perceptions and decision quality are mediated by knowledge and comprehension of risk information. Moreover, the risk communications (decision aid conditions) supported comprehension and subsequent decision quality. Interestingly, there is a significant relationship between knowledge and risk perception, such that increased knowledge actually attenuates risk perceptions. Prior flood experience also significantly predicted weather risk perceptions. Though risk perceptions did not directly impact decision quality in this model, there is some evidence that an indirect relationship exists, mediated by knowledge.

There is more than one theoretical framework that attempts to explain flood risk perception and behavior. Some common theories include the Protection Motivation Theory (PMT), Protective Action Decision Model (PADM) and the Risk Information Seeking and Processing Framework (RISP; Griffin et al., 1999; Grothmann & Reusswig, 2007). While these theories have tried to unpack the relationship between risk perception and behavior during floods, this study provides one of the first empirical and holistic looks at the individual differences that support flood decision making.

Still, there are a few limitations that must be noted. First, though there were significant differences between the three conditions presented (control, text only, text with icon array), there was little meaningful difference between the two conditions that received the intervention (i.e., text only vs. text with icon array). One reason for this may be that the text information was more salient and providing the visual aid had relatively limited benefits in the presence of detailed text information. Additionally, visual aids (icon arrays) are often most effective for individuals who are graph literate and not numerate. As the current study did not test graph literacy, it is hard to determine its role on the salience of the visual aid. Future research should also consider the impact of dynamic or adaptive flood risk communications (e.g., flood maps; Rollason et al., 2018).

Finally, the assessments developed to measure prior knowledge, comprehension and decision quality may have been too easy to assess a wide range of participant skill. Initial Item Response Theory analyses indicate that while these items discriminated well between participants, they were also relatively easy to answer correctly.

This study suggests that to motivate protective action and higher quality decisions, the public may benefit from increased knowledge about flooding events and accurate comprehension of risk information (supported by increased numeracy or transparent risk communications). While the present study focused on flooding and storm surge risks, results suggest there may be many opportunities to reduce or detect decision vulnerability, by focusing on the role of individual differences on decision making and risk literacy in other weather or natural hazards domains (e.g., earthquakes, tornados).

ACKNOWLEDGEMENTS

Support for this research was provided by grants from the U.S. National Science Foundation EPSCoR program (IIA-1301789). The analyses for the project were conducted with support from NOAA's Office of Weather and Air Quality through the U.S. Weather Research Program, with support from the National Institute for Risk & Resilience at the University of Oklahoma.

REFERENCES

Allan, J.N., Ripberger J.T., Ybarra, V.T., & Cokely, E.T. (2017a). Tornado Risk Literacy: Beliefs, biases, and vulnerability. *In Proceedings of the Naturalistic Decision Making 13th International Conference.*

Allan, J. N., Ripberger, J. T., Ybarra, V. T., & Cokely, E. T. (2017b). The Oklahoma Warning Awareness Scale: A Psychometric Analysis of a Brief Self-Report Survey Instrument. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 1203-1207). Sage CA: Los Angeles, CA: SAGE Publications.

Blake, E. S., & Zelinsky, D. A. (2018). Hurricane Harvey (AL092017): 17 August–1 September 2017. National Hurricane Center Tropical Cyclone Report, 76.

Botzen, W. W., & van den Bergh, J. C. (2012). Risk attitudes to low-probability climate change risks: WTP for flood insurance. *Journal of Economic Behavior & Organization*, *82*(1), 151-166.

Brewer, N. T., Weinstein, N. D., Cuite, C. L., & Herrington, J. E. (2004). Risk perceptions and their relation to risk behavior. *Annals of behavioral medicine*, *27*(2), 125-130.

Bubeck, P., Botzen, W. J., & Aerts, J. C. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis: An International Journal*, *32*(9), 1481-1495.

Cokely, E. T., Feltz, A., Ghazal, S., Allan, J. N., Petrova, D., & Garcia-Retamero, R. (2018). 26 Skilled Decision Theory: From Intelligence to Numeracy and Expertise. *The Cambridge Handbook of Expertise and Expert Performance,* 476*.*

Cokely, E. T., & Kelley, C. M. (2009). Cognitive abilities and superior decision making under risk: A protocol analysis and process model evaluation. *Judgement and Decision Making, 4(1)*, 20-33.

Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring risk literacy: The Berlin Numeracy Test. *Judgment and Decision Making*, *7(1),* 25-47.

Demuth, J. L., Morss, R. E., Lazo, J. K., & Trumbo, C. (2016). The effects of past hurricane experiences on evacuation intentions through risk perception and efficacy beliefs: A mediation analysis. *Weather, Climate, and Society*, *8*(4), 327-344.

Dhami, M. K., Hertwig, R., & Hoffrage, U. (2004). The role of representative design in an ecological approach to cognition. *Psychological bulletin*, *130*(6), 959.

Insurance Information Institute. (2017). Homeowners Insurance: Understanding, Attitudes and Shopping Practices. *2016.*

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, *9*(2), 127-152.

Garcia-Retamero, R., & Cokely, E. T. (2017). Designing visual aids that promote risk literacy: A systematic review of health research and evidence-based design heuristics. *Human Factors*, *59*(4), 582-627.

Garcia-Retamero, R., & Galesic, M. (2010). Who profits from visual aids: Overcoming challenges in people's understanding of risks. *Social science & medicine*, *70*(7), 1019-1025.

Griffin, R. J., Dunwoody, S., & Neuwirth, K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. *Environmental Research, 80,* 230-245.

Goebbert, K., Jenkins-Smith, H. C., Klockow, K., Nowlin, M. C., & Silva, C. L. (2012). Weather, climate, and worldviews: The sources and consequences of public perceptions of changes in local weather patterns. *Weather, Climate, and Society*, *4*(2), 132-144.

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: why some residents take precautionary action while others do not. *Natural Hazards*, *38*(1-2), 101-120.

Grounds, M. A., & Joslyn, S. L. (2018). Communicating weather forecast uncertainty: Do individual differences matter?. *Journal of Experimental Psychology: Applied, 24(1),* 18*.*

Holmes Jr, R. R., & Dinicola, K. (2010). 100-Year flood–it's all about chance. *US Geological Survey General Information Product*, *106*(4).

Johnson, E. J., Hershey, J., Meszaros, J., & Kunreuther, H. (1993). Framing, probability distortions, and insurance decisions. *Journal of risk and uncertainty*, *7*(1), 35-51.

Kahan, D. (2011). Industrial strength risk perception measure. CCP Blog. December 31.

Kahan, D. M. (2015). Climate‐science communication and the measurement problem. *Political Psychology*, *36*, 1-43.

Knabb, R. D., Rhome, J. R., & Brown, D. P. (2006). Tropical cyclone report: Hurricane Katrina, August 23-30, 2005. *Fire Engineering*, *159*(5), 32-40.

Lindell, M. K., & Perry, R. W. (2012). The protective action decision model: theoretical modifications and additional evidence. *Risk Analysis: An International Journal*, *32*(4), 616-632.

Ludy, J., & Kondolf, G. M. (2012). Flood risk perception in lands "protected" by 100-year levees. *Natural hazards*, *61*(2), 829-842.

NOAA. (2019). Calculating the Cost of Weather and Climate Disasters. *National Centers for Environmental Information (NCEI)*

Peters, E. (2012). Beyond comprehension: The role of numeracy in judgments and decisions. *Current Directions in Psychological Science*, *21*(1), 31-35.

Peters, E., Baker, D. P., Dieckmann, N. F., Leon, J., & Collins, J. (2010). Explaining the effect of education on health: A field study in Ghana. *Psychological science*, *21*(10), 1369-1376.

Peters, E., Hibbard, J., Slovic, P., & Dieckmann, N. (2007). Numeracy skill and the communication, comprehension, and use of risk-benefit information. *Health Affairs*, *26*(3), 741-748.

Petrolia, D. R., Landry, C. E., & Coble, K. H. (2013). Risk preferences, risk perceptions, and flood insurance. *Land Economics*, *89*(2), 227-245.

Petrova, D., Garcia-Retamero, R., Catena, A., Cokely, E., Heredia Carrasco, A., Arrebola Moreno, A., & Ramírez Hernández, J. A. (2016). Numeracy predicts risk of pre-hospital decision delay: A retrospective study of acute coronary syndrome survival. *Annals of Behavioral Medicine*, *51*(2), 292-306.

Ripberger, J. T., Krocak, M., Wehde, W., Allan, J.N., Silva, C. L., & Jenkins- Smith, H. C. (under review). Tornado warning reception, comprehension, and response in the United States.

Ripberger, J. T., Silva, C. L., Jenkins‐Smith, H. C., Carlson, D. E., James, M., & Herron, K. G. (2015). False alarms and missed events: The impact and origins of perceived inaccuracy in tornado warning systems. *Risk analysis*, *35*(1), 44-56.

Rizopoulos, D. (2006). ltm: An R package for latent variable modeling and item response theory analyses. *Journal of statistical software*, *17*(5), 1-25.

Rollason, E., Bracken, L. J., Hardy, R. J., & Large, A. R. G. (2018). Rethinking flood risk communication. *Natural hazards*, *92*(3), 1665-1686.

Shultz, J. M., & Galea, S. (2017). Mitigating the mental and physical health consequences of Hurricane Harvey. *Jama*, *318*(15), 1437-1438.

Siegrist, M., & Gutscher, H. (2006). Flooding risks: A comparison of lay people's perceptions and expert's assessments in Switzerland. *Risk Analysis*, *26*(4), 971-979.

Sitkin, S. B., & Weingart, L. R. (1995). Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity. *Academy of management Journal*, *38*(6), 1573-1592.

Sjöberg, L., & Drottz‐Sjöberg, B. M. (1991). Knowledge and risk perception among nuclear power plant employees. *Risk analysis*, *11*(4), 607-618.

Schwartz, L. M., Woloshin, S., Black, W. C., & Welch, H. G. (1997). The role of numeracy in understanding the benefit of screening mammography. *Annals of internal medicine*, *127*(11), 966-972.

Terpstra, T. (2011). Emotions, trust, and perceived risk: Affective and cognitive routes to flood preparedness behavior. *Risk Analysis: An International Journal*, *31*(10), 1658-1675.

Terpstra, T., & Lindell, M. K. (2013). Citizens' perceptions of flood hazard adjustments: an application of the protective action decision model. *Environment and Behavior*, *45*(8), 993-1018.

Whitfield, S. C., Rosa, E. A., Dan, A., & Dietz, T. (2009). The future of nuclear power: Value orientations and risk perception. *Risk Analysis: An International Journal, 29(3*).