Perceptions of Hurricane Destructiveness and Self-Reported Likelihood of Evacuation

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November 2008

This research was funded by a grant from the University of Colorado Natural Hazards Center through its Quick Response Research Program, which is funded by National Science Foundation grant No. CMMI0734304.

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Introduction

As society has continued to develop the coastal regions of the southeastern United States, hurricanes will pose ongoing challenges to coping, adjustment, and survival (Changnon, Pielke, Changnon, Sylves, & Pulwarty, 2000; Pielke & Sarewitz, 2005). The hurricane seasons of 2004 and 2005 produced storms resulting in record property losses, injuries, deaths, and psychological trauma. Hurricane Katrina was particularly noteworthy in this regard in that at least 1,810 people died (Louisiana Department of Health and Hospitals, 2006),81 billion US dollars of damage was done, and upwards of half a million people were evacuated to different geographic regions of the United States(Blake, Rappaport, Landsea, 2007). In addition to the property and monetary losses, hurricanes also pose significant challenges to psychological adjustment and coping (Norris, Perilla, & Murphy, 2001). Hurricanes can lead to significant increases in the incidence rate of posttraumatic stress disorder (PTSD) and other emotional problems in the aftermath of the storm (Norris, Perilla, Riad, Kaniasty, & Lavizzo, 1999).

The Saffir-Simpson Scale. To ensure physical safety and psychological well-being, it is important for the public in coastal areas to both obtain and to understand information that the National Hurricane Center provides about the path and intensity of an approaching hurricane. The Saffir-Simpson hurricane scale provides an indication of the storm's intensity based upon its maximum sustained winds (Simpson 1974; Simpson & Riehl, 1981). The Saffir-Simpson scale has been used widely over the last 30 years to convey hurricane intensity and destructive potential. Importantly, the Saffir-Simpson categorization is a linear and interval-level scale ranging from 1 (minimal damage) to 5 (catastrophic damage). For each increase in hurricane category (i. e., from 1 to 2, 2 to 3, and so forth), there is an approximately linear, uniform increase in the wind speed and the accompanying storm surge, as depicted in Figures 1a and 1b.

With linear increases in winds and tidal surges, the destructive potential of hurricanes increases exponentially. The weather public, however, may not fully understand the danger and destructiveness associated with each category of hurricane on the Saffir-Simpson scale. Corresponding to each numerical category of hurricane are the accompanying range of hurricane winds and the storm surge. Beyond the verbal descriptors that range from *Minimal* to *Catastrophic*, very little information is conveyed in the Saffir-Simpson scale about what the increasing magnitudes of winds *may actually do* in terms of damage to property, infrastructure, or threatening the loss of life. As part of its website, the National Hurricane Center has provided additional descriptive and historical information to illustrate the damage that can correspond to hurricanes of various intensities (http://www.nhc.noaa.gov/aboutsshs.shtml).

Hurricane Intensity. Although hurricanes are categorized and described according to linear increases in wind speed, the amount of kinetic energy dissipated by a hurricane, which relates to its danger, destructiveness, and lethality is related approximately to the third power of its sustained winds (Emanuel, 1998, 2005). That hurricane-related damage to property and infrastructure increases exponentially with wind speed (and the Saffir-Simpson classification of a hurricane) is provided in the work of Pielke and Landsea (1998) and Pielke, Gratz, Landsea, Collins, Saunders, and Musulin (2008). In examining the normalized costs of hurricanes from 1900 to 2005, both potential and actual costs of hurricane damages increased exponentially as a function of hurricane category. Compared to a category 1 hurricane, category 2 hurricanes resulted in approximately 7 times the amount of damage and a category 3 storm could potentially produce 18 times the damage. A category 4 hurricane produced about 98 times the damage as a category 1 storm and a category 5 hurricane resulted in 144 times the damage on average (Pielke et al., 2008). Along with such damage from winds and storm surges that flow inland, deaths from hurricanes also increase dramatically with increases in storm category (Blake, Rappaport, Jarrell, & Landsea, 2005).

Perceptions of Hurricane Intensity. Do coastal and inland residents in vulnerable areas realize that with each increase in hurricane intensity on the Saffir-Simpson scale that the destructive power of hurricanes increases exponentially? Several reasons can be cited to suggest that most people likely do not have this awareness. First, people may not readily understand that linear increases in one variable (i. e., in wind speeds) can result in exponential increases in a causally-related variable (i. e., in property destruction). Exponential relationships can be difficult to understand because people have been socialized in educational settings and other areas of life to use a *counting orientation* in processing relationships among quantities (Comfrey & Smith, 1994, 1995). This orientation emphasizes that: addition and subtraction are the basic mathematical operations, the basic unit of growth/increase is 1, and that multiplication stems from repeated addition, among other things. Although people can understand that particular values of one variable *correspond* to values of another variable, the counting orientation may preclude a deeper understanding of *how* the two variables such as hurricane intensity and its destructive power *covary* with each other (Comfrey & Smith, 1994).

A second reason that people may not understand exponential relationships stems from the widespread use of the intuitive, but often erroneous rule, *Same A-Same B* (Stavy & Tirosh, 2000). That is, when people are comparing quantities within an object or system, they may conclude that because $A_1 = A_2$, that the same relationship holds for other quantities in the system, $B_1 = B_2$. In actuality, however, $B_1 \neq B_2$. Stavy and Tirosh presented a wide range of examples in which a majority of both children and adults exhibited difficulties in comprehending inequalities in covariation relationships. Within some domains the tendency to make the *Same A-Same B* error becomes more pronounced with age. With respect to using the Saffir-Simpson scale, this error would manifest in the form of assuming that the difference in the destructive potential between a category 2 and a category 3 storm *is equivalent* to that between a category 3 and a category 4 storm *because* the increases in wind speed between the these storm categories is the same. The *Same A-Same B* strategy is very similar to the *Linear Default* assumption from the fields of epidemiology and risk analysis in which the risk one experiences is seen directly related to the dose that is received (Wilson & Crouch, 2001). In the present context the linear default assumption would suggest that the risks associated with a hurricane depends linearly upon the intensity of the storm

Two prior studies have documented that the public is susceptible to the the *Same A-Same B* error or that they use the *linear default* assumption when evaluating hurricane risks (Stewart 2007). In the first study, 75% of 346 undergraduate students who evaluated, using an open-ended format, the relative monetary costs of damages of increasingly intense hurricane produced linearly increasing damage estimates. In the second study, conducted when hurricane Ernesto threatened the United States east coast in 2006, 50% of 402 randomly-sampled coastal-dwelling residents evidenced the same linear pattern or responses that underlies the underestimation of hurricane damage potential (Stewart 2007).

Finally, people may be prevented in understanding the magnitude of a hurricane of any given category because of what this author refers to as the *sub-exposure effect*. The Saffir-Simpson intensity of a hurricane is based upon a storm's *maximum sustained* winds, which often occur very close to the eye wall of storm. Compared to the total areal extent of the named storm and the segments of coastal or inland areas under a hurricane warning, only a very small part of any given storm may expose people to the corresponding levels of winds, storm surge, and ensuing damages. A much larger proportion of people actually may experience meteorological conditions that are of a lesser magnitude that those that are closer to the hurricane's eye. Thus, exposure to or experience with weaker storm effects that are ostensibly attributed to a storm of a given intensity on the Saffir-Simpson scale may result in a systemic underestimation of hurricane damage potential. Sub-exposure to hurricane intensities in this manner for long-time coastal dwelling residents may provide evaluative *anchors* that contribute to their self-perceptions as being *storm-hardy* or *storm-resilient.* Such sub-exposure and anchoring effects may lead the people to discount the severity of subsequent storms so that they do not make preparations or evacuate (Dash and Gladwin 2005; Glantz 2005).

Research Questions

This review of the literature naturally leads to two primary research questions that the author will empirically address in this project. First, what are peoples' perceptions of the destructive potential of hurricanes that exemplify the five Saffir-Simpson categories? Part of this question also involves examining how perceptions of hurricane destructiveness vary with changes in hurricane intensity. To what extent will people utilize produce linear (*Same A-Same B*) damage profiles when evaluating hurricane destructiveness? Alternatively, what proportion of people will demonstrate an awareness of the exponential increase in hurricane damage with increasing hurricane intensity? The pursuit of this question represents a replication of Stewart (2007) using a slightly different methodology.

The second research question follows from the first: Is there another way to convey the destructive potential of hurricanes within each Saffir-Simpson Category so that people exhibit a greater degree of preparatory attitudes ahead of a major hurricane (i. e., are more willing evacuate)? A plausible alternative for communicating hurricane destructiveness involves comparisons of hurricane damage potential with category 1 storms after Piekle and Landsea (1998) and Pielke et al. (2008). Here, a category 2 hurricane can be described a potentially causing 7 times as much damage as a category 1 storm. Similarly, a category 3 storm may result in 18 times the damage as a category 1 hurricane. How might such an alternative way of communicating hurricane information affect the public's attitudes towards preparations ahead of the storm?

Hypotheses. Regarding the first research question and following from the author's prior research (Stewart, 2007), it was hypothesized that a majority of people will not be aware of the exponential growth of damage that is possible as hurricanes increase in intensity. Instead, people will produce linearly (*Same A-Same B*) response profiles or some other pattern that underestimates destructive potential. Concerning the second research question, it was hypothesized that the use of exponentially increasing damage potential information will result in greater self-reported likelihood for evacuation with increasing hurricane intensity compared to the use or naming of a Saffir-Simpson category only.

Research Methodology

Participants. The participants were 396 randomly selected people who lived in a county that adjoined the Gulf of Mexico or the Atlantic Ocean. The participants were selected through random digit dialing procedures that were conducted by the University of Georgia Survey Research Center. The sample included 127 men and 269 women. There were 321 (81%) Caucasian American participants, 39 (10%) African Americans, 15 (4%) Hispanic Americans, 7 (2%) Asian American, and 3% multi-ethnic or other. The mean age of the participants was 56.4 years and the median was 58.0 years (standard deviation = 16.1 years). The participants' ages ranged from 18 to 91 years. The participants reported that they had lived along the coastal region for a mean of 30.4 years (median = 26 years, standard deviation = 21.3 years, range = 88 years). Men and women in the sample did not differ with respect to their age or the amount of time that they lived along the coast. Ethnicity was equally represented among the sample gender and people of different races did not differ with respect to their age or the time that they had lived in the coastal region.

Survey Instrument. A copy of the survey instrument is included in the appendix of this report. The current instrument was based upon a very similar survey that Stewart (2007) used to examine perceptions of hurricane destructive potential in a sample of coastal dwelling residents on the Atlantic coast of the United States in 2006. The current survey comprised three sections. The first section inquired first about the individual's self-reported understanding of what is meant by hurricanes of different categories. In this question the Saffir-Simpson scale was not explicitly mentioned. The respondents used a 5-point rating scale (1 = *No Understanding at All* to 5 = *Complete Understanding*); all numerical points had verbal exemplars. Questions 2 through 5 asked the participants to use a 1 to 1000 scale to indicate the amount of damage to their community that would be produced by a direct hit of hurricanes of different categories. A category 1 hurricane was used as the evaluative anchor and participants then provided damage estimates for hurricanes in categories 2 through 5 compared to a category 1 storm. For example, item 2 read as follows: *If a Category 1 hurricane directly struck your community and produced an amount of damage that is represented by the number "1," what number would you think best represents the amount or degree of damage to your community that would be produced by the direct hit of a Category 2 hurricane? (Please say a number between 1 and 1000 or indicate that you do not know).*

In the author's prior research on perceptions of hurricane destructiveness, the participants were given instructions to produce open-ended damage estimates, i. e., no endpoints or scales were used so that the participants in these studies would not feel either constrained or cued in the responses by the framework of a scale that was provided (Stewart, 2007). Based upon this earlier work, however, and given the fact that from Pielke et al. (2008) that normalized damages can increase exponentially with increasing hurricane intensity, it was thought that a 1 to 1000 potential damage scale would be sufficiently open-ended and unconstraining to allow people to produce exponentially increasing damage estimates if they perceived or were aware of them. Thus, this section of the survey represented an effort to replicate the results of Stewart (2007) using a different methodology.

The second section of the survey instrument, item 6, existed in two different versions, the first of which was a simple and unelaborated report of a hurricane's intensity based upon the Saffir-Simpson scale while the second conveyed damage capabilities that increased with each category of hurricane (i. e., increased exponentially). The respondents, after hearing the various part of item 6 then used a 7-point rating scale (1= *Extremely Unlikely*, 2 = *Moderately Unlikely*, 3 = *Somewhat Unlikely*, 4 = *Not Sure*, 5 = *Somewhat Likely*, 6 = *Moderately Likely*, and 7 = *Extremely Likely*) to indicate the likelihood of evacuating their home if government officials recommended it. Each numerical rating point in the scale was provided with a verbal exemplar to make the scale as clear and unambiguous as possible. For the condition in which the intensity was based upon the Saffir-Simpson scale alone, the phrasing for a category 3 hurricane was: *If a Category 3 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it?* By comparison, the corresponding item in the condition in which damage potentials were presented in exponential format read: *If a hurricane were forecasted to directly strike your community and the hurricane was now capable of producing 18 times as much damage in your community compared to when it first became a hurricane, how likely would you be to evacuate your home if the government officials in your community recommended it?* p(See the appendix for a full listing of the items). The Participants were randomly assigned to receive either the Saffir-Simpson intensity information or that provided by the exponential format.

The third section of the survey (items 7 through 12) collected factual and demographic data from the respondents that included age, race, and gender. The participants also indicated the length of time that they lived along the coastline (in years), whether they had ever been evacuated from an area because of the threat of a hurricane, or whether their or their family's property sustained damage from a hurricane (both *yes* or *no* in format).

Procedures. Prior to the conduct of the project, both the research design, survey procedures, and survey instrument was evaluated and approved by the University of Georgia Institutional Review Board. The data collection was accomplished by the University of Georgia Survey Research Center (SRC). The SRC assists the research mission of the University of Georgia by providing a wide range of design and analysis consultation services, data collection, and data analysis. The SRC was provided with the 12-item survey and the two alternate versions of item 6 that were randomly administered to people who were contacted to participate in the survey. The appendix contains the telephone script that was used to enlist participants for this study.

The survey procedures involved contacting people residing in 49 Gulf Coast counties through a random-digit dialing process. All of the counties bordered the Gulf of Mexico in the states of Texas, Louisiana, Mississippi, Alabama, and Florida. The SRC contacted 1,109 coastal residents to obtain the sample of 396; the cooperation rate was 36%. Using a sample size of 396 people the sampling error is no greater than ±5%. That is, if 50% of the sample gave a certain response to a question, one can be 95% certain that between 45 and 55% of the population as a whole would give that same response.

The SRC collected the data from September 4 to 9, 2008. This time interval was chosen because it was a very active time for hurricanes in the Caribbean Sea and the Gulf of Mexico (See Figures 2 and 3). On September 1, 2008 Hurricane Gustav made landfall in southwestern Louisiana as a strong category 2 hurricane. At this time Tropical Storm Hanna and Hurricane Ike were moving into positions that would threaten the Gulf and Atlantic coasts of the United States. Then Tropical Storm Hanna made landfall along the South and North Carolina coastlines on September 6th. Finally, Hurricane Ike struck the Galveston Bay area of Texas on September 13th, 2008 as a strong category 2 hurricane. This timeframe was purposely chosen for the survey for two reasons. First, when hurricanes are active and with several days of threatening coastal residents the storms are much more *perceptually salient* (Stokols, 1979). This perceptual salience also tends to be accentuated by widespread media coverage of the threats posed by major hurricanes. This means that residents within coastal counties would be more likely to be gathering information about the hurricane threat. Second, collecting data within several days of an actual hurricane threat coincides with the timeframe when people make decisions about how to best prepare for the hurricane and whether they should evacuate. Thus, to maximize the external validity of the study, the data were collected when hurricanes were posing real or potential threats to coastal residents.

Data Analyses. Robust estimation techniques were used to calculate measures of location/central tendency and in testing the project hypotheses (Wilcox 2005). In this regard, the participants' responses to survey items that used rating scales were treated as ordered categories. Such a data analysis approach can provide greater statistical power and relies less upon the data possessing a normal distribution.

Results

Understanding of Hurricane Categories. Approximately 94% (N = 353) of the respondents reported that they had *some, much, or complete* understanding of what is meant by hurricanes of different categories. The median level of understanding was 4.0 and the 20% trimmed mean was 4.43 (standard error = .06). The remaining 6% of respondents indicated *little* or *no* understanding of hurricane categories. This result suggested that most people had a working understanding of what is meant by the Saffir-Simpson hurricane categories. Understanding of hurricane categories was not related to age, years of coastal residence, or the participant's race.

Prior Experiences with Hurricanes. There were 194 (49%) people who indicated that they had evacuated their homes previously because of a hurricane. Additionally, 288 (73%) people indicated that they or their families sustained property damage from a hurricane. Sustaining property damage and evacuating were related, X^2 (N = 396, df = 1) = 14.67, $p < .0001$, $r_\Phi = .19$. People who experienced hurricane damage to their property also were more likely to have evacuated than people who had not experienced such damage; this statistic only conveys an association and is not meant to imply any causal relationships. The degree of self-reported understanding of hurricane categories was related to whether or not the survey participants had experienced property damage previously. People who reported prior property damage (mean = 4.28, median = 5.00) had significantly greater understanding of hurricane categories than those who had not reported property damage (mean = 3.93, median = 4.00, Mann-Whitney U = 12094.5, $p < .0001$). There were no statistically significant relationships of race with prior hurricane evacuations or with sustaining property damage.

Hurricane Damage Perceptions. Figure 4 depicts the three types of hurricane damage profiles that emerged when the survey participants were asked to use the 1 to 1000 scale to estimate the degree of damage that would result to their community following a direct hit of hurricanes in categories 2 through 5. Participants were cued in each survey question that the damage produced from a direct hit from a category 1 hurricane was represented by 1; this was done to so that a category 1 hurricane served as an evaluative anchor for the subsequent ratings. Because some participants did not provide ratings for all levels of hurricane, data for 351 of the 396 participants was analyzed to address this question.

The hypothesis about damage perceptions was only partially supported. The most frequent profile involved exponential growth between categories 1 and 3, followed by a gradual, slower growth for higher category (3 through 5) hurricanes toward the maximum value of the scale. There were 155 (44%) participants who provided damage estimates that approximated this profile's shape. The second most frequent profile was an approximately linear one that was produced by 140 (40%) of the participants. This finding was in accord with the hypothesis. Finally, there were only 56 (16%) survey participants that produced an exponentially growing damage perception profile as hurricane categories increased from 2 to 5. That this profile was rare among the survey participants also was in accord with the hypothesis about hurricane damage perceptions.

It is interesting to note that although the survey administrators primed the participants in reading items 2 through 5 that a category 1 hurricane produced a 1 with respect to potential damage, the participants produced ratings for a category 2 hurricane that were at least 100 times as great. It also was noteworthy that the most frequent type of profile (quick exponential growth followed by a leveling off) produced the highest overall damage estimates compared to the linear and the exponential growth profiles. From Figure 4 one can see that the lowest overall damage estimates were produced by those participants who viewed damage as growing exponentially with hurricane intensity. An equation was developed for the ratings produced by this group. The equation demonstrated a good fit do the data.

$$damage\ estimate = 50.34 + \frac{10.31(e^{.79(category\#)} - 1)}{.79}$$

In follow-up analyses, no relationships were observed between the type of hurricane damage profile produced and gender, experience of prior hurricane damage, prior evacuation experience, gender, or years the person lived along the coast.

Both age and race were associated with the type of damage profile that the person produced. The respondents who produced exponential growth profiles (mean = 51.3 years) were significantly younger than those who produced the linear profiles (mean = 57.3 years, $p = .02$) and those who produced exponential growth towards the maximum value profiles (mean = 57.0 years, $p = .02$). Regarding race, compared to Caucasian and African Americans, Hispanic Americans produced proportionately exponential growth profiles (8%) compared to linear (46%) and exponential growth towards the maximum (46%), X^2 (N = 334, df = 4) = 14.10, $p < .007$, $r_\Phi = .21$.

Likelihood of Evacuation. A two-way mixed model (split-plot) analysis of variance was performed to examine the relationship of the survey participants' rated likelihood of evacuation as a function of the experimental group to which they were randomly assigned (Saffir-Simpson Scale versus Exponential) and the intensity of the hurricane (categories 1 through 5), which was a repeated measure factor (i. e., all participants provided evacuation likelihood ratings for all storm intensities).

The second hypothesis was supported. Statistically significant main effects were observed for both experimental group (F (1, 346) = 8.57, $p = .0036$) and for storm intensity (F (4, 1392) = 313.01, $p < .0001$). These main effects were qualified by a significant group by storm interaction, F (4, 1392) = 16.45, $p < .0001$. This interaction means that the survey participants' likelihood of evacuation ratings for storms of different intensities depended upon whether they were in the Saffir-Simpson or in the Exponential group. Figure 5 shows the mean evacuation likelihood ratings for each group as a function of storm intensity.

It is evident from Figure 5 that framing hurricane intensity communications in terms of exponentially increasing effects (compared to using Saffir-Simpson category names alone) resulted in significantly higher reported likelihoods of evacuating for both category 2 and category 3 hurricanes. With respect to a category 1 hurricane both groups indicated, using the evaluative anchors of the rating scale. that they were *somewhat unlikely* to evacuate if recommended to do so. The means of the Saffir-Simpson and exponential groups did not differ and this was not surprising as the category 1 hurricane was used as a standard of comparison and no exponential damage information was presented for a hurricane of this category. The differences between the groups were noteworthy and statistically significant for category 2 and category 3 storms. People were *moderately likely* to evacuate when they were informed that the hurricane was capable causing seven times the damage as when the storm first became a hurricane. People who received the Saffir-Simpson category information alone were *Not Sure* whether they would evacuate. For a category 3 hurricane, the survey participants in the exponential information group were *Moderately Likely* to evacuate compared to those in the Saffir-Simpson group who were *Somewhat Likely* (see the plot of means in Figure 5). The survey participants in the exponential group produced higher mean values of evacuation likelihood for both category 4 and category 5 hurricanes, although the difference with the Saffir-Simpson group was not statistically significant at the category 5 level.

Contributions of Prior Evacuation and Damage Perception Profiles. The author conducted several ancillary analyses to explore the contributions of peoples' past hurricane evacuations and their perceptions of hurricane damage to their reported likelihood of evacuation. Here, the effects of prior evacuation (yes or no) and the type of hurricane damage profile that the participants produced (linear, exponential growth, exponential growth to a maximum) were added to the mixed model analysis of variance whose results were reported above.

The survey participants who reported that they had evacuated for a previous hurricane (mean = 5.80) indicated that they were significantly more likely to evacuate again if government officials recommended it compared to people who had not evacuated previously, mean = 5.07, F (1, 1392) = 18.77, $p < .0001$. Expressed in terms of the rating scale verbal anchors, people who evacuated previously were *moderately likely* to evacuate again whereas those who never had evacuated previously were *somewhat likely* to do so. The prior evacuation variable did not interact with any of the other variables (i.e., storm intensity, group).

The type of damage profile that participants produced was significantly related to their reported likelihood of evacuating for a hurricane, F (2, 1392) = 3.19, $p = .04$. The 56 survey participants who exhibited exponential growth perceptions of hurricane damage potential (mean = 5.69) indicated that they were significantly more likely to evacuate if it was recommended compared to the 140 participants who produced linearly increasing damage perceptions (mean = 5. 13). The participants who exhibited exponential growth toward the maximum (N = 155, mean = 5.48) did not differ significantly in their reported likelihood to evacuate compared to the exponential or linear growth groups.

No additional variables were related to the reported likelihood of evacuation (i. e., experience of prior hurricane damage, age, years lived along the Gulf Coast, gender, or race).

Discussion

The ability to conduct a survey that included both random sampling and random assignment has provided new and interesting perspectives on Gulf coast residents' perceptions and intended behaviors regarding hurricanes. As expected, a minority of respondents (16%) indicated an understanding of hurricane destructive potential that is roughly in accord with what is known about the physical properties of hurricanes (Kerry, 2005) and the damage that hurricanes at different intensities can inflict upon coastal regions (Pielke et al., 2008). Similarly, it was expected that a larger proportion of the respondents would produce a linear profile of potential damages for the reasons outlined in the literature review. Compared to people exhibiting an exponential growth perception profile, there were significantly more people (40%) who produced perceptions that hurricane destructiveness increased linearly with hurricane intensity. In this regard the first hypothesis was supported.

An unexpected finding was that a majority of the survey respondents produced an exponential growth profile that leveled off toward the maximum value of the scale (i. e, a value of 1000). There are two possible explanations for this, the first of which it that beyond a category 1 or 2 hurricane, people viewed the major hurricanes (i. e., category 3 or higher) as quite destructive and less variable in their destructive extent that people who exhibited unlimited exponential growth profiles. No follow-up analyses indicated a possible basis for the endorsement of the exponential growth towards the maximum profile. That is, one might conjecture that people who have experienced property damages from hurricanes, and/or who have evacuated due to a hurricane may exhibit a kind of precautionary appreciation of hurricane destructiveness that is conveyed in a quick rise towards the higher ends of the 1000 point scale. Alternatively, one might conjecture that a lack of experience (i. e., less years lived along the coast) might produce a fearful, *all are destructive* perception of hurricanes. Again, nothing in variables of the survey was found that would support this conjecture.

A second possible explanation is that the finding of an exponential growth towards the maximum is an artifact of the 1 to 1000 potential damage scale that the author used. That is, supplying people with a minimum and maximum value of a rating scale for a task such as hurricane destructiveness may cue then how about to respond or what the researcher has in mind about the way the scale should be used. That people *used-up* the scale fairly quickly is evidenced by the exponential growth towards the maximum followed by a leveling off (see Figure 4). Stronger support for this latter explanation also comes from Stewart (2007). In a methodologically similar study of randomly-sampled coastal residents, *no* exponential growth towards a maximum value was observed among the participants. The dominant profiles were linear (64%) followed by exponential growth (36%). The important difference in Stewart (2007) was that the respondents were asked in an open-ended format to provide numerical hurricane damage estimates. No ratings scales or endpoints were used as in the present study. Regardless, the research reported here replicates the findings of Stewart (2007) in observing that the exponential growth profile was the least frequent and was less than one half as prevalent as linear perceptions of hurricane destructiveness.

The other noteworthy findings from the follow-up analyses on perceptions of destructiveness were that Hispanic Americans had proportionately less understanding of the exponential growth in hurricane damage that could result compared to people of other races. The reasons for this finding are not clear and cannot be determined from the data that was collected. One conjecture is that some portions of the Hispanic Americans in the sample have only more recently learned to speak English and thus may not have been exposed as long to information that could educate them about hurricane dangers in the United States.

The author's second hypothesis received support: people provided with exponentially increasing damage estimates of hurricanes reported greater likelihoods of evacuation compared to those with hurricane category information that was unelaborated. Although differences between the two formats were not pronounced for category 4 and 5 hurricanes, there was a significant and practical level of difference between the formats for category 2 and 3 storms. Increasing the likelihood of coastal residents' compliance with evacuation orders is an important priority in that 39 (55%) of the 52 deadliest hurricanes between 1851 and 2004 were category 2 or 3 in intensity (Blake et al., 2007). Similarly 30 of the 50 most damaging hurricanes were category 2 or 3 storms (Pielke et al., 2008). Because perceptions of hurricane intensity are an important predictor of actual evacuation behavior (Whitehead, et al. 2000), framing the destructive potential of hurricanes in a way that more truly renders their actual behavior should become an important priority.

Recommendations. With these findings the author is not advocating the replacement of the Saffir-Simpson scale. The longevity of the scale, its popularization among the United States public over many successive hurricane seasons, and its demonstrated value in conveying hurricane information all argue for its continued use. The results of this project as well as Stewart (2007) indicated that people were familiar with the Saffir-Simpson scale. Consequently, the scale should be retained as an *abscissa* or *x-axis*. What needs to be added to each hurricane category on the *x-axis* is greater explanation and dissemination of the destructive potential that occurs as an *ordinate* or *function* of the hurricane category. In practice, this means not only categorizing hurricane winds and storm surge, but also characterizing how *destructive potential increases exponentially with increases in category*. The emphasis here is upon helping the public understand the *form of the relationship* that exists between hurricane winds and destructiveness, not upon the provision of conceptual anchors, fixed numbers, or categorical predictions of destructiveness. The use of the latter in communications runs of the risk of predicting dire consequences that, if or when they fail to materialize, can lead to the experience of a false alarm and lack of responsiveness subsequently (Dow & Cutter, 1998). That an awareness of the *exponential form* of the relationship between hurricane intensity and destructiveness may have benefits for the public was indicated in the follow-up analyses of evacuation likelihood. Although the exponential growth group produced some of the numerically lowest overall damage estimates compared to the linear and exponential growth towards the maximum group, the former group expressed significantly *greater* likelihoods of evacuation. Subsequent research should examine this relationship further.

A second recommendation concerns the *uniformity myth* that all people in an affected coastal region hear, perceive, and act upon hurricane warning information in the same (or uniform) manner. As this research (as well as Stewart 2007) has demonstrated, people differ in the destructive potential they attribute to hurricanes of differing intensities. The *form of relationship* that the person perceives between intensity and destructiveness may be a significant contributor to one's likelihood to evacuate. Additionally, the results of this project suggested that older persons and Hispanic Americans may not fully understand the destructive potential of hurricanes. These groups should be examined further and also targeted for additional education efforts so that their decisions about hurricane preparedness and evacuations can be more fully informed.

A third recommendation concerns research methodology. Subsequent social science studies should weigh the potential benefits of conducting hurricane-related research ahead of an approaching hurricane. The days before a hurricane makes landfall provides an externally-valid timeframe for studying peoples' decision-making regarding hurricane preparation and evacuation. As in this study, using a survey research center to obtain a modest amount of data from an acceptably large sample may provide insights regarding hurricane perceptions, thoughts, and behaviors in real time. Another methodological recommendation concerns the study of hurricane damage perceptions. The author in the present study attempted to replicate a previous finding (e. g., Stewart 2007) using a different rating scale method. For reasons discussed above, subsequent research may benefit from using an open-ended format for soliciting perceptions, especially if there are concerns that supplying respondents with an upper limit may provide cues on how they should respond.

Limitations. There are two limitations to this study, the first of which concerns the self-report nature of the data. Although the survey questions are straightforward and brief in nature, this may not have precluded people from responding when they were unsure about an item in the survey. Further, self-report data can be affected by motivations of the survey participants to present themselves in the most positive light as possible. The second limitation stems from the first. That is, the survey did not behaviorally assess what people did by way of evacuation when Hurricanes Hanna and Ike affected the Gulf Coast of the United States. People may behave differently than their verbal responses suggest. Nonetheless, using a random sample and random assignment procedures, people in the exponential information condition indicated a greater likelihood of evacuating compared to the standard Saffir-Simpson information alone.

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Appendix

Hurricane Destructiveness Survey Questions

1. How much understanding do you have of what is meant by a Category 1 Hurricane, a Category 2 Hurricane, and so forth?

1 = No understanding at all
2 = Little or minimal understanding
3 = Some understanding
4 = Much understanding
5 = Complete understanding

2. If a Category 1 hurricane directly struck your community and produced an amount of damage that is represented by the number "1," what number would you think best represents the amount or degree of damage to your community that would be produced by the direct hit of a Category 2 hurricane? (Please say a number between 1 and 1000 or indicate that you do not know).

3. If a Category 1 hurricane directly struck your community and produced an amount of damage that is represented by the number "1," what number would you think best represents the amount or degree of damage to your community that would be produced by the direct hit of a Category 3 hurricane? (Please say a number between 1 and 1000 or indicate that you do not know).

4. If a Category 1 hurricane directly struck your community and produced an amount of damage that is represented by the number "1," what number would you think best represents the amount or degree of damage to your community that would be produced by the direct hit of a Category 4 hurricane? (Please say a number between 1 and 1000 or indicate that you do not know).

5. If a Category 1 hurricane directly struck your community and produced an amount of damage that is represented by the number "1," what number would you think best represents the amount or degree of damage to your community that would be produced by the direct hit of a Category 5 hurricane? (Please say a number between 1 and 1000 or indicate that you do not know).

Randomized Condition #1:

6. If a Category 1 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it? Please use the following scale.

1 = Extremely Unlikely
2 = Moderately Unlikely
3 = Somewhat Unlikely

4 = Not Sure
5 = Somewhat Likely
6 = Moderately Likely
7 = Extremely Likely

Using this same scale, if a Category 2 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a Category 3 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a Category 4 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a Category 5 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it?

Randomized Condition #2:

6. If a Category 1 hurricane were forecasted to directly strike your community, how likely would you be to evacuate your home if the government officials in your community recommended it? Please use the following scale.

1 = Extremely Unlikely
2 = Moderately Unlikely
3 = Somewhat Unlikely
4 = Not Sure
5 = Somewhat Likely
6 = Moderately Likely
7 = Extremely Likely

Using this same scale, if a hurricane were forecasted to directly strike your community and the hurricane was now capable of producing 7 times as much damage in your community compared to when it first became a hurricane, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a hurricane were forecasted to directly strike your community and the hurricane was now capable of producing 18 times as much damage in your community compared to when it first became a hurricane, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a hurricane were forecasted to directly strike your community and the hurricane was now capable of producing 98 times as much damage in your community compared to when it first became a hurricane, how likely would you be to evacuate your home if the government officials in your community recommended it?

If a hurricane were forecasted to directly strike your community and the hurricane was now capable of producing 140 times as much damage in your community compared to when it first became a hurricane, how likely would you be to evacuate your home if the government officials in your community recommended it?

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7. Have you ever been evacuated from an area because of the threat of a hurricane?

1= Yes
2 = No

8. Have you ever experienced a hurricane in which your property or your family's property was damaged?

1 = Yes
2 = No

9. What is Your Age? (years)

10. What is Your Race?:

11. Gender:
Male Female

12. For approximately how long have you lived along the Gulf Coast? (years)

Survey Research Center Telephone Script

Gulf Coast Hurricane Study

Hello, my name is [NAME], and I'm calling from the University of Georgia in Athens. The Survey Research Center in conjunction with the Department of Counseling and Human Development, is conducting a short survey this evening a survey of opinions regarding Gulf Coast residents' perceptions of hurricane damage, and I'd like to interview a member of your household. Would you be willing to help us out for a few minutes this evening? (The interview should last about 5 – 7 minutes).

INTERVIEWER: IF RESPONDENT HAS ANY QUESTIONS READ

You can call Dr. Alan Stewart, Associate Professor at the University of Georgia at 706-542-1263 with any questions about this research study. All research at the University of Georgia is governed by an Institutional Review Board to protect your rights as a participant. If you have any questions about your rights as a research participant you may contact the Institutional Review Board at 706-542-3199 or email at IRB@uga.edu.

In order for the results of the survey to be representative of the state's population, I need to speak to the adult aged 18 or older in the household who last celebrated a birthday. Would that be you?

1. Yes [CONTINUE]
2. No [WHEN WOULD BE A GOOD TIME TO REACH THAT PERSON?]

   [REINTRODUCE YOURSELF AND THE STUDY OR ARRANGE TIME FOR CALL-BACK AND GET THE RESPONDENT'S FIRST NAME]

Great! Before I start, I need to let you know that any information you provide for me will be kept strictly confidential and your participation is completely voluntary. You can skip any questions you don't want to answer, and you may discontinue participation at any time if you. No risk or discomfort is anticipated from participation in this study, and you will benefit by providing data that may help improve how people deal with the effects of natural disasters. Also, my supervisor may listen to part of the interview for quality control purposes.