



Houston Strong: Linguistic Markers of Resilience after Hurricane Harvey

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Abstract

Objective: Hurricane Harvey was one of the most destructive hurricanes in United States' history and negatively impacted a majority of Houstonians. It is not uncommon for individuals who are exposed to a natural disaster, like a hurricane, to develop debilitating trauma symptoms. However, for those individuals who do not manifest clinically significant trauma symptoms, it has been hypothesized that one important variable in post-disaster functioning is resilience. The broad aim of this study was to determine if the language individuals used to write about their experience of Hurricane Harvey would be associated with their resilience later on, with the ultimate goal of understanding if linguistic analysis adds valuable information to our assessment of the projected course of mental health after a natural disaster.

Method: Using a sample of Houstonian adults, the computer program Linguistic Inquiry and Word Count (LIWC) was used to analyze narratives about Harvey, collected online in response to a brief prompt shortly after the event. Specific linguistic markers were examined to determine associations with an individual's resilience six months post-disaster.

Results: Results indicate that greater use of 'discrepancy' words (e.g., should, would) and fewer 'see' (e.g., saw, images), and 'focus past' words (e.g., ago, did) significantly predicted resilience six months later.

Conclusion: Findings suggest that linguistic analysis has the capacity to contribute to the prediction of resilience after disasters and holds promise for large-scale assessment of psychological functioning after a hurricane.

Keywords

Linguistic Analysis, Resilience, Trauma, Stress, Natural Disaster, Hurricane Harvey, Assessment

Introduction

Hurricane Harvey was one of the most destructive hurricanes in the history of the United States and negatively impacted many Houstonians. Indeed, it is estimated to have caused nearly \$125 billion dollars in damage [1], and resulted in over 80 fatalities. In fact, a majority of Houstonians were affected in some way—through home and vehicle damage as well as disruptions in employment and income [2]. Along with the physical destruction, a survey suggests that 32% of

individuals in the Texas counties affected by Harvey reported adverse effects to their mental health (e.g., taking new medication for mental health problems, increased alcohol use) as a result of the hurricane, with 18% specifically reporting worsened mental health [2]. It is not uncommon for individuals who are exposed to a natural disaster, like a hurricane, to develop trauma symptoms [3-6]. However, for those individuals who do not manifest clinically significant trauma symptoms, it has been hypothesized that one important variable in post-disaster functioning is resilience [7,8]. With this in mind, the broad aim of this study was to determine if the language individuals used to write about their experience of Hurricane Harvey would be associated with their resilience later on, with the ultimate goal of understanding if linguistic analysis adds valuable information to our assessment of the projected course of mental health after a natural disaster.

In the aftermath of a natural disaster, such as a hurricane, many individuals will experience debilitating posttraumatic stress disorder (PTSD) symptoms [4-6,9], such as intrusive re-experiencing, avoidance of trauma related stimuli, increased psychological arousal, and mood-related changes [10]. Indeed, a prior meta-analysis found that up to 85% of individuals will experience acute stress symptoms after being exposed to a natural disaster [5], however, the prevalence of PTSD after a natural disaster is variable, ranging from five to 60% [4]. This range suggests that although many individuals' mental health is negatively affected in the immediate aftermath of a natural disaster, there is variability in their trajectory of mental health problems over time. Specifically, a notable portion develop PTSD but many individuals do not go on to develop psychopathology [4,6,11] and instead, employ characteristics of natural coping and demonstrate the capacity to return to their pre-disaster level of functioning without intervention [12,13]. Resilience is defined as the characteristics that allow individuals to effectively deal with adversity [8]. Though resilience in the context of Hurricane Harvey has not been empirically examined, it was detected in a prior longitudinal study that tracked Texas residents' trauma symptoms after Hurricane Ike. Researchers found that five percent of participants met criteria for PTSD two to five months post hurricane, but a majority of those individuals experienced a resolution of their symptoms, demonstrating resilience, when evaluated three months later [9]. Although five percent of participants may seem minor, in the context of a major city such as Houston, that fraction represents over 100,000 individuals. As such, there is a great need to understand how to identify individuals who, after the emergence of significant trauma symptoms, will demonstrate resilience—a piece of information that could assist in the effective allocation of post-disaster mental health resources.

Recent research has aimed to better understand how to assess symptom severity and treatment progress for those who experience traumatic events, with an eye towards detecting those who will be resilient in the aftermath of a trauma [14-16]. Indeed, there are several limitations inherent to the current methods (e.g., self-report, clinical interviews) of measuring psychological functioning generally, and predicting the trajectory of functioning specifically, particularly in a post-disaster environment when resources are scarce [17-20]. Advances in technology have been a tremendous asset in utilizing novel methodologies, and accumulating research highlights the

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value of conducting linguistic analysis to provide greater insight into individuals psychological functioning both concurrently and over time [21-23]. To date, the most common method of linguistic analysis uses the computer program Linguistic Inquiry and Word Count (LIWC; [24]). LIWC is a computer program that analyzes language by searching for and counting psychologically-relevant words across multiple text files [25]. LIWC analyzes every word in a narrative, determines if it is in the dictionary, and then places the word into a category. For instance, the word “the” is determined to be in the dictionary, and is then categorized as an article, whereas the word “hurt” would be put in the category emotionality and then specified as a negative emotion word. LIWC is also able to produce objective characteristics of the narrative, such as word count, narrative length, and use of speech fillers (e.g., um, like, you know; [26]). Thus, LIWC is able to evaluate a narrative and transform subjective content into objective data.

Prior research using LIWC broadly indicates that LIWC assesses three processes particularly relevant to individuals’ symptomology and well-being after a traumatic event: emotionality, attentional focus, and thinking styles. Emotionality is a measure of how an individual experiences the world by examining the extent to which emotion words (positive or negative) are used, how the emotion words are expressed, and the valence of such words [25]. Attentional focus provides additional information on an individual’s processing, priorities, and intentions by analyzing pronoun use and verb tense [25]. For instance, if an individual is experiencing emotional pain it is more likely that first-person singular pronouns will be used as the individual is more likely to focus on himself [27]. Lastly, thinking style is evaluated by examining nouns, verbs, conjunctions, and the cognitive process words that are used to connect thoughts; and this language use reflects how an individual interprets and processes information in their environment to make sense of it [25]. LIWC analyzes these broad processes by identifying specific linguistic markers that correspond to 80 different categories, which are simple (e.g., articles) to complex (e.g., cognitive process words).

LIWC is able to evaluate language beyond the surface level content an individual is expressing to gain more in-depth data on psychological symptoms and processing, which has implications for using LIWC to objectively measure cognitive and affective states. In fact, recent research indicates that language use can predict the genetic expressions that are indicative of nonconscious well-being (e.g., stress, depression, anxiety) better than reported affective experience [28]. In other words, examining linguistic markers within narratives provides greater insight into individuals’ mental health and overall well-being than their subjective report of health and affective experience. Accordingly, these findings suggest that language use, and specifically LIWC metrics, have the ability to provide more objective measurement of cognitive and affective states than clinical interviews, which could potentially elucidate our understanding of resilience post-disaster.

Accumulating research suggests that LIWC metrics do in fact have the ability to capture relevant linguistic markers that are indicative of victim’s psychological state and trauma symptomology [9,29]. Specifically, existing literature on linguistic markers in trauma narratives has primarily been conducted using adults and has found emotion words, pronoun use, and cognitive process words to be the strongest predictors of trauma symptoms; additionally, increased word count and increased use of somatosensory detail have been shown to predict trauma symptoms [21,29-31]. In a meta-analysis

that reviewed 22 studies of linguistic markers of trauma symptoms, negative emotion words were found to be related to increased symptoms [29]; while, empirical data suggests a positive relation between trauma symptoms and singular pronoun use in general, and a negative association with third person plural pronouns (i.e., they; [28,31]). Additionally, greater use of cognitive process words, which are those that express causal and insightful thinking [e.g., 25], are linked to lower trauma symptoms [26,30], and there is some support for greater word count being indicative of increased trauma symptoms [22,23]. Finally, somatosensory detail has been determined to be important in trauma narratives, such that increased trauma symptomology is associated with greater references to body states [23,32] as well as tactile details (e.g. feel, touch; [22]). Therefore, although the literature base on language use in trauma narratives is in its early stages, empirical evidence is accumulating that suggests trends about which linguistic markers are relevant to trauma symptoms.

While the aforementioned literature has uncovered linguistic markers that are relevant to trauma symptoms, empirical research has yet to examine whether there are linguistic markers of resilience that can add predictive utility to our assessment of post-disaster functioning by detecting individuals who will demonstrate high levels of resilience after a natural disaster. In other words, we sought to examine if linguistic markers could detect resilience—as they have detected trauma symptoms in previous research—in a post disaster context in order to enhance our ability to measure trauma symptom trajectory and detect individuals who will be in need of long-term services. Against this background, the aim of the current study was to use narrative data collected online and the computer program LIWC to analyze the language use of adults in the greater Houston area and determine whether specific linguistic markers were associated with an individual’s resilience after Hurricane Harvey. As this is the first examination of language use in the context of resilience, no prior hypotheses were made, and data analyses were exploratory.

Method

Participants

The current study used data collected shortly after Hurricane Harvey (1 to 2-month post-disaster) and data collected six months post-disaster from the same participants. Participants had to be 18 years of age or older and reside in the greater Houston area at the time of Hurricane Harvey in order to participate. Participants ranged from 18 to 73 years of age ($M = 30.02$, $SD = 12.08$) and the racial/ethnic breakdown was as follows: 51.2% Caucasian, 6.5% Asian, 11.4% African-American, 26.0% Hispanic/Latina, and 4.5% Multiracial or other. Sample size varied by time point with measure at baseline $n = 123$ and at follow up $n = 61$. As such, only participants with complete baseline and follow-up data were included in this study. Notably, those participants who were missing follow up data were significantly different from those who completed both time points with regard to age, $t(117) = -2.947$ $p = .014$, race, Chi-Square = 16.443; $p = .014$, and education level, Chi-Square = 20.978; $p < .001$. Participants in younger age groups, of ethnic minorities, and “some college” were less likely to complete the follow up survey. In addition, participants who completed and did not complete the second assessment differed on resilience baseline scores $t(107.38) = -.197$, $p = .05$, with those who completed the second assessment reporting more resilience ($M = 78.60$) than those who did not complete the second assessment ($M = 73.02$). These factors all provide interpretive context reviewed in the discussion section. To ensure quality linguistic analysis, only

those participants who wrote about Hurricane Harvey using greater than 50 words was included in this study [25]. Six participants were excluded based on this criterion. Thus, the final sample used for this study was $n = 61$.

Procedure

Subjects were recruited for participation via Craigslist (an online advertisement website and discussion forum) and Reddit (social news and media aggregation website) using the Houston specifier, local listservs, and word-of-mouth. Interested individuals followed a provided link to the Qualtrics survey, read through a cover letter, and consented to the study by pressing next, at which time they were provided a space to enter their email, which was subsequently attached to an ID number. They then completed a battery of self-report questionnaires and provided a brief write up about Hurricane Harvey. Using the email participants provided, they were contacted to complete the six-month follow up survey, which consisted of a self-report battery and the same prompt to write about Hurricane Harvey. Upon completion of each survey, subjects were entered in a drawing for a chance to win one of three \$50 gift cards. IRB approval from the appropriate institution was obtained.

Measures

Demographics: To gather demographic information about the participants, several standard identifying questions were asked concerning age, gender, race/ethnicity, marital status, sexual orientation, education level, employment information (i.e., employed, hours per week, income). Participants were also asked how long they have lived in Texas, and specifically Houston, as well as residence type and how prepared they felt for Hurricane Harvey. Finally, to assess how affected they were by Harvey, participants responded to the question, "How were you affected by Hurricane Harvey? Check all that apply," with responses ranging from "witnessing flooding" to "loss of a loved one." This question was used to compute a count variable of the number of stressors to which individuals were exposed in order to control for the amount of Harvey-related stress in subsequent analyses.

Resilience: The Resilience Scale (RS-14; [33]), a 14-item self-report measure, was used at baseline and six-month follow-up to assess participants resilience. The measure contains five subscales of important factors of resilience: self-reliance, meaning, equanimity, perseverance, and existential aloneness. Subjects are asked to report their level of agreement with statements about themselves and their behavior on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). This yields a dimensional T-score rating of resilience, with higher scores indicating greater resilience. The measure demonstrated high levels of reliability in the current sample, with a Cronbach's alpha of .90.

Objective Language Analysis: To evaluate how participants responded to a prompt about Hurricane Harvey at baseline and follow-up, a content-analysis computer program, Linguistic Inquiry and Word Count (LIWC), was used. The prompt read, "Please write at least five sentences about Hurricane Harvey." The LIWC program was used to analyze the text from the written response and compute the total percentage of words in each linguistic category. These percentages were then converted to 100-point scales along a 0-100 dimension based upon "research-based composites" [34]. All linguistic markers and subcategories were explored in the current study.

Results

First, a paired-samples t-test was run in order to examine the differences in resiliency scores over time (i.e., between baseline and follow-up). The results indicate that there was no significant difference between resiliency at baseline ($M=78.28$, $SD=12.51$) and resiliency at follow-up ($M=79.23$, $SD=11.85$), $t(60) = -0.66$, $p = .51$. These results indicate that individuals who demonstrate resilience initially tend to maintain it six months later.

In order to examine whether specific linguistic markers were associated with an individual's resilience after Hurricane Harvey, correlations between the LIWC linguistic markers and resilience six months after Hurricane Harvey were conducted. Correlations indicated "discrepancy" words ($r = .356$, $p = .004$), a subcategory of cognitive process words, "see" words ($r = -.289$, $p = .022$), a subcategory of perceptual process words, and "past focus" words ($r = -.311$, $p = .013$) were all significantly correlated with an individual's resilience after Hurricane Harvey.

Given these findings, multiple regression analyses were used to test if these linguistic markers significantly predicted resilience six months after the natural disaster. However, we first examined whether we needed to control for age, gender, race/ethnicity, and how impacted the participants were by Hurricane Harvey. There was no significant correlation between age and resilience ($r = .17$, $p = .20$) nor was there a significant correlation between the impact of Harvey and resilience ($r_s = .04$, $p = .71$). Next, an independent samples t-test was conducted to examine whether differences existed in resilience by gender. There was no difference in resilience between males ($M = 81.86$, $SD = 10.96$) and females ($M = 79.04$, $SD = 12.24$); $t(61) = 0.77$, $p = .44$. An one-way ANOVA was also conducted to examine whether differences existed in resilience by racial/ethnic group, and there were no differences between racial/ethnic groups; $F(4,58) = 0.70$, $p = .60$. Therefore, gender and race/ethnicity were not included as covariates. Thus, resilience was entered as the dependent variable and the linguistic markers (i.e., "discrepancy" words, "see" words, "past focus" words) were entered as the predictor variables. The results of the regression indicated the three linguistic markers explained 28% of the variance in resilience, $R^2 = .28$, $F(3, 57) = 7.30$, $p < .001$. More specifically, it was found that "discrepancy," ($\beta = 0.34$, $p < .001$), "see" ($\beta = -0.24$, $p = .04$), and "past focus" ($\beta = -0.31$, $p = .01$) all significantly predicted resilience six months after Hurricane Harvey. In particular, "discrepancy" words were related to an increase in resilience while "see" and "past focus" were related to a decrease in resilience.

Discussion

The aim of the current study was to examine if the language used by Houstonian adults to write about their experience during Hurricane Harvey was associated with their resilience six-months later. More specifically, this examination was conducted with the broader goal of understanding if linguistic markers of resilience exist that can add valuable information to our assessment of trauma symptoms and projected course of individuals mental health after a natural disaster. Given that this is the first study to conduct an analysis of how language use post-disaster is related to resilience, data analysis was exploratory, and no hypotheses were made. Results indicate that certain linguistic markers, in an account about Hurricane Harvey, significantly predicted resilience six months later, namely greater use of 'discrepancy' words and fewer 'see' and 'focus past' words.

Although there is no prior literature related to language use and resilience, findings from the current study are consistent with other empirical data. Indeed, present findings suggest that greater use of discrepancy words (e.g., should, would), which is a subcategory of cognitive processing words, is indicative of greater resilience six months later. This is in line with existing literature which documents links between cognitive processing words and reduced trauma symptoms. Specifically, greater use of cognitive processing words in a trauma narrative have been found to be related to decreased trauma symptomology, such that they predict fewer trauma symptoms [30] and reduced symptom severity [26]. Similarly, the construct of cognitive flexibility, which is closely related to that of cognitive processing, has also been linked to decreased trauma symptoms; and more importantly, cognitive flexibility is associated with increased resilience to stress [35]. In other words, existing literature suggests that the more an individual demonstrates cognitive processing and flexibility, the fewer trauma symptoms they will experience and the more resilience they will exhibit after a traumatic event. As such, it is hypothesized that greater use of discrepancy words in narrative about Hurricane Harvey is indicative more cognitive flexibility and processing of the event which, in turn, led to increased resilience.

Furthermore, our findings are consistent with prior literature on sensory detail in trauma narratives and related symptomology. Specifically, our findings suggest that use of fewer see words (e.g., saw, images), a subcategory of perceptual process words, when writing about Hurricane Harvey was related to increased resilience. In general, literature posits that sensory detail is more commonly found in trauma narratives as compared to other types of narratives [29,32] and tactile details (e.g., feel, touch), a component of sensory details, have been found to predict PTSD avoidance symptoms 6 years after experiencing a genocide [22]. As such, existing literature suggests a positive association between trauma symptoms and sensory detail in that the constructs fluctuate together. Thus, our results are in line with the notion that those individuals who are not experiencing significant trauma symptoms are less likely to use sensory details when describing their experience. One possible explanation for our findings in relation to resilience is that individuals who use fewer see words, exhibit greater resilience because they are less enmeshed in the memory of the hurricane. On the other hand, those who use more see words remain focused on the perceptual aspects of the hurricane, and perhaps, this prevents the individual from processing the meaning of the event; and individuals are instead stuck in the moment of the event, impeding the process of resilience.

This explanation may also account for the current findings related to the use of focus-past words, which suggest that using language with a greater emphasis on the past is predictive of lower levels of resilience. In fact, research suggests that a greater focus on the past in narratives can be indicative of rumination and a focus on what has been lost, and narratives that 'pine in the past' have been related to greater distress after experiencing a traumatic event [36]. Additionally, there is evidence to suggest that individuals who focus less on the past are more likely to experience resilience. For instance, Smith and colleagues [37] found that establishing and maintaining future orientation after trauma is linked to resilience and growth, while trait mindfulness and acceptance is linked to resilience after a traumatic event [38]. Thus, those individuals who are not solely oriented to the pains of the past, whether that be through a present or future focus, exhibit greater resilience than those individuals who are stuck in the memory of the traumatic event. This notion is consistent with therapeutic interventions which aim to assist individuals in

becoming present and setting future goals as a means of attenuating distress [38,39].

As this was the first study to examine if there are relevant linguistic markers of resilience after a traumatic event, it makes an important contribution to the existing literature. Indeed, findings from this investigation contribute to the general scientific literature related to resilience and measurement of functioning in a post-disaster environment. More specifically, findings demonstrate that LIWC is able to provide objective information that can assist in measuring and predicting resilience after a natural disaster, extending the literature on the detection of resilience by demonstrating utility of a novel methodology. This study can therefore serve as a foundation for other studies examining language use and resilience, in particular after a natural disaster.

In addition to expanding existing literature, the findings from the present study have implications for the assessment of resilience and psychological functioning after a natural disaster. In fact, one of the primary motivations for this investigation was the current limitations in accurately measuring psychological functioning generally, and trauma symptoms specifically, in a post-disaster environment when resources are limited. Accumulating evidence suggests that LIWC can provide objective information that can be incorporated into the assessment psychological functioning and symptomology [23,28]. Current findings indicate that this method can also be used to detect those individuals who are more likely to display higher levels of resilience after a natural disaster. Such information can be used to enhance our accuracy of measuring trauma symptom trajectory and detecting those individuals who will be in increased need of services. As accurate measurement of functioning is crucial for effective resource allocation and treatment planning, the current findings provide important information for streamlining individualized treatment. More importantly, the current methodology has implications for gathering more accurate measurement of functioning after a natural disaster as the approach can be completed on a large scale and requires no trained clinicians or formal interviewing processes.

The current findings are in need of replication as this is only the first examination of linguistic markers relevant to resilience. Regardless, present results suggest that components of cognitive processing words and perceptual processes words, along with a past orientation have the ability to predict resilience six months after a natural disaster. LIWC's predictive utility may therefore assist in post-disaster relief by differentiating between those individuals who are at higher risk for developing chronic trauma symptoms and psychological distress as compared to those who are more likely to demonstrate resilience. Along with replication, future research should focus on whether coaching a shift in language would foster/enhance resilience. Existing research indicates differences in narrative language, before and after, an individual has participated in psychotherapy related to trauma [40,41] but to our knowledge no studies exist that examine an intervention which target language use as the mechanism of change. If effective, such interventions could be used in adjunct to trauma narrative therapies.

Limitations

There are important limitations that should be considered in the current study. First, in order for LIWC analyses to be reliable, written narratives must be 50 words long. This requirement may result in not capturing the experience and symptoms of individuals who are reluctant to discuss the event and used fewer than 50 words

to write about Harvey. Second, attrition reduced the sample size at follow-up. Importantly, follow-up analyses indicated that baseline resilience level differed among participants who did and did not complete the follow-up survey. Thus, it is possible that the attrition rate was a manifestation of differences in resilience, a retention bias which could have affected our results. However, we also examined differences in trauma symptomatology among participants and found that baseline trauma symptoms did not differ among participants who did and did not complete the follow-up survey, $t(119) = -.55, p = .59$, suggesting that the attrition rate was likely not a manifestation of differences in increased trauma symptomatology. Further, based on these follow-up analyses, it appears that younger individuals with “some college” education were the most likely participants to not complete the follow-up survey. It is hypothesized that this may reflect college students who were no longer receiving extra credit for their participation or who had since graduated and no longer used the email they provided. Additionally, it is common for post-natural disaster studies to evidence poor retention of participants [3,42].

Third, previous research using LIWC analysis after a traumatic event has asked participants to produce a trauma narrative. However, the current study analyzed a response to an open-ended question in which participants were asked to write about Hurricane Harvey, without specific instructions focusing on their experiences. This may have limited our ability to harvest more substantive information common in trauma narratives, such as emotionality. Regardless, as the aim of the current study was to establish linguistic markers of resilience, this methodical choice likely did not impact the outcome of the research question. Along the same lines, the current study used an online survey in which participants types their response about their experience. This provided participants the opportunity to edit and correct their account. It is possible that this impacted the accounts produced by participants and consequently the data collected. Finally, the online nature of the study may have resulted in reaching participants who were not as severely affected by the hurricane as they online access to respond to the survey. Thus, the sample may evidence higher rates of resilience in general, which may have resulted in easier detection of relevant linguistic markers. As such, future studies should examine the specificity and sensitivity of this methodology in more affected samples.

Notwithstanding these limitations, the current study addressed a gap in the linguistic marker literature, as the first study to examine language use and resilience. It also contributes to the literature base of resilience after natural disasters. The current methodology has important implications for the assessment of psychological functioning and subsequent allocation of resources generally, but in particular for the assessment of resilience after a natural disaster, when large groups of people need to be reached with limited resources.

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