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Prospective Analysis of Linguistic Analysis as a Method for Assessing Trauma Symptoms After Hurricane Harvey Among Houstonian Adults

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Hurricane Harvey was one of the most destructive hurricanes in United States' history and negatively impacted a majority of Houstonians. Posttraumatic stress disorder symptoms are a common consequence for individuals who experience this form of trauma. Additionally, a dose–response effect has been documented in trauma symptoms following natural disaster, with more severe trauma related to increased symptomology. Given the severity of Hurricane Harvey, Houstonians constitute a high-risk population for experiencing heightened trauma symptoms. Limitations of current methods for assessing trauma symptoms are particularly salient after a large-scale natural disaster, when the availability of mental health resources may be especially limited. The aim of the current study was to use the computer program Linguistic Inquiry and Word Count to analyze Houstonian adults' narratives about Harvey (collected online in response to a brief prompt shortly after the event) to determine if specific linguistic markers are associated with an individual's trauma symptomology concurrently (1 to 2 months postdisaster) and prospectively (6 months postdisaster). Results indicate that greater use of biological process words (e.g., blood, pain), its subcategory body words (e.g., hands, spit), and fewer cause words (e.g., because, effect) were related to increased trauma symptoms at baseline. Additionally, use of fewer cognitive process words and greater use of bio words at baseline predicted greater symptom reduction at follow-up, extending previous research findings. Findings suggest that linguistic analysis holds promise for large-scale assessment and symptom monitoring after a hurricane.

Keywords: linguistic analysis, trauma, natural disaster, Hurricane Harvey, assessment

In late August, 2017, Houston, Texas, was hit by one of the most damaging natural disasters in the U.S. history, Hurricane Harvey. Indeed, it is estimated to have caused nearly $125 billion dollars in damage, making it one of the most destructive hurricanes to hit the United States (National Oceanic and Atmospheric Administration; the Hurricane Research Division, 2018), and resulted in more than 80 fatalities. Additionally, two thirds of Houstonians were negatively impacted through home and vehicle damage and disruptions in employment and income, and one in nine individuals were still displaced from their home nearly 3 and half months later (Hamel, Wu, Brodie, Sim, & Marks, 2017). Although the physical destruction of Harvey is evident, the impact on mental health may be less apparent. In fact, a recent 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. With this in mind, the broad aim of this study was to examine the utility of a new, simple assessment in predicting posttraumatic distress. Specifically, the present study examined if the psycholinguistic properties of short narratives produced by Houstonians about the hurricane predicted their trauma symptomology both concurrently and prospectively.

It is not uncommon for individuals who are exposed to a natural disaster, like a hurricane, to develop debilitating posttraumatic stress disorder (PTSD) symptoms (D'Andrea, Chiu, Casas, & Deldin, 2012; Galea, Nandi, & Vlahov, 2005; Pietrzak et al., 2012; Tang, 2006). Broadly, PTSD is characterized by symptoms such as intrusive reexperiencing, avoidance of trauma-related stimuli, increased psychological arousal, and mood-related changes, resulting from exposure to a traumatic event and lasting for longer than a month (American Psychiatric Association, 2013). Based on a meta-analysis of trauma symptoms after disasters, it is estimated that up to 85% of individuals affected by a natural disaster will experience acute stress symptoms (Tang, 2006), and estimates of PTSD after a natural disaster range from 5% to 60% (Galea et al., 2005). Specifically, in a longitudinal study examining rates of PTSD in Texas residents after Hurricane Ike, researchers found that five percent of participants met criteria for PTSD 2 to 5 months post disaster (Pietrzak et al., 2012), and several types of hurricane-related consequences (e.g., damage to residence, loss of possessions, injury) have been found to be associated with increased trauma symptoms (Hirth, Leyser-Whalen, & Berenson, 2013). Also notable is that a dose–response effect has been documented in the trauma symptoms that result from natural disasters (Galea et al., 2005; Ying, Wu, Lin, & Jiang, 2014). Therefore, it can be assumed that rates of trauma symptoms will be particularly elevated after Hurricane Harvey given the severity of the event.

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Unfortunately, there are currently numerous impediments to measuring trauma and its effects on individuals after a disaster. The gold standard for gathering information regarding trauma symptoms is through clinical interviews (Barlow, 2014) with the rationale that a trained professional can ask appropriate questions and discern the symptoms the victim is experiencing. However, factors such as a victim's reluctance to discuss trauma symptoms (a PTSD symptom in itself) impact the information extracted even by clinical interviews (Walsh, Jamieson, MacMillan, & Trocmé, 2004), which is further complicated by the inherent subjectivity and inaccuracies of clinical judgment (Guy, 2008; Jensen & Weisz, 2002). In fact, Zimmerman and Mattia (1999) posited that when using clinical interviews, half of actual PTSD cases are missed and factors such as a clinician's preconceived notions and biases (Garb, 2005) can impact the reliability of clinical interviews. Additionally, clinical interviews require previously trained clinicians and, further, interviewing individuals about trauma symptoms consumes the time of the victim and clinician, resulting in a long and expensive process (Lacalle Sisteré, Domènech Massons, Granero Pérez, & Ezpeleta Ascaso, 2014; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000). This issue becomes particularly complicated by a natural disaster that affects a large number of people, reducing the availability of trained clinicians conducting the interviews. In fact, it is most common for information about trauma symptoms to be collected by a lay person following a natural disaster given the magnitude of individuals affected, and there is presently no consensus in the field about the best instrument for use by lay persons (Galea et al., 2005), increasing the likelihood for error and variability in symptom measurement in the postdisaster context.

Given the aforementioned challenges inherent in measuring the effects of trauma, broadly, and after a natural disaster, recent research has aimed to better understand how to assess symptom severity and treatment progress for those who experience traumatic events (Butcher, Kretschmar, Lin, Flannery, & Singer, 2014; Miller & Veltkamp, 1995). Advances in technology have been a tremendous asset in combating some of the aforementioned methodological challenges in the assessment of trauma symptoms. Recently, the analysis of a victim's language has been used to evaluate symptomology and cognitive processing (Gray & Lombardo, 2001; Marshall, Henderson, Barker, Sharp, & Venta, 2017; Ng, Ahishakiye, Miller, & Meyerowitz, 2015). The most common method of linguistic analysis uses the computer program Linguistic Inquiry and Word Count (LIWC; Pennebaker, Booth, & Francis, 2007). LIWC is a computer program that analyzes language by searching for and counting psychologically relevant words across multiple text files (Tausczik & Pennebaker, 2010). LIWC analyzes every word in a narrative, determines if it is in its 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 and use of speech fillers (e.g., um, like; Jaeger, Lindblom, Parker-Guilbert, & Zoellner, 2014). Thus, LIWC is able to evaluate a narrative and transform subjective content into objective data.

Overall, the goal of LIWC is to use objective linguistic data to glean information about an individual's cognitive processing, including attentional focus, emotionality, and thinking styles. Thus, LIWC evaluates language beyond the surface level content an individual is expressing and may provide more in-depth data on trauma symptoms and processing, without the need for a trained clinician. In fact, recent research provides support for LIWC's ability to predict the neurobiological processes that are indicative of nonconscious well-being (e.g., stress, depression, anxiety) better than individuals' reported affective experience (Mehl, Raison, Pace, Arevalo, & Cole, 2017). In other words, analyzing language use provides greater insight into individuals' mental health and overall well-being than their subjective report of health and affective experience. These findings implicate language use, specifically LIWC metrics, in objectively measuring individual's cognitive and affective states.

Accumulating research suggests that evaluating the linguistic markers of trauma narratives can provide important insight into a victim's psychological state and potentially predict later symptomology (Gray & Lombardo, 2001; Kleim, Horn, Kraehenmann, Mehl, & Ehlers, 2018; Marshall et al., 2017; Ng et al., 2015). Current literature focuses primarily on trauma narratives produced by adults and has found cognitive process words, pronoun use, and use of somatosensory detail to be predictive of trauma symptoms (Alvarez-Conrad, Zoellner, & Foa, 2001; Crespo & Fernández-Lansac, 2016; Gray & Lombardo, 2001; Papini, Yoon, Rubin, Lopez-Castro, & Hien, 2015). Cognitive process words are those that express causal and insightful thinking (Tausczik & Pennebaker, 2010). Overall, greater use of cognitive process words, like "think" and "hence," is associated with lower trauma symptoms (Alvarez-Conrad et al., 2001; Jaeger et al., 2014). Specifically, trauma narratives with increased use of cognitive process words predicted lower trauma symptoms (Jaeger et al., 2014), and in trauma-exposed females who were currently being treated for PTSD, greater use of cognitive process words was associated with decreased symptom severity (Alvarez-Conrad et al., 2001).

Additionally, empirical data suggest a positive relation between trauma symptoms and pronoun use in general. Specifically, research indicates a diagnosis of PTSD is positively associated with third-person singular pronouns (i.e., he or she) but negatively related to third-person plural pronouns (i.e., they; Mehl et al., 2017; Papini et al., 2015). Authors hypothesized that trauma symptoms may be more likely to be expressed from a self-focused perspective rather than a perspective that emphasizes social support. Papini and colleagues (2015) also reported a positive association between the severity of reexperiencing symptoms and singular pronouns in general. Likewise, lasting trauma symptoms have been found to be related to greater use of first-person singular pronouns (e.g., I; D'Andrea et al., 2012). However, these results were not replicated in an adolescent inpatient sample, and no associations between general pronoun use and trauma symptoms were found (Marshall et al., 2017). Finally, regarding somatosensory detail, Beaudreau (2007) determined that increased references to body states and symptoms in narratives were associated with trauma symptoms and poorer adjustment. These findings are echoed by Marshall et al. (2017) who found body words (e.g., ache, heart), a subcategory of somatosensory detail, were related to increased trauma symptoms. Further evidence for a link between somatosensory detail and trauma symptoms comes from an evaluation of trauma narratives produced about genocide and symptomology measured 6 years later (Ng et al., 2015). All sensory detail

words were analyzed but only tactile details (e.g., feel, touch) were associated with a greater risk of PTSD avoidance 6 years later.

In addition to the existing literature on LIWC and trauma symptoms, Ehlers and Clark's (2000) cognitive model of PTSD provides guidance on how language use is theoretically related to trauma symptomology. In their model, they suggested that reexperiencing primarily consists of sensory impressions and the associated emotions, indicating somatosensory and affect words would be more common in the narratives of individuals experiencing increased trauma symptoms. Specifically, the model posits that individuals who have not processed their trauma are more likely to use affect words, typically negative emotion words (Crespo & Fernández-Lansac, 2016; Eid, Johnsen, & Saus, 2005) when describing the incident, rather than cognitive words, and cognitive process words would predict fewer symptoms as they suggest greater understanding and processing of the event. This theory is consistent with existing literature that links increased trauma symptoms to greater use of somatosensory detail and emotion words (Beaudreau, 2007; Crespo & Fernández-Lansac, 2016; Marshall et al., 2017; Ng et al., 2015) and fewer cognitive process words (Jaeger et al., 2014).

However, longitudinal studies appear to be mixed in their support of the cognitive model of PTSD, with one study demonstrating consistent finding (Kleim et al., 2018) and others contradicting it (D'Andrea et al., 2012; Marshall et al., 2017). Specifically, Kleim and colleagues (2018) found that fewer cognitive processing words predicted chronic PTSD in assault victims. Conversely, two previous studies contradict this theory, as they document greater use of cognitive process words predicting lasting trauma symptoms (D'Andrea et al., 2012; Marshall et al., 2017). One explanation is that individuals who initially use sensory and affect words to describe their trauma have more room for improvement, due to increased trauma symptoms, and may show reduced symptomology as they process and gain understanding related to their trauma, whereas the opportunity for symptom improvement is reduced for those individuals who use more cognitive process words initially (Marshall et al., 2017). Regardless, Ehlers and Clark's (2000) cognitive model of PTSD provides a framework for investigating how language use about a traumatic experience relates to subsequent trauma symptomology, and existing literature is generally consistent with the theory. Additional research is needed to confirm these assertions and clarify how language use is related to symptomology over time.

In sum, trauma symptoms following natural disasters are prevalent and may be particularly problematic after Hurricane Harvey, given the magnitude of its destruction and the variety of ways in which it affected Houstonians. Unfortunately, current methods pose several challenges to gaining in-depth, accurate measures of trauma symptoms. Most problematic after a natural disaster, though, are the time and (human) resources needed to conduct standard clinical interviews, which interfere in gathering objective information about trauma symptoms when large populations are affected. However, accumulating research suggests that LIWC can provide objective data regarding internal states without a trained interviewer—data that could allow for more accurate assessment of trauma symptoms and the ability to predict an individual's symptom change, both of which would contribute to more efficient, effective, and customized treatment. Although LIWC has shown promise in detecting trauma symptoms and trajectory, research has yet to apply LIWC following a natural disaster. Given the prevalence of trauma symptoms following a hurricane (Tang, 2006), the severity of Hurricane Harvey (National Oceanic and Atmospheric Administration; the Hurricane Research Division, 2018), and lack of research (Crespo & Fernández-Lansac, 2016), there is a great need to understand how Houstonians talk about their exposure to a traumatic event and if the objective metrics of their language relate to their trauma symptoms.

Therefore, 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 symptomology concurrently and over time. Based on the existing literature, we expected use of (a) fewer cognitive process words, (b) greater pronoun use (i.e., first- and third person), and (c) greater somatosensory detail to be associated with increased trauma symptoms. Although limited, previous research indicates fewer cognitive process words and fewer first-person pronouns (D'Andrea et al., 2012; Marshall et al., 2017) at baseline relate to greater symptom change (i.e., more decrease in symptoms). Thus, we predicted that use of fewer cognitive process words and first-person pronouns at baseline would predict a greater reduction in symptomology over time.

Method

Participants

The current study used data collected shortly after Hurricane Harvey (1- to 2-month postdisaster) and data collected 6 months postdisaster 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. Sample size varied by time point, such that for the trauma symptom measure at baseline, $n = 123$, and at follow-up, $n = 61$. 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, $\chi^2 = 16.443$, $p = .014$, and educational level, $\chi^2 = 20.978$, $p \leq .001$. Participants in younger age groups, of ethnic minorities, and "some college" were less likely to complete the follow-up survey. Participants who completed and did not complete the second assessment did not differ on trauma symptoms baseline scores, $t(119) = -.548$, $p = .585$. 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. To ensure quality linguistic analysis, only those participants who wrote about Hurricane Harvey using greater than 50 words were included in this study (Tausczik & Pennebaker, 2010). Six participants were excluded based on this criterion.

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 e-mail, 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 e-mail participants provided, they were contacted to complete the 6-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. Institutional review board 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, and 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 indicated all the ways in which they were impacted. Specifically, they 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.

Trauma symptoms. The Impact of Events Scale–Revised (IES-R; Weiss, 2007) is a 22-item self-report measure used at baseline and 6-month follow-up to assess posttraumatic stress related to a particular event. The measure contains three subscales of factors of trauma symptoms: Avoidance, Hyperarousal, and Intrusion. Subjects are asked to report their distress level over the past 7 days on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*). This yields a dimensional *T* score ratings of trauma symptoms, with higher scores indicating greater trauma symptoms. The IES-R has been shown to have good internal consistency reliability and validity across all four scales (Othman, Dahlan, Borhani, & Rusdi, 2016). The scale appeared to have good internal consistency in this sample, $\alpha = .95$.

Objective language analysis. To evaluate how participants responded to a prompt about Hurricane Harvey at baseline and follow-up, a content-analysis computer program, 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" (Pennebaker Conglomerates Incorporated, 2015). Linguistic markers that were used for the current project are (a) cognitive process words total score, (b) pronoun use total score, (c) somatosensory detail, and all of their accompanying subcategories.

Data Analytic Plan

Before data analysis, missing data patterns, skewness, and kurtosis were analyzed. Bivariate relations between LIWC metrics and posttraumatic stress symptoms were assessed using Pearson correlations. Multivariate analyses were conducted using latent growth curve analyses to model the trajectory of posttraumatic stress symptoms from baseline to follow-up. This method specifies parameters of change (e.g., slope) to form a model of change across time. Predictors of change, in this case LIWC metrics, were then added to this baseline model. Intercept and slope parameters were regressed on hypothesized LIWC metric.

Results

Bivariate correlations between the IES-R, LIWC metrics, and age are presented in Table 1. Although correlations with the IES-R did not reveal a significant relation with cognitive process words in general, a subcategory (i.e., cause words) was significantly, negatively related to IES-R total score. Additionally, the biological process portion (i.e., bio words) of somatosensory detail, as well as a subcategory (i.e., body words) were significantly, positively correlated with the IES-R. No evidence of a significant relation between pronoun use, emotion words, or age and the IES-R was demonstrated. Regarding severity of trauma exposure, participants responses to "How were you affected by Hurricane Harvey?" ranged from experiencing zero to seven stressors, with most participants endorsing experiencing two types of trauma, the most common of which were "Hearing about tragedies happening to others," "Witnessing flooding," and "Flood damage to residence."

Longitudinal growth curve analyses were used to examine links between LIWC metrics and IER-R concurrently (i.e., intercept parameter) and from baseline (1 to 2 months postdisaster) to follow-up (6 months postdisaster; i.e., slope parameter). The variance of the slope was constrained to 0 to identify the model. No evidence of problematic skewness (all smaller than ± 1) or kurtosis (all smaller than ± 2) was noted in baseline data. Little's test indicated that data were missing at random ($\chi^2 = 74.332$, $p = .155$); thus, maximum likelihood estimation was used to handle missing data. As would be expected for a community sample, the

Table 1
Correlations Between LIWC Metrics, Trauma Symptoms, and Age

Measure	PTSD total symptoms
Cognitive process	−.085
Insight	−.066
Cause	−.205*
Discrep	−.026
Tentat	−.012
Certain	.029
Differ	.049
Perceptual process	.089
See	.061
Hear	.056
Feel	−.015
Biological process	.243**
Body	.314**
Health	.095
Ingest	.060
Age	−.119

Note. LIWC = Linguistic Inquiry and Word Count; PTSD = posttraumatic stress disorder.
* $p < .05$. ** $p < .01$.

average total symptom score at baseline (i.e., intercept parameter) was low (M_{Int} = 16.193, SE = 3.497), below the IES-R clinical cutoff of 24, though there was significant variability in these scores ($Variance_{Int}$ = 73.879, SE = 15.449, z = 4.782, $p < .001$). The average slope parameter indicated that trauma symptom scores declined linearly and significantly ($p < .001$) by 9.176 points from baseline to follow-up. Cognitive process words total score, pronoun use total score, somatosensory detail, and all of their accompanying were added to the model as covariates. Relations between predictor variables measured at baseline and growth parameters appear in Table 2. Regarding the intercept parameter, bio words and body words were associated with increased total symptoms at baseline. Bio words were negatively associated with the slope parameter, indicating that participants who used greater bio words experienced greater symptom reduction. Insight words were positively associated with the slope parameter, such that participants who used more insight words at baseline experienced less symptom reduction over time.

Discussion

The first aim of this study was to examine if the LIWC metrics that have been linked to trauma symptoms in adults after various human-made disasters would also be related to trauma symptoms after a natural disaster, specifically a hurricane. Based on the existing literature, it was predicted that greater use of pronouns, somatosensory detail, and fewer cognitive process words would be associated with increased trauma symptoms. Results partially supported our hypotheses, with greater use of biological process words (bio words; e.g., blood, pain) and one of its subcategories body words (e.g., hand, spit)—both components of somatosensory detail—and fewer cause words (e.g., because, effect; a subcategory of cognitive process words) related to higher levels of trauma symptoms. Excerpts from participant narratives highlighting these findings can be found in Table 3. When examined together in multivariate analyses, only bio and body words remained significant predictors of baseline trauma symptoms.

Previous literature, similar to present findings, indicates that somatosensory details are common in trauma narratives and are related to increased trauma symptoms. Somatosensory details can be broken down into sensory experiences and references to biological/body states, both of which have been linked to trauma symptoms (Beaudreau, 2007; Marshall et al., 2017; Ng et al., 2015). Indeed, Beaudreau (2007) determined that increased references to body states and symptoms in narratives were associated with trauma symptoms as well as poorer adjustment, and Marshall et al. (2017) documented a positive relation between body words and trauma symptoms—a relation mirrored in the present findings. However, the current study did not find evidence of a link between sensory detail words and trauma symptoms, suggesting that perhaps references to body states and biological processes are stronger indicators of trauma symptoms. Previous research suggests that perceptual detail in trauma narratives bring about the intrusive, distressing memories typical in PTSD (Ehlers & Clark, 2000; Follmer Greenhoot, Sun, Bunnell, & Lindboe, 2013) and, thus, it may be that when individuals describe their trauma experience, they use these perceptual details and body state references because they are reexperiencing the event, to some extent, at that time. It has also been suggested that narratives dominated by perceptual details rather than cognitive process words are associated with greater symptomology because the individual has been unable to make sense of the trauma, and thus, is using somatosensory details rather than causal and insight words to describe the event (Ehlers & Clark, 2000).

This notion is further supported by the present study's findings on cognitive process words. Specifically, cause words, a subcategory of cognitive process words, were negatively related to trauma symptoms at baseline, highlighting the importance of understanding the *cause* of a traumatic experience when processing the event. In general, a negative relation between cognitive process words (broadly) and trauma symptoms has been consistently documented in existing literature (Alvarez-Conrad et al., 2001; Jaeger et al., 2014). Findings on bio, body, and cause words complement each other and suggest that individuals who are experiencing increased trauma symptoms are likely to use more somatosensory details and fewer cognitive process words when describing the traumatic event. These results mirror previous findings documenting a combination of increased somatosensory detail and fewer cognitive process words in trauma accounts from individuals experiencing increased symptomology. For instance, Marshall and colleagues (2017) showed that greater use of body words and fewer insight words (a subcategory of cognitive process words) were indicative of greater trauma symptoms in inpatient adolescents.

Furthermore, our findings are consistent with our guiding conceptual framework as well as other theories regarding PTSD. Indeed, cognitive models of PTSD (e.g., information processing model, Ehlers and Clark's model) theorize that individuals with PTSD cannot integrate the traumatic event with their already existing beliefs and underlying schemas, and the inability to inte-

Table 2
Relations Between Predictor Variables and Growth Parameters

Measure	Estimate	*SE*	*p* value
Intercept regressed on			
Cogproc	0.298	1.801	.869
Insight	−1.419	1.834	.439
Cause	−1.347	1.975	.495
Discrep	1.663	2.008	.407
Certain	0.625	2.098	.766
Tentat	−0.645	1.593	.686
Differ	−0.367	1.905	.847
I_Words	−0.224	0.504	.657
We	0.085	0.547	.876
Bio	1.947	1.028	.058[a]
Body	5.886	2.936	.045[a]
Slope regressed on			
Cogproc	−2.464	1.767	.163
Insight	4.005	1.867	.032[a]
Cause	3.088	1.980	.119
Discrep	−1.715	2.024	.397
Certain	0.913	2.056	.657
Tentat	1.229	1.454	.398
Differ	1.183	1.974	.549
I_Words	−0.403	0.474	.395
We	−0.446	0.492	.365
Bio	−3.391	1.012	<.001[a]
Body	−1.406	2.792	.615

[a] Statistically significant relation between the growth parameter (i.e., intercept, slope) and predictor variables (e.g., Linguistic Inquiry and Word Count metrics).

Table 3
Excerpts From Narratives Highlighting Relevant Linguistic Markers

Linguistic marker	Example
Cause words—High	"This hurricane was significant due to its size and the amount of damage it created, but also because of the insurance coverage controversy it created."
Cause words—Low	"Hurricane Harvey was a very devastating experience. Some of my family members lost everything."
Bio words	"It was the most horrific and life altering crisis I've ever witnessed. . . . It's like the city was swallowed by the Gulf of Mexico."
Body words	"After seeing the sight I had seen, each time someone mentions Hurricane Harvey, my heart aches a little."

grate competing information results in cognitive avoidance (Barlow, 2014). Additionally, from a psychodynamic perspective, the process of mentalizing, which enables an individual to reflect on his or her own mind to make sense of internal experiences (Fonagy, 1991), is hindered by traumatic experiences and subsequent symptoms. In both perspectives, the aim of treatment is to reduce avoidance of unwanted thoughts, feelings, and internal experiences by promoting metacognitive processes and processing of the trauma.

The second aim of this study was to determine if LIWC metrics that have been linked to symptom change after various human-made disasters (D'Andrea et al., 2012; Marshall et al., 2017) would also predict significant symptom change over time in the aftermath of a hurricane. Specifically, it was predicted that greater use of cognitive process words and first-person pronouns would predict lasting trauma symptoms. Results partially supported these hypotheses, in that there was evidence of a significant effect of insight words (a subcategory of cognitive process words) on the slope of change in trauma symptoms across 6 months. Indeed, individuals who used fewer cognitive process words when writing about Harvey at baseline demonstrated a greater decrease in trauma symptoms as compared with individuals who used more cognitive process words. These findings are consistent with the two studies that have examined symptom change over time using LIWC metrics (D'Andrea et al., 2012; Marshall et al., 2017). Although not included as a hypothesis, given the strong relation bio and body words demonstrated with baseline trauma symptoms, these linguistic markers were included in analyses examining symptom change over time. Only bio words were found to have a significant effect on symptom change over time, such that individuals who used more bio words in writing about Harvey at baseline demonstrated greater symptom reduction at follow-up.

Similar to previous longitudinal studies, and in the context of the first aim of the study, individuals with more severe trauma symptoms also used fewer cognitive process words (i.e., cause words) and greater bio words at baseline and experienced greater symptom reduction over time. It may be that these individuals had more room for improvement, due to higher trauma symptoms, and therefore demonstrated greater reduction in symptoms, whereas individuals who initially used greater cognitive process words and fewer somatosensory details experienced lasting symptoms because there was reduced opportunity for symptom improvement. Findings on the use of insight words and bio words and how they relate to symptom change over time again complement each other and are consistent with Ehlers and Clark's cognitive model of PTSD. Indeed, the theory suggests that those with increased symptoms are more likely to use perceptual details rather than cognitive process words, due to reexperiencing symptoms and difficulty processing the event, when describing a traumatic event. The current study provides evidence that trajectory in trauma symptoms is based, in part, on an individual's initial language use because that is an indicator of the severity of their symptoms and the room they have for improvement in those symptoms.

Notably, despite insight words being indicative of symptom change over time, they were not related to trauma symptoms at baseline; rather cause words, a different subcategory of cognitive process words, were related. One explanation may be the subtle difference in the depth of cognitive processing between cause and insight words, as cause words (e.g., because, effect) could be more indicative of a simplistic understanding, whereas insight words (e.g., think, know) may suggest a deeper, more reflective understanding of an event. It may be that using words indicative of a basic understanding of why an event happened is more predictive of individuals' initial symptom response, whereas using words that suggest in-depth and reflective conceptualization of an event predict individuals' long-term symptomology. However, this is merely a hypothesis, and further research is warranted to better understand these relations. Regardless, subcategories of cognitive process words in general appear to be relevant to trauma symptoms. Also noteworthy, contrary to our hypothesis, first-person pronouns did not predict significant symptom change across time. Indeed, first-person pronouns, or any category of pronouns, were not related to total trauma symptoms at baseline. This finding is consistent with one of the previous studies examining the utility of LIWC metrics in predicting symptoms change over time (Marshall et al., 2017) and is at odds with the other (D'Andrea et al., 2012). The inconsistency in findings on first-person pronouns could reflect the difference in methodology across the studies, for instance face to face (D'Andrea et al., 2012) or indirect (Marshall et al., 2017) collection of trauma accounts, or difference in the type of traumatic experience assessed across these studies. Nevertheless, further research is needed to uncover the nature of cognitive process words and pronoun use and how they relate to trauma symptomology.

As this was the first study to examine linguistic markers and trauma symptoms after a natural disaster, it makes an important contribution to the existing literature. Indeed, findings from this investigation contribute to the general scientific literature related to cognitive processing and trauma symptom development. Additionally, present findings indicate that LIWC metrics are related to trauma symptoms after a hurricane and change in those symptoms over time, replicating findings from existing literature. Further, findings extended the literature base of linguistic markers and trauma symptoms to a post–natural-disaster sample. This study can therefore serve as a foundation for other studies examining language use and change in trauma symptoms over time, in particular for studies examining natural disasters.

Along with expanding the literature base, the current findings have implications for the assessment and treatment of trauma symptoms. One of the main motivations for this study was the

difficulty of collecting trauma symptom data via self-report and clinical interview after a natural disaster. Mounting evidence—including the current study—suggests that LIWC is able to provide objective information that can be integrated into the assessment of trauma symptoms. As an accurate measurement of symptoms is essential for effective treatment planning, the current findings provide a valuable tool for tailoring treatment to individuals. In fact, it has been suggested that early linguistic markers may complement self-report questionnaires (e.g., PTSD Checklist) in identifying those as risk for chronic trauma symptoms (Kleim et al., 2018) and can provide an additional layer of information, such as cognitive processing styles, which are not gathered from a checklist but are relevant for treatment. More importantly, the methodology used in the present study demonstrates that such an approach could be used to gather a more accurate measurement of symptoms on a large scale that requires no trained clinicians or formal clinical interviewing/assessing, a crucial asset after a natural disaster. Also, the use of an open-ended prompt, like that in the current study, to question people about a traumatic event may mitigate the risk of lay people inadvertently exacerbating trauma symptoms through a misguided assessment process (Kagee, 2002), further highlighting the potential benefit of the present methodology.

Although the current investigation is in need of replication, the present study suggests that cognitive process words and somatosensory details have the ability to predict trauma symptoms change over time. LIWC's predictive utility may therefore assist postdisaster relief workers in more accurately targeting individuals in need of treatment and, once in in treatment, assist clinicians in identifying specific psychological processes as mechanisms of change, though specific research in this regard is needed. Indeed, by predicting an individual's progression early on in treatment, clinicians and therapists can collaborate proactively to customize treatment and strategize how to manage foreseeable challenges (Verlinden et al., 2015).

There are limitations of the current that should be noted. First, LIWC analysis requires that at least 50 words are used in a written narrative for the analyses to be reliable, which may not capture the experience and symptoms of individuals who are reluctant to discuss the event. Similarly, the current study did not account for cultural differences in the linguistic expression of traumatic experiences. Although we recognize the influence of these factors (Bailey, Venta, & Langley, 2020), the aim of the current study was to establish relevant linguistic markers and establish a base of literature for future research, which should include an examination of such differences. Second, attrition reduced the sample size at follow-up. Based on follow-up analysis, 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 e-mail they provided. Additionally, it is not uncommon for postnatural disaster studies to evidence poor retention of participants (Nolen-Hoeksema & Morrow, 1991). Still, longitudinal analyses were made possible through the use of maximum likelihood estimation and, further, analyses indicated that baseline trauma symptoms did not differ among participants who did and did not complete the follow up survey, suggesting that the attrition rate was likely not a manifestation of increased trauma symptomatology.

Third, previous research on linguistic markers in trauma narratives has typically used methodologies that ask a participant to produce a trauma narrative. The current study, however, 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, which may have limited our ability to gather more substantive qualities (e.g., emotions) that are typical in trauma narratives. Still, this methodological choice examined the performance of LIWC in a nonclinical settings—where lay people could use an open-ended prompt and simple software without risk to the participants. Additionally, as the current study used an online survey to gather information, participants typed their response about Harvey, and thus had the opportunity to edit and correct their account. It is possible that these differences in the method of extracting this information impacted the narrative, and subsequent data produced by participant. Also, given the current methodology, the study was unable to gather information about participants' predisaster functioning or ensure that participants were in Houston at the time of the hurricane; however, participants were asked if they had received mental health treatment before the hurricane and how long they had live in Houston. The online nature of the study may also have resulted in missing individuals most affected by the hurricane, as they may not have had online access at the time; however, every effort was made to gather optimal data in the 1 month timeframe after the hurricane. Lastly, on the whole, the sample evidenced low rates of trauma symptoms and the criterion was based on self-report. As such, future studies must aim to focus on the sensitivity and specificity of this methodology when compared with clinical diagnosis of PTSD.

Notwithstanding these limitations, the current study addressed a gap in the linguistic marker and trauma symptom literature, as the first study to examine these constructs after a natural disaster. The current methodology has important implications for the assessment and treatment of trauma broadly, but in particular for the assessment of PTSD after a natural disaster, when large groups of people need to be reached with limited resources.

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