HHS Public Access

Author manuscript

Psychol Sci. Author manuscript; available in PMC 2016 April 01.

Published in final edited form as:

Psychol Sci. 2015 April ; 26(4): 363–373. doi:10.1177/0956797614562218.

Sadness shifts to anxiety with time and distance from national tragedy in Newtown CT

Bruce Doré, **Leonard Ort**, **Ofir Braverman**, and **Kevin Ochsner**

Department of Psychology, Columbia University

Abstract

How do increasing temporal and spatial distance impact the emotions we feel and express in response to tragic events? Standard views suggest decreases in emotional intensity but are silent on changes in emotional quality. Using a large Twitter dataset, we identified temporal and spatial patterns in emotional and cognitive word use on the topic of the Sandy Hook Elementary School shooting. Although sadness words decreased with time and distance, anxiety words showed the opposite pattern, associated with concurrent increases in language reflecting causal thinking. In a follow-up experiment, we found that thinking about abstract causes (versus concrete details) of this event similarly evoked decreased sadness but increased anxiety, which was associated with perceptions that a similar event may occur in the future. These data challenge current theories of emotional reactivity and identify time, space, and abstract causal thinking as factors that elicit categorical shifts in emotional responses to tragedy.

Introduction

In the wake of unthinkable tragedy, how do the passing of time and the spread of spatial distance impact the way we respond as individuals and as a society? In addressing this question empirically, we stand to build our understanding of how basic psychological mechanisms contribute to real-world patterns of experience and behavior, with potential implications reaching from the feelings of individual people to policy decisions at community and national levels.

Prior research and everyday intuition converge on the idea that we react with decreasing intensity to emotional events as they increase in distance from us in time and space (e.g., Blanchard et al. 1997; Pennebaker & Harber, 1993). However, less is known about the psychological processes that bring these overall decreases about, or whether such processes might generate distinct patterns of change for particular categories of emotional response. This is especially surprising because different categories of negative emotion have distinct implications for how we think and behave. Sadness, for example, can engender constrained, repetitive thinking and sap motivation to act (Brinkmann & Gendolla, 2008; Carver &

Corresponding authors: Bruce Doré Kevin Ochsner Psychology Department Columbia University 324 Schermerhorn New York NY 10027 USA bpd2108@columbia.eduko2132@columbia.edu.

Authorship

BD and KO designed the research. BD, LO, and OB collected and managed the data. BD analyzed and visualized the data. BD wrote the manuscript and KO provided critical revisions.

Scheier, 1998), whereas anxiety can prompt a vigilant cognitive style and spur actions that effectively manage or avoid potential threats (Maner, 2009; Oatley & Johnson-Laird, 1987).

We considered these issues in the context of responses to a shooting that occurred at Sandy Hook Elementary on December 14, 2012, in which 20 children and 6 adults were murdered. One of the deadliest shootings in United States history, the traumatic impact of this event was felt across the country (Brown, 2012). Though trauma research has traditionally relied on field- or lab-based methods, modern internet-based data sources provide unprecedented capacity for tracking responses to momentous events as they unfold, minimizing distortions and biases that emerge when people are prompted to recollect on their past experiences (Levine, 1997). Using data access protocols from Twitter, a social media platform used by hundreds of millions of people, we conducted a large-scale observational study that tracked responses to this tragedy across the continental United States over nearly six months.

With these data we were able to ask novel questions about the nature of sadness and anxiety responses to tragedy. Extrapolating from prior work on emotion and psychological distance, a *non-specific distance hypothesis* predicts that sadness and anxiety decay at a single rate. That is, if remoteness has direct effects on emotional intensity, it should affect different categories of negative emotion to a similar extent. Alternatively, a *construal level hypothesis* predicts that sadness and anxiety may diverge to the extent that they arise from appraisals driven by concrete versus abstract mental representations of an emotion-eliciting event (Trope & Liberman, 2010; Lazarus, 1991).

According to construal level theory (Rim, Hansen, & Trope, 2013), as people move in time or space from an event, their representation of that event should become less focused on its concrete features (e.g., what happened), and more focused on its abstract features (e.g., why it happened). From the view of appraisal theories of emotion (e.g. Lazarus, 1991; Scherer, Schorr, & Johnstone, 2001), this shift in representation should bring about a corresponding shift in emotional tone away from forms of negative emotion evoked primarily by the low-level features of this tragedy, like sadness (a response to irrevocable loss – here, the loss of life), to those evoked more by high-level features of the tragedy, like anxiety (a response to uncertain threat – here, the potential threat posed by the tragedy's relatively abstract causes). We tested the competing non-specific distance and construal-level hypotheses in an observational study, and considered the causal mechanisms underlying observed patterns in a follow-up study that experimentally manipulated participants' construal of this tragedy.

STUDY 1: Using Twitter to track responses to the Newtown shooting over time and space

We gathered tweets (brief public messages posted to twitter.com) containing the keywords "Newtown" or "Sandy Hook" for nearly six months following the tragedy, sampling over three discrete time periods: Dec 14 – Dec 21, 2012; Jan 27 – March 3, 2013; and April 26 – May 30, 2013 (see Figure 1A). Tweets were accessed via calls to the Twitter Streaming Application Programming Interface (API) (Twitter, 2013).

Ethics statement

All study procedures were approved by the Columbia University Institutional Review Board.

Data cleaning

All tweets were downloaded in real-time as they were published to the Streaming API (see SOM). Inspection of the resulting dataset revealed that some of the tweets we had sampled represented duplicated, spammed, and/or non-English content. We attempted to filter this content in order to focus our analyses on tweets with original, English-language content from individual users. We excluded all instances of 1) *retweeted* content, 2) tweets containing less than 60% English dictionary words, 3) multiple tweets from a single user, and 4) tweets from different users that contained identical content (see SOM and Table S1 for more details on these exclusions).

In order to estimate the proportion of tweets in the cleaned dataset that were issued by personal vs. news media accounts, we had four raters code a random sample of 1000 tweets (tweets were coded in groups of 200 tweets at a time; each tweet was coded by two raters) as having been posted by an individual person or by a news media organization (with a third option for unclear/other), based on the name of the account and the content of the tweet. The individual versus news media judgments showed good levels of average absolute agreement (93%; Krippendorff's $\alpha = .66$), suggesting that the majority of tweets in the cleaned dataset had been posted by individuals (82%) and a minority posted by news media organizations (5%) (see SOM for further description of this sample of tweets).

Dataset variables of interest

Predictor variables—Each message from Twitter was time-stamped, allowing us to quantify temporal distance from the tragedy's occurrence (in seconds). In order to quantify spatial distance, we constrained our analyses to users whose reported location field information (from their Twitter profile) could locate them to a United States city or state (e.g., “New York City”, “Arcata, California”, “Colorado”, or “Florida panhandle”), leaving us with a dataset of 43,548 tweets (see Figure 1B). We used an open-source geocoding database to convert this location field information to approximate latitude and longitude coordinates (OpenStreetMap contributors), and conducted subsequent manual checks to flag and correct or remove geocoding errors and ambiguities (see SOM). In order to validate these geocoded coordinates we compared them against captured global positioning system (GPS) location data, available for approximately 0.6% of our sample, and found that the two types of location data agreed within 200 miles for 92% of tweets with both types of data available. Finally, for each tweet we calculated geometric distance from Sandy Hook, Connecticut using the Haversine formula (Sinnott, 1984).

Outcome variables

We derived several outcome variables of psychological relevance on a tweet-by-tweet basis. As an index of the societal-level expression of thoughts related to this tragedy, we estimated tragedy-related tweet volume across time and space, operationally defined as the per-second

rate of publication at the moment of publication for each tweet in our dataset. We next quantified the emotional and cognitive content of the tweets using Linguistic Inquiry and Word Count (LIWC), a prominent lexicon and software package that computes frequencies of words reflective of particular psychological states (Pennebaker et al., 2007). The LIWC dictionary includes multiple word category dimensions that have been validated against human judgments of texts' psychological content. We focused on three broad classes of content. First, we considered present-tense verbs and first-person pronouns, which indicate attention to one's self and one's present temporal context and thus reflect a sense of psychological immediacy (Tausczik & Pennebaker, 2010). Second, we considered affect words, reflective of experience and expression of emotional states in general (Kahn et al, 2007), as well as sadness words and anxiety words, categories that reflect particular kinds of negative emotion (Tov et al., 2013; Tausczik & Pennebaker, 2010). Third, we looked at words that reflect attention to causal processes, which in the context of traumatic events are known to mark a relatively more complex and abstract style of thought focused on creating causal explanations (Tausczik & Pennebaker, 2010; Boals & Klein, 2005).

Analyses

We used regression models to quantify independent effects of time (rescaled for interpretation as number of months) and approximate distance (rescaled for interpretation as thousands of miles) on tweet features (rescalings were conducted via multiplication by a conversion factor). We simultaneously included covariates of no interest to model effects of total tweet word count, county-level population density (U.S. Census Bureau, 2012), local politics (i.e., percentage of popular vote that went to Mitt Romney in the 2012 presidential election, at county- and state-levels; Rogers & Cage, 2013), and linear, quadratic, and cubic effects of time of day. These covariates allowed us to statistically account for potential third variables that may have obscured or driven relationships between remoteness and use of particular word categories. For example, the total word count covariate allowed us to account for the possibility that time and distance led to changes in overall number of words used. The local politics and population density covariates allowed us to account for the possibility that social and political qualities of one's local environment are related to distance from Newtown and also predictive of word use. The time of day covariates allowed us to account for circadian changes in word use.

For tweets-per-second, we tested exponential decay by taking the natural log transform of tweets-per-second and entering this transformed variable into an ordinary least squares model. For raw LIWC word count variables, because they followed overdispersed count distributions (i.e., with variance greater than mean), we fit these data with negative binomial regression models (see Hilbe, 2011).

Results

Average word counts—To characterize the affective content of the tweets in our dataset, we computed word count averages for the emotion categories provided by LIWC. Collapsing across time and distance, our dataset consisted of tweets with a mean of 14.89 total words (SE = .03), and a mean of .97 affect words (SE = .005). Within negative emotion

categories, we found our tweets had a mean of .16 sadness words (SE = .002), a mean of .05 anxiety words (SE = .001), and a mean of .26 anger words (SE = .003).

Effects on expression, immediacy, and overall affect—Consistent with the non-specific distance hypothesis (which posits that remoteness has general effects on emotion) and construal-level hypotheses (which posits that remoteness leads to more abstract forms of representation), we found that time led to an exponential decrease in tweet-per-second rate, b = -1.27, 95% CI = [-1.28, -1.26], p < .001, and linear decreases in number of first-person pronouns, b = -.062, 95% CI = [-.082, -.043], p < .001, presenttense verbs, b = -.069, 95% CI =[-.079, -.059], p < .001, and overall affect words, b = - .073, 95% CI =[-.082, -.064], p < .001. Increasing spatial distance brought about an independent and corresponding pattern, evoking an exponential decrease in in tweets-per-second, b = -.040, 95% CI =[-.056, -0.022], p < .001, as well as linear decreases in first-person pronouns, b = -.049, 95% CI = [-.081, -.017], p < .005, present-tense verbs, b = -.022, 95% CI = [-.038, -.006], p < .01, and overall affect words, b = -.033, 95% CI = [-.047, -.020], p < .001. In summary, we observed time- and distance-related changes in word use suggesting decreases in posting of tragedy-related content, expression of psychological immediacy, and expression of emotion.

Effects on sadness, anxiety, and causal thought—Next we considered changes in sadness, anxiety, and causality words, for which a construal-level hypothesis makes unique predictions. Consistent with this hypothesis, we found that time led to a decrease in sadness words, b = -.377, 95% CI = [-.405, -.349], p < .001, an increase in anxiety words, b = .116, 95% CI = [.079, .152], p < .001, and an increase in causality words, b = .021, 95% CI = [.004, .038], p < .05. Similarly, distance brought about a decrease in sadness words, b = -.057, 95% CI = [-.091, -.022], p < .001, and increases in anxiety words, b = .105, 95% CI = [.044, .166], p < .001, and causality words, b = .050, 95% CI = [.023, .077], p < .001 (see Figure 2A, B, & C). Moreover, a path model (with time and distance as predictors, causality words as a mediator, anxiety words as an outcome, and total tweet word count as a covariate) revealed that higher levels of anxiety words evoked by both time and distance were partially mediated by associated increases in causality words; time indirect effect = .006, 95% CI = [.003 .009], p < .001, distance indirect effect = .005, 95% CI = [.000, .009], p < .05. An analogous path model with sadness words as an outcome indicated that causality word count did not significantly mediate the effects of either time, indirect effect = -.0006, 95% CI = [-.002, .0004], p =.24, or distance, indirect effect = -.002, 95% CI = [-.004, .001], p =.23, on sadness words. These two path models were implemented via the gsem (generalized structural equation modeling) command in Stata 13, with family set to ‘negative binomial’. Significance of indirect paths was assessed with the nlcom command (which computes ‘delta method’ standard errors) (StataCorp, 2013).

Effects on anger—For comparison purposes, we also investigated effects of time and distance on anger, an emotion previously identified as a key component of the societal-level reaction to violent tragedy (e.g., Lerner et al., 2003). We found that anger word use did not change significantly across time, b = -.01, 95% CI = [-.03, .01], p = .37, but did increase significantly with increasing distance, b = .10, 95% CI = [.07, .13], p < .001. (For additional

information about the magnitude of the effects of time and distance, see supplementary Tables S2 and S3.)

Mapping patterns of sadness, anxiety, and causality words—To more thoroughly model and visualize patterns of word use across space, we ran a series of three-dimensional spatial regression models which, by fitting a smooth surface to the observed data, predict tweet features (y) across the continental US as a function of latitude (x_1) and longitude (x_2). To define these surfaces, we implemented a penalized thin plate regression spline method using the *bam* function within the *mgcv* package in R (Wood, 2003). The mapped surfaces (see Figure 2) represent levels of word use with variations in color, and model precision (i.e., the inverse of prediction standard error, determined in part by data density) with variations in opacity. As expected, these mapped models are consistent with the linear regression analyses reported above (which collapsed latitude and longitude into a single distance dimension), but provide more information about the spatial patterns that brought about the distance- and time-based change in sadness, anxiety, and causality words.

Word-level analyses—To characterize the nature of these relationships at the level of individual words, we correlated time (in seconds) and approximate distance (in miles) on each of the words in the LIWC sadness, anxiety, and causality categories. Table 1 summarizes the results of these analyses by showing, for the LIWC sadness, anxiety, and causality categories, the five words most strongly associated with distance and the five words most strongly associated with time. We corrected for multiple comparisons within word category using the False Discovery Rate (FDR) procedure (Benjamini & Hochberg, 1991). (For additional information about word-level patterns of affective words, see supplementary Figure S1.)

STUDY 2: Focusing on the abstract causes of this tragedy evokes a pattern of sadness and anxiety that mirrors effects of time and distance observed on Twitter

Study 1 revealed a remoteness-associated shift from sadness to anxiety and suggested increases in abstract thinking as a potential intermediate causative factor bringing this shift about. In order to test this effect directly, we conducted a follow-up experiment testing the hypothesis that a specific type of abstract thought – thinking about the broader causes of the Newtown shooting – can evoke a pattern of decreased sadness and increased anxiety. Because focusing on the abstract causes of tragedy should be particularly anxiety-evoking if these causes are perceived as unresolved, this experiment also asked if perceptions that the causes of this tragedy are unresolved and that risk for similar tragedies is ongoing contributes to this pattern of increased anxiety.

Ethics statement

All study procedures were approved by the Columbia University Institutional Review Board.

Participants and design

Participants were 100 US adults (61F; mean age = 35.5, SD = 10.9) recruited via Amazon's Mechanical Turk crowdsourcing platform (the week of November 11, 2013). The sample size was determined in advance, giving 97% power to detect a "medium" ($\delta = 0.5$) within-subjects effect and 80% power to detect the same size between-subjects effect at a one-tailed alpha of 0.05. After consent, participants were randomly assigned to either an abstract construal condition, in which they were asked to type two to three sentences about the broader causes of the Sandy Hook massacre (i.e., why the tragedy happened), or a concrete construal condition, in which they were asked to type two to three sentences about the event's concrete details (i.e., how the tragedy happened). Immediately following this manipulation, participants rated their current feelings of sadness and anxiety (order counterbalanced across subject) on a 100-point sliding scale (0 = *not at all*; 100 = *strongest I have ever felt*). All participants also answered two questions meant to index their perception (0 = *disagree strongly*; 100 = *agree strongly*) that the causes of this tragedy remain unresolved and risk for similar events is ongoing (1. "I believe that the factors that led to this event happening have not been resolved"; 2. "I think that a similar tragedy is very likely to happen in the future").

Results

Manipulation check—Two coders blind to condition rated the texts generated during the construal level manipulation on a 5-point scale (1-*concrete* to 5-*abstract*). This measure showed good inter-rater reliability (Cronbach's $\alpha = .86$), and an independent samples t-test revealed that the manipulation of construal level elicited the intended pattern of abstract vs. concrete thinking ($M_{concrete} = 2.31$; SD = 1.13; $M_{abstract} = 3.80$; SD = .89), $t(98) = 7.07$, $p < .001$, $d = 1.43$. Additionally, examination of LIWC variables revealed that high-construal texts contained more causality words ($M_{abstract} = 1.07$, SD = 1.08) than low-construal texts ($M_{concrete} = 0.46$, SD = 0.70), b = .85, 95% CI = [.36, 1.34], $p < .001$.

Effects of construal level and emotion category—Next we examined the effects of construal level (between-subject: abstract vs. concrete) and emotion category (within-subject: sadness vs. anxiety) on affect intensity ratings by conducting a 2 × 2 mixed ANOVA. This revealed a main effect of emotion category, $F(1, 98) = 74.1$, $p < .001$, partial $\eta^2 = .43$, and a construal level by emotion category interaction, $F(1,98) = 17.1$, $p < .001$, partial $\eta^2 = .15$, such that focusing on the abstract causes of this tragedy decreased sadness, $t(98) = -2.23$, $p < .05$, $d = .45$, but increased anxiety, $t(98) = 2.62$, $p < .01$, $d = .53$ (means and associated confidence intervals displayed in Figure 4). These findings indicate that, although thinking about the Newtown shooting generally evokes more sadness than anxiety, thinking about the event's abstract causes (versus its concrete details) leads to a (between-group) shift in emotional tone away from sadness and toward anxiety, a pattern that mirrors the effects of spatial and temporal distance we observed in responses on Twitter.

Effect of perceived risk and lack of resolution—As expected, the two questions that assessed perceived risk and lack of resolution of the tragedy's causes were highly correlated (Spearman-Brown $\rho = .51$, $p < .01$), so we averaged these two items to derive a single summary score. Responses on this summary showed high overall levels of perceived risk

and lack of resolution (M = 72.7; SD = 19.8) that did not differ appreciably across abstract versus concrete construal groups, t(98)= .94, p = .83, d = .19. However, regression analysis revealed that the construal level manipulation moderated the relationship between perceived risk/resolution and self-reported anxiety at the trend level, interaction b = .54, 95% CI = [-.04, 1.12], p = .07, such that perceived risk and lack of resolution was predictive of greater anxiety for the abstract construal group, b = .62, 95% CI = [.21, 1.04], p < .005, but not for the concrete construal group, b = .08, 95% CI = [-.32, .49], p = .68. Although the trend-level interaction limits high-certainty inference about the difference between the abstract and concrete construal conditions, this pattern of results suggests that anxiety elicited by focusing on this tragedy is driven in part by perceptions that its contributing factors are unresolved and that a similar event may occur in the future.

Discussion

Leveraging a large-scale observational study and follow-up experiment, we aimed to identify and explain the impact of time and space on emotional responses to the Sandy Hook elementary school shooting. Consistent with intuitive predictions drawn from current theories, we found that temporal and spatial distance were associated with decreases in word use reflective of tragedy-related thought, psychological immediacy, and overall intensity of emotional expression. However, our data also suggest novel updates to models of emotion and distance by showing that temporal and spatial distance predicted a shift in emotional tone away from sadness and toward anxiety, consistent with a construal-level hypothesis and in contrast to a non-specific distance hypothesis. Moreover, our results suggest that this shift (particularly the increase in anxiety) emerges in part because remoteness prompts higher-level consideration of the unresolved causes of tragedy.

Implications for therapeutic and prevention initiatives

According to a 2013 poll, 33% of United States parents reported fearing for their child's safety at school, an 8% increase from 2012 (Gallup, 2013). Understanding how particular emotions lessen, persist, or increase with time and space may help identify more effective modes of individual- or societal-level therapeutic support. Because sadness and anxiety have distinct implications for behavior, building this understanding may also help identify factors that influence support for tragedy prevention initiatives – temporal and spatial dynamics in feelings of sadness and anxiety for example, may affect support for school safety policies or legislative change. Here, work examining the impact of construal-level and emotional experience on political behavior may be particularly instructive.

Implications for emotion theory

More generally, these data highlight the importance of distinguishing between categories of negative emotion, adding to a tradition highlighting valence-independent contributions of emotional appraisal processes (Lerner & Keltner, 2000; Lazarus, 1991; Oatley & Johnson-Laird, 1987). This study also complements work showing that distance can facilitate humor (McGraw et al., 2012), together challenging models of reactivity that posit generic decreases in emotion with increasing psychological distance (e.g., Mühlberger et al., 2008). Similarly, the observation that abstract thinking has opposite effects on sadness versus anxiety is not

easily accounted for by models positing a simple reciprocal relationship between cognition and emotion (e.g., Drevets, 2003). Instead this suggests that, for real-world tragedy, cognitive processes may commonly act to amplify the intensity of certain emotions (see Gross & Barrett, 2011).

Causes, construal-level, distance, and emotion

In our experiment, we found that thinking about abstract causes of tragedy increased anxiety and decreased sadness. Because causal and abstract thinking co-occur (Rim, Hansen, & Trope, 2013), the cognitions our participants engaged in may be similar to those that occur spontaneously in response to tragedy. However, we did not ask whether causal and abstract thinking have separable effects, nor did we quantify feelings of distance or uncertainty, which may have unique effects on emotion (see SOM for analyses of expressed uncertainty). In particular, although participants in Study 2 thought about abstract causes, it's likely that focusing on a concrete and familiar cause of tragedy may also be anxiety-eliciting to the extent that this cause is perceived as presenting ongoing risk. However, whether time or distance systematically increase attention to concrete causes is unclear – this is an empirical question worthy of further study. In general, work designed to estimate independent and interactive effects of construal level, subjective distance, and causal thinking could deepen our mechanistic understanding of distance effects on emotion.

Implications for psychological methods

Our approach is guided by the idea that psychological models with descriptive and explanatory power benefit from grounding experimental hypotheses in both theory and systematic observation of real-world behavior (Neisser, 1976; Reis & Gosling, 2010). Although for much of psychology's history naturalistic observation has been subject to steep practical limitations in scope, the internet resources used here allowed us to unobtrusively collect responses widely distributed in space and time, revealing systematic patterns of spontaneous behavior that may have been impossible to detect with traditional methods (see Yarkoni, 2012).

Limitations and future directions

Several limitations of this research are worth addressing, which may provide direction for future work. First, the groups we sampled from differ from the general population in meaningful ways. For example, Twitter users are relatively young: in 2012 people aged 18-29 were most likely to use Twitter (Smith & Brenner, 2013). Work with more representative samples may reveal differences corresponding to development and life history.

Limitations are also posed by the nature of our tweet collection protocol. Collection was intermittent in time, allowing only weak inference about word use between or beyond collection periods – for example, emotions may continue to change in meaningful ways beyond six months (see Norris et al., 2002). This could be addressed with software facilitating uninterrupted access to the Streaming API. Related, because the API gives access to a sample of tweets that could differ meaningfully from Twitter's overall activity, protocols that access all of Twitter (see Morstatter et al., 2013) would extend our method.

Also, sampling Twitter by usernames (not keywords) could be used to gather longitudinal data appropriate for quantifying within-person change.

There are also theoretical questions worth pursuing further. First, our analyses revealed that causality words were associated with increases in anxiety words, but not decreases in sadness words. One potential explanation for this pattern is that causality words mark a cognitive process contributing to anxiety (e.g., attention to abstract causes) more so than sadness, which could be linked to a separable process (e.g., decreased attention to concrete loss).

Second, future work could sample a wider range of emotion categories (and life experiences) to deepen our understanding of distance and emotion. The importance of this issue is suggested by our finding that anger words were used frequently, (see SOM and Figure S2), increased over distance, and remained high over time. While this interesting pattern may have several potential explanations, it is consistent with prior research indicating that anger is a common response to tragedy (e.g., Lerner et al., 2003) and results from an affront for which blame can be assigned (Lazarus, 1991). Why the perception of this or other tragedies might vary with spatial but not temporal distance could be explored in future work that considers the combined effects of anger, anxiety, sadness, and other emotions on downstream behaviors.

Third, we note that construing tragedy at a high level entails shifting one's focus from idiosyncratic features to more abstract qualities (like causes), which may elicit anxiety if perceived as threatening. In line with this reasoning, anxiety was associated with perceptions that this tragedy's causes remain unresolved. This suggests differences between events that differ along this dimension, which could be examined with future studies. Further, researchers could examine effects of news-media on public understanding of the details and causes of tragedies, risk assessment, and resulting emotions.

Conclusion

Does emotion fade with time and distance? Here we suggest that time and distance can provide a bird's eye view that alerts us to the scope of an unresolved threat. Although a complete understanding of the consequences of violent tragedy will require sustained efforts from diverse perspectives, we hope that psychological science leveraging the complementary strengths of naturalistic and experimental approaches will be able to contribute meaningfully to this enterprise.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We thank Daisy Burr, Ehjeen Kim, and Theodore Stephano for research assistance; David Sparks for sharing visualization code; NIA R01AG043463-01 & Conte PAR-11-126.

References

Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society. Series B (Methodological). 1995:289–300.

Blanchard EB, Hickling EJ, Forneris CA, Taylor AE, Buckley TC, Loos WR, et al. Prediction of remission of acute posttraumatic stress disorder in motor vehicle accident victims. Journal of Traumatic Stress. 1997; 10:215–234. [PubMed: 9136089]

Boals A, Klein K. Word use in emotional narratives about failed romantic relationships and subsequent mental health. Journal of Language and Social Psychology. 2005; 24(3):252–268.

Brinkmann K, Gendolla GH. Does depression interfere with effort mobilization? Effects of dysphoria and task difficulty on cardiovascular response. Journal of Personality and Social Psychology. 2008; 94(1):146–157. [PubMed: 18179324]

Brown, S. World reaction: 'My heart is in Newtown' CNN. Dec 17. 2012 Retrieved from www.cnn.com

Carver, CS.; Scheier, MF. On the self-regulation of behavior. Cambridge University Press; New York: 1998.

Drevets WC. Neuroimaging studies of mood disorders. Biological Psychiatry. 2000; 48(8):813–829. [PubMed: 11063977]

Gallup. Parents' School Safety Fears Haven't Receded Since Newtown. 2013. Retrieved 2013 from www.gallup.com/poll/164168/parents-school-safety-fears-haven-receded-newtown.aspx

Gross JJ, Barrett LF. Emotion generation and emotion regulation: One or two depends on your point of view. Emotion Review. 2011; 3(1):8–16. [PubMed: 21479078]

Hilbe, JM. Negative binomial regression. Cambridge University Press; Chicago, IL: 2011.

Kahn JH, Tobin RM, Massey AE, Anderson JA. Measuring emotional expression with the Linguistic Inquiry and Word Count. The American Journal of Psychology. 2007:263–286. [PubMed: 17650921]

Lazarus, RS. Emotion and adaptation. Oxford University Press; New York, NY: 1991.

Lerner JS, Gonzalez RM, Small DA, Fischhoff B. Effects of Fear and Anger on Perceived Risks of Terrorism A National Field Experiment. Psychological Science. 2003; 14(2):144–150. [PubMed: 12661676]

Lerner JS, Keltner D. Beyond valence: Toward a model of emotion-specific influences on judgement and choice. Cognition & Emotion. 2000; 14(4):473–493.

Levine LJ. Reconstructing memory for emotions. Journal of Experimental Psychology: General. 1997; 126(2):165–177.

Maner JK. Anxiety: Proximate processes and ultimate functions. Social and Personality Psychology Compass. 2009; 3(5):798–811.

McGraw AP, Warren C, Williams LE, Leonard B. Too close for comfort, or too far to care? Finding humor in distant tragedies and close mishaps. Psychological Science. 2012; 23(10):1215–1223. [PubMed: 22941877]

Morstatter F, Pfeffer J, Liu H, Carley KM. Is the sample good enough? Comparing data from Twitter's streaming API with Twitter's firehose. Proceedings of ICWSM. 2013

Mühlberger A, Neumann R, Wieser MJ, Pauli P. The impact of changes in spatial distance on emotional responses. Emotion. 2008; 8(2):192–198. [PubMed: 18410193]

Neisser, U. Cognition and reality: Principles and implications of cognitive psychology. WH Freeman; San Francisco, CA: 1976.

Norris FH, Friedman MJ, Watson PJ, Byrne CM, Diaz E, Kaniasty K. 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. Psychiatry: Interpersonal and biological processes. 2002; 65(3):207–239.

Oatley K, Johnson-Laird PN. Towards a cognitive theory of emotions. Cognition and Emotion. 1987; 1(1):29–50.

OpenStreetMap Contributors. API v0.6. OpenStreetMap Wiki. 2013. Retrieved 2013 from wiki.openstreetmap.org/wiki/API_v0.6

Pennebaker, JW.; Chung, CK.; Ireland, M.; Gonzales, A.; Booth, RJ. The development and psychometric properties of LIWC2007. LIWC.Net; Austin, TX: 2007.

Pennebaker JW, Harber KD. A social stage model of collective coping: The Loma Prieta earthquake and the Persian Gulf War. Journal of Social Issues. 1993; 49(4):125–145.

Reis, HT.; Gosling, SD. Social psychological methods outside the laboratory.. In: Fiske, S.; Gilbert, D.; Lindzey, G., editors. Handbook of Social Psychology. 5th ed.. Vol. 1. Wiley; New York: 2010. p. 82-114.

Rim S, Hansen J, Trope Y. What happens why? Psychological distance and focusing on causes versus consequences of events. Journal of Personality and Social Psychology. 2013; 104(3):457. [PubMed: 23276264]

Rogers, S.; Cage, F. Full US 2012 county-level results to download. The Guardian. 2013. Retrieved from http://www.theguardian.com/news/datablog/2012/nov/07/us-2012-election-county-results-download

Ross J, Irani I, Silberman M. Six, Zaldivar A, Tomlinson B. "Who are the Crowdworkers?: Shifting Demographics in Amazon Mechanical Turk". ACM CHI EA. 2010; 2010:2863–2872.

Scherer, KR.; Shorr, A.; Johnstone, T., editors. Appraisal processes in emotion: theory, methods, research. Oxford University Press; Canary, NC: 2001.

Sinnott RW. Virtues of the Haversine. Sky and Telescope. 1984; 68:158.

Smith, A.; Brenner, J. Twitter use 2012. Pew Internet & American Life Project Web site. 2013. Retrieved from http://pewinternet.org/Reports/2012/Twitter-Use-2012

StataCorp. Stata 13 Structural Equation Modeling Reference Manual. Stata Press; College Station, TX: 2013.

Tausczik YR, Pennebaker JW. The psychological meaning of words: LIWC and computerized text analysis methods. Journal of Language and Social Psychology. 2010; 29(1):24–54.

Tov W, Ng KL, Lin H, Qiu L. Detecting well-being via computerized content analysis of brief diary entries. Psychological Assessment. 2013; 25(4):106–1078.

Trope Y, Liberman N. Construal-level theory of psychological distance. Psychological Review. 2010; 117(2):440. [PubMed: 20438233]

Twitter. The Streaming APIs. Documentation. 2013. Retrieved from dev.twitter.com/docs/streaming-apis

U.S. Census Bureau. Population Estimates. 2013. Retrieved from www.census.gov/popest/data/index.html

Wood SN. Thin plate regression splines. Journal of the Royal Statistical Society: Series B (Statistical Methodology). 2003; 65(1):95–114.

Yarkoni T. Psychoinformatics: New horizons at the interface of the psychological and computing sciences. Current Directions in Psychological Science. 2012; 21(6):391–397.

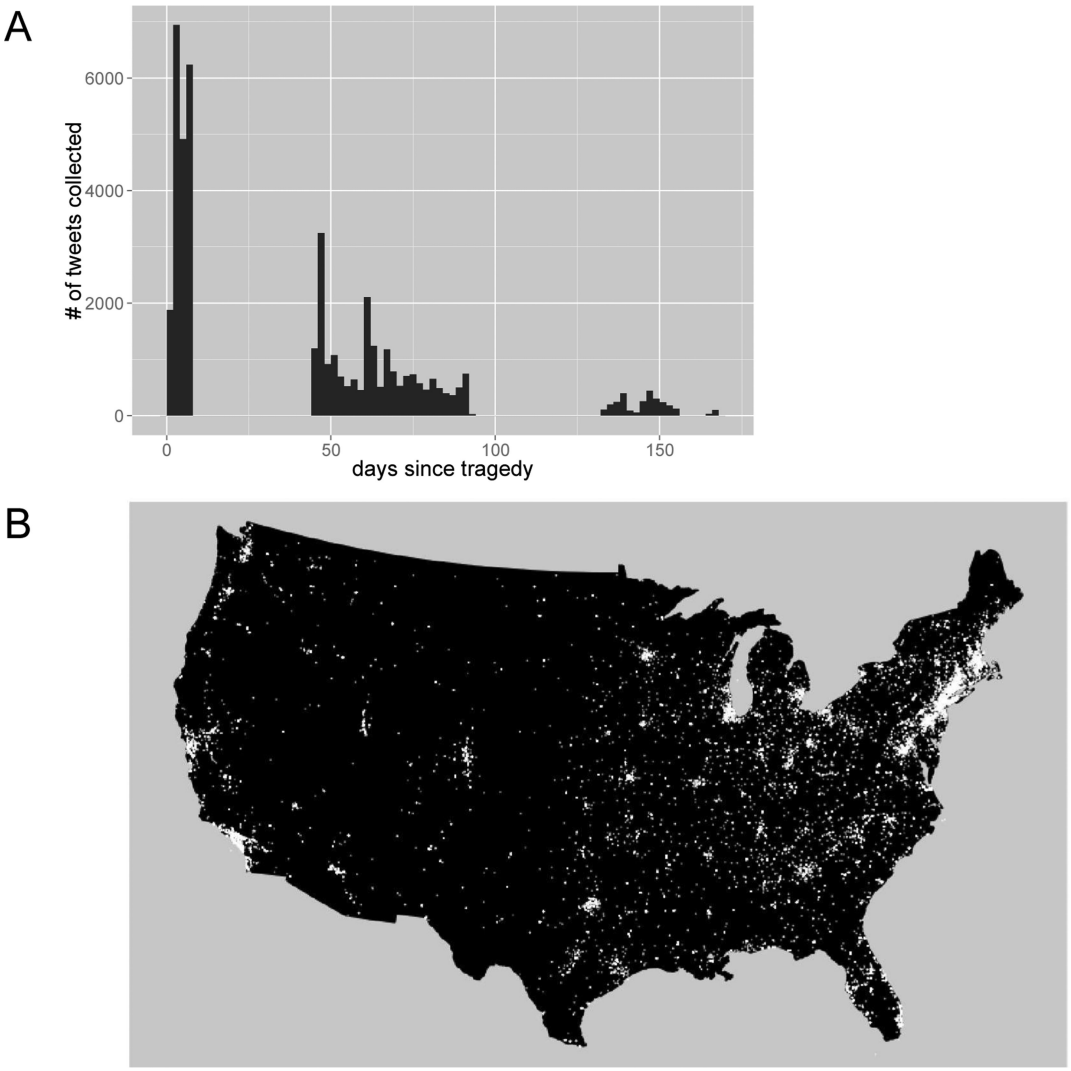

Figure 1.

Tweets issued within the continental US containing the keywords “Newtown” or “Sandy Hook”, collected in real-time via Twitter's Streaming API, distributed across A) time and B) space.

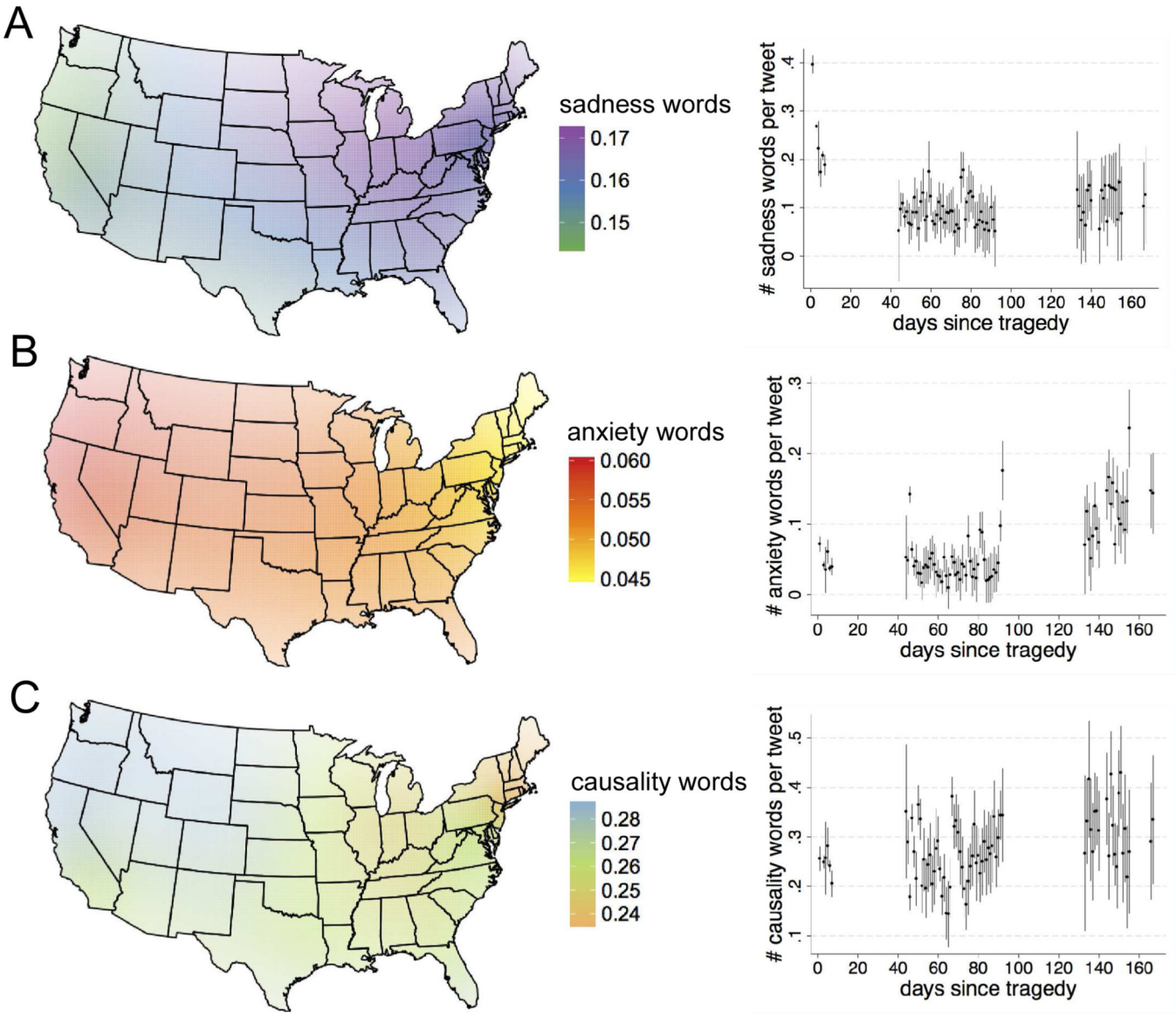

Figure 2.

Change in word use (per tweet) across space (represented by color, with prediction precision represented by opacity), and across time (aggregated to 24h bins, with error bars reflecting 95% CI) for LIWC dictionary A) sadness, B) anxiety and C) causality words, in tweets containing the words “Newtown” or “Sandy Hook” issued across the continental US during three sampling periods between Dec 14, 2012 and May 30, 2013. Depicted patterns indicate that sadness words decrease, but anxiety and causality words increase, with distance and time from the tragedy.

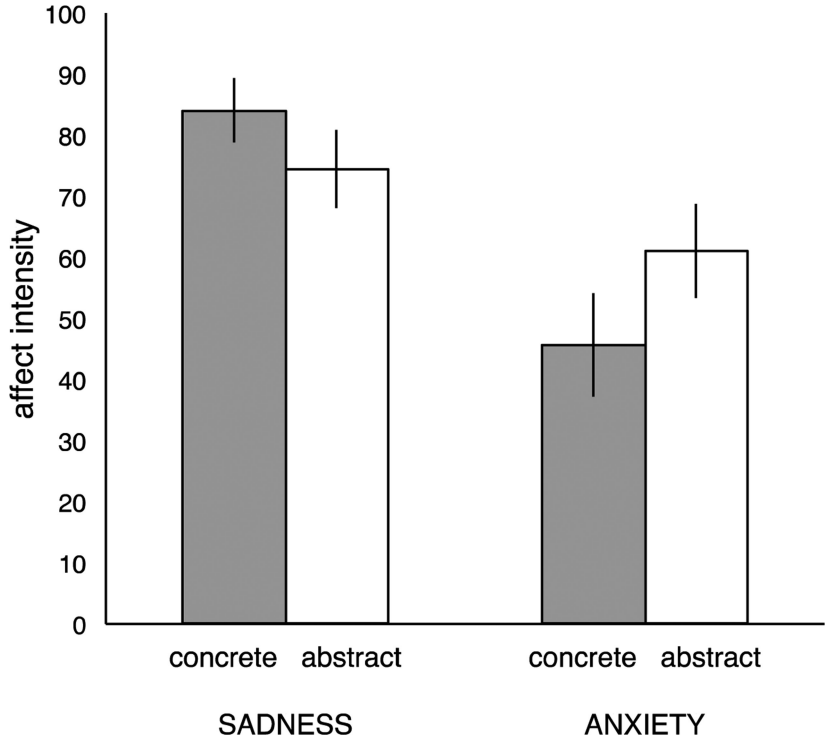

Fig 3.

Focusing on the abstract causes of the Newtown shooting (vs. its concrete details) brings about decreased sadness but increased anxiety. Error bars reflect 95% CI of the mean.

Table 1

Individual words from LIWC sadness, anxiety, and causality word categories most strongly associated with increasing time and distance from the Sandy Hook tragedy, reported as Spearman's rank correlation rho (ρ) ± 95% CI. Bold indicates coefficients 1 surviving FDR 2 correction at $p < .05$.

		change over TIME			change over DISTANCE	
SADNESS		**ρ**	**95% CI**		**ρ**	**95% CI**
words	traged*	**−0.1428**	[−0.140, −0.146]	lost	**−0.0138**	[−0.013, −0.015]
	mourn*	**−0.0620**	[−0.060, −0.064]	sad	**−0.0125**	[−0.011,−0.014]
	griev*	**−0.0552**	[−0.053, −0.057]	sobbing	−0.0117	[−0.011,−0.013]
	lost	**−0.0548**	[−0.053, −0.057]	loss*	−0.0117	[−0.011,−0.013]
	sadde*	**−0.0469**	[−0.045, −0.049]	depress*	−0.0102	[−0.009, −0.011]
ANXIETY						
words	craz*	**0.0584**	[0.056, 0.061]	doubt	**0.0245**	[0.023, 0.026]
	obsess*	**0.0546**	[0.052, 0.057]	craz*	**0.0199**	[0.019, 0.021]
	terror	**0.0515**	[0.049, 0.054]	fearful	**0.0133**	[0.012, 0.014]
	fearful	**0.0499**	[0.048, 0.052]	unsure	**0.0128**	[0.012, 0.014]
	scare	**0.0393**	[0.029, 0.033]	obsess*	**0.0120**	[0.011, 0.013]
CAUSALITY						
words	since	**0.0884**	[0.086, 0.091]	used	**0.0262**	[0.025, 0.028]
	used	**0.0392**	[0.037, 0.041]	reason*	**0.0223**	[0.021, 0.024]
	caus*	**0.0392**	[0.037, 0.041]	why	**0.0178**	[0.017, 0.019]
	force*	**0.0319**	[0.030, 0.034]	motiv*	**0.0175**	[0.016, 0.019]
	use	**0.0207**	[0.019, 0.022]	source*	**0.0160**	[0.015, 0.017]