Research Article

Linguistic Markers of Psychological Change Surrounding September 11, 2001

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ABSTRACT—*The diaries of 1,084 U.S. users of an on-line journaling service were downloaded for a period of 4 months spanning the 2 months prior to and after the September 11 attacks. Linguistic analyses of the journal entries revealed pronounced psychological changes in response to the attacks. In the short term, participants expressed more negative emotions, were more cognitively and socially engaged, and wrote with greater psychological distance. After 2 weeks, their moods and social referencing returned to baseline, and their use of cognitive-analytic words dropped below baseline. Over the next 6 weeks, social referencing decreased, and psychological distancing remained elevated relative to baseline. Although the effects were generally stronger for individuals highly preoccupied with September 11, even participants who hardly wrote about the events showed comparable language changes. This study bypasses many of the methodological obstacles of trauma research and provides a fine-grained analysis of the time line of human coping with upheaval.*

The study of social and psychological responses to emotional upheavals has always faced special methodological challenges. Many gold standards of traditional research, such as experimental control, random assignment, repeated assessments, and multiple methods, are difficult to employ when studying unpredictable life events. Research on collective upheavals has generally relied on retrospective self-reports provided days, weeks, or even months after the event. This is troublesome given findings about memory distortions when recalling events with high emotional impact and personal involvement (Hirst, Manier, & Miller, in press; A.A. Stone et al., 2000). Even if individuals' responses are not distorted, the reflective state in which they respond to these measures may differ from their more naturalistic, ongoing experience. Finally, detailed data on subjects' baseline (preupheaval) behavior has been available only in rare, serendipitous circumstances (e.g., Nolen-Hoeksema & Morrow, 1991).

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The field would benefit from research that (a) tracks responses to upheavals as they naturally unfold, providing a continuous time line of coping; (b) goes beyond self-report; and (c) compares subjects' thoughts, feelings, and behavior with their habitual states prior to the upheaval. This study describes the application of a relatively new methodology—computerized text analysis—to a recent cultural phenomenon—public on-line diaries—as they reflect responses to the overwhelming personal and cultural upheaval of September 11, 2001.

The explosive growth of the Internet has opened new venues for social science research (Gosling, Vazire, Srivastava, & John, in press; Thomson, Murachver, & Green, 2001). The sharing of experiences on-line provides researchers with the opportunity to track psychological reactions to personal and public events quickly, unobtrusively, and in large populations. One recent Internet phenomenon is on-line journaling. Users publish their ongoing personal diaries (known as Weblogs or "blogs") on a Web site where they can be read and discussed by others. Recent research on Internet usage has estimated that 8,820,000 Americans have written in an Internet journal at least once (Pew Internet & American Life Project, 2003), and livejournal.com, the largest single journaling Web site, records approximately 170,000 entries every day.

On-line personal journals can provide naturally occurring windows into people's thoughts and feelings. Users' regular reports approximate a continuous measure of their emotions and cognitions, helping to reduce recall biases and other memory distortions in responding. Some journals have daily entries stretching back for years, permitting a fine-grained longitudinal analysis of psychological change. Archived entries can also be used to compare writing before and after an event to produce a within-subjects measure of psychological response.

Computerized text analysis is a valuable tool for extracting psychological observations from the enormous databases of verbal material now available to researchers (Mehl, in press). One recent text-analysis program, Linguistic Inquiry and Word Count (LIWC; Pennebaker, Francis, & Booth, 2001) searches for words across more than 70 linguistic categories. LIWC has been extensively validated and has provided substantial evidence about the social and psychological implications of word use (see Pennebaker, Mehl, & Niederhoffer, 2003).

People's natural language use carries important information about their personalities, social situations, ongoing emotional and cognitive

coping processes, and idiosyncratic reactions to crisis. For example, individuals use more first-person singular pronouns if they are young (Pennebaker & Stone, 2003), when they are depressed or dealing with a personal crisis (Pennebaker & Lay, 2002; Rude, Gortner, & Pennebaker, in press), and if they are induced to be honest as opposed to deceptive (Newman, Pennebaker, Berry, & Richards, 2003). An elevated use of references to other people in e-mails or personal diaries can signal lower testosterone levels (Pennebaker, Groom, Loew, & Dabbs, 2004) or a greater sense of community, as among people talking about Princess Diana in public chat rooms immediately following news of her death (L.D. Stone & Pennebaker, 2002).

One of the frustrations of linguistic analyses is that there is an almost infinite number of dimensions to extract from written or spoken text. Drawn broadly from the social and health psychology literature, four general themes linked to current thinking on coping can be explored using a text-analytic approach: emotional processing, cognitive processing, social and interpersonal concerns, and psychological "closeness" or "distance" relative to the topic being discussed. We discuss each briefly in turn.

There is little disagreement that adverse life events are emotionally painful. Although most individuals who experience traumatic events do not become clinically depressed or develop posttraumatic stress disorder, studies generally find a temporary increase in negative mood (Koss & Kilpatrick, 2001; Stroebe, Hansson, Stroebe, & Schut, 2001). Positive emotions, when present, help protect mental health in the aftermath of crisis (Fredrickson, Tugade, Waugh, & Larkin, 2003). Unfortunately, there is no clear sense of how long—hours, days, or months—emotions persist after an emotional upheaval. A goal of the present research was to determine how long emotional states linger by analyzing participants' use of positive and negative emotion words.

Cognitive activity is likely to increase after an upheaval as individuals try to comprehend, make sense of, and eventually find meaning in what happened (e.g., Davis & Nolen-Hoeksema, 2001). Developing a narrative may be a core component of understanding a traumatic event. Previous studies have found that an increased use of causal words (e.g., *because*, *cause*, *effect*) and other words suggestive of cognitive processing (e.g., *realize*, *understand*) predicts recovery from trauma (Pennebaker et al., 2003). We predicted that to the extent that an upheaval forces people to try to understand their worlds, we would find an increase in this type of language after September 11.

Personal and collective upheavals also affect people's social lives. Traumatic events are often followed by social sharing, seeking of social support, changes in social interactions, and an increased collective orientation (Mehl & Pennebaker, 2003; Pyszczynski, Solomon, & Greenberg, 2002; Rimé, Finkenauer, Luminet, Zech, & Philippot, 1998). Linguistically, the increased concern with social dynamics in the wake of a trauma should be reflected in more frequent references to other people, including a higher rate of second-person, third-person, and first-person plural pronouns (reviewed in Pennebaker et al., 2003).

Finally, clinicians and researchers have noted that people adopt a variety of defenses in dealing with threatening events. One of the most common is distancing or detachment, wherein individuals psychologically remove themselves from the event (e.g., Horowitz, 1976; Shapiro, 1965). This defense is apparent in a linguistic device called verbal nonimmediacy (Wiener & Mehrabian, 1968), or in its factor-analytically derived inverse, immediacy (Pennebaker & King, 1999), also called involved production (Biber, 1988). When people are writing with high psychological distance (compared with low psychological distance), they use longer words and more articles, and avoid present tense and first-person singular. We predicted that an emotional upheaval would provoke increased distancing (a drop in immediacy).

This study tracked linguistic indicators of psychological change in response to the September 11 attacks. The political, social, and psychological implications of these events are hard to exaggerate. Almost 3,000 people were killed, and tens of thousands more exhibited pronounced emotional distress (Galea et al., 2002; Schuster et al., 2001; Silver, Holman, McIntosh, Poulin, & Gil-Rivas, 2002), changes in behavior (Penner, 2003), and changes in self-reported personal traits (Peterson & Seligman, 2003). The study of people's responses to September 11 thus offers a unique opportunity to map the natural time course of coping with a widespread cultural upheaval.

We downloaded the diary entries of 1,084 high-frequency users of livejournal.com for 2 months prior to and after the September 11 attacks and analyzed these entries using LIWC. Changes in participants' language use from their pre-September 11 baselines were tracked along four dimensions: emotions, cognitive processing, social responses, and psychological distancing. The study provides fine-grained analyses of people's immediate responses in the first 2 weeks following the attacks, as well as broader analyses of longer-lasting reactions.

Three broad questions were addressed: (a) How did September 11 affect people's emotional, cognitive, social, and psychological lives? (b) What was the natural time course of these responses? What were the immediate and the longer-lasting effects? (c) To what extent did preoccupation with the events of September 11 affect the magnitude and time course of subsequent linguistic changes? What other factors contributed to people's responses to the attacks?

METHOD

Participants and Data Collection

The initial sample included all U.S. users of livejournal.com whose self-reported profiles included their age and state of residence, and indicated permission for search engines to access their diaries. Journals were downloaded for those users who had at least one public entry during the 2 months prior to September 11 and at least 12 of the 21 time periods afterward. A time period was defined as 1 day during the first 2 weeks (September 11–24) and as 1 week thereafter (September 25–November 5). The final sample consisted of 1,084 participants, who wrote approximately 26,000,000 words in 71,800 entries. On average, participants updated their journals every 2 days in the 2 months prior to September 11 (mean number of entries = 29.9) and every 1.6 days in the 6 weeks afterward (mean number of entries = 36.4).

The mean age for the sample was 24.7 years ($SD = 8.3$). Of the participants, 53% were female, 40.7% were male, and 6.3% did not report their gender. Although data on city of residence were not available, 66 participants (6.1%) were from New York State. Because they might have been affected differently or more severely than residents of other states, we conducted analyses to examine this possibility. Information on race and education level were unavailable, but demographic research indicates that users of "social" Web sites like livejournal.com are representative of the American population on these variables (Howard, Rainie, & Jones, 2001).

Linguistic Analyses

LIWC checks each word of a document against an internal dictionary of more than 2,300 words and word stems. Each word is assigned to specific linguistic categories, and the percentage of total words in each category is reported. For example, the word *cried* falls into four categories: sadness, negative emotion, overall affect, and past-tense verb. Our analysis focused on four linguistic indicators: emotional positivity, cognitive processing, social orientation, and psychological distancing. Findings concerning other linguistic variables are available upon request.

Emotional Positivity

The emotional-positivity index was calculated as the difference between the LIWC scores for positive emotion words (e.g., *happy*, *good*, *nice*) and negative emotion words (e.g., *kill*, *ugly*, *guilty*). Across time periods, these scores were virtually mirror images. Higher scores indicate greater overall emotional positivity.

Cognitive Processing

The cognitive-processing index indicates how often participants used words such as *think*, *question*, and *because*. Psychologically, it reflects the extent to which participants were concerned with organizing and intellectually understanding the issues addressed in their writing.

Social Orientation

The social-orientation index indicates how often participants used words such as *talk*, *share*, or *friends* and personal pronouns other than first-person singular. Psychologically, it reflects how much participants referred to other people in their writing.

Psychological Distancing

The psychological-distancing index is a factor-analytically derived composite variable based on the LIWC scores for articles and words of more than six letters and inverse scores for first-person singular pronouns, words indicating discrepancy from reality (e.g., *would*, *should*, *could*), and present-tense verbs. Previous research has shown that these linguistic variables naturally correlate in speech and writing (Biber, 1988; Pennebaker & King, 1999). Low-scoring samples can be described as using personal, experiential language with a focus in the here and now. High-scoring samples can be characterized as having an abstract, impersonal, and rational tone (Wiener & Mehrabian, 1968).

Preoccupation With September 11

The preoccupation index was calculated using a list of 27 target words such as *Osama*, *World Trade Center*, *hijack*, and *Afghanistan* (the September 11 dictionary). Independent raters endorsed these words as highly and specifically related to September 11 and its aftermath, with an agreement rate of 82%. High scores indicate focus on or preoccupation with the events of September 11 and their aftermath.

Data-Analytic Strategy

Data Aggregation

Participants' language use for the 2 months prior to September 11 was averaged into a pre-September 11 baseline. Data from afterward were aggregated into seven 2-day periods, followed by three 2-week periods. This strategy allowed for a fine-grained inspection of participants' short-term responses, as well as broader analyses of long-term shifts in language use. Periods without writing were filled in by linear interpolation between adjacent periods.

Grouping for Preoccupation With September 11

An average of 0.28% of the words in each entry were recognized by the September 11 dictionary ($SD = 0.27\%$). An overall preoccupation score was calculated by averaging use of September 11 words over all periods. Preoccupation was higher for males than females, $r(1014) = -.215$, $p < .001$, and higher for older participants than for younger participants, $r(1082) = .226$, $p < .001$; it was marginally higher for participants from New York than for other participants, $r(1082) = .058$, $p = .06$. For analysis of the moderation effects of preoccupation, participants were categorized as high (highest 25%), medium (middle 50%), or low (lowest 25%) in preoccupation.

RESULTS

Qualitative Content Analysis of Entries

To obtain an idea of the content of the on-line journals, we asked a rater who was blind to the research questions of the study to code 200 randomly selected entries. Half the entries were from immediately before September 11, and half were from immediately afterward. Pre-September 11 entries described everyday activities such as outings with friends and family (34%), hobbies (20%), and romantic relationships (15%). The average entry contained 1.2 topics. In the days immediately following September 11, these topics remained, but their frequency was reduced in favor of topics like death and religion, and a preponderance of entries about the attacks (71%).

Quantitative Linguistic Analysis of Entries

Participants' scores were expressed as changes from baseline standardized within preoccupation group. A series of 3 (preoccupation group) × 8 (time period: baseline plus Days 1–2, 3–4, 5–6, 7–8, 9–10, 11–12, 13–14) mixed-factors repeated measures analyses of variance (ANOVAs) was computed. When necessary, F tests were adjusted for lack of sphericity using the Greenhouse-Geisser correction formula. Degrees of freedom were 7 and 7,567 for the main effect of time (subscript "Time"), 2 and 1,081 for the main effect of preoccupation group (subscript "Preocc"), and 14 and 7,567 for the interaction term between time and preoccupation (subscript "Preocc × Time"). Longer-lasting shifts in language use were identified by testing the last 6 weeks against the baseline using 3 × 4 mixed-factors repeated measurement ANOVAs.

Emotional Positivity

First 2 Weeks. Participants initially dropped in emotional positivity, $F_{\text{Time}} = 60.61$, $p < .001$, $\eta_p^2 = .05$ (Fig. 1a). Positivity bottomed during the September 11–12 period, with an average drop from baseline of 1.36 *SD* units. Emotional positivity then increased monotonically and returned to its pre-September 11 baseline within 1 week. Higher September 11 preoccupation was associated with lower emotional positivity overall ($F_{\text{Preocc}} = 14.39$, $p < .001$, $\eta_p^2 = .026$), and preoccupation significantly moderated the time course of participants' emotional positivity ($F_{\text{Preocc} \times \text{Time}} = 1.78$, $p = .04$, $\eta_p^2 = .003$), with a more pro-

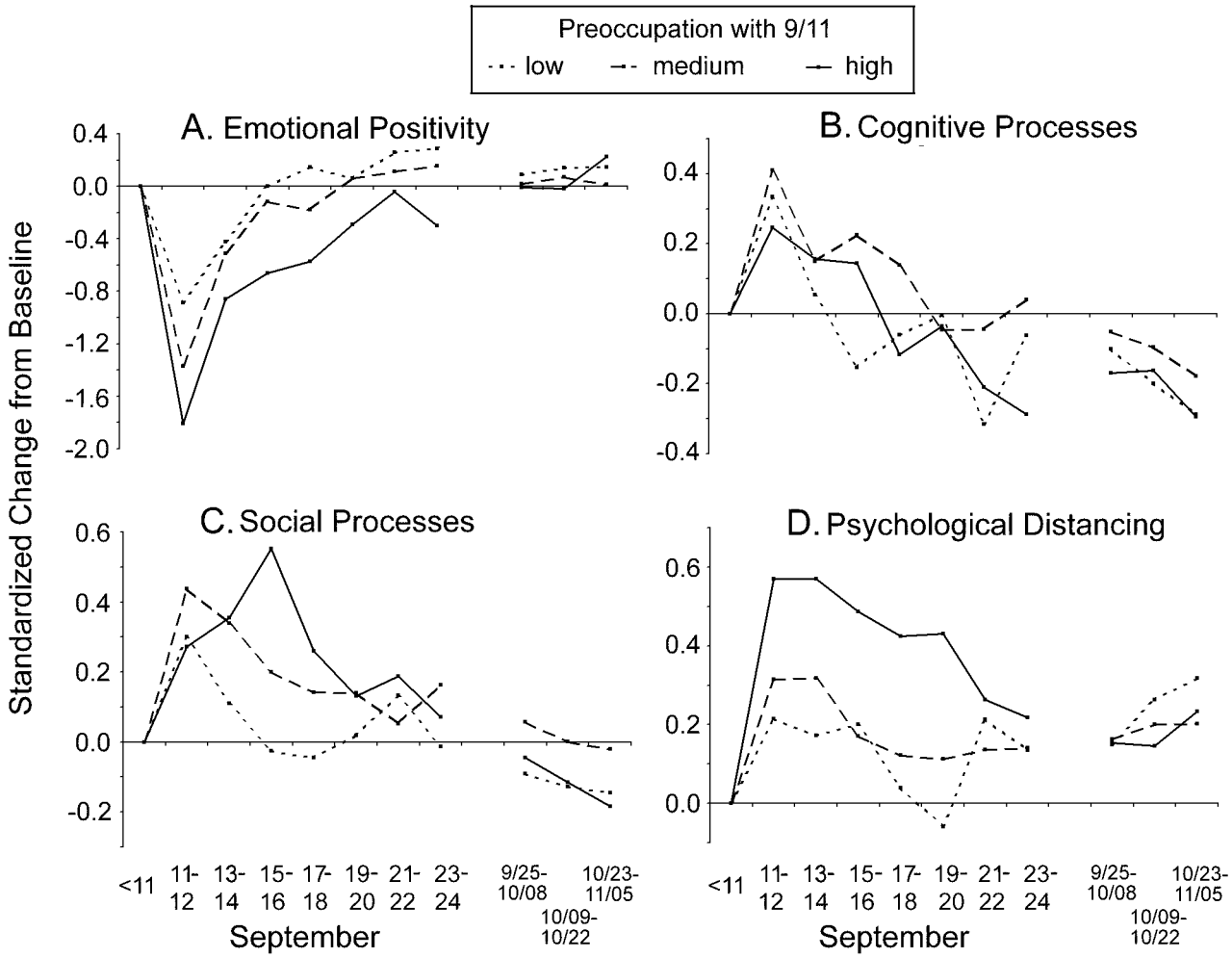

Fig. 1. Psychological changes after September 11, 2001, as indicated by participants' language use in their journal writings ($N = 1{,}084$). Participants' overall use of September 11–related words (e.g., *Afghanistan*, *World Trade Center*) was used to divide them into preoccupation groups: lowest 25%, middle 50%, and highest 25%. The graphs depict deviations from group mean baseline expressed in baseline *SD* units. Emotional positivity was calculated as the difference between scores for positive and negative emotion words. Psychological distancing was derived from use of articles and words of more than six letters, and reverse scores for first-person singular pronouns, discrepancy words (e.g., *would*, *could*), and present tense.

nounced drop and slower return to baseline for the high-preoccupation group than the other groups.

Weeks 3–8. During the 6 weeks of follow-up, there was a nonsignificant trend toward increased emotional positivity relative to baseline, $F_{\text{Time}} = 2.23$, $p = .09$, $\eta_p^2 = .002$. No group or interaction effects emerged.

Cognitive Processing

First 2 Weeks. Participants evidenced sharp increases in cognitive processing on September 11 and 12, but cognitive-processing indices dropped below baseline within the first week ($F_{\text{Time}} = 9.89$, $p < .001$, $\eta_p^2 = .009$; Fig. 1b). No other effects emerged.

Weeks 3–8. Cognitive processing remained below baseline for the entire follow-up period, $F_{\text{Time}} = 35.18$, $p < .001$, $\eta_p^2 = .011$. Again, no other effects emerged.

Social Orientation

First 2 Weeks. Over the first 2 weeks, social references in people's writings changed, $F_{\text{Time}} = 6.36$, $p < .001$, $\eta_p^2 = .006$ (Fig. 1c), and the changes were moderated by September 11 preoccupation, $F_{\text{Preocc} \times \text{Time}} = 1.99$, $p = .02$, $\eta_p^2 = .004$. All three groups experienced a post-September 11 increase in social orientation and returned to baseline within the 2-week period, but participants with higher preoccupation showed more pronounced responses and slower returns to baseline. The main effect for preoccupation was not significant.

Weeks 3–8. Participants' social references dropped below baseline during the follow-up period, $F_{\text{Time}} = 3.69$, $p = .012$, $\eta_p^2 = .003$. No other effects emerged. A strong negative linear trend over these 6 weeks ($F_{\text{Time}} = 10.90$, $p = .001$, $\eta_p^2 = .01$) suggests that social orientation declined continuously. By the end of the study, the medium-preoccupation group was at baseline, and the high- and low-preoccupation groups were below baseline.

Psychological Distancing

First 2 Weeks. All three groups experienced an increase in psychological distancing on September 11 and 12, and by the end of the initial 2 weeks, none had returned to baseline, $F_{Time} = 11.53$, $p < .001$, $\eta_p^2 = .011$. The high-preoccupation group showed more pronounced responses than the other groups, $F_{Preocc \times Time} = 2.25$, $p = .009$, $\eta_p^2 = .004$, and more distancing overall, $F_{Preocc} = 5.10$, $p = .006$, $\eta_p^2 = .009$.

Weeks 3–8. Psychological distancing remained elevated compared with baseline for the entire 6 weeks of the follow-up period, $F_{Time} = 25.12$, $p < .001$, $\eta_p^2 = .023$. No other effects emerged.

Additional Analyses

A set of additional repeated measures ANOVAs yielded no significant differences between participants from New York State and those from elsewhere in the United States. Significant gender differences existed at baseline: Indices of social orientation and cognitive processing were higher for females than for males, and males showed more psychological distancing than females. However, gender produced no significant interactions in Gender × Preoccupation × Time ANOVAs. Increasing age predicted increases in baseline positivity and psychological distancing, and decreases in baseline social and cognitive language. A small number of interactions involving age were significant, but the effects were sporadic and inconsistent (details are available from the authors).

Finally, the pre-September 11 baseline period was divided into nine approximately weekly periods, and the data for these periods were analyzed in the same way as the post-September 11 data. No significant effects emerged, suggesting that the post-September 11 effects differ substantially from normal fluctuations.

DISCUSSION

The September 11 attacks provoked substantial changes in linguistic indicators of psychological function in the daily writing of livejournal.com subscribers. In the short run, participants expressed more negative emotions, were more cognitively and socially engaged, and were more psychologically distant in their daily journal writings. Within 2 weeks, their moods and social referencing returned to baseline, but the increase in distancing persisted, and their level of cognitive analysis was significantly lower than it had been before September 11. The change in psychological distancing lasted throughout the 6 weeks of the follow-up period, and social referencing continued its descent during that time. Participants who were most preoccupied with the terrorist attacks (i.e., who mentioned it most in journal entries) showed the most dramatic linguistic shifts. However, participants who rarely mentioned September 11-related topics in their diaries showed language changes that were comparable in nature and time course, though generally less pronounced, suggesting the presence of psychological change in the absence of overt concern with September 11.

Perhaps the most important unanswered question related to our findings is who livejournal.com users are. Does their writing reflect the social, psychological, and linguistic patterns of society in general? Our sample included both genders and spanned a wide age range (though younger than average), and demographic research suggests that they are roughly representative of the race and education makeup of the United States (Howard et al., 2001). The current sample is undoubtedly atypical in that it represents a group of people who are comfortable sharing their private lives with a worldwide audience, and other distinguishing features may remain unknown. Nevertheless, the similarity of response by people differing in their preoccupation with September 11, as well as the similar response patterns across age, sex, and New York residency, suggests that the psychological reactions of users of livejournal.com may reflect the psychological reactions of the American population in general. The issue of the representativeness of Weblogs and other on-line forums must be the focus of future research in the growing area of Internet science.

The results for emotional positivity address a central question about the experience and regulation of emotions. Whereas social psychologists think of emotions as short-lived, typically dissipating within seconds, minutes, or, at most, hours (Feldman Barrett, Gross, Conner, & Benvenuto, 2001), clinical psychologists usually consider them to last much longer—sometimes weeks or years (e.g., Lehman, Wortman, & Williams, 1987). The emotional-positivity index revealed a dramatic but short-lived reaction, with even high-preoccupation participants returning to baseline within approximately a week. Although the cognitive and psychological responses linked to these emotions clearly continued, the emotions themselves wore off quickly.

We do not mean to suggest that emotional responses are unimportant. The ability to experience positive emotions following a tragedy is critical for resilience (Fredrickson et al., 2003), and the ubiquity of negative emotional reactions is useful as a marker of traumatization (Rimé et al., 1998). Although we did not include direct measures of coping, the lower levels of emotional positivity among participants in the high-preoccupation group suggest that they were somewhat less successful at coping with the events than other participants were.

The immediate increase in references to other people is consistent with the literature indicating that humans and other social animals affiliate more during periods of threat than at other times (Schachter, 1959). Indeed, connections with others during emotional upheavals have been shown to serve a protective function (see Cohen & Wills, 1985). Additionally, some portion of this increase in use of social language indicates a broader concern with the victims of the attacks or with the writer's community or nation. Qualitative analysis revealed that 44% of post-September 11 entries dealt with a large social group such as a city or nation, as opposed to 0% of entries from before the attacks. This change in focus is corroborated by the large and immediate surge in volunteerism that followed the attacks (Penner, 2003) and by nationwide psychological surveys demonstrating increases in interpersonal and prosocial personal strengths (Peterson & Seligman, 2003).

Language indicative of cognitive processing showed a similar sharp spike and quick return to baseline, but was followed by a surprisingly prolonged depression for all participants, irrespective of preoccupation level. The initial increase suggests that in the confusion and speculation that followed the attacks, people sought to understand the causes and meanings of the events and, perhaps, of issues in their own lives (Taylor, 1983). The subsequent reduction is reminiscent of the urban-stress phenomenon, in which unpredictable or uncontrollable loud noises lead to decreased cognitive skills (Glass & Singer, 1972; Hygge, Evans, & Bullinger, 2002). These findings suggest that the fear and uncertainty experienced after September 11 may have eventually become a similar impediment to people's capacity to process complex information.

Psychological distancing—measured as a low use of first-person singular pronouns, present-tense verbs, and discrepancy words and a high use of big words and articles—showed a large and prolonged increase after September 11. This linguistic pattern is also seen in formal, task-oriented contexts as opposed to more informal, emotion-oriented settings (Biber, 1988). To the extent that our findings reflect the psychological processes of Americans in general, they suggest that the events of September 11 induced a state of psychological shock in which Americans became more cognitively wary, more detached, and less experiential (Epstein, 1994).

The overall greater magnitude of the reactions for high-preoccupation participants is consistent with findings that the perceived severity of a trauma correlates with the severity and longevity of the need to discuss it (Rimé et al., 1998). However, the between-groups homogeneity in reactions is also noteworthy: Even participants in the lowest 10% of preoccupation, tested in a separate analysis, showed similar patterns. Low-preoccupation participants were undoubtedly exposed to news of the attacks and forced to process information about them in the immediate aftermath. Even one and a half months later, their linguistic indices remained largely in concert with those of the high-preoccupation group.

Our sample presents an overall picture of subtle but pervasive change 2 months after September 11. At this point, the on-line writers were no longer overtly distressed, grieving, or angry, but remained wary. Cognitive processing and social integration, which were important in the immediate aftermath of the attacks, were in a prolonged decline, possibly because of exhaustion or long-term stress. Future research may reveal whether there were corresponding changes in people's daily activities and behavior, or whether the changes were primarily in people's perspectives, thoughts, and emotions.

This project offers fresh insights into how people respond psychologically to large-scale upheavals that affect large populations. The short-term effects found here converged with those found after smaller-scale disasters, such as tragic deaths in a college community (Gortner & Pennebaker, 2003) and the death of Princess Diana (L.D. Stone & Pennebaker, 2002). However, our extended analyses revealed unexpected long-term changes as well: The cognitive effects of traumatic events may persist for long periods of time, even after the emotional effects have faded and in the absence of a conscious focus on the inciting event. In years to come, on-line sources such as livejournal.com, together with an increasingly sophisticated approach to text analysis, have great potential to help reveal the broad and subtle effects of cultural and personal upheavals.

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