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CORRESPONDENCE: clarksco@uwec.edu

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Factors influencing non-expert term usage during a disaster: An analysis of the 2004 Indian Ocean tsunami

Xai Her[1,2], Ellen K. Buelow[1,3], and Scott K. Clark[1]

[1]Department of Geology, University of Wisconsin–Eau Claire, 105 Garfield Avenue, Eau Claire, Wisconsin 54701, USA
[2]Department of Geology and Environmental Geosciences, Northern Illinois University, Davis Hall 312, Normal Road, DeKalb, Illinois 60115, USA
[3]Department of Geological Sciences, San Diego State University, MC-1020, 5500 Campanile Drive, San Diego, California 92182-1020, USA

ABSTRACT

Understanding how the general public uses science terminology during disasters has implications for improving communication between disaster experts and the public and for informing efforts designed to cultivate science literacy. This study presents an analysis of quotes in U.S. newspaper and newswire articles from people who identified the 26 December 2004 Indian Ocean tsunami either as a *tidal wave* or as a *tsunami* immediately after the disaster. Quotes from 147 individuals were assigned codes based on their location, nationality, and connection to the event. Individuals coded as experts (n = 16) only uttered *tsunami*. English-speaking non–tsunami experts in impacted countries were significantly more likely to identify the tsunami as a *tidal wave* than were individuals in non-impacted countries. Of 31 quoted non–tsunami experts who were in an impacted country, 52% described the disaster as a *tidal wave*; only 2% of distal non–tsunami experts (n = 100) uttered *tidal wave*. Of particular note, four of ten quoted tourists from the U.S. who experienced the tsunami uttered *tidal wave*, whereas none of 27 quoted residents in the U.S. did so. Our results suggest that even if people are aware of appropriate terminology, many individuals will utter more familiar, colloquial, and linguistically simpler words instead of more accurate terminology, especially when experiencing elevated levels of stress, such as during the aftermath of a disaster. The implication for disaster communication efforts is that while a term that was once considered jargon can become widely known and adopted, many people will resort to a more familiar term unless the scientific jargon resonates with their personal, conceptual image of the disaster.

INTRODUCTION

In the immediate aftermath of a natural disaster, the challenges of effective communication amongst emergency responders, relief organizations, disaster experts, government officials, the media, and the public can be daunting (Grupp and Heider, 1975; Auf der Heide, 1989; Garnett and Kouzmin, 2007; Manoj and Baker, 2007; Laakso and Palomäki, 2013). Garnett and Kouzmin (2007, p. 171) cited "communications gaps, missed signals, information technology failures, administrative buffering, turf battles and deliberate and unintentional misinterpretations …" as reasons why "Hurricane Katrina was as much a communication disaster as it was a natural and bureaucratic disaster". The effectiveness of communication efforts between experts and the general public has been studied across a wide range of natural disasters, including earthquakes (Marincioni et al., 2012), tsunamis (Gregg et al., 2006), hurricanes (Peacock et al., 2005; Garnett and Kouzmin, 2007; Morss and Hayden, 2010), floods (Lave and Lave, 1991; Bell and Tobin, 2007; Kellens et al., 2011), tornadoes (Schumacher et al., 2010), heat waves (Sheridan, 2007), and wildfires (Auf der Heide, 1989; Paveglio et al., 2009).

The specific communication issue that is addressed in this study is that even if people speak the same language (e.g., English) they do not always *use* the same language (i.e., technical jargon). Dissemination of information during emergency situations is hindered by "the lack of a common vocabulary between response organizations and between organizations and citizens" (Manoj and Baker, 2007, p. 52). An example of inter-specialist jargon-induced problems occurred during a 1970 outbreak of wildfires in California when inter-agency firefighting efforts were hampered by a lack of common terminologies between organizations because of differences in the names of position titles, equipment, facilities, and actions between urban and wildland organizations, and also between various urban fire departments (Auf der Heide, 1989). The general issue of jargon-related communication problems between experts and the general public has been widely acknowledged in the literature (e.g., Lerner et al., 2000; Höppner et al., 2010; Kennedy, 2007; Hassol, 2008; Mitchell et al., 2008; Rowe and Alexander, 2008; Somerville and Hassol, 2011). For example, Hassol (2008) recommended that scientists could improve their communication efforts to a general audience on topics like climate change by using words such as *human-caused* and *time* instead of jargon such as *anthropogenic* and *temporal*. Somerville and Hassol (2011) listed examples of scientific words, such as *uncertainty* and *bias*, whose colloquial meanings are drastically different than their meaning in a scientific context. They encourage scientists to choose terms (e.g., *range* and *offset from an observation*) that are less likely to obfuscate the intended meaning. However, while specialists' jargon can cause confusion to people outside the specific field of interest (Mitchell et al., 2008), jargon is used specifically because it provides meanings that are clear and precise (Quarantelli, 1995). The alternative of using colloquial synonyms is not always a viable option because of the ever-present potential for miscommunications due to the ambiguity of many colloquial terms. In this study, we analyze the use of scientific jargon by the general public during the aftermath of a disaster, and address the following question: What can be learned about the adoption of scientific jargon by

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the general public from trends in the utterance of *tidal wave* and *tsunami* in the aftermath of the 2004 Indian Ocean tsunami?

Tsunami is used by the science community to describe fast-moving, high-amplitude waves that are caused by events such as underwater earthquakes, landslides, or volcanic eruptions (Pacific Tsunami Warning Center, 2014a). The term has been used by disaster specialists to issue tsunami warnings to the general public at least as far back as when the Pacific Tsunami Warning Center (PTWC) was established in 1968 (PTWC, 2014a). However, the term has for the most part been considered to be scientific jargon. For example, prior to 2005, *The Associated Press Stylebook and Briefing on Media Law* (*AP Stylebook*), which is used by many journalists as *the* prescriptive dictionary, stated that the term "… is not widely used and should be explained if used" (Goldstein, 2004, p. 271). *Tidal wave* also has a long history as a term for earthquake-generated ocean waves. However, tsunamis can travel up to 100× faster than normal waves such as those caused by tidal forces (PTWC, 2014b). Conflation of the term *tidal wave* with the concept of an ebbing tide has the potential to trivialize the danger of a tsunami and to impact disaster education efforts that inform people how to react to one of the potential early warnings of an impending tsunami.

The 2004 Indian Ocean Tsunami

On 26 December 2004, the seafloor off the west coast of northern Sumatra ruptured, causing a moment-magnitude (M_w) *9.1* earthquake and generating a tsunami that spanned the Indian Ocean (U.S. Geological Survey, 2004). The combined loss of life from the earthquake and tsunami has been estimated at between 228,000 and 300,000, with over a million people being displaced from locations all around the Indian Ocean (U.S. Geological Survey, 2004; Kawata et al., 2005). Many of the deaths that resulted from the tsunami have been attributed to an ineffective warning system and a lack of awareness of what a tsunami is (Morin et al., 2008). The PTWC had issued a tsunami warning to countries including Indonesia and Thailand approximately one hour after the earthquake was detected, but according to Samarajiva (2005), neither officials nor the media in many of those countries noticed the warning alerts, and therefore, official warnings within those counties were not given. Knowledge of natural warning signs such as feeling the earthquake or seeing the sea quickly recede could have saved lives, but tragically those warning signs were not heeded by many residents and tourists (Gregg et al., 2006). Lives were lost when people wandered out onto newly exposed beaches to gather fish that had been stranded there when the waters receded. Apparently, people were unaware that the receding sea—which might have appeared to them to be an ebbing tide—was actually caused by the trough of the first wave in the tsunami train (Gregg et al., 2006; Morin et al., 2008). However, lives can be saved through a combination of local knowledge and timely education efforts (Walshe and Nunn, 2012). During the 2004 Indian Ocean tsunami, people did survive when they correctly interpreted the natural warning signs of the tsunami. For example, inhabitants of the Indonesian island of Simeulue had an oral history on the relationship between a tsunami and an earthquake, and they fled to higher ground after feeling the earthquake (McAdoo et al., 2006). In an example of how formal science education saved lives, a young British girl named Tilly Smith, who was on vacation with her family in Thailand, remembered the natural warning signs of a tsunami that she had learned in her geography class. When she saw that the sea was quickly receding, she alerted people and was able to save an estimated 100 lives (Larcombe, 2005). Education about and literacy of environmental risks are vital for residents and tourists who are in areas that are prone to natural disasters.

Adoption and Application of Science Literacy

An understanding of scientific terms is a well-recognized component of science literacy (Koelsche, 1965; National Research Council, 1996; Miller, 2004; Brossard and Shanahan, 2006). As stated by Brossard and Shanahan (2006, p. 51): "If citizens know scientific and technological terms they see frequently in the media, one could argue that they are scientifically literate within the bounds of normal civic discourse." At a deeper cognitive level than having the ability to recognize scientific terms is the adoption and application of those terms. This use of scientific language facilitates scientific thinking and helps a person "to make sense of events in the natural world" (Yore et al., 2003, p. 715).

Whether or not a person utters a scientific term or a widely accepted colloquial term when describing a natural disaster, like a tsunami, depends on more than just their level of science literacy. As noted by Harkins and Wierzbicka (2001, p. 5), "a careful examination of linguistic data can provide clues to what people mean when they use [specific] words or expressions." Importantly, the context of a stimulus affects which word is uttered (Rahman and Melinger, 2009). Are people possibly communicating something different in uttering *tidal wave* rather than *tsunami* during the immediate aftermath of a tsunami? The theory of semantic representation provides a framework for understanding when people might utter *tidal wave* as opposed to uttering *tsunami*. The theory of semantic representation posits that beyond the role of linguistic cues, such as syntax and patterns in the co-occurrence of words, affective (i.e., emotional) information is foundational in the learning and representation of meanings (Vigliocco et al., 2009). In regards to the specific role of how the emotional reaction to stress affects word choices, Pennebaker and Lay (2002) documented how the then-mayor of New York, Rudolph Giuliani, expressed himself differently under various levels of stress: "… during his crisis periods [both his personal crises and the 11 September 2001 terrorist attacks on the World Trade Center], his words became simpler and his language became more personal" (Pennebaker and Lay, 2002, p. 279). Ungerer (2004) provided an example of a lexical mistake caused by the combination of stress and a lack of familiarity with a term that, if it had occurred in a real-life situation rather than a training exercise, might have resulted in fatalities. During a hazard response training exercise, a vinyl chloride leak was reported to a technical

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operations unit. A member of that unit who handled the report misread *vinyl chloride* as *chlorine gas*, a term with which he was more familiar. This led to a dangerously inappropriate response recommendation by the operations unit. As Ungerer (2004, p. 88) points out: "In an emergency situation, it is more likely that common and familiar terms are (falsely) recalled than that unfamiliar terms are processed correctly". Each of these studies looked at how stress affected the words used by an individual. The massive amount of news coverage on the 2004 Indian Ocean tsunami provides an opportunity to study the effect of a large-scale disaster on the word choice of cohorts of individuals.

The 2004 Indian Ocean tsunami marked a turning point in the media's usage of the two terms *tsunami* and *tidal wave*. In the aftermath of the disaster, the media began to move away from using *tidal wave* in their descriptions of the tsunami. On the day of the tsunami, 40% of the newspaper and newswire articles exclusively used *tidal wave*, 5% exclusively used *tsunami*, and 55% of articles used both terms. However, in the years since that disaster nearly all newspaper and newswire articles have abandoned the use of the colloquial term *tidal wave*. In the aftermaths of subsequent tsunamis, newspapers and newswires have nearly unanimously adopted the scientific term *tsunami* (Clark, 2010). At a time when the media was reporting heavily on the 2004 Indian Ocean tsunami and working to choose the most appropriate word to describe it, they were also publishing quotes that revealed individuals' choice of terminology. Quotes, like those analyzed here, provide an opportunity to study how individuals, commonly eyewitnesses, tell their personal stories in their own words (Zelizer, 1989). The research presented here is an analysis of individuals' usage of the two terms *tsunami* and *tidal wave* in quotes extracted from U.S. newspaper and newswire articles during the first week after the 2004 Indian Ocean tsunami. Three questions are addressed: (1) Are there identifiable patterns of usage in the word choices of cohorts of individuals? (2) If so, what might explain the patterns? (3) What are the implications for science literacy and communication efforts during future disasters?

METHODS

The LexisNexis® Academic database of U.S. newspaper and newswire articles was searched for articles published during the week following the 2004 Indian Ocean tsunami that contained the keywords *earthquake* and either *tsunami* or *tidal wave*. The generated corpus of 2726 articles was downloaded on 23 February 2010. All text in the corpus was copied and pasted into a spreadsheet. This step placed sentences and identifying attributes of the articles into ~95,000 cells within a single column in the spreadsheet. Using the spreadsheet's find-and-replace function, every cell in the spreadsheet was then searched for the keywords *tsunami* and *tidal wave*. Any cell that contained either of those terms (n = 9932) was highlighted. All cells except for the highlighted cells and those cells with the articles' identifying number were deleted. By removing most of the extraneous text, this step reduced the potential for errors of omission during the subsequent step. Next, the data set was transferred into a text file that was visually scanned for instances where *tsunami* or *tidal wave* was contained within a quotation. When an utterance of either *tsunami* or *tidal wave* was determined to be specifically referencing the 2004 Indian Ocean tsunami, the quotation was tallied and the researcher referred to the original article to record the article's title, byline, and date of publication, as well as the person's location and perspective relative to the tsunami (e.g., government official, non-governmental organization [NGO] staff member, resident of the country in which interviewed, tourist). Location was coded as proximal if the quoted individual was in an impacted country when they were interviewed. Location was coded as distal if the individual was not in a directly impacted country. Government officials ranged from presidents and prime ministers to local representatives, and NGO staff were mostly associated with international charity and relief organizations. Duplicated quotes, which appeared in the LexisNexis® Academic corpus because multiple outlets will republish the same story, were removed during the coding process.

Reproducibility of the coding steps was confirmed via an inter-rater reliability analysis (ref. Bresciani et al., 2009). The original coding rubric was written and applied by the first author. Subsequently, the second and third authors independently coded subsets of the data set so that every quote was coded by two researchers. The second author coded the data for everyone except individuals who had been sought out by the media to provide expert-sourced information. Individuals who were originally identified as experts were not included in the original coding because the intent of the study is a focus on utterances by non-experts. When the first and second authors compared their data sets, they did not agree on the exact number of quoted individuals, with determinations of 121 and 126 quoted individuals, respectively. They were in agreement on 94 of the individuals. The two researchers then discussed all differences between their analyses and reached full agreement on relevant quotes from 128 non-experts. The reasons why the researchers' lists did not initially include all 128 quotes included initial differences of opinion as to a quote's relevancy to the 2004 Indian Ocean tsunami, difficulties in determining which individual was being quoted in articles that contained multiple quotes from numerous individuals, and errors of omission as some quotes were not seen by one or the other researcher in the initial coding.

The first and third authors discussed the set of quotes that had been initially identified as being from individuals who had been contacted by the media because of their tsunami expertise (e.g., geophysicists, geoscientists, and wave engineers). They determined that 16 of those quotes were from tsunami experts, but three other quotes were from individuals who might be considered to be experts, but who were not quoted in the context of their expertise. Those three quotes were moved into the non-experts cohort.

After the coding results revealed an overall preference in the utterance of *tsunami*, the first and third authors revisited the instances when *tidal wave* was uttered. Each of those utterances was coded according to whether or not it was used in a context that contained a strong sense of emotion. For example, "… practically devastated as a result of the tidal wave" (government official in

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Sri Lanka, 29 December 2004) was interpreted to have a strong emotional context, whereas "If they knew that an earthquake had happened, why didn't they know that there were likely to be these tidal waves …" (British tourist in Thailand, 27 December 2004) was coded as not having a strong emotional context. Coding to determine whether a person was speaking within the context of experiencing strong emotions is, by its nature, subjective. That said, each researcher initially coded the context of the quotes independently, and the initial inter-rater agreement was 83%. After discussing the differences in the coding, 100% agreement was reached. The complete agreement between the researchers supports an interpretation that while subjective, the results from the coding of emotional states are reliable.

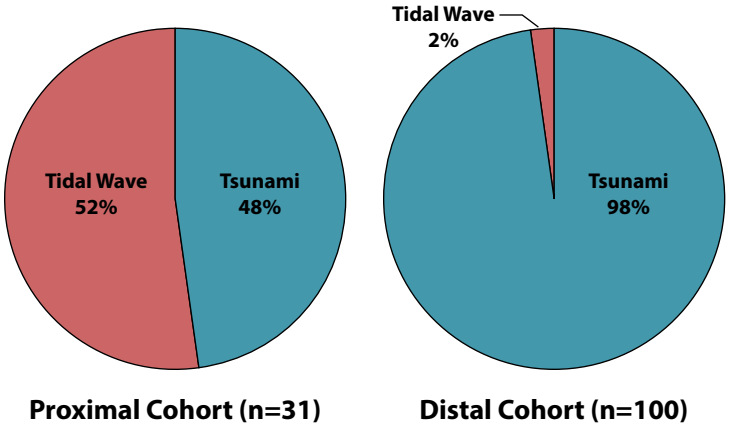

Figure 1. Quoted utterances of *tsunami* and *tidal wave* by individuals who were proximal or distal to the 2004 Indian Ocean tsunami.

RESULTS

The final data set consists of quotes from 147 individuals. All of the individuals (n = 16; 3 proximal and 13 distal) who were quoted in the context of being an expert on some facet of the tsunami used only the term *tsunami*. The expert cohort is not analyzed further in this study. Individuals coded as non-experts (n = 131) included 31 individuals located in impacted countries (labeled as the proximal cohort) and 100 individuals who were in non-impacted countries (labeled as the distal cohort). Sixteen of the 31 proximal individuals (52%) used the term *tidal wave* to describe the tsunami (Fig. 1). This included an NGO staff member who noted that Indians and Sri Lankans were unaccustomed to tsunamis. He was the only individual in the data set whose quote included both *tidal wave* and *tsunami*:

"No one around India and Sri Lanka has ever witnessed or experienced a tsunami. While weather experts have had some experience in tidal waves and there was some warning, most people were still unable to get away. But this is a first for the Indian Ocean since the 1830s" (NGO staff in India, 28 December 2004).

Two of 100 distal individuals (2%) uttered *tidal wave* (Fig. 1). A non-parametric analysis (Mann-Whitney *U* test) shows the difference in term utterances between these two cohorts to be statistically significant ($P < 0.001$).

Proximal countries wherein U.S. newspaper and newswire reporters obtained quotes were India (n = 6), Indonesia (n = 1), Kenya (n = 1), Malaysia (n = 2), Sri Lanka (n = 9), and Thailand (n = 12). The countries wherein the most people used the term *tidal wave* were Sri Lanka (n = 6), Thailand (n = 6), and India (n = 3) (Table 1). Within the proximal cohort, quoted individuals were identified as government officials (n = 9), NGO staff (n = 6), residents (n = 5), and tourists (n = 11). The countries of origin for the tourists were the United States (n = 10) and Great Britain (n = 1). Government officials (6 out of 9), NGO staff (4 out of 6), and tourists (5 out of 11) were much more likely to refer to the tsunami as a tidal wave (Fig. 2) than were residents (1 out of 5). Indeed, the only proximal resident to use *tidal wave* was a non-native resident who was teaching at a school in Thailand. All of the other quoted individuals in Thailand who uttered *tidal wave* were tourists. In Sri Lanka and India, some government officials and NGO staff used the term *tidal wave*, but none of the three residents used it (Table 1).

Quotes from individuals who were not in an impacted country were overwhelmingly obtained from people living in the U.S. (n = 94). Other distal quotes came from American Samoa (n = 1), Canada (n = 1), Netherlands (n = 1), Norway (n = 1), and Switzerland (n = 2). Quoted individuals in the distal cohort were government officials (n = 28), NGO staff (n = 44), residents (n = 27), and members of

TABLE 1. USAGE OF *TSUNAMI* AND *TIDAL WAVE* BY COUNTRY WITHIN THE PROXIMAL COHORT

	India *tsu.–t.w.*	Indonesia *tsu.–t.w.*	Kenya *tsu.–t.w.*	Malaysia *tsu.–t.w.*	Sri Lanka *tsu.–t.w.*	Thailand *tsu.–t.w.*
Government official	2–2	–	–	1–0	0–4	–
NGO staff	1–1*	1–0	0–1	–	1–2	–
Resident	1–0	–	–	–	2–0	1–1
Tourist	–	–	–	1–0	–	5–5
Total	4–3*	1–0	0–1	2–0	3–6	6–6

Note: tsu.—tsunami; *t.w.—tidal wave*; NGO—non-governmental organization.
*The data for India include an NGO staff member who used both terms, and each of those usages was counted.

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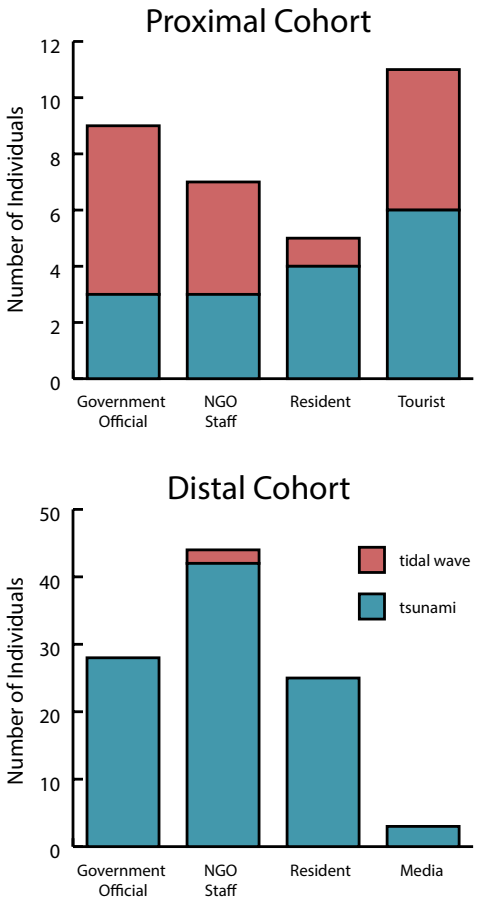

Figure 2. Quoted utterances of *tsunami* and *tidal wave* by subgroups of proximal and distal cohorts after the 2004 Indian Ocean tsunami. The proximal cohort consisted of 31 individuals, with one staff member of a non-governmental organization (NGO) in India having used both terms.

the media (n = 3; Fig. 2). The only quoted individuals in this cohort who used *tidal wave* were two NGO staff members who were working in the U.S.

Seven of the 16 proximal quotes (44%) and one of the two distal quotes that included the term *tidal wave* were coded as revealing a strong sense of emotion connected to the use of that term. For example:

"If there was anyone who should have got swept away by this tidal wave, it should have been us…we were eyeball to eyeball with the wave" (NGO staff in Sri Lanka, 29 December 2004).

"Some have had their children slip out their arms when the tidal waves struck" (non-native resident in Thailand, 29 December 2004).

"All of a sudden, they started hearing people scream and running towards the hotel. Initially, they thought it was a terrorist attack. People started yelling 'tidal wave'" (U.S. tourist in Thailand, 01 January 2005).

Not everyone who spoke with a strong sense of emotion used *tidal wave*. Some individuals who were in an impacted country and a few distal individuals uttered *tsunami* when speaking emotionally:

"When the tsunami hit, it washed away all the single-story buildings. Had we been in our bungalow, we would have been washed away into the sea or dragged under a ton of mud and debris and wood" (U.S. tourist in Thailand, 31 December 2004).

"There's [sic] pictures of people from the tsunami and a gentleman holding his child. It puts everything in perspective" (U.S. resident, 29 December 2004).

"The earthquake and resulting tsunamis that struck Southeast Asia are a human tragedy of monumental proportion" (NGO staff in the U.S., 31 December 2004).

However, the majority of distally obtained quotes, like the one shown below that dealt with issues such as providing aid or pledging support of the victims, did not indicate a strong sense of emotion:

"… another opportunity for us to work with a local organization who has the resources, relationships and understanding of the immediate problem to provide specific relief to those directly hit by the tsunamis" (NGO staff in the U.S., 31 December 2004).

Quotes from one U.S. resident and three individuals in the proximal cohort (two from India and one from Sri Lanka) spoke of how people living in India and Sri Lanka have never experienced a tsunami. For example:

"Sri Lanka has never been hit by tidal waves … in its known history" (government official in Sri Lanka, 28 December 2004).

"The word 'tsunami' is completely foreign to Sri Lankans" (U.S. resident, 27 December 2004).

DISCUSSION

Differences between the utterances of individuals in the proximal and distal cohorts are striking. Whereas just over one-half of those who were in an impacted country used *tidal wave*, almost none of the quoted distal individuals identified the disaster as a tidal wave (Fig. 1). Analysis of the proximal quotes suggests four possible reasons for why *tidal wave* was used by so many people in that cohort: (1) a perception that the terms *tidal wave* and *tsunami* are synonymous and, therefore, interchangeable; (2) a lack of prior knowledge of tsunamis; (3) term usage that might have mirrored the temporal trends seen in the media's shift away from the use of *tidal wave* during the week following the tsunami; and, (4) emotional responses to disaster-related stress causing people to use the simpler and more familiar term. We will examine the potential of each of these reasons as a contributing factor.

Tidal Wave and *Tsunami* as Synonyms

On the day that the tsunami struck, the media treated the two terms as synonyms (Clark, 2010), and the 2004 edition of the prescriptive *AP Stylebook* included the following guidance for journalists: "**tidal wave:** A term often used incorrectly for *seismic sea wave*. These waves are caused by underwater earthquakes, landslides or volcanoes and are sometimes referred to as *great sea waves*. Scientists call them *tsunamis*, a term that is not widely used and should be explained if used" (bold and italicized text in original; Goldstein, 2004, p. 271). While the guidance was telling journalists that it was incorrect to use *tidal wave*, it also made it clear that journalists should not expect the general public to be familiar with the term *tsunami*. To this day, many descriptive dictionaries, such as The American Heritage Desk Dictionary and Thesaurus (American Heritage Publishing Company, 2014) continue to list the two terms as synonyms, so it should not be surprising that many people would have thought of the two words as synonyms. Indeed, based on the long-standing, widely held

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perspective that the two terms are interchangeable, it is surprising that so very few people in non-impacted countries used *tidal wave*. Ninety-eight percent of the predominantly American distal cohort uttered *tsunami*. That suggests that those individuals were knowledgeable and comfortable using the more precise term in late 2004. While this data set suggests widespread adoption of the term in the U.S., there is also evidence that the term was widely used in many other parts of the world as well. In an email correspondence between the authors and Norm Goldstein, the former editor of the *AP Stylebook*, Mr. Goldstein stated that "… our [internationally based] reporters covering the 2004 tsunami … felt that the word *tsunami* was in much more common use in other parts of the world than *tidal wave* and with international news of greater interest, AP should concur" (N. Goldstein, 2012, personal commun.).

Role of the Lack of Prior Knowledge of Tsunamis

Evidence that a lack of prior knowledge of tsunamis was a factor in which term was uttered is seen in the quotes from four individuals who explicitly stated as much regarding people from India and Sri Lanka: "The word *tsunami* is completely foreign to Sri Lankans" (U.S. resident, 27 December 2004). However, over 40% of the individuals from those two countries did use the term *tsunami*. It was not members of the general public who used *tidal wave*, but rather government officials and NGO staff. Even without prior experience, the quoted residents in both of those countries were aware of and uttered the term *tsunami*. The data support an interpretation that, overall, *tsunami* was in common use in many countries, including those that were impacted by the tsunami. This suggests that the specific issue of a lack of familiarity with the term *tsunami* is not an issue for a majority of English-speaking people. Evidence presented in Clark (2010) showed that newspaper and newswire media coverage of seismically induced ocean waves that have occurred since 2004 has almost unanimously used *tsunami* and excluded *tidal wave*. Those findings indicate that familiarity with the term *tsunami* has only solidified with time.

Term Usage Possibly Mirroring the Media

The first day after the tsunami during which more than one-half of newspaper and newswire articles exclusively used *tsunami* in their descriptions of the disaster was 29 December 2004 (Clark, 2010). If a change in the ratio of individuals' utterance of the two terms tracked that of the media, we would expect to see a contemporaneous shift in quotes published after that date. Proximal quotes published on the last two days of 2004 did show an 8:4 preference for *tsunami* (Table 2). However, two of the three quotes from proximally situated individuals published on 01 January 2005, which was the last day analyzed in this study, included the use of *tidal wave*. With no more than seven proximal quotes published on any one day during the studied period, it is not possible to make a statistically supported interpretation on the temporal trend of term usage. While it cannot be ruled out that the media's change in term preference may have had a nearly instantaneous influence on the use of *tidal wave* and *tsunami* by proximal individuals, Mr. Goldstein's remarks cited above suggest that the opposite is more likely. To wit, the public's familiarity with the term *tsunami* helped to persuade the media to abandon *tidal wave*.

Emotional Responses to Disaster-Related Stress

As noted by Pennebaker and Lay (2002), an individual's word choice can provide a perspective on that person's emotional status, and people who are experiencing the stress of an emergency situation are more likely to recall common and familiar terms rather than unfamiliar terms (Ungerer, 2004). In contrast to the scientific term *tsunami*, the colloquial term *tidal wave* explicitly includes the descriptive word *wave*. Anyone who is not fluent in Japanese would need to be educated as to what a tsunami is to know that it means a devastating form of ocean wave. Coding of the quotes that included *tidal wave* detected emotional distress in 44% of the proximal individuals' descriptions of their own or their fellow citizens' personal experiences with the tsunami. From the first quotes after the disaster through 29 December 2004, the utterance of *tidal wave* in an emotional context accounted for 40% of the total utterances of *tidal wave*. That fraction increased to 50% of the utterances over the last three days of the first week after the disaster (Table 2). It was during this time frame that the media was moving away from using *tidal wave*, but the quotes from individuals who were emotionally stressed by the tsunami are not suggestive of a similar trend. An interpretation that the stress of experiencing the disaster affected how individuals identified the waves is supported

TABLE 2. DAILY TRENDS IN FREQUENCY OF *TSUNAMI* AND *TIDAL WAVE* IN RECORDED QUOTES, AND IN THE NUMBER OF TIMES THAT *TIDAL WAVE* WAS USED IN AN EMOTIONAL CONTEXT

	Proximal cohort			Distal cohort		
	tsunami	*tidal wave*	*tidal wave* in an emotional context	*tsunami*	*tidal wave*	*tidal wave* in an emotional context
27 December 2004	2	4	2	11	0	0
28 December 2004*	3	4	0	15	0	0
29 December 2004	2	2	2	21	0	0
30 December 2004	4	3	1	30	2	1
31 December 2004	4	1	0	16	0	0
01 January 2005	1	2	2	5	0	0

Note: No relevant quotes were published on the day of the tsunami (26 December 2004).
*The proximal data for 28 December 2004 includes a non-governmental organization staff member who used both terms.

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by a direct comparison of quotes from U.S. tourists against U.S. residents. Four of the ten quoted U.S. tourists uttered *tidal wave*, while none of the 27 U.S. residents did so. Based on the term usage of U.S. residents, it is quite plausible that many or all of those tourists had heard of the term *tsunami*, but reverted to the more familiar *tidal wave* under the stress of the experience.

Additional support for the interpretation that the stress related to a person's proximity to a disaster, such as a tsunami, influences the words that person uses can be inferred from comments made by a journalist who had reported on the 2004 Indian Ocean tsunami. The journalist, who had been contacted as part of a larger research project, explained in an email why he had used both *tidal wave* and *tsunami* in his articles about the disaster: "Tsunami, to me, says a major ocean event, viewed, metaphorically, from 20,000 feet. A tidal wave, to me, says something a person might have experienced personally, on ground level" (anonymous reporter, 2012, personal commun.).

Broader Natural Disaster Communication Implications

The Geological Society of America's position statement on geoscience and natural hazards policy emphasizes "the crucial role of geoscience education and outreach in broadening the public's understanding of their risk from natural hazards and the available options to reduce risk" (Geological Society of America, 2012, p. 1). This call for geoscientists to communicate their science directly to the public was recently reiterated by Brian Tucker of GeoHazards International in an interview with the news magazine, *Eos*. During the interview, which was conducted in the aftermath of the 25 April 2015, devastating M_w 7.8 earthquake in Nepal, Mr. Tucker stated that geoscientists and engineers have a responsibility "to translate scientific and engineering advances into language the risk managers and the public can use" (Showstack, 2015, p. 11). Both individually and by working within agencies and organizations, a growing number of geoscientists have been reaching out to inform and educate the general public about natural disasters and extreme weather through websites (e.g., U.S. Geological Survey [USGS] Earthquake Hazards Program, http://earthquake.usgs.gov/; Pacific Tsunami Warning Center [National Weather Service], http://ptwc.weather.gov/; National Hurricane Center [National Oceanic and Atmospheric Administration], http://www.nhc.noaa.gov/), books such as *The Dynamics of Disaster* (Kieffer, 2013), and social media, including blogs (e.g., Geology in Motion, http://www.geologyinmotion.com/; the Natural Disasters Association blog, http://www.n-d-a.org/blog/) and Twitter (e.g., USGS seismologist Dr. Lucy Jones, username @DrLucyJones). As more and more geoscientists answer the call to become active in community outreach, it is worthwhile to caution that "doing an adequate job [of informing and educating the public about risk] means finding comprehensible ways of presenting complex technical material that is clouded by uncertainty and inherently difficult to understand" (Slovic, 1986, p. 403). A critical component of presenting information that is "inherently difficult to understand" is the use of effective terminology. Whereas the argument for experts to avoid jargon when communicating with a general audience has merits, we caution that simply abandoning technical jargon is not the answer. Jargon can be a barrier to effective communication, but the use of colloquial terms can also create cognitive barriers to understanding a disaster. Knowing which terms to use in communicating about natural disasters and phenomena is more nuanced than solely avoiding technical jargon. An individual's understanding of the meaning of a term can be influenced by a range of factors from the stress experienced during a disaster to a lack of familiarity with terminology or even something as seemingly irrelevant as their political affiliation. Schuldt et al. (2011) reported that members of the U.S. Republican Party are more likely than members of the Democratic Party to use *global warming* than they are to use *climate change*. They are also less likely to acknowledge that the climate is changing when climate change is referred to as *global warming*. In the same study, Democrats' perspectives on the issue were reported to be unaffected regardless of which term was used. In another study on people's perceptions of climate change, Leiserowitz et al. (2014) found that *global warming* is more likely to be associated with extreme weather phenomena, whereas *climate change* is more likely to be associated with general changes in weather patterns.

A critical need exists to learn which specific terms that accurately describe aspects of a natural disaster or phenomenon are effective, and which are likely to cause confusion or lead to misinterpretations of the presented information. Addressing that need requires analysis of how the terms are used by the target audience. Data mining of social media provides a relatively novel approach that has the potential to analyze term usage by thousands or even millions of individuals' comments related to a disaster. For example, "tweets" posted on the social networking service Twitter have recently emerged as a valuable tool for studying people's reactions to natural disasters. Analyses of tweets have shown that Twitter can be effective at alerting people to a developing disaster and at disseminating alerts during the disaster (Doan et al., 2012; Murthy and Longwell, 2013; Takahashi et al., 2015). Doan et al. (2012) analyzed over 1.5 million tweets from an 84-day period during and after the 2011 earthquake and tsunami that struke the Tohoku region of Japan. Their analysis showed that tweets can be used to track the mood of affected populations as well as serve as an early warning system. Whereas some future research on how people use and perceive terms related to natural disasters will likely continue to utilize quotes obtained from traditional media sources, analysis of social media posts has the potential to provide vast amounts of data relevant to studies of public perceptions of disasters and of disaster communication efforts.

STUDY LIMITATIONS

This investigation relied on the assumption that all quoted individuals spoke English when being interviewed. We found no indication of any translations or uses of an interpreter, but if any individuals were speaking a language other than English, that would severely affect our ability to interpret those

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quotes. The sample numbers between the proximal and distal cohorts are significantly different (31 proximally and 100 distally quoted individuals), and a larger number of proximal quotes would have allowed for a statistical analysis of inter-country utterances. However, the number of quotes is constrained by the real-world limitations of the corpus, which did include 2726 U.S. newspaper and newswire articles. This investigation only analyzed U.S. newspaper and newswire media, and future work that analyzes articles published in other countries and transcripts from television interviews could provide further insights into the interpretations presented here. In 2011, Japan experienced a devastating tsunami that, like the 2004 Indian Ocean tsunami, was widely covered by the English-speaking press. However, because the 2011 tsunami occurred in Japan and the term *tsunami* originated in Japan, the findings presented in this article cannot be effectively compared to quotes from individuals who were impacted by that tsunami.

CONCLUSIONS

By analyzing quotes from 131 non-experts in the aftermath of a single disaster, this study documented multiple reasons for why a person might use alternative terminologies when discussing a disaster. Any explanation for why *tidal wave* was uttered by over 50% of the quoted individuals from impacted countries needs to be compatible with an explanation for why 98% of the distal individuals did not utter *tidal wave*. The evidence presented in this data set and feedback that Associated Press editors had received from their internationally based reporters that *tsunami* is in common use overseas suggests a widespread knowledge of the term *tsunami*. That said, a lack of prior knowledge about tsunamis may have contributed to some of the utterances of *tidal wave*. The use of *tidal wave* as a synonym is a possibility, but with nearly everyone in the distal cohort uttering *tsunami*, and the international prevalence of the term *tsunami*, it does not seem to be a reasonable explanation for the spatial pattern documented here. The media's move away from the use of *tidal wave*, which was just beginning in the days following the disaster, likely has increased the widespread knowledge of the term *tsunami* in the intervening years since 2004, but the media's role in affecting word utterance in the immediate aftermath is not clear, and may not have influenced any of the proximal quotes. Stress, which is what one would expect people to experience in the aftermath of a disaster, is interpreted as the most likely reason many individuals who were close to the tsunami used *tidal wave*. Unfortunately, it is also likely to be the most resistant to being changed through educational and outreach efforts. As Vigliocco et al. (2009) stated in their theory of semantic representation, emotional cues are foundational in the semantic representation of meanings. Under the stress of a disaster, even professional personnel, such as NGO staff or government officials, are susceptible to recalling and using more familiar and linguistically simpler terminology, instead of lesser-known, more accurate terminology (also known as jargon). Even with improvements in the public's science literacy, the use of non-accurate, and potentially dangerous, colloquial synonyms is likely to persist. The implication for post-disaster communication efforts is that while a term that was once considered jargon can become widely known and adopted, many people will resort to a more familiar term unless the scientific jargon resonates at a personal level. With time, education efforts, and continued adoption of *tsunami* by the media, it may be that emotional, stress-related descriptions of tsunamis shift away from describing a tsunami as a *tidal wave* and instead refer to it as a *tsunami wave*. While technically redundant, that term does retain the familiar, explicit, and linguistically simple term *wave*, but avoids potential conceptual conflation with tidal fluctuations. Disaster literacy education efforts and the adoption of precise and accurate terms by the media can mitigate the issue of non-familiarity for the general public, and those education efforts are likely to be most effective during the aftermath of a disaster, when people are seeking information and when the media have the public's attention (Peters, 1993). Determining the degree to which public education and outreach efforts are effective will likely come from analyzing comments posted in social media venues.

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