How Emotions Unfold in Online Discussions After a Terror Attack

Completed Research Paper

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Abstract

In the wake of a terror attack, social media is used for sharing thoughts and emotions, accessing and distributing information, and memorializing victims. Emotions are a big part of this, but there is a gap in our understanding on how those emotions evolve and what kinds of social media uses they are related to. Better understanding of the emotional and topical developments of online discussions can serve not only to fill the aforementioned gap, but also assist in developing better collective coping strategies for recovering from terror attacks. We examine what types of conversations unfolded online after the Boston Marathon Bombing and what kinds of emotions were associated with them, accounting for regional differences, and present a process model covering the general trends of such conversations. Although the phases apply to reactions to terror attacks on a general level, there are proximity-based differences to the location of the terror attack.

Keywords: social media, sentiment analysis, emotions, terror attack

Introduction

Social media has become an important means of relaying real time information in different types of crisis situations, often surpassing the more traditional media in the speed of providing the latest news (Eismann et al. 2016; Huang et al. 2015). However, information sharing is not the only motivation for social media use during and after crises – memorializing victims and sending well-wishes to the affected, confirming the well-being of loved ones, coordinating relief efforts, and expressing thoughts and emotions related to the crisis event are commonplace as well (Huang et al. 2010; Kaufmann 2015; Neubaum et al. 2014; Takahashi et al. 2015).

Expressions of emotions in the wake of a disaster are not merely a process of venting, they serve a purpose. Talking about personal traumas is linked to better physical and psychological health in the months and years following the trauma (Pennebaker and Harber 1993). In addition, collective emotions are associated with higher solidarity, improving the resilience of the affected community (Garcia and Rimé 2019). It is therefore no surprise that emotions are found to be contagious, online environments being no exception to this (Fowler and Christakis 2008; Hancock et al. 2008; Kramer et al. 2014; Kwon and Gruzd 2017). Emotions also play a role in how people share information online (Gruzd 2013; Hansen et al. 2011; Oh et al. 2013; Stieglitz and Dang-Xuan 2013), some emotions more strongly than others (Berger 2011; Berger and Milkman 2012). We decided to focus on terror attacks in particular because they are often temporally clearly defined (as opposed to an ongoing situation of undefined length such as

natural disasters or wars) to ensure a clear view on how emotional processes develop as a result of a crisis event as opposed to an ongoing sequence of related events.

Given the contagiousness of emotions, and their relevance regarding a community's well-being through developing resilience, better understanding of collective emotional processes could not only improve our understanding of how emotions act as indicators of a community's ability to cope with the incident, but could also point us towards ways of improving coping in situations where it is most direly needed. In spite of steadily improving understanding on emotional reactions to crisis events, we still lack a nuanced view on how different emotions develop as people are processing the crisis, and what kinds of topics and concerns are related to those emotions.

How people use social media in the wake of a crisis varies by their proximity to the event. People close by focus more than others on relief coordination, while people farther away engage in greater levels of memorializing (thoughts and prayers, condolences) (Takahashi et al. 2015). People in the directly affected area are in a key position to provide situational information contributing to the collective awareness and support, whereas people far away are in a more passive spectator position (Mukkamala and Beck 2018). It is possible the differences in actions enabled by proximity affect the emotions experienced throughout the post-crisis discussion. In order to shed light on how topics and emotions develop in online conversations after a crisis, and to what extent the developments are regionally specific, we set out to answer the following question:

RQ: *How do emotions and topics of conversation manifest and change over time after a terror attack, and how proximity specific are the emotional and topical developments?*

This study uses Twitter data related to the Boston Marathon Bombing in April 2013. The bombing was widely discussed both locally and internationally, most of the conversation being in English, enabling the comparison of local and global phenomena.

The main events following the bombing are listed in Table 1 to provide an overview as context for the online conversations discussed in this paper. Approximately 4 hours after the start of the marathon, two bombs went off near the finish line, killing three people and injuring hundreds of people. Three days later, the police published surveillance footage of the suspects based on witness accounts. At that point the identity of the suspects was not yet known. Five hours after the footage was released, the suspects shot an MIT police officer, the assumed motive being seizing his gun. Half an hour later, the suspects seized a car and took the car's owner as hostage. When they pulled over to fill the tank, the hostage managed to escape to another nearby gas station to call 911. He had left his cell phone in the car, allowing the police to track down the suspects. At 12:53 a.m. on the night of the 19th of April, the police identified the suspects, and a gun fight ensued. One of the suspects got injured and was being wrestled down by the police, when the second suspect drove a car at the police and the injured suspect, and managed to escape. The injured suspect died about an hour later in a hospital, and his fingerprints helped identify the suspects as Tamerlan and Dzhokhar Tsarnaev. At 7 a.m., the police released the picture and name of the surviving suspect, Dzhokhar, commenced a door-to-door search in the Watertown area, and ordered residents to stay indoors. About 12 hours later, when the shelter in place order had been briefly lifted, a Watertown resident went into their yard to check on their boat, and found a man in it. By 8:30 p.m. the police had surrounded the boat, and 15 minutes later the suspect surrendered. (FBI archives 2013; O'Neill 2015; Wikipedia n.d.)

This work contributes to existing knowledge by increasing the understanding of emotional and topical developments and phases in online discussion following a terror attack, and by developing a process model for phases in post-terror conversations. The theoretical background for the phase model is outlined in the next section. Following that, we describe the data used in this study and outline our methodology. We then report our findings and discuss them, after which we present our conclusions as well as suggestions for future research.

Table 1. The Timeline of Events		
15th April	2:49 p.m.	Two bombs go off near the finish line of the marathon
18th April	5:20 p.m.	Police publishes photos of the suspects (no names yet)
	10:25 p.m.	Suspects shoot an MIT police officer on campus
	11:00 p.m.	Suspects seize a car and take a hostage at gunpoint
19th April	12:15 a.m.	Hostage escapes and calls 911
	12:43 a.m.	A gunfight breaks out between the suspects and the police in Watertown
	12:50 a.m.	One of the suspects drives a car at the policemen and the other suspect, and escapes
	1:35 a.m.	The suspect apprehended at the scene is pronounced dead. His fingerprints lead to identifying both suspects.
	7 a.m.	Photo and name of the remaining suspect published. The police start a door-to-door search in Watertown, residents are ordered to shelter in place
	6-7 p.m.	Shelter in place order briefly lifted. A Watertown resident goes into his yard to check on his boat, and finds a man under the tarp.
	8:30 p.m.	The police have surrounded the boat the suspect is hiding in
	8:45 p.m.	The suspect surrenders

Table 1. The events following the Boston Marathon Bombing

Theoretical Background

Seeking and sharing information is one of the most important uses of social media following a terror event (Eismann et al. 2016; Heverin and Zach 2010; Huang et al. 2015). Social media often is the best up-to-date source of situational information in a crisis situation (Mukkamala and Beck 2016), and information originating from the proximity of the affected area is generally perceived as more credible (Starbird and Palen 2010; Thomson et al. 2012). We have reason to believe emotions play a role in how information is shared in these situations (Huang et al. 2015; Hyvärinen and Beck 2019; Kaufmann 2015), as is also the case more generally on social media (Berger 2011; Berger and Milkman 2012; Gruzd 2013; Hansen et al. 2011; Oh et al. 2013; Stieglitz and Dang-Xuan 2013). Aside from information sharing and seeking, social media is used in crisis situations to memorialize victims and offering condolences, confirming the well-being of close ones, coordinating help, and self-expression (Huang et al. 2015; Kaufmann 2015; Neubaum et al. 2014; Takahashi et al. 2015). The variety of uses gives reason to suspect that in any given crisis situation, there are likely to be various simultaneous conversations unfolding online, serving different purposes, and that there may be different phases during which people focus on specific uses. Although previous research provides valuable insight on emotions in post-crisis online conversations, the discussions have so far been treated as a homogenous entity instead of examining the temporal development of the prevalent topics and uses.

In our quest to understand emotional developments in online conversation, we examined existing psychological theories of emotional reactions and processes during and after crises in order to determine the degree to which they hold in a social media context. Although some theories have been extended and updated after the emergence of online social environments, none of the alterations or updates – to the best of our knowledge – account for the potential shift in conversational habits that may be related to the new environment. Therefore, one of the contributions of this study is determining how well the theories developed in an offline context are applicable to online social environments.

The *social stage model of coping* (Pennebaker and Harber 1993) outlines three stages of coping in the context of a crisis event. The model was developed based on data on the Loma Prieta Earthquake, and further tested on data on the Gulf War. During the initial *emergency phase*, people both talk and think

about the traumatic event frequently. Rumination is common, and is frequently accompanied by elevated anxiety, depression, and trouble sleeping. At this phase, talking about the event may help resolve some of the distress. The emergency phase is followed by an *inhibition phase*, where thoughts about the event are still recurrent, but conversation around the topic decreases significantly. People reported still feeling the need to share thoughts around the event, but being tired of being the receiver of others' emotions and thoughts, leading to a collective inhibition reaction. Suppressing post-traumatic thoughts was found to increase health issues an inter-personal conflict during the inhibition phase. In the final phase, *adaptation*, thoughts around the event become less recurrent, and the social and health indicators of people affected by the crisis will mostly have returned to normal levels.

This study focuses on the emergency phase of the coping model, where people affected by the crisis actively discuss their thoughts and emotions related to the event, and identifies distinct sub-phases based on topical and emotional shifts in the conversation. The reactions to a terror attack can be divided into immediate, *proximal*, reactions, and *distal* reactions that follow after the initial reaction phase (Pyszczynski et al. 1999; Yum and Schenck-Hamlin 2005). The predominant proximal reactions to an act of terror were found to be shock and disbelief (Yum and Schenck-Hamlin 2005). Emotional reactions were found common, as well as concerns for close ones and their safety. The *distal reaction* phase contains behaviors such as altruism, seeking value and meaning, information seeking and sharing, enforcing social connections, heightened patriotism or nationalism, and counter-bigotry advocacy (Yum and Schenck-Hamlin 2005). The proximal and distal reactions are responses to an increase in death-related thoughts, and are an attempt to control ensuing anxiety (Pyszczynski et al. 1999). Particularly in the proximal phase, we expect to see high levels of expression of emotions in online conversations – according to the theory of the social sharing of emotions, experiencing an emotion will create a need to share that emotion (Rimé 2009). In specific, we expect to find high levels of anxiety, anger, and sadness, as those are the emotions people report experiencing elevated levels of following an act of terror (Lerner et al. 2003; Morrison et al. 2001; Pennebaker and Harber 1993; Smith et al. 2001). The proximal and distal reactions and the emotions and topics related to them are outlined in detail in the Findings section phase by phase.

It is likely that not all of the conversations around the thoughts and emotions elicited by a terror attack are expressed online. However, better understanding the dynamics in online conversations can offer valuable information on the emotional atmosphere in the community processing the crisis.

Methods and Data

Data

The data set used in this study consists of tweets related to the Boston Marathon Bombing, collected during and shortly after the event 15th–23rd of April 2013 using Radian6, a social media analytics tool enabling the collection of large datasets from Twitter based on a collection of keywords. In this study, we focused exclusively on a subset of the tweets containing geolocation information in order to be able to analyze geographically specific phenomena. After pre-processing and filtering out out-of-scope (e.g. non-English and off-topic) tweets, the data set consists of 89 688 tweets. Using the coordinates in the tweet metadata, we divided the data into three region categories; Massachusetts including Boston (7 910 tweets), the United States, excluding Massachusetts (57 783 tweets), and outside of the US (23 995 tweets), see Table 2 for details.

Sentiment Analysis

Because we wanted to analyze the sentiment in the data set in more detail than polarity only, we chose to use LIWC2015 (Linguistic Inquiry and Word Count) (Pennebaker et al. 2015), a widely used and well-established lexicon-based text analysis tool capable of analyzing psycholinguistic features, including sentiment, in unstructured text. For each unit of text, LIWC calculates the percentage of emotion specific words, based on which it assigns a score to each text unit for each emotion. In addition to positive and negative sentiment, it provides analysis of the three negative emotions that are frequently mentioned in research on terror events: anger, anxiety, and sadness. This allows for a deeper understanding on the emotional processes that develop over time. Each tweet in the dataset was given a rating of the presence of

positive sentiment, anger, anxiety, and sadness. For examples of tweets containing high levels of emotions, see Table 3, and for the varying intensity of each emotion over time, see Figure 1.

Table 2. Dataset Size			
	Massachusetts	The US	Abroad
15th April	1930	23123	11102
16th April	1121	9647	5380
17th April	591	3083	1034
18th April	301	2484	706
19th April	1717	9935	2721
20th April	1183	6638	1900
21st April	268	941	554
22nd April	327	1191	383
23rd April	176	741	215
In total:	7910	57783	23995

Table 2. The number of tweets in each region category for each day in the dataset

Table 3. Examples of Emotions in the Dataset	
Positive	*"love you Boston hope everyone's safe"* *"Thank you FBI. Thank you Boston Police. Thank you first responders. #heroes"*
Anxiety	*"Terrorist attacks on Boston??? #scare"* *"Boston bombing :"(horrible"*
Anger	*"Fucking shocking scenes in Boston fucking terrorist bastards"* *"Boston kill that asshole so we can all rage safely tomorrow @cosmic_revenge"*
Sadness	*"Pray for Boston #tragic #sad"* *"So sad and heartbreaking #Boston #bostonmarathon"*

Table 3. Examples of positive emotion, anxiety, anger, and sadness in the tweets analyzed

Topic Modeling

Topic modeling is a way of clustering data entries into topical categories using machine learning approaches like Latent Dirichlet Allocation, LDA (Debortoli et al. 2016). This study uses MineMyText (http://www.minemytext.com/) for LDA-based topic modeling. Although topic modeling is a good way of getting an overview of the topics in the data, there are some steps in the process that are up to the user to take care of. Topic modeling does not utilize predefined categories nor does it label the clusters it creates; the task of making sense of the clusters is left for the researcher. The user also decides the number of topic clusters, and the suitable number of topics is found through iteratively testing numbers and manually inspecting the clusters. After testing numbers in the range of 20-90, increasing by ten at each iteration, we settled on 70 categories. Fewer than that would have yielded categories where several topics were clearly conflated into the same cluster, whereas more than that would have led to several near identical categories.

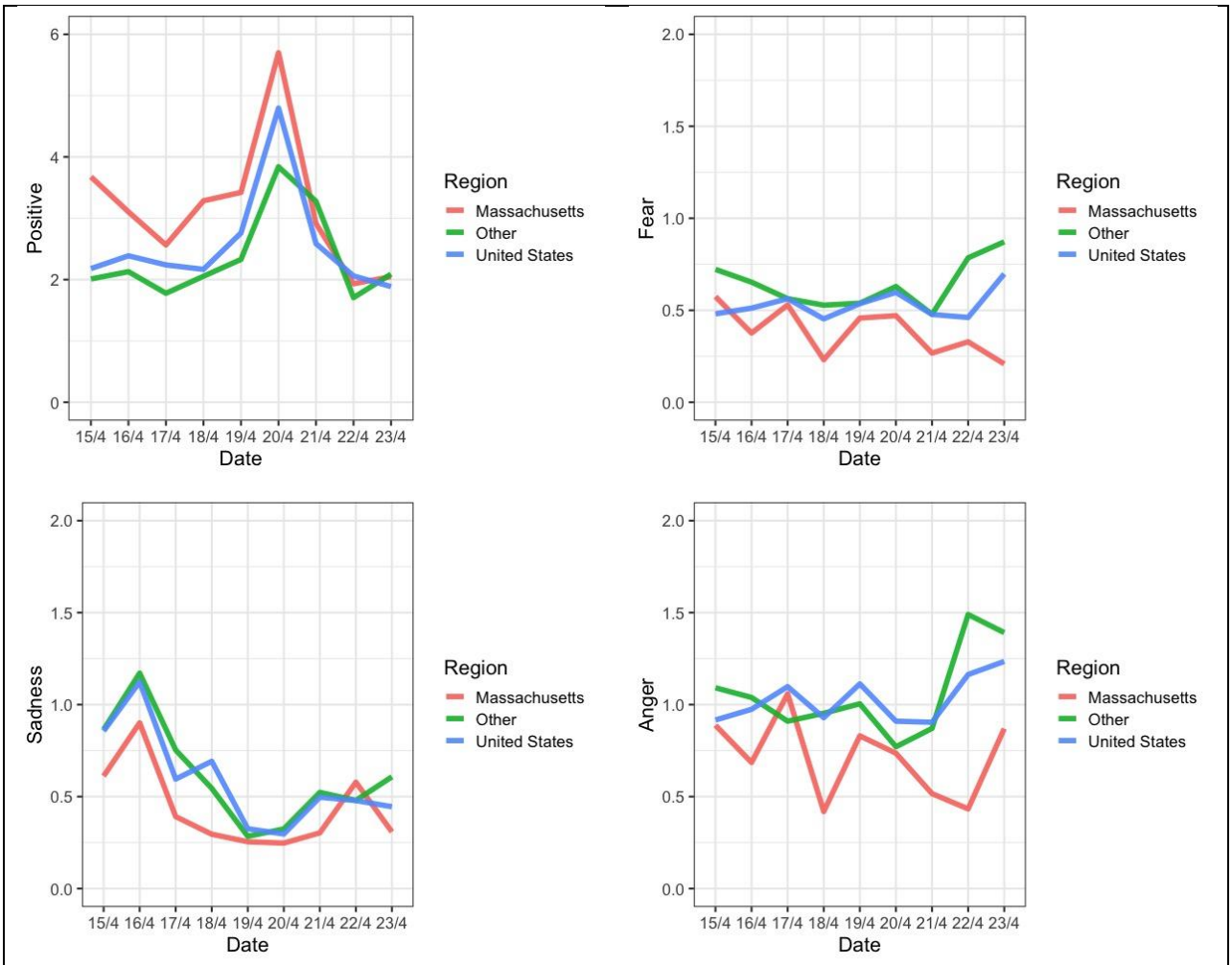

Figure 1. The levels of positive emotion, sadness, anxiety, and anger in tweets from each geographic region during the week after the terror event.

The topics were given labels based on manually inspecting the top 50 tweets and most frequent words for each topic. The appropriateness of the labels was verified by a second person, who labeled 33% (21 out of 70) of the topics. The labels differed in two cases, which led to slight alterations in the topic labels. Clustering the topics into higher level categories was done by two people independently of each other. The coders agreed on 66 out of 70 topics, and the remaining four edge cases were assigned categories through discussing and reasoning together. The resulting topical categories are listed in Table 4.

Some topics are clearly more emotional than others; for instance, sharing news articles is often fairly neutral, whereas the different types of shock or condolence themed categories contain high average levels of negative emotions. Certain topics are continuously present in the discussion throughout the week, while others are transient, and specific to either a phase in the emotional aftermath or a concrete event.

The topic categories *comments on politics and terrorism, comparison to other events, media and reliability,* and *miscellaneous comments* mostly contain people expressing their opinions, and commenting and interpreting information related to the terror attack. For the analysis in the following section, these topical categories are collectively referred to as *opinions and comments*. The four categories referred to in the analysis as *information sharing* are *sharing news, updates on suspect chase, suspect caught,* and *communication from authorities*.

Table 4. Topic Categories		
	Examples of topics	Example tweets in topic category
Shock and upset (10 topics)	Shock and disbelief, Shocked at the news, Upset at bomber, Footage and initial reactions	*Who the hell thinks it was funny to put bomb @ the Boston marathon ! Like wtf is wrong with people .. People piss me off. #prayforboston*
Memorializing (8 topics)	Thoughts and prayers, Casualties, Prayers and God	*Thoughts and prayers going out to the families and victims of the bombings at the Boston marathon #bostonmarathon #explosion #atrocious #usa*
Safety (5 topics)	Safety concerns (be safe), Relief x is safe, Safety and practical in Boston	*I can breathe a sigh of relief: Friends and Family are safe. Hope and Best wishes for all who have Friends and Family in #Boston too.*
Support gestures (11 topics)	Gratitude at police, Runners' support gestures, Love and support to Boston	*So proud of the amazing men and women of the Boston Police Department!!! My respect for them is incredible! #BOSTONSTRONG #BostonPolice*
Comments on politics and terrorism (5 topics)	Political comments and Islam, Comments on Terrorism, Conspiracy speculations	*Fox News' guy said "we should kill all Muslims" that's like 1,600,000,000 people in the world in response to the Boston bombing, ok mate. :*
Comparison to other events (2 topics)	Comparison to elsewhere, Crazy world	*15 people die on a car bombing in Iraq and nobody gives a fuck, at the same time 2 people die in Boston and the world goes crazy...smh*
Media and reliability (5 topics)	Commenting on footage, Doubts on reliability of news	*@jilevin: CNN, the AP, and Fox News Get Boston Marathon Bombing Arrest Story Wrong http://t.co/tfTDToQcKM What happened to real reporting?*
Miscellaneous comments (6 topics)	Miscellaneous personal views and feelings, Justice, Anger at other people	*People moaning about tweets about the bombings in Boston. We are aware it won't change anything, show a little respect and consideration.*
Sharing news (7 topics)	Initial reports, Suspects and their family, Sharing witness accounts	*2 bombs blew up at the end of the Boston marathon a few minutes ago. A lot of people injured. God I hope everyone will be alright!*
Updates on suspect chase (5 topics)	Police action during Watertown manhunt, MIT shootout, Casualties during suspect chase	*State Police, MIT Police, Watertown Police, #BPD, Boston University Police among agencies at the scene in #Watertown. Comm. a struggle.*
Suspect caught (2 topics)	Suspect in custody: police announcement, Suspect in custody news	*Suspect mit shooting and boston marathon bombing in custody. Its over. Cnn live boston police tweet confirmation*
Communication from authorities (4 topics)	Reports related to security, Following police updates, Notifications and instructions from the police	*FBI releases new images showing full faces of 2 #BostonMarathon bomb suspects http://t.co/k5Xpk47moT & PICTURE http://t.co/FBSyhxXLKL*

Table 4. The topic categories for the topics found in the data, example topics, and example tweets from the topic category in question

Findings

The Phases of Online Conversation Following an Act of Terror

This section reports the insight we gained from the literature and the data on how emotions and topics evolve in online conversations in the aftermath of a terror attack. We discuss both general and regionally specific phenomena. We identify five phases for the post-terror attack conversation: *shock, making sense, subsequent event, closure,* and *aftermath*. For each phase, we outline the relevant findings from previous research regarding emotional and behavioral processes, after which we report whether and how those findings are confirmed by our data. Figure 2 gives an overview of the process and its phases, and the changes in topics and emotions for each region.

Shock

The first, *proximal* reactions to a terror attack include shock, disbelief, elevated emotions, and safety concerns (Yum and Schenck-Hamlin 2005). The emotions reported frequently as a consequence of a terror event are most commonly anxiety, anger, and sadness (Lerner et al. 2003; Morrison et al. 2001; Pennebaker and Harber 1993; Smith et al. 2001). Sharing and obtaining information is also a common way of reacting, and the primary motivation for using social media in a crisis situation (Eismann et al. 2016). Another typical way of reacting to a disaster event, whether man-made or a natural disaster or accident, is to come together to memorialize the victims and pass condolences to their close ones – a behavior that in particular people farther away from the event site engage in as a way of participating (Hughes et al. 2008; Takahashi et al. 2015).

Following the Boston Marathon Bombing, the shock phase seemed to take around 1-2 days, with the peak number of social media messages within 24 hours of the event. The predominant topics regardless of location were expressing shock and upset, sharing information of the terror attack, and memorializing – condolences to the casualties and their families (see Table 5). Within the nation, and in particular in the affected area, safety related topics (being concerned of or relieved for close ones' safety) were also prominent. Abroad, the most prominent topic after shock, information sharing, and memorializing was opinions and comments related to the event and terrorism in general.

Table 5. Shock Phase		
Massachusetts	*US*	*Abroad*
Memorializing	Memorializing	Memorializing
Information sharing: Sharing news	Shock and upset	Shock and upset
Shock and upset	Information sharing: Sharing news	Information sharing: Sharing news

Table 5. The most prevalent topic categories during the shock phase for each region

Based on previous findings, we initially assumed that people close to the affected area would express more and stronger negative emotions associated with the event (Morrison et al. 2001). However, the opposite was found – people in the Boston and Massachusetts area exhibited higher averages of positive and lower averages of negative emotions in their online communication than people farther away.

Social media users abroad started out with a fairly high baseline of anxiety and anger, whereas those emotions seemed to develop more slowly for the users within the affected region and nation. Sadness levels were at their highest everywhere one day after the terror attack, after which the expression of sadness rapidly decreased.

Making Sense

After the initial shock reaction to a terror attack, people enter the *distal reaction* phase, characterized by behaviors such as altruism, seeking value and meaning, information seeking and sharing, enforcing social

connections, heightened patriotism or nationalism, and counter-bigotry advocacy (Yum and Schenck-Hamlin 2005). People affected by the crisis attempt to process their feelings, make sense of what has happened, and rationalize about it in an attempt to reconstruct a sense of normality (Kaufmann 2015). They will often try to find answers to questions such as why the event occurred, who is responsible, and how to prevent it from occurring again (Houston et al. 2015). This sensemaking process is often challenging due to incomplete information, which often leads to the spread of misinformation (Huang et al. 2015). Based on the previous findings, we expected to see information sharing, expressions of opinions with heightened emotion, speculation on the identity of the perpetrator(s), and false news in the messages following the bombing. On the other hand, we also expected to see some part of the users expressing altruism and positive sentiments such as gratitude, love, and support, as is typical for people with high resilience in the aftermath of crises (Fredrickson et al. 2003). What we did not expect was how region specific the aforementioned behaviors were in the sense making phase.

After the shock had settled, sadness levels started to decrease and social media users started trying to make sense of what had happened. Many shared information, sometimes more avidly than is productive; at this point false news started circulating to the extent where they made the list of top ten most discussed topics. The users expressed malcontent with traditional media being too slow to report new information, and rumors started spreading. Several innocent people were painted as the bomber based on online information while the real culprits were not identified until later on.

Discussions about politics, terrorism, and religion started to emerge, as well as comparisons of the bombing to recent bombings in Iraq by the US forces (see Table 6 for top topics in the making sense phase). Some of the topics in this category were laced with negative emotions, anger in particular. This fits the urge to defend one's world view and seek for values and meaning described in previous research. One of the political commentary topics also contained several counter-bigotry advocacy themed tweets reminding people to not jump to conclusions or prematurely accuse a religious or ethnic group.

Table 6. Making Sense Phase		
Massachusetts	*US*	*Abroad*
Support gestures	Opinions and comments: political comments and Islam, comments on news, comparison to other events	Opinions and comments: political comments and Islam, comments on news, comparison to other events
Information sharing: sharing news and communication from authorities	Information sharing: sharing news and communication from authorities	Information sharing: sharing news and communication from authorities
Opinions and comments: political comments and Islam, comments on news	Memorializing	Memorializing

Table 6. The most prevalent topic categories during the making sense phase for each region

In the Massachusetts area, the sense making phase was where collective and supportive topics started dominating the conversation, such as gratitude towards authorities and about loved ones being safe, different types of concrete and verbal support gestures towards Boston, the trending of the hashtag #bostonstrong as one of the many examples. Positive emotions were increasingly present in their messages. It seems like the directly affected area quickly started building collective support and resilience, while people farther away expressed more anxious and angry opinions. Anger and anxiety were also present in the messages from the affected area, initially increasing but shortly thereafter decreasing rapidly.

Outside of the affected area, both within the nation and abroad, most tweets were comments and opinions on the events or news. Information sharing – whether factual or not – as well as memorializing were also frequent, and the levels of anger and anxiety remained high.

Subsequent Event Leading to Closure

The fundamental aim and effect of terrorism is to cause fear and uncertainty. The threat of terror creates a sense of psychological insecurity that leads to a need for closure (Orehek et al. 2010). A high need for closure increases group-centrist behavior such as pressure towards opinion uniformity, endorsement of autocratic leadership, ingroup favoritism, conservatism, and perpetuation of group norms (Kruglanski et al. 2006). The anger and fear in some of the more political topics during the sense making phase could be outcomes of such a need for closure. It is possible that events leading to concrete closure regarding a terror attack, such as apprehending the terrorist, provide people with a sense of closure that allows them to let go of the anxiety stemming from uncertainty and a sense of threat, and start distancing themselves from the traumatic event, which would manifest as a reduced need to talk about the event and the emotions that it provoked. It could also help increase positive emotions that help foster resilience that helps people recover from the psychological trauma (Fredrickson et al. 2003).

The chase after the bombers formed a secondary event in the timeline following the terror attack, which can be seen as a sharp increase in the tweet volume. A little past midnight on the 19th of April, the authorities got on the trail of the Tsarnaev brothers, commencing a 21 hour long suspect chase followed closely by the online community. Information circulated on Twitter faster than news agencies could keep up with, and many tweeted live updates heard on the Boston area police scanner. The local levels of anxiety and anger increased, as safety concerns related to the manhunt worried people. However, by far the most discussed topics regardless of location were predominantly related to sharing timely information regarding the suspect chase (see Table 7). Gratitude towards authorities was also expressed in all regions. Outside of Massachusetts, opinions and comments were frequent.

Table 7. Subsequent Event Phase		
Massachusetts	*US*	*Abroad*
Information sharing: updates on suspect chase	Information sharing: updates on suspect chase and communication from authorities	Information sharing: several topics
Safety	Opinions and comments: comments on news	Opinions and comments: comments on news
Support gestures: gratitude at police	Support gestures: gratitude at police	Support gestures: gratitude at police

Table 7. The most prevalent topic categories during the subsequent event phase for each region

Table 8. Closure Phase		
Massachusetts	*US*	*Abroad*
Support gestures	Information sharing: suspect in custody and updates on suspect chase	Information sharing: several topics
Information sharing: suspect in custody and updates on suspect chase	Support gestures	Opinions and comments: comments on news
Opinions and comments: comments on news	Opinions and comments: comments on news	Support gestures: gratitude at police

Table 8. The most prevalent topic categories during the closure phase for each region

Once the suspect was finally apprehended, there was a strong surge of positivity in the online conversation, including strong gratitude towards the police, decreasing in intensity with distance to Boston (see Table 8). In the Massachusetts area, sharing the news quickly gave way for a strong collective supportive sentiment. Farther away, the information sharing lasted slightly longer, perhaps partly due to information propagation taking some time, as well as the time differences between continents in the case of users outside of the US. After the information regarding the suspect chase had spread, the conversation turned back to expressing opinions and commenting on news articles and events. The increase in anxiety in the US and abroad during the closure phase is curious. It could be a delayed reaction to the manhunt, or people returning to thoughts of overall anxiety about terrorism once the excitement is over.

Aftermath

Finding answers to the questions of who and why, as well as apprehending the person responsible for the act of terror likely served to give people a concrete sense of closure. Getting closure enables people exposed to a crisis situation to move beyond the trauma and get on with their lives (Skitka et al. 2004). It is also possible that since the terror attack was a transient event with a human causing it, the emergency phase of the social stages of coping is passed through more quickly than in the case of an earthquake (with extensive practical consequences) or war situation (which lasts longer than a single day event), and the community transitions into the inhibition phase sooner than the two weeks predicted by the model.

After the reactions to the news of the suspect being caught, the number of tweets dropped to a fraction of the volume of the previous days. The excitement was over, there was no longer an urgent need for timely information. The few posts that were made from the 21st of April onwards contain elevated levels of anxiety, anger, and sadness. This might mean that the users lingering after the closure phase are slower than the majority of the community at processing their emotions related to the event. This could be due to low resilience, as resilience has been found to negatively correlate with the frequency of negative emotions after terror attacks (Fredrickson et al. 2003). In the affected area, most of the messages at this point were expressions of gratitude and support, and information sharing, while on the national level and abroad, most of the discussion consisted of opinions and comments (see Table 9).

Table 9. Aftermath Phase

Massachusetts	*US*	*Abroad*
Support gestures	Opinions and comments: several topics	Opinions and comments: several topics
Information sharing: sharing news and updates on suspect chase	Information sharing: several topics	Information sharing: several topics
Opinions and comments: comments on news and miscellaneous comments	Support gestures	Support gestures

Table 9. The most prevalent topic categories during the aftermath phase for each region

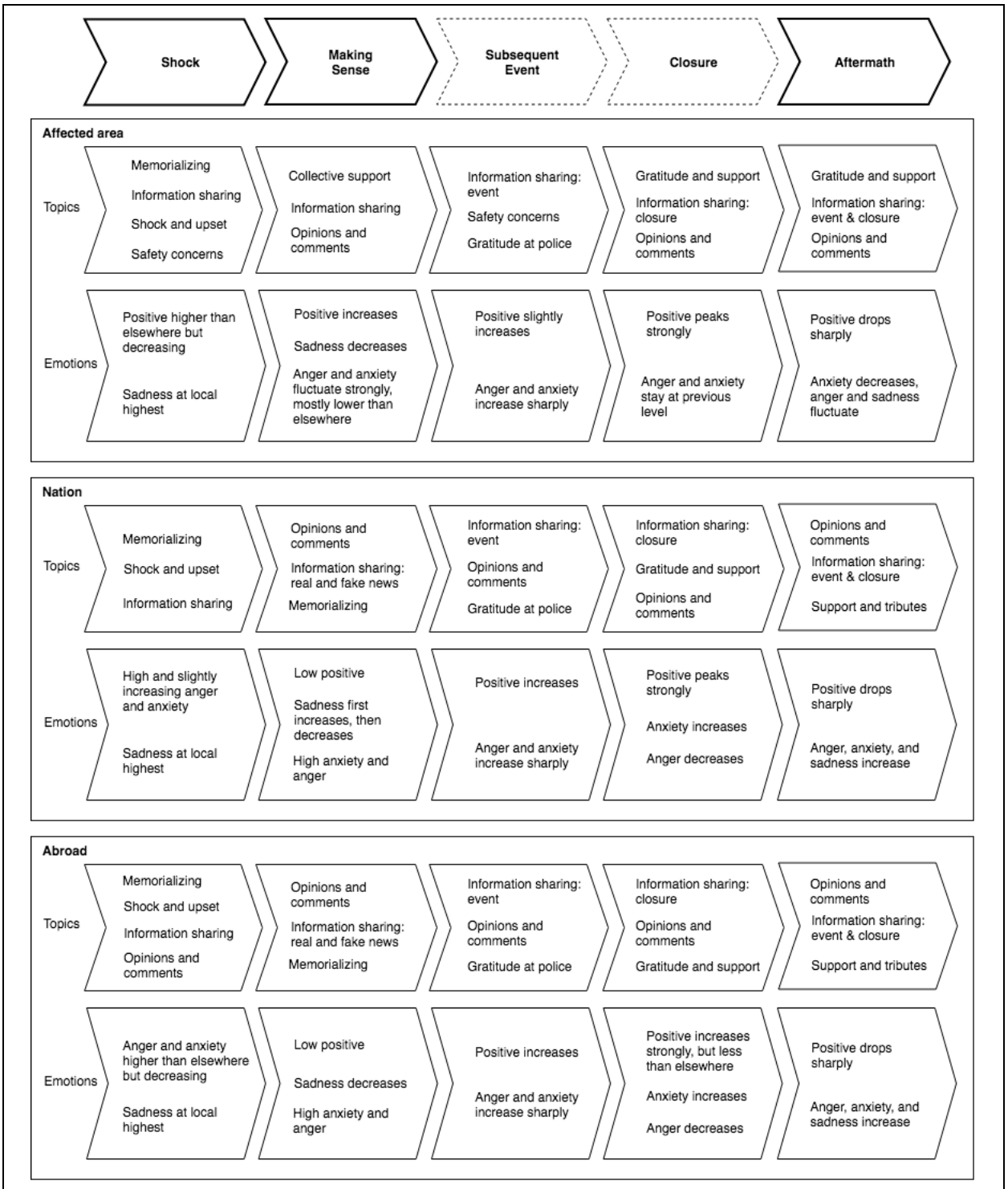

Figure 2. The topical and emotional phases of online conversation in each geographic region after a terror event followed by a subsequent event leading to closure.

A Model of Online Conversations After a Terror Attack

Based on the findings from the literature and data, we constructed a process for how conversations unfold after a terror event that is soon followed by an event that leads to closure (see Figure 2). The model contains topical and emotional trends for three levels of geographic proximity to the event site; the directly affected area, the affected country, and outside of the affected country.

Some of the phenomena are specific to geographic proximity. In particular collective, supportive gestures and emotions are predominant in the affected area, and stronger than farther away throughout the whole process. Information sharing cycles for specific news topics are shorter close to the event site, which could mean people distribute and access information with a smaller time lag than in more remote locations.

Locals also talk about safety more than others, both in terms of concern and relief for close ones. Farther away, the dominant topics include memorializing (e.g. different types of "thoughts and prayers" messages), and expressing political opinions, often containing high levels of anger and anxiety. The levels of negative emotions are higher throughout the whole process farther away than in the affected area. Conversely, positive emotions are consistently higher in the affected area than elsewhere, and was the only region with a notable increase in positive emotions during the sense making phase: gratitude towards authorities as well as support and love towards Boston are prevalent themes through the whole period.

The subsequent event increases anxiety locally, where the consequences are most tangible. Once the subsequent event leads to closure, positive emotions spike strongly in all regions, and topics such as information confirming the closure and gratitude towards authorities are strongly represented. This is quickly followed by a decrease in all elevated emotions as well as the overall volume of the conversation.

After the subsequent event and closure, the volume of messages drops rapidly to a fraction of the previous phase. The people who remain express higher average levels of each of the negative emotions than at the end of the closure phase, mostly sharing the news preceding the closure and expressing opinions (with the exception of the directly affected area, where support and gratitude are still strong themes).

The phases of the process are applicable to all geographic regions although the predominant topics and emotions vary at different proximities. Shock and upset were the primary reactions regardless of region during the first phase, and the transition to the making sense phase was simultaneous. In line with previous research, people using social media for information distribution is strongly present throughout the process.

Discussion

The first reactions to the bombing are unsurprisingly shock, upset, and disbelief. People send thoughts and prayers, worry about whether their close ones are safe, and try to figure out what happened.

After the shock wears out, people start collectively making sense of the event. Negative emotions in comments and opinions are probably an attempt at working towards closure, as value affirmation, moral outrage, and outgroup derogation have been found to facilitate psychological closure after a terror event (Skitka et al. 2004). The primary distal reactions to terrorism – searching for meaning and value, increased bigotry and patriotic sentiment, counter-bigotry activism, increased altruism, and greater appreciation of heroes (Pyszczynski et al. 2003) – are all present in the conversation after the shock phase. False news start circulating as people feel the urge to share and obtain information faster than media sources can verify news, and even some conspiracy theories are presented.

The making sense phase is where we start seeing regional differences in dealing with the trauma. Contrary to what one might expect, the highest anxiety levels in online conversations are not in the affected area, but abroad, whereas people close to the event site communicate more positive emotions than farther away. Why are they being positive rather than upset? Could it be that local people feel a stronger sense of agency or self-efficacy due to being able to access and share situational information and help out with practical matters locally? High levels of self-efficacy correlate with high performance accomplishments and low emotional arousal (Bandura 1982), which could mean that from an emotional standpoint, the Bostonians are faring better than remote mourners. Another explanatory factor for the prevalence of positive emotions in local tweets is that there was a strong trend of spreading grateful, supportive, loving

messages. Being able to focus on something positive may help people build resilience, embrace positive emotions, and find meaning in connecting with others who share the experience.

It is not always the case that a terror attack is soon followed by an event that leads to closure, for instance in form of apprehending the terrorist. In some cases, the culprit is never caught, or the attack involves a planned suicide, or the terrorist is caught long after the attack. There might be other types of events that follow the initial attack, and they may not give people closure, without which people are often left with a lingering sensation of anxiety and insecurity from which they gradually return to a normal state. In the case of the Boston Marathon Bombing, the rapid drop of social media activity after the closure phase could mean that once the threat is removed, the levels of emotional arousal decrease to a level where people no longer feel a pressing urge to frequently share their emotions regarding the event, and are ready to move on to the inhibition phase of coping. Due to there being many alternatives for the consequences of a terror attack, it is difficult to describe the events in detail without compromising generalizability. Nevertheless, based on the literature on emotional processes, we posit that the shock, making sense, and aftermath phases are present in terror attacks regardless of the details, and potential additional events that might affect the pace of closure occur before the aftermath phase, leading to a general model with the three universal phases and an additional, optional phase for one or more case specific events (see Figure 3).

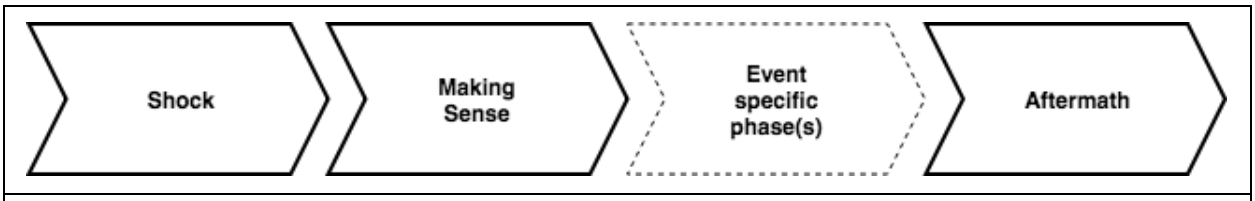

Figure 3. The process model for online discussions following terror attacks

Some people linger online during the aftermath phase, either sharing news from the closure phase, commenting events, or expressing opinions. Negative emotions, in particular outside of the affected area, are elevated. It could be that some people are more vulnerable to the anxiety caused by a terror attack, and that low resilience causes them to need a longer time to recover from the trauma. Perhaps they were not ready for the inhibition phase when the majority transitioned into it, leaving them to seek peer support from individuals experiencing the same. Understanding the lingerers better could perhaps help us devise strategies for helping people who are particularly strongly affected by crisis events.

The social stage model of coping posits that the emergency phase – where both thoughts and discussion sparked by a crisis are recurrent – lasts around two weeks. However, if the aftermath phase marks the shift from emergency stage to inhibition stage, the development found in our data is more rapid than suggested by the stage model. There are a few possible explanations for this. Firstly, the type of crisis event in question will undoubtedly determine some of its dynamics. The model is originally based on studies on a natural disaster (the Loma Prieta earthquake) and the Gulf War. It could be that the progression from the emergency stage to the inhibition stage is more rapid in context of an event with a short time span, an identifiable hostile actor, and a concrete conclusion to the events in the form of apprehending the person responsible and thus removing the remaining threat and allowing people to put their fears at rest. Determining which factors play a role in determining the duration of the emergency phase requires further research, but it seems plausible that there is some variation between different types of crises.

Secondly, the model was developed during a time when social media did not exist, and all of the information propagation happened through traditional media. Social media has enabled a faster information cycle than was possible before, granting people faster access to the information based on which they make sense of the events. Online communication also enables emotion sharing towards recipients that used to be impractically far away (geographic distance) or implausible (strangers). Perhaps the online environment enables people to iteratively express their emotions at a more rapid rate than in offline conversations, speeding up the process of dealing with those emotions, and thus speeding up the process of transitioning from emergency to inhibition phase sooner than would have been the case before social media changed our communication dynamics. This means that some of the theories and models

developed before the emergence of social media, while remaining valid, should be applied with awareness of the potential changes in communication styles and paces introduced by new technological possibilities.

The findings regarding the emotional and topical phases of post-crisis online discussion hold potential to facilitate real-time monitoring of social media streams in order to obtain relevant situational information. The better we understand the emotional and topical profiles for the various uses of social media in the wake of a crisis, the better we can focus our search on the relevant one by using emotions and topics as criteria for filtering. For instance, during the shock phase, it is fairly probable that messages containing high levels of sadness will predominantly be condolences with little informational value. Accounting for this would allow filtering out a large majority of social media content during that phase, speeding up the discovery of useful information.

Conclusions and Future Work

This study investigated how topics and emotions evolve in online discussion in the wake of a terror attack, accounting for the geographic proximity of the tweet location to the event site. Based on literature and analysis of tweets related to the Boston Marathon Bombing, a process model was developed for the phases of online conversation after a terror attack, outlining topical and emotional developments for different geographic proximities. The phases of the model are shock, making sense of the event, potential event specific phase(s), and aftermath. The potential events in the case of the Boston Marathon Bombing are a subsequent event and closure. One of the relevant limitations of such a model is that it is impossible for the it to be both generalizable and specific enough to accurately describe all the phases of the post-terror coping. We therefore proposed a general model with an optional, case-specific additional phase to allow for variation in how post-terror events unfold.

People in the affected area express higher levels of positive emotions and lower levels of negative emotions. A large part of the positive emotions expressed by locals were related to collective gestures of support and love, and gratitude towards authorities. People farther away were more preoccupied by commenting on the events, expressing opinions in messages containing elevated levels of anger and anxiety.

We contribute to the existing knowledge in the following ways: Firstly, we propose a process model for the collective emotional phases following a terror attack. By providing a high-level explanation of emotional and topical patterns of collective behavior confirmed by established theories, this model helps future research identify and predict those patterns, allowing further examination of phase specific phenomena, as well as situation specific features such as cultural factors or the degree of closure. Secondly, our study increases the overall understanding of how emotions develop after a terror attack, and how they are related to specific topics and locations. A fine-grained analysis of location, topics, and emotions enables better access to the social and psychological processes that unfold in online conversations. Thirdly, we show that emotional and topical post-crisis processes described by the social stage model of coping and the dual-process model are also present in online conversations, in spite of the theories predating the emergence of social media. However, the duration of the phases may not generalize well into the online environment, which is why we recommend caution in applying similar theories to online phenomena until the theories are extended to account for the possible changes resulting from the characteristics of online interaction. Finally, a practical contribution of this study is relevant to the emergency aid actors filtering real time crisis information from social media feeds; understanding which topics, characterized by which emotions, are more likely to primarily contain self-expression instead of situationally relevant information allows for more efficient filtering.

In future research, it would be interesting to examine terror attacks where the terrorist either eliminates themselves as a planned part of the attack, or attacks where the terrorist is not caught in the immediate aftermath of the event. It is likely that the topical and emotional trends of those types of events differ due to the lack of sense of closure, which may prolong anxiety and uncertainty. It would also be interesting to look into what role agency plays in recovering from a terror event, both on a collective and individual level. As the sense of agency is related to reduced levels of emotional arousal, it might be possible to devise ways of helping people recover from a traumatic event more quickly by increasing their agency over both their own psychological processes and the concrete consequences of the event.

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