

**THREE ESSAYS ON THE ROLE OF SOCIAL MEDIA IN SOCIAL CRISES:
A COLLECTIVE SENSEMAKING VIEW**

Doctoral Dissertation

by

Onook Oh

May 13, 2013

A dissertation submitted to the Faculty of the Graduate School of
the State University of New York at Buffalo
in partial fulfillment of the requirements for the degree of Doctor of Philosophy

**Department of Management Science and Systems
School of Management**

UMI Number: 3598728

All rights reserved

INFORMATION TO ALL USERS

The quality of this reproduction is dependent upon the quality of the copy submitted.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if material had to be removed, a note will indicate the deletion.



UMI 3598728

Published by ProQuest LLC (2013). Copyright in the Dissertation held by the Author.

Microform Edition © ProQuest LLC.

All rights reserved. This work is protected against unauthorized copying under Title 17, United States Code



ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

ACKNOWLEDGEMENT

My hat is off to my dissertation committee (Dr. H.Raghav Rao, Dr. Rajiv Kishore, Dr. Sanjukta Das Smith, and Dr. Shambhu Upadhyaya), all my colleagues (too many to list), my wife (Sunhae Kwon), my daughter (Kyeong-Joo Oh), my mother (Jungja Lee), and parent-in-law (Heejung Kwon and Dongbun Kim). Thank you for all your guidance, friendship, patience, and love. You are all parts of my life and long journey. Thank you again!

Table of Contents

ABSTRACT	v
ESSAY 1: INFORMATION CONTROL AND TERRORISM: TRACKING THE MUMBAI TERRORIST ATTACK TROUGH TWITTER	1
1. INTRODUCTION	1
2. PPRIOR LITERATURE	3
2.1 Cyber Terrorism.	3
2.2. Information Warfare (IW)	5
3. ANALYSING THE MUMBAI TERRORIST EVENT	6
3.1 Situation Awareness: Terrorist Perspective.....	7
3.2 Case Study: Mumbai Terrorist Incident.....	9
4. CONTENT ANALYSIS OF MUMBAI TWITTER FEED	12
5. INFORMATION CONTROL FRAMEWORK	17
6. CONCLUSION	21
ESSAY 2: COMMUNITY INTELLIGENCE AND SOCIAL MEDIA SERVICES: A RUMOR THEORETIC ANALYSIS OF TWEETS DURING SOCIAL CRISES	24
1. INTRODUCTION	24
2. SOCIAL CRISIS AND INFORMATION ISSUES	25
3. THEORETICAL FOUNDATION: RUMOR THEORY AND SOCIAL CRISES	27
3.1 Anxiety	29
3.2 Information Ambiguity: Source Ambiguity and Content Ambiguity	30
3.3 Personal Involvement.....	32
3.4 Social Ties: Direct Message	33
4. RESEARCH METHODOLOGY	35
4.1 Backgrounds of the Three Social Crises Under Analysis	35
4.2 Data Collection.....	38
4.3 Unitizing	39
4.4 Coding Scheme.....	40
4.5 Inter-Coder Reliability	41
4.6 Analysis Method.....	43
5. RESULTS	45
6. DISCUSSION	47
6.1 Key Findings	47
6.2 Theoretical Contributions.....	53
6.3 Practical Contributions	53
7. FUTURE RESEARCH AND CONCLUSION	55
ESSAY 3: FROM PRINT AND REPRINT TO TWEET AND RETWEET: AN EXPLORATION OF SOCIAL MEDIA, INFORMATION DIFFUSION AND RADICAL SOCIAL CHANGES	57
1. INTRODUCTION	57
2. THE ROLE OF SOCIAL MEDIA IN SOCIAL CHANGES: A TECHNO-CENTRIC VS. HUMAN-CENTERED VIEW	59
3. PRINT TECHNOLOGIES AND SOCIAL CHANGES: BUILDING THE RESEARCH FRAMEWORK	63
4. FROM PRINT AND REPRINT TO TWEET AND RETWEET	66

5. BACKGROUND OF THE 2011 EGYPT REVOLUTION	69
6. RESEARCH METHOD	70
6.1 Data Collection and Cleaning.....	70
6.2 Testing a Power-Law Structure to Identify Influential Voices.....	72
6.3 Retweet Network: Assembling of Multiple Voices into Connected Ideas	75
7. DATA ANALYSIS	79
7.1 Characteristics of Frequently Retweeted Users.....	79
8. DISCUSSION	84
9. CONCLUSION	87
CONCLUDING REMARKS	89
REFERENCES	92
APPENDIX 1	102

ABSTRACT

Flexible, mobile, and distributive social web technologies afforded online users with unprecedented opportunities to connect previously disconnected groups of people at a distance surrounding shared interests or common issues. Reflecting the opportunities opened by social web technologies, recent extreme events have exposed both positive and negative aspects of collective online behaviors in response to social crises. This dissertation extends the traditional literature on post-disaster collective behavior into the context of social web technologies, and develops notions of techno-social collective behavior, human-machine collaborative information process, and collective sense-making. To do that, this dissertation explores collective online behaviors which have been repeated during recent social crises (e.g., Mumbai Terrorist Attack in 2008, Toyota Recall in 2010, Egypt Revolution in 2011, and Seattle Café Shooting Incident in 2012 etc), and explicates the upside and downside of techno-social collective behavior and its technological and social implications.

This dissertation comprises of three essays. The first essay looks at the downside of social media in the context of the 2008 Mumbai terrorist attack. It uses Situation Awareness theory to identify antecedents of terrorists' opportunistic decision-making in the volatile and extreme environment of terrorist attack. Specifically, it argues how situational information, which was broadcast through live media and Twitter, could contribute in enhancing the terrorists' opportunistic decision making process and, as a result, increased the effectiveness of hand-held weapons to accomplish their terrorist goals. To substantiate the argument, by utilizing the framework drawn from Situation Awareness theory, this study (1) analyzes the contents of Twitter postings on the Mumbai terrorist attack, and (2) exposes the vulnerabilities of collective situation reporting through Twitter. In conclusion, based on the result of the content analysis, it presents a conceptual framework to deter and/or delay terrorists' decision-making process.

The second essay explores the information quality issue of Twitter under three social crisis situations: Mumbai Terrorist Attacks in 2008, Toyota Recall in 2010, and Seattle Cafe Shooting Incident in 2012. Using rumor theory, I conceptualize online users' collective tweeting behavior in response to social crises as collective information processing to make sense of, cope with, and adapt to uncertain external situation. This essay explores two interlocking issues of social crises: (1) under what condition does collective social reporting develop into a successful information processing to cope with crisis problems, and (2) under what condition does collective social reporting degenerate into rumor-mill. To answer these questions, I collect and analyze Twitter data for Mumbai Terrorist Attack in 2008, Toyota Recall in 2010, and Seattle Café Shooting Incident in 2012. The result of the data analysis reveals that information with no clear source provided was the most important, personal involvement the next important, and anxiety the least, yet still important, rumor causing factor in Twitter under social crisis situation. This essay concludes with a few suggestions to control rumor spread through social media during uncertain situation of social crises.

The third essay explores the role of Twitter during the 2011 Egypt Revolution. To set the research framework, this essay first reviews how historians analyze the role of print technology during the Protestant Reformation in the early 16th century. Through this review, I argue that (1) revolutionary ideas (like Martin Luther's) cannot be revolutionary unless it is distributed, shared and supported by many others, and (2) efficient communication technologies are essential to distribute and share revolutionary ideas with a large number of supporting others. I argue that the historians' approach not only bears similarity with that of sociomateriality, but offers a useful angle to explicate the role of social media during the 2011 Egypt Revolution. Following the historians' approach and employing the sociomateriality perspective, I analyze retweet communication patterns to determine (1) how influential figures emerge among a multitude of online individuals, and (2) what are the implications of the emergence of those influential figures. By presenting the results of the retweet

data analysis, I argue that the collective retweeting practice during the Egypt Revolution can be understood as collective and collaborative information processing to extract and share *reliable* situational information as *rapidly* as possible so that they can enhance the collective level of situational awareness and expand the boundary of shared understanding during the unfolding crisis situation. This provides important insights to anticipate imminent social changes.

Keywords: Social media, Twitter, extreme events, collective behavior, collective sense-making, situation awareness, sociomateriality, social changes, information diffusion, Mumbai terrorist attack, Egypt revolution, social information processing, rumor theory, community intelligence, social reporting

ESSAY 1: INFORMATION CONTROL AND TERRORISM: TRACKING THE MUMBAI TERRORIST ATTACK THROUGH TWITTER

1. INTRODUCTION

On November 26, 2008, terrorists mounted multiple attacks on Mumbai, resulting in arguably the worst terrorist incident in the history of India. According to the analysis of B. Raman, a former head of the Counterterrorism Division of the Research & Analysis Wing (R&AW) in India, the Mumbai terror attack was “the first mass casualty terrorism against innocent civilians, using hand-held weapons” in India (Indian Ministry of External Affairs 2009). His analysis implies that the use of hand-held weapons in the Mumbai terror incident enabled the attackers to convey their political agenda through the mainstream media. He argues that, given the preference of traditional anti-Indian terrorists for “timed or remotely controlled improvised explosive devices (IEDs),” the exploitation of hand-held weapons against civilians is indicative of a tactical shift in terrorist strategy - IEDs tend to rain indiscriminate blows on target areas in a short period of time such that it is not effective enough to send their messages about whom they intend to kill for what political agenda. Furthermore, because the visual impact that can be created by IEDs lasts at best one or two hours, the duration of media coverage is much shorter than for hand-held weapon attacks. Raman’s main point is that, compared to the traditional IED attacks, the hand-held weapons strategy employed by Mumbai terrorists were more effective in conveying their political message vividly through media over a long duration, almost 60 hours.

Raman’s analysis provides insight to consider Mumbai terror in terms of the triadic dynamics of (1) communication media including TV and Web, (2) attackers’ synchronous monitoring of live media and Web and collection of situation information and, (3) use of the collected situation information for opportunistic decision making in terrorist action. Although the focus of Raman’s analysis is not about

how Mumbai terrorists used public or social media to their advantage, a close reading of terrorists' phone conversations intercepted by the Indian government shows that the terrorist group collected situational information on the fly through live media and websites. They opportunistically utilized such information to make decisions of where and how to mount their attacks, and whom to kill with precision. That is, the remote handler's synchronous process of (1) monitoring of live media and websites, (2) collection of situational information on Mumbai under terrorist operation, (3) opportunistic decision making, and (4) delivery of action commands to onsite terrorist commandos not only enhanced the effectiveness of hand-held weapons but also facilitated the precise attack.

This paper analyzes the role of situation assessment process as an antecedent of terrorists' opportunistic decision making in the volatile and extreme environment of the Mumbai terrorist attack. The main argument of this paper is that the situational information which was broadcast through live media and Twitter contributed to the terrorists' decision making process and, as a result, it enhanced the effectiveness of hand-held weapons to accomplish their terrorist goal. We show that considerable amount of situational information was relayed to mainstream media via Twitter. To show that, we carry out content analysis of Tweets, and present that Twitter played a significant role in relaying situational information of Mumbai terrorist attack to the local and global mainstream media in an uncontrolled ad hoc way.

Through a review of cyber terrorism literatures, we identify critical issues caused by mobile and participatory social media, Twitter, in the terrorism context. By utilizing Information Warfare (IW) literature and Situation Awareness (SA) theory, this paper aims to (1) analyze the content of Twitter postings of the Mumbai terror incident, and (2) expose the vulnerabilities of Twitter as a participatory emergency reporting system in the terrorism context. An important finding is that unregulated real time Twitter postings can contribute to increase the level of situation awareness for terrorist group to make their attack decision. This paper presents practical implication of our findings

for anti-terrorism policy makers and anti-terrorism security forces. After that, this paper proposes a research agenda for the design of Web 2.0 based participatory emergency reporting systems in terrorism context. This paper concludes that such systems need to incorporate information control mechanisms to deter or prevent the decision making of terrorists.

2. PPRIOR LITERATURE

2.1 Cyber Terrorism.

This section describes previous research on cyber terrorism, particularly focusing on terrorism research which investigate how and why terrorists use websites. Terrorism researches dealing with terrorists' uses of website seem to center around two approaches: content analysis of terrorists' web documents (Tsfati et al. 2002; Weimann 2004; Denning 2009; Anderson 2003) and explication of terrorists' web technologies in supporting communication, interaction, and presentation (Qin et al. 2007).

In terms of content analysis, the plethora of research pronounces common findings. For instance, since the 9/11 terrorist attacks, terrorist organizations have gone through fundamental changes by actively adopting Internet for various reasons (Anderson 2003). According to Ariely (2008), similar to the organizations of the post-industrial age, terrorist groups have transformed toward "knowledge-centric" "networked organizations" to leverage information technology to achieve their goals with efficiency and innovation. In this frame, terrorist group members are analogous to knowledge workers. As is the knowledge organization, terrorist groups actively take advantage of the global Internet infrastructure to publicize political agenda, collect data on targets to attack, recruit supporters, exchange ideas, raise funds, transact or launder money, share terrorist manuals, and train terrorist members (Tsfati et al. 2002; Weimann 2004; Denning 2009).

An interesting research by Qin et al. (2007) supports the findings on how and why terrorists use websites. This research argues that, while terrorist and extremist groups' web knowledge is comparable with that of the US government agencies, their use of multimedia, online forums, and chat rooms are much more sophisticated than that of US government's websites. This finding indicates that terrorist groups are employing web technologies very actively to deliver their political propaganda with rich media (such as graphics or multimedia), to recruit potential terrorists and coordinate terrorist action (through chat room), to train terrorist members (through interactive web forum), to share or transit secret manuals to concoct chemical or explosive bombs (through exchange of steganography or ciphered files).

However, so far, the research has not taken into consideration Web 2.0 based mobile social media such as Twitter and mobile phone, which enable instantaneous information exchange and communication on the road at group level. Given Gartner's predictions that (1) "within five years, 70 percent of collaboration and communications application [...] will be modeled after user experience lessons from smartphone collaboration applications," and (2) "by 2012, over 50 percent of enterprises will use activity streams that include microblogging," extreme mobile device exchanging real time information of activity streams is supposed to cause unprecedented challenges in anti-terrorism efforts (Gartner 2010). For instance, the US army intelligence report includes Twitter as a potential terrorist tool that can be adversely used by terrorist groups to coordinate precise attack by sharing real time situational information on the move (Shachtman 2008; Sigler 2008). They express concerns that Twitter can be a dangerous terrorist tool, especially when it is used in combination with Global Positioning System (GPS), voice-changing software, and mobile cellular phone. One of many virtual scenarios included in the report (Shachtman 2008) is as follows:

“Scenario 2: Terrorist operative ‘A’ has a mobile phone for Tweet messaging and for taking images. Operative ‘A’ also has a separate mobile phone that is actually an explosive and/or a suicide vest for remote detonation. Terrorist operative ‘B’ has the detonator and a mobile to view A’s Tweets and images. This may allow ‘B’ to select the precise moment of remote

detonation based on near real time movement and imagery that is being sent by ‘A’” (Shachtman 2008).

This scenario is imaginary. However, it implies a significantly different dimension from those identified from previous studies on terrorists’ usage of web technologies. As Twitter is a web 2.0 based social media that is compatible with 140 character-based mobile texting devices, information exchange or sharing is not tied to wired computers or laptops. That is, Twitter enables coordination of terrorist action on the move based on the exchange of real time situational information at group level. Borrowing Ariel’s (2008) expression, sharing of real time situational information on the move can enable the “sophisticated usage of the most primitive weapons”.

This scenario has surprising similarity, although not exactly same, with the Mumbai terrorist attack, which will be detailed later in this paper in the content analysis section. In other words, the effectiveness of primitive hand-held weapons had been maximized when the terrorist groups’ attack decision was coordinated with the exchange of real time situational information on the move through satellite phone between remote handlers in Pakistan and field attackers in Mumbai. Mumbai Terrorist attack shows that the exchange of up-to-date situation information can enable the “sophisticated usage of the most primitive weapons” to inflict harm against civilians. In this regard, anti-terrorist operations to suppress terrorism are an example of information war to maintain informational superiority between security forces and terrorist group.

2.2. Information Warfare (IW)

In the warfare situation, informational superiority operates as necessary means to achieve the end of suppressing the adversary. In this means-end framework, the nature of information tends to be tactical, situational or sometimes deceptive. The transformative nature of information is attributable to the frequent change of situation in warfare state: e.g., (1) the enemy constantly competes with allies to stay in a state of information superiority, and (2) the battlefield is filled with uncertainty and

complexity under extreme conditions. Therefore, information control in battlefield operation is not necessarily based on factual data. Rather, in the warfare situation, information is an element “to be disseminated in a controlled fashion and, if necessary, to be created at will” in order to gain the information superiority over opponent (Hutchinson 2006). That is, since the warfield is filled with high level of uncertainties, both allies and adversaries need frequent updates and exchanges of situational information to maintain the position of information superiority.

According to the Chairman of the Joint Chiefs of Staff instruction (CJCSI) Number 3210.01 of 1996, IW is defined as:

[A]ctions taken to achieve information superiority by affecting adversary information, information-based processes, and information systems while defending one's own information, information-based processes, and information systems (Haeni 1997).

This directive presumes the earning of information superiority as a necessary condition for decision making in the war state. At the operational level, the goal of IW is to stymie the adversary's decision making and protect one's ally through various means of information control. The definitions of IW are similar to Situation Awareness (SA) theory in that the military action is preceded sequentially by the situation awareness and then decision making (Endsley(a) 1995). This temporal process of SA as an antecedent of decision-making and military action will be detailed in the next section.

3. ANALYSING THE MUMBAI TERRORIST EVENT

To analyze Twitter content of Mumbai terrorist attack, we expand IW concept to information control. In this paper, information control is defined as a mean to maintain information superiority by deterring or preventing terrorists' decision making such that it contributes to allies' operations of suppressing terrorist action. Conversely, the failure of information control creates a situation where terrorists gain information superiority over allies such that they can mount precise attacks to bring

about detrimental harm against the public. Therefore, we approach information control in terrorism as a strategically essential antecedent to stymie or minimize terrorists' gaining of situation awareness information and suppress the terrorist action.

Web 2.0, which is characterized as an open participatory or collaborative web platform (McAfee 2006), is rapidly shifting the mode of communication. Collaborative social reporting media, Twitter, spreads the notion that the maintenance of a symbiotic relationship between the public and government is essential to conduct a successful operation in extreme events (Lee 2002). However, our content analysis of Twitter in the Mumbai terror event discloses many unexpected problems as a participatory emergency reporting system. To understand these problems, SA theory is utilized to analyze the Mumbai Tweeter page from the terrorist perspective.

3.1 Situation Awareness: Terrorist Perspective

This section starts with an assumption that “the key to success in conflict is to operate within the opponent’s decision cycle” (Taipale 2005). In this regard, Situation Awareness (SA) theory is important to understand the decision making process of terrorists. SA theory has been developed from and applied to the military discipline, this paper uses SA theory to analyze the opportunistic (but highly calculated) decision making process of Mumbai terrorists. SA theory specifies situation assessment as three distinct cognitive processes for gaining information superiority and positions SA as a critical antecedent of decision making for goal achievement.

Fundamentally, “situation awareness is understanding the state of environment” (Endsley(b) 1995). It provides the foundation for decision making followed by action in the operation of complex task. This model assumes that the higher level of SA is likely to produce better decision making followed by better performance, that is, better action. Endsley specifies SA as three distinct levels of cognitive processes as shown in Figure 1.

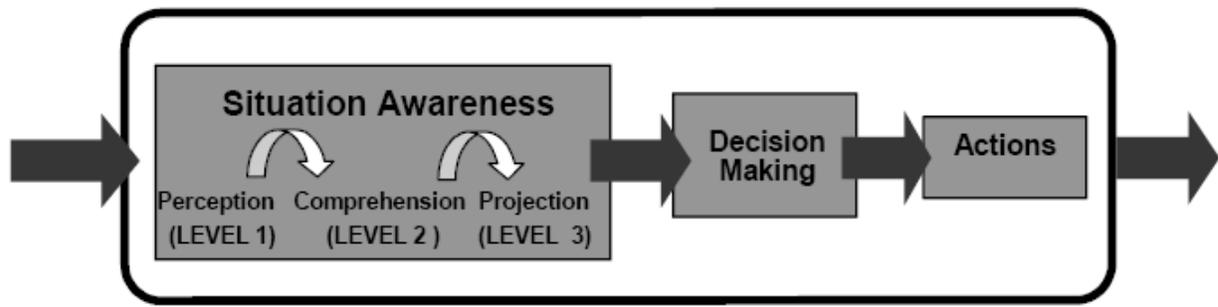


Figure 1. Model of situation awareness levels and decision-action process (Strater et al. 2001)

At level one, an actor “perceives” diverse relevant information from dynamically changing external environments. At this level, understanding of situation is not formed yet. At best, it recognizes the relevance of situation for her/his goal achievement. At level two, the relevant information pieces are integrated into meaningful and understandable forms in conjunction with an actor’s goal. Finally, at level three, the integrated meaning and understanding are projected into the future to predict the future state or event after the action (Endsley(b) 1995). Once the information of the external situation is processed from perception through comprehension to projection, calculated decision making follows to take certain action. In the process of SA, from level one to level three, the perception, comprehension, and projection of situational information are contingent upon the goal which an actor intends to achieve. That is, the actor’s goal operates as a driving force to assess and decide the relevance, meaningfulness, and projection of situational information (Endsley(a) 1995).

The important point here is that Mumbai terrorist group also made an effort not only to maintain their information superiority, but to obtain up-to-date situational information by systematically monitoring mainstream media and websites. Once they obtained the situational information, they filtered it through the interpretive scheme of their political goals to decide the terrorist action to take. The process of Mumbai terrorist group’s situation assessment process is detailed in the following case section.

3.2 Case Study: Mumbai Terrorist Incident

SA theory brings insight to analyze Mumbai terrorists' decision making process for terrorist action in conjunction with their political goal. Raman suggests that the Mumbai terrorist group had three point political agendas to accomplish: (1) an anti-India agenda, (2) an anti-Israel and anti-Jewish agenda, and (3) an anti-US and anti-Nato agenda (Raman 2009). He believes that an anti-Indian agenda was designed to "create fears in the minds of foreign businessmen about the security of life and property in India and in the minds of the Indian public about the competence of the Indian security agencies to protect them." To accomplish these goals, the terrorists targeted the two luxury hotels of Taj and Oberoi Trident where many foreign businessmen stayed, and also targeted many Indian civilians in public places such as the railway station. For the anti-Israel and anti-Jewish agenda, Raman suggests that the terrorist group's objective was in line with anti-Israel and anti-Jewish agenda of Al Qaeda terrorist group. To accomplish this political agenda, the terrorists attacked the Nariman House which was used as a Jewish Center building. For the anti-US and anti-NATO agenda, Raman maintains that the Mumbai terrorist groups also followed the causes of Al Qaeda and the Afghan Taliban. As an evidence of his analysis for three political agenda of Mumbai terrorist group, he presents that "Of the 25 foreigners killed, nine were either Israelis or Jewish persons, 12 were from countries which have contributed troops to the NATO in Afghanistan and four were from other countries. Nationals of European countries, which are not participating in the war against terrorism in Afghanistan, were not targeted" (Raman 2009).

In pursuit of these three political goals, an analysis of satellite phone conversations between terrorist commandos in Mumbai and remote handlers in Pakistan shows that the remote handlers in Pakistan were monitoring the situation in Mumbai through live media, and delivered specific and situational attack commands through satellite phones to field terrorists in Mumbai. For instance, the remote handler reminds one of his field terrorists that "Everything is being recorded by the media,"

and orders him to “Inflict the maximum damage. Keep fighting. Don’t be taken alive” so that their tenacious terrorist action is broadcasted (Indian Ministry of External Affairs, 2009).

Another phone conversation between a terrorist in Nariman House and a remote handler named Wassi presents the “situation assessment” process through monitoring of live media.

Wassi: Keep in mind that the hostages are of use only as long as you do not come under fire because of their safety. If you are still threatened, then don’t saddle yourself with the burden of the hostages, immediately kill them.

Receiver: Yes, we shall do accordingly, God willing.

Wassi: **The Army claims to have done the work without any hostage being harmed. Another thing; Israel has made a request through diplomatic channels to save the hostages. If the hostages are killed, it will spoil relations between India and Israel.**

Receiver: So be it, God willing.

The remote handlers in Pakistan perceive (level one of SA) through live media that Israelis are in the Jewish Center without being harmed. Next, he comprehends (level two of SA) situation by integrating the facts about Israelis being taken hostage in the building and Israel government’s diplomatic effort to save the Israelis hostages. Lastly, he predicts (level three of SA) that killing Israeli hostages will disrupt the diplomatic relations of India and Israel, which is their anti-Israel political goal.

From the IW perspective, this conversation shows that Indian government failed in information control. In other words, the Indian government did not need to disclose the information that Israel government requested to save the Israeli hostages. This unnecessary information brought information superiority to the Mumbai terrorist group, and they were able to use this information to maintain high level of SA. Eventually, combined with their three political agendas, the high level of SA led to effective and dynamic decision making to mount precise terrorist actions against civilians even in the extreme condition. One important point is that uncontrolled media aided remote handlers to sustain

high level of SA, which led to their dynamic and highly calculated decision making to mount a precise attack against Jewish hostages.

The phone conversation provides evidence that the Mumbai terrorist groups understood the value of up-to-date situation information during the terrorist operation. They tried hard not to lose their information superiority to the Indian Anti Terrorist Squad (ATS) and National Security Guard (NSG). They understood that the loss of information superiority can compromise their operational goal. The following phone conversation between a remote handler in Pakistan and a field attacker in the Taj hotel shows terrorist's effort to maintain information superiority over Indian security forces:

Handler: **See, the media is saying that you guys are now in room no. 360 or 361. How did they come to know the room you guys are in?...Is there a camera installed there? Switch off all the lights...If you spot a camera, fire on it...see, they should not know at any cost how many of you are in the hotel, what condition you are in, where you are, things like that...these will compromise your security and also our operation [...]**

Terrorist: I don't know how it happened...I can't see a camera anywhere (Khetan 2009).¹

Another phone conversation shows that the terrorists group used the web search engine to increase their decision making quality by employing the engine as a complement to live TV which does not provide detailed information of specific hostages. For instance, to make a decision if they need to kill a hostage who was residing in the Taj hotel, a field attacker reported the identity of a hostage to the remote controller, and a remote controller used a search engine to obtain the detailed information about him:

Terrorist: He is saying his full name is K.R. Ramamoorthy.

Handler: K.R. Ramamoorthy. Who is he? ... A designer ... A professor ... Yes, yes, I got it ... [The caller was doing an internet search on the name, and a results showed up a picture of Ramamoorthy] ... Okay, is he wearing

¹ A documentary of Mumbai terror shows how remote handlers in Pakistan controlled field attackers in Mumbai through satellite phone by monitoring live TV. The video is available at: http://www.liveleak.com/view?i=1e4_1246490858 (Last accessed November 12th, 2009).

glasses? [The caller wanted to match the image on his computer with the man before the terrorists.]

Terrorist: He is not wearing glasses. Hey, ... where are your glasses?

Handler: ... Is he bald from the front?

Terrorist: Yes, he is bald from the front ... he is fat and he says he has got blood pressure problems (Khetan 2009).

All these phone conversation evidences illustrate that the Mumbai terrorist group had a systematic mechanism of retaining the high level of situation awareness by monitoring live media and utilizing web search. They were collecting and analyzing up to date situation information from Pakistan, and the analyzed information was delivered wirelessly as an action command to the field attackers in Mumbai. Eventually, these situation assessment processes contributed to enhance the effectiveness of hand-held weapons terrorists used, and it resulted in calculated attack against civilians.

4. CONTENT ANALYSIS OF MUMBAI TWITTER FEED

This section discusses the issue of Web 2.0 social networking website from the perspective of information control and SA theory. As in the previous section, we posit that uncontrolled TV media and Twitter websites have potentially contributed to increase in terrorists' SA. To show the potential link of uncontrolled Twitter and terrorists' high level of SA, this section analyzes contents of Twitter postings.

Launched in July 2006, Twitter experienced around 900% growth during 2008 (Nusca 2009). Its rapid penetration speed seems to be related with 140 character based user interface which is compatible with the texting interface of mobile cellular phone. Especially, the compatibility of Twitter with text messaging interface of mobile phone lifted the constraints of wired connection to get connected with multiple people of social networking sites. This guess is supported by the report

of PEW Research Center which states that, as of December 2008, more than 75% of Twitter users tend to search website wirelessly either on a wireless laptop, PDA, or mobile cellular phones (Lenhart et al. 2009). Due to its mobile and rapid communication capabilities being equipped with a built-in digital camera, web browser, and digital camcorder, Twitter demonstrated its potential as emergency reporting systems in many natural disaster situations (Gabarain 2008; Mills et al. 2009; Wagner 2007). Subsequent to the successful reports of Twitter, US Federal Emergency Management Agency added Twitter to the national emergency response network (Tynan 2009). Now, a notion is being built surrounding Twitter that the cooperative relation between the public and the government is essential to conduct a successful operation during emergency situations.

The Mumbai Twitter page (<http://www.twitter.com/Mumbai>) that was used for data collection for this content analysis was voluntarily formed by online users and moderators to update and share the situational information of the Mumbai terrorist attacks. All postings that have been posted in the page were actual events that happened in Mumbai. Through this Twitter page, online users encouraged blood donation, posted contacts of Mumbai police help line, updated situational information of major Hotels and Nariman House which were under terrorist attack, signaled that s/he is in the site of terrorist attack, or broadcast their safety etc. Due to its real time postings by scene witnesses, news channels such as BBC, CBC, CNN, NPR, and Al-Jazeera etc cited messages from Mumbai Twitter page (Kievit 2008), and many users were followed and interviewed by worldwide mainstream media companies for their active postings. For example:

“CNN (US) called me up – she said she saw my twitter and then flickr. Spoke to her for 10 mins. She might call me back again!”

“#mumbai folks in south mumbai - if you're on skype video and can talk to a Toronto journalist, please contact @krisreyes”

“journalists are looking for folks tweeting about #mumbai. please message @anlugonz from the BBC if you're interested in being interviewed”

The Twitter postings were more real and up-to-date than blogs and traditional news media. Some users added comments like “twitter rocks – I am getting accurate and better information than MSM like Times Now!” or “CNN has been playing catch up to twitter :)”. Truly, Twitter played a significant role to relay situational information of the Mumbai terror attack to mainstream media around the world, and, at the same time, the live TV reports were linked back to Twitter.

However, as those live Twitter postings were made collectively and voluntarily in an uncontrolled ad hoc way, it included lots of sensitive situational information directly related to Indian government’s operational activity. Consequently, it caused concerns from many Twitter users, because seemingly innocent postings and live coverage could potentially aid terrorists who were monitoring those media reports and online postings through satellite phones and other communication media. Furthermore, an online news source reported that “someone in India thinks Twitter offers a bigger risk than traditional blogging or even heritage media” (Riley 2008). Some exemplary postings of this genre include:

“RT @celebcorps remember when tweeting details that it is CONFIRMED terrorists have satphone (*satellite phone* – authors added) access to net sources (1:50 AM Nov 27th, 2008 from Ubiquity)”

“Indian government has requested to stop tweeting live updates about Mumbai (8:08 AM Nov 27th, 2008 from web)”

“why is Times Now still revealing the strategy and positions of commandos @ Nariman House? #mumbai (3:58 AM Nov 28th, 2008 from twhirl)”

Our analysis of Mumbai Twitter data showed that concerns about uncontrolled collective Twitter postings were not groundless. To identify the Twitter postings that could have been beneficial for remote handlers in Pakistan to enhance their level of SA, we conducted a content analysis with posting data of the Mumbai Twitter page.

Content analysis is a research method that describes manifest content of communication in an quantitative, objective, and systematic way (Kishore et al. 2004-5). This method is widely used in

information systems research. Following the recommended steps (Krippendorff 1980; Meindl et al. 1985), we used SA theory framework to create a coding scheme. As the value of SA information is decided against an actor's goals, we used the three point political agenda of Mumbai terrorists as our coding scheme: anti-India, anti-Israel and anti-Jewish, and anti-US and anti-NATO (Raman 2009). If a Twitter posting contains information that could have been beneficial to increase SA of remote handlers in Pakistan such that they could either avoid Indian security forces' suppression activity or mount counter attack against civilian, then the Twitter posting was coded as '1'. Some exemplary postings that were coded as '1' are as follows:

“<http://tinyurl.com/5wr2v6> helipad at the bottom right and Nariman house at the top left ... look at zoom level”² (6:13 PM Nov 27th, 2008 from web)

“.:)! RT@thej Friend: How come top ATS³ cops got killed not other police men? Me: Dude its not IT industry” (10:34 PM Nov 27th, 2008 from web)

“Retweeting @baxiabhishek: #mumbai Richard Stagg, British High Comisioner flew from New Delhi and is on the ground at Taj Hotel. Impressive.” (10:56 PM Nov 26th, 2008 from twhirl)

Two masters' students in the US, majoring in management information systems were employed to separately code Twitter data. One was a student of a large Northeastern University, and other a student of a large Southeastern University. Both students had personal deep knowledge of the location (Mumbai) and its surroundings. Before coding, three phone conferences were instituted to discuss and understand the context and history of the Mumbai terror attack and the Mumbai Twitter page. It was ensured that both clearly understood the three point political agenda of the Mumbai terrorist group and the SA concept. The coding was made in two rounds. The first round was a pilot test to verify the level of mutual understanding of the research topic and coding scheme.

After the first round of content analysis, one author and the two coders had a phone conference with disagreed data. The author moderated disagreement between coders, refined the coding scheme, confirmed mutual understanding, and then worked on the second round coding of

² The URL is a link to Google map which indicates Nariman House under terrorist attack.

³ ATS stands for Anti-Terror Squad

which result is represented as Table 1. The Kappa coefficient value was 0.965, which represents the extent to which the probability of agreed understanding between coders is higher than that can be obtained by chance (Krippendorff 1980). Our Kappa value confirms that the inter-coder reliability is reliable.

Political Goal	Situational Information (Sample Twitter Postings)	# of situational info / # of total posting	% of situational info
Anti-India	<p>“#mumbai - avoid stepping out tomorrow to avoid chaos on roads. Govt offices will remain open.”</p> <p>“#mumbai - interviewing a Korean who's wife is still stuck in the Old wing. They were taken to the rooftop. He hasn't talked to her yet.”</p> <p>“Live gunfire outside Bombay hospital near metro cinema acc. to NDTV. Fear that terrorists will enter the hospital. Mumbai blasts”</p>	168/934	17.98%
Anti-Israel and Anti-Jewish	<p>“RT @robpas - Stratfor via IBN is reporting that there are Jewish and Israeli hostages at the Chabad House in Mumbai, India #mumbai.”</p> <p>“mumbai Authorities attack Nariman House with commandos and helicopter”</p> <p>“#Mumbai DG of NSG on Times Now. Nariman House - 5 hostages dead bt 1,2,4 floor so far. 3rd floor is still not clear.”</p>	106/934	11.34%
Anti-US and Anti-NATO	<p>“#mumbai Times Now quotes British high commission saying 7 British citizens injured in attacks.”</p> <p>“mumbai Official death toll now 101 including several Australians, one Japanese national”</p> <p>“Retweeting @baxiabishek: #Mumbai Richard Stagg, British High Commissioner flew from New Delhi and is</p> <p>“Retweeting @baxiabishek: #Mumbai Richard Stagg, British High Commissioner flew from New</p>	43/934	4.6%

Table 1. Content analysis result of Mumbai Twitter data

In table 1, the first columns indicates three political agendas of Mumbai terrorist group which was identified by Raman (Raman 2009). The second column presents exemplary Twitter posts which

can be beneficial for Mumbai terrorist group in enhancing their SA to accomplish their specific political goal (in the first column). The third and last columns show number and percentage of Twitter posts belonging to each political goal of the Mumbai terrorists. That is, out of total 934 Mumbai Twitter posts, 17.98 percent of posts contained situational information which can be helpful for Mumbai terrorist group to make an operational decision of achieving their Anti-India political agenda. Also, 11.34% and 4.6% of posts contained operationally sensitive information which may help terrorist group to make an operational decision of achieving their political goals of Anti-Israel/Anti-Jewish and Anti-US/Anti-Nato respectively.

5. INFORMATION CONTROL FRAMEWORK

Following the SA theory, the result in table 1 shows that the situational information in the second column retains a complementary relationship with a specific political goal indicated in the first column. In other words, situational information in the second column alone does not have any signification or directional value for terrorist group's decision making until each situational information in the second column is processed through different political goals in the first column. Following the terminology of SA theory, the situational information (in the second column) remains at level one ("perception") in the SA chain. At this lowest level, the remote handler of the terrorist group simply "perceives" the situational information without comprehension of its informational value. However, when the situational information is processed by their specific political goals, a meaning begins to emerge with a particular directional value. This process belongs to level two of SA chain in which the remote handler of field terrorists understand the value of the situational information in conjunction with their political goal to achieve. Once the remote handler understands the informational value, they "project" the comprehended meaning of the situational information to

the future to predict the future state or event after the action, which belongs to level three in the SA chain. For example, when terrorists observe situational information that a Korean wife “is still stuck in the Old wing,” if they anticipate that killing her can prevent Koreans from investing capital in India, then they may kill her to complete their Anti-India political goal.

In conjunction with SA theory, table 1 provides a clue to conceptualize the information control framework to deter or prevent decision-making process of terrorist groups. As SA theory posits and our analysis of terrorists’ phone conversation shows, the value of situational information is interpreted and determined by their political goals. Therefore, their political goals can be seen as the interpretive scheme to process situational information. This interpretive scheme is represented as a vertical axis in Figure 2, and, in case of Mumbai terror, it was composed of three prolonged political agenda: anti-India, anti-Jewish, and anti-NATO.

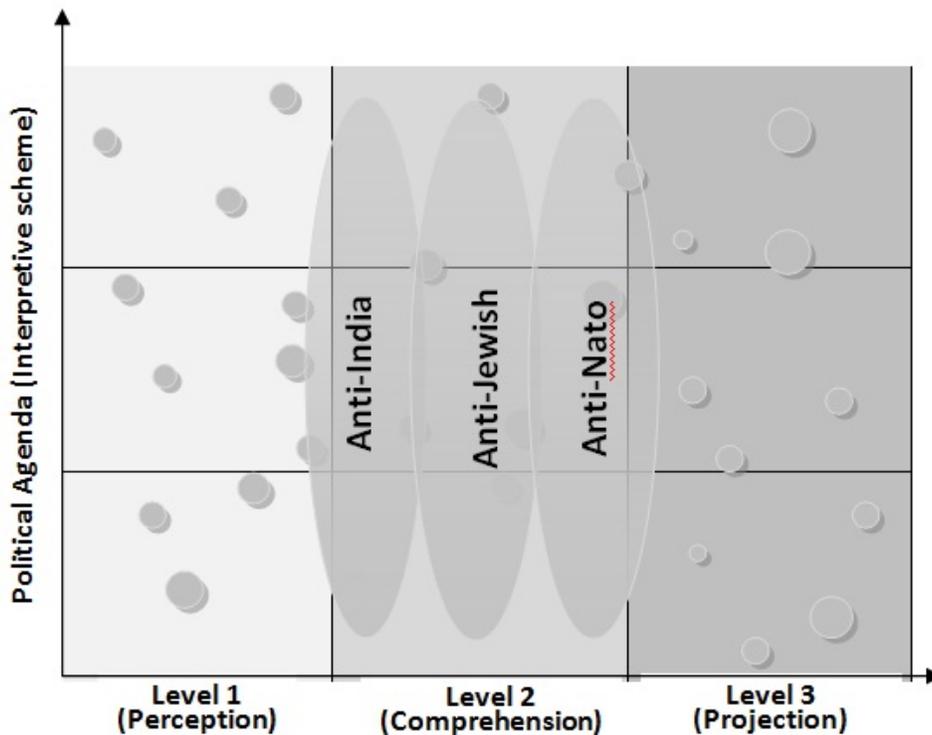


Figure 2. Information Control Framework

Using this interpretive scheme, terrorists process situational information following three staged cognitive process of “perception,” “comprehension,” and “projection,” which is represented on the horizontal axis. Looking at our suggested information control framework in Figure 2, we can see that terrorist’s “perception” is triggered by situational information which is obtained through monitoring of live TV or websites. At this stage (Level 1), as the given situational information is not filtered through interpretive scheme (three political goals), the information itself does not contain any meaningful value which can lead to terrorist’s decision making.

However, when the situational information passes through interpretive scheme (three political agenda) at level two (“comprehension”), the information is weighted with value for terrorist group to make calculated decision for their action. Once the value of situational information is determined by interpretive scheme, terrorists can project virtual scenario (Level 3 “projection”) to predict the outcome of their proposed action. Through this situation assessment process, if terrorists anticipate that their action can contribute to accomplish their political goals, then they will take their terrorist action.

Three staged situation assessment process of terrorist group (horizontal axes in Figure 2) shows that, while the first stage (“perception”) of the situation assessment is externally triggered through situational information which is posted by Tweeter users, the second stage (“comprehension”) of situation assessment involves terrorists’ cognitive (or interpretative) process upon the given situational information. That is, while the “perception” is triggered by external causes (situational information tweeted by Twitter users), the “comprehension” already involves terrorist’s cognitive (interpretative) process, which pertains to terrorists’ ‘internal’ attribute. Therefore, theoretically speaking, the information control measure to prevent terrorists’ decision-making process must take place before the second stage (“comprehension”) of situation assessment process by using terrorists’ political goals as interpretative scheme (vertical axes in Figure 2) to identify deleterious situational information. In other word, the vertical axes denotes the interpretative scheme

which is required for security operation teams to identify deleterious information and make citizens aware which information is harmful or helpful for security operation with all possible communication channels such hyperlink, blog, RSS, email, text message, live TV and Retweet etc. Ideally, this step needs to be initiated before it reaches the second stage (“comprehension”) of terrorist’s situation assessment process.

Given Figure 2, it is essential for government or anti-terrorism operation team to understand that information control strategy needs to be derived from thorough understanding of terrorist groups’ political goals. Because terrorists’ political goals function as interpretative filters to process situational information, understanding of adversaries’ political goals may reduce costs for security operation teams to monitor and decide which tweets need to be controlled. Therefore, we suggest that the first step of information control in the context of participatory social reporting and terrorism is to analyze and understand the political agenda of terrorist groups.

When it comes to information control measures regarding participatory social media in the terrorism context, to the best of our knowledge, there are no references to refer to. This implies that the collective social reporting is not only a relatively new and rapidly growing phenomenon, but the Mumbai terrorist attack is the first incident which exposed the vulnerability of social reporting. However, to derive information control measures in the context of social reporting and terrorism, we can learn some lessons from the failure of media control during the wars such as Vietnam War (1959-1975), Falklands War (1982), Grenada War (1983), Panama War (1989), and Afghanistan War (2001 to present), and Iraq War (2003 to present) (Hutchinson 2009; Moore 2009; Hallin 1993). The war and media control literature highlight that modern wars require public support from both national and international levels to conduct successful operations.

In light of public support in anti-terrorism operations, as Wimann (2004) points out, “the use of advanced techniques” to control information –e.g. techniques “to monitor, search, track, and analyze communications” -- “carries inherent dangers”, as it can not only undermine public

accountability and freedom of speech but lead to the loss of the public support. With this note of caution, we suggest an information control strategy. First, information control measure needs to be implemented in a way to encourage public accountability, and, at the same time, guarantee freedom of speech. Second, during terrorist attacks, government or security forces should monitor social reporting media such as Twitter and actively be involved in the social reporting process. That is, government and security forces need to make citizens aware what is harmful or desired information for security operation with credentials and authoritative voices by actively using such communication channels as hyperlink, blog, RSS, email, text message, live TV and Retweet etc.

We believe that the strength of our information control framework is that it is derived from detailed content analysis of real data including terrorists' actual phone conversation. That is, the suggested information control framework (Figure 2) does not stand on artificial assumptions, but it reflects terrorists' decision-making process in real terrorist incident. Therefore, it is expected that the suggested information control framework can be enriched and refined by future researchers.

6. CONCLUSION

Our qualitative analysis of terrorist's phone conversation supports the validity of SA theory in analyzing terrorists' decision-making process. Through this analysis, we found that Mumbai terrorists actively monitored live media and used web search engines as a means to enhance their level of SA. Also, our close reading of Mumbai Twitter data found that the Twitter site played a significant role in relaying situational information to the mainstream media, which was monitored by Mumbai terrorists. Therefore, we conclude that the Mumbai Twitter page indirectly contributed to enhancing the SA level of Mumbai terrorists, although we cannot exclude the possibility of its direct contribution as well. Our quantitative content analysis of Mumbai Twitter data found that many Twitter posts (see above table 1) could potentially have contributed to enhancing terrorists' SA level

by exposing operationally sensitive information without any information control. Based on these findings and following SA theory, we presented the information control framework, and argued that understanding terrorist groups' political goals is essential for successful information control. Also, one feasible information control measure was suggested.

Contributions of our research are as follows. Empirically, we identified how terrorists obtain and adversely use situational information, which is reported by networked citizens. Also, by interpreting phone conversation of terrorist group members through the lens of SA, we identified comprehensive process of their decision making in the extreme and uncertain condition of terrorist attack. Given that "the key to success in conflict is to operate within the opponent's decision cycle" (Taipale 2005), it is expected that identified terrorist group's decision-making process can serve as guidance for future research on terrorism and information control, especially in the context of wide spread Web 2.0 based social media.

As our description of terrorist's decision-making process was derived from the analysis of their actual phone conversation, we trust that this study sets the foundation for future researchers to investigate information control measures for social media in the terrorism context. It is worthy of mentioning that, to our knowledge, this research is the first report, which investigates the relationship between Web 2.0 based social media and terrorism with real case of the Mumbai terrorist attacks. Given that the Mumbai terrorist attack was the first incident in which participatory social media played significant role in spreading operationally sensitive information, we hope that the proposed information control framework can trigger further research to explicate the best information control mechanism in social reporting and terrorism context.

Our research has practical implications for national security policy makers, anti-terrorism security forces, and Web 2.0 based emergency reporting system designers in the terrorism context. They need to know that the Mumbai terrorist groups maintained a systematic mechanism of obtaining and maintaining high level of SA. Therefore, the best efforts needs to be made to find ways

to deter or prevent terrorist groups from sustaining high level of SA either through information control policy, Twitter posting monitoring, or system design. Especially, given that the terrorists' decision making process is mainly driven by their political agenda, ongoing analysis of terrorist's political agenda will provide policy makers, anti-terrorism security forces, and systems designers with clues to build a strategic framework for information control. That is, they can develop information control policy or mechanism by employing the terrorist group's political agenda as interpretive scheme to decide which postings need to be controlled or not.

ESSAY 2: COMMUNITY INTELLIGENCE AND SOCIAL MEDIA SERVICES: A RUMOR THEORETIC ANALYSIS OF TWEETS DURING SOCIAL CRISES

1. INTRODUCTION

Social media services and consumer computing devices are rapidly changing the ways of creating, distributing, and sharing emergency information during social crises (Palen et al. 2010; Palen et al. 2009; Shklovski et al. 2010; Shklovski et al. 2008; Starbird et al. 2010). During large scale crises (e.g., natural disasters and terrorist attacks), it has become the norm that the incident is initially reported by a local eyewitness with a mobile communication device, the report is rapidly distributed through social media services, and mainstream media involvement follows (Oh et al. 2010; Oh et al. 2011). Indeed, online citizens have shown the potential of being first responders who can improvise an effective emergency response by leveraging their local knowledge, typically not available to professional emergency responders who are not familiar with the local community (Li and Rao, 2010). Despite these advantages, many warnings have been raised about the information quality of crisis reports contributed by voluntary online citizens. A recent examination of some of Google's real-time search results for Tweeter and blogs reveals that real time information was mostly "fabricated content, unverified events, lies and misinterpretation" (Metaxas and Mustafaraj 2010). For this reason, despite the potential of social media services and voluntary reports, they are often despised as collective rumor mills that propagate misinformation, gossip, and, in extreme cases, propaganda (Leberecht 2010).

Acknowledging the duality of social media as a potential tool for social reporting and a collective rumor-mill, this study explores the information quality issue in the context of social crises. We conceptualize the participatory social reporting phenomenon as collective intelligence and information processing to make sense of, cope with, and adapt to situational and informational uncertainties under crises (DiFonzo and Bordia 2007). This study attempts to answer two questions:

(1) under what conditions does collective social reporting function as a community intelligence mechanism to address crisis problems; and (2) under what conditions does social reporting degenerate into a rumor-mill? To develop a theoretical framework for these questions, we rely on the literatures on rumor and social crises. To empirically test the framework, we analyze Twitter data from three different crisis incidents: the Mumbai terrorist attack in 2008, Toyota recalls in 2010, and the Seattle café shooting incident in 2012.

This paper proceeds as follows. In the next section, we introduce the literatures on rumors and social crises. We then synthesize these two literatures to develop our research model and hypotheses. After that, the research methodology is introduced, hypothesis tests are performed, and results are discussed. In closing, limitations and future research possibilities are suggested.

2. SOCIAL CRISIS AND INFORMATION ISSUES

Social crises are characterized by the severe consequences of the incident, low probability of incident occurrence, informational and situational uncertainty, and decision-making pressure under time constraints (Runyan 2006). Unfamiliar, unplanned, and unpredictable crisis situations quickly render inoperative day-to-day routine practices which sustain some level of social behavior, communication norms, and normalized interaction (Stallings and Quarantelli 1985). Inevitably, this out-of-the-ordinary crisis situation accompanies collective anxiety, improvised group behaviors, and adaptive collaboration among the public (Bharosa and Janssen 2010; Janssen et al. 2010; Kendra and Wachtendorg. 2003; Majchrzak et al. 2007).

One of the main problems that have obstructed improvised collaboration within and between the public and emergency responders has been the complexity in information processing and sharing (Bharosa et al. 2010; Jenvald et al. 2001; Singh et al. 2009; Yang et al. 2009). Scanlon (2007) relates the unusual and improvised communication behavior under large-scale social crisis to the “information

convergence” phenomenon that suddenly overloads major communication systems. This out-of-the-ordinary communication behavior during a crisis is associated with the twin problems of “information overload and information dearth” (Shklovski et al. 2008).

Information overload and information dearth signify the two enduring and interlocking problems that prevent sense-making of urgent situations and emergency response operations. First, from the emergency responders’ perspective, too many inquiries and reports, many of which are not accurate or reliable, hamper emergency response teams in efficiently delivering relevant and trustworthy information to the right responders at the right time (Bharosa et al. 2008; Bharosa et al. 2010). For example, during the Mumbai terrorist attacks, the police control room was flooded with incorrect reports of explosions at leading hotels such as the J. W. Marriott, (Chakraborty et al. 2010). Second, from the perspective of a citizen, the information dearth problem indicates a lack of local information which is desperately needed by citizens of affected areas to make localized decisions. As the main cause of the information dearth problem, the disaster literature identifies mainstream media. The literature maintains that institutional mainstream media have a tendency to repeatedly zoom in on to the sensational aspects of a disaster from a single onlooker’s perspective (Wenger and Friedman 1986), and they are highly dominated by cultural influences or institutional policies. As a result, rather than trusting mainstream media, citizens often turn to their own local social networks or resources at hand to obtain local information which is relevant and needed for their understanding of the local situation and decision making (Mileti and Darlington 1997; Shibutani 1966; Wenger and Friedman 1986). Therefore, it is not surprising that unexpected social crises in recent years almost always involve high traffic in social media websites through various forms of information exchange, including online posting, linking, texting, tweeting, retweeting etc.

To root the study in a robust theoretical framework, the next section introduces rumor theory in the context of crisis communication, and suggests testable hypotheses along with key variables.

3. THEORETICAL FOUNDATION: RUMOR THEORY AND SOCIAL CRISES

From a social psychological perspective, Shibutani (1966) relates rumor phenomena to information convergence which typically occurs in the early stages of a social crisis. He considers rumoring as a collective and improvised information seeking and exchanging behavior among citizens to control social tension and solve crisis problems. Rumoring is defined as a collective and collaborative transaction in which community members offer, evaluate, and interpret information to reach a common understanding of uncertain situations, to alleviate social tension, and to solve collective crisis problems (Bordia 1996; Bordia and DiFonzo 1999; Bordia and DiFonzo 2004; Shibutani 1966). Rumor, as an instance of crisis communications in a community, is born and makes its way through “social support” (Festinger 1962). From its birth, as rumor involves communicational dynamics surrounding shared issues in a community, the generation and transmission of rumor are inseparable in practice. Therefore, to highlight the connective and dynamic nature of rumor, this paper uses the terms like ‘rumor,’ ‘rumoring,’ and ‘rumormongering’ interchangeably.

When people encounter unexpected crisis events, emotional tension in the affected community increases. To release the social tension, people initially turn to reliable “institutional channels” such as the mainstream media and attempt to make sense of uncertain situations with the information collected. At this initial stage, if people in the affected community fail to obtain relevant and timely information, they begin to mobilize informal social networks such as friends, neighbors, local news, and other possible sources. And then, using the information collected through these backchannels, people “improvise news” to fill the informational gap of mainstream media. Shibutani (1966) calls this informally “improvised news” as rumor, which functions as a collective effort to reach a common understanding of the situational uncertainty and to relieve emotional tension. In this view, rumoring helps the community to cope with and adapt to ambiguous crisis situations until the level of social tension is brought under check.

Shibutani's (1966) description of the rumoring procedure as a kind of emergency communication endeavor concurs with many findings of crisis research which report that victims avoid mainstream media and actively adopt informal communication channels during social crisis events (Quarantelli and Wenger 1989). According to a survey of citizens affected by the Southern California wildfires in 2007, many respondents felt that the institutional mainstream media were not providing local information in a timely manner which was desperately needed by residents of the affected areas (Mills et al. 2009; Sutton et al. 2008). In response, many people turned to social media services to fill the information gaps left by mainstream media (Shklovski et al. 2008), and others intentionally learned how to use texting devices and online message boards to exchange crisis information and to stay connected with their acquaintances (Shklovski et al. 2010).

Although originating from different domains, the rumor research and crisis research camps have close affinity in that both camps view improvised and emergent crisis communication as a typical non-routine group behavior. One major difference is that, while the former camp approaches the improvised crisis communication as a rumor phenomenon, the latter takes the perspective of information convergence which overloads the communication infrastructure. However, a close reading of both literatures reveals that rumor phenomena and information convergence are interlocking problems born out of unpredictable, unfamiliar, and unplanned social crisis situations. This is easy to see when rumor researchers argue that "disasters and other crises are characterized by high importance, high ambiguity, low critical sensibility, and many rumors" (Rosnow and Fine. 1976), or "in wartime, ..., the conditions for rumor are optimal" (Allport and Postman. 1947).

Close kinship between studies of rumor and social crises is also found in the seminal rumor model of Allport and Postman (1947). The rumor model was the product of a study of unusual group communication during social crises. After investigating the characteristics of rumors which were prevalent during World War II, they suggested that rumor spread is a function of "*importance*" and

informational “*ambiguity*.” This implies that, for the birth and dissemination of a rumor, the theme of the story must be important to both message sender and recipient, and the truthfulness of the story must be masked with some level of ambiguity. If the story is not important, there is no psychological incentive for people to pass along the story to other persons. Also, if the story does not contain some level of ambiguity, then it is already a fact which does not need subjective elaboration and interpretation. This seminal rumor model is expanded, refined, and tested in this paper. The next sections introduce key rumor variables to build empirically testable hypotheses.

3.1 Anxiety

Although Allport and Postman’s (1947) rumor model offered key variables for rumor-mongering conditions, measurement of the *importance* variable was a thorny problem until Anthony (1973) introduced “anxiety” as its proxy variable. Her rationale for employing the anxiety measurement scale (i.e., Taylor Manifest Anxiety Scale) was that it may be difficult for a person to articulate the importance of a particular rumor. However if one feels *anxious* about the rumor, it signals that the content in the rumor message is *important* to her/him. Otherwise, it is not.

The inclusion of the “anxiety” concept contributes in differentiating two conceptually distinct dimensions of rumor mongering motives: the affective dimension (“anxiety”) and the cognitive dimension (“ambiguity”). Allport and Postman (1947) expressed a similar notion that rumor is motivated by “intellectual pressure along with the emotional” (p. 37). Emotional pressure indicates the affective dimension (“anxiety”), and the intellectual pressure points to cognitive dimension (“ambiguity”) of rumoring. To develop the first hypothesis, in this section, we focus on the affective dimension of anxiety, and the cognitive dimension will be revisited when we introduce the second hypothesis in the next section.

According to Allport and Postman (1947), seen from the affective dimension, rumoring is a justification process to relieve one's emotional tension by elaborating a story to gain acceptance from listeners. Therefore, the more anxious an individual, the more likely he/ she is to spread rumors. The consistent conclusion of rumor research on social crisis is that rumor endures until the perceived external uncertainties disappears and its attendant anxiety subsides (Knapp 1944; Prasad 1935; Prasad 1950; Rosnow and Fine 1976). Following these findings, and given the uncertain and apprehensive nature of social crises, the first hypothesis is presented:

H1: The level of anxiety during social crises is positively associated with rumors (rumor mongering).

3.2 Information Ambiguity: Source Ambiguity and Content Ambiguity

Beside anxiety, ambiguous information is another important factor of rumor spread. Ambiguous information is mainly caused either by the destructive impact of disasters, which suddenly incapacitate communication infrastructures (Kendra and Wachtendorg 2003), or by the deliberate holding back of critical information by organizations in the interests of security (Rosnow 1991). Under extreme and ambiguous situations, people frequently experience a shortage of reliable information to understand uncertain situations, and, consequently, tend to improvise news to fill the gap of informational ambiguity with subjective elaboration, fanning the rumor mill (Shibutani 1966).

Rumor researchers implicitly present two different dimensions of informational ambiguity: source ambiguity and content ambiguity. Source ambiguity concerns the trustfulness of the information source which guarantees the veracity of the circulating information. Content ambiguity attends to the interpretative clarity of meaning contained in the information. Shibutani's (1966) notion of "improvised news" as rumor implies the both dimensions of source ambiguity and content ambiguity. Facing social crises, people initially turn to institutional news channels to obtain reliable

information, and then mobilize unofficial social networks to fill the information gap of the institutional news channels. In a similar vein, many rumor researchers have also argued that, when information is void of trustful sources, people tend to make predictions with their own subjective wishes or bounded knowledge to reduce cognitive ambiguity (Knopf 1975; Rosnow 1991; Rosnow and Fine 1976). It can be inferred from this logic that, if information is attached with verifiable sources, then it may suppress the incentive to devise rumors.

Content ambiguity refers to the level of interpretive ambiguity contained in the information. Fundamentally, it stands on the underlying assumption that “our minds protest against chaos” (Allport and Postman 1947). From a cognitive perspective, the intellectual effort to extract clear meaning out of a chaotic state is an endeavor to remove ambiguity from the information (DiFonzo and Bordia 2007; Festinger 1962; Kapferer 1990; Knopf 1975; Rosnow and Fine 1976). Therefore, the more ambiguous the information content, the more frequent communications of information seeking, sharing and elaboration among community members.

Festinger’s (1962) description of “cognitive dissonance” exemplifies the relationship between ambiguous information and rumoring. He explains cognitive dissonance with the example of an earthquake in India in 1934. Subsequent to the severe earthquake, fearsome rumors began to circulate *outside*, but not *inside*, the affected community. These rumors were mostly about the aftermath of the earthquake: “The water of the River Ganges disappeared at the time of the earthquake, and people bathing were embedded in sand.” To explain why these rumors were prevalent only *outside*, but not *inside* the destruction area, Festinger (1962) argues that the neighboring people outside the destruction area were experiencing “cognitive dissonance.” That is, although they had the feeling of fear from hearing about the earthquake, because they had not witnessed the disaster, they only had ‘uncertain’ and ‘equivocal’ information about the earthquake. What Festinger’s cognitive dissonance work suggests is that rumor sets in motion “in situations of

relative collective ignorance and ambiguity about an event” (Tierney and Aguirre 2001). Given that social crises create uncertain information which is void of trustful source and contains interpretive ambiguity, the second hypothesis is presented as follows:

H2a: The level of source ambiguity in the circulating information during social crises is positively associated with rumors (mongering).

H2b: The level of content ambiguity in the circulating information during social crises is positively associated with rumors (mongering).

3.3 Personal Involvement

Although Anthony (1973) employs anxiety as a proxy to measure the *importance* variable of Allport and Postman’s (1947) original rumor model, Rosnow (1991) suggests including the perceived *importance* as a separate variable. He refines it as “outcome-relevant involvement” to indicate that “the amount of rumor-mongering will vary according to an incident’s thematic importance” to the people involved (Rosnow 1991). This is consistent with Allport and Postman’s (1947) postulate that “the amount of rumor circulation will vary with the importance of the subject to the individuals concerned.” This means that for a rumor to spread, the incident’s subject matter must be important for both the information sender and recipient. Otherwise, there is no incentive for the recipient to pass along the story to other persons. In this sense, importance is represented as a subjective feeling of *personal involvement*⁴ in the rumor related incident, which is conceptually different from Anthony’s (1973) *anxiety*.

Rosnow (1991) believes that the personal “affective state – acute or chronic” is an important rumor spreading factor, because it is not necessarily evoked by external events, but somehow is already imbued with personal disposition even before experiencing the rumor related incidents

⁴ We thank an anonymous reviewer who suggested adding the ‘personal involvement’ variable to our original rumor model.

(Rosnow 1991, p. 487). The external incident's importance to the individual concerned is based on "a synthesis of the relevance of a situation and whether it evoked caring or involvement" (p. 487). Rosnow et al's (1988) rumor research on a murder incident at a local college supports the argument. It revealed that the student group of the college, which experienced the murder incident, transmitted almost twice the number of rumors compared to the control group of the neighboring college. While this research did not include the "importance" or "personal involvement" as an independent variable, we can surmise that the college student group who experienced the shocking murder incident on their campus dorm may have had higher levels of personal involvement perception with the incident than the control group. From this, we submit a third hypothesis on the role of personal involvement feeling in rumor transmission:

H3: Feelings of personal involvement with regard to social crises is positively associated with rumors (mongering).

3.4 Social Ties: Direct Message

Rumoring involves collective talking, interactive information sharing and "social support" (Festinger 1962) among like-minded groups of people. By nature, people tend to share information with acquaintances within their communal boundary, and "people are biased toward believing rumors from those they know" (Garrett 2011, p. 259). Therefore, social ties, personal contacts, and relations in close proximity are factors that influence people to share information with other community members (Collins 2001), and they form repeatable communication routines through which information flows (Tsai and Ghoshal 1998).

Although the social tie concept has not been extensively tested as a distinct variable in previous rumor studies, its importance has been sporadically mentioned with different expressions. For example, Allport and Postman (1947) maintain that rumors "avoid crossing social barriers and therefore have a restricted circulation" (p. 35). In a similar vein, Festinger

(1962) suggests that “social support” is mandatory for rumor dissemination. These statements imply that a rumor is more likely to spread within a community which is sustained by affective trust and strong social ties. That means, in a tightly woven community, affective social ties are likely to impose “social pressure against fact-checking,” reducing “the probability that recipients will verify the information for themselves” (Garett 2011, p.259-60).

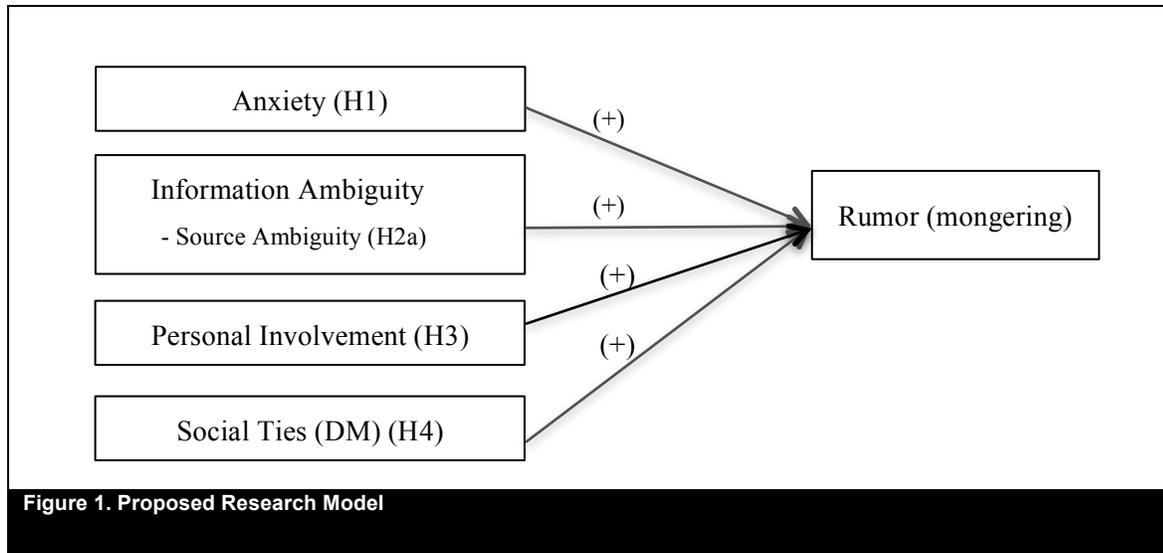
Garett’s (2011) political rumor research shows the effect of existing social ties on rumor transmission. His survey provides evidence that, compared to rumors learned from the public web, rumors received through emails from acquaintances (e.g., friends, colleagues or family members) are more likely to be believed and biased in the pattern of dissemination and credulity. As a reason for the strong bias effect of email communication upon rumor, Garret (2011) maintains that, different from the public web, email is a more closed and informal communication channel, which capitalizes on “existing social networks” such as friends, colleagues, and family members.

As an extension of this rumor study, Garret (2011) suggests that social networking services (i.e., Facebook and Twitter) may replicate rumor dynamics similar to those shown in email communication. The main reason is that, similar to informal email communication and different from the public web, social networking sites are mainly built around existing social relations. Acknowledging the effect of social relations on rumor transmission, we propose that Directed Messages (DM) in Twitter⁵, which are addressed to specific individuals in the Tweeter’s social network, may be more likely to result in rumors. Therefore, a fourth hypothesis is proposed:

H4: Directed messages in Twitter are positively associated with rumor (mongering).

In aggregate, our research model on rumor mongering is represented as figure 1.

⁵ Directed message is a message sent to specific Twitter user by attaching “@” in front of the recipient’s Twitter ID. It can be sent to only a specified user. Therefore, conceptually it is close to publicly displayed private e-mail.



4. RESEARCH METHODOLOGY

To test our hypotheses, we used three different Twitter datasets: (1) the Mumbai terrorist attack in 2008, (2) the Seattle café shooting incident in 2012, and (3) the Toyota recall in 2010. The first two datasets represent man-made crises but with different scales and impacts, and the third dataset deals with the business crisis of Toyota recalls.

These three types of incidents are appropriate for this research for two reasons. First, as the rumor literature suggests, large-scale crises offer optimal conditions for rumor-mongering. Second, analysis of data from three different types of social crisis will offer generalizable insights on the quality of social information produced by the online public.

4.1 Backgrounds of the Three Social Crises Under Analysis

4.1.1 *The Mumbai Terrorist Attack in 2008*

The Mumbai terrorist attack of November 2008 was arguably the worst terrorist incident in the history of India. A group of terrorists killed 165 and injured 304 persons at the heart of India's

financial capital, Mumbai by using a combination of improvised explosive devices, grenades, and hand-held guns (Indian Ministry of External Affairs 2009). The unfolding tragedy was broadcast live through India's mainstream TV media and live web streaming for almost 60 hours without any restraint. The scenes were terrifying enough to create anxiety and confusion in the minds of the Indian people (Oh et al. 2011; Raman 2009).

Within minutes of the initial attack, a local Mumbai resident posted a stream of onsite pictures at a photo sharing site, Flickr. Almost concurrently, a group of people voluntarily formed a Twitter page with a link to the Flickr site, and spread eyewitness accounts of the terrorist attacks with texts, photos, and links to other sources. Through tweets, online users expressed condolences, encouraged blood donations, posted help line contacts, broadcast information about their safety to their family, reported eyewitness accounts of the unfolding situation etc.

For active situational reports, some users added comments like "*twitter rocks – I am getting accurate and better information than MSM like Times Now!*" or "*CNN has been playing catch up to twitter :)*". However, despite the rapid dissemination of situational information, much confusion existed in the Twitter space due to too many rumors (Gahran 2008). As a result, many Twitter users expressed concerns regarding the reliability of news sources⁶, finger-pointed specific users as abusers of the Twitter space, showed distrust in Twitter, or requested Twitter users to post only direct observations.

4.1.2 Seattle Café Shooting Incident in 2010

In May 20th, 2012, a gunman in Seattle, WA, killed 5 people and injured 1 person before committing suicide. It was reported that the gunman had gotten into fights with musicians at Café Racer and have been made to leave by a bartender. At that moment, he pulled out two handguns and

⁶ Exemplary tweets expressing concerns about rumors are as follows: "#mumbai Please tweet only direct observations, RT rumors are just decreasing the signal/noise ratio." "where did you get that info? its crap. all of this is live on TV. pls stop spreading such stuff without verifying #mumbai"

shot at customers and employees. He fled the scene right away, went to a parking lot in the downtown area where he killed a woman and hijacked her car. Later that afternoon, the gunman shot himself to death as the police approached him (CNN 2012; McNerthney 2012). During the search operation, the Mayor, the Seattle Police Department and local newspapers (such as SeattleTimes, SeattlePI, Komo News etc.) were deeply involved in tweeting to broadcast the unfolding situation.

The police at first treated the shooting incidents at the café and the parking lot as separate crimes. The informational confusion and ambiguous situations about the shooters' whereabouts created discomfort in the minds of the community members (Johnson 2012; Winter 2012). Many people expressed anxiety and doubted the quality of information circulating through Twitter. Example tweets include: "Twitter is not a great place to get reliable sourcing on #Seattle shootings right now. So many conflicting reports," or "#DowntownShooting #RooseveltShooting How does this make sense? Suspect Downtown was blond and suspect on Roosevelt was brown haired?"

4.1.3 Toyota Recalls in 2010

Starting from the end of 2009 and throughout 2010, Toyota suffered from a series of recall nightmares. On September 2009, Toyota announced its biggest recall ever of more than 4 million vehicles for a problem related to accelerator pedals getting trapped in the floor mat. Four months later, on January 2010, they announced another large-scale recall of around 2.3 millions vehicles in the U.S. for potentially faulty accelerator pedals (Allen and Sturcke 2010). On April 2010, they recalled around 600,000 minivans in the U.S. for potential corrosion problems in the spare tire carrier cable. On July 2010, they announced additional recalls of over 400,000 cars in the U.S. and Canada for more serious mechanical problems in the steering system, which could cause deadly road accidents (Reuters 2010).

Following the serial recalls, in May 2011, sales of Toyota declined by a third compared to May 2010. To make matters worse, along with the effect of the economic downturn affecting the overall US car industry, the company faced a backlash from the mainstream and social media for their problematic safety checks, quality controls, and frequent recalls. Reflecting the impact of the business crises and its attendant consumer safety concerns, during the recall periods, Toyota became a trend word on Google and Twitter mostly with negative comments (Wasserman 2011).

4.2 Data Collection

The data collection process for the three crisis incidents is detailed below.

4.2.1 Mumbai Terrorist Attack 2008

As soon as Mumbai terrorist attack occurred on November 26 in 2008, we manually collected 929 tweet messages and their user IDs. Subsequently, to increase the sample size, we read through the 929 tweet messages and collected additional user IDs embedded in the tweet messages as a form of directed message or retweets. Through this process, we identified total 602 user IDs who might have posted messages during the Mumbai attack. By tracking back all Twitter messages of those 602 user IDs⁷, we collected a total of 20,920 Twitter messages for the period November 26th to November 30th, 2008. For our qualitative hand coding of the data, we randomly selected 7,000 Twitter messages out of the entire Twitter messages. One of the authors and two masters' students (who were familiar with the Mumbai scenario from personal experience) read through all the 7,000 tweets to remove thematically irrelevant tweets.

⁷ To retrieve the archival Twitter messages, we created our own Twitter data collection application in compliance with Twitter API terms of Service. The application is available from the authors upon request.

4.2.2 Seattle Café Shooting 2012

As soon as we heard the news about the shooting incident in Seattle, Washington, at 5:20PM Central Time on May 30th 2012, we began data collection with four hashtagged keywords: #DowntownShooting, #SeattleShooting, #Seattle, and #RooseveltShooting. Those hashtagged keywords were determined by our monitoring of the live tweet messages through the Twitter search engine. We concluded our data collection at 2:00 PM Central Time on May 31st when we heard the official news that the shooter had committed suicide. We collected a total of 9104 tweet samples during the period.

4.2.3 Toyota Recall 2010

Twitter data on Toyota Recall 2010 was obtained from the authors of Stieglitz and Krüger⁸ (2011). The sample size that we received from the authors was 37,323, which were collected between March 21 and July 31 in 2010 by using the keyword combination of “Toyota” and “recall”. From the data we obtained, we randomly selected and read 5,000 tweets to check if they were relevant to the Toyota recalls. All tweets were relevant to the Toyota recalls and we saved them for pilot and actual coding for our study.

4.3 Unitizing

Bordia and DiFonzo (1999; 2004) suggest that, before content coding, a paragraph, sentence, or narrative should be dissected into a unit of “one complete thought.” They suggest that “a complete thought provides enough information so that it can be interpreted by others and can stimulate a reaction in them” (Bordia and DiFonzo 2004). Given that the Twitter message has a maximum of 140 characters, our data sample was already unitized into a unit of “one complete thought” for coding.

⁸ The authors thank Drs. Stieglitz and Krüger for generously allowing us to use their Twitter data for our study.

4.4 Coding Scheme

We coded each tweet message to measure the effect of anxiety, information ambiguity (content ambiguity and source ambiguity), personal involvement and direct message on rumor.

Detailed coding schemes for dependent and independent variables are attached as Appendix 1. To develop the coding scheme for the dependent variable, rumor, we referred to various rumor definitions (Buckner 1965; Rosnow et al. 1988; Rosnow and Kimmel 2000). To create the coding scheme for independent variables, we modified the Rumor Interaction Analysis Systems (RIAS) to our research context (Bordia and DiFonzo 2004). The RIAS is a coding scheme to categorize “communication postures” represented in rumor text into 14 categories. Its purpose is to understand how interactive human communication changes over the life of a rumor to solve two problems (‘anxiety’ and ‘uncertainty’) implied in rumor. However, as the purpose of our study is to identify the rumor causing factors, we borrowed only those definitions which are relevant to our rumor model (Figure 1) (e.g., “apprehensive statement” for anxiety, “personal involvement statement,” “interrogatory statements” for content ambiguity).

To code the dependent variable, rumor, we used Rosnow and Kimmel’s (2000) rumor definition: “*Unverified* proposition or belief that bears *topical relevance* for persons actively involved in its dissemination” (italicized by authors). We also referred to the actual questionnaire items that Rosnow et al. (1988) used in their rumor research on the murder incident at a campus dorm of a local college: “any report, statement, or story that one may have heard for which there is *no immediate evidence to verify* its truth” (italicized by authors). Finally, to sharpen the relevance of theme in the Twitter messages, we employed Buckner’s (1965) rumor definition: “*Unconfirmed* message passed from one person to another that *refers to an object, person, or situation* rather than an idea or theory” (italicized by authors).

In brief, these rumor definitions involve three dimensions: unverified proposition, topical relevance, and referents of the statement (that is, “an object, person, or situation rather than an idea or theory”). Therefore, in the Twitter context, three conditions have been applied to code a tweet as a rumor: (1) if the tweet message explicitly indicates a person (e.g., the prime minister of Indian government), source (e.g., BBC, NDTV, link to web address etc.), context or known data to serve as proof or verification for the statement, AND (2) if the tweet is topically relevant to three types of crises under this study, AND (3) if the tweet statement refers to “an object, person, or situation rather than an idea or theory” (Bordia 1996; Rosnow et al. 1988; Rosnow and Kimmel 2000; Buckner 1965). Rumor, and all independent variables were coded as dichotomous (either 1 or 0). Along with exemplary tweet messages, the full coding scheme for dependent and all independent variables is detailed in Appendix 1.

All variables were coded as dichotomous because of the content analytic coding procedure used. Previous rumor studies in the off-line context have used survey or interview methods along with psychometric measurement scales as a means to measure the perceived level of different variables (e.g., anxiety, importance, ambiguity etc.) on an interval scale (Anthony 1973; Buckner 1965; Rosnow et al. 1988). However, as our study involves reading and content coding for the unobtrusively collected tweet texts, we coded our variables as dichotomous by checking whether or not a tweet message contains traits of variables suggested in our research model.

4.5 Inter-Coder Reliability

We followed the steps for content coding and analysis suggested by Krippendorff (1980) and Landis and Koch (1977). For the content coding, two masters and two undergraduate students were hired to separately code the Twitter data. Two masters’ students with deep local knowledge of the Mumbai terrorist attack and its surroundings separately coded the Mumbai terrorist attack data. Two

other undergraduate students separately coded the Seattle Café shooting incident data. After finishing the coding of those two datasets, one masters and one undergraduate student independently coded the Toyota recall data.

To build a coding book (Appendix 1), three meetings were held to understand the histories of the three different social crises and the role of Twitter during those crises situations. The authors were not involved in content coding. Hypotheses and measurement models were not shared with student coders, and they were not allowed to communicate with each other while coding. They were asked not to code the data more than an hour per each day so as not to make errors in coding due to fatigue.

Pilot data coding was carried out in two rounds for the Mumbai terror data, and in three rounds for the Seattle café shooting and Toyota recall datasets. Our goal for pilot coding was to repeat coding and refine the coding book until independent coding results reached the *kappa* value greater than .70, indicating a probability of agreed understanding between coders that is significantly higher than what can be obtained by chance⁹ (Krippendorff 1980; Landis and Koch 1977).

	Mumbai Terrorist Attack 2008		Toyota Recalls 2010			Seattle Café Shooting 2012		
	1st Coding	2nd Coding	1st Coding	2nd Coding	3rd Coding	1st Coding	2nd Coding	3rd Coding
Rumor	0.77	0.84	0.63	0.71	0.79	0.75	0.80	0.89
Anxiety	0.81	0.82	0.85	0.85	0.82	0.73	0.80	0.86
Personal Involvement	0.89	1.00	0.63	0.85	0.83	0.64	0.71	0.96
Source Ambiguity	0.75	0.86	0.63	0.82	0.74	0.59	0.71	0.92
Content Ambiguity	0.74	0.81	0.77	1.00	0.85	0.59	0.83	0.94

⁹ Landis and Koch (1977) suggest that *kappa* value 0.21~0.40 is fair, 0.41~0.60 moderate, 0.61~0.80 substantial, and 0.81~1.00 almost perfect agreement between independent coders.

Social Ties	0.79	0.99	0.48	0.79	0.89	0.64	0.77	1.0
Sample Size	100	300	100	100	300	100	100	300

The first pilot coding was to verify the level of mutual understanding of the coding book. For the first pilot coding, we used 100 tweet samples that we randomly selected from our original datasets. If the first pilot coding result did not reach the threshold *kappa* value of .70, then two authors and all student coders conducted video conferences to discuss the disagreed coding results. As Table 1 shows, coding result for the Mumbai terrorist attack exceeded the desired threshold *kappa* value of .70 at the first round of coding. Therefore, coders performed next coding with 300 sample tweets. Coding for the other two datasets (Toyota Recalls and Seattle Café Shooting) exceeded the threshold *kappa* value of .70 after the second round of coding. Therefore, we proceeded to the third round of coding for these two datasets with 300 sample tweets per each. The final pilot coding results with 300 tweet messages confirmed that our coding book is robust, and therefore, one masters and two undergraduate student coders proceeded to separately code the entire 3,500 tweet data samples of the three different social crises. We ensured that the pilot sample data (400 tweet sample for the Mumbai terrorist attacks and 500 tweet samples for the Toyota recalls and the Seattle shooting incident) were excluded from 3,500 sample data of three different incidents (total 10,500 tweets) that we used for our logistic regression analysis.

4.6 Analysis Method

Due to the dichotomous nature of the dependent variable (rumor), we employed logistic regression. Logistic regression is appropriate “with an outcome variable that is dichotomous and predictor variables that are continuous or categorical” (Field 2005, p. 218). It does not assume linear relationships between the dependent and independent variables, and independent variables need not be interval, nor normally distributed, nor linearly related (Tabachnick and Fidell, 1996). Further, the

results have direct interpretations as odds-ratios. The Spearman rank correlation test (Table 2) indicates that all correlations are less than 0.5, indicating that no significant multicollinearity problems exist (Kishore et al. 2004-5). Also, the correlation between rumor and source ambiguity is not in the range of statistical concern (.358 for the Mumbai Terrorist Attack, .301 for Toyota Recall, and .280 for Seattle Shooting Incident). Note that the Twitter data are observable and explicit, (as opposed to latent ones) that community members actually tweeted during the situation of social crises. We also ensure that our sample sizes (3,500 tweets per each crisis incident) are large enough to suppress the potential Type I and Type II errors. The concern of Type II errors can be suppressed with a large sample size, and the immunity of Type I error can be ensured by the significance of p-value (Larson-Hall 2010).

Table 2: Spearman's Correlations						
Mumbai Terror 2008						
	Rumor	Anxiety	Sorc Amb	Cont Amb	Per Inv	Soc Tie
Rumor	1					
Anxiety	.182**	1				
Sorc Amb	.358**	.291**	1			
Cont Amb	.047**	.074**	.179**	1		
Per Inv	.239**	.328**	.360**	-0.01	1	
Social Tie	-.189**	0.012	0.011	.108**	-.038*	1
Toyota Recalls 2010						
	Rumor	Anxiety	Sorc Amb	Cont Amb	Per Inv	Soc Tie
Rumor	1					
Anxiety	.050**	1				
Sorc Amb	.301**	0.012	1			
Cont Amb	0.021	.083**	-0.021	1		
Per Inv	.060**	.259**	-0.005	.189**	1	
Social Tie	0.03	.156**	0.016	.041*	.228**	1
Seattle, WA, 2012 Shootings						
	Rumor	Anxiety	Sorc Amb	Cont Amb	Per Inv	Soc Tie
Rumor	1					

Anxiety	.164**	1				
Sorc Amb	.280**	.378**	1			
Cont Amb	.045**	.162**	.180**	1		
Per Inv	.142**	.455**	.275**	.078**	1	
Social Tie	0.005	-0.004	.055**	.044**	-0.015	1
** indicates correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						
Abbreviations: Sorc Amb - Source Ambiguity; Cont Amb - Content Ambiguity; Per Inv - Personal Involvement; Soc Tie - Social Ties						

The rumor model tested is as follows:

$$P(\text{Rumor}) \approx \text{Anxiety} + \text{Source Ambiguity} + \text{Content Ambiguity} \\ + \text{Personal Involvement} + \text{Direct Message}$$

As our Twitter datasets were collected over specific time periods, we performed Durbin-Watson tests to verify that the error terms in our datasets did not contain any first order autocorrelations. (Durbin and Watson 1951; Savin and White 1977). Values of the Durbin-Watson statistics (d) were 1.94, 1.99, and 1.96 at $p < .05$ for each of the three datasets (Mumbai, Seattle and Toyota). As all these values are between lower ($d_U = 1.93$) and upper bound ($4 - d_U = 2.07$) of critical values at $p < .05$, we do not detect any autocorrelations between the error terms, validating that the error terms are independent of each other (Murray 2005)¹⁰.

5. RESULTS

Using logistic regression analysis, we estimated the probability of rumor-mongering for the five independent variables during the three different types of crisis incidents. Results of the regression

¹⁰ To test for the independence of error terms in the logistic regression model, first order autocorrelation test was performed. The Durbin-Watson test, and the resulting d-statistic are used to perform this test. If the d-statistic value is between lower and upper bound critical values (d_U) and $4 - d_U$ at $p < .05$, then no autocorrelation exists in the dataset. If the d-statistic value is less than the lower bound critical value (d_L) at $p < .05$, then it confirms that positive autocorrelation exists in the dataset. If the d-statistic value is greater than $4 - d_L$, then it indicates that negative autocorrelation exists in the dataset. All d-statistic values in our datasets (1.94, 1.96, 1.99) were between the lower ($d_U = 1.93$) and upper ($4 - d_U = 2.07$) bound critical values, which indicate that error terms in our datasets are independent of each other (Murray 2005).

analysis are presented in Table 3. The results indicate a good model fit for the Mumbai terrorist attack data, $\chi^2(5) = 680.21$ ($p < .001$), for Toyota recall data, $\chi^2(5) = 260.94$ ($p < .001$), and for Seattle Shooting incident data, $\chi^2(5) = 292.69$ ($p < .001$). Table 3 also shows that H1 is supported for the Mumbai terror case at the significance level of $p < .01$, for the Seattle shooting incident case at the significance level of $p < .05$. However, H1 is only marginally supported for the Toyota data at $p < .10$. This implies that, during the Mumbai terrorist attacks, a Twitter message charged with anxiety is 1.406 times more likely to be a rumor than an anxiety-free message. In the Seattle Shooting incident, the probability of an anxious Twitter message to be a rumor is 1.299 times higher than a non-anxious one. In the Toyota Recalls, although the probability that an anxious Twitter message is likely to be a rumor is 1.59 times higher than a non-anxious one, its significance level is marginal at $p < .1$.

Table 3: Results for the Independent Effects on Rumor (95% CI for Exp(b))

	Mumbai Terror 2008			Toyota Recall 2010			Seattle Shooting 2012			Hypothesis
	B(SE)	Sig.	Exp(B)	B(SE)	Sig.	Exp(B)	B(SE)	Sig.	Exp(B)	
Constant	-1.364 (.066)	0.000	.256	-1.799 (.078)	0.000	.165	-2.323 (0.079)	0.000	0.098	
Anxiety	.341 (.096)	0.000	1.406 ***	.464 (.257)	.071	1.59 *	.262 (.123)	0.033	1.299 **	H1: Partially Supported
Source Ambiguity	1.444 (.086)	0.000	4.237 ***	1.509 (.088)	0.000	4.523 ***	1.387 (.103)	0.000	4.001 ***	H2a: Supported
Content Ambiguity	.1 (.108)	0.357	1.105	.194 (.201)	.337	1.214	-.104 (.19)	0.586	0.902	H2b: Rejected
Personal Involvement	.53 (.09)	0.000	1.699 ***	.766 (.28)	.006	2.151 ***	.337 (.149)	.0204	1.401 **	H3: Supported
Social Tie	-1.114 (.093)	0.000	.328	.142 (.284)	.619	1.152	-.114 (.284)	0.687	0.892	H4: Rejected
Model Fit	$\chi^2 = 680.21, df=5$ ($p < .001$)			$\chi^2 = 260.94, df=5$ ($p < .001$)			$\chi^2 = 292.69, df=5$ ($p < .001$)			

***. Significant at the 0.01 level. **. Significant at the .05 level. *. Significant at the .10 level.

Table 3 shows significant effects of source ambiguity upon rumor at $p < .01$ for all three crisis cases, leading to strong support for H2a. In other words, the probability that a Twitter message whose source is ambiguous is likely to be a rumor is 4.237 times, 4.523 times, and 4.001 times higher than a Twitter message having source information for the cases of Mumbai terror, Toyota Recall and Seattle Shooting, respectively. Table 3 also shows the significant effects of personal involvement upon rumor for all three crisis cases but with slightly different significance levels. The probability that a message implying a feeling of personal involvement is likely to be a rumor is 1.699 times ($p < .01$), 2.15 times ($p < .01$), and 1.401 times ($p < .05$) higher than a message which does not imply a feeling of personal involvement for different cases, supporting H3.

A comparison of the coefficient values for each independent variable of the three supported hypotheses (H1, H2a and H3) shows consistent patterns. In other words, all three different cases of social crises show that source ambiguity is the most important, personal involvement is the next important, and anxiety is the least yet marginally important rumor causing factor. However, different from our expectation, we could not find effects of content ambiguity and social tie upon rumor. Therefore, H2b and H4 are not supported.

6. DISCUSSION

6.1 Key Findings

The results of logistic regression indicate that, while content ambiguity does not contribute to rumor mongering, source ambiguity does so very significantly. This result needs contextual interpretation from the views of collective communication behavior in virtual space during social crises.

Twitter messages coded for content ambiguity were mainly composed of questions seeking information on the crisis situation or doubts expressing suspicion on Twitter posts¹¹. Questioning or doubtful statements explicitly display the subjective nature of those messages. The tone of those messages signals that those messages were not persuasive statements intended to make others believe and spread the received messages. As a result, contrary to H2b, content ambiguity variable turned out to be a non-significant rumor mongering factor. In contrast, messages in the category of source ambiguity frequently resembled third person situation reports without sources being attached¹². In their postures, these statements looked like news reports, but without clear source, data or context described. This might have influenced their role as a rumor mongering factor.

The non-significant effect of content ambiguity and highly significant effect of source ambiguity upon rumor mongering highlights the nature of citizen centric social reporting behavior under crises. As rumor studies tell, it is a spontaneous collective information processing behavior “to make sense of an unclear situation or to deal with a possible threat” (DiFonzo and Bordia 2007). However, given that collective information diffusion and processing essentially go parallel with the collective sense-making process in the Twitter space, citizen reporting cannot lead to successful sense making without a sufficient number of messages being supported with trusted sources. This means that, unlike the mainstream media where professional reporters check information sources before publication, the shortage of reliable information in the social media space may be more likely to lead to questions seeking information, doubts expressing suspicions, subjective interpretations, or rumors.

¹¹ For example, “Fact or fiction? Indian gov't trying to stop tweets about Mumbai?” (from the Mumbai terrorist attack data), or “How does this make sense? Suspect [in] downtown was blond and suspect on Roosevelt was brown haired?” (from the Seattle shooting incident Twitter data).

¹² “#mumbai The terrorist attacked a hospital for women and children and took patients hostage” (from the Mumbai terrorist attack data). “Toyota Moving Forward With Recall, Multiple Factories Closed” (from the Toyota recall data).

Another important finding is that, contrary to the traditional rumor research in the offline context, the results in table 3 shows that the effect size of anxiety on rumoring is much lower than that of source ambiguity. As Rosnow's (1991) meta-analytic exploration of rumor studies shows, traditional rumor researchers have consistently reported that anxiety is normally the most influential rumor mongering factor. However, in our case, the influence of anxiety (ranging from 1.299 to 1.59 in its coefficient values) on rumor was much lower than that of source ambiguity (ranging from 4.001 to 4.523 in its coefficient values).

This reversed influence can be described by the characteristics of social relations and their attendant communication patterns, which are propelled by different modes of community. Traditional rumor studies have been built upon the idea of territorial community. That is, as triggers of rumor transmission, rumor theory has maintained that social crises cause collective anxiety and ambiguous situation, which are commonly experienced by people living in the adjacent territorial boundary of the crisis stricken community. (Allport and Postman 1947; Festinger 1962; Shibutani 1966). Therefore, when rumor theorists argue that rumors tend to "avoid crossing social barriers and therefore have a restricted circulation" (Allport and Postman 1947) or it cannot travel without "social support" (Festinger 1962), they assume a territorial community in close proximity, which is somehow sustained by repeated social relations, some level of affective trust, and enduring shared values etc. Therefore, the tightly knitted territorial community is likely to impose social influences to accept the received message without checking facts or the source of the ambiguous information (Garrett 2011). That means, people tend to trust information they receive from those they know, and replace with affective trust their disbelief in the received information, even when its source is ambiguous. Therefore, in the traditional territorial community supported by affective trust and pre-existing social relations, shared anxiety may have been the more important rumor-causing factor, compared to source ambiguity.

However, communication through the virtual space of Twitter has very different characteristics in terms of social relations and communication modes especially under social crises. As Twitter communications are rapidly improvised in response to the social crises, territorial community boundary, pre-existing social ties, social influence, shared anxiety, and affective trust may be very weak or even almost absent. It is highly likely that (1) Twitter communication on Mumbai terrorist attack was improvised at the national level, (2) Twitter communication under the Seattle shooting incident was mainly made at the Seattle community level, and (3) Twitter communication on Toyota case may not even imply any traits of traditional territorial community. Instead, they might have gathered on Twitter with temporary crisis issues to seek and share information on the unfolding crisis situations. Therefore, compared to the territorial community, the virtual Twitter space might have been an improvised loose community where social relations are weak, affective trust is low, and hence little social pressure to accept ambiguous information as it is. In other words, as the Twitter community has weaker social pressures, Twitter users do not easily accept dubious reports with ambiguous sources. A few exemplary tweet messages that express distrust for unreliable information are as follows:

“wish that people wouldn’t clutter @mumbai with stupid speculation and half-baked opinions”
(from Mumbai terrorist attack data).

“I’m seeing conflicting information about how many are dead from #RooseveltShooting – is it 2,3, or 4? Male or female?” (from Seattle shooting incident data).

“Is it true that the Lexus engine will explode? Who said that?” (from Toyota recall data).

However, although aspects of the virtual community are dominant in Twitter, it does not necessarily mean that territorial traces are completely erased in a virtual community. The traces of territorial community are represented in the personal involvement statements¹³ in that those statements may have been posted by Twitter users who were in close proximity to the physical location of Mumbai and Seattle¹⁴. However, the fact that the effect of personal involvement upon rumor (from 1.401 to 2.151) is much lower than that of source ambiguity (from 4.001 to 4.532) shows that, in aggregate, the Twitter space is dominated by the virtual characteristics of online community.

As to social ties, which were measured by directed messages, we could not find its effect on rumors, hence H4 is rejected. According to our close reading of directed messages, the main reason for the insignificance of H4 is that online users used directed messages primarily to ask about personal safety, share anxious feelings with their acquaintances, and for short chats. It was very rare to use directed messages for situational information gathering and dissemination, hence they did not lead to rumor dissemination.

	Mumbai Terror '08	Toyota Recall '10	Seattle Shooting '12
	Frequency (%)	Frequency (%)	Frequency (%)
Rumor	1211 (34.61%)	1133 (32.38%)	649 (18.54%)
Anxiety	782 (22.35%)	77 (2.20%)	561 (16.03%)
Source Ambiguity	1670 (47.73%)	2136 (61.05%)	1512 (43.20%)
Content Ambiguity	537 (15.35%)	131 (3.74%)	163 (4.66%)
Personal Involvement	987 (28.21%)	69 (1.97%)	298 (8.51%)
Social Ties	1112 (31.78%)	63 (1.80%)	86 (2.46%)
Sample Size	3,500	3,500	3,500

¹³ “hearing navy sounds at the helipad near my house ...” (from Mumbai terrorist attack data). “Dueling helicopters above our house. Shooting suspect was shot and killed. Which shooting is unknown. #downtownshooting #rooseveltshooting” (from Seattle shooting incident data).

¹⁴ Our appreciation goes to an anonymous reviewer who suggested the “personal involvement” variable.

Lastly, it is noteworthy to mention the result of descriptive statistics in Table 4. First, the very low frequency of anxiety in the Toyota recall data (2.20%), compared to that of the Mumbai terrorist attack (22.35%) and the Seattle shooting (16.03%), confirms the insights of early rumor researchers that community crises (like war, terrorist attack, or natural disaster) involve high levels of anxiety at the community level (Allport et al. 1947; Rosnow et al. 1976; Oh et al. 2010; Oh et al. 2011; Shibutani 1966). Given that the Toyota recall case is more about a business crisis which is not attached to a physical community, it is understandable that the frequency of anxiety is very low (2.2%), the effect of anxiety upon rumor is only marginal at $p < .1$, but the effect of source ambiguity upon rumor is very high at $p < .01$. It implies that, different from other community crisis situations, rumors under business crisis tend to be driven primarily by informational problems and very marginally by collective anxiety. We can infer this reason from the fact that, while citizens facing the Toyota recalls have alternatives of not purchasing or not using the Toyota products, community crises like the Mumbai terrorist attack and the Seattle shooting incident do not offer alternatives for citizens other than fleeing their communities. In addition, relative to the Toyota recall data (1.97%), the higher frequency of personal involvement in the cases of the Mumbai terrorist attack (28.21%) and the Seattle shooting incident (8.51%) reveals that community disasters are more likely to exert direct effects upon community members to consider them as personal problems. For the same reason, it is no wonder that the frequency of anxiety is lowest in the business crisis of the Toyota recall case.

Comparison of the two different community crises of the Mumbai terrorist attack and the Seattle shooting incident show different patterns of communication. The frequencies of all variables (rumor, source ambiguity, personal involvement, anxiety, content ambiguity, and social ties) in the large-scale Mumbai terrorist attack are consistently higher than the corresponding frequencies in the local scale of the Seattle shooting incident. As detailed in the previous section on the backgrounds of the three crises, the different frequencies reflect the differences in scales and impacts of the two community crises.

6.2 Theoretical Contributions

By extending the traditional rumor theory to the social media context, we identified key variables (source ambiguity, personal involvement, and anxiety) that explain rumor dissemination on Twitter during diverse crisis events - the Mumbai terrorist attack, the Seattle shooting incident, and the Toyota recalls. .

The findings of our study reveal interesting patterns of collective information processing, similar to those observed in offline contexts in prior research, yet with different modes, scale, and implications. This result is contrary to findings of traditional rumor research in which anxiety is normally considered the most influential factor in rumor spread. To explain the changed order of influences on rumors in the Twitter space, we contrasted two different types of community: tightly knit territorial community and improvised virtual community for temporal emergency situations. Our interpretation is that, while the traditional territorial community replaces disbelief with affective trust for the ambiguous information, improvised virtual community executes cognitive distrust for ambiguous information to understand uncertain situations and to reduce cognitive ambiguity. Also the descriptive statistics in Table 4, confirmed that, while information of ambiguous provenance is a general rumor causing factor across business and community crises, the business crisis of the Toyota recalls show much lower levels of anxiety than the other two community crises in their collective reporting.

6.3 Practical Contributions

Many rumor researchers have warned that, unless properly managed, negative rumors can decrease morale and increase distrust in the capacity of the organization and government to protect their customers and citizens (Allport and Postman 1947; Rosnow and Fine 1976). Symptoms of these deleterious effects were actually visible in our data set as well:

“from karmayog #mumbai We are witnessing a lack of leadership from elected or appointed public representatives, bureaucrats, spiritual leader” (from the Mumbai terrorist attack data).

“The mayor of #Seattle is a complete idiot. Guns don't kill people, people kill people.#fb” (from the Seattle shooting incident data).

“Dear Toyota, it would be easier to let us know which cars we can keep as it seems like almost all of them has been recalled.” (from the Toyota recall data)

As Rosnow suggests (1991), one important task for crisis response is to control rumors and obtain and distribute local and reliable information to the affected communication as early as possible. The fact that source ambiguity is the most important rumor causing factor across business and community crises provides an important implication for such responses. Under crisis situations, if there are too many situation reports with ambiguous or no information source, then we can surmise that rumor mills are being constructed. It may be a strong signal that people are desperately searching and sharing situational information through their social networks but without reliable information from authoritative sources.

We believe that emergency response teams, in firms or governments, need to understand the crisis communication patterns and rumor mongering conditions. The descriptive statistics in Table 4 indicates that the low frequency of anxiety (2.20%) and high frequency of source ambiguity (32.38%) in the Toyota recall suggests that firms in business crisis should pay attention to information issues to control rumor dissemination. In contrast, in cases of community disasters, emergency responders need to make extra efforts to distribute reliable information and, at the same time, control collective anxiety in the community to suppress rumor spread. That means, if unambiguous and localized situational information is not provided to the affected community in a timely manner, their collective information processing is very likely to encourage rumors. Therefore, emergency response teams need to put in place prompt response systems to refute the wrong

information and provide citizens with timely, localized, and correct information through multiple communication channels such as website links, social network websites, RSS, email, text message, radio, TV or Retweets etc. In fact, given that the motivation of rumoring is fundamentally “to deal with a possible threat” (DiFonzo and Bordia 2007) , provision of timely and certain information may lead to a successful threat management in partnership with voluntary online citizens.

7. FUTURE RESEARCH AND CONCLUSION

To the best of our knowledge, this study is the first application of rumor theory to social media and community intelligence. As a result, our suggested model needs replications and refinements in different social media contexts. Further, as we coded all variables as binary data types, there could be significant information loss during coding and analysis. It was, however, an inevitable choice in the situation that coders should manually read and code all data of tweet texts for all variables. To overcome this limitation, development and use of richer measurement scales for all variables would be beneficial. Future studies can combine archival data of social media with survey response data of online users who are involved in social reporting under different crisis situations.

As the former national incident commander, Thad Allen, testified, it is almost certain that “there will never be a major disaster that won’t involve public participation” (Berinato 2011). This offers many opportunities for the IS community to contribute in solving crisis problems in business and society. Among many, we suggest two promising research opportunities.

First, unlike human response in traditional business contexts, much human response during crises is reflexive. Therefore, evidence from prior extreme events should be used to guide interventions and agency response during social crises. In the past, such research has been hampered by the lack of proximate data from social crises. However, the introduction of Twitter and other

social media services has provided researchers with a precious window of data on information processing by concerned respondents, usually in the immediate aftermath of crisis incidents. In this regard, analysis of social media data on social crises will offer invaluable insight to enhance individual and institutional capability to monitor and identify threats, needs and opportunities to solve many crisis problems.

Second, although many pundits have portrayed rosy pictures about the potential of online crowds for collaborative problem solving (Kazman and Chen 2009; Surowiecki 2005; Tapscott and Williams 2006), less attention has been paid to the information quality issues in the context of citizen-centric social media technologies. However, given that information quality and the perceived trust on the online information are critical success factors for e-commerce (Gefen et al. 2008) and information systems (DeLone and McLean 2003), the quality of social information produced by a multitude of social media users is likely to determine the success of collaborative problem solving by the voluntary online public especially under social crisis situations. This study will be a good starting point to understand the issue of social information quality.

**ESSAY 3: FROM PRINT AND REPRINT TO TWEET AND RETWEET: AN
EXPLORATION OF SOCIAL MEDIA, INFORMATION DIFFUSION AND RADICAL
SOCIAL CHANGES**

1. INTRODUCTION

The 2011 serial social movements in Arab nations have stirred debates regarding the role of social media technologies in social changes. The first uprising sparked in Tunisia on December 17th, 2010 in the form of civil resistance right after a 26 year-old street vendor, Mohamed Bouazizi, set himself on fire in front of a government building in protest of government officers' violent confiscation of his wares and humiliating treatment (Time 2011b). While mainstream media both in Tunisia and the globe had been silent about the incident, the story rapidly flooded social media space such as Facebook, Twitter, YouTube, and numerous Blog websites (Howard et al. 2011). Since then, the protest quickly crossed the borders of multiple neighboring countries into Egypt (January 25th, 2011), Syria (January 26th, 2011), Algeria (February 11th, 2011), Yemen (February 11th, 2011), Bahrain (February 16th, 2011), and Libya (February 16th, 2011). In that short period of time, the presidents of Tunisia, Egypt, and Libya were forced to step down from their twenty-three, thirty, and thirty-two years of dictatorship respectively. Indeed, the speed and scale of the serial revolutions, which diffused like wildfire across the Arab nations, were unprecedented in human history, and so were the scale of social media campaigns, the speed of information diffusion, and connections of previously disconnected individuals (Ghonim 2012; Howard et al. 2011).

To explicate the role of social media during the Arab Spring movements, media pundits and scholars have offered various views. Their arguments seem to be divided into binary opposition between what Orlikowski (2007) calls the “*techno-centric perspective*” and “*human-centered perspective*”. They unquestionably assume that human and technologies are separable and choose one perspective over the other to unfold unidirectional descriptions of the role of social media in

social changes. As a result, this view involves some level of simplification, and misses the techno-social dynamics that emerges in practice when a multitude of individuals are inseparably connected and intermingled in and through social media space.

In this paper, we acknowledge the utility of the sociomaterialist approach (Leonardi and Barley 2008; Orlikowski and Scott 2008), which proposes an inseparably entangled view between human and non-human technologies to analyze the role of technologies in organizational and social changes. We first appraise the method that historians took to analyze the role of print technology in bringing about the Protestant Reformation in the 16th century. Applying the same method, subsequently, to the context of the 2011 Egypt Revolution, we explicate (1) how social media allows connection of previously disconnected group of individuals with similar ideas and shared interests, (2) how influential figures emerge through the support of a multitude of connectable individuals, and (3) how collective sense-making process develops. This study is, to our knowledge, the first quantitative empirical study that applies the angle of sociomateriality to explicate the role of social media in social changes. Our study also contributes in explicating how the technological feature of the Twitter service known as “retweets” generates “affordance” (Gibson 1977; Leonardi 2011; Majchrzak and Markus 2013; Markus and Silver 2008) to make radical social changes by enabling the connecting of previously disconnected groups of people with shared interests at unprecedented speed, scale and dynamics. To “sort[ing] the ‘fads of the day’ from developments that [may] have lasting impact” (Goes 2013, p.v), we study “the phenomenon of the “print and reprint” and take a comparative approach in explicating the patterns of connections afforded by the technological feature of “tweets and retweets” in Twitter.

In the following sections, we first review the “techno-centric” and “human-centric” perspectives on the role of social media during the 2011 Egypt revolution. We then review the methods that historians used to analyze the role of print technology in bringing about the Protestant

Reformation in the 16th century. Subsequently, we apply the historians' method to the social media context to analyze the role of social media during the 2011 Egypt Revolution. Some background information on the Egypt revolution and Twitter data collection method follows. We then apply a power-law distribution test and carry out a network analysis to explicate how influential figures emerged through affordance offered by the retweet feature of the Twitter technology. Discussion, contributions, limitations, and conclusions follow at the end.

2. THE ROLE OF SOCIAL MEDIA IN SOCIAL CHANGES: A TECHNO-CENTRIC VS. HUMAN-CENTERED VIEW

To explicate how the Arab Spring movements could move so fast at such a large scale, media pundits and scholars have suggested different views on the role of social media in social changes. Notwithstanding many different views, their arguments seem to swing like a pendulum between two ends of what Orlikowski (2007) called the “*techno-centric* perspective” and “*human-centered* perspective.” The techno-centric perspective assumes that technology is largely “exogenous, homogeneous, predictable, and stable” (Orlikowski 2007, p. 1437), and focuses on explicating the aspect of *objective* technology that exists separately from human action. It tends to take a unidirectional view to describe how technologies cause organizational or social changes “independently of human action” (Leonardi 2009, p.280). The downside of this perspective is that it blinds capabilities of autonomous human agency that can select, use, manipulate, or even avoid specific technologies to their advantages in particular situations to produce outcomes that they desire. Likewise, the human-centric perspective also takes a unidirectional view, but from the opposite direction. Privileging the human agency, it “focus[es] on how humans make sense of and interact with technology in various circumstances” (Orlikowski 2007, p. 1437). In this perspective, attention

is paid to the aspect of *perceived* technologies, rather than *objective* artifacts, to explicate how users in various situations differently perceive, interpret, and use technologies to make organizational or social changes to their own advantages. One major weakness of this approach is that, although technological artifacts are everywhere in our living and working environments (Yoo 2010), be it intentional or not, they are blind to the effects of material agency which affords or constrains the possibility of human action of technology users (Orlikowski and Scott 2008).

In describing the role of social media for the Egypt Revolution, a strong advocate of the techno-centric perspective is Wael Ghonim, considered one of the most influential 100 people in 2011 (Time 2011a), who played the pivotal role in coordinating the street protests through Facebook, Twitter, Google Docs and many social technologies (Ghonim 2012). In his interview with CNN (2011a), Ghonim maintains that “if you want to have a free society, just give them the Internet.” In another interview with CBS (2011), he emphatically stresses that “if there was no social networks, it [the Egypt Revolution] would have never been sparked. [...] Without Facebook, without Twitter, without Google, without YouTube, this would never have happened.” His optimism in technologies is so positive that he seems to believe that Internet technologies are inherently emancipatory. Considering that he credits social media technologies for starting the Egypt revolution, his view on the role of social media is closer to techno-centrism.

Counter to the techno-centric approach, a human-centric view has been presented by scholars as well. They maintain that revolutions always have existed well before Internet technologies were born as can be seen from the case of the French revolution (1789-1799) and many others. They consider autonomous human intention as a primary condition for social changes, and technologies as ancillary instruments to serve the higher human purposes. Their typical arguments include “People with grievances will always find ways to communicate with each other” (Gladwell 2011), or “The dozen or more protesters that self-immolated in Egypt didn’t do it for the tweets” (Kravets 2011).

In and of itself, such different perspectives may not be problematic in that they can offer alternative insights in explicating the role of social media in social changes. However, it seems inevitable that, to the extent that they choose one perspective over another one, it involves some level of simplification, leaving behind blind spots to look at the role of social media technologies for social changes. For instance, the case of Libyan uprisings shows that the Ghonim's (2012) rather techno-centric assertion did not work in the particular political situation of Libya. During the Arab Spring, Libyan people *perceived* Facebook and Twitter as surveillance tools of the Gaddafi's secret police to hunt down protesters, and therefore, they intentionally avoided using those popular social media websites for revolutionary conversations. Instead, they turned to a clandestine dating website (www.mawada.net) and used enigmatic poetic expressions¹⁵ to secretly coordinate street protests against the dictatorial regime (ABC 2011). Likewise, the human-centric arguments of Gladwell (2011) and Kravets (2011) also show only partial explanatory power. Therefore, without considering the role of social technologies which afford a space for large-scale of human interaction, it is hard to explain how such a large scale social movements, dubbed the Arab Spring, could spread across multiple national borders in such a short period of time. Furthermore, in a networked society where our everyday experiences are always and already mediated through ubiquitous digital technologies (Yoo 2010), it seems even unrealistic to imagine that human actions can be detached from digital technologies.

Acknowledging the inherent blind spots both in the techno-centric and human-centric perspectives, the notion of sociomateriality offers a practical lens to fill the gap left by those two competing viewpoints (Leonardi and Barley 2008; Leonardi 2011; Orlikowski and Scott 2008). The sociomaterial approach essentially denies the unquestionably accepted assumption that human and non-human technologies exist as separable entities. Instead, it maintains that human and non-human

¹⁵ For example, an exemplary poetic expression to coordinate protests is as follow: "My lady, how I want to climb this wall of silence ... Maybe we can meet on Yahoo Messenger." (ABC 2011).

technologies exist and evolve through a mutually constitutive relationship. The mutually constitutive relationship between human and non-human technology is not a static notion. Rather it implies that human beings and non-human technologies have their own unique agential capabilities that can act upon but cannot fully control each other. Thus, the non-human technologies as material agents can act upon human beings to shape human actions, and likewise, human agents can act upon non-human technologies to use, manipulate, or evade technologies to their own advantages (Leonardi 2011). Denying the binary opposition between subjective human beings and objective non-human technologies, “the sociomaterial (no hyphen)” approach asserts the “ontological fusion” that human beings and non-human technologies are dynamically shaping each other and its mutually constitutive relations are inseparable in practice (Orlikowski and Scott 2008).

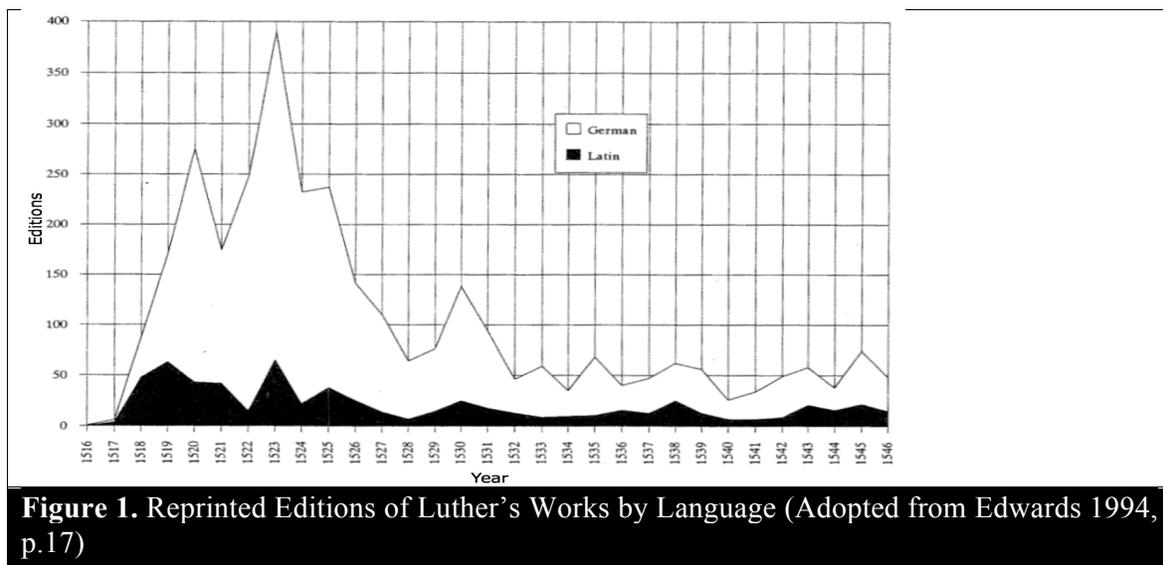
Among different perspectives, this study adopts the sociomaterial approach to explicate the role of social media technologies in social changes. To do that, we focus on elucidating how revolutionary figures emerge and their voices are diffused through the technological feature of retweets in Twitter as an antecedent of revolutionary collective actions. Although we recognize that the Egypt Revolution involved a mass campaign of various social media (e.g., Facebook, YouTube, Flickr, Google Docs, and Blogs etc.) (Ghonim 2012; Howard et al. 2011), we pay special attention to Twitter for the following two reasons. First, as Ghonim (2012) confesses in his memoir, due to the extreme mobility of Twitter being highly compatible with mobile phones, Twitter was the most agile social media service in creating and spreading situational information regarding protests from the ground in close to real time. Second, many local correspondents of mainstream media and individual journalists have tweeted situational news mainly through Twitter and those news tweets have been retweeted by a multitude of Twitter users around the world. Therefore an analysis of Twitter data can show the global dynamics at the intersection of social media technologies, mainstream media, and online users.

3. PRINT TECHNOLOGIES AND SOCIAL CHANGES: BUILDING THE RESEARCH FRAMEWORK

A group of historians studying early modern European society attribute the outbreak of the Reformation (religious revolution) to the printing technology invented in 1439 and its derivative social dynamics (Edwards 1994; Eisenstein 2005). Different from many historians, they deny attributing the Reformation to the innovative interpreter of the Bible, Martin Luther, who posted the ninety-five theses on the wall of the All Saints' Church in Wittenberg in 1517. Instead, they look at the agential capability of print technology, which enabled people to duplicate and disseminate limitless copies of Luther's contentious pamphlets at low cost and with great speed. They mainly analyze the implications of the reprinted quarto format small pamphlets which were easy to mass copy, distribute, hide, and share on the streets, in taverns, and in their daily lives (Edwards 1994, p.15). In this approach, Martin Luther is considered as a subversive writer who provided intellectual fodder for the Reformation rather than an intended revolutionary (Edwards 1994, p.7), and a multitude of medieval people are seen as implicit supporters and disseminators of Luther's ideas by adding their own comments, desires, jokes, satires, or fun illustrations.

In fact, Martin Luther himself expressed puzzlement about the fact that the public read, interpreted, duplicated, and disseminated his theses, because they were written in scholarly Latin language exclusively for academic circles (Eisenstein 2005, p.168). What we can learn from his puzzlement is that Luther himself and his ninety-five theses itself might have been a necessary but not sufficient condition for the Reformation. The simple truth is that an idea itself cannot be revolutionary without gaining large-scale social support from others and having some technologies which can connect the previously disconnected group of people with shared ideas and experiences. In

this regard, the mass-copying print machines were truly revolutionary to holistically explain the Reformation. That is, the printing machines afforded the capability to duplicate Luther's pamphlets at a low cost, kept previously disconnected people connected with similar ideas and experiences, and multiplied and broadcasted the shared ideas and experiences to a much larger and diverse audience with greater speed which was impossible in the preprint age (Edwards 1994; Eisenstein 2005). From this perspective, the print technology is not only considered as a message-transmitting vehicle but as an active message-shaping agent which facilitates secular interpretations of orthodox theology from its users' perspectives, and performs a large-scale sense-making process along with a multitude of people with its capability of production, reproduction, and dissemination.



Apparently, to understand the scale of *connections* of the previously disconnected people and its derivative social dynamics (e.g. the emergence of shared revolutionary ideas), we need to appreciate the material capabilities of printing technologies such as reprinting cost, reprinting speed, scale of potential reach of the reprinted pamphlets, and multiplying revolutionary ideas etc. Indicators of the large-scale connection and expansion of the shared revolutionary ideas can be inferred from statistics on the reprinted volumes of propaganda pamphlets, which Edwards (1994)

succinctly described as “what was new in the Reformation...is the sheer scale of the propaganda effort” (p. 17). For instance, it was reported that, during the first two years of the Reformation, which was sparked when Luther posted the ninety-five theses in 1517, there was more than a 530% increase in the production of small pamphlets (refer to figure 1). From the printing machines in German-speaking lands between 1500 and 1530, approximately 10,000 pamphlet editions were reprinted. Among these, “almost three-quarters appeared between 1520 and 1526, and most were due to the Reformation movement. Martin Luther alone was responsible for approximately 20 percent of the overall total” (Edwards 1994, p.17). Obviously, multiplication and dissemination of small pamphlets implies the inseparably intertwined reality of the social and print technologies. That is, such a rapid reprint and dissemination of small pamphlets was made possible through the print technologies, and, at the same time, the expansion of Luther’s revolutionary ideas and development of collective sense-making cannot be achieved separately from the affordance which was generated by print technologies.

What we can learn from these historians’ study of the religious revolution is their flexible yet practical approach, which does not easily fall into either the human-centric or techno-centric viewpoint. Their research framework does not give privilege either to human intention or printing technologies to describe the emergence of radical social changes. Instead, they zero in on “the dialect between the fixity of print and the fluidity of reception [by pamphlet-message recipients having different backgrounds and ideas],” and the emergence of the attendant sociomaterial dynamics (Edwards 1994, p. 4). Specifically speaking, their view is based on observing the emergence of mass amounts of printed pamphlets, analyzing its sociomaterial implications, and identifying the role of affordance which enabled the inseparably entangled techno-social dynamics. This research framework is similar to what Orlikowski (2007) called “sociomaterial practice” which “take[s] seriously the recursive intertwining of humans and technology” (p. 1437). That means, in the

sociomaterial research method, the fundamental idea is to explicate empirical consequences of inseparably entangled reality of human and technology, but without sacrificing agential capabilities of both non-human technology and human intention (Orlikowski 2005). In that regard, focusing on the sudden *emergence* of a high volume of the Luther's contentious pamphlets is a very practical approach to explore the role of print technologies in radical social changes but without giving privilege either to print technology or human intention.

By exploring the sudden emergence of Luther's contentious pamphlets, historians could explain the inseparably intermingling dynamics of (1) Luther's revolutionary ideas, (2) sociomaterial effects of print technologies connecting previously disconnected groups of people with shared ideas, and (3) the collective power of the newly connected crowd. This approach avoids raising questions like 'what is human?', 'what is machine?', or 'what is human-machine interaction?' in which human and non-human machine are assumed as separate entities. Rather, it takes *emergence* as a form of sociomaterial effects in which drawing a line between human beings and non-human technologies is just artificial or at best analytical instead of being practical.

Following the practical approach of those historians and acknowledging the insight of the sociomaterialist relational ontology, the following sections analyze the tweet and retweet phenomena during the 2011 Egypt Revolution. Analogous to print and reprint phenomena during the Reformation, our goal is to identify if any opinion leader, who is comparable to Luther, emerges by analyzing those whose tweets messages are most frequently retweeted. Thus, we may be able to better understand the role of social media in social changes.

4. FROM PRINT AND REPRINT TO TWEET AND RETWEET

Since the advent of Twitter in 2006, it has received a good deal of attention as a resilient and rapid tool for real time information diffusion in response to social crises such as natural disasters (Vieweg et al., 2010; Li and Rao, 2010; Oh et al. 2010), terrorist attacks (Gupta 2011; Oh et al. 2011), and social movements (Bruns et al. 2009; Lotan et al. 2011; Maghrabi et al. 2011; Mungiu-Pippidi et al. 2009; Starbird et al. 2012). Due to its short message service (SMS) interface, which is highly compatible with mobile phones, Twitter turned out to be extremely mobile and rapid in broadcasting local situational information. In addition, Twitter's tree-like structure, which does not require reciprocal relationships between users, enables very fast information diffusion compared to other social media services (Lerman et al. 2012).

As a practice of relaying others' tweet messages, the retweet feature in Twitter has generated different sociomaterial dynamics in various situations. boyd et al. (2010) describe that retweeting is an expanded way of loose socializing. They maintain that retweeting is not just spreading others' tweets but also a way of participating in a diffuse conversation without the needs of direct participation. Kwak et al. (2010) conceptualize the retweet frequency of certain tweet messages as a measure of "popularity" for the message or its author. Similarly, Suh et al. (2010) suggest that, although retweeting behavior has various motivations (e.g. entertaining a specific audience, commenting on someone's tweet, publicly agreeing with someone, saving tweets for future personal use, etc.), retweeted messages are likely to have additional informational value. Despite the different conceptualizations of retweet, noticeable agreements exist that the retweeted messages or its authors may have more information nuggets than other tweets in that the messages draw attention of other users to read and retweet.

Some empirical studies on retweets support that retweeted messages include high informational values. Suh et al. (2010) report that, in general, tweet messages with URLs and hashtagged keywords are more likely to be retweeted than those that are not, and a strong linear

relationship exists between the number of followers and its retweetability. In a natural disaster context, it has been reported that retweeted messages are more likely to contain situation-related or action-related information than non-retweeted messages (Qu et al. 2010; Vieweg et al. 2010). These findings support that retweeted messages may have more situational and relevant information than non-retweeted ones, and in that regard, the frequency of retweeted messages or its authors can be good proxy measures for informational values or the influence of its authors (Suh et al. 2010). From the sociomaterialist perspective, the collective retweeting phenomena, like the reprinting phenomena during the Reformation, can be somehow recognized as human-machine collaborative sense-making processes to share the situation information and enhance the level of situational awareness as precursory connective behaviors to make social changes.

Drawing on findings from those retweet studies, we use the frequency of retweeted messages as a proxy measure to identify the emergence of influential ideas which are shared and supported by a multitude of connective online users. It parallels the practices of printing and reprinting of Luther's pamphlets through which crowds accept his messages and expand the scale of supporting groups as potential participants in social changes. Obviously, as historians argued, the diffusion of the reprinted pamphlets may involve large scale sense-making as a critical antecedent of upcoming revolution (Edwards 1994; Eisenstein 2005). Therefore, it can be hypothesized that the sociomaterial implications of printing and reprinting can also be found in the patterns of tweeting and retweeting during the 2011 Egypt revolution. However, despite the outward similarity, it is noteworthy to mention that the tweeting and retweeting phenomena during the 2011 Egypt revolution may have different dimensions from that of printing and reprinting in its speed and scale of information diffusion and its attendant sense-making process at the collective level. Also, given that modern society is much more institutionalized and globalized than before (Foucault 1995), the ideas of opinion leaders may take much more diverse forms than during the age of the Reformation.

Therefore, identifying and measuring the *emergence* of the most frequently retweeted users during the Egypt revolution may offer valuable insights to explicate the role of Twitter in radical social changes.

5. BACKGROUND OF THE 2011 EGYPT REVOLUTION

In his book, *Revolution 2.0*, Ghonim (2012) suggests that the eruption of the 2011 Egypt revolution goes back to June 10th, 2010 when he anonymously created a Facebook page, “We Are All Khaled Said”. He made his emotional comment “Today they killed Khaled. If I don’t act for his sake, tomorrow they will kill me” along with a horrifying picture of Khaled Said (Ghonim 2012, p. 60). The purpose of the Facebook page was to publicize the brutality of the Egypt government and its police officers who murdered 28 year-old blogger Khaled Said for the reason that he criticized the Mubarak regime through his blog site. The response for the first post was immediate and more than 36,000 joined the page in a single day (Ghonim 2012, pp. 60-62). Using the Facebook page, Ghonim planned multiple events of the “Silent Stands of Prayer for the Martyr Khaled Said” in major cities in Egypt from June through August in 2010 (Ghonim 2012). Using diverse social media sites, young participants shared and spread pictures and videos of the events including the police’s ruthless treatment of peaceful participants. Over time, the “We Are All Khaled Said” page evolved into a hub to build situational awareness, perform online polls, express solidarity, charge the corrupt Mubarak regime, and coordinate the ensuing street protests.

Stimulated by the serial “Silent Stands” events, and encouraged by the Tunisian Revolution on December 17th, 2010 through which president Ben Ali resigned from his 23 years of dictatorship, Egyptian people planned the first large-scale non-violent civil resistance in Cairo on January 25th, 2011. The purpose was to publicly express their grievances on oppressive emergency law, high

inflation and unemployment rate, corrupt government officials, and, most importantly, to demand that their president of thirty years, Hosni Mubarak, should step down. For this protest, the role of social media technologies was significant in coordinating the ensuing demonstrations. For instance, Ghonim documented and uploaded to Google Docs all information relevant to the January 25th protest which included “the reasons for protesting and for choosing this day and these locations” and “the unified chants [...], phone numbers for activists responsible for supporting arrested protestors, and for redirecting demonstrators to other locations if the protests at any one place were obstructed” (Ghonim 2012, p. 164). The file was accessed by more than 50,000 people and distributed through “online forums, political websites, Facebook, and Twitter” (p. 164). Literally, what is new in the Egypt Revolution was the sheer volume of the social media campaign.

Appalled by the escalating numbers of protesters and the power of social media technologies, the Mubarak regime attempted to respond with rubber bullets, security police forces, pro-Mubarak “thugs,” and a brutal disconnect of Internet and national cellular wireless services. However, despite Mubarak’s persistence to hold his position, resistances of angry protesters had gotten more intense and international pressure increased against the oppressive Mubarak regime. On February 11th, 2011, the vice president announced that Mubarak would delegate power to the Supreme Council of Egyptian Armed Forces to resign his thirty years of presidency. At last, revolutionary protesters celebrated the end of 30 years of dictatorship.

6. RESEARCH METHOD

6.1 Data Collection and Cleaning

We initially collected Twitter data with sufficient extra days before and after the time period of the Egypt revolution ranging from January 25th to February 11th of 2011. Because Twitter does not

allow keyword search for historical data, we chose to collect archival Twitter data by back-tracking each individual user account that might have tweeted surrounding the time period of the Egypt Revolution. Due to the sheer volume of tweet posts and the keyword search constraints, we followed three steps for our data collection strategy: (1) collect Twitter user accounts who might have tweeted surrounding the time period of the Egypt Revolution, (2) track back all those user accounts and retrieve their past tweet messages, and (3) clean out tweet messages that are irrelevant to the Egypt Revolution by using “Egypt” as a filter word.

From January 25th 2011 till February 11th 2011, with the help of four masters’ students, we began Twitter data collection eight times per day, with one hour for each data collection. This data collection process was used to collect sufficient number of Twitter user IDs so that we could track back their entire messages later. Based on our heuristic observation of dominant hash keywords during the Egypt Revolution, we used “Egypt” “#Mubarak,” “#Jan25,” “#Tahrir,” and “#Cairo” as search keywords in the advanced Twitter search engine (<https://twitter.com/#!/search-advanced>).

The “external data sources” feature in Microsoft Excel software was used to retrieve the XML-based RSS feed of Twitter data into an Excel spreadsheet. Through this practice, we collected a total of 50,778 Twitter user accounts from January 25th to February 11th, 2011. Subsequently, we developed and used a Twitter API application to track back and retrieve tweet posts of all those twitter user accounts. A total of 1,915,429 tweets were collected for the 50,778 Twitter user IDs ranging from January 12th to March 10th, 2011. All these tweet data were imported into a Microsoft SQL Server system to perform data cleaning. We used “Egypt,” “#Mubarak,” “#Jan25,” “#Tahrir,” and “#Cairo” as parameters to filter out irrelevant data. Through this filtering process, the sample size was reduced to 343,581 Twitter messages posted by 20,565 distinctive users from January 12th to March 10th, 2011.

As our primary goal of this study is to identify the emergence of frequently retweeted users,

we performed an additional filtering process to extract only retweet data along with its user IDs from the 343,581 tweet data. Although including the “RT @userID” at the beginning of retweeted messages has become the convention of designating retweeted messages, there are still variations in its notation. In some cases, users include “via userID” or add the “RT @userID” at the end or middle of tweet messages (Starbird and Palen 2010). Hence, to extract retweet messages out of entire 343,581 tweet samples, we used two retweet conventions as filtering parameters: (1) “RT @userID” at any place of retweeted messages, and (2) “via userID”. Through this additional filtering process, for our analysis, we secured a total of 133,743 retweet messages from 15,636 distinct user IDs.

6.2 Testing a Power-Law Structure to Identify Influential Voices

As a means to detect the emergence of influential voices in Twitter during the Egypt revolution, we identified those Twitter users whose tweet messages were most frequently retweeted by other Twitter users. Referring back to the example of sociomaterial dynamics surrounding the print technology of the Reformation age, it is conceptually analogous to identifying influential voices such as Martin Luther whose pamphlets were most favored and thus most frequently reprinted and disseminated by the crowd. Barabasi et al.’s (2000) scale-free power-law distribution test is appropriate to statistically examine the emergence of influential voices in the Twitter space. Barabasi et al. (2000) originally demonstrated the existence of power-law distribution in the Web space by showing that a small number of highly popular websites receive extremely large numbers of hyperlinks by other websites and a large number of websites receive a very small number of hyperlinks. This distribution pattern is sometimes called the “preferential attachment tendency” (Barabasi et al. 2000), which leads to a “rich-get-richer mechanism” (Easley et al. 2010, p. 566).

Barabasi et al. (2000) formulate the power-law distribution as follows:

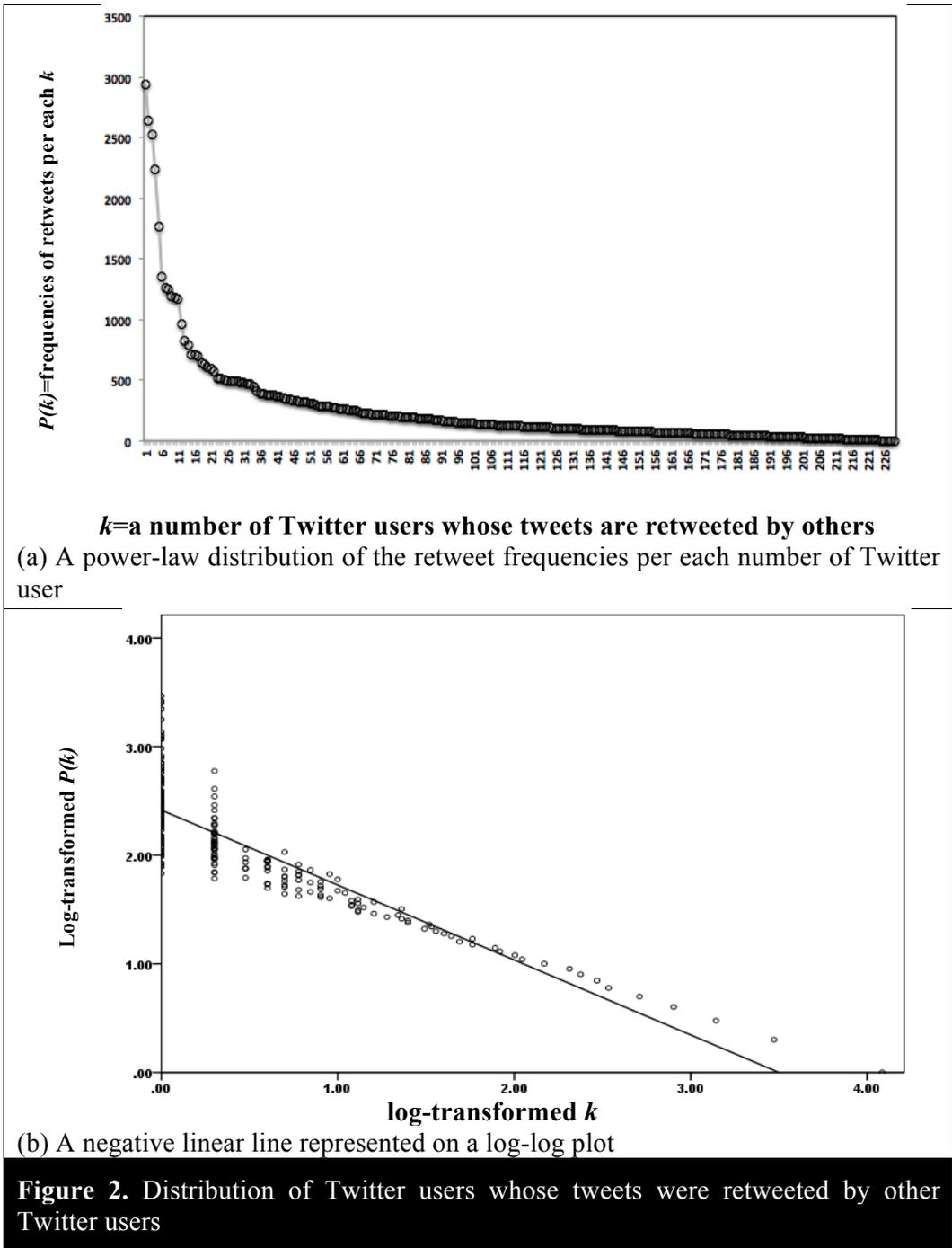
$$P(k) \sim k^{-r}$$

The total number of retweets, $P(k)$, that k number of Twitter users receive in total, follows a power law with exponent $-r$. If the power-law distribution exists in terms of retweets, then the distribution should be represented as a negative linear line when plotted on a log-log scale, which will make the statistical test possible (Moody et al. 2003):

$$P(k) = ak^{-r} \rightarrow \ln P(k) = \ln(a) - r \ln(k) \quad (1)$$

A negative linear relationship is tested between the log-transformed value for the number (k) of individual Twitter users and the log-transformed value for the frequencies of retweets for each individual, k , which is $P(k)$.

Our result indicates that a significant negative linear relationship exists between the k and $P(k)$ with $R^2 = .755, F(1, 227) = 701.229, \beta_1 = -.690$, at $p < .001$. Therefore, it supports the existence of uneven power distribution, suggesting that very few Twitter users' messages were extremely frequently retweeted by a large number of other Twitter users. This means that our data shows that ideas of a few Twitter users were highly attended by extremely large number of Twitter users during the Egypt Revolution. Figure 2 visually represents the uneven power-law distribution. Figure 2(a) and 2(b) visualize that, during the 2011 Egypt revolution, very few powerful Twitter users' tweet messages have been favored by extremely large numbers of other Twitter users while a majority of Twitter users' tweet messages have been minimally retweeted. For example, figure 2(a) shows that, while one Twitter user's tweet messages were retweeted 2,933 times by other Twitter users, 226 users' tweet messages were very marginally or not retweeted by others.



The distribution chart in Figure 3 shows the influence of the top 20 most frequently retweeted users (black colored area) against the total retweeted users (both white and black colored areas). Comparison of the distribution chart in Figure 3 with the reprint distribution chart in Figure 1 offers

insight to recognize similar patterns of sociomaterial dynamics in different communication technologies. However, despite the outward similarity, it is noteworthy to mention that the implications of different scale (Y-axes in Figure 1 and Figure 3) and speed (X-axes in Figure 1 and Figure 3) in information diffusion is not trivial, because it accompanies not only different speed and scale of collective sense-making but different speed and scale in the development of revolutionary social changes.

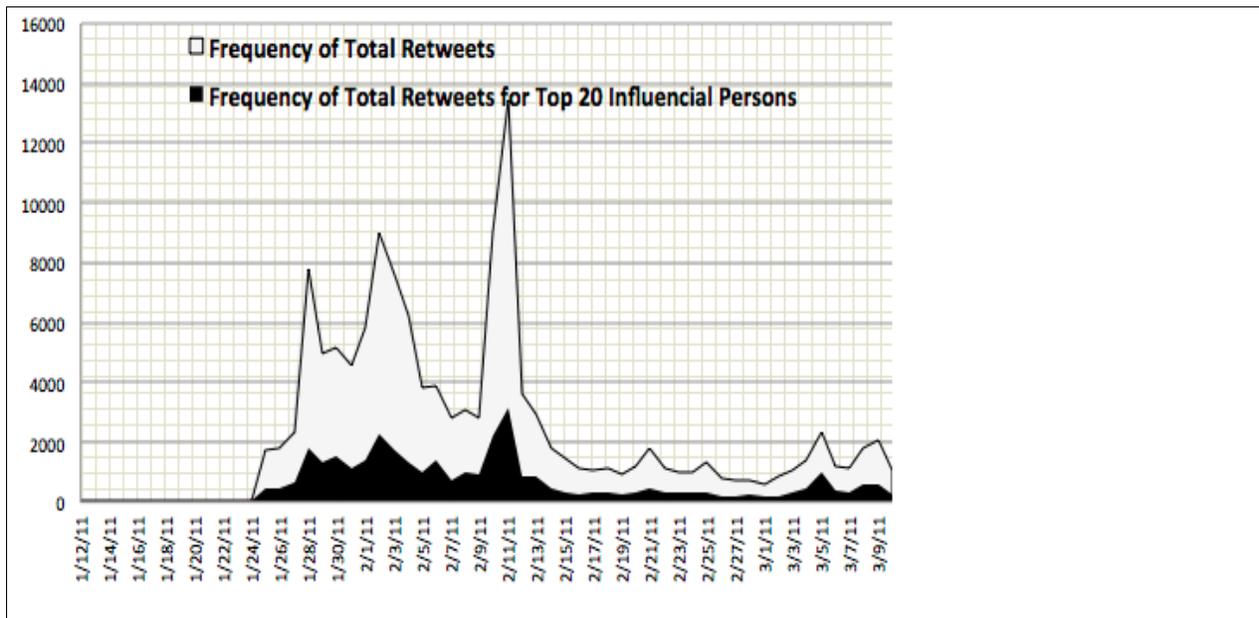


Figure 3. Distribution of Twitter users whose tweets are retweeted by other Twitter users

6.3 Retweet Network: Assembling of Multiple Voices into Connected Ideas

6.3.1 Social Network Analysis

Drawing upon the sociomaterial insights, the previous section showed how print and social media technologies inseparably engage with social actors and how the revolutionary ideas emerge in a form of power-law distribution to make social changes. In this section, to have a closer look inside the space of the power-law distribution, we explore the connective pattern of retweets. In this endeavor, rather than identifying *whose* voices were most influential during the Egypt Revolution,

we focus on explicating the role of Twitter technology that affords to assemble the disconnected multiple voices into connected ideas to make social changes. To do so, this section explores the connected pattern of retweets and the emergence of a handful of dominant voices. It also explicates its sociomaterial implications for social changes.

Our data reflects that, different from the Reformation Age, the contemporary world has become more globalized, specialized, and institutionalized. Therefore, heterogeneous retweets coexist, originating from different countries and diverse entities¹⁶ such as individuals, individual journalists, mainstream media, online journalism, or other organizations/institutions. Therefore, we code user IDs into different categories: individual, professional individual journalist, professional online journalism, mainstream media and other organizations. Definitions of these different entities are presented in Table 1 in the next section.

6.3.2 Data Selection

To explore and visualize the connective pattern of retweeted users, out of a total of 15,636 user IDs that were used for the power-law distribution test, we selected the top 10.3% of user IDs (1,613/15,636) which account for 65.68% of total retweeted messages (87,837/133,743). The selection criterion was made based on user IDs that received at least 10 times of retweet attention from others. We found that, among the selected 1,613 user IDs, 237 Twitter user IDs were suspended after the Egypt revolution. Removing the suspended user IDs, the final sample for analysis comprised of 1,376 user IDs (1,613-237). The reduction of sample size was necessary in order to manage the data with Pajek, a software application for the analysis and visualization of large networks. We believe that the data reduction did not seriously dampen the power of our analysis, due to the power-law distribution pattern among a multitude of Twitter users.

¹⁶ Hereafter, user IDs, users, and entities are used interchangeably for easier reading flow.

6.3.3 Data Coding

Before analyzing the connected pattern of retweets (e.g., who retweeted whose tweet), we coded all Twitter user IDs into one of six different entity categories as presented in Table 1. To code the user IDs, we adopted and modified Kwon et al.'s (2012) coding scheme to our context. To identify the entity type for each user ID, we referred to user profile information from their Twitter pages. If their Twitter pages do not publicize profile information, we read through their tweet messages to make an informed judgment. Note that, although the 'individual journalists' category includes correspondents¹⁷ who work for mainstream media, we did not code them under the category of mainstream media for the following four reasons. First, those correspondents' profiles mostly specify that their tweets are not official news of mainstream media to which they belong¹⁸. Second, they mostly use their personal pictures instead of their company logos in their profile pages. Third, their writing style is very individualistic compared to professional mainstream media where they belong. Lastly, many times, they specify that their retweets do not endorse the retweeted messages¹⁹. It seems that, until correspondents' onsite tweet reports pass through the gatekeeping process by editorial board of mainstream media, they consider their tweets as personal reports (Kwon et al. 2012).

Entity Type	Description	Examples
Individuals	<ul style="list-style-type: none"> • Twitter accounts of individual users. • Does not belong to or is not affiliated with any formal organization. 	Twitter.com/Ghonim Twitter.com/SultanAlQ assemi

¹⁷ For example, twitter.com/BBCKimGhattas, twitter.com/jonjensen, twitter.com/bencnn (Accessed March 5th, 2013).

¹⁸ For example, although the user ID 'zelaky' is a reporter of an Egyptian mainstream news media, *Egypt Today*, his profile page specifies that his tweet messages reflect only his own individual opinion. His profile information (twitter.com/zelaky) reads as follows: "Egyptian journalist... Egypt Today news paper... little news and more opinions... this account expresses my personal opinion." This page is written in Arabic language. The Arabic profile page was translated by an Arabic graduate student. (Accessed March 5th, 2013).

¹⁹ For example, a CNN correspondent BenCNN (twitter.com/bencnn) specifies in his profile that "Article RTs NOT endorsement." Or, a BBC correspondent, Ghattas, (twitter.com/BBCKimGhattas) clarifies that "RT not=endorsement." (Accessed March 5th, 2013).

Individual journalists	<ul style="list-style-type: none"> Identify themselves as professional journalist or correspondent 	twitter.com/bencnn twitter.com/jonjensen
Mainstream Media	<ul style="list-style-type: none"> Newswire, broadcasting, or print mass media. Must have offline presence (e.g. offline-based headquarters or offline edition of newspapers). Should target mass audiences, including a broad range of topics as listed on their websites. 	Twitter.com/cnn Twitter.com/ajenglish
Professional Online Journalism	<ul style="list-style-type: none"> Journalistic writing style yet no offline edition. Have its own independent domain name 	twitter.com/Huffington Post twitter.com/alternet
Organizations or Institutions	<ul style="list-style-type: none"> Any organizational / institutional / community twitter account that was not categorized in any category above. This may represent governmental, corporate, educational, research, or organizational advocacy websites. 	twitter.com/wikileaks twitter.com/meedan
Others	<ul style="list-style-type: none"> Twitter user IDs that do not belong to any of above categories or are not identifiable. 	

For coding, two graduate assistants were employed. Both originated from the Middle East and one was very well versed in the Arab language and culture. Pilot coding was performed with 100 random user IDs to ensure that the coders had a good understanding of the coding rules. We ensured that the randomly selected 100 pilot data did not come from our sample user ID data under analysis. The inter-coder reliability test for the pilot coding was satisfactory, Cohen's Kappa $k=.794, p<.001$ ²⁰. As the pilot coding result confirmed that both coders had a good understanding of the coding rules, they proceeded to separately code actual user ID data. (One coder coded 806 user IDs, the other 807. The suspended 237 user IDs were removed after the coding). The coders were instructed not to code more than an hour per day to avoid coding errors due to fatigue.

²⁰ Landis and Koch (1977) suggest that kappa value .20-.40 is fair, .41-.60 moderate, .61-.80 substantial, and .81-1.00 almost perfect agreement between coders.

7. DATA ANALYSIS

7.1 Characteristics of Frequently Retweeted Users

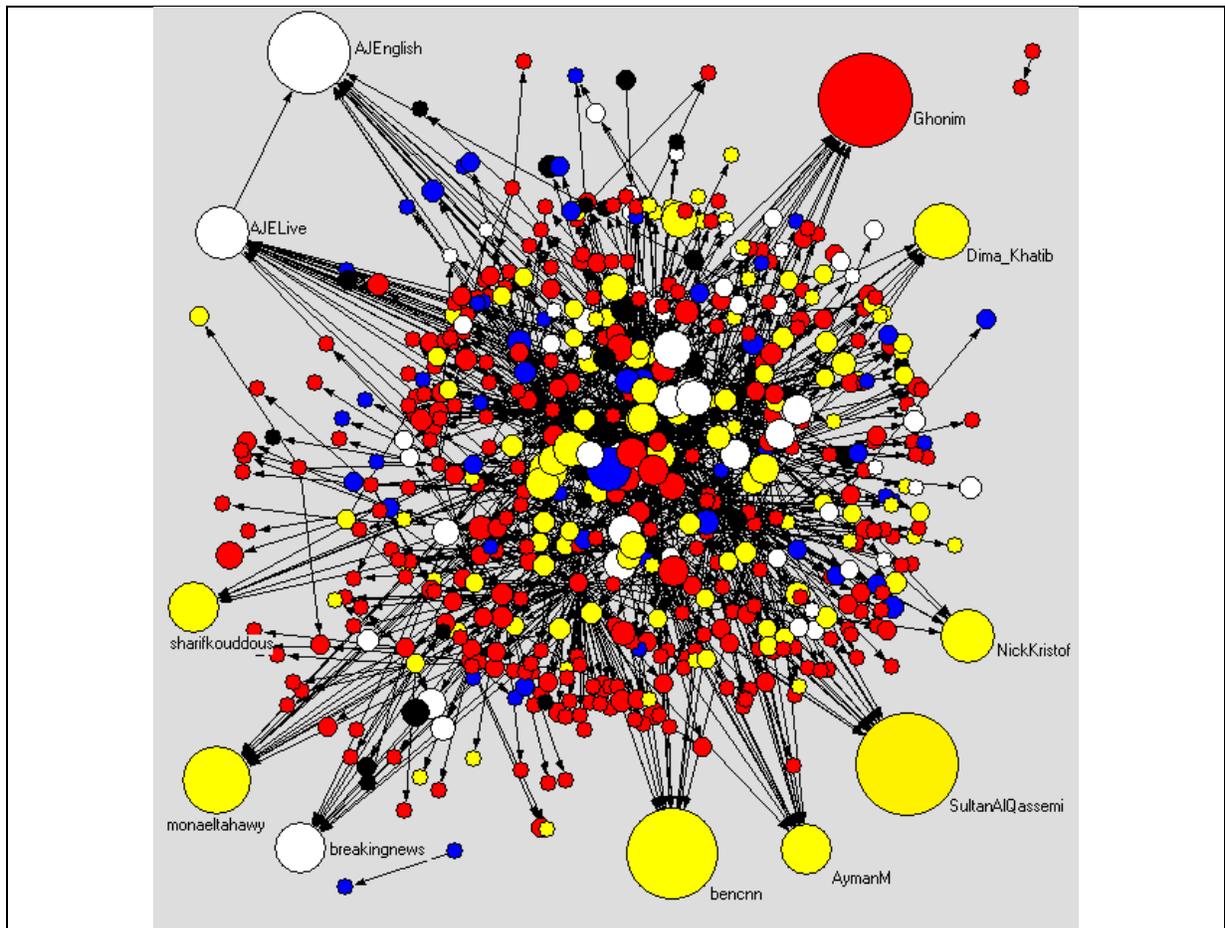
The coding results are summarized in Table 2 and visualized in Figure 4. Table 2 shows (1) population densities of different entities, and (2) the total number of retweet messages that each entity received from others. The third column in Table 2 and number of circles in different colors in Figure 4 depict that the ‘individual’ entity has the densest population (60.83%, red color). The next densest populations are, in decreasing order, individual journalist (19.19, yellow color), other organization (8.87%, blue color), mainstream media (6.61%, white color), and professional online journalism (4.51%, black color).

Table 2. Frequency of user IDs and number of retweets received			
Entity Type	Color code in Figure 4	Population Density for Each Entity	Total Number of Retweets Received
Individuals	Red	837 (60.83%)	30,869 (35.48%)
Individual Journalists	Yellow	264 (19.19%)	32,532 (36.70%)
Other Organizations	Blue	122 (8.87%)	5,675 (6.5%)
Mainstream Media	White	91 (6.61%)	14,973 (17.05%)
Professional Online Journalism	Black	62 (4.51%)	3,788 (4.3%)
Sum		1,376 (100%)	87,837 (100%)

However, considering the existence of a power-law distribution in retweet patterns (Figure 2), the population density shows only a partial picture of the retweet dynamics. A comparison of the third and fourth columns in Table 2 makes this clear. While individual entities (60.9% of total entities) received 35.48% of the total amount of retweet attention from others, individual journalists (19.11% of total entities) received 36.70% of the total number of retweets, and mainstream media (6.61% of total entities) received 17.5% of the total number of retweets.

In Figure 4, the different colors represent the different entities as indicated in the legend. Each circle represents a Twitter user. The size of circle represents the number of retweets that the

Twitter user received from others. That is, the larger the circle, the higher the number of retweets the user received from others. Therefore, the number of circles in different colors can be conceptualized as a population of different entity types in the Twitter universe, while the size of a circle can be interpreted as the level of attention that each user Twitter received from others. Beside the population densities of different entities which are represented as the number of circles of different colors, the different sizes of circles show that, while a very small number of users attracted extremely high number of retweet attentions, many other users remain as supporters for those several dominant user IDs.



* red – individuals; yellow – individual journalists; white – mainstream media; black – professional online journalism; blue – other organizations

Figure 4. Retweet networks during the 2011 Egypt Revolution.

For instance, while the user, ‘@Ghonim’ in the ‘individual entity’ category (represented as a large red circle) attracted very high retweet attention, the other 836 individual users (represented as many small red circles) remain as peripheral supporters. Likewise, in the ‘individual journalist’ category, seven user IDs (represented as big yellow circles such as ‘@SultanAlQassemi,’ ‘@Dima_Khatib,’ ‘@NickKristof,’ ‘@AymanM,’ ‘@bencnn,’ ‘@monaeltahawy,’ and ‘@sharifkouddous’) attract a high amount of retweet attention, but the other 257 individual journalists (represented as small yellow circles) do not. In the ‘mainstream media’ category, three mainstream media (represented as the big white circles of ‘@AJEnglish,’ ‘@AJELive,’ and ‘@BreakingNews’) dominate the amount of retweet attention, while 88 other mainstream media remain as marginal. Lastly, 122 institutional organizations and 62 online journalists can be considered as marginal speakers by failing to attract others’ retweet attention.

Table 3. Number of Retweet frequencies of Top 11 Twitter users

Rank	User IDs	Entity Type (Color code in Fig. 4)	RT frequency (%)
1	SultanAlQassemi	Individual Journalist (yellow)	2,933 (2.19%)
2	Ghonim	Individual (red)	2,636 (1.97%)
3	Bencnn	Individual Journalist (yellow)	2,521 (1.88%)
4	AJEnglish	Mainstream Media (white)	2,236 (1.67%)
5	monaeltahawy	Individual Journalist (yellow)	1,771 (1.32%)
6	Dima Khatib	Individual Journalist (yellow)	1,358 (1.02%)
7	NickKristof	Individual Journalist (yellow)	1,264 (0.95%)
8	AJELive	Mainstream Media (white)	1,247 (0.93%)
9	BreakingNews	Mainstream Media (white)	1,196 (0.89%)
10	sharifkouddous	Individual Journalist (yellow)	1,181 (0.88%)
11	AymanM	Individual Journalist (yellow)	1,167 (0.87%)
Total			19,510 (14.59%)

The amount of retweet attention received by these eleven dominant user IDs is summarized in table 3. Out of the entire retweet sample (133,743 retweets posted by 15,636 Twitter users), the selected top 10.3% (1,613) users account for 65.68% of the total number of retweets (=87,837/133,743) while the selected top 0.07% users (=11/15,636) account for 14.59%

(=19,510/133,743) of the total number of retweets. To paraphrase Table 3, during the 2011 Egypt Revolution, one individual, three mainstream media (two based in Qatar²¹ and one in the U.S.), and seven individual journalists attracted a comparatively extremely large amount of retweet attention, accounting for a total of 14.59% of all retweets. This shows that, compared to the Reformation Age, the types of entities involved have been diversified and the role of institutional organizations (e.g., mainstream media) has become more prominent. Yet, we can still confirm that, similar to the Reformation age, a small number of influential users emerge through retweet support from a large online crowd.

To better understand why the eleven users attracted disproportionately high amount of retweet attention from others, we investigate who they are and what kind of role they played. In case of the user ID @Ghonim, it is not difficult to imagine why his tweets were the second most frequently retweeted. He anonymously created the Facebook page “We Are All Khaled Said” through which he sparked and coordinated multiple street protests and constantly updated the unfolding situation to fuel the subsequent protests. For this Facebook activity, he was arrested by the state security forces of the Egypt regime. Right after he was released from detention, he acknowledged in an interview with an Egyptian TV channel²², that, as an ordinary Google employee, he had been the administrator of the revolutionary Facebook page. Since then, he was recognized as a young techno-savvy revolutionary icon that represented the leaderless Egypt revolution. Given Ghonim’s history as an anonymous administrator of the Facebook page, it is not difficult to infer that the sudden exposure of his identity through TV interviews might have driven Twitter users to follow and retweet his tweet messages.

²¹ In fact, both @AJEnglish and @AJELive are Al Jazeera’s Twitter accounts.

²² Refer to following YouTube Videos on Wael Ghonim’s interview.
<http://www.youtube.com/watch?v=SjimpQPQDuU> (Interview Part I),
http://www.youtube.com/watch?v=yW59LZsjE_g (Interview Part II), and
<http://www.youtube.com/watch?v=V690GO7YzgA> (Interview Part III).

The most frequently retweeted user (@SultanAlQassemi) identifies himself as a freelance columnist living in Dubai, United Arab Emirates (Adams 2011). He disclosed that he was glued to Twitter and the TV screen to translate news on the uprising in Egypt from Arab into English and tweeted to the world once every 45 seconds for three weeks straight without sleeping or eating properly. He emphasized “I don’t put much opinion in my tweets” and stated that he stuck to the “matter-of-fact approach” (Adams 2011).

Represented as yellow circles in Figure 4, the other six individual journalists (including local correspondents dispatched by mainstream media) played a similar role as @SultanAlQassemi. As trained individual journalists, they emphasized their independence from mainstream media and they broadcast close to real-time eyewitness accounts of the unfolding situation with their own personal comments. Beside the one individual (@Ghonim) and seven individual journalists, there were three users IDs that represent mainstream media: @BreakingNews for Breaking News (www.breakingnews.com) and @AJEnglish and @AJELive for Al Jazeera (www.aljazeera.com). Although @BreakingNews is part of the mainstream media (NBC News Digital Network²³), its operation is independent and strategically optimized for Twitter and social media platforms. To achieve its goal of broadcasting reliable breaking news close to real-time, the organization is affiliated with more than 300 news organizations and individual journalists “with a track record of covering breaking news.” They have the infrastructure to exchange reliable real-time news stories through hashtags (#breaking and #breakingnews) and @breakingnews mentions²⁴. Al Jazeera was established in 2006 and is funded by the rulers of Qatar (called the Emirs of Qatar). Al Jazeera has gained a reputation that they are “neither dominated by geopolitical nor commercial interests,” and their strategic goal is geared toward reaching out to “typically ignored audiences” and “cultural ‘others’” (el-Nawawy and Powers 2010, p.61) to give a “voice to the voiceless” (p. 71).

²³ <http://www.breakingnews.com/about/faq> (Retrieved March 9th, 2013).

²⁴ <http://www.breakingnews.com/about/partners> (Retrieved March 9th, 2013).

8. DISCUSSION

Key questions in the context of the 2011 Egypt Revolution include, (1) what are the implications of the power-law distribution in the retweet patterns that are disproportionately skewed toward individual journalists rather than toward individuals, mainstream media, and other institutional organizations? (2) why did online citizens prefer to retweet those seven individual journalists' tweets that others' ones during the 2011 Egypt Revolution? and (3) what is the role of social media in social changes? As Ghonim (2012) raises, was the 2011 Egypt Revolution “truly a spontaneous movement led by nothing other than the wisdom of the crowd” (p. 293)? Or does the power-law distribution in retweets simply represent a variant of repeated web phenomena such as “long-tail vs. superstars” (Brynjolfsson et al. 2010), “group polarization” (Sunstein 2001), Cyber-Balkans (Van Alstyne and Brynjolfsson 2005), or core-periphery (Kane 2011)? We argue that, during the Egypt Revolution, the power-law distribution skewing toward the individual journalists is the reflection of online users' deliberate retweet practices to share *reliable* situational information as *rapidly* as possible to enhance the collective level of situation awareness and expand the boundary of shared meaning on the unfolding uncertain situation. Proponents of social movement theory contend that collective action is highly correlated with collective sense-making processes (Aguirre 1994; McPhail 1991; Turner and Killian 1957). In other words, for a collective action to emerge against a political regime, as instances of a collective sense-making process, a high level of shared meaning and situational awareness has to be established among potential participants. Without having these established, collective action to make social changes either cannot be initiated or is likely to result in failure.

Yet, a successful collective sense-making process comes at a price, because it has to presume the attainment and sharing of *reliable* situational information in a *timely* manner. Despite the collective efforts of making sense of uncertain situations, if the information is not perceived to be reliable and timely, the chance of successful sense-making and collective action is low.

The important role of reliable and timely information in collective sense-making enables us to explain why the individual journalists received the highest retweet attention from online users. We argue that this is because, as professionally trained reporters, those individual journalists (including local correspondents) could tweet onsite situational information much *faster* than mainstream media, and in a much more *reliable* way than amateur Twitter users on the streets. In fact, the crisis literature has constantly reported problems with mainstream news reports in crisis situations. Researchers point out that, in a crisis, mainstream media are slow, highly influenced by institutional policy, or repeatedly focus on sensational scenes (Wenger and Friedman 1986). Therefore, people affected by a crisis quickly realize that mainstream media lack local and timely information that they desperately need for their sense-making and local decision-making (Mills 2009; Shibutani 1966). Therefore, we believe that the collective and deliberate retweeting of individual journalists' situational tweets can be understood as collective efforts in a crisis to overcome two information problems in their collective sense-making process: (1) the slowness of mainstream media and (2) the unreliability of amateur individuals' tweet reports. We argue that, conscious or not, Twitter users' retweeting behaviors in a crisis situation might be driven by a collective motivation to find and share *reliable* information *rapidly* such that they can engage in successful sense-making. This collective motivation could be realized by their deliberate retweeting of individual journalists' onsite situation reports rapidly. In that sense, the collective retweeting behavior can be seen as distributive, large-scale, and real time human-machine collaborative information processing to extract *reliable* and *timely* situational information out of millions of heterogeneous and chaotic real time tweets.

Therefore, we surmise that this rapid and distributed collaborative human-machine information processing could have enabled the real-time collective sense-making at a global scale, and that this was possible through the affordance of social media.

To understand this collective, collaborative, distributed, and rapid sense-making process through retweets, we need a sociomaterial perspective as historians had to understand the role of print technologies in the Reformation. We have to recognize that the social and the technological are already inextricably related and entangled to form our reality in practice (Orlikowski 2007), and, in that sense, borrowing Guattari's (1995) term, our society is already techno-social as a "social machine." As soon as we separate the technological and the social into two distinct identities, it becomes impossible to explain the Arab Spring 2011 in terms of the speed and the scale of information diffusion, collective sense-making, and the rapid spread of the collective movements that cut across multiple national borders in such a short period of time.

Making inferences from our data analysis, we believe that social media services and consumer information and communication devices (e.g., mobile phones equipped with a digital camera, video recorder, web browsers, multimedia messaging service, file exchanger, email, document tools etc.) have been used as powerful and low cost communication tools for crises through which people can collectively process information to detect and share reliable and timely situational information at close to real-time speed. Given that collective sense-making is one of the most important aspects of social movements to change political structures (Turner and Killiam 1957; Shibutani 1966), we believe that this illustrates the critical role and potential of social media during the 2011 Egypt Revolution.

9. CONCLUSION

In recent years, the notion of sociomateriality has gained popularity as a frequently cited, debated, and criticized concept²⁵ among scholars of information systems and organization studies. For this, scholars in the domains of information systems and organization science have responded with empirical studies that mostly follow a qualitative research method (Barrett et al. 2012; Jonsson, et al. 2009; Leonardi 2011; Scott et al. 2010). To the best of our knowledge, this study is the first quantitative study using the sociomaterial perspective. In this respect, we view this study as an interface to introduce the sociomaterial perspective for quantitative empirical IS research.

Our study explains how a technological feature of the Twitter service, the retweet, generates “affordance” (Gibson 1977; Dobson, 2001; Leonardi 2011; Majchrzak and Markus 2013; Markus and Silver 2008) for social changes by enabling connections of previously disconnected groups of people at unprecedented speed, scale, and dynamics. However, our study has a few limitations in explaining the role of social media in social changes. First, among many social media campaigns that might have been mobilized for the Egypt Revolution (such as Facebook, YouTube, and other services), our data source was limited to Twitter and our focus was on a single feature - the retweet. Therefore, we are unsure if the emergence of influential users – as demonstrated by the power-law distribution in retweets – can be repeated in the context of other social media services. Future research may need to investigate if Facebook pages or YouTube video clips might have received skewed attention from others while many other ones did not. We may then gain a more nuanced understanding on the role of retweets compared to other social media technologies.

Another limitation is that, as we only focused on the role of Twitter for social changes during the Egypt Revolution, we do not know the relative impact of offline activities. That means, this study

²⁵ For debates on agential realism and critical realism as philosophical foundations of sociomateriality, refer to Leonardi (2013), Mutch (2013), and Scott and Orlikowski (2013). For a criticism for the creation of new “academic jargon,” sociomateriality, refer to Sutton (2010). For a comprehensive review on and application of sociomateriality for interdisciplinary research, refer to Leonardi et al. (2012).

could not show how important the role of social media was for the Egypt Revolution in comparison to other offline activities that might have existed. For this question, we could have at best surmised that the speed and scale of the Egypt Revolution and the other Arab Spring movements were unprecedented in human history, and, therefore, we argue that the dimensions of speed and scale demonstrated in the Arab Spring cannot be understood without taking into account the connective powers of digital technologies.

To summarize, drawing on historians' flexible yet practical research framework on the role of print technology in the Reformation, this study analyzed the sociomaterial implications of social media technologies, information diffusion, collective sense-making, and radical social changes. Avoiding human-centrism and techno-centrism, we took the perspective of an inseparably intermingled reality view of humans and technologies and their attendant sociomaterial dynamics in the context of the Reformation and the Egypt revolution. We argued that an idea or individual himself is not revolutionary unless his ideas are connected and diffused (either through reprint or retweet) through large-scale social support from a multitude of crowds. In this regard, the innovation is the use of social media technology, which affords to connect previously disconnected groups of people with shared ideas at an unprecedented speed, scale, and by way of techno-social reconfigurations. Therefore, when we view Figure 4, it may be tempting to just focus on who are the influential users – on the surface they are the ones who correspond to the big circles – in the networked space. However, the more important issue is to recognize how those few influential entities emerged from a large number of *connected* small crowds (represented as a multitude of small circles), where the connections are digital enabling crowds to interconnect at a distance with real time speed. If we simply ask questions like ‘who are those big circles or influential users?’ then we are likely to fall into the trap of human centrism, from which we can have only a limited explanatory power to understand the Egypt Revolution. Instead, the sociomaterial questioning allows us to better

understand the dynamics of “Revolution 2.0,” “a spontaneous movement led by nothing other than the wisdom of the crowd” (Ghonim 2012, p. 293). It allows us to better understand how the use of social media enabled collective sensemaking that gave shape to a leaderless revolution which in eighteen days achieved “what was impossible for years” (p. 292).

CONCLUDING REMARKS

This dissertation explored the role of Twitter under various social crisis situations that involve a high level of situational uncertainties and collective anxiety. With the case of the 2008 Mumbai Terrorist Attack and using Situation Awareness theory, the first essay showed the negative effects of online users’ situation reporting through Twitter. It argued that (1) the collective situation reporting can be adversely monitored by terrorist groups to make opportunistic decisions in the volatile external situation, and (2) it can help terrorist groups in mounting precisely calculated attacks to achieve their political goals. Based on the content analysis and its findings, a conceptual framework for information control was suggested to deter or delay the terrorist groups’ decision-making process.

The second essay investigated the information quality issue under three different social crisis situations of the Mumbai Terrorist Attack in 2008, the Toyota Recall in 2010, and the Seattle Café Shooting Incident in 2012. By synthesizing the literature on extreme events and Rumor Theory, the rumor phenomenon of a crisis situation has been conceptualized as citizens’ collective efforts to make sense of, cope with, and adapt to an uncertain crisis situation. For this study, I argued that, in the age of social web technologies, the traditional rumor phenomenon has been repeated as collective crisis reporting (such as tweeting, retweeting, situation update in Facebook, and Wiki etc.) in the social media space under various crisis situations. With this conceptualization, this essay analyzed

Twitter data of those three incidents, and found three important rumor causing factors (source ambiguity, personal involvement, and anxiety). In conclusion, based on the findings, I submitted intervention strategies to reduce and/or refute false rumor generation such that online citizens and emergency responders can better respond to a social crisis situation with high quality social information.

With the case of the 2011 Egypt Revolution, the third essay investigated the role of social media in radical social changes. Special attention was paid to the facts that the moving speed and scale of the Egypt Revolution was unprecedented in human history, and it cannot be easily explained without considering the role of social media technologies that enable rapid connections of previously disconnected groups of people at a distance with shared political issues. Following the historians' approach on the role of print technology during the Reformation in the early 16th century, the essay investigated how the retweet feature of Twitter enabled online citizens to maintain a high level of situation awareness during the volatile situation of the Egypt Revolution. By analyzing the retweet patterns of Twitter data, I found that, among others, individual journalists' tweet messages received the highest level of retweet attention from other Twitter users, because they could broadcast *reliable* situation information in a *rapid* speed from the location of the protest sites. In conclusion, I argued that, during the 2011 Egypt Revolution, the retweet feature of Twitter was a powerful mechanism that facilitates a collective sense-making process among a heterogeneous group of online citizens, which is a critical antecedent to anticipate the imminence of radical social changes.

Riding the waves of social web technologies, media pundits have portrayed rosy pictures about the potential of social media and connective online citizens in solving various organizational and social problems. A few buzzwords – crowdsourcing, collective intelligence, participatory problem solving, citizen-centric innovation etc. – manifest upbeat expectations about the promises of social technologies. However, less attention has been paid to the downside of social media and its attendant issue of information quality, especially in the context of social crises. In that regard, this

dissertation built a foundation to pursue lines of research on information quality and collective sense-making in the context of social technologies and social crises. Given that perceived trust in online information is a critical factor for information systems success (DeLone and McLean 2003) and trustful e-commerce (Gefen et al. 2008), it is expected that exploring the conditions for producing quality social information will offer valuable insights to facilitate the collective sense-making process at the social level, and to solve various social crisis problems in partnership with online citizens

Obviously, this dissertation has limitations. As this dissertation focused solely on Twitter, it is dubious if the findings of this dissertation are generalizable to other social media services such as Facebook, Wikipedia, YouTube etc. Therefore, to expand the generalizability of this dissertation, the measurement methods and theories (such as Situation Awareness theory in the first essay, the rumor model in the second essay, and the power law distribution test in the third essay) need to be replicated and refined to other types of social media services, communication devices (e.g., laptop versus mobile phones etc.), and contexts of crisis incidents. By doing that, not only can we better understand the techno-social crisis behavior at the collective level, but also we are more able to collaborate with online citizens to solve unexpected social crisis problems.

REFERENCES

- ABC. 2011. "Libya: Romancing a Revolution," <http://abcnews.go.com/WNT/video/libya-romancing-revolution-dating-site-revolts-protectors-organize-12994859>. Accessed March 31, 2013.
- Aguirre, B.E. 1994. "Collective Behavior and Social Movement Theory." In R.R. Dynes and K.J. Tierney (Eds.) *Disasters, Collective Behavior, and Social Organization*, Newark, DE: University of Delaware, pp. 257-272.
- Alberts, D.S., Garstka, J.J. ad Stein, F.P. 1999. *Network Centric Warfare: Developing and Leveraging Information Superiority*, CCRP Publication Series.
- Allen, K. and Sturcke, J. 2010. "Timeline: Toyota's Recall Woes," *The Guardian*, February 23rd, <http://www.guardian.co.uk/business/2010/jan/29/timeline-toyota-recall-accelerator-pedal>. Accessed September 17th, 2012.
- Allport, G.W., and Postman, L. 1947. *The Psychology of Rumor*, New York: Henry Holt and Company.
- Anderson, A. 2003. "Risk, Terrorism, and the Internet," *Knowledge, Technology, & Policy*, (16:2), pp. 24-33.
- Anthony, S. 1973. "Anxiety and Rumor," *The Journal of Social Psychology* (89), pp. 91-98.
- Ariely, G. 2008. "Chapter II: Knowledge Mangement, Terrorism, and Cyber Terrorism," *Cyber Warfare and Cyber Terrorism*, eds. L.J. Janczewsk and A.M. Colarik, New York: Yurchak Printing Inc., pp. 7-25.
- Barabasi, A. L., Albert, R., Jeong, H., & Bianconi, G. 2000. "Power-law Distribution of the World Wide Web," *Science*, (287), pp, 2115a-2115bb.
- Barad, K. 2003. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs* (28:3), pp. 801-831.
- Barrett, M., Oborn, E., Orlikowski, W.J., and Yates, J. 2012. "Reconfiguring Boundary Relations: Robotic Innovations in Pharmacy Work," *Organization Science* (23:5), pp. 1448-1466.
- Berinato S. 2011. "You Have to Lead from Everywhere: An Interview with Admiral Thad Allen, USCG (Ret.)," *Harvard Business Review*, November, pp. 1-4.
- Bharosa, N., Janssen, M., Rao, H.R., and Lee, J. 2008. "Adaptive Information Orchestration: Architectural Principles Improving Information Quality," in *Proceedings of the 5th International ISCRAM Conference*, Washington, DC, pp. 556-565.
- Bharosa, N., Lee, J., and Janssen, M. 2010. "Challenges and Obstacles in Sharing and Coordinating Information during Multi-Agency Disaster Response: Propositions from Field Exercises," *Information Systems Frontiers* (12:1), pp. 49-65.
- Bhaskar, R. 1979. *The Possibility of Naturalism*. Harvester: Hemel Hempstead, UK.
- Bordia, P. 1996. "Rumor Interaction Patterns on Computer-Mediated Communication Networks," Ph.D Dissertation, Psychology Department, The Temple University.
- Bordia, P., and DiFonzo, N. 1999. "Rumor as Group Problem Solving: Development Patterns in Informal Computer-Mediated Groups," *Small Research Group* (30:8), pp. 8-28.
- Bordia, P., and DiFonzo, N. 2004. "Problem Solving in Social Interactions on the Internet: Rumor as Social Cognition," *Social Psychology Quarterly* (67:1), pp. 33-49.
- Boyd, D., Golder, S., and Lotan, G. 2010. "Tweet, Tweet, Retweet: Conversational

- Aspects of Retweeting on Twitter,” In *Proceedings of HICSS*. Kauai, HI, January 6.
- Bruns, A., and Eltham, B. 2009. “Twitter Free Iran: An Evaluation of Twitter’s Role in Public Diplomacy and Information Operations in Iran’s 2009 Election Crisis,” in *Communication Policy & Research Forum 2009*, November 19th-20th, University of Technology, Sydney.
- Brynjolfsson, E., Hu, Y., and Smith, M.D. 2010. “Long Tails vs. Superstars: The Effect of Information Technology on Product Variety and Sales Concentration Patterns,” *Information Systems Research* (21:4), pp. 736-747.
- Buckner, H.T. 1965. “A Theory of Rumor Transmission,” *The Public Opinion Quarterly* (29:1), pp. 54-70.
- Chakraborty, R., Agrawal, M., and Rao, H.R. 2010. “An Exploratory Study of Information Processing Under Stress: The Case of Mumbai Police Control and First Responders during Terrorist Attacks of November 26, 2008,” Pre-ICIS ISGSEC Workshop on Information Security and Proviacy, St. Louis, Missouri, December 12th, 2010.
- CBS. 2011. “Wael Ghonim’s 60 Minutes Interview: Egypt’s New Age Revolution,” <http://www.youtube.com/watch?v=2KGSVxg3KaE>. Accessed March 31 2013.
- CNN. 2011a. “CNN: Egyptian Activist, Wael Ghonim ‘Facebook to Thank for Freedom,’” http://www.youtube.com/watch?v=JS4-d_Edius. Accessed March 31 2013.
- CNN. 2011b “In the Arena: CNN-Wael Ghonim: ‘No Longer’ Time to Be Negotiated,” <http://www.youtube.com/watch?v=WkrBPL84eGk>. Accessed March 31, 2013.
- CNN. 2012. “Police: ‘Hero’ Saved Several Seattle Café Patrons as Gunman Opened Fire,” May 31st. http://articles.cnn.com/2012-05-31/us/us_washington-cafe-shooting_1_police-chief-jim-pugel-shooting-gunman?_s=PM:US. Accessed September 17th, 2012.
- Collins, H.M. 2001. “Tacit Knowledge, Trust and the Q of Sapphire,” *Social Studies of Science* (31:1), pp. 71-85.
- DeLone, W. and McLean E.R. 2003. “The DeLone and McLean Model of Information Systems Success: A Ten-Year Update,” *Journal of Management Information Systems* (19:4), pp.9-30.
- Denning, D.E. 2009. "Chapter 10: Terror's Web: How the Internet is Transforming Terrorism," *Handbook on Internet Crime*, eds. Y. Jewkes and M. Year, Willan Publishing.
- DiFonzo, N., and Bordia, P. 2007. "Rumor Transmission," in: *Encyclopedia of Social Psychology*, R.F. Baumeister and K.D. Vohs (eds.), Thousand Oaks, CA: Sage.
- Durbin, J. and Watson, G.S. 1951. “Testing for Serial Correlation in Least Squares Regression. II,” *Biometrika Trust* (38:1), pp.159-177.
- Easley, D. and Kleinberg, J. 2010. *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*. New York, NY: Cambridge University Press.
- Edwards, M.U. 1994. *Printing, Propaganda, and Martin Luther*, Los Angeles, CA: University of California Press.
- Eisenstein, E.L. 2005. *The Printing Revolution in Early Modern Europe*, New York, NY: Cambridge University Press.
- Endsley(a), M.R. 1995. "Toward a Theory of Situation Awareness in Dynamic Systems," *Human Factors* (37:1), pp. 32-64.

- Endsley(b), M.R. 1995. "Measurement of situation awareness in dynamic systems," *Human Factors* (37:1), pp. 65-84.
- Festinger, L. 1962. *A Theory of Cognitive Dissonance*, Stanford, CA: Stanford University Press.
- Field, A. 2005. *Discovering Statistics Using SPSS*, London, UK: SAGE Publications.
- Foucault, M. 1995. *Discipline & Punish: The Birth of the Prison*, 2nd Ed. New York, NY: Vintage.
- Gabarain, C. 2008. "Twitter and the Sichuan earthquake: proving its value?"
<http://eapblog.worldbank.org/content/twitter-and-the-sichuan-earthquake-proving-its-value>
 (Accessed Nov. 15th, 2009).
- Gahran, A. 2008. "Tracking a Rumor: Indian Government, Twitter, and Common Sense,"
<http://www.contentious.com/2008/11/27/tracking-a-rumor-indian-government-twitter-and-common-sens/>
 (Accessed June 6th, 2010).
- Garrett, R.K. 2011. "Troubling Consequences of Online Political Rumoring," *Human Communication Research* (37), pp. 255-274.
- Gartner, 2010. "Gartner Reveals Five Social Software Predictions for 2010 and Beyond,"
<http://www.gartner.com/it/page.jsp?id=1293114> (Accessed June 6th, 2010).
- Gefen, D., Benbasat, I., and Pavlou, P.A. 2008. "A Research Agenda for Turst in Online Environment," *Journal of Management Information Systems* (24:4), pp. 275-286.
- Ghonim, W. 2012. *Revolution 2.0: The Power of the People is Greater Than the People in Power: A Memoire*, Boston, New York: Houghton Mifflin Harcourt.
- Gibson, J.J. 1977. "A Theory of Affordance," in R. Shaw and J. Bransford (Eds.)
Perceiving, Acting and Knowing: Toward an Ecological Psychology, Hillside, NJ: Lawrence Erlbaum Associates, Inc., pp. 67-82.
- Gladwell, M. 2011. "Does Egypt Need Twitter?" *The New Yorker*,
<http://www.newyorker.com/online/blogs/newsdesk/2011/02/does-egypt-need-twitter.html#ixzz1CqneJJOu>. Accessed March 31, 2013.
- Goes, P. 2013. "Editor's Comments," *MIS Quarterly* (37:1), pp. iii-vii.
- Guattari, F. 1995. *Chaosmosis: An Ethico-Aesthetic Paradigm*. Trans. By P. Bains and J. Pefains. Bloomington & Indianapolis, IN: Indiana University Press.
- Gupta, A., and Kumaraguru, P. 2011. "Twitter Explodes with Activity in Mumbai Blast! A Lifeline or an Unmonitored Daemon in the Lurking?," IIIT, Deli, Technical Report.
http://precog.iiitd.edu.in/psosm_www2012/a2-gupta.pdf. Accessed April 8, 2013.
- Haeni, R.E. 1997. "Information Warfare - an Introduction," The George Washington University Cyberspace Policy Institute, January, pp. 1-16.
- Hallin, D. 1993. "The Uncensored War," *Peace Review*, (51:1), pp.51-57.
- Howard, P.N., Duffy, A., Freelon, D., Hussain, M., Mari, W., and Mazaid, M. 2011. "Opening Closed Regimes: What Was the Role of Social Media During the Arab Sprint?," Project on Information Technology & Political Islam, Working Paper, University of Washington.
- Hutchinson, W. 2006. "Information warfare and deception," *Informing Science* (9), pp.213-223.
- Indian Ministry of External Affairs. 2009. "Mumbai Terror Attack: Dossier of Evidence,"
<http://www.investigativeproject.org/documents/misc/277.pdf>. Accessed September 16th, 2012.
- Janssen, M., Lee, J., Bharosa, N., and Cresswell, A. 2010. "Advances in Multi-Agency Disaster Management: Key Elements in Disaster Research," *Information Systems Frontiers* (12:1), pp. 1-7.

- Jenvald, J., Morin, M., and Kincaid, J.P. 2001. "A Framework for Web-based Dissemination of Models and Lessons Learned from Emergency-Response Exercises and Operations," *International Journal of Emergency Management* (1:1), pp. 82-94.
- Johnson, G. 2012. "Seattle Gunman Kills 5, Injures 1 Before Shooting Self to Death," *Huffington Post*, May 31st. http://www.huffingtonpost.com/2012/05/30/seattle-shootings-leave-4_n_1556911.html. Accessed September 16th, 2012.
- Jonsson, K., Holmström, J., and Lyytinen, K. 2009. "Turn to the Material: Remote Diagnostics Systems and New Forms of Boundary Spanning," *Information and Organizations* (10), pp. 233-252.
- Kallinikos, J., Aaltonen, A., and Marton, A. 2013. "The Ambivalent Ontology of Digital Artifacts," *MIS Quarterly* (37:2), pp. 357-370.
- Kane, G.C. 2011. "A Multimethod Study of Information Quality in Wiki Collaboration," *ACM Transactions on Management Information Systems* (2:1), pp.1-16.
- Kapferer, J.-N. 1990. *Rumors: Uses, Interpretations, and Images*, New Brunswick, NJ: Transaction Publishers.
- Kazman, R., and Chen, H.M. (2009). "The Metropolis Model: A New Logic for Development of Crowd-Sourced Systems," *Communications of the ACM* (52:7), pp. 78-84.
- Kendra, J.M., and Wachtendorg, T. 2003. "Elements of Resilience After the World Trade Center Disaster: Reconstituting New York City's Emergency Operation Centre," *Disasters* (27:1), pp. 37-53.
- Khetan, A. 2009. "60 Dark Hours at Hotel Taj," in *26/11 Mumbai Attacked*, H. Baweja (ed.), New Delhi: Roli Books, pp. 46-83.
- Kievit, R. 2008. "Twitter messages feed major news channels," <http://static.rnw.nl/migratie/www.radionetherlands.nl/features/media/081128-twitter-redirected> (Accessed Nov. 9th, 2009).
- Kishore, R., Agrawal, M., and Rao, H.R. 2004-5. "Determinants of sourcing during technology growth and maturity: An empirical study of e-commerce sourcing," *Journal of Management Information Systems* (21:3), pp. 47-82.
- Knapp, R.H. 1944. "A Psychology of Rumor," *Public Online Quarterly* (8), pp. 22-27.
- Knopf, T.A. 1975. *Rumor, Race and Riots*, New Brunswick, NJ: Transaction Books.
- Kravets, D. 2011. "What's Fueling Mideast Protests? It's More Than Twitter," *Wired*, <http://www.wired.com/dangerroom/2011/01/social-media-oppression/>. Accessed March 31, 2013.
- Krippendorff, K. 1980. *Content analysis: An introduction to its methodology*, CA: Sage.
- Kwak, H., Lee, C., Park, H., and Moon, S. 2010. "What is Twitter, a Social Network or a News Media?," In Proceedings of International WWW Conference, Raleigh, NC., pp.591-600.
- Kwon, K.H., Oh, O., Agrawal, M., and Rao, H.R. 2012. "Audience Gatekeeping in the Twitter Service: An Investigation of Tweets about the 2009 Gaza Conflict," *Transactions on Human-Computer Interaction* (4:4), pp. 212-229.
- Landis, J.R., and Koch, G.G. 1977. "The Measurement of Observer Agreement for Categorical Data," *Biometrics* (33), pp.159-174.
- Larson-Hall, J. 2010. "Chapter 4: Changing the Way We Do Statistics: Hypothesis Testing, Power, Effect Size, and Other Misunderstood Issues," *A Guide to Doing Statistics*

- Research Using SPSS*. New York, NY: Routledge, pp. 96-125.
- Leberecht, T. 2010. "Twitter Grows Up in Aftermath of Haiti Earthquake," *CNET News*, January 19 (http://news.cnet.com/8301-13641_3-10436435-44.html).
- Lee, W.E. 2002. "'Security Review' and the First Amendment," *Harvard Journal of Law & Public Policy*, (25:2), pp.743-763.
- Lenhart, A., and Fox, S. 2009. "Pew internet project data memo regarding Twitter and status updating," Pew/Internet.
- Leonardi, P. 2009. "Crossing the Implementation Line: The Mutual Constitution of Technology and Organizing Across Development and Use Activities," *Communication Theory* (19), pp. 278-310.
- Leonardi, P. 2010. "Digital Materiality? How Artifacts Without Matter, Matter," *First Monday* (15:6), June 7. <http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/3036/2567>
Accessed April 8, 2013.
- Leonardi, P. 2011. "When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies," *MIS Quarterly* (35:1), pp. 147-167.
- Leonardi, P. 2013. "Theoretical Foundation for the Study of Sociomateriality," *Information and Organization* (23), pp.59-76.
- Leonardi, P. and Barley, S.R. 2008. "Materiality and Change: Challenges to Building Better Theory about Technology and Organization," *Information and Organization* (18), pp.159-176.
- Leonardi, P.M., Nardi, B.A., and Kallinikos, J. (Eds). 2012. *Materiality and Organizing: Social Interaction in a Technological World*. Oxford University Press: Oxford, UK.
- Lerman, K., Ghosh, R., and Surachawala, T. 2012. "Social Contagion: An Empirical Study of Information Spread on Digg and Twitter Follower Graphs," <http://arxiv.org/abs/1202.3162>. Accessed April 8, 2012.
- Li, J., and Rao, H.R. 2010. "Twitter as a Rapid Response News Service: An Exploration in the Context of the 2008 China Earthquake," *Electronic Journal of Information Systems in Developing Countries* (42), pp. 1-22.
- Lotan, G., Graeff, E., Ananny, M., Gaffney, D., Pearce, I., and Boyd, D. 2011. "The Revolutions Were Tweeted: Information Flows During the 2011 Tunisian and Egyptian Revolutions," *International Journal of Communications* (5), pp. 1375-1405.
- Majchrzak, A., Jarvenpaa, S.L., and Hollingshead, A.B. 2007. "Coordinating Expertise Among Emergent Groups Responding to Disasters," *Organization Science* (18:1), pp, 147-161.
- Majchrzak, A., and Markus, M.L. 2013. "Technology Affordance and Constraints Theory (of MIS)," in *Encyclopedia of Management Theory*, E.H. Kessler (ed.), Thousand Oaks, CA: Sage Publications. Available at SSRN: <http://ssrn.com/abstract=2192196>. Accessed April 8, 2013.
- Markus, M.L., and Silver, M.S. 2008. "A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Feature and Spirit," *Journal of Association for Information Systems* (9:10), pp.609-632.
- McAfee, A.P. 2006. "Enterprise 2.0: The dawn of emergent collaboration," *MIT Sloan Management*, Spring, pp. 20-28.

- McNerthney, C. 2012. "Shooting Suspect Visited Bar Before; Gave Off a 'Bad Vibe'," *Seattle PI*, May 31st. <http://www.seattlepi.com/local/article/Seattle-shooting-two-killed-three-wounded-3595992.php#ixzz1wTdZntvJ>. Accessed September 17th, 2012.
- McPhail, C. 1991. "Challenging the Myth: Sherif, Turner and Killian," in *The Myth of the Madding Crowd*, New York: Walter de Gruyter Inc., pp.61-103.
- Meindl, J.R., Ehrlich, S.B., and Dukerich, J.M. 1985. "The romance of leadership," *Administrative Science Quarterly* (30:1), pp. 78-102.
- Metaxas, P.T., and Mustafaraj, E. 2010. "From Obscurity to Prominence in Minutes: Political Speech and Real-Time Search," in *Proceedings of the WebSci 10: Extending the Frontiers of Society On-Line*, Raleigh, NC, April 26-27.
- Mileti, D.S., and Darlington, J.D. 1997. "The Role of Searching in Shaping Reactions to Earthquake Risk Information," *Social Problems* (44:1), pp. 89-103.
- Mills, A., Chen, R., Lee, J., and Rao, H.R. 2009. "Web 2.0 emergency applications: How useful can Twitter be," *Journal of Information Privacy and Security* (5:3), pp.3-26.
- Moore, D.W. 2009. "Twenty-First Century Embedded Journalists: Lawful Target?," *The Army Lawyer*, eds. A.M. Tulud, A.B. Ching, and C.J. Strong, Department of Army, pp.1-32.
- Mungiu-Pippidi, A., and Munteanu, I. 2009. "Moldova's 'Twitter Revolution'," *Journal of Democracy* (20:3), pp.136-142.
- Murray, M.P. 2005. *Econometrics: A Modern Introduction*, 1st Edition, New Jersey: Prentice Hall.
- Mutch, A. 2013. "Sociomateriality – A Wrong Turning?," *Information and Organization* (23), pp.28-40.
- Nusca, A. 2009. "Twitter's active users grow 900% in one year," <http://blogs.zdnet.com/BTL/?p=12919> (Accessed Nov. 10th, 2009).
- Oh, O., Agrawal, M., and Rao, H.R. 2011 "Information Control and Terrorism: Tracking the Mumbai Terrorist Attack through Twitter," *Information Systems Frontier* (13), pp.33-44.
- Oh, O., Kwon, K.H., and Rao, H.R. 2010. "An Exploration of Social Media in Extreme Events: Rumor Theory and Twitter during the Haiti Earthquake 2010," International Conference on Information Systems, MI, Saint Louis.
- Orlikowski, W.J. 2007. "Sociomaterial Practices: Exploring Technology at Work," *Organization Science* (28), pp. 1435-1448.
- Orlikowski, W.J. and Scott S.V. 2008. "Sociomateriality: Challenging the Separation of Technology, Work and Organization," *The Academy of Management Annals* (2:1), pp. 433-474.
- Palen, L., Anderson, K.M., Mark, G., Martin, J., Sicker, D., Palmer, M., and Grunwald, D. 2010. "A Vision for Technology-Mediated Support for Public Participation & Assistance in Mass Emergencies & Disasters," in *Proceedings of ACM-BCS Visions of Computer Science 2010*, The University of Edinburgh, UK, April 14-16, pp.1-12.
- Palen, L., Vieweg, S., Liu, S.B., and Hughes, A.L. 2009. "Crisis in a Networked World Features of Computer-Mediated Communication in the April 16, 2007, Virginia Tech Event," *Social Science Computer Review* (27:5), pp. 1-14.
- Prasad, J. 1935. "The Psychology of Rumor: A Study Relating to the Great Indian Earthquake of 1934," *British Journal of Psychology* (41), pp. 129-144.

- Prasad, J. 1950. "A Comparative Study of Rumours and Reports in Different Earthquakes," *British Journal of Psychology* (41:129-144).
- Qin, J., Zhou, Y., Reid, E. Lai, G. and Chen, H. 2007. "Analyzing Terror Campaigns on the Internet: Technical Sophistication, Content Richness, and Web Interactivity," *International Journal of Human-Computer Studies*, (65), pp. 71-84.
- Quarantelli, E.L., and Wenger, D. 1989. "A Cross-Societal Comparison of Disaster News Reporting in Japan and the United States," Preliminary Paper #142, Disaster Research Center, University of Delaware.
- Qu, Y., Huang, C., Zhang, P., and Zhang, J. 2011. "Microblogging After a Major Disaster in China: A Case Study of the 2010 Yushu Earthquake," In *Proceedings of CSCW*, Hangzhou, China, pp.25-34.
- Rajesh, B., Hoyt, T., Hussain, R., and Mandal, S. 2009. *The 2008 Mumbai Terrorist Attacks: Strategic Fallout*. RSIS Monograph Series No. 17, Singapore: S. Rajaratnam School of International Studies, Nanyang Technological University.
- Raman, B. 2009. "Mumbai terrorist attack - some aspects," <http://globalpoliticsonline.com/wped/2009/01/17/mumbai-terrorist-attack-some-aspects/> (Accessed Nov. 15th, 2009).
- Reuters. 2010. "Toyota Recalling Over 416,000 Cars in U.S., Canada," *Reuters*, July 29th. <http://www.reuters.com/article/2010/07/29/us-toyota-recall-idUSTRE66S1KR20100729>. Accessed September 16th, 2012.
- Riley, D. 2008. "Report: Indian government trying to block Twitter as terrorists may be reading it," <http://www.inquisitr.com/9863/report-indian-government-trying-to-block-twitter-as-terrorists-may-be-reading-it/> (Accessed Nov. 9th, 2009).
- Rosnow, R.L. 1991. "Inside Rumor: A Personal Journey," *American Psychologist* (46:5), pp. 484-496.
- Rosnow, R.L., and Kimmel, A.J. 2000. "Rumor," in: *Encyclopedia of Psychology*, A.E. Kazdin (ed.), Oxford University Press and American Psychology Association, New York, pp. 122-123.
- Rosnow, R.L., Esposito, J.L., and Gibney, L. 1988. "Factors Influencing Rumor Spreading: Replication and Extension," *Language and Communication* (8), pp. 29-42.
- Rosnow, R.L., and Fine, G.A. 1976. *Rumor and Gossip: The Social Psychology of Hearsay*, New York, NY: Elsevier Inc.
- Runyan, R.C. 2006. "Small Business in the Face of Crisis: Identifying Barriers to Recovery from a Natural Disaster," *Journal of Contingencies and Crisis Management* (14:1), March, pp. 12-26.
- Savin, N.E. and White, K.J. 1977. "The Durbin-Watson Test for Serial Correlation with Extreme Sample Sizes or Many Regressors," *Econometrica* (45:8), pp. 1989-1996.
- Scanlon, J. 2007. "Convergence Unlimited: Overloaded Call Centers and the Indian Ocean Tsunami," *International Journal of Emergency Management* (4:2), pp. 211-238.
- Scott, S. and Orlikowski, W. 2010. "Reconfiguring Relations of Accountability: The Consequences of Social Media for the Travel Sector," In *proceedings of Academy of Management Annual Meeting*, August 1, 2010.
- Scott, S. and Orlikowski, W. 2013. "Sociomateriality – Taking the Wrong Turning? A Response to Mutch," *Information and Organization* (23), pp.77-80.
- Shachtman, N. 2008. "Spy Fears: Twitter Terrorists, Cell Phone Jihadists," <http://www.wired.com/dangerroom/2008/10/terrorist-cell/> (Accessed June 4th, 2010).

- Shankar, D., Agrawal, M., and Rao, H.R. 2011. "Emergency Response of Mumbai Terror Attacks: An Activity Theory Analysis," eds. R. Santanam, M. Sethumadhavan, M. Virendra. *Cyber Security, Cyber Crime and Cyber Forensic: Applications and Perspectives*, IGI Global. (Formthcoming).
- Shibutani, T. 1966. *Improvised News: A Sociological Study of Rumor*, Indianapolis: The Bobbs-Merrill Company INC.
- Shklovski, I., Burke, M., Kiesler, S., and Kraut, R. 2010. "Technology Adoption and Us in the Aftermath of Hurricane Katrina in New Orleans," *American Behavioral Scientist* (53:8), pp. 1128-1246.
- Shklovski, I., Palen, L., and Sutton, J. 2008. "Finding Community Through Information and Communication Technology During Disaster Events," in *Proceedings of 2008 ACM Conference on Computer Supported Cooperative Work*, San Diego, CA, November 8-12, pp. 127-136.
- Siegler, M.G. 2008. "Osama bin Twitter: Terrorists hone the micro-message," <http://social.venturebeat.com/2008/10/26/osama-bin-twitter-terrorists-hone-the-micro-message/> (Accessed June 4th, 2010).
- Singh, P., Singh, P., Park, I., Lee, J., and Rao, H.R. 2009. "Information Sharing: A Study of Information Attributes and their Relative Significance during Catastrophic Events," *Cyber-Security and Global Information Assurance: Threat Analysis and Response Solutions*, K.J. Knapp (ed.), IGI Global.
- Stallings, R.A., and Quarantelli, E.L. 1985. "Emergent Citizen Groups and Emergent Management," *Public Administration Review* (45), pp. 93-100.
- Starbird, K., and Palen, L. 2010. "Pass It On?: Retweeting in Mass Emergency," in *Proceedings of the 7th International ISCRAM Conference*, Seattle, USA, May.
- Starbird, K. and Palen, L. 2012. "(How) Will the Revolution be Retweeted?: Information Diffusion and the 2011 Egyptian Uprising," in *Proceedings of Conference on Computer Supported Cooperative Work*, Seattle, WA, USA, February 11-15.
- Stieglitz, S. and Krüger, N. 2011. "Analysis of Sentiments in Corporate Twitter Communication – A Case Study on an Issue of Toyota," in *Proceedings of 22nd Australian Conference on Information Systems (ACIS)*, Sydney, Australia.
- Strater, L.D., Endsley, M.R., Pleban, R.J., and Matthews, M.D. 2001. "Measures of platoon leader situation awareness in virtual decision-making exercise," US Army Research Institute for the Behavioral and Social Sciences.
- Sustein, C. R. 2001. *Republic.Com*. Princeton, NJ: Princeton University Press.
- Sutton, J., Palen, L., and Shklovski, I. 2008. "Backchannels on the Front Lines: Emergent Uses of Social Media in the 2007 Southern California Wildfires," in *Proceedings of 5th International ISCRAM Conference*, Washington, D.C.
- Surowiecki, J. (2005). *The Wisdom of Crowds*. Doubleday, New York.
- Tabachnick, B.G. and Fidell, L.S. 1996. *Using Multivariate Statistics*. NY: HarperCollins.
- Taipale, K.A. 2005. "Destabilizing Terrorist Networks: Disrupting and Manipulating Information Flows in the Global War on Terrorism," Yale ISP 2005 Global Flow of Information, Draft.
- Tapscott, D., and Williams, A.D. 2006. *Wikinomics: How Mass Collaboration Changes Everything*, New York: Penguin Group.

- Tasi, W. and Ghoshal, S. 1998. "Social Capital and Value Creation: The Role of Intrafirm Networks," *The Academy of Management Journal* (41:4), pp. 464-476.
- Tierney, K.J., and Aguirre, B.E. 2001. "Testing Shibutani's Prediction of Information Seeking Behavior in Rumor," Preliminary Paper #307, Disaster Research Center, University of Delaware.
- Time. 2011a. "Time 100: Wael Ghonim" (April 21).
http://www.time.com/time/specials/packages/article/0,28804,2066367_2066369_2066437,00.html. Accessed March 31, 2013.
- Time. 2011b. "Bouazizi: The Man Who Set Himself and Tunisia on Fire" (January 21).
<http://www.time.com/time/magazine/article/0,9171,2044723,00.html>. Accessed March 31, 2013.
- Tsfati, Y., Weimann, G. 2002. "www.terrorism.com: Terror on the Internet," *Studies in Conflict & Terrorism* (25), pp.317-332
- Turner, R., and Killian, L. 1957. *Collective Behavior*, Englewood-Cliff, NJ: Prentice-Hall.
- Tynan, D. 2009. "Twitter added to federal emergency response network,"
<http://www.infoworld.com/d/adventures-in-it/twitter-added-federal-emergency-response-network-719> (Accessed Nov. 14th, 2009).
- Vieweg, S., Hughes, A., Starbird, K., and Palen, L. 2010. "Micro-blogging During Two Natural Hazards Events," in *Proceedings of CHI*, Atlanta, GA.
- Wagner, M. 2007. "Google Maps and Twitter are essential information resource for California fires,"
www.informationweek.com/blog/main/archives/2007/10/google_maps_and.html (Accessed Nov. 14th, 2009).
- Wasserman, T. 2011. "How Toyota Used Social Media to 'Digg' Itself Out of a PR Nightmare,"
Mashable Social Media, September 1st, <http://mashable.com/2011/09/01/toyota-digg-recalls/>. Accessed September 17th, s0112.
- Weimann, G. 2004. "www.terror.net: How Modern Terrorism Uses the Internet," Special Report, United States Institute of Peace (116), pp.1-12.
- Wenger, D., and Friedman, B. 1986. "Local and National Media Coverage of Disasters: A Content Analysis of the Print Media's Treatment of Disasters Myths," *Journal of Mass Emergencies and Disasters* (4:3), pp. 27-50.
- Wilcox, M.W.A. 2003. "Security Reviews of Media Reports on Military Operations: A Response to Professor Lee," *Harvard Journal of Law & Public Policy*, (26), pp.355-368.
- Winter, M. 2012. "Suspected Gunman, 5 Others Dead in Seattle Shootings," *USA Today*, May 30th.
<http://content.usatoday.com/communities/ondeadline/post/2012/05/seattle-shootings-kill-3-wound-3/1#.UFelqKSe5eJ>. Accessed September 17th, 2012.
- Yang, J., Lee, J., Rao, A., and Touqan, N. 2009. "Inter-Organizational Communications in Disaster Management," in: *Handbook of Research on ICT-Enabled Transformational Government: A Global Perspective*, Weerakkody, Janssen and Dwivedi (eds.), IGI Global.
- Yoo, Y. 2010. "Computing in Everyday Life: A Call for Research on Experiential Computing," *MIS Quarterly* (34:2) pp, 214-231.
- Yoo, Y., Lyytinen, K., Boland, R., Berente, N., Gaskin, J., Schutz, D., and Srinivasan, N. 2010. "The Next Wave of Digital Innovation: Opportunities and Challenges:

Report on the Research Workshop: ‘Digital Challenge in Innovation Research’,”
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1622170 (Accessed April
8, 2013).

APPENDIX 1

Coding Scheme		
Variable	Definition	Data Type
Rumor (DV)	<p>A Twitter message which does NOT explicitly indicate a person (e.g., the prime minister of Indian government), source (e.g., BBC, NDTV, website etc), context or known data to serve as a proof or verification for the message. The message MUST be topically relevant to the incidents under this study (Mumbai terrorist attack, Toyota recalls, and Seattle shooting incident), and it MUST refer to an object, person, or situation rather than an idea or theory. (Bordia 1996; Rosnow and Kimmel. 2000; Rosnow et al. 1988; Buckner 1965)</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “stock markets a bit up n down. The Sensex has always risen after terror attacks in 1993 and 2006. Hope so this time too!” (coded as ‘1’, indicating a rumor). 2. “Metro cinema attacked by grenades. All were killed b4 nsg [National Security Guard, authors added] storming” (coded as ‘1’, indicating a rumor). 3. “Injured reports rise from 185 to 187 now. #mumbai CNN.com” (coded as ‘0,’ indicating not a rumor). 	Binary
Source Ambiguity (IV)	<p>A Twitter message which does not contain an external source (such as name of media or links to external media, video, picture etc.) or/and a Twitter message that expresses distrust and/or ambiguity about the source.</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “#Mumbai IDesiTV.com Video stream link http://idesitv.com/starnews.php. Very <i>spotty</i> info about Oberoi/Trident and Santa Cruz Airport.” (coded as ‘1,’ indicating that the message expresses ambiguity about the source). 2. “more hostages at the Cama hospital - #Mumbai” (coded as ‘1,’ indicating that the message does not provide information source.). 3. “Live twitter news feed for Mumbai attacks http://tinyurl.com/6b4wjj” (coded as ‘0,’ indicating that the information source is not ambiguous). 	Binary

<p>Anxiety (IV)</p>	<p>A Twitter message “that express rumor related fear, dread, anxiety or apprehension, and statement that express a ‘threatened’ feeling” (Bordia 1996).</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “<i>Scared</i> to sleep not knowing what i’ll wake up to #mumbai” (coded as ‘1’) 2. “How will India bounce back? <i>Sadly</i> I have no faith in the leadership to take control and stop these heinous acts!” (coded as ‘1’) 3. “Good going by the NSG we are proud of what you did in #mumbai ...” (coded as ‘0’, indicating no anxious feeling). 	<p>Binary</p>
<p>Personal Involvement (IV)</p>	<p>A Twitter message “that describe[s] experiences of the person, in the context of the rumor” (Bordia 1996, p.22). A Twitter message that expresses that s/he is personally involved in, committed to, or has some relationship to the event (McPhail 1991, p. 77).</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “hearing navy sounds at the helipad <i>near my house</i> ... still 90+ snaps to be uploaded. plan to catch up on TV now!” (coded as ‘1’). 2. “ im locked inside Vitthals restaurant with a few frnds. shutters down . this is <i>as close as</i> i can get to the action #mumbai” (coded as ‘1’) 3. “Still blown away by the twitter response to Mumbai” (coded as ‘0’) 	<p>Binary</p>
<p>Content Ambiguity (IV)</p>	<p>A Twitter message that expresses ambiguity or distrust about the Twitter message content. A Twitter message that expresses that the given information is conflicting in nature. A Twitter message for which a person expresses distrust or confusion (Allport and Postman. 1947). “Questions seeking information. This category does not include sarcastic remarks or persuasion attempts.” (Bordia 1996).</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “Just received SMS/calls with info on further shootings in Marine Lines, Fountain and Princess Street; rumors? or true? #Mumbai” (coded as ‘1’) 2. “what is #mumbai wisdom? Number of terrorists? No captured? No killed?” (coded as ‘1’) 3. “Interview of Navy commando's in CNN IBN” (coded as ‘0’) 	<p>Binary</p>

<p>Social Ties (Directed Messages) (IV)</p>	<p>A Twitter message directed to specific user account.</p> <p>Examples</p> <ol style="list-style-type: none"> 1. “@xxxx @yyyyy Nick, apparently yes. For latest Mumbai tweets: http://tinyurl.com/55h2m8” (coded as ‘1’) 2. “@yyyy is your family safe?” (coded as ‘1’). 	<p>Binary</p>
--	--	---------------