A Little Goes a Long Way: Serial Transmission of Twitter Content Associated with Hurricane Irma and Implications for Crisis Communication

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Although numerous studies have attempted to analyze Twitter content related to crises and disasters, less is known about the prominence of serial transmission or the message attributes that drive retweeting. The current study examined 3.57 million tweets collected in the aftermath of Hurricane Irma. The findings suggest that informational tweets, those containing specific imperative language, and those containing graphic elements played a more prominent role in the conversation. Likelihood of serial transmission was not related to follower count or account verification. Implications for emergency management are discussed.

INTRODUCTION

In recent years, citizens have become increasingly reliant on social media when gathering information and making decisions related to the impact of natural disasters and other cataclysmic events. In uncertain times, it can be expected that people will turn to mediated information sources in order to make sense of highly equivocal circumstances. Social media platforms such as Twitter can provide members of affected publics with timely, updated information and behavioral recommendations.

Although a number of studies have attempted to identify the types of content associated with different search terms during crises and disasters, or the message characteristics that engender serial transmission, less is known about the universe of content associated with particular natural disasters, the prevalence of serial transmission within these contexts, and the message factors that lead to serial transmission. The

current study examines 3.57 million tweets marked with the hashtag #Irma, collected over the course of Hurricane Irma's impact on the southeastern United States in September 2017. The results suggest that most of the content pulled from the Twitter API during that time was retweeted, and that 200 individual tweets accounted for 27% of the content. These tweets are evaluated in terms of their linguistic and content characteristics, in order to get describe what content is accounting for the bulk of the conversation. The findings are discussed in terms of their implication for emergency managers, and best practices in designing Twitter content that is likely to become prominent in social media conversations regarding crises and disasters.

Media Use during Crises and Disasters

The objective of crisis and risk communication is to mitigate the harm caused by an event, and provide people with tangible solutions that can be used to help them adapt to changing circumstances (Reynolds & Seeger; 2005). Given their unexpected nature, crises and disasters tend to induce high levels of uncertainty amongst those who may be directly affected. The reduction of this uncertainty then becomes paramount for the affected individual, as uncertainty is a fundamentally noxious psychological state that drives resolution (Berger, 1987). In the organizational literature, Weick (1995) and others have labeled these moments "cosmology episodes." Weick (1993) describes the cosmology episode as the moment at which an individual realizes ''I've never been here before, I have no idea where I am, and I have no idea who can help me'' (pp. 634-635). When presented with such a cosmology episode, individuals will then seek out information from any one of a number of sources in order to reduce their uncertainty, though misdated information has historically been considered the most commonly used source (Brashers, Neidig, Haas, Dobbs, Cardillo, & Russell, 2000; Heath, Liao, & Douglas, 1995; Murch, 1971 Spence et al., 2006). This also leads to consideration of what sources are most relied upon and why.

Media dependency literature (see Defleur & Ball-Rokeach, 1989) argues that under conditions in which audiences experience ambiguity, their adherence to trusted sources and reliance on media with which they have prior positive experiences may become intensified. It is not surprising then, that given the conditions surrounding crises and disasters, a substantial body of research has indicated that media dependencies intensify during crises, and that media may be an effective tool in engendering audience responses under these conditions (Hindman & Coyle, 1999; Hirschburg, Dillmann, & Ball-Rokeach, 1987; Loges, 1994, Lowrey, 2004).

Considering dependency and uncertainty reduction processes alongside each other, most individuals will seek to acquire information from trusted media sources in the time leading up to, during, and immediately following a large scale disaster. In this context, Americans are becoming increasingly reliant upon social media as an information source. A 2009 study indicated that new media technologies were their preferred source of news and information, while more recent research indicates that social media usage now constitutes a large percentage of the time adults spend online though one platform or another (Neilsen media Research, 2011; Zogbuy Interactive, 2009). Taken together, it is apparent that social media should play a major role in the management of crisis and disasters, at least in identifying the information people are exposed to when reducing uncertainty and informing decision making. More recent research suggests that this is, in fact, the case.

Social Media

Recent studies have indicated that the public will use social media, and specifically Twitter, as a trusted information source under trying or equivocal circumstances (Armstrong & Gao, 2010; Palser, 2009; Sutton, Palen, & Shklovski, 2008). Data indicates that individuals in harm's way will want emergency management officials and local government to use social media to distribute information, and part of the appeal appears to lie in the speed at which up to date and breaking information can be transmitted (Kavanaugh et al., 2011). These individuals may also turn to social media for continual updates if they experience frustration with legacy media, and it is likely the case that social media resources such as Twitter complement, rather than supplant, existing media dependencies (Jin & Liu,

2010; Palen et al. 2010; Liu, et al. 2013; Sutton, Palen, & Shklovski, 2008; Westerman, Spence & Van Der Heide, 2012).

Language Type and Serial Transmission

The formal features of Twitter are likely to play a role in the manner in which communication takes place. For example, the connection between retweeting and the implication of endorsement has received some attention in the literature, as has the role of direct messaging in creating the illusion of dialogue (Boyd, Golder, & Lotan, 2010; Honey & Herring, 2009; Hui, Tyshchuk, Wallace, Magdon-Ismail, & Goldberg, 2012). Some evidence has also been found suggesting that the inclusion of graphic elements and links out to URLs may increase the likelihood that a message is retweeted (Hughes & Palen, 2009; Suh, Hong, Pirolli, & Choi, 2010).

Other research has begun to look at the content of these messages and their impact on serial transmission and conversational prominence. Sutton, Spiro, Johnson, Fitzhugh, Gibson, & Butts (2014) examined titter content from emergency management officials in the aftermath of a wildfire in California, and found that information concerning the good of the community (though not specific remedial actions) as likely to be retweeted. As such, statements concerning the impact on a broad area were more likely to gain prominence in the conversation, while those pertaining to specific areas or terrain were not.

In a follow-up study, Sutton and colleagues (2014) discovered that language structure also plays a critical role in serial transmission, as most tweets related to the 2013 Colorado floods used declarative statements, as opposed to imperative statements or a combination of both. This is troubling considering that other research indicates that warning messages are more effective when they contain some combination of both imperative and declarative language (Frisby, Sellnow, Lane, Veil, & Sellnow, 2013). By definition, declarative statements are those that state a condition is occurring, while imperative statements provide some kind of tangible behavioral advice, similar to research in other domains advocating for the induction of behavioral efficacy.

Past content analytic research has also examined imperative versus declarative language use in varying risk contexts. Rainear, Lachlan, Oeldorf-Hirsch, & DeVoss (2017) conducted an examination of tweets related to emergency management agencies during an Atlantic hurricane, and discovered that tweets using declarative language were much more common than those using imperative language, or a combination of both. Thus, despite evidence that imperative statements are more likely to engender retweeting, emergency management agencies may be more likely to rely on declarations than issue specific remedial actions that can be taken in the face of a natural disaster in order to protect health, life, and property.

Clearly, there are a number of attributes associated with Twitter users, or with the content itself, that my make messages more likely to be retweeted. Retweeted messages are more likely to become a part of the dialogue, and are more likely to be received by those seeking information associated with crises and disasters. Less is known, however, about the relative proportion of retweeted content in a universe of tweets associated with a given event. As an initial exploration of these proportions, the following research question is proposed as it pertains to Hurricane Irma:

RQ1: What proportion of Twitter content associated with #Irma is retweeted information?

In order to approximate the impact of user attributes on how often a message related to the crisis is retweeted, the following research questions are proposed:

RQ2: Is there a relationship between follower count and the frequency with which a message is retweeted?

RQ3: Are messages from verified accounts more likely to be retweeted than those from unverified accounts?

Finally, in order to replicate and extend prior research on the matter (Lachlan, et al., 2014; Rainear, et al., 2017), the following research questions are proposed concerning message attributes that may facilitate serial transmission:

RQ4: *What linguistic features are common in retweeted messages?*

RQ5: *Are imperative messages more commonly retweeted than declarative messages?*

RQ6: *What content types are commonly found among retweets?*

RQ7: *Are messages targeted at specific stakeholders more likely to be retweeted?*

RQ8: *What impact do visual elements have on the frequency of retweets?*

METHODS

Data Collection

Tweets (n=3,577,308) published between September 5th and September 14th with hashtag "#irma" were captured using R package "rtweets". Among them, 3,069,685 (85.8%) were retweets, and 507,623 (14.2%) were original tweets. The frequency of each retweet was calculated, and the top 200 most retweeted original messages were included in this current study. The original publisher of each tweet was identified, and the following information regarding the original sender was automatically generated: username, number of follower, verified account, URL, graphic, video, content type and intended target. The 200 most frequently retweeted messages were identified, which (when retweeted) accounted for approximately 27% of the harvested data.

Analysis Plan

The central research questions in the study were evaluated in three steps. First, the aggregated data set of 3.57 million tweets were examined to determine the prevalence of serial transmission. After determining the frequency of retweets, the top 200 most frequently retweeted tweets were identified in order to determine how much content they accounted for, and to drill down into the specific content attributes that may be contributing to serial transmission, while accounting for most of the content in the larger data set (see below). This set of 200 original tweets was then subject to three sets of analyses. First, correlations and mean comparisons were used to determine if verified accounts and follower count had any impact on the number of retweets within this set. Next, LIWC (Pennebaker, Francis, & Booth, 2001) was used to examine linguistic markers and general language trends. Finally, a simple content analysis using human coders explored the prevalence of language strategy and graphic elements, along with their contribution to the likelihood of serial transmission.

Intercoder Reliability

In order to assess the research questions addressing specific content characteristics, the most commonly retweeted messages were pulled from the data for further analysis. In total the 200 most frequently retweeted messages were identified, which (when retweeted) accounted for approximately 27% of the harvested data. These tweets were then coded by a team of two graduate assistants.

Central to the fifth research question, the language style exhibited in the tweet was coded as imperative, declarative, both, or neither. Primary content type was coded as information, affect, humor, or other, consistent with the coding scheme utilized by Lachlan, et al. (2014). Appraisals of the intended target of the tweet included civilians, relief agencies, and other. Finally, the inclusion of a URL, graphic element, or embedded video were identified as binary yes/no variables. Two graduate students were recruited to serve as coders on the data. They were intensively trained in the coding categories over a period of two weeks, and a 10% subsample was selected for intercoder reliability assessment. This

reliability check was conducted using ReCal 2.0 (Freelon, 2010). The coders indicated adequate levels of reliability for all variables except inclusion of URL (all Scott's Pi > .70). Inclusion of URL was subsequently dropped from further analysis.

RESULTS

Proportion of Retweeted Content

An examination of the content collected suggests that the information collected from the Twitter API and marked with the hashtag #Irma overwhelmingly consisted of retweets. All told, about 87% of the 3.57 million tweets harvested consisted of retweeted content. Sorting by the frequency with which they were retweeted, the top 200 most retweeted messages accounted for 968,732 tweets, or about 27%. Tweets from verified accounts constituted 156 of these messages, which in turn accounted for 751,271 retweets. An informal examination of these verified accounts suggests that they were mostly emergency management agencies and recognized news sources. In summation, 21% of the 3.57 million tweets collected were retweets of content originally stemming from a verified account and found in the top one fifth of retweet frequency.

Followers and Verified Accounts

Research questions two and three sought to explore the relationship between the frequency of retweets and both the number of followers on the account sending the tweet, and whether or not this account was verified. First, a simple bivariate correlation was conducted to explore the relation between follower count and the number of times a given message was retweeted. The results reveal almost no relationship between the two. The correlation was detected at r = -.015, p = .815, *n.s.*

A follow-up analysis then examined whether verified accounts would have more weight in the likelihood of serial transmission. Within the subsample of the 200 most common retweets, the average number of retweets was compared for verified and non-verified accounts. The results indicate that there are no significant differences between the verified and unverified sender accounts in terms of the frequency with which the messages were retweeted, t (198) = .134, p = .893, *n.s.*. Further, an examination of the means for each group reveals remarkable similarity. Messages from unverified accounts (M = 4942.27, SD = 5651.82) were retweeted on average about as much as those from verified accounts (M = 4815.84, SD = 5472.58). The dispersion of these distributions is also noteworthy; across the entire data set the number of retweets ranged from 1571 to 48372 (range = 46801). This suggests that while most of the messages amongst the top 200 came from verified accounts, there were a substantial number that did not, and that these messages did not vary within the set in terms of their likelihood of serial transmission.

LIWC Analysis

In addressing research question four, the exploratory analysis using LIWC (Pennebaker, Francis, & Booth, 2001) reveals interesting findings concerning the nature of the most retweeted content. Across the 200 tweets in the data set, LIWC was able to identify 4422 unique words, for an average of 22.11 words per tweet. Positive emotions (3.03%) were more common than negative emotions (1.58), with anxiety (1.45), anger (0.16), and sadness (0.52) associated with a very small number of identified terms. Similarly, few utterances were associated with negative consequences; for example, 0.59% were related to health, while 0.32% referenced death. A substantial number of words were related to motion (12.12), perhaps indicating references to the motion of the storm or evacuation efforts, while references to time (6.06) also accounted for a notable percentage of identified utterances. Words categorized in LIWC as Insight (e.g. "think" or "know") comprised 7.07%.

Human Coder Analysis

A number of content attributes were examined using human coders, and both their occurrence and in some cases their impact on frequency of retweet was considered in addressing research questions five through eight. Of the 200 tweets examined, 152 (76%) were categorized as declarative in nature, while 21

were categorized as imperative, 6 as both, and 21 as neither. An examination of the average number of retweets within these groups suggests a pattern similar to that detected by Sutton and colleagues (2014). The mean number of retweets for imperative tweets (5875.57) is higher than that for declarative (5090.62), and substantially higher than those containing both (1930.83) and neither (2856.43). While the associated oneway ANOVA analysis failed to reach statistical significance, F (3,196) = 1.85, p <.14, language type accounted for a small but notable percentage of the variance in frequency of retweet, η^2 = .03.

Research question six sought to examine the broad categories of tweets that appear amongst the top 200, based on content types developed by Lachlan and colleagues (2014). A total of 130 (65%) were classified as primarily related to information. Affect accounted for 35 tweets, humor for 6, and other for 29. A oneway ANOVA analysis across tweet type suggests that the tweets easily categorized into one of these three labels were more frequently retweeted than those identified as unknown, F (3,196) = 2.56, p <.05, η^2 = .04. Interestingly, tweets most closely associated with affect received the highest average of retweets (5742.94), followed by humor (5182.83), information (5161.26), and other (2264.38). However, when considered proportionately, the informational tweets account for 670,963 out of 968,732, or 70% of the tweets under consideration in the analysis. Framed another way, tweets ranking in the top 200, and construed primarily as informative, accounted for 19% of the 3.57 million tweets harvested.

Research question seven asked if frequency of retweet would vary depending on the targeted stakeholder. All but one of the top 200 tweets were judged to be targeted at civilians.

Finally, research question eight sought to examine the impact of visual elements on the frequency with which retweeting took place. A total of 65 tweets linked to a static graphic, while 135 did not. In terms of links to embedded video, 103 linked to video of some kind, while 97 did not; it should be noted that no tweets were identified that contained links to both static graphics and video. Tweets that contained some kind of graphic element were retweeted more frequently (5465.77) than those who did not (4561.66). By contrast, the means for those that did (4853.18) and did not (4861.04) link to an embedded video were shockingly similar.

Considering these findings in proportion also sheds some insight into the importance of graphics in engendering retweets. Tweets containing static elements and ranked in the top 200 accounted for 355,275 total retweets. This accounts for 37% of the total number of retweets in the top 200, and just less than 10% of the 3.57 million tweets that took place.

DISCUSSION

The current study examines the content and language used in tweets collected after the landfall of Hurricane Irma. Specifically, this study sought to better understand serial transmission and the various attributes of tweets such as the type of language used, account verification, and the use of graphics or other web links in times of environmental crisis and risk. Broadly, this study sought to understand what might cause a tweet to be retweeted by others in the context of a major hurricane. Although previous research has examined the content, frequency and type of account profiles of retweeted information in a crisis (Lin et al, 2016b), to our knowledge, the current study is the first to provide the proportion of retweets and examine the top retweeted tweets during a crisis. The number of retweets demonstrates the original tweet's significance during information diffusion. The tweets included in the present study were the most widely disseminated tweets related to Hurricane Irma. Thus, answers to why these messages received the most attention on Twitter are useful for future studies to predict information diffusion on social media and for emergency managers to develop effective crisis-related messages. The results offer an interesting take on source verification, language valence, and message type in this specific situation. Applied to practitioners, these findings may be useful in determining how best to construct messages on Twitter so they may be disseminated to the largest audience.

The first finding of note is that followers and verified accounts were not significantly associated with the frequency of retweets among the most popular tweets during hurricane Irma. Previous studies show that an account with a large number of followers and is considered as an expert tend to be regarded as a

credible source (Lee & Sundar, 2013) and can lead to more shares on social media (Suh, Hong, Pirolli & Chi, 2010), and that the presence of retweets did not increase perceptions of source credibility in a heath related content (Lin et al, 2016a). However, these studies have not examined if follower numbers and account credibility can be directly related to the number of retweets during a crisis. Compared to the credibility of the source, social media users may be more interested in emotional or unexpected content during an emergency event. For example, the second most retweeted message during hurricane Irma was a video showing a dog saving another dog from flood posted by an unverified account. By tracking this video, we found that it was not taken during hurricane Irma. Even though this tweet was a misinformation posted by a source with low credibility, the content of the tweet was successful in arousing viewers' interests to retweet it. This finding implies that tweet content may be more important than the source credibility to predict information diffusion in Twitter when disasters take place.

The lack of importance in user verification is also interesting due to its opposition to current literature, which states individuals look to trusted officials and credible sources in times of uncertainty, such as crisis and risk situations (Defleur & Ball-Rokeach, 1989). The current data suggest this verification or credibility is unimportant to users even in times of heightened uncertainty leading to a similar amount of information being disseminated by both verified and unverified accounts. In sum, the relative insignificance of verification suggests that emergency managers and government officials need to be vigilant, as irrelevant content or misinformation may enter the conversation and quickly ascend to dominate the dialogue. Twitter content from unqualified individuals and random users may present a legitimate danger to the dissemination of useful information, and it may be the case that irrelevant or inaccurate information is countered by emergency communication professionals.

Findings using LIWC analysis (Pennebaker, Francis, & Booth, 2001) further examined and provided beneficial results regarding the most retweeted content. Messages were primarily of positive valance, and contained words that were considered to convey positive emotions. A small number of tweets were negatively valenced or contained negative emotions. Additionally, the outcomes of many of the messages were generally associated with positivity and a large portion of the messages that were retweeted consisted of words involving motion, time, and insight into the surrounding risk. This finding may also be useful for those crafting emergency response messages in real time on twitter; constructive language, and references to motion and time may have a certain degree of "stickiness," and users may be inclined to relay this information on to others. This is also consistent with research in other domains arguing for the effectiveness of actionable information and behavioral advice.

The present study also indicated that even though the majority of tweets and words used in these tweets did not contain sentiments, emotionally charged tweets were more likely to be retweeted. Previous studies imply that sentiments can increase users' cognitive and affective responses, such as attention, interest, and emotional arousal, which lead to more shares on social media (Stieglitz & Dang-Xuan, 2013). From initial observations, many of the tweets which contain emotionally charged content are unverified accounts. For example, among top 15 most retweeted tweets, only three accounts were unverified with comparatively small numbers of followers. All of them tweeted affect-related contents including stories about animals in natural disasters. In doing so, these unverified increased their influence and retweet rate. In contrast, only a few verified accounts posted emotional content. Many of these messages centered on helping behaviors, or asked people to pray for the victims.

Of particular note were the content of the messages examined by human coders. Of the top 200 tweets of those harvested, tweets that were coded as "informative", or primarily providing information, were more frequently retweeted than messages that were categorized into the labels "affect", "humor", or "other". This finding is especially interesting considering these informative messages consisted of nearly 20% of the 3.57 million tweets harvested for this study. This finding would suggest informative messages are more likely to be retweeted and disseminated during similar times of uncertainty, crisis, and risk. Additionally, tweets that were easily categorized into a label were more frequently retweeted than tweets that fell into the "other" category, suggesting message clarity is an important factor of serial transmission.

Regarding language structure, even though the majority of tweets used declarative language, imperative tweets were more likely to receive serial transmission. Imperative content, which often

consists of clear instructions and direct guidelines, are found to be effective in disseminating crisis-related messages. In fact, there is a demand for imperative messages in dangerous situations (Sellnow, Sellnow, Lane & Littlefield, 2012). The present study also shows that users were more interested in imperative tweets, which contained instructions on evacuation, finding shelters, avoiding misinformation, etc. This finding is useful for emergency managers to develop effective messages, in that receivers will expect crisis-related messages to contain imperative language and direct instruction. Once again, there is initial evidence that declarative language standing alone may not be as effective as declarative language, and that the inclusion of actionable instructions is critical to both inform at risk audiences and increase the likelihood that they will relay the message to others.

Implications for Emergency Managers

In terms of practical implications, officials such as crisis managers, network analysts, and public relations officers may take interest in the findings of user verification, valence, and content. According to the findings of this study, messages framed positively and with informative messaging may have the strongest possibility of being retweeted, thus boosting the number of people to which important messages regarding crisis, risk, safety, health, and emergency response may reach. When salient information and safety are priorities, any information to better the effectiveness of crisis and risk messaging is a great benefit to those creating and disseminating these important messages.

Further, the findings regarding user verification, and the lack of correlation between follower count and retweets, may be beneficial for those seeking to better understand the proliferation of a message from various opinion leaders or public relations officials. In other words, it is not enough to assume that verified accounts and those with a large number of followers will be those that dominate the dialogue, and we must consider common citizens and other organizations as substantive contributors to the conversation.

Limitations

Any study, especially one that is dealing with exploratory elements of social media in crisis and risk situations, such as the current study, befalls limitations. With an extremely large dataset such as this, major limiting factors such as uneven cell sizes, and the massive size of standard deviations may have an impact on the levels of significance. Additionally, due to the specificity of the context and sample, generalizability of the discussed results is limited to Floridians using Twitter and specific handles and hashtags during Hurricane Irma. Future research should expand to examine multiple states, social media platforms, and communities affected by a crisis and risk scenario to better gain an understanding of the manner in which messages are disseminated through a social network.

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