

Research Article

How Did Rumors on Twitter Diffuse and Change in Expression? An Investigation of the Process of Spreading Rumors on Twitter during the 2011 Great East Japan Earthquake

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Twitter has been emerging as a major communication channels during disasters. The characteristics of Twitter—quickly and widely diffusing information and allowing every user to be an information transmitter—can be effective for problem solving in anxious and ambiguous situations such as disasters; however, false rumors on Twitter can be a serious problem. Rumor research has suggested that rumors are a kind of collective sense-making when mass media cannot provide people with enough information (e.g., during disasters). Furthermore, the expression of the rumor changes during the process of spreading. This study investigated the data of 187 thousand tweets related to the Cosmo Oil rumor during the Great East Japan Earthquake of March 2011 and analyzed the change in Twitter expressions and the collective sense-making process during this catastrophe. The results of this study suggest that collective sense-making is rare in diffused tweets, partly because of the gatekeeping role of hubs (i.e., users who have many followers on Twitter). Rumor discussion on Twitter during disasters might be suitable for broadcasting static information than for collective sense-making.

1. Introduction

Twitter is a microblogging service where users post messages up to 140 characters. In 2018, it had 326 million monthly active users worldwide. Because there are no limits to the number of followers (i.e., readers of specific Twitter users' feeds), popular Twitter users can distribute their Twitter posts ("tweets") to a large number of people. For example, President Trump of the United States had, as of 2018, over 55 million followers. Another feature of Twitter communication is the ease with which posts can be forwarded to other users ("retweets"). Twitter users can allow their followers to read other user's tweets using only two clicks on the "retweet" button for each tweet that they read. Because of these characteristics, specific tweets can spread to millions of people over a very short period on Twitter [1].

Twitter is emerging as one of the main communication channels during disasters. Using Twitter, authorities were able to directly distribute necessary information to people, including disaster victims, and people could actively exchange disaster-related information during the flooding of Red River Valley in 2009 [2], the Great East Japan Earthquake in 2011 [3], and Hurricane Sandy in 2012 [4]. However, Twitter also spreads misinformation and false rumors. During the 2011 Great East Japan Earthquake, a prominent false rumor claiming that rainfall contained harmful material began to spread right after the explosion of the LPG tanks at Cosmo Oil Co., Ltd. (known as the "Cosmo Oil rumor"). Furthermore, during Hurricane Sandy in 2012, fake images of the hurricane widely and quickly diffused worldwide on Twitter. False rumors can confuse people and authorities, as well as interfere with managing the disaster. Governments

have begun struggling with false rumors spreading via social media, including Twitter.

Rumor research suggests that rumors are a form of collective sense-making process rather than mere transmission of information (or misinformation) [5–7]. During disasters, people experience anxiety and their need for information explodes; however, mass media sometimes cannot supply enough information to meet the suddenly huge demand. In the absence of formal information about a highly anxiety-inducing and ambiguous situation, people become motivated to share and evaluate information in order to explain the situation. Rumors have been defined as “unverified and instrumentally relevant information statements in circulation that arise in contexts of ambiguity, danger or potential threat, and that function to help people make sense and manage risk” [8].

From this point of view, rumor should not necessarily be excluded during a disaster. In order to foster the potentially positive uses of rumor and inhibit the negative ones, understanding the dynamics of rumor discussion on Twitter would be exceedingly important. This study investigates the pattern of expression changes over time and the collective sense-making process on Twitter using real tweet data about the Cosmo Oil rumor.

2. Related Work

2.1. Expression Changes in Rumor. Rumor researchers have shown that the expression of rumors changes over time and have studied the patterns and mechanism of such change. Allport and Postman conducted laboratory studies on expression changes in rumors. They instructed participants to describe a drawing and transmit that description through a chain of participants without discussion [9]. Rosnow and Fine also conducted field studies using false rumors, such as the “Paul McCartney is dead” rumor. These studies identified four patterns of rumor expression change: *leveling*: “the loss of detail and the reduction in length at each successive transmission”; *adding*: the “addition to rumor content in the form of new material or additional details”; *sharpening*: “the accenting and highlighting of certain details in the rumor message”; and *assimilation*: “the shaping of rumor content—through leveling, adding, and sharpening—so as to be in greater accord with personal cognitive schemas” [8].

RQ1: What kind of expression change is observed in Cosmo Oil rumor on Twitter over time?

2.2. Rumor as Collective Sense-Making. Laboratory studies of rumor such as Allport and Postman’s were criticized because the listener was not allowed to seek clarification or cross-examine the speaker, whereas such interactions do tend to be observed in real-life rumor situations [5]. Shibutani proposed the perspective of rumor as a form of collective sense-making: when formal information is absent and people are in an anxiety-inducing and ambiguous situation (e.g., during a disaster), people tend to compensate by informally interpreting the situation [7]. Although the perspective of rumor as collective sense-making has been supported through many

field studies, it has, until now, lacked quantitative evidence because of the difficulties in collecting data on real-life rumor transmission.

Computer-mediated communication (CMC) has enabled researchers to record all interactions during rumor transmission, thus providing the necessary quantitative evidence for rumor as a collective sense-making process. Bordia and Rosnow [6] devised a general scheme for coding and analyzing statements in rumor transmission on a CMC network, and Bordia and DiFonzo [5] modified this scheme to create the Rumor Interaction Analysis Systems (RIAS). They identified 14 types of rumor statements through an analysis of 14 rumor discussions in CMC discussion groups using RIAS and found that the most frequent statement in the rumor discussions was the sense-making type (29.4%). Additionally, they divided the progression of rumor discussions over time into quarters by dividing the number of postings by 4 and derived the main types of statements in each quarter. They found that interrogatory statements peaked during the first quarter, while sense-making statements peaked during the third quarter. Their findings suggest that rumor discussion is a collective sense-making process and that the types of statements made in such discussions change over time. On the other hand, Oh et al. [10] analyzed tweets related to the Haichi Earthquake in 2010 using the RIAS and found that sense-making tweets were very rare. They posited that the Twitter interface, which limits tweets to 140 characters, might make such sense-making statements difficult.

RQ2: What statement types are observed in Cosmo Oil rumor spread over Twitter and how do the amount of these statement types change over time?

2.3. Rumor Diffusion on Twitter. Since Twitter has a distinct user-follower network and a distinct message forwarding function (retweets), rumor transmission on Twitter might have different features from face-to-face interaction or CMC discussion groups. Mendoza et al. [11] observed there are far more denials and questions about tweets of false rumors than about tweets related to confirmed truths and suggested that false rumors can be detected using an aggregate analysis of tweets. However, the number of denying/questioning tweets does not necessarily equate to the number of readers.

Kwak et al. [1] noted that retweets generally reach an average of 1,000 users, regardless of the number of followers of the user who made the original tweet. Arif et al. [12] examined rumors on Twitter during a hostage crisis in Sydney in 2015 and proposed that tweets from accounts with low followers could still diffuse widely when they have a high number of derivative tweets (i.e., identifiable downstream tweets that are copies of the original tweets, including retweets and small amount of rewords). Hence, the number of retweets might be deemed a rough estimate of the number of readers of the tweets. Furthermore, it would be difficult for rumor tweets with few retweets (which would imply few readers) to contribute to the collective sense-making on Twitter. Thus, rumor tweets with many retweets (*diffused* rumor tweets) and ones with few retweets (*nondiffused* rumor tweets) should be examined separately.

TABLE 1: Statement coding category and its definition.

Category	Definition
Authenticating (Au)	Statements expressing the speaker’s attempt to add credibility to what he or she was saying.
Sense-making (Sm)	Statements reflecting attempts to solve the problem of whether or not the rumor is true, including providing information to solve the problem.
Emotional (Em)	Emotionally charged expressions that include both positive and negative feelings.
Interrogatory (I)	Questions seeking information.
Directive (Dr)	Statements that suggests a course of action.
Unrelated (Ur)	Statements that are not relevant to the original rumor.
Uncodable (Uc)	Statements that are not able to be categorized.

RQ3: What is the difference between *diffused* rumor tweets and *nondiffused* ones in terms of expression changes and statement types in Cosmo Oil rumor?

3. Methods

3.1. Background of the Cosmo Oil Rumor. The Great East Japan Earthquake hit eastern Japan at 14:46 (JST) on March 11, 2011. The magnitude 9.0 earthquake caused an explosion at the LPG tanks of Cosmo Oil Co., Ltd. in Ichihara city, Chiba prefecture at 17:04 and various TV and radio stations reported on the explosion repeatedly. After the explosion, a tweet that said “rain with harmful materials is falling” began to rapidly diffuse on Twitter, chain mail, and mixi (a Japanese domestic social networking service). On March 12, Cosmo Oil Co., Ltd., the authorities, and mass media officially denied the Cosmo Oil rumor, causing it to subside almost instantly.

3.2. Data. Twitter Japan gave us permission to use all tweet data posted from March 11 to March 17, 2011, in the workshop for big data on the Great East Japan Earthquake—Project 311 [13]. It contains the following information on each tweet: tweet ID, account ID, timestamp, and tweet text. Any tweets deleted before the workshop began were not included in the data. We extracted the tweets related to the Cosmo Oil rumor from the all tweet data using the keyword “cosmo.” A dataset of 187,202 extracted tweets (*Cosmo Oil dataset*) was used in this study.

Authors and three research collaborators read all the tweet contents in the *Cosmo Oil dataset* and extracted notable tweets for understanding the dynamics of the change in expression and diffusion process of Cosmo Oil rumors. We operationally defined *diffused* tweets as tweets that had been retweeted over 100 times; 87 tweets were classified as *diffused*, with all other tweets being classified as *nondiffused*. The total number of tweets and retweets of these *diffused* tweets was 75,831. *Diffused* tweets and their retweets account for 40.5% of the *Cosmo Oil dataset*.

3.3. Coding. Coding was performed with reference to the classification by Arif et al. [12] and the RIAS [5], who employed five mutually exclusive categories—affirm, deny, neutral, unrelated, and uncodable—to capture the overall trend of the rumor discussion on Twitter. Bordia and DiFonzo [5] employed 14 categories of statements to RIAS

to analyze the rumor discussion in CMC discussion groups. They were prudent, apprehensive, authenticating, interrogatory, providing information, belief, disbelief, sense-making, directive, sarcastic, wish, personal involvement, digressive, and uncodable. Oh et al. [10] revised RIAS to analyze the rumor discussion on Twitter and dropped the seven categories of digressive, personal involvement, wish, sarcastic, apprehensive, providing information, and sense-making, because they were very rare in their dataset of tweets related to the Haiti Earthquake. They also replaced apprehensive statements with emotional ones, which included both positive and negative dimensions.

First, we coded the attitude of the rumor tweets in the *Cosmo Oil dataset* with the same categories used by Arif et al.—affirm, deny, neutral, unrelated, and uncodable—to capture the overall stance of the Cosmo Oil rumor discussion. A tweet coded as “affirm” implies that it endorses or affirms the rumor whereas a tweet coded as “deny” disputes or refutes the rumor. A tweet coded as “neutral” neither directly affirms nor denies the rumor but is still related to the story.

Second, we coded the statements of the tweets to capture the sense-making process in the Cosmo Oil rumor discussion in detail based on the following seven categories: authenticating, sense-making, emotional, interrogatory, directive, unrelated, and uncodable, as shown in Table 1. These categories were referring to RIAS and were not necessarily mutually exclusive. The statements that may have been coded as belief, disbelief, and prudent, using RIAS were coded as affirm, deny, and neutral, respectively in the first step of our coding procedure as noted above. As Oh et al. analyzed, we replaced apprehensive statements in RIAS by emotional and omitted the three categories of sarcastic, wish, and personal involvement from RIAS because they were very rare in the *Cosmo Oil dataset*. The providing information category was also omitted. Because information providing statements were presumed to be responses to interrogatory statements [5], it was difficult to distinguish between responses to interrogatory statements and mere information transmission in the rumor discussion on Twitter. We retained the sense-making category in RIAS because our research interest focused on the sense-making process in the rumor discussion.

In this study, we recruited two coders from among our university students, instructed them how to code tweets using the coding manual, and let them code all the *diffused* tweets and the notable *nondiffused* tweets introduced in this

paper later. The intercoder reliability: Cohen’s κ [14] for classification of the attitude of the rumor tweets was 0.73 and that for statements of the rumor tweets was 0.84. These reliabilities could be judged as substantial agreement and almost perfect agreement, respectively [15].

3.4. Dividing the Diffused Tweets. To capture expression changes over the course of the Cosmo Oil rumor discussion, we divided *diffused* tweets into “quarters,” with reference to the analysis method proposed by DiFonzo and Bordia [8]. We divided all *diffused* tweets except unrelated (Ur) ones into quarters by dividing the number of *diffused* tweets chronologically by 4, and then counting the number of each type of attitude and statement in each quarter. While DiFonzo and Bordia divided and analyzed all posts (7 to 54 posts) in the 14 rumor discussions on computer discussion groups, it was quite difficult to divide and count each type of attitude and the statements of all tweets (187,202 tweets) in the *Cosmo Oil dataset* in the same way. However, because the percentage of diffused tweets and their retweets was not small in the *Cosmo Oil dataset* as noted before, and because tweets with a large number of retweets would have been read by far more people than would tweets with fewer retweets [1], we judged that dividing only *diffused* tweets would be acceptable in this research.

4. Results

In this chapter, we introduce the texts of tweets that featured communication about the Cosmo Oil rumor. The texts includes the timestamp, tweet text, the number of retweeted (number plus “RT” in parentheses), and the statement category. User information is referred to only when it is necessary.

4.1. Diffused Rumor Tweets. The first *diffused* tweet of the Cosmo Oil rumor occurred at 6 pm (Tweet A). We identified it as the *original rumor tweet* and named the main text of the tweet as the *core rumor text* (underlined part of the original rumor tweet).

Tweet A (directive)

@username (03-11 18:43:40)

[Please share] To residents around Chiba city! Due to the Cosmo Oil explosion, harmful material has become adherent to clouds, and is falling with rain. When you go outside, bring an umbrella or a raincoat. Don’t let your body be exposed to rain!!! (1,759RT)

After the original rumor tweet was posted, the number of tweets related to the Cosmo Oil rumor exploded. A total of 18 *diffused* rumor tweets affirmed the rumor. Since two of these tweets referred to the rumor as related information for other discussions, we concluded that 16 *diffused* tweets contributed to the discussion of the Cosmo Oil rumor. Interestingly, all 16 *diffused* rumor tweets quoted the full text or core rumor text of the original rumor tweet without changes. Since the downstream tweets kept the text of the original rumor tweet almost intact, it seems evident that leveling, sharpening, and assimilation did not occur in the discourse of the Cosmo

TABLE 2: Numbers of attitudes in each quarter.

	Affirm	Deny	Neutral
Q1 (n=20)	17	3	0
Q2 (n=19)	0	19	0
Q3 (n=19)	0	19	0
Q4 (n=19)	1	17	1

Oil rumor. Adding was observed in authenticating statements in some tweets. Another feature of the *diffused* affirming tweets was that these 16 tweets contained only two statement categories: authenticating and directive.

Tweet B (03-12 00:12:30, directive)

Share more! (core rumor text), Please let everyone know this!! (1,342RT)

Tweet C (03-11 19:58:50, authenticating and directive)

Fuji television said so. RT (original rumor text). (614RT)

Tweet D (03-12 09:23:42, authenticating and directive)

The information from the factory worker. Take care of outing and don’t reveal your skin. (core rumor text) Please let everyone know this!! (2,055RT)

It took about 16 hours from the posting of the original rumor tweet for the first *diffused* rumor tweet denying the rumor to appear (“NHK” in tweet E is Japanese national public broadcasting organization).

Tweet E (03-12 11:00:14, authenticating and sense-making)

[Can I say a few words?] It is a HOAX that exposure to rain is dangerous, harmful material is mixed in rain due to the explosion. NHK also said so. Don’t share the rumor, it bothers the Cosmo staff. I heard that when the oil burns, it will produce only carbon dioxide. (2,055RT)

When Cosmo Oil Co. Ltd., authorities, and Asahi Shimbun (a daily newspaper in Japan) officially denied the Cosmo Oil rumor, denial tweets spread widely in an instant. The most retweeted deny tweet was posted by Urayasu City Hall in Chiba prefecture.

Tweet F (03-12 15:31:53, authenticating and directive)

@urayasu_koho

A false chain mail has been sent, saying that harmful material is falling with the rain due to the LPG tank explosion at the Cosmo Oil Chiba refinery. We have asked the Fire, Earthquake and Disaster Defense Division of Chiba prefecture and confirmed it to be false. Please act only with accurate information. (21,078RT)

We arranged 77 *diffused* rumor tweets in chronological order and divided them into quarters; then we counted each type of attitude (Table 2) and statement (Table 3). Unrelated (Ur) *diffused* tweets (10 tweets) were excluded from this analysis. Because there were no uncodable tweets regarding attitude, and because the only uncodable tweet about statement was a tweet that simply expressed denial of the rumor, the property of which was already considered in Table 2, the “uncodable” column was omitted from both tables.

TABLE 3: Numbers of statements in each quarter.

	Au	Sm	Em	I	Dr
Q1 (n=20)	7	1	0	0	20
Q2 (n=19)	17	1	0	0	8
Q3 (n=19)	17	2	0	0	7
Q4 (n=19)	15	0	0	1	13

Table 2 shows that (1) almost all affirmative tweets are concentrated in Q1, (2) denial tweets dominated from Q2 to Q4, and (3) there are very few neutral tweets in any of the quarters. These patterns directly reflect the existence of an official denial. There were no official denials to the Cosmo Oil rumor in Q1, whereas Cosmo Oil Co., Ltd. denied the rumor in Q2 and Urayasu City Hall and Asahi Shimbun denied it in Q3.

Table 3 also suggests a similar pattern. Less than half of the statements were coded as authenticating (Au) in Q1, while most of the statements in Q2 to Q4 were classified as such. This change is consistent with the finding of Oh et al. [16], who noted that information with no clear source was the most important rumor-causing factor on Twitter. Second, there were very few sense-making and interrogatory statements and no emotional statements in any of the periods. The ratio of directive statements in all tweets is the highest in Q1, which then dropped in Q2 to Q3 before increasing again in Q4.

4.2. Nondiffused Rumor Tweets. In this section, we analyze the changes of expression, attitude, and statements of *nondiffused* rumor tweets using the same framework as the *diffused* ones. However, it is quite difficult to count the number of each type of change over 100 thousand tweets. Thus, we introduce typical tweets in the *Cosmo Oil dataset* for each type of change.

While adding was the only type of expression change observed in *diffused* rumor tweets, we observed other types in the *nondiffused* rumor tweets.

Tweet G (03-11 18:00:26, directive)

I heard that water solution is flying apart as a consequence of the Cosmo Oil fire in Ichihara city, Chiba prefecture. Absolutely do not get exposed to rain, prevent it with a mask. I also heard that Shinkansen of the Tohoku, Joestu, and Akita lines will be stopped all day today. (7RT)

The timestamp of Tweet G is 43 minutes earlier than Tweet A: the original rumor tweet. Since Tweet G was posted earlier than Tweet A, and the content is quite similar, we presumed that Tweet G was the seed of the original rumor (*rumor seed tweet*). There are notable expression changes between the rumor seed tweet and the original rumor tweet: (1) the content concerning the “Shinkansen” (Japanese superexpress) in the seed rumor was omitted in the original rumor (leveling); (2) the expression “water solution” was changed into the more intense “harmful material” (sharpening); (3) references to clouds, umbrellas, and raincoats were added (adding); and (4) the text of the original rumor was more focused on the central theme of the rumor—that

rainfall contained harmful material—than the seed rumor (assimilation). In short, all four types of expression change in rumor occurred from the seed rumor to the original rumor.

Tweet H (03-11 19:02:19, directive)

[Please share] Cosmo Oil in Itsui, Chiba prefecture exploded. Rain with harmful material (danger to the body) is falling due to the fire fighting. The air is also harmful. Kawasaki iron mill, too. Please don't go out except when necessary. It is dangerous to be within a 20 km radius of the explosion. (6RT)

Expression changes did not only occur from the seed rumor to the original rumor. Tweet H was posted after the original rumor tweet. References to umbrellas and raincoats were omitted from Tweet H (leveling), while references to a different danger zone, the potential harm caused by the air, and a description of the breadth of the danger zone were added (adding). The text of Tweet H is unified, as with the original rumor; however, Tweet H took a slightly different focus due to its differing context (sharpening).

Tweet I (03-11 21:13:36, authenticating)

[According to Chiba TV] I heard that the Cosmo Oil fire in Ichikawa city is safe because there are no leaks of toxic gas or harmful material. I saw the tweet "rain with harmful material is falling", but there are no such reports. (11RT)

As Tweet E shows, the first *diffused* deny tweet was posted 16 hours after the original rumor tweet. However, the first *nondiffused* deny tweet was posted about 1 hour later. Tweet I, a deny tweet with an authenticating statement, was posted about 2 hours later.

Tweet J (03-11 21:07:31, directive)

Although I do not know whether it is true or false, I heard that rain with harmful material is spreading. Prevent your skin from being exposed to rain with a raincoat or an umbrella. (0RT)

While one of the features of the *diffused* rumor tweets was that there were very few neutral tweets (Table 2), there were several neutral tweets among the *nondiffused* rumor tweets. These tweets often withheld judgment about the truth of the rumor and attempted to maintain neutrality just in case, even when they experienced doubt (Tweet J).

Tweet K (03-11 23:30:01, sense-making)

I don't want this tweet to be shared. If purified oil or LPG is burning only CO2 and water will be made. Even in the case of incomplete combustion, no harmful material will be made. RT [Forwarding] (original rumor text). (0RT)

Tweet L (03-11 20:57:59, interrogatory)

What is the information source for the tweet: "rain with harmful material is falling"? (0RT)

Tweet M (03-11 20:11:32, emotional)

I'm scared ... (original rumor text). (1RT)

In terms of statement type, we observed very few sense-making and interrogatory statements and no emotional statements among the *diffused* rumor tweets (Table 3). However, all the three types of statements were observed among the *nondiffused* rumor tweets. In Tweet K, the user rebutted the

rumor using his/her knowledge of chemistry. Many users also questioned the source of the information of the original rumor tweet (Tweet L). In Tweet M, the user expressed his/her fear on the rumor text straightforwardly.

5. Discussion

We assumed that rumor is a kind of collective sense-making and investigated tweet data about the Cosmo Oil rumor during the Great East Japan Earthquake in 2011 in order to clarify the pattern of expression changes over time and sense-making process of rumor on Twitter. In this section, we summarize our findings based on the three research questions.

Arguably, the most notable finding of this study is that both the pattern of expression change and the sense-making process of rumor differed substantially between *diffused* and *nondiffused* tweets (RQ3; Table 4). For *diffused* tweets, almost the entirety of the original rumor text or core rumor text was quoted in downstream tweets. This resulted in little expression changes, except for adding to the original text. On the other hand, all four types of expression change were observed in *nondiffused* tweets: leveling, adding, sharpening, and assimilation (RQ1).

Similarly, there seems to be no collective sense-making process in *diffused* tweets; attitudes to the rumor were only affirm or deny, and very few were neutral. Furthermore, very few sense-making statements and interrogatory statements, and no emotional statements were made. This pattern can be interpreted as a generally positive attitude towards rumor at the early stage. However, the pattern changes entirely once an official information source transmits accurate information. This pattern resembles the often passive audiences of mass media. The patterns in the *nondiffused* tweets are the opposite: various types of statements were observed, including sense-making, interrogatory, and emotional (RQ2). Users raised various questions and offered their thoughts on solving the problem, regardless of whether they believed the rumor to be true or false. This type of interaction exactly corresponds to a collective sense-making process. Users also easily expressed their rumor-related feelings of anxiety.

The question is, why is there such an enormous difference in patterns on Twitter? One of the reasons why certain tweets are *diffused* and *nondiffused* is follower distribution on Twitter. Since follower distribution on Twitter is largely skewed [1], hubs (users who have a much larger number of followers than ordinary users; e.g., president Trump or celebs) can influence the diffusion process of tweets. According to the survey report by Impress Corporation [17], Japanese Twitter users had an average of 54.4 followers in 2011, and 0.9% of Japanese Twitter users had more than 1,000 followers. Yasuda [18] analyzed the Cosmo Oil rumor tweets data and suggested that retweets by minihubs (twitter accounts with 1,000 or more followers) or hubs (twitter accounts with 10,000 or more followers) were critically important for the spread of rumor tweets, especially at the early stage of their diffusion. Further, she inferred that the hubs did not necessarily have the ability to discriminate truth from false rumor, as the hubs (e.g. fashion models or artists) were not specialists or authorities.

In this research, Tweet F was posted by the Urayasu City Hall account, which had 14,408 followers in 2011. However, while the account that first posted Tweet E had a small number of followers (389 followers in 2018), one of the accounts that retweeted Tweet E was a hub with a significantly greater number of followers (16,973 followers in 2018). Therefore, in the case of Tweet E, the hub seemed to enhance the diffusion of the tweet.

Since information sharing on Twitter tends to be motivated by reputation and efficacy [19], it seems plausible that hubs—whose tweets will be read by many strangers—would be more conscious of the content of their retweets than would ordinary users. Questioning (interrogatory), considering (sense-making), and being open to both pros and cons (neutral) are important factors in the collective sense-making process; however, these types of tweets seem to be avoided by hubs' followers, perhaps because of their high information processing load, especially during disasters. Hence, hubs on Twitter would be more likely to retweet a mere fact or conclusion than part of a complex and ambiguous sense-making process. If this interpretation is correct, the rarity of sense-making statements on Twitter is not only because of the 140-character limit for tweets, as suggested by Oh et al. [10], but also because of the role of hubs similar to opinion leaders in the two-step flow of communication [20, 21] or gatekeepers [22].

Twitter, at least in the information spaces composed by *diffused* tweets, does not seem suitable for dynamic collective sense-making. Rather, it seems more suited to exchanging static information during crises. The reason for the few expression changes in *diffused* tweets could be explained by this idea as well. Once a tweet attains the position of a *diffused* tweet, it becomes a kind of standard. The flood of modified tweets of these standards would confuse ordinary users, therefore hubs would be motivated to avoid to retweet them. Within such an information space, even if an ordinary user offers a significant question, useful insights, or expert knowledge, their information would be filtered by hubs and would not reach a broader audience. Instead, they would be buried in the flood of disaster-related information.

6. Conclusion

This study sheds light on the difference in expression changes between *diffused* rumor tweets and *nondiffused* rumor tweets during the Great East Japan Earthquake in 2011. The contrast between the few expression changes in *diffused* tweets and the many such changes in *nondiffused* tweets implies the existence of information filters on Twitter, namely, hubs.

However, there are still some limitations in this study. First, this study analyzed the data of only one rumor case on Twitter during a disaster. These findings should be further validated and replicated for other cases. Second, the classification criteria for *diffused* and *nondiffused* should be checked. The operational criteria in this study—over or less than 100 retweets—might be inappropriate. Third, the analysis of the *nondiffused* tweets should involve more than merely selecting example tweets. Indeed, we should analyze the *nondiffused* tweet data as a whole. Finally, because we did not have user

TABLE 4: Difference between *diffused* and *nondiffused* tweets.

	Expression change	Attitude	Statement type
Diffused	Small	Affirm/Deny/Very few neutral	Very few sense-making/interrogatory/emotional statements
Non-diffused	Large	Affirm/Deny/Several neutral	Several sense-making/interrogatory/emotional statements

network data on Twitter nor hubs' psychological motivation for retweets, we could not examine the gatekeeping role by hubs.

The more our daily communication depends on social media platforms including Twitter, Facebook, Instagram, etc., the more their influence will increase. The perspective that hubs influence not only which tweet is diffused but also which type of discourse emerges as a result can provide further insight into the dynamics of rumor discussion on Twitter. Further, our research perspective may be applicable not only to rumors but also to other types of communication, both on Twitter and other social media platforms.

Data Availability

The tweet data used to support the findings of this study have not been made available because the authors agreed about the terms and conditions stipulated by Twitter Japan, which have restricted the data set to be redistributed.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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