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Social Roles and Consequences in Using Social Media in Disasters: a Structurational Perspective

Fang Liu[1] · Dongming Xu[1]

Abstract Disaster management officials, as well as the general public, are increasingly using social media to communicate. Such usage has resulted in new and emergent social consequences for disaster management and has reformed the roles of its relevant stakeholders. However, the existing literature on social media use in disasters is still preliminary and incomplete, and does not capture the change in social roles that stakeholders have taken and the consequences of the actions that people take in using social media. In this paper, by using Structuration theory as a meta-theory and by analysing the posts and comments in three officials' Facebook fan pages in three different disasters, we theorize the social structures (i.e., social roles and social consequences) and the human actions taken by both the public and the disaster management officials during disasters. Furthermore, we explain how the social structures emerge out of the human actions involved, and how the social structures further shape those actions. Our research provides theoretical and practical insights into how the usage of social media in disasters benefits disaster management and reinforces the roles of the different stakeholders.

Keywords Disaster management · Facebook · Structuration theory · Social media

✉ Dongming Xu
d.xu@busienss.uq.edu.au

Fang Liu
f.liu@business.uq.edu.au

[1] UQ Business School, The University of Queensland, St Lucia, QLD 4072, Australia

1 Introduction

Various disasters such as earthquakes, tsunamis, cyclones, landslides and catastrophic accidents pose an ever-present challenge to disaster management. In coping with such disasters, social media, such as Twitter, or Facebook (FB), has been increasingly used by both the public and disaster management officials (Lindsay 2010; Hughes and Palen 2009; Kaewkitipong et al. 2016). For example, to better help people cope with disasters, Facebook has developed the "Safety Check" feature that allows people in a disaster area to confirm that they are safe. After the Paris attacks in 2015, about 4.1 million people used this feature in the first 24 h (Peterson 2016); Twitter is also widely used – after Hurricane Sandy in 2012, 52.55 million related messages from 13.75 million unique users were posted on Twitter (Kryvasheyeu et al. 2016).

Because disaster situations are non-routine situations, when people use social media in disasters, they tend to "improvise", which brings new and emergent online behaviours (Sutton et al. 2008). Such behaviours have resulted in new and emergent social consequences of disaster management (Sutton et al. 2008). For example, by using social media, the levels of community members' negative emotions evoked by the disasters can be reduced (Nan and Lu 2014). At the same time, the use of the social media can re-arrange the roles of stakeholders in disasters (Sutton et al. 2008; Kaewkitipong et al. 2012). By understanding the social consequences and the social roles resulting from using social media in disasters, we can provide insights into how to effectively use social media in disasters to better facilitate disaster management.

Many extant studies have noted and discussed the new behaviours that have emerged after the wide adoption of social media in disaster contexts (e.g., Nan and Lu 2014; Sutton et al. 2008; Kaewkitipong et al. 2012). However, most of these

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studies are exploratory and descriptive (e.g., Sutton et al. 2008; Bruns et al. 2012), and very few recent studies provide theoretical accounts of how social media has been used to shape disaster response (e.g., Tim et al. 2016). As we will explain in the following sections, these works are still incomplete in their understanding of the influence of social media on disaster response.

To provide a more complete theoretical account in this paper, we seek to answer the following research question: *what are the social structures,* i.e., *social roles and social consequences, created or reproduced by using social media during disasters?* We focus on two types of social structures – the social roles of disaster management officials, and the public and social consequences of using social media during disasters. Specifically, social roles emphasize the sum of the behavioural expectations that pertain to a particular category of people (in this paper, either the public or disaster management officials) (Callero 1994; Chandola et al. 2007); while social consequences are the social benefits or changes which result from using social media in disasters (Dijkers et al. 2000; Kiarie et al. 2010), where such benefits or changes may or may not pertain to a particular group of people. In many cases, social roles can be treated as types of social consequences (Orlikowski and Robey 1991), while in this paper, we distinguish between social roles and social consequences. By doing so, we can not only explain the general social structures created or reproduced by using social media in disasters; we can also explain the social structures that pertain to a particular group of people, so that we can provide tailored insights for different group of people.

We refer to Structuration theory as a meta-theory to guide our research. From a Structurational perspective, human actions on social media in disasters produce and reproduce social consequences and social roles in disasters (Orlikowski and Robey 1991). In this paper, we focus on the human actions that are taken by both the public and the disaster management officials, who play important roles in creating and reproducing social structures in disasters (Kaewkitipong et al. 2016).

To identify these human actions, we collected and analyzed posts and comments in three official's Facebook fan pages during three different disasters. We analyzed three different cases to enable a broader exploration of the research questions and theoretical elaboration (Eisenhardt and Graebner 2007). The data analysis involves both automatic coding and manual coding. In the automatic coding phase, text mining techniques helped to automatically identify the human actions of both the public and the disaster management officials. Manual coding was conducted to confirm, adjust, and enrich the results achieved by the automatic coding. We then aggregated the human actions into overarching dimensions to build a theoretical model, which we believe will contribute to disaster management research and practice.

In the following sections, we first review the literature relating to the use of social media in disasters and introduce our theoretical foundation – Structuration theory. Then, we describe our research method and findings. We conclude the paper by describing the theoretical and practical implications of this study.

2 Literature on Social Media Use in Disasters

A disaster is a "serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources" (National Science and Technology Council 2005). Such contexts demand that the technologies "have a high level of agility and responsiveness to respond to uncertain situations" (Park et al. 2015). Social media is one type of such technology that can potentially facilitate quick and effective disaster response (Tim et al. 2016).

Given the wide adoption of social media and the increasingly important role social media has played during disasters in recent years (Fraustino et al. 2012), many studies have begun to focus on the use of social media in disasters. One line of research takes a "design science" approach to develop new processes or techniques to facilitate the use of voluntary or geographic information posted online in disasters for disaster management (e.g., Ostermann and Spinsanti 2012; Horita and Albuquerque 2013; De Albuquerque et al. 2015; Bunker et al. 2015; Cheong and Lee 2011). The design science research provides practical approaches as to how to utilize information, especially the geographic information posted online in disasters.

The other line of research takes a "behavioural research" approach – the approach we take in this paper; however, this line of research is still at a preliminary stage (Tim et al. 2016; Ling et al. 2015). Most of those studies are descriptive; i.e., these studies seek to capture the type, the number, and the characteristics of posts about a disaster (e.g., Hughes and Palen 2009; Starbird et al. 2010; Vieweg et al. 2010; Bruns et al. 2012; Qu et al. 2009; Oh et al. 2011), or the types of online behaviours involved, such as re-tweeting, resourcing, brokering, or list building (Starbird et al. 2010; Vieweg et al. 2008; Sutton et al. 2008). These studies provide indispensable basic data concerning the different ways in which social media is used in disasters (Spector 2001).

However, we have found only a few recent studies that focus on providing theoretical accounts of the ways social media is used to shape disaster response, which are summarized in Table 1.

As shown in Table 1, rather than theorizing the social consequences or social roles resulting from using social media in disasters, Pan et al. (2012) emphasize the information flow on

Table 1 Studies which theorize how social media changes disaster response

	Disaster	Theoretical foundation	Key findings
Pan et al. (2012)	2003 SARS crisis, 2004 Sri Lankan Tsunami, 2005 Hurricane Katrina, 2008 Cyclone Nargis	Information Flow and Information Networks	Four information network structures were identified: information star, information pyramid, information forest, and information black-out.
Nan and Lu (2014)	2008 Sichuan Earthquake	Complex Adaptive Systems Theory	Message content dynamics, actualized IT affordance dynamics, and feedback loop dynamics jointly produce the orderly phases.
Ling et al. (2015)	2011 Thailand flood	Empowerment	Social media enable communities to attain collective participation, shared identification and collaborative control through structural, resource, and psychological empowerments.
Tim et al. (2016)	2011 Thailand flood	Boundary Object	Social media was enabled by the communities to serve as a compendium of information, a channel of intercommunication, and a catalyst of immersion
Kaewkitipong et al. (2016)	2011 Thailand flood	Socialization Theory and Structuration Theory	Social media produce the structures of legitimacy, dominance, and significance before, during and after a disaster.

social media, while Nan and Lu (2014) emphasize the sequence of phases produced by self-organized actions and interactions. The works of Ling et al. (2015) and Tim et al. (2016) capture the roles of social media and the results enabled by these roles, but their work only accounts for how the general public use social media. Disaster management officials also play important roles in disasters by using social media (Kaewkitipong et al. 2016). Although Kaewkitipong et al. (2016)'s work seeks to capture the social structures resulting from using social media in disasters, their focus is only on the social structures relating to the direction and intensity of information flow, and they only generally conclude that the structure of domination was produced in the disaster response phase.

In summary, the existing studies either did not adequately theorize the social consequences or social roles resulting from using social media in disasters, or did not identify and consider the various ways social media was used by both the public and disaster management officials. Therefore, we need to provide a more complete view of the social structures created or reproduced by using social media in disasters, including both the social consequences and the social roles. And we need to account for two types of stakeholders – both the public and the disaster management officials.

3 Theoretical Foundation

The theoretical foundation of this paper is Giddens' Structuration theory (1984). Giddens (1984) describes Structuration theory as a meta-theory, which can be used as a basis for a high level of abstraction to guide our theoretical analysis (Gregor 2006). We adopt Structuration theory as our theoretical foundation because Structuration theory can

capture the ways in which the social structures are produced and reproduced when people use social media to communicate in disasters.

Specifically, Structuration theory establishes associations between social structures and human actions. According to Structuration theory, human action is the "capacity to make a difference" (Giddens 1984 pp. 14), and social structure is defined as "rules and resources recursively implicated in social reproduction; institutionalized features of social systems have structural properties in the sense that relationships are stabilized across time and space".

Figure 1 is a simple representation of Gidden's Structuration theory (Vyas et al. 2016). Structuration theory suggests that the process of structuration involves three realms, in which social structures and human actions are considered as two sides of one whole. On one hand, social structures can constrain and enable human actions. On the other hand, human actions have a transformative capacity that can produce and reproduce social structures. Specifically, human actions take place under certain conditions (the middle realm/modalities of structuration), such as interpretive mechanisms, power, and norms. Under these conditions, human actions can create, reinforce, or reproduce social structures, such as traditions, institutions, moral codes, and established ways of doing things.
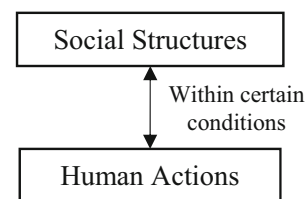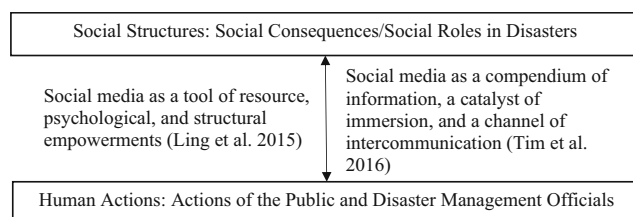

Fig. 1 A simple representation of Gidden's structuration theory (Vyas et al. 2016)

Information Systems researchers have drawn on Structuration theory to gain insights into IS phenomena. Early examples include Barley's (1986) study of the implementation of identical technology by different officials, Orlikowski's (1992) case study of the development and use of Computer-Aided Software Engineering tools, and Walsham and Han's (1993) study on IT strategy implementation. In recent years, Structuration theory has been used to explain social structures and the structuration processes in developing and implementing e-government initiatives (Devadoss et al. 2002; Puron-Cid 2013), and implementing ERP systems (Furumo and Melcher 2006).

Among the three realms involved in Structuration theory, information technology (i.e., social media) occupies the central realm of the structuration process (Orlikowski and Robey 1991). The works of Ling et al. (2015) and Tim et al. (2016) can fit in the central realm (See Fig. 2), because their works explain the role of social media in disasters. Specifically, Ling et al. (2015) focused on social media's roles of empowerment – a mechanism by which a community gains mastery over its affairs. They theorized three types of empowerments: resource, psychological, and structural empowerments, and explained how social media enables the community to attain collective participation, shared identification, and attain collaborative control through the three empowerments. Tim et al. (2016) argued that social media can serve as a compendium of information, a catalyst of immersion, and a channel of intercommunication in three phases after a disaster (1. readiness and rescue, 2. rescue and relief and 3. relief and recovery).

However, to only focus on the central realm is not enough for understanding social media use in disasters, because according to Structuration theory, social media itself cannot determine social structures because it is external to human actions (Vyas et al. 2016). Instead, social structure can only be created or reproduced through human actions or practice (Orlikowski 2000, 1992), while social media acting as an objective set of conditions, rules, or resources mediates (facilitates and constrains) human action, thereby contributing to the production and reproduction of social structures (Orlikowski and Robey 1991).

As noted earlier, Kaewkitipong et al. (2016) conducted a study that captured the social structures created by using social media before, during, and after the disaster. While Kaewkitipong et al. (2016)'s work seeks to capture all three realms in Structuration theory, they treat social media as a knowledge sharing tool only, and their focus is on the social structures relating to the direction and intensity of information flow between the public and disaster management officials. They only generally concluded that the structure of domination was produced in the disaster response phase. However, besides the structure of domination, other social structures may be created and reproduced, because social media can be used for purposes other than the mere sharing of information, and can have many other influences on disaster response. For example, social media can be used to convey emotions in disasters (Nan and Lu 2014). As a result, to provide a more complete view of social media use in disasters from a structurational perspective, in this paper we seek to explain the creation and the reproduction of two types of social structures: social consequences of using social media in disasters, and social roles of disaster management officials and the public.

4 Research Method

Because the nature of our research topic requires a qualitative approach, we chose an interpretive case study as an appropriate method (Devadoss et al. 2002). An interpretive case study seeks to produce an understanding of the context of the information, and the process whereby the information systems influence, and are influenced by, the context (Walsham 1993). We conducted our case study by collecting and analyzing the posts and comments in three disaster management official Facebook pages concerning three different types of disasters. In this section, we first introduce our data source, followed by an explanation of how we analyze the datasets. The data analysis procedure involves both text mining techniques and manual coding.

4.1 Data Collection

As shown in Table 2, the three disasters that we chose to examine occurred in the last three years (Houston Flooding 2015, North Stradbroke Island Bushfire 2014, and Boston Marathon Bombing 2013) to ensure that our results were not unduly swayed by the nature of any specific disaster. For details of the three disasters, see Table 3. We collected posts and comments from Facebook fan pages of three officials who were responsible for disaster management in these disasters. We chose the posts and comments on Facebook fan pages as our data sources, because such data can reveal behaviours of both disaster management officials and the public – after a disaster, disaster management officials can post updates and

Social Structures: Social Consequences/Social Roles in Disasters

Social media as a tool of resource, psychological, and structural empowerments (Ling et al. 2015)	Social media as a compendium of information, a catalyst of immersion, and a channel of intercommunication (Tim et al. 2016)

Human Actions: Actions of the Public and Disaster Management Officials

Fig. 2 A simple representation of the proposed model and literature on roles of social media

Table 2   Types, search terms, and the time period for data collection

Disasters	Fan page of official	Data collection time period	Number of posts and comments		
			Officials	The public	Total
Houston Flooding 2015	City of Houston Office of Emergency Management	8–31 May, 2015	117	68	185
North Stradbroke Island Bushfire 2014	Redland City Council	30 December, 2013–14 January, 2014	235	889	1124
Boston Marathon Bombing 2013	*Boston Marathon*	15–20 April, 2013	23	16,325	16,348

answer the public's requests through their Facebook fan pages while the public can also post messages and comments on these fan pages.

From the number of posts and comments shown in Table 2, we can see that the datasets show different patterns. After the Boston Marathon bombing, we found that 16,325 of the posts and comments were from the public. The public generated such a large number of posts and comments, because the public was "on edge" after this terrorism event. In the Boston Marathon bombing dataset, only 23 posts and comments came from the disaster management officials, less than from the other datasets, because the flooding and the bushfire disasters lasted for a few days and the officials continuously sent messages online to provide ongoing updates. In the dataset of the North Stradbroke Island Bushfire, although the number of posts and comments from the public was also larger than that of the officials, the number of posts and comments from the officials was largest among the three datasets (the number was 235). This was because after the bushfire, the officials also actively posted updates and responded to the public's comments. However, in the dataset of the Houston Flooding, there were more posts and comments from the officials than from the public. As a result, we have the potential to capture the variety of patterns established by both the disaster management officials and the public by analyzing these three datasets.

4.2 Data Analysis

We analyzed our case study data based on thematic analysis, identifying patterns and themes in the data (Given 2008). Our research questions and research aim are used to guide the process of thematic analysis. This consists of interpreting the data in the three datasets and triangulating the results for the three datasets before drawing final conclusions.

The interpretive case study method is effective for analyzing human actions (Walsham 1995), which is one of the three realms in Structuration theory (Orlikowski and Robey 1991). However, the separation of the three realms in Structuration theory is purely for analytical convenience (Rose 1998). In practice, the three realms are closely linked (Devadoss et al. 2002). Through analyzing human actions revealed by our disaster data, we can then identify the social roles and social consequences produced and reproduced by these human actions.

Because our aim is to identify and explain the phenomena from perspectives of both disaster management professionals and the public, the first step we took in analyzing the data was to divide each of the three datasets into two sub-datasets based on whether the sender of the posts/comments was an official or the public. We then proceeded to perform the thematic analysis for each sub-dataset.

Table 3   Descriptions of the three disasters

Disasters	Descriptions
Houston Flooding 2015	A slow-moving storm system dropped tremendous precipitation across much of Texas and Oklahoma during the nights of May 24–26, 2015, triggering record-breaking floods. During May 25–26, nearly 11 in. (280 mm) of rain fell near Houston, setting off further flash floods. In Houston, at least 2500 vehicles were abandoned, when drivers had to seek higher grounds, and four people lost their lives.
North Stradbroke Island Bushfire 2014	North Stradbroke Island is an island that lies in Moreton Bay in the Australian state of Queensland. On December, the 29th, 2013 at around 6:30 pm, a fire broke out on one side of the island. It was believed to be caused by a lightning strike. During the bushfire disaster, about 60% of the island's bushland was consumed by bushfires, which led to the evacuation of nearly 900 campers on New Year's Day, 2014. No life or property was lost.
Boston Marathon Bombing 2013	The Boston Marathon bombings took place on April 15, 2013, when two pressure cooker bombs exploded during the running of the race at 2:49 pm EDT, killing three people and injuring an estimated 264 others. The bombs exploded about 12 s and 210 yards (190 m) apart, near the finish line on Boylston Street.

Given the volume of the datasets we conducted a two-phase data analysis. In the first phase, we used text mining techniques to automatically code the data and identify actions of both the public and the disaster management officials in all of the three datasets. In the second phase, we manually coded the data to confirm, adjust, and enrich the results we had derived in the first phase of the analysis.

To be more specific, in the first phase of the data analysis, we used a computer-aided tool – Leximancer – to do the automatic coding. Leximancer was first developed and released in 2000 by the Key Centre for Human Factors and Applied Cognitive Psychology at the University of Queensland, Australia (Martin and Rice 2007). Leximancer helps identify, classify, and map key themes and ideas embedded in text-based data (Smith and Humphreys 2006). The approach that Leximancer uses differs from standard content analysis approaches, because in Leximancer, particular word strings are not required; instead, Leximancer identifies which concepts exist in a set of texts, allowing concepts to be automatically coded in a grounded fashion (Cretchley et al. 2010), and allows meaningful themes to be automatically identified based on the occurrence of concepts in text segments (Smith and Humphreys 2006). Leximancer has been used for qualitative data analysis in academic research settings in business and management studies, in social and cultural studies, and in education research (e.g., Crofts and Bisman 2010; McKenna and Rooney 2012; Zaitseva et al. 2013). We chose Leximancer, because Leximancer is an effective tool for recognizing themes, including themes which might otherwise have been missed or overlooked had we manually coded the data.

To extract the key themes emerging from the data, Leximancer first identified the initial concepts based on the word's occurrence. After the initial concepts were identified, we discarded irrelevant words to minimize noise in the data. Then, based on the initial concepts, Leximancer generated the concept map. Concepts that co-occur within the same two-sentence coding block attract one another strongly when the map is clustered, so that similar concepts tend to settle together in close proximity (Cretchley et al. 2010). Clusters of concepts are grouped by themes to summarize the main ideas in particular clusters. In other words, a theme is a group or cluster of concepts that share certain commonalities as identified by their close proximity on the Leximancer Concept Map (Leximancer 2011). Each theme is automatically named after the most prominent concept in that group, while the researcher can re-name themes when appropriate (we re-named some of them, as discussed later).

The reliability of our study's results was achieved by adjusting the number of themes that Leximancer can produce. With several iterations, the number of the themes was optimized. Such iterations help ensure that the themes in the concept maps remain stable and saturated. The stability and saturation were indicated by the consistency of the themes and the fact that no further themes emerged.

In the second phase, we first interpreted and re-named the themes automatically generated in Leximancer by reading the posts and comments in each theme. The names of the themes automatically generated in Leximancer were taken from the most frequently appearing concept in each theme (Leximancer 2011). Typically, the name is one or two words. Such simple words cannot accurately reflect the human actions underlying each theme. For instance, the themes are named as Storm/Flooding/Warning, which do not convey the meanings of who is doing what in this disaster. We therefore interpreted and re-named the themes by identifying the human actions the themes reflect. As we will show in the findings section, some themes identified by Leximancer reflect the same human action; we therefore combined these themes together. The process of re-naming also involves the triangulation among the results from all sub-datasets – we seek to find the names that can reflect the common actions the public or the disaster management officials took in the three different disasters.[1]

The next important aim in the manual coding phase is to identify human actions that were not captured in the automatic coding phase. We manually coded all posts and comments in these sub-datasets for the bushfire and flooding disasters because the posts and comments were less than 1000. For the posts and comments from the public in the Boston Marathon Bombing dataset, we randomly selected 1000 messages to code.

We paid special attention to the interaction between the public and the disaster management officials, as revealed in the datasets in the manual coding. In the first phase, we ran automatic coding in Leximancer for sub-datasets of the public and disaster management officials separately, which was unlikely to reveal the interactions between the public and the disaster management officials. As we showed in the next section, in the manual coding phase, we identified several human actions that had not been revealed by Leximancer.

Based on Structuration theory, social structures (including social consequences and social roles) and human actions were considered separately for interpretation purposes (Orlikowski and Robey 1991). After we identified human actions in automatic and manual coding, we then aggregated the human actions into overarching dimensions that made up the bases of the emergent social roles and social consequences that resulted from using social media in disasters. We conducted several iterations until no additional theoretical dimensions could be identified (i.e., we had reached theoretical saturation). We then built a model to explain how using social media in disasters

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[1] When we report the findings in the following section, we report both the name automatically generated by Leximancer and the name of the human actions we re-named in the manual coding phase.

produces and reproduces social consequences and social roles. In the following section, we report our findings, including the human actions we identified in the coding processes and a model of social media use in disasters.

5 Findings

In this section, we first describe the human actions identified in the data analysis. We then propose a model of social media use in disasters from a structurational perspective. This explains how social roles and social consequences are produced and reproduced through using social media in disasters.

5.1 Human Actions

We first present the actions of the disaster management officials. We then present the actions of the public.

5.1.1 Actions Taken by Disaster Management Officials

Four types of actions of the disaster management officials emerged from the data analysis: (1) providing official situational updates, (2) providing advice for local victims, (3) providing information on recovery processes, and (4) responding to victims' questions/ requirements.

Table 4 summarizes the four types of actions and provides example quotes based on each type of action in the three disasters. As noted in the section 4.2, most of the actions were identified based on the themes identified in automatic coding, and re-named based on manually analyzing posts and comments for each theme. In Table 4, we also provide the original name of the themes identified by Leximancer.

First, the disaster management officials provided situational updates on social media during the disasters. This type of action is the most common and basic for disaster management officials. Using their Facebook page, disaster management officials sought to inform the public about the progress of the disaster. As shown in Table 4, in the dataset of Houston Flooding 2015, three themes identified in Leximancer reflect this action – *storm, flood,* and *warning*. It indicates that the City of Houston Office of Emergency Management used their FB page to send warnings information about the storm and flood to the public. In the dataset of Stradbroke Island bushfire 2014, one theme identified in Leximancer reflects this action– *fire*. It indicates that the Red City Council used their FB page to inform the public about the developments of the bushfire, e.g., the wind pushed smoke of the fire towards the southern Moreton bay islands. In the dataset of the Boston Marathon Bombing 2013, one theme identified in Leximancer reflects this action – *events*. It indicates that the Boston Marathon officials used their fan page to send updates about this negative event to the public.

Second, the disaster management officials provided advice for local victims on social media. Different from providing official situational updates, which aims to inform the general public, disaster management officials also use their FB page to provide tailored information or advice for location victims on safety, and how best to act and recover from the disaster. As shown in Table 4, in the dataset of Houston Flooding 2015, one theme identified in Leximancer reflects this action – *Houston*. It indicates that the City of Houston Office of Emergency Management used its FB page to provide advice to people in Houston, e.g., they advised local people to stay at home. In the dataset of Stradbroke Island bushfire 2014, two themes identified in Leximancer reflect this action – *water* and *news*. It indicates that the Red City Council used their FB page to provide advice on how to use water and how to find news about the fire. In the dataset of Boston Marathon Bombing 2013, one theme identified in Leximancer reflects this action – *runners*. As runners were the direct victims of the bombing, the Boston Marathon officials used their FB page to inform them as to how to claim their bags and medals.

Third, the disaster management officials provided information on the recovery process on social media. Different from providing official situational updates, which focuses on the process of the disaster itself, the information on the recovery process places more emphasis on the efforts taken by the disaster management officials. Providing information on the recovery process is important, as the victims then can know that the disaster management officials are ready to help and properly care for them in extreme situations. As shown in Table 4, in the dataset of Houston Flooding 2015, one theme identified in Leximancer reflects this action – *recovery*. It indicates that the City of Houston Office of Emergency Management used their FB page to provide information on the process of flood recovery. In the dataset of Stradbroke Island Bushfire 2014, one theme identified in Leximancer reflects this action – *power*. That indicates that the Red City Council provided information on the process of restoring power after the storms on their FB fan page. In the dataset of Boston Marathon Bombing 2013, one theme identified in Leximancer reflects this action – *Boston*. It indicates that the Boston Marathon officials used their fan page to provide the information on the recovery processes about the tragedy in Boston.

Finally, social media was used by disaster management officials to respond to victims' questions/ requirements. This action was identified by manual coding only. In all three datasets, the disaster management officials took efforts to answer the questions or to respond to the requests. They did so by replying to the posts or comments that the public posted on their fan pages. For example, in both the datasets of Houston Flooding 2015 and Stradbroke Island Bushfire 2014, the disaster management professionals responded to the requirement on helping find their loved ones (see Table 3).

Table 4 Actions taken by disaster management officials

Human actions	Disaster	The theme identified by Leximancer	Example quotes
Providing official situational updates	Houston Flooding 2015	Storm/ Flooding/ Warning [updates/ warnings about storm, floods]	"severe thunderstorm warning for southern portions of Houston until: pm http://irws.wrh.noaa.gov/weather/alertinfo/" "flooding expected to continue in humble/kingwood as the san Jacinto drains communities to our north." "flash flood watch until pm for Houston. expect strong storms to cause flooding."
	Stradbroke Island bushfire 2014	Fire [updates about the fire]	"the fire is not threatening any properties and is burning within containment lines. The fire is causing a large smoke haze, with a south-easterly wind pushing smoke towards the southern Moreton bay islands." "smoke - as a result of the large fire, smoke can be expected to affect areas from the sunshine coast to gold coast."
	Boston Marathon Bombing 2013	Events [updates about the tragic events]	"Executive director of the Boston athletic association Tuesday, April 16, 2013 The Boston athletic association (B.A.A.) extends its deepest sympathies to all those who were affected by Monday's tragic events."
Providing advice for local victims	Houston Flooding 2015	Houston [advice for people in Houston]	"The city of Houston wants you back in your home we are here to help you determine how best to rebuild/repair come talk to us! all situations are unique." "flood advisory for much of Houston. http://irws.wrh.noaa.gov/weather/alertinfo/"
	Stradbroke Island bushfire 2014	Water [advice on how to use water]/News [advice on how to find news]	"until we can get the system back up and running we are asking the community to put off any unnecessary outdoor watering from gardening to washing cars over the next few days, particularly given the hotter temperatures and the likelihood we will see an increase in consumption and general water use to stay cool" "fill containers with water - eg bath, sinks, buckets, wheelie bins, etc" "If you are not seeing our posts in your news feed, i would suggest the following:) visit our Facebook page often. You can also follow us on twitter or read our news updates at http://news.redland.qld.gov.au) set up notifications for each time we post on Facebook."
	Boston Marathon Bombing 2013	Runners [advice for runners]	"if you are unable to get to trinity place, baggage is being mailed out upon request, and we will soon announce a procedure to mail medals out as well. we ask for your patience in this process" "Baggage claim is now open on Berkeley street between Boylston street and St. James avenue. All unclaimed bags will remain secure."
Providing information on recovery processes	Houston Flooding 2015	Recovery [recovery processes]	"the city of Houston floodplain management office is working with recovery agencies to provide information about flood recovery and rebuilding. Information on the two sessions scheduled for July 7th can be found below or at Houstonrecovers."
	Stradbroke Island bushfire 2014	Power [recovery processes on power outage]	"Energex crews will start restoring power once the storm activity passes. to report fallen powerlines to Energex call 13 19 62." "primary supplies are still off due to bushfires on Straddie. crews working to restore power to both lines."
	Boston Marathon Bombing 2013	Boston [recovery processes on the tragedy in Boston]	"over volunteers, medical personnel, the organizing committee, and hundreds of thousands along the race route"

Table 4 (continued)

Human actions	Disaster	The theme identified by Leximancer	Example quotes
Responding to victims' questions/ requirements	Houston Flooding 2015	NA (identified by manual coding)	"We are cooperating with the city of Boston, the commonwealth of Massachusetts, and all federal law enforcement officials." "Patricia - If he was in Houston and you need to report him missing, you can contact the Houston Police Department at ..." "Thanks Sara - we've got Houston 311 looking into the issue with the form. It's working some of the time, but we're working on making sure it's up all the time. Residents can still report flooding by calling."
	Stradbroke Island bushfire 2014	NA (identified by manual coding)	"Megan, can you please private message us some more information regarding your parents, including an address. If you are concerned about your parents there may be someone who can do a door knock if you are unable to contact them by phone."
	Boston Marathon Bombing 2013	NA (identified by manually coding)	"Yes, come to 40 Trinity Place, just off of Stuart Street."

*We provide additional interpretations for the themes identified by Leximancer in []

5.1.2 Actions Taken by the Public

Five types of public actions emerged from the data analysis: (1) Providing local updates, (2) Providing suggestions for officials, (3) discussing response options, (4) expressing emotions, and (5) expressing gratitude for official work.

Table 5 summarizes the five actions and provides example quotes about each action in three different disasters. Similar to the human actions taken by the disaster management officials, most of the actions were identified based on the themes captured in automatic coding, but we re-named them in the manual coding phase.

First, the public uses social media to provide local updates. By posting what happened in local communities after a disaster on a disaster management officials' FB page, the public can deliver the most recent updates about their local community or their personal issue relating to the disaster to disaster management officials, so that the disaster management officials can respond much more quickly and accurately. As shown in Table 5, in the dataset of Houston Flooding 2015, two themes identified in Leximancer reflect this action – *weather* and *rain*. This theme indicates that the public tried to inform the City of Houston Office of Emergency Management of the real-time weather status and the real-time impacts of the extreme weather. In the dataset of Stradbroke Island Bushfire 2014, two themes identified in Leximancer reflect this action– *Straddie* and *power*. It indicates that the public tried to inform the Red City Council that they were experiencing power outage on Stradbroke Island with the expectation that the government would take action to restore the power supply. In the dataset of the Boston Marathon Bombing 2013, one theme identified in Leximancer reflects this action – *news*. It indicates the public also wanted to deliver some local news to the Boston Marathon officials. This theme also indicates that many people sent messages on social media complaining that TV news and online news about the bombing was slow and unreliable. Such messages can be treated as local updates about the validity of available news. Such updates are very important messages that remind the disaster management officials that they need to check whether their official messages are updated and valid, and that they need to check and correct the misinformation that is widely spread among the public (Veil et al. 2011).

Second, the public uses social media to provide suggestions/feedback to officials. The public seeks to help the officials to better respond to the disaster situations through providing suggestions/feedback to the disaster management officials on social media, which is different from providing local updates on social media that aim to seek help from the disaster management officials. As shown in Table 5, in the dataset of Houston Flooding 2015, this action is identified by manual coding. Specifically, after the City of Houston Office of Emergency Management asked the public to report

Table 5 Actions taken by the public

Human actions	Disaster	Themes identified by Leximancer	Example quotes
Providing local updates	2015 Texas Flooding	Weather/Rain [updates about weather or rain]	"I shared for I lived in Fort Bend County and I have a Cousin who moved down from Michigan to Houston and she has rain damage to her Car, but was on 2nd floor so the apt was OK."
	2014 Stradbroke Island Bushfire	Straddie /Power [updates about power outage on the island]	"Sheldon has been without power for a while: (" "Power returned at midnight. Pretty good, family candle light dinner." "At that same time, there were several fire vehicles in the bush (my daughter said she reckons she saw at least)."
	2013 Boston Bombing	News [local news and updates about news validity]	"Why is their a helicopter circling my neighborhood for the last hour? Minor dr; Holmes, wornal area. Its not marked news or police." "I used CNN and other sources to follow information right after the bombing, and every day I use a feed aggregator that pulls from many news sources. There's so much misinformation coming out on this story that I no longer trust any 'breaking' stories or 'new' information." "I rarely watch TV news because it is so repetitive with headline information, but short on details. Often, as in this case, they are rushing to grab 'the story' without verifying their information with the proper sources. The same applies to online news, especially of fast breaking (or wanna be fast breaking) stories." "Yet another example of the media so ratings hungry that they'll report anything rather than wait for actual facts. It's why I don't watch the news."
Providing suggestions/feedback to officials	2015 Texas Flooding	NA (identified by manual coding)	"The 'fill out a form...' button in this page isn't working"
	2014 Stradbroke Island bushfire	Water [suggestions on water use]	"Starkey street, wellington point has large pieces of bark & lots of leaves in the streets gutters. More so half way down the street. Its blocking drains. Those sweep machines will not do the job. Council need to clean this up so water can flow freely down to the drains. Its only a matter of time til we see a huge downpour of rain. Cheers." "Maybe they should use recycled water for fires?" "or use sea water hello"
	2013 Boston Bombing	NA (identified by manual coding)	"You should give everyone who was still in the race, but forced to stop running a medal they earned it!" "Just an idea. Those injured should receive Boston marathon survivor medals. And those three taken should receive a Boston marathon statue of lifetime devotion."
Discussing response options	2015 Texas Flooding	Evacuation [discussions about evaluation]	"'run from water, hide from wind.' if you're not in an evacuation zone, stay off the road so others that have to evacuate can get to safe ground"
	2014 Stradbroke Island bushfire	NA (identified by manual coding)	"I just wanted to offer if there are any residents of straddie that need somewhere on the mainland to stay or need their pets looked after safely they are more than welcome at our house."
	2013 Boston Bombing	Boston [discussions about how to respond to the tragedy in Boston]	"Check your local running store. The independent running retailers association is sponsoring runs and shirts proceeds go to same fund." "Boston Marathon Relief Fund assists injured and their families! Today was the first day in what may be a long road to recovery for many involved in The Boston Marathon bombings. Through our program, America's Fund, we have set up the Boston Marathon Relief Fund to aid in the recovery of those injured in this attack." "this coming Sunday we'll be running and embracing all the injured and the ones that departed this earth before us in the 4th Run Cabo - Cabo Fitness Club Half Marathon"

Table 5 (continued)

Human actions	Disaster	Themes identified by Leximancer	Example quotes
Expressing emotions	2015 Texas Flooding	Repent [expressing negative emotions]	"*Prayers going up!!!*" "*it's not too late for Texas to repent for their un-godly ways! gods wrath will continue to drown out the sinners of the state of date rape jokes, republicans, and heterosexual marriage!*"
	2014 Stradbroke Island Bushfire	Safe [expressing hope about safety]	"*Hope everyone remains safe on Straddie!*" "*Stay safe, prayers are with you all*"
	2013 Boston Bombing	Prayer [expressing hopes and prayers]	"*You were in our thoughts & prayers!*" "*Our prayers from Mexico. we are really sorry for your loss, wish you can pass this terrible tragedy.*"
Expressing thanks for official work	2015 Texas Flooding	NA (identified by manual coding)	"*Thank you*"
	2014 Stradbroke Island Bushfire	Thank [expressing thanks]	"*Thank you for all your consistent and valued work in keeping us updated. Our sincere appreciation to the Firies SES, Energex, Sibelco and RCC for a heroic effort under trying conditions.*"
	2013 Boston Bombing	Thank [expressing thanks]	"*Thank you for all that you have done and the security provided that kept so many safe.*"

*We provide additional interpretations for the themes identified by Leximancer in []

the impact of the flood on their homes or businesses online, people found that the "fill out form" button was not working and provided this feedback through the Facebook fan page. In the Stradbroke Island Bushfire 2014 dataset, one theme identified in Leximancer reflects this action – *water*. This theme indicates that the public provided suggestions to the Red City Council on how to better utilize water to stop the fire. In the Boston Marathon Bombing 2013 dataset, this action was identified by manual coding only. Specifically, the public suggested that the Boston Marathon officials should provide medals to those who were injured.

Third, the public uses social media to discuss response options. By doing so, the public can help each other work out ways to cope with the disaster, rather than simply relying on the disaster management officials. As shown in Table 5, in the Houston Flooding 2015 dataset, one theme identified in Leximancer reflects this action – *evacuation*; that is, the public used the FB page of the City of Houston Office of Emergency Management to discuss evacuation options. In the dataset of Stradbroke Island Bushfire 2014, this action was identified by manual coding. Specifically, some people sent messages offering shelter to the residents affected by the fire. In the Boston Marathon Bombing 2013 dataset, one theme identified in Leximancer reflects this action – *Boston*. As shown in Table 5, this theme indicates that the public used the FB page of Boston Marathon Management Officials to discuss the relief fund programs for the Boston Marathon bombing.

Fourth, the public uses social media to express emotions. During disasters, people express their feelings of anxiety about, and their support for, those affected by the disasters. As shown in Table 5, in all of the three datasets, the public vent their negative emotions and send their hopes through the FB page of disaster management professionals. The relevant themes identified by Leximancer are *repent, safe, and prayer* respectively.

Fifth, the public uses social media to express gratitude for the work of officials. In particular, after the disaster management officials posted on their FB pages the actions they took to respond to the emergency situations, the public commented to show their appreciation of the roles played by the disaster management officials during the disasters. As shown in Table 5, in the datasets of both Stradbroke Island Bushfire 2014 and Boston Marathon Bombing 2013, themes called "*Thank*" were identified in Leximaner. Although the automatic coding did not identify such a theme in the Houston Flooding 2015 dataset, manual coding revealed that the public also expressed their gratitude on the FB page of the City of Houston Office of Emergency Management.

5.2 A Model of Social Media Use in Disasters: a Structuration Perspective

Figure 3 presents the model that emerged from our data analyses. This model explains social media use in disasters from a structural perspective. As a meta-theory, structuration theory provides a high-level synthesis that reflects the connections between human actions and social structures (Orlikowski and Robey 1991). According to Structuration theory (Giddens 1984), human actions constantly produce and reproduce the social structures. Consistent with Structuration theory, our model involves both social structure (i.e., social consequences and social roles) and human actions (i.e., actions of both the public and the disaster management officials) (Rose 1998).

In the proposed model, the realms of social structures (including social roles and social consequences) and human actions were considered separately for interpretation purposes (Orlikowski and Robey 1991), but in practice, the two realms are interlinked. Therefore, by further analyzing and categorizing the human actions identified in the previous section, we can further identify the social roles and consequences that are produced and reproduced by using social media (Devadoss et al. 2002).

Specifically, as shown in Fig. 3, by using social media, the public and the disaster management officials form and reform two social roles: (1) the public's influences on disaster recovery and (2) The official's dominations over the disaster. They also produce and reproduce three social consequences: (1) situational awareness, (2) emotional relief, and (3) acknowledgment of efforts. The double-headed arrows in Fig. 3 suggest that social roles and social consequences both emerge out

of human actions. At the same time, they also serve to shape future human actions (Orlikowski and Robey 1991).

Social media as modality mediates human actions. As shown in Fig. 3, consistent with Orlikowski and Robey (1991), social media constitutes a central realm in the model. Social media is a set of rules and resources which mediates (facilitates and constrains) human actions, and therefore contributes to the production and reproduction of social structures. As modalities in the central realm, social media does not determine the social structure or human actions. Instead, social media has to be appropriated by humans (DeSanctis and Poole 1994), and it is the actions taken by humans on social media that produce and reproduce the social roles and consequences which arise in disasters. In the following sections, we explain how social roles and social consequences are produced and reproduced via social media in disasters in detail.

5.2.1 Social Roles

As suggested by Structuration theory, social media is a facility that enables stakeholders in disasters, including the public and the disaster management officials, to allocate their resources such as knowledge, expertise, and capabilities, which creates a differential distribution of power and constitutes a system of domination (Kaewkitipong et al. 2016; Orlikowski and Robey 1991). Because of the use of social media, two social roles have been formed and reinforced by disasters: the public's influence on disaster recovery and the officials' dominations over disaster recovery.

Fig. 3 A model of social media use in disasters: a structuration perspective
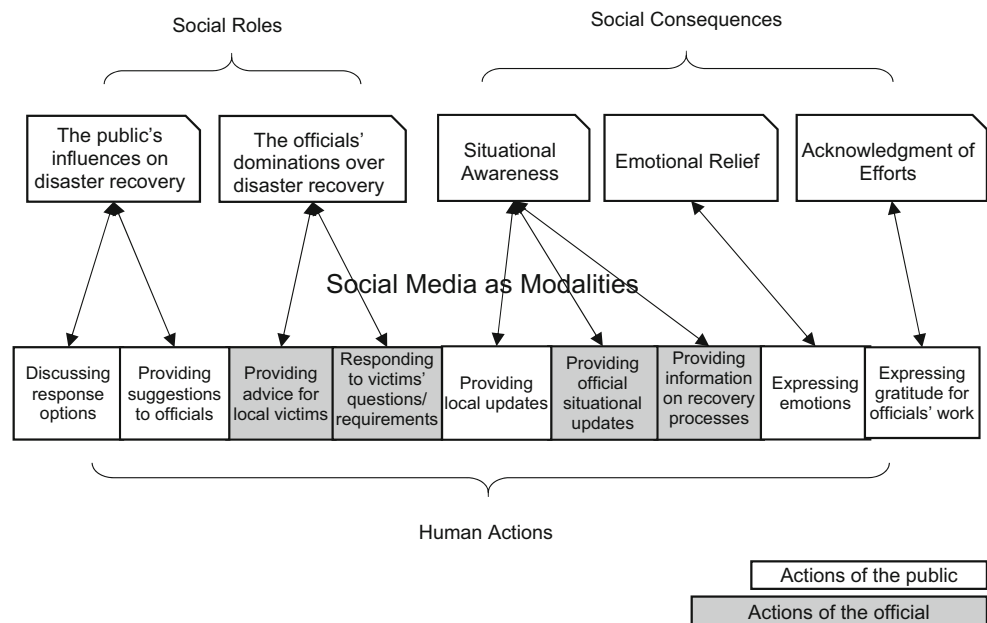
The Public's Influence on Disaster Recovery Traditionally, disaster management officials dominate the disaster recovery process, while social media empowers the public with a new role to actively influence disaster recovery.

As shown in Fig. 3, on the one hand, the public can help each other by discussing response options. When the assistance or information provided by disaster management officials is not enough or late, the information provided by local communities in the affected area can become a useful resource. By discussing response options online, both the public and the victims can utilize collective intelligence to resolve emergent issues and seek relief from the emergent situations (Vieweg et al. 2008; Palen et al. 2009).

On the other hand, the public can also affect the decision making of disaster management officials by providing suggestions or feedback to them on social media, because those people from local communities are more familiar with the current situations in the affected area (Shklovski et al. 2008). Facilitated by social media, people in the affected area can report exactly what they are witnessing. Those posts of local knowledge from the general public can turn into "first-hand news", which can be more reliable and powerful than reports from the mainstream media. By utilizing such local knowledge, disaster management officials are more likely to make better informed decisions. In addition, the public can remind the disaster management officials that the available information may suffer from some validity issues (see the example from Boston Marathon Bombing case above), so that the disaster management officials can take actions to correct misinformation or make official information up-to-date.

In summary, social media enables the general public to wield their power and subsequently produce their influence and domination. This finding is also consistent with the findings in Kaewkitipong et al. (2016). The power or information not only flows from disaster management officials to the victims or the public, with the extensive usage of social media; the power or information can also flow from the public to both the public and the disaster management officials.

In addition, as indicated by the double-headed arrows in Fig. 3, the social role of the public not only emerges out of the actions of the public; it also further shapes the actions of the public – to better wield their power and influence disaster response, the public increasingly discusses response options and provides suggestions for disaster management officials on social media.

The Officials' Domination over Disaster Recovery Although the public takes an important role in disaster recovery by using social media, the disaster management officials still dominate the disaster recovery, and the use of social media reinforces their domination.

Disaster management officials always have greater power than the public, because they have more professional knowledge about disaster management and relief, which has long been recognized as an importance source of power (Pfeffer and Pfeffer 1981). In disasters, social media as a facility can facilitate the distribution of such power so as to affirm the domination of disaster management officials. As shown in Fig. 3, the disaster management officials use social media to provide advice for local victims, and also to respond to victims' questions or requirements. By doing so, the disaster management officials can convey their professional knowledge to the victims. If such professional knowledge was unable to reach victims of disasters in time, the victims might feel that the emergency services have been "keeping people in the dark" (ABC News 2014). That is to say, the domination of disaster management officials cannot be replaced, even though the role of the public in disaster recovery is becoming increasingly important due to the use of social media.

In summary, social media facilitates the power wielding, and further transforms and re-affirms the domination, of disaster management officials. This is also consistent with the findings of Kaewkitipong et al. (2016)). That is, by using social media, the power or information still flows from disaster management officials to the victims or the public. Subsequently, the domination of those disaster agencies can be affirmed and reinforced by social media.

In addition, as indicated by the double-headed arrows in Fig. 3, the social roles of the disaster management officials not only emerge out of their actions. Their roles further shape their actions, to dominate the process of disaster response. The disaster management officials increasingly provide advice for local victims and respond to victims' questions/ requirements on social media.

5.2.2 Social Consequences

Social consequences are the social benefits or changes which result from using social media in disasters (Dijkers et al. 2000; Kiarie et al. 2010). The three social consequences identified as having been produced and reproduced by the use of social media in disasters, include (1) situational awareness, (2) emotional relief, and (3) acknowledgment of efforts.

Situational Awareness As shown in Fig. 3, situational awareness is the state of understanding what is happening in a given event with many actors and other moving parts, and their meaning and the projection of their status in the near future (Endsley 1995; Vieweg et al. 2010). Situational awareness has been recognized as a critical part of making effective decisions for emergency response (Yin et al. 2012). Traditionally, to increase the public awareness of a situation, the disaster

management officials need to contact traditional media to report their updates. The communication channels from the public to the disaster management officials are also limited and inconvenient. It is also difficult for the disaster management officials to be aware of the current situations of those affected by the disaster.

The growing use of social media during disasters reproduces the way in which situational awareness is established. As shown in Fig. 3, two actions taken by the disaster management officials (i.e., providing official situational updates and providing information on recovery processes) and one action taken by the public (i.e., providing local updates) reproduce this social consequence – the situational awareness of both the disaster management officials and the public are significantly enhanced.

On one hand, rather than seeking assistance from traditional news media to publish new updates, the disaster management officials can inform the public directly of official situational updates and information on recovery processes, by posting on social media. By using social media, the public can receive the posts sent by the disaster management officials immediately. In this way, disaster management officials may enhance the situational awareness of the public much quicker than before.

On the other hand, using social media, the public can post nearly real-time local updates about disaster scenes, such as aerial images and photos. These local updates are considered as collective intelligence (Oh et al. 2013). By leveraging the public's collective intelligence, disaster management officials can better understand what happens in an affected area; that is, their situational awareness is also enhanced. Because of the enhanced situational awareness, disaster management officials can make informed decisions for deploying aid, rescue and recovery operations more effectively (Yin et al. 2012).

In summary, acting as modality, social media provides a field for both the disaster management officials and the public to post real-time messages online to establish better situational awareness. In addition, as indicated by the double-headed arrows in Fig. 3, this social consequence not only emerges out of the actions of both the disaster management officials and the public, it also further shapes human actions – to increase situational awareness. Both the disaster management officials and the public increasingly use social media to provide official situational updates, information on recovery processes, and local updates.

Emotional Relief As shown in Fig. 3, the second social consequence of employing social media is emotional relief. Because what is happening in disasters always disrupts people's basic capacity to understand, disasters are often accompanied by extreme emotional arousal, stress, fear, a sense of loss, shock, hopelessness, and sometimes denial (Sellnow and Seeger 2013). As a result, releasing negative emotions is

essential for disaster recovery (Sellnow and Seeger 2013). Existing research on traditional media use suggests that by listening to radios or reading news articles, the public can release some of the emotions which have been stirred by disasters (DeSanto 2013).

Besides *passively* capturing news content on mass media, due to the use of social media during disasters, the public now can relieve their emotions *actively* online. As shown in Fig. 3, we found that the public can *actively* vent and express their emotions by posting messages on social media. Expressing these emotions on social media is a way of seeking social support online (Carver et al. 1989). By obtaining such support, those who are feeling insecure, anxious, or helpless can be reassured about the disaster (Oh et al. 2013).

In summary, acting as modalities, social media provide outlets for the public to post their emotions online, which help relieve negative emotions stirred by disasters. In addition, as indicated by the double-headed arrows in Fig. 3, such social consequences not only emerge out of the actions of the public; they also further shape human actions – to relieve their emotions, the public increasingly use social media to express their emotions to cope with the situation.

Acknowledgment of Efforts As shown in Fig. 3, the third type of social consequence is acknowledgment of efforts. Acknowledgment of efforts is the disaster management officials' perception that victims or society know and appreciate their efforts in responding to the current situations (Mueller et al. 2008). Acknowledgment of efforts is important, because being acknowledged, disaster management officials can be better motivated to provide aid, rescue and recovery operations (Gagné and Deci 2005). However, as we mentioned earlier, the traditional communication channels between the public and the disaster management officials have been limited, so it has been difficult for disaster management officials to directly receive acknowledgment for their efforts from the public.

The growing use of social media during disasters provides a new and a more direct channel for disaster management officials to be acknowledged. As shown in Fig. 3, the public now can express their thanks and gratitude to disaster management officials by posting messages on social media. The efforts of disaster management officials can be acknowledged by the public much more easily and more directly.

In summary, acting as modalities, social media make acknowledging disaster management officials' efforts a significant marker of social practices in disasters (Bruns et al. 2012). In addition, such social consequence not only emerges out of the actions of the public; it also further shapes human actions – to acknowledge the efforts of disaster management officials, the public increasingly use social media to express thanks to disaster management officials' efforts.

6 Discussion

In this paper, we propose a model to explain social media use in disasters from a structurational perspective. This study first identifies human actions taken on social media by both the public and the disaster management officials in disasters. The actions taken by the public include providing local updates, expressing emotions, expressing gratitude for official work, discussing response options, and providing suggestions to officials. The actions taken by the disaster management professionals include providing official situational updates, providing information on recovery processes, providing advice for local victims and responding to victims' questions or requirements. Second, we theorize that two social roles result from using social media in disasters: the public's influences on disaster recovery, and the officials' dominations over disaster recovery. Third, we theorize that three social consequences result from using social media in disasters: situational awareness, emotional relief, and acknowledgment of efforts. Fourth, we explain how the social consequences and social roles emerge out of the actions of the public and the disaster management professionals, and how the social consequences and social roles further shape the future actions of both types of stakeholders in disasters.

As noted previously, of the three realms in Structuration theory, the existing literature focuses more on the central realm - the role of social media. Our research therefore puts emphasis on the other two realms (the social structure realm and human action realm). By doing so, we provide a more comprehensive analysis of the understanding of social media use in disasters through the Structuration theory lens.

Figure 4 presents a combined structurational model, in which we combine the two realms explained in our study with the central realm identified in the existing literature – we show how the three types of empowerments and the three types of roles identified by Ling et al. (2015) and Tim et al. (2016) can fit in the middle realm of the structurational model proposed in this paper.

Table 6 summarizes the relationships between the social roles and consequences identified in this paper, and the empowerments and roles of social media as theorized by Ling et al. (2015) and Tim et al. (2016). As shown in Fig. 4 and Table 6, acting as a compendium of information, social media helps both the public and disaster management officials to acquire situational awareness through the resource empowerment process; acting as a catalyst of immersion, social media helps the public to relieve their emotions and acknowledge the efforts of the disaster management officials through the psychological empowerment process; acting as a channel of intercommunication, social media helps the public to influence disaster recovery and helps the disaster management professionals to dominate disaster recovery through the structural empowerment processes.

From a methodology perspective, this paper provides an example that combines both automatic coding and manual coding together in a case study. Such a method is especially useful in research relating to social media use. Because the volume of data on social media has always been overwhelming (Zhang et al. 2002), it is unlikely that we would manually code all of the online data, while text mining techniques can deal with the relatively large volume of data easily. However, we cannot simply rely on text mining to automatically code the data, because the results generated by text mining need to be interpreted, and text mining may miss some important themes. As a result, manual coding is still necessary. As this study shows, the manual coding phase helps identify the human actions underlying each theme identified in the automatic coding phase, and helps find the themes relating to the interactions between the public and the disaster management officials, which are missing in the results of the automatic coding alone.

7 Contributions and Implications

By taking a structurational perspective, this research adds new knowledge to social media use during disasters. The proposed model in this paper contributes to the existing literature by providing a more complete view of social media use in disasters from a structurational viewpoint. Specifically, we conceptualize two types of social structures (social roles and social consequences) and the human actions taken by both the public and the disaster management officials, and we build a model that explains how human actions relating to social media use facilitate the creation and the reproduction of social structures in disasters. Our research also allows us to theorize about the ways social media is used by both the public and disaster management officials.

Using multiple cases in our study has given it better generalizability. In our data analysis, we employed triangulation among the results from all datasets from three cases, so that our results reflect the common human actions the public or the disaster management officials took in the three different disasters. Consequently, the results also reflect the social structures that are most likely to be created and reproduced in disasters by using social media. Meanwhile, we are aware that the data collected is from one social medial platform, Facebook. We argue that our results may also be applied to other similar social media platforms, which have similar functions to Facebook, such as Twitter – they allow disaster management officials to post messages on their pages and allow the public to comment on disaster management officials' pages. As long as social medial platforms facilitate this two-way interaction between the disaster management officials and the public, our proposed model will apply to other platforms as well.

Fig. 4 Combined model
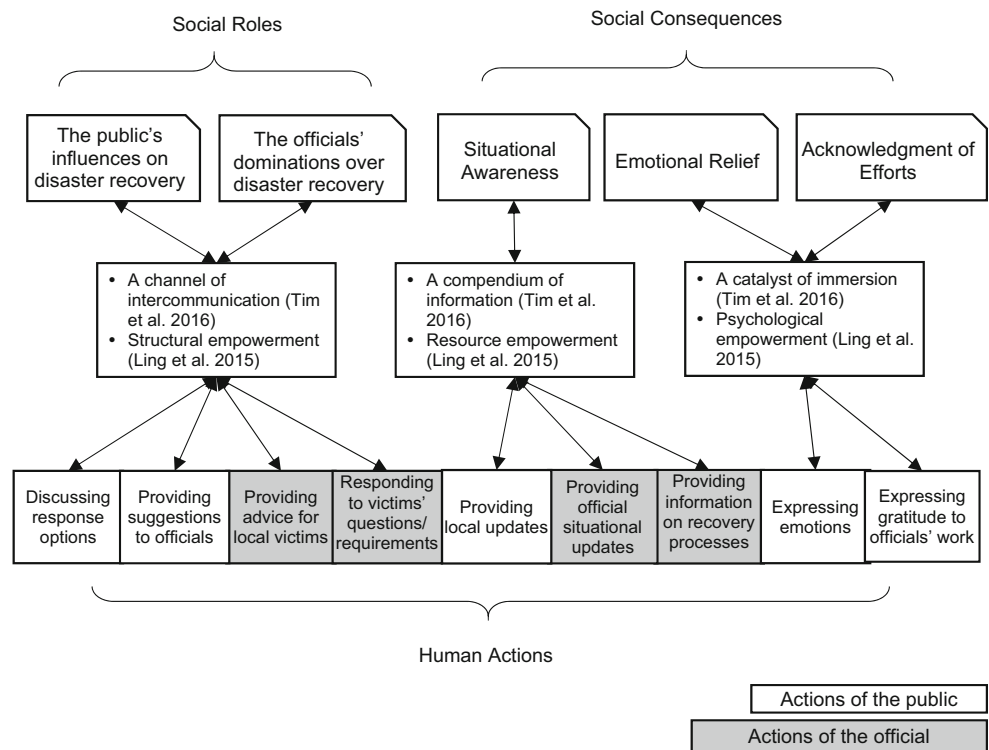
Future research is encouraged to apply our theoretical lens to explain and elaborate upon both the public's roles and the disaster management officials' roles in disaster recovery when they use social media during disasters, and to explain and elaborate upon the three important social consequences resulted from using social media in disasters.

While we use a qualitative method in this paper, future research might explain these social consequences quantitatively. Specifically, as our model indicates, situational awareness, emotional relief, and acknowledgement of efforts can be achieved by using social media in disasters. These three social consequences can be treated as dependent variables. Measurements can be developed to measure these social consequences, and factors that lead to these social consequences can be identified based on the model proposed in the paper.

Practically, this study indicates that social media appears to be very useful in facilitating effective disaster management.

Specifically: (1) It increases people's situational awareness of both the public and of disaster management officials; (2) It helps to relieve people's negative emotions aroused by a disaster; (3) It helps disaster management officials know that their efforts on disaster management are acknowledged by the public.

As a result, it is important for disaster management officials to adopt social media first, and then encourage the public to use social media to communicate during disasters. On the one hand, it is necessary for disaster management officials to open their own official accounts on social media and to use their social media pages to send warnings before a disaster occurs (Murray 2014). Besides just reading these posts and comments, they also need to respond to the requests from the public promptly, and try their best to resolve the problems reported by the public. By doing so, the public can know that the disaster management officials are ready to respond and help.

Table 6 Relationships between social structures and social media roles in literature

Social structures identified in this paper	Empowerments of social media in Ling et al. (2015)	Roles of social media in Tim et al. (2016)
Situational awareness	Resource empowerment	A compendium of information
Emotional relief Acknowledgment of efforts	Psychological empowerment	A catalyst of immersion
The public's influences on disaster recovery The officials' dominations over disaster recovery	Structural empowerment	A channel of intercommunication

On the other hand, it is necessary for disaster management officials to encourage the public to use social media to communicate with others, including the disaster management officials. Especially, they need to inform the public that they have official pages or accounts on social media, so that the public can follow their pages or accounts before they actually need it in a disaster. To prevent the public from missing important updates sent by disaster management officials on social media during a disaster, disaster management officials can tell the public how to get notifications every time they post. On Facebook, this is done by visiting a disaster management official's fan page, hovering over the like button and clicking 'Get Notifications' (Murray 2014).

This study also indicates that although disaster management officials still dominate the disaster recovery process, the public is increasingly playing an important role. Our findings suggest that the public can provide useful local updates and advice for the disaster management officials by posting or commenting on social media. Disaster management officials need to pay attention to the posts and comments generated by the public, because the local updates and advice provided by the public can potentially help their decision-making.

The public can even send messages pointing out the validity issues about the available news or information. When receiving such messages, disaster management officials need to correct any invalid information. In addition, disaster management officials need to ensure the validity of their official information. For example, they need to clearly understand who can approve information and what the approval process is before they post anything on social media (Murray 2014). As soon as a piece of information has been approved, it should be published as soon as possible, because timeliness is very important for disaster-related messages (Palen et al. 2010). They must also check actively and constantly whether the information generated by the public during disasters is valid or not. If not, they need to send a message to correct it as soon as possible.

8 Conclusions

In this paper, we propose a model that explains social media use in disasters from a structurational perspective. We collected data from three different disasters (including both man-made and natural disasters) to increase the generalizability of our study. However, we do not expect that our findings could be used to explain every possible usage of social media in all disasters in the future. First, every disaster has its unique features, and we expect that some features of disasters may result in other innovative uses of social media, which then may create other social structures concerning the disaster. In this paper, we focus more on the common social structures in the three different disasters, while future research might focus on the differences between the social media use in different disasters by theorizing about the features of disasters.

Second, in this paper, we only collected and analyzed data from Facebook. Although social media platforms have some common features, each platform also has its unique features, and some features may relate to the creation and reproduction of other social structures that cannot be explained by our model. Therefore, future research could also compare the differences between social structures created and reproduced on different social media platforms during a single disaster.

Moreover, technology is not fixed. New features of social media introduced in the future, or the development of other communication media, may further change the online behaviours of both the public and the disaster management officials, which may then result in other social structures. As a result, we expect that more research relating to social media use during disasters should be conducted in an ongoing way. By doing so, researchers can continually provide new and useful insights for both research relating to social media use in disasters, and research into disaster management practices, as the technology develops.

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Fang Liu is a PhD in Information Systems at the UQ Business School, University of Queensland. She has a Bachelor and Masters of Information Systems from Renmin University of China. She conducted research on IT capabilities, technology use in emergency management, and disaster/crisis management.

Dongming Xu is a senior lecturer in Business of Information Systems at the UQ Business School, University of Queensland. She has a PhD in Information Systems from the City University of Hong Kong. Her research interests include IT innovations, social media use, disaster management, business intelligence, and decision making.