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The limits of crisis data: analytical and ethical challenges of using social and mobile data to understand disasters

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Abstract Social media platforms and mobile phone data are commonly mined to produce accounts of how people are responding in the aftermath of crisis events. Yet social and mobile datasets have limitations that, if not sufficiently understood and accounted for, can produce specific kinds of analytical and ethical oversights. In this paper, we analyze some of the problems that emerge from the reliance on particular forms of crisis data, and we suggest ways forward through a deeper engagement with ethical frameworks and a more critical questioning of what crisis data actually represents. In particular, the use of Twitter data and crowdsourced text messages during crisis events such as Hurricane Sandy and the Haiti Earthquake raised questions about the ways in which crisis data act as a system of knowledge. We analyze these events from ontological, epistemological, and ethical perspectives and assess the challenges of data collection, analysis and deployment. While privacy concerns are often dismissed when data is scraped from public-facing platforms such as Twitter, we suggest that the kinds of personal information shared during a crisis—often as a way to find assistance and support—present ongoing risks. We argue for a deeper integration of critical data studies into crisis research, and for researchers to acknowledge their role in shaping norms of privacy and consent in data use.

Introduction

There is now a well-established pattern: a disaster strikes, and the crisis data collection begins. For example, when typhoon Yolanda struck the Philippines on November 7, 2013, a variety of data collection and mapping exercises were underway within hours. This included crisis map constructions, a crowdsourced tweet verification project, and many organizations and individuals began scraping Twitter for a range of purposes.[1] The use of big data techniques during crisis events—such as gathering and analyzing a range of large online datasets, both public and private—has brought new insights into how people experience a crisis. Sources such as Twitter,

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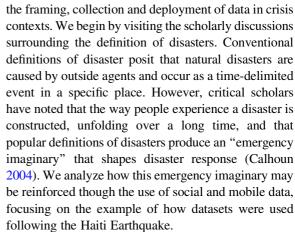e-mail: megfinn@uw.edu

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[1] For example, the crowd sourcing of tweet verification was initiated by MicroMappers on behalf of the UN's Office for the Coordination of Humanitarian Affairs (UN OCHA), while groups such as GIS Corps were conducting crisis map construction.

Facebook, Flickr and YouTube have been mined and studied to produce more detailed accounts of how some people are communicating in networked environments. These efforts have resulted in some fascinating findings. For example, USGS researchers have shown that they can use Twitter to detect an earthquake, in some cases more quickly than traditional seismic instrumentation (Earle et al. 2011). In other cases, it has resulted in emergency services being able to engage with more requests for help, and quash rumours before they take hold (Shaw et al. 2013; Tanaka et al. 2012). There are also new opportunities to "de-frame" (McCosker 2013) disasters from unhelpful or incorrect traditional media accounts by using social data sources (Button 2002, 2010; Tierney et al. 2006). This paves the way for humanitarian groups and researchers to analyze the available data and develop their own understandings.

While big data approaches can be effective in representing and tracking those who are using mobile phones and social media, there are also limits to what these data sets can tell researchers. Oversights can occur when these limits are not sufficiently understood and accounted for. In the case of the Philippines, only 36 % of the population has access to the internet (World Bank 2010). According to one account, the UN OCHA MicroMappers effort gathered a total of 230,000 tweets, 55,000 of which were relevant or unique (Meier 2013a). In the worst hit areas, tweet rates dropped further due to ongoing power outages, with an 18.7 % drop in relevant tweets 2 days after the typhoon hit (Meier 2013b). To compare, approximately 20 million tweets were posted in the first 4 days of Hurricane Sandy (Shih 2012)—which, as we discuss below, had its own issues with representativeness. For organizations working at the site of disasters, social media data can provide tactical information about how to intervene or what to do next. However, it is necessarily a partial and skewed picture of a disaster.

This paper addresses the ontological, epistemological, and ethical challenges that arise when social media datasets are used to understand crisis events. From the way that disasters are defined, to the issue of who is represented in these data sets, to problems of privacy and consent, there are hard problems facing those who would operationalize big data techniques to understand a crisis. This paper builds on critiques of big social data (boyd and Crawford 2012; Mahrt and Zharkov 2013; Tufekci 2014; Coté 2014) to consider the limitations in the framing, collection and deployment of data in crisis contexts. We begin by visiting the scholarly discussions surrounding the definition of disasters. Conventional definitions of disaster posit that natural disasters are caused by outside agents and occur as a time-delimited event in a specific place. However, critical scholars have noted that the way people experience a disaster is constructed, unfolding over a long time, and that popular definitions of disasters produce an "emergency imaginary" that shapes disaster response (Calhoun 2004). We analyze how this emergency imaginary may be reinforced though the use of social and mobile data, focusing on the example of how datasets were used following the Haiti Earthquake.

Then we turn to the epistemological limitations of relying on Twitter data. Here we present several challenges. First, there is the question of how to account for the particularities of Twitter, specifically how the platform and its algorithms shape and influence the way tweets are created and retweeted. We argue that the information circulated on Twitter has its own biases, and in addition to issues of representativeness, it can only offer an attenuated view into a much broader set of communicative practices occurring during a crisis. Furthermore, the presence of many 'bots' (automated Twitter accounts) present complex interpretive challenges for researchers working with Twitter datasets. We analyze these issues by looking at the example of Hurricane Sandy, and how Twitter data was used during that event.

Finally, we examine the ethical issues of working with social media datasets. In many respects, these are the most difficult challenges, compared to issues of representativeness or interpretation. What power do people in a disaster have to determine how their data is used? How is consent understood and determined, if at all? How is the concept of 'privacy' produced, reimagined or negotiated? We conclude by considering the intertwined nature of these challenges, and argue for the need to integrate critical data studies into crisis events research, and to examine the assumptions that underlie using social and mobile data as a system of knowledge during a crisis.

Ontological limitations

The way that disasters are defined can strongly determine how social media datasets are operationalized

during a crisis event, and vice versa. According to its classic definition, a disaster is a temporary break from the norm (Tierney 2007: 505). Delimiting time around a disaster can often make it difficult to comprehend long term structural issues that led to the traumatic event, and to track how long recovery takes.

Decades of research have shown that the ways in which disasters are defined are central to how particular events are studied.[2] The dominant definition of a disaster is:

> …an event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented ([Quoted from] Fritz 1961: 655 in Tierney 2007: 505).

The key qualities of this definition—that it is bound in space and time—underpin much of the analysis of social media and disasters as well as popular discourse about disasters. Sociologist Kathleen Tierney critiques this definition of disaster:

> Virtually every aspect of Fritz's definition—that disasters are events, that they are concentrated in time and space, that physical losses are an essential element in disasters, and so on—is problematic and contested, and yet this conceptualization remains highly influential (Tierney 2007: 505).

The work of many geographers and anthropologists deconstructs the "persistent Western nature-culture dualism" in their definition of disasters (Johns 1999: xvii). The nature/culture divide neglects to acknowledge the underlying social causes of disasters, such that these events appear to come from outside society: so-called "Acts of God". As Watts (1983: 259) points out:

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[2] Researchers in geography and anthropology note a difference between "hazard," which refers to an "agent" such as an earthquake, and "disaster" as "the process in which the agent and specific physical, social, and economic factors participate" (Oliver-Smith 1986: 8). We note that there are different histories for the various words used to describe these events—disaster, crisis, emergency, catastrophe—but for the sake of brevity, we will not address this in detail here.

…for though a drought may be a catalyst or trigger mechanisms in the sequence of events which leads to famine conditions, the crisis itself is more a reflection of the ability of the socioeconomic system to cope with the unusual harshness of ecological conditions and their effects. To neglect this fact is to resort to a fatalism which sees disasters as 'Acts of God', placing responsibility upon nature and in the process missing a major political point.

Thus most researchers agree, per the title of Hartman and Squires' book, that there is "No Such Thing As A Natural Disaster" (2006). To understand a disaster, and particularly suffering during and after a disaster, one needs to take a long view. After the attention of the public is a gone, the "aftermath" is when the hard work of attempting to rebuild "the familiar" occurs (Erikson 1976). One needs to look years after a disaster, sometimes decades, to understand its full impact.

Social media datasets depict a specific time period, typically defined by the spike in Twitter messages or the use of particular hashtags. This can make it difficult to understand both the causes of disaster and the entire period of aftermath where the impact is realized. This further reifies a problematic short-term conceptions of disaster. In this sense, the analysis of social media during and after a disaster can resemble traditional media coverage, which has been often accused of paying attention to only the most sensational stories in a truncated timeframe (Button 2002, 2010; Sangari 2009). Additionally, looking at social media data within a short-term disaster framework does not provide the context of long-term communicative practices that allow researchers to understand the meaning of the spike in social media activity for individuals or communities. As Tufekci has shown, during a dramatic event such as Turkey's Gezi protests, people will simply stop using a hashtag while they continue to send tweets about what they see (2014). The focus on social media, and the hashtag in particular, can miss the full scope of an event, as well as the long-term reasons for and implications of the disaster that are highlighted by critical disaster studies.
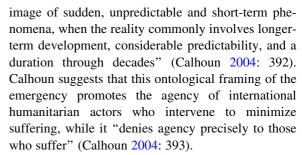
Haiti Earthquake of 2010

After the earthquake in Haiti in 2010, the Haitian government said that 230,000 people were killed;

other estimates put the death toll at 158,000 (O'Connor 2012). Twitter and many other kinds of social media were used by people all over the world in an attempt to make sense of the earthquake, express empathy, and follow the events as they unfolded. Using social media, witnesses contributed their perspectives, and a range of actors engaged in "crisis mapping" (Meier 2011; Shanley et al. 2013). Crisis mapping refers to the broad practice of combining "crowd-generated data such as social media feeds and photographs, with geographic data… in support of disaster management" (Shanley et al. 2013: 866). One key crisis mapping platform is Ushahidi, which has been in use since 2007. Amongst other things, Ushahidi allows users to put user-generated reports on a map. While the Ushahidi technical platform is well developed and stable enough that it has been utilized for a variety of crises, the social practices associated with its use are very much in flux. For example, the processes associated with "verifying" information are seen as both necessary to prevent the spread of destructive rumors and to challenge existing media regimes (Ford 2012).

Closely related to the concept of crisis mapping is "digital humanitarianism," or "the set of social and institutional networks, technologies and practices that enable large numbers of remote and on-the-ground individuals to collaborate on humanitarian projects" (Burns 2014a: 51). While many of the practices and technologies associated with crisis mapping have been in use for several years, Haiti marked the recognition of digital humanitarianism "as a specialized field" (Burns 2014b). Several issues are invoked by the imbrication of technologies and practices associated with crisis mapping "in the context of vulnerable populations during a crisis" (Shanley et al. 2013: 866): the trustworthiness of crowd-generated maps from the perspective of humanitarian actors; privacy, liability and intellectual property laws; concerns about fair access to datasets; and ethical considerations. Work on digital humanitarianism further highlights the inclusion of large humanitarian actors and the complex power relations at play (Burns 2014a, b). As we discuss below through examples of digital humanitarianism projects in Haiti, the use of social media data to analyze a crisis can reproduce a problematic "emergency imaginary" (Calhoun 2004). Similar to the ontological framing implied by the broad "Acts of God" perspective, the emergency imaginary is "an

image of sudden, unpredictable and short-term phenomena, when the reality commonly involves longer-term development, considerable predictability, and a duration through decades" (Calhoun 2004: 392). Calhoun suggests that this ontological framing of the emergency promotes the agency of international humanitarian actors who intervene to minimize suffering, while it "denies agency precisely to those who suffer" (Calhoun 2004: 393).

Of the multiple projects that sought to make the events in Haiti legible to the international aid community through large-scale Twitter processing efforts (Zook et al. 2010), we focus on two. The first, called Mission 4636, gave Haitians a number to text for free to report what they saw. In the second project, Ushahidi Haiti Project volunteers put SMS, email, and web-based submissions on a map for the general public (Morrow et al. 2011). These projects overlapped—two weeks after the work started on Mission 4636, Ushahidi volunteers posted some of data from Mission 4636 on their map (Munro 2013).

The volunteers working on Mission 4636 were mostly Haitians in the diaspora and Haitian nationals whose local knowledge made them ideal collaborators (Munro 2013). They translated the messages from Kreyol to English, which were then forwarded to disaster responders, mostly the US military (Munro 2013). Reports as to the utility of the information provided were varied: some sources said that most of the detailed information was useless while the aggregate information was helpful (Dugdale et al. 2012). Other reports said that individual text messages provided valuable tactical information (Palen et al. 2010; Verma et al. 2011).

Regardless of the usefulness of the information for aid workers, Mission 4636 produced some unintended effects. Some argued it reproduced the unequal power relations between the poor Haitians who supplied information, the diaspora who processed information, and the rich humanitarians from the West who acted on the information. The "uneven mobilities" between those Haitians affected by the earthquake and the humanitarian actors flying to Haiti to help them were reproduced in the data platforms (Sheller 2013). There is evidence that this power differential troubled Haitians who participated in these systems. For his Masters research, journalist and academic Jean-Yves Clémenzo went to Haiti where he had spent years as a journalist and conducted fifteen qualitative interviews

with people who had used the 4636 SMS code. Clémenzo found that almost none of the people he spoke to had heard of Ushahidi, and were unaware their messages were being made public—they considered them private messages (2011). Further, the people who had used Mission 4636 were disappointed that the 4636 SMS code was unidirectional—Haitians could SMS, but there was no response (Clémenzo 2011).

The issue of reified power relations and unidirectionality were also present in Ushahidi Haiti Project. Even though Ushahidi was theoretically usable to anyone, reports about the project suggest that only international aid workers used it (Morrow et al. 2011). This may be a sufficient goal, but if so, it is problematic to assume it has a wider participatory framework. Indeed, as Mimi Sheller observed: "very few Haitians had broadband access of the kinds of mobile smartphones that allow those with network capital to make use of mobile geo-mapping technologies," (Sheller 2013: 197).

Since the text messages were translated into English, the products of that translation—such as maps and policy reports—were also in English. This prevented the Kreyol speakers who texted for help from accessing the project outputs and benefitting from their own data. As Sutherlin (2013) suggested, "the design of the crowdsourcing application disenfranchises the true beneficiaries from the product, the information" (399). If the aggregated data from crowdsourced applications "becomes the basis for policy-making about the crisis themselves" (Sutherlin 2013: 397), as some researchers suggest it could and should be, then it would seem imperative the people who contribute information have access to the derivatives from their informational activities. As Sutherlin, a Mission 4636 participant, reported, "From my experience, the application was not designed in consultation with Haitian policy experts or Kreyol speakers. Disaster victims were not treated as a separate crowd and they were not treated as the end beneficiaries of the task" (Sutherlin 2013: 402).

While it is unclear if ordinary Haitians engaged with the outputs of these projects, it is possible that the information used to populate the Ushahidi Haiti Project maps violated the privacy of those who used Mission 4636. While Mission 4636 had a specific information flow embedded in its process that accounted for the privacy needs of Haitians (and their

sympathetic translators), the Ushahidi map was theoretically accessible to everyone. A report on Mission 4636 by Robert Munro, one of the project coordinators, argued, "the biggest concern for Mission 4636 was that people's identities would be exposed, which is why the messages were not published online." Munro went on:

> Mission 4636's partners did not have permission to publish the 4636 messages on a public-facing map (by their own conditions for publication), and this action resulted in privacy breaches. In a more high-risk conflict context this would have serious consequences for those people whose identities were exposed. (Munro 2013: 250)

Although crowdsourcing projects can allow the voices of those closest to a disaster to be heard, some projects most strongly enhance the agency of international humanitarians. There is a need to critique the assumptions that frame the use of volunteered geographic information (Elwood et al. 2012), particularly in crisis situations. The emergency imaginary being reproduced in ways that enhance the agency of those with the best tools and access, while public-facing crisis maps have the potential to expose people to further risk.

Epistemological limitations

Twitter datasets also present many epistemological challenges for researchers working to understand a disaster. For example, how do researchers account for the role that Twitter's platform plays in shaping and influencing the messages that people choose to tweet and retweet? How can they distinguish between human activity and non-human agents like bots? How should they account for the cultural specificities of how people use Twitter, including their location, age, economic status and language? Finally, there are questions about demographic skew—should Twitter users to be taken as representative of the population at large? These are some of the many issues that materially affect how a data set should be interpreted during and after a crisis event.

Representation and discussion of a crisis event on Twitter is a constructed phenomenon: events on Twitter are made, not born (Vis 2013b). It is not a neutral platform for observing people in a natural
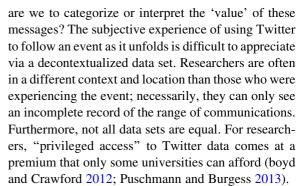
communicative space, nor is it divorced from the lived experience of a crisis. Instead, it is a space which has its own specific correspondence to the unfolding of a material event. Many dynamics shape tweeting practice, and Twitter is used to pursue goals that go well beyond 'witnessing' an event. Twitter use is often described as *performative*, and this introduces a range of analytical hurdles (Papacharissi 2012; Marwick and boyd 2011). People tweet in a cultural context that can be particularly difficult for geographically distant researchers to parse. Additionally, some news organizations and journalists use disaster events to increase their follower count and their readership by amplifying the most dramatic images and updates (Vis 2013a). But these issues notwithstanding, Twitter can provide valuable insights into how some entities are communicating during a disaster, so long as great care and attention is given to what is being represented in that data, and how those messages may have multiple contexts and meanings.

The Twitter platform itself plays a role in shaping the representation of an event by promoting certain tweets based on an accounts' number of followers, one's social network, and other heuristics that are only known to Twitter Inc (Gillespie 2010). Particular types of tweeting, retweeting, and linking practices on Twitter can make for "information cascades" (Lotan et al. 2011) that can evolve into a "drama of instantaneity", where tweets are "personal, emotive, and involved the sharing of opinion and fact without distinguishing between the two" (Papacharissi and de Fatima Oliveira 2011: 21). In this way, Twitter acts as a kind of affective "contact zone" where events, technologies and emotions move and develop, and no neat divisions exist between news and the personal:

> At once public in reach and private in effect, Twitter moves between the space of the communal and the intimate. [Events are] rendered and re-rendered through thousands of discreet, subjective viewpoints. With great velocity and on a large scale, major news events are processed in public: the textures and inflections shift between individuals and communities (Crawford 2010: 148–149).

In a crisis, someone may be reporting what they see in a 'citizen journalism' style, while also alerting friends and relatives to their wellbeing, while also recirculating both verified and unverified reports of others: how

are we to categorize or interpret the 'value' of these messages? The subjective experience of using Twitter to follow an event as it unfolds is difficult to appreciate via a decontextualized data set. Researchers are often in a different context and location than those who were experiencing the event; necessarily, they can only see an incomplete record of the range of communications. Furthermore, not all data sets are equal. For researchers, "privileged access" to Twitter data comes at a premium that only some universities can afford (boyd and Crawford 2012; Puschmann and Burgess 2013).

Bots further complicate issues of interpretation. Large numbers of tweets in datasets are produced algorithmically from non-human agents, but are often included in analyses of human activity. Bots are a significant population in many online spaces where they are programmed to automatically send updates, follow other accounts, and generally participate within the platform while looking as plausibly human as possible. A study by security researchers Andrea Stroppa and Carlo De Micheli (2013) found 20 million "fake" accounts—approximately 9 % of Twitter's active users. Those bots are also friending and retweeting other bots, producing a complex bot culture which is an emerging phenomenon unto itself (for discussions of bot activity in the context of Wikipedia, see Geiger and Ribes 2010; Geiger 2011, 2014; Van Dijck 2013: 137–140). How are researchers to parse out human messages from algorithmically generated messages? This is an ongoing, non-trivial technical challenge, yet it is very rare that crisis studies based on Twitter data will acknowledge that bots constitute a part of the collected data.

Finally, Twitter data is not a representative sample of people's experiences during a crisis. Crisis events have always presented the difficulty of differential vulnerability: "disasters unmask the nature of a society's social structure… the distribution of power within a society reveals itself" (Oliver-Smith and Hoffman 2002: 9). By considering Twitter data alone, specific voices will be heard and others will be missing entirely. Twitter use still skews to younger, more urban demographic groups, even in wealthy nations like the US. In effect, this means older, less affluent and more vulnerable communities are often the least likely to be self-representing on a platform like Twitter.

We can see that single data channels are narrow in capacity and skewed in particular ways: social media data is always partial and incomplete. As Price and

Ball recount, in the context of conflict-related violence research,

> Basing answers and policy decisions on analyses of partial datasets with unknown, indeed unknowable, biases can prove to be misleading. These concerns should not deter researchers from asking questions of data; rather, it should caution them against basing conclusions on inadequate analyses of raw data (2014, 10).

By expanding the lens of crisis data to include the wider ecologies of communicative activity generated by humans and code, and also by considering who is and is not represented, we can avoid some of the more obvious epistemological errors. Nonetheless, there remain considerable risks in pointing to patterns within large social media datasets to help understand crisis events. As Dixon (2012) points out, it "begs the question of whether we are seeking patterns where none exist, or creating them ourselves through the software and information artifacts that are made as part of the research process" (2012, p. 16). In sum, Twitter's platform is inhabited by a mix of humans, institutions and bots, all engaging for a wide range of reasons. The challenge for researchers is how to account for what is in the data (including bots and biases) and what isn't (such as populations who are the most vulnerable and least connected) while helping to make sense of a crisis.

Hurricane Sandy and social media data

Hurricane Sandy was the largest Atlantic hurricane on record, affecting many populations from the Caribbean to the US East Coast. More than 20 million tweets were sent about the storm between October 27 and November 1, 2012 (Shih 2012). This represents a significant dataset for crisis informatics researchers, and several studies based on this data have already emerged.

For example, one study that combines the Sandy Twitter data with Foursquare data found that grocery shopping peaked the night before the hurricane, while nightlife had a significant spike the day afterwards (Grinberg et al. 2013). While this is an interesting finding, it is considerably skewed, and should not be taken to represent the wider experience of Sandy. According to Pew Research Center's Internet & American Life Project, in 2013 Twitter is used by

16 % of US online adults (Brenner and Smith 2013a), while "check-in" services like Foursquare are only used by 7 % (Zickuhr 2013b). More significantly, this does not constitute a representative sample of the US population. The majority of tweets in the Sandy corpus come from Manhattan, where there is the highest concentration of smartphone owners and Twitter and Foursquare users. Very few messages originated from the more severely affected areas, such as Breezy Point, Coney Island, the Rockaways, and areas outside of the US (see Lotan 2012). The Twitter and Foursquare datasets offers perspectives that are inherently skewed towards the privileged urban-dweller's experience of the disaster in the US.

The data is further slanted due to extended power blackouts after the hurricane, resulting in overrepresentation of areas that have more access to power (Crawford 2013). We call this a "signal problem": a dataset may be assumed to accurately reflect the social world, but there are problematic gaps, with little or no signal coming from particular communities. Signal problems are compounded when crisis informatics studies focus only on input signals and information provided by social and mobile media users, given that these technologies are always differentially adopted. For example, approximately 45 % of Americans own a smartphone, but for people over 65, smartphone penetration is as low as 11 % (Rainie 2012). Those who are older, less wealthy, and not living in urban centers are not as well-represented in social and mobile data, resulting in data that the geographers Crutcher and Zook (2009) observe is "colored by the fundamental divides pre-existing in society and in some cases can amplify them" (532–533).

It is critically important for researchers to assess and account for the gaps in their dataset. This includes determining which kinds of individuals and communities are excluded, asking what kinds of communications circulate on social media platforms, and, crucially, recognizing that these communications are also created for—and shaped by—the platforms where they appear. In order to make claims about the ways in which social media datasets reflect the world, researchers should consider such questions as: where is the data is coming from? Which populations (human and non-human) are represented? What are its weaknesses? What are the ethics of using that data? None of these questions are straightforward or easy when drawing on Twitter data to interpret a crisis event.

While such data can give an impression of how those who are most connected are responding, it is at its most useful when considered as just one signal among many.

Ethical issues and the question of consent

Despite the enormous data gathering efforts that now accompany crisis events, there has been very little discussion of the ethics of using this data. What are the implications of using social media data when people are at their most vulnerable, using those platforms to seek help, update friends and family on their wellbeing, or sharing images of damaged property or physical injuries? In a survey of academic Twitter data studies, Zimmer and Proferes (2014) analyzed 382 scholarly articles, dissertation and theses published between 2007 and 2012 from a variety of disciplines, and found just 16 articles contained any discussions of ethics. Only 5 articles "acknowledge the presence of ethical issues that shaped how the Twitter data was collected and managed, such as changing the names of participants to ensure their anonymity," (Zimmer and Proferes 2014: 256). So should we worry about the ethical use of crisis data?

Given many data platforms are seen as public, it is assumed that people can manage their own settings and engage in informed privacy self-management. But as Daniel Solove has argued, while the idea of self-managed privacy is laudable, it is rarely achieved, as "even well informed and rational individuals cannot appropriately self-manage their privacy" (2012: 2). Of course, many people are not well informed about the extent of data collection or how many parties can purchase access to Facebook data or scrape their Twitter feeds. Data platforms can represent an 'omnopticon' where the many surveil the many (Rose-Redwood 2006).

In the context of big data approaches, multiple data feeds are combined which can generate intimate insights without the person's knowledge (Crawford and Schultz 2014). Solove describes this as the "aggregation effect":

> The difficulty with the aggregation effect is that it makes it nearly impossible to manage data. The ways in which data can be combined to reveal more data are constantly evolving. This

makes it very hard to assess whether revealing any piece of information will sometime later on, when combined with other data, reveal something sensitive (Solove 2012: 9).

This is particularly significant in a crisis situation when people reveal location data, whether intentionally or unwittingly through the sharing of photos or requests for help that reveal highly sensitive personally identifying information. If, in a moment of crisis, people tweet information about their location, food and water needs, personal well-being and health status of friends and family, these tweets can then be the grist for data analysis techniques for years to come (Cohen 2012: 18). This data can be scraped and held on a range of databases indefinitely, opening the risk that it could be used in discriminatory contexts in areas such as employment, property and health insurance.

Context is critical here: people's privacy preferences depend on their circumstances, and their choices shift depending on their situation (Solove 2012: 8; Nissenbaum 2010). For people who are suffering, the importance of protecting their "private data" may be a much lower priority than gaining help or locating friends and loved ones. Moreover, the very idea of 'privacy' is a social object which is produced in relation to spatial information technologies, and its meaning shifts between cultural contexts and institutions, as the work of Elwood and Leszczynski has argued (2011).

A concern with the current use of crisis data is that the ends may be seen to justify the means. If drawing together all available data sources can assist in building better crisis maps, or verifying claims of damage more quickly, issues of consent or possible risk often fall into the background. Ioannidis has addressed some of the ethical issues in using datasets for research without consent in biological research (2013). In "Informed Consent, Big Data, and the Oxymoron of Research That Is Not Research" Ioannidis writes that the availability of so much commercially gathered data, "informed consent is seen as clashing with the emerging concept of duty to participate" (2013: 40). Similarly, in the context of crisis data, data collection from as many sources as possible is often justified for 'the greater good' regardless of the biases or gaps in the data, or whether the data use produces any material improvements in crisis recovery. The result is data sets that can be

overly intrusive, collect personally identifying information without informed consent, and may have serious unintended consequences, particularly when brought together with other kinds of personally identifying data (Crawford et al. 2013).

There are risks when crisis research projects make decisions on an adhoc basis regarding what data should be used and when, with little or no consideration about privacy and the ethics of data use. As the Haiti case made clear, text messages deemed "private" by translators were widely published through crowdsourcing efforts. People who sent these text messages did not consent to that particular use for their data. The decisions about how these messages were used was made by distant others and shaped by a platform that prioritizes publicly displayed maps. Tene and Polenetsky argue that principles of privacy and data use must be balanced against societal values such as public health, national security and law enforcement, and economic efficiency. In their view, "where the benefits of prospective data use clearly outweigh privacy risks, the legitimacy of processing should be assumed even if individuals decline to consent" (2012: 67). We suggest this is inadequate for crisis settings. The risks of big data approaches cannot always be known in advance, and communities experiencing a disaster should not be further exposed to potential harm without their consent. We could ask: *who* gets to decide when the benefits outweigh the risks? Who "assumes the legitimacy of processing"? When the answer to this question is not the community itself, but parties far from the affected region, this raises significant ethical problems.

Ultimately, the question is one of power: what power do people in a crisis event have to shape how their data will be gathered and used? To return to Solove, even under normal conditions people in an online context have "minimal bargaining power regarding their privacy" because "the choices offered to people can be structured in ways that nearly forces them to consent" (2012: 11). This is particularly concerning when there are few communications channels functioning after a disaster, and people will seek help or broadcast information about their whereabouts or safety wherever they can. The status of that information, shared under extreme conditions, should earn greater protections and ethical consideration rather than less. But it is important to note that ethical challenges cannot be met with a single 'solution' or

approach. Crisis researchers play a significant role in shaping data ethics through their own recognition or disregard for the complexity of issues such as privacy and consent during a disaster.

Conclusion

We have offered an analysis of some of the known limits for conducting research about crises with big social datasets. The definition of disaster that researchers use opens up particular research avenues and closes down others, and while looking at short time frames around an event can be useful for gaining tactical information about a disaster, it can obscure the social conditions which contribute to suffering. Particular ontologies of disaster also can reproduce troubling power relationships between those who suffer during a crisis and those who can help. We also addressed the difficulties of interpreting social media datasets, particularly when considering the context of a tweet's creation. Tweets represent a complex set of communicative practices by both humans and bots; furthermore, participation on Twitter is influenced by the tweets in a user's feed, which is in turn influenced by Twitter's algorithms. Hurricane Sandy illustrates the inherent geographical and demographic biases in Twitter data, so that certain groups are well represented and others are absent. Finally, we examined the ethics of working with social media sets, particularly the privacy and consent issues that emerge when people have publicly posted information, but not agreed to participate in a research project.

For the purposes of this paper we have considered the ethical, epistemological and ontological challenges separately, but of course they are inexorably linked, and raise new research questions when considered together. Researchers who situate their work in critical and historical traditions have the potential to make much needed interventions. For example, one research program at the University of Colorado is motivated by the idea of empowering local people who tend to be the first "first responders" in disaster situations (e.g. Palen et al. 2010, 2007). This program is situated in a critical tradition of disaster sociology which understands people as pro-social, rather than as unpredictable agents who are likely to panic and riot after a disaster: much life-saving work in "search and rescue" operations is done by citizens, not professionals.

We see enormous potential in bringing critical data studies to crisis research, from considering the influence of temporal framing to make visible the causes and effects of disaster, to considering pre-existing structural inequities connected to class, race, and gender that make certain populations particularly vulnerable in a disaster. Critical approaches also address the way code can recursively shape content. While we know that the design of platforms powerfully structure what users see (Gillespie 2010; Van Dijck 2013), we don't know how these algorithms impact the content that is produced in response. In other words, we don't yet have conclusive accounts of how algorithms participate in the creation of "calculated publics" (Gillespie 2014) in a crisis context. What does it mean to acknowledge the reflexivity embedded in a dataset extracted from a "calculated public"?

Whenever they create datasets, researchers are making interpretive decisions that imply particular ontologies and ethical commitments. For example, when researchers build a dataset from a source like Twitter, the timeframe, locations, or hashtags that define the parameters of that dataset invoke a particular disaster imaginary. We have techniques for cleaning data, but these techniques always involve choices, such as whether or not to incorporate data that identifies highly sensitive personal information or places people at risk. These decisions can—and should—be made explicit to others as best practices are established. While the data that is included tells a story, the "data not seen and not made" (Vis 2013b) also needs to be acknowledged. In less than a decade, social and mobile data has become a prevalent system of knowledge during a crisis. In order for this to be a positive shift, researchers need to critically examine, and make plain, their interpretive, ethical, and ontological assumptions.

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