

A SOCIOTECHNICAL VIEW OF INFORMATION DIFFUSION AND SOCIAL CHANGES: FROM REPRINT TO RETWEET

Research In Progress

Onook Oh

The Center for Collaboration Science
Univ. of Nebraska at Omaha
oooh@unomaha.edu

Nargess Tahmasbi

College of Info Science & Technology
Univ. of Nebraska at Omaha
narjestahmasbi@unomaha.edu

H. Raghav Rao

UB School of Management
SUNY at Buffalo
GSM, Sogang University, S. Korea
mgmtrao@buffalo.edu

Gert-Jan de Vreede

The Center for Collaboration Science
Univ. of Nebraska at Omaha
gdevreede@unomaha.edu

Abstract

This research in progress study explores the role of Twitter during the 2011 Egypt revolution. Drawing on a research method of historians who investigated the role of print technology during the Protestant Reformation in Western Europe during the early 16th century, we explicate the socio-technical implications of information diffusion through retweeting during radical social changes. Through retweet analysis, we identify inseparable dynamics of (1) existence of a few opinion leaders, (2) a large number of supporting individuals, and (3) the emergence of attendant collective sense-making process as a critical antecedent of radical social changes.

Keywords: The 2011 Egypt Revolution, Social Media, Twitter, Print Technology, Social Changes, Collective Sense-Making, Information Diffusion

Introduction

The 2011 serial social movements in Arab nations have stirred debates regarding the role of social media technologies in social changes. The first uprising sparked in Tunisia on December 17th, 2010 in the form of civil resistance right after a 26 year-old unemployed college graduate set himself on fire in front of a government building. While mainstream media both in Tunisia and the globe had been silent, the story rapidly flooded social media networks such as Facebook, Twitter, YouTube, and numerous Blog websites (Howard et al. 2011). Since then, the protest quickly crossed the borders of neighboring countries into Egypt (January 15th, 2011), Syria (January 26th, 2011), Algeria (February 11th, 2011), Yemen (February 11th, 2011), Bahrain (February 16th, 2011), and Libya (February 16th, 2011). In that short period of time, the presidents of Tunisia, Egypt, and Libya stepped down from their twenty-three, thirty, and thirty-two years of dictatorship respectively.

To describe these unprecedented large-scale social movements in Arab nations, many news media and scholars have suggested different views on the role of social media. Despite different views, however, the discussions seem to swing like a pendulum between two ends of what Orlikowski (2007) called the “*techno-centric* perspective” and “*human-centered* perspective.” The techno-centric perspective assumes that technology is largely “exogenous, homogeneous, predictable, and stable” that exists as a separate entity outside the realm of human being (Orlikowski 2007, p. 1437). Therefore, its main interest is to describe technological effects that bring about organizational or social changes “independently of human action” (Leonardi 2009, p.280). In contrast, “the *human-centric* perspective” tends to “focus on how humans make sense of and interact with technology in various circumstances” (Orlikowski 2007, p. 1437). Therefore, technology is understood based on various meanings assigned by different humans in different circumstances, hence minimizing the role of technology itself. Fundamentally, the “*human-centric* approach” takes the “voluntarist” stance that argues “human have agency (what philosophers call ‘free will’) and can shape their environments to achieve their interests and goals” (Leonardi and Barley 2008, p. 160). These two viewpoints unquestionably assume human and technology as separate entities which execute unidirectional impact from one entity to the other. Although these different perspectives may offer alternative insights to understand the role of technology in organizational and social changes, at the same time, the unidirectional approach is likely to blind the important dynamics in practice that may occur when human and technologies are inseparably intermingling with each other (Orlikowski 2005). However, the bipolar viewpoints are still being repeated among media pundits and academics to describe the role of social media during the Egypt revolution.

Wael Ghonim, who organized the Egypt revolution through Facebook, suggests that the Egypt revolution started on Facebook (Smith 2011), and “without Facebook, without Twitter, without Google, without YouTube, this [the Egypt revolution] would never have happened” (CBS 2011). He also wrote in his recent book, *Revolution 2.0*, that “this leaderless revolution” was the “Revolution 2.0 model” which was “truly a spontaneous movement led by nothing other than the wisdom of crowd” (Ghonim 2012, p.293-294). Apparently, the new term *Revolution 2.0* echoes the participatory Web 2.0 technologies, and his entire book is interwoven with two storylines of social media activities and street protests. Indeed, he attributes the demise of the Mubarak regime to social media technologies and a multitude of anonymous individuals who collaborated online toward a unified revolutionary goal. In this regard, Ghonim’s viewpoint of the 2011 Egypt revolution reflects the techno-centric approach.

In opposition to Ghonim’s description, counterviews have been presented. Some people argue that revolutions always have existed well before Internet technologies were born. They assume social media technologies and human beings as separate entities, and then consider human intention as a primary condition for social changes and technologies as ancillary tools to serve the higher human ends. Their typical arguments are “People with grievances will always find ways to communicate with each other” (Gladwell 2011), or “The dozen or more protesters that self-immolated in Egypt didn’t do it for the tweets” (Kravets 2011). Given those arguments assume humans and technology as separate entities and they stress more on the former, their viewpoint on social changes tends to reflect human-centric approach.

However, despite the risk of ascribing the complex social changes to a few media sources, it is obvious that the recent rapid diffusion of large-scale serial uprisings has been unprecedented in human history. That means, setting aside the question of whether the Arab revolution has been successful or not, it is hard to explain how serial revolutions could so rapidly spread to multiple Arab nations in such a short period of time and cannot be easily explained without considering the effects of social media technologies. Added to this, the Egyptian government’s brutal disconnecting of Twitter, Facebook, Internet and cellular wireless services

demonstrates that the rigid political regime recognized those social technologies as subversive threats for the established regime. In this regard, the limitation of the human-centric viewpoint on social changes seems clear, and still we cannot disregard the technological effects in social changes. In reverse, it has been known that social media played a significant role in the Moldova revolution (Mungiu-Pippidi et al. 2009) and Iran's civil resistance after the presidential election (Bruns et al. 2009). Yet, the role of social media in these revolutions are not considered as impactful as the Arab revolution, meaning that techno-centrism lacks the nuanced understandings of various social, political, and economical factors to describe the role of social media technologies in social changes.

Among different perspectives and positions, this study purposes to explicate the role of social media technologies in social changes. Although we recognize that the Egypt revolution involved a mass campaign of various social media (e.g., Facebook, YouTube, Flickr, Google Docs, and Blogs etc.) (Ghonim 2012; Howard et al. 2011), we pay special attention to the Twitter for following two reasons. First, as Ghonim (2012) confesses in his memoir, due to extreme mobility of Twitter working on cell phones equipped with short messaging service, digital camera and video recorder, Twitter was the most fast and mobile social media services to spread situational information from the ground in close to real time. Second, as many local correspondences of mainstream media wired situational news mainly through Twitters and those break news have been retweeted by a multitude of Twitter users around the globe, Twitter best shows dynamics of information diffusion at the intersection of social media and mainstream media to spread real time situational information from the street.

Therefore, as an effort to investigate the dynamic process of information diffusion and identify influential voices among huge amounts of tweet messages, our research proposes to (1) discover what kinds of and how much information is diffused through Twitter, and (2) what sociotechnical implications this diffused information has in explicating the role of Twitter during the 2011 Egypt revolution. Especially, we focus on analyzing the tweet messages diffused through retweet features of the Twitter technology. As a preliminary work, our research framework is introduced by reviewing the research method that historians adopt to analyze the role of print technology in bringing Western Europe out of the religious Middle Age through the Protestant Reformation in the 16th century. We believe that the historians' approach to the role of print technology and its attendant social changes will offer valuable insights to build our research framework to investigate the role of Twitter during the Egypt revolution. In the next sections, following the presentation of our research framework, a literature review of Retweet studies will be discussed. After that, the background history of the 2011 Egypt revolution and Twitter data collection method sections will follow. This research in progress study concludes with a few preliminary findings from the Retweet data analysis, future research plans, and the contribution of this study in IS theory.

Print Technologies and Social Changes: Building the Research Framework

A group of historians studying early modern European society attribute the outbreak of the Reformation (religious revolution) to the printing technology and its derivative social dynamics (Edwards 1994; Eisenstein 2005). Different from many historians, they deny that the source of the Reformation was the interpreter of the Bible, Martin Luther, who posted the ninety-five theses on the wall of the All Saints' Church in Wittenberg. Instead, they look at the capability of print technology, which enabled people to duplicate limitless copies of Luther's contentious pamphlets at low cost. Mainly they analyze the implications of the reprinted quarto format small pamphlet which is easy to hide, transport, distribute, and share on the streets, in taverns and in their daily lives (Edwards 1994, p.15). In this approach, Martin Luther is merely considered as an "opinion leader of the movement" rather than an intended revolutionary (Edwards 1994, p.7), and a multitude of medieval people are seen as disseminators of Luther's pamphlets along with their own comments.

In fact, Martin Luther himself expressed puzzlement about the fact that the public read, duplicated, and disseminated his pamphlets which were meant exclusively for academic circles (Eisenstein 2005, p.168). What we can learn from his puzzlement is that Luther himself and his ninety-five theses itself were a necessary but not sufficient condition for the Reformation. The simple truth is that an idea itself cannot be revolutionary without gaining large-scale social support and having some technologies which can connect the previously disconnected group of people with shared ideas and experiences. In this regard, the mass-copying print machines were truly revolutionary during the Reformation. They offered the capability to duplicate Luther's pamphlets at a low cost, kept previously disconnected people connected with similar ideas and

experiences, and multiplied and broadcasted the shared ideas and experiences to a much larger and diverse audience with greater speed that was impossible in the preprint age (Edwards 1994; Eisenstein 2005). From this perspective, the print technology is not only considered as a message-transmitting vehicle but as an active message-shaping agent which facilitates secular interpretation of orthodox theology and performs a large-scale sense-making process along with a multitude of people with its capability of interpretation, production, reproduction, and dissemination.

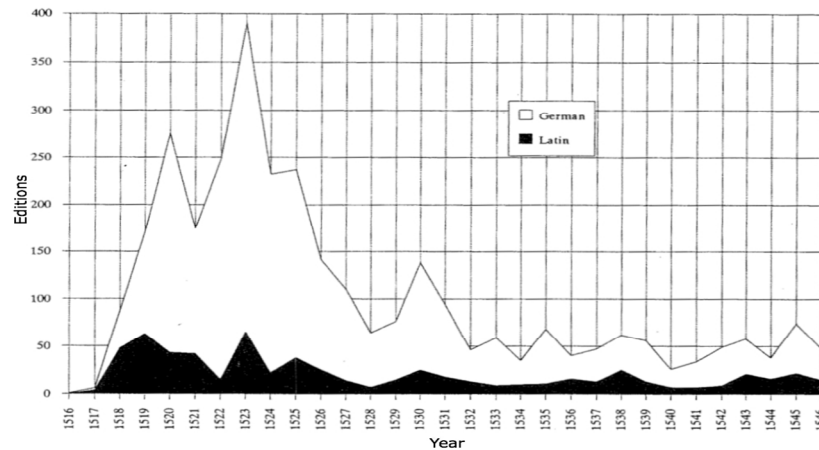


Figure 1. Reprinted Editions of Luther's Works by Language (Adopted from Edwards 1994, p.17)

Apparently, to understand the scale of *connection* of the previously disconnected people and its derivative social dynamics (e.g. the emergence of shared revolutionary ideas), we need to appreciate the capability of printing technologies in terms of its reprinting speed, scale of its potential reach, cost for the reprinting, etc. Indicators of the large-scale connection and expansion of the shared revolutionary ideas can be found from statistics on the reprinted volumes of propaganda pamphlets, which Edwards (1994) succinctly described as “what was new in the Reformation...is the sheer scale of the propaganda effort” (p. 17). For instance, it was reported that, during the first two years of the Reformation, which was sparked when Luther posted the ninety-five theses in 1517, there was more than a 530% increase in the production of small pamphlets (refer to figure 1). From the printing machines in German-speaking lands between 1500 and 1530, approximately 10,000 pamphlet editions were reprinted. Among these, “almost three-quarters appeared between 1520 and 1526, and most were due to the Reformation movement. Martin Luther alone was responsible for approximately 20 percent of the overall total” (Edwards 1994, p.17). Obviously, multiplication of small pamphlets implies inseparably intertwined social reality of print technologies, which incur vigorous sociotechnical dynamics such as large scale information sharing and collective “sense-making” as the most critical antecedent of collective social movement (Turner and Killian 1957).

What we can learn from these historians interpretation of the religious revolution is their flexible but practical view, which does not easily fall into either the human-centrism or techno-centrism camp. Their research framework does not give privilege either to human intention or printing machines to describe the technology-mediated radical social changes. Instead, they zero in on “the dialect between the fixity of print and the fluidity of reception [by pamphlet-message recipients having different backgrounds],” and the emergence of the attendant sociotechnical dynamics (Edwards 1994, p. 4). Specifically speaking, their view is based on observing the emergence of mass amounts of printed pamphlets and explicating its sociotechnical implications. This research framework is similar to what Orlikowski (2007) called “sociomaterial practice” which “take[s] seriously the recursive intertwining of humans and technology” (p. 1437). That means, that in the sociomaterial research method, the fundamental idea is to explicate some empirical consequences of inseparably entangled reality of human and technology, but without sacrificing both technological influences and human intentionality (Orlikowski 2005). In that regard, focusing on the sudden ‘emergence’ of Luther’s contentious pamphlets is a very practical approach to explain both effects of print technology and human intention but without giving privilege either to print technology or human intention as separate entities.

By exploring the sudden *emergence* of Luther’s contentious pamphlets, historians found inseparable intermingling of (1) Luther’s revolutionary ideas, (2) the effects of print technologies, and (3) the large-scale

crowd who read, interpret and disseminated Luther's revolutionary ideas. This research method avoids the raising questions like 'what is human?', 'what is machine?', or 'what is human-machine interaction?' in which human and machine are assumed as separate entities. Rather, it takes the *emergence* as constituting sociotechnical¹ effects where a separation line between human and technology is just artificial instead of being practical.

Following the practical research method of those historians and also the recent sociomaterialist approach, this study analyzes the tweet and retweet phenomena during the 2011 Egypt Revolution. We start the study with an analysis of the *emergence* of large-scale tweets and retweets, which are analogous to the print and reprint phenomena during the Reformation. Subsequently, we dig into the retweet data to understand its sociotechnical implications in terms of (1) the opinion leader(s), if any exist, who are comparable to Martin Luther and (2) the longevity of various types of retweets and their characteristics.

From Print and Reprint to Tweet and Retweet

Since the advent of Twitter in 2006, it has received a good deal of attention as a resilient and rapid information diffusion tool especially under social crisis situations such as natural disasters (Vieweg et al., 2010; Oh et al. 2010), terrorist attacks (Gupta 2011; Oh et al. 2011), and social movements (Bruns et al. 2009; Lotan et al. 2011; Maghrabi et al. 2011; Mungiu-Pippidi et al. 2009; Starbird et al. 2012). Due to its short texting service interface on cell phones, it turned out to be extremely mobile and rapid in tweeting onsite situation reports to the online community. Additionally, Twitter's tree-like structure, which does not require reciprocal relationships among users, enables very fast information diffusion compared to other social media services (Lerman et al. 2012).

As a practice of broadcasting others' original tweet messages, the retweet feature has especially been recognized as a popular information diffusion mechanism. Boyd et al. (2010) describe that retweeting is an expanded way of loose socializing. He maintains that retweeting is not just spreading others' tweets but also a way of participating in a diffuse conversation without the needs of direct participation. Kwak et al. (2010) conceptualize the retweet frequency for certain tweet messages as a measure of "popularity" for the message or its author. Similarly, Suh et al. (2010) suggest that, although retweeting behavior has various motivations (e.g. entertaining specific audience, commenting on someone's tweet, publicly agreeing with someone, saving tweets for future personal use, etc.), retweeted messages may have certain informational values. Despite the different conceptualizations of retweet, salient agreements exist that the retweeted messages or its authors may have certain information values or influential voices in the online community in that the messages draw public attention from other Twitter users to be retweeted.

Some empirical studies on retweet support that retweeted messages may include high informational values. Suh et al. (2010) reports that, in general, tweet messages with URLs and hashtagged keywords are more likely to be retweeted than those that are not, and a strong linear relationship exists between the number of followers and its retweetability. In a natural disaster context, it has been reported that retweeted messages are more likely to contain situation-related information (Qu et al. 2010; Vieweg et al. 2010) or action-related information than non-retweeted messages (Qu et al. 2010). These findings support that retweeted messages may have higher information value than non-retweeted ones, and in that regard, the frequency of retweeted messages and its authors can be a measure of informational value and the Twitter users' influence (Suh et al. 2010).

Drawing on findings from those retweet studies, we conceptualize the frequency of retweeted messages as a proxy measure for specific Twitter users' influence. It parallels the practices of printing and reprinting of Luther's pamphlets through which crowds accept his messages and expand the scale of supporting groups as potential participants in the social changes. Obviously, as historians argued, the diffusion of the reprinted pamphlets co-occurs with large scale sense-making as a critical antecedent of upcoming revolution (Edwards 1994; Eisenstein 2005; Turner et al. 2010). Therefore, it can be hypothesized that the sociotechnical implications of the printing and reprinting may be similar to that of tweeting and retweeting during the 2011 Egypt revolution. However, despite the outward similarity, it is noteworthy to mention that tweeting and

¹ Orlikowski and Scott (2008) intentionally use the portmanteau 'sociomaterial' without hyphen to announce the "ontological fusion" which recognizes that "these entities [the social and the material] necessarily entail each other in practice" (p. 465).

retweeting phenomena during the 2011 Egypt revolution may have significantly different implications from that of printing and reprinting in its speed and scale of information diffusion and its attendant sense-making at the collective level. Also, given that the modern society is much more complex and globalized than before, the voices of opinion leaders may take much more diverse forms than during the age of the Reformation. Therefore, identifying and measuring the *emergence* of the most frequently retweeted users and understanding the characteristics of the most frequently retweeted messages during the Egypt revolution may offer valuable insights to better explicate the role of Twitter in radical social changes.

Research Method

Background of the 2011 Egypt Revolution

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

Stimulated by the serial “Silent Stands” events, and encouraged by the Tunisian Revolution on December 17th, 2010 through which president Ben Ali resigned from his 23 years of dictatorship, Egyptian people planned the first large-scale non-violent civil resistance in Cairo on January 25th, 2011. The purpose was to publicly express their grievances on oppressive emergency law, high inflation and unemployment rate, corrupt government officials, and, most importantly, to demand their president of thirty years, Hosni Mubarak, to step down. For this protest, the role of social media technologies was significant in coordinating the ensuing demonstrations. For instance, Ghonim documented and uploaded to Google Docs all information relevant to the January 25th protest which included “the reasons for protesting and for choosing this day and these locations” and “the unified chants [...], phone numbers for activists responsible for supporting arrested protestors, and for redirecting demonstrators to other locations if the protests at any one place were obstructed” (Ghonim 2012, p. 164). The file was accessed by more than 50,000 people and distributed through “online forums, political websites, Facebook, and Twitter” (p. 164). Literally, what is new in the Egypt revolution was the sheer volume of the social media campaign.

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

Data Collection and Cleaning

As the initial goal of this study is to identify the emergence of the frequently retweeted users and understand the characteristics of the retweeted messages during the Egypt revolution, we collected Twitter data with sufficient extra days before and after the time period of the Egypt revolution ranging from January 25th to February 11th of 2011. Because Twitter does not allow keyword search for historical data, we chose to collect archival Twitter data by back-tracking each individual user accounts who might have tweeted surrounding the time period of the Egypt revolution. Due to the sheer volume of tweet posts and the keyword search constraint, we followed a three steps of data collection strategy: (1) collect Twitter user accounts who might have tweeted surrounding the time period of the Egypt revolution, (2) track back all those user accounts and retrieve their past tweet messages, and (3) clean out tweet messages that are irrelevant to the Egypt

revolution by using “Egypt” as a filter word.

On January 25th, 2011, we began Twitter data collection eight times per day, with one hour for each data collection. This data collection was to collect sufficient number of Twitter user IDs so that we could track back their entire messages later. We used “Egypt” as a search keyword in the advanced Twitter search engine (<https://twitter.com/#!/search-advanced>). The “external data sources” feature in Microsoft Excel software was used to retrieve the XML-based RSS feed of Twitter data into an Excel spreadsheet. Through this practice, we collected a total of 50,778 Twitter user accounts from January 25th to February 11th, 2011. Subsequently, we used the Twitter API to track back and retrieve tweet posts of all those twitter user accounts. A total of 1,915,429 Twitter data were collected for the 50,778 Twitter user accounts which ranges from January 12th to March 10th, 2011. All these tweet data were imported into a Microsoft SQL Server system to perform data cleaning. We used “Egypt” as a parameter to filter out irrelevant data. Finally, the sample size used for this study is 343,581 Twitter messages posted by 15,636 users from January 12th to March 10th, 2011.

Although the use of single search keyword (“Egypt”) may have limitations in representing the Twitter space during the Egypt revolution, the search keyword “Egypt” could capture the largest portion of population data, more than any other potential search keywords such as “Mubarak,” “Jan25,” and “Cairo” etc. However, due to the large volume of data stream, we decided to use the most dominant search keyword, “Egypt,” for our data collection.

Testing a Power-Law Structure to Identify Influential Users

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

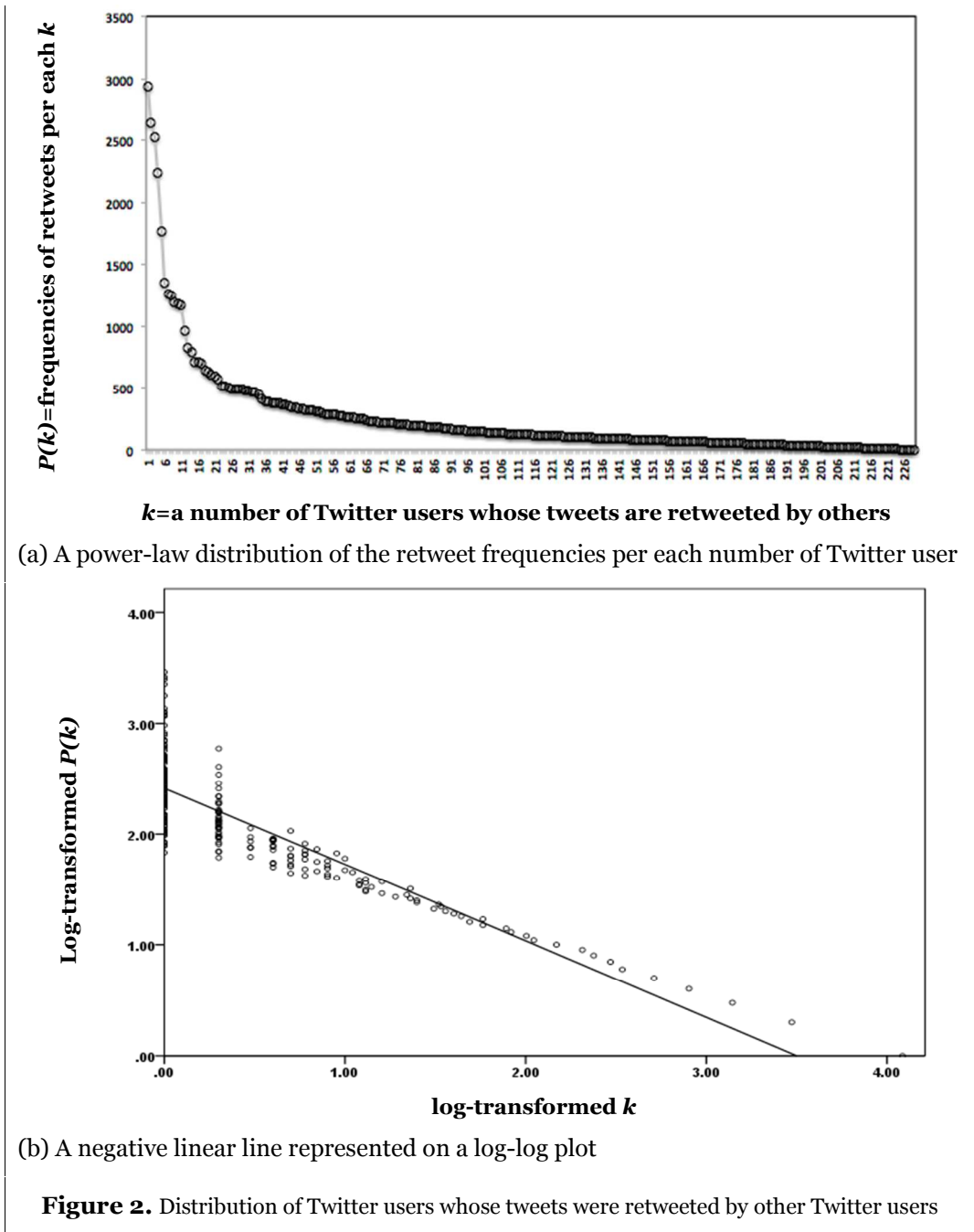
$$P(k) \sim k^{-r}$$

This means the probability that a specific Twitter user’s tweet message is retweeted k times follows a power law with exponent r . If the power-law distribution exists in terms of retweets, then the distribution should be represented as a negative linear line when plotted in the log-transformed scales, which will make the statistical test possible (Moody et al. 2003):

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

A negative linear relationship is tested between the log-transformed value for the number (k) of individual Twitter users and the log-transformed value for the frequencies of retweets for each number of individuals, k , which is $P(k)$. Our result indicates that a significant negative linear relationship exists between the k and $P(k)$ with $R^2 = .755$, $F(1, 227) = 701.229$, $\beta_1 = -.690$, at $p < .001$. Therefore, it confirms uneven power distribution, suggesting that a very few influential Twitter users’ messages were extremely frequently retweeted by a large number of other Twitter users.

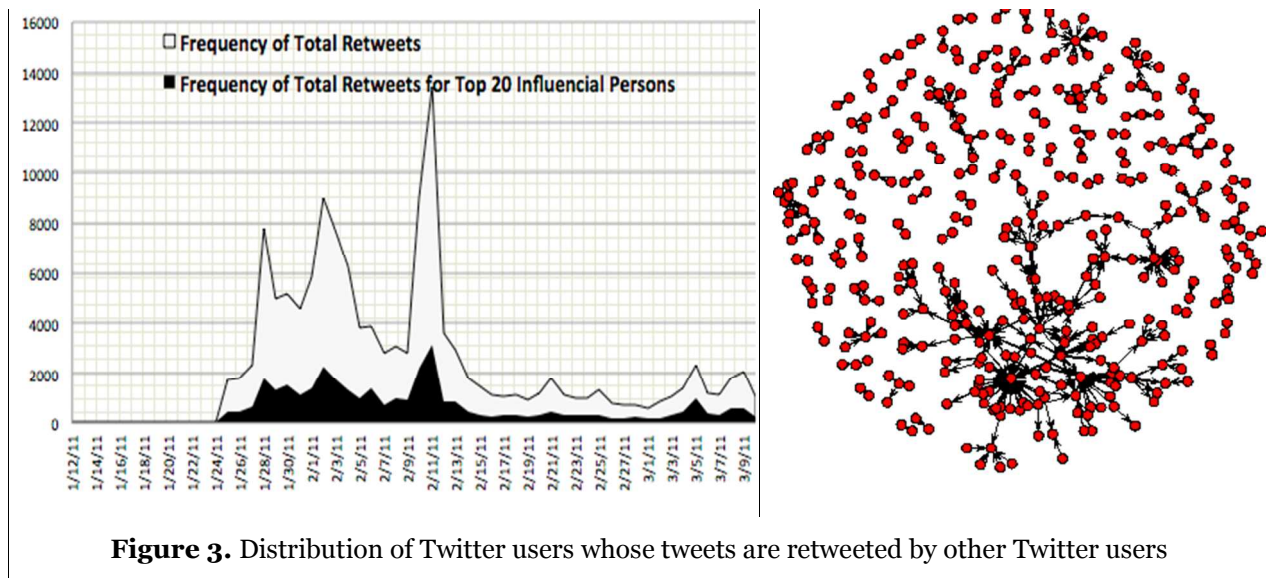
This means that our data confirms that a few influential opinion leaders existed in the Twitter space during the Egypt revolution. Figure 2 visually represents the uneven power-law distribution. Figure 2(a) and 2(b) visualize that, during the 2011 Egypt revolution, very few powerful Twitter users’ tweet messages have been favored by extremely large numbers of other Twitter users and a majority of Twitter users’ tweet messages have been minimally retweeted. For example, figure 2(a) shows that, while one Twitter user’s tweet messages were retweeted 2,933 times by other Twitter users, 226 users’ tweet messages were not retweeted at all by others.



The distribution chart in the left column of Figure 3 visually shows the influence of the top 20 most frequently retweeted users (black colored area) against the frequency of total retweet messages (white colored area). Comparison of this retweet distribution chart with the reprint distribution chart in figure 1 offers insight to read similar patterns of sociotechnical dynamics in different communication technologies. However, despite the similarity, it is noteworthy to mention that the implications of different scale (Y-axes in figure 1 and figure 3) and speed (X-axes in figure 1 and figure 3) of information diffusion is not trivial, because it accompanies not only different speed and scale of collective sense-making but different speed and scale in the development of revolutionary social changes.

Additionally, the social network graph in the right column in figure 3 represents that, whereas a majority of retweets was spread from a few central users' tweet messages, most tweets messages were retweeted only once (dyad connection) or twice (triad connection). It means that, during the Egypt revolution, while a few

central Twitter users received a large number of retweet attention from other Twitter users, most Twitter messages were disregarded without receiving retweets from others.



Conclusion

Drawing on the historians' research framework on the relationship between print technology and the Reformation, this study analyzed the sociotechnical implications of communication technologies, information diffusion, and development patterns of radical social changes. Avoiding human-centrism, techno-centrism, and human-machine interaction view, we took the perspective of an inseparably intermingled reality view of human and technologies and its attendant sociotechnical dynamics in the context of the Reformation and the Egypt revolution. So far, we found that a revolutionary idea or individual itself is not revolutionary unless they receive large-scale social support from the multitude of crowds. Also, this study found that communication technologies, be it print technology or social media technology, plays a pivotal role in expressing and aggregating social supports through the form of collective information diffusion and, possibly, its derivative collective sense-making. In this regard, revolutionary individuals or ideas are made through collective uses of communication technologies, which connect the previously disconnected ideas or experiences.

A few research questions still remain to complete this research in progress. This study successfully demonstrated the mechanism of how revolutionary ideas and figures emerge through inseparable interplays of a few central figures (or their ideas), large number of crowds, and some communication technologies. However, we did not discover yet who are the central figures (e.g. who were the most frequently retweeted users) and what the characteristics of those central figures' messages are. Another question to address involves how long those central ideas survived (e.g. how many nodes the central figures' messages were retweeted along). All these questions essentially converge into a larger question of how collective sense-making processes are developing to achieve the goal of radical social changes. To answer this question, we need to pay more attention to the variant 'social' dynamics emerging around the social 'technologies' by recognizing the inseparable reality of technosociety (with no hyphen). This research in progress study leaves these questions as future research topics.

Acknowledgements

The authors would like to thank the editors and the referees for their critical comments that have greatly improved the paper. This research has been funded in part by NSF under grants 0916612, 1134853, 1227353, 1241709. The research of the third (corresponding) author is also supported by Sogang Business School's World Class University Project (R31-20002) funded by Korea Research Foundation and Sogang University research foundation. The usual disclaimer applies.

References

- Barabasi, A. L., Albert, R., Jeong, H., & Bianconi, G. 2000. "Power-law Distribution of the World Wide Web," *Science*, (287), pp. 2115a-2115bb.
- Boyd, D., Golder, S., and Lotan, G. 2010. "Tweet, Tweet, Retweet: Conversational Aspects of Retweeting on Twitter," In *Proceedings of HICSS*. Kauai, HI, January 6.
- Bruns, A., and Eltham, B. 2009. "Twitter Free Iran: An Evaluation of Twitter's Role in Public Diplomacy and Information Operations in Iran's 2009 Election Crisis," in *Communication Policy & Research Forum 2009*, November 19th-20th, University of Technology, Sydney.
- CBS. 2011. "Wael Ghonim's 60 Minutes Interview: Egypt's New Age Revolution," <http://www.youtube.com/watch?v=2KGSVxg3KaE>. Retrieved 2012-03-09.
- Easley, D. and Kleinberg, J. 2010. *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*. New York, NY: Cambridge University Press.
- Edwards, M.U. 1994. *Printing, Propaganda, and Martin Luther*, Los Angeles, CA: University of California Press.
- Eisenstein, E.L. 2005. *The Printing Revolution in Early Modern Europe*, New York, NY: Cambridge University Press.
- Ghonim, W. 2012. *Revolution 2.0: The Power of the People is Greater Than the People in Power: A Memoire*, Boston, New York: Houghton Mifflin Harcourt.
- Gladwell, M. 2011. "Does Egypt Need Twitter?" *The New Yorker*, <http://www.newyorker.com/online/blogs/newsdesk/2011/02/does-egypt-need-twitter.html#ixzz1CqneJJOu>. Retrieved 2012-03-05.
- Gupta, A., and Kumaraguru, P. 2011. "Twitter Explodes with Activity in Mumbai Blast! A Lifeline or an Unmonitored Daemon in the Lurking?," IIIT, Deli, Technical Report. http://precog.iiitd.edu.in/psosm_www2012/a2-gupta.pdf. Retrieved 2012-04-21.
- Howard, P.N., Duffy, A., Freelon, D., Hussain, M., Mari, W., and Mazaid, M. 2011. "Opening Closed Regimes: What Was the Role of Social Media During the Arab Spring?," Project on Information Technology & Political Islam, Working Paper, University of Washington.
- Kravets, D. 2011. "What's Fueling Mideast Protests? It's More Than Twitter," *Wired*, <http://www.wired.com/dangerroom/2011/01/social-media-oppression/>. Retrieved 2012-03-05.
- Kwak, H., Lee, C., Park, H., and Moon, S. 2010. "What is Twitter, a Social Network or a News Media?," In *Proceedings of International WWW Conference*, Raleigh, NC., pp.591-600.
- Leonardi, P. 2009. "Crossing the Implementation Line: The Mutual Constitution of Technology and Organizing Across Development and Use Activities," *Communication Theory* (19), pp. 278-310.
- Leonardi, P. and Barley, S.R. 2008. "Materiality and Change: Challenges to Building Better Theory about Technology and Organization," *Information and Organization* (18), pp.159-176.
- Lerman, K., Ghosh, R., and Surachawala, T. 2012. "Social Contagion: An Empirical Study of Information Spread on Digg and Twitter Follower Graphs," <http://arxiv.org/abs/1202.3162>. Retrieved 2012-04-23.
- Lotan, G., Graeff, E., Ananny, M., Gaffney, D., Pearce, I., and Boyd, D. 2011. "The Revolutions Were Tweeted: Information Flows During the 2011 Tunisian and Egyptian Revolutions," *International Journal of Communications* (5), pp. 1375-1405.
- Maghrabi, R.O., and Salam, A.F. 2011. "Social Media, Social Movement, and Political Change: The Case of 2011 Cairo Revolt," in *Proceedings of the 30th International Conference on Information Systems*, Shanghai, China.
- Moody, J., and White, D. 2003. "Structural Cohesion and Embeddedness: A Hierarchical Concept of Social Groups," *American Sociological Review*, (68:1), pp. 103-127.
- Mungiu-Pippidi, A., and Munteanu, I. 2009. "Moldova's 'Twitter Revolution'," *Journal of Democracy* (20:3), pp.136-142.
- Oh, O., Kwon, K.H., and Rao, H.R. 2010. "An Exploration of Social Media in Extreme Events: Rumor Theory and Twitter during the Haiti Earthquake 2010," International Conference on Information Systems, MI, Saint Louis.
- Oh, O., Agrawal, M., and Rao, H. R. 2011. "Information Control and Terrorism: Tracking the Mumbai Terrorist Attack through Twitter," *Information Systems Frontiers* (13:1), pp. 33-43.

- Orlikowski, W.J. 2005. "Material Works: Exploring the Situated Entanglement of Technological Performativity and Human Agency," *Scandinavian Journal of Information Systems* (17:1), pp. 183-186.
- Orlikowski, W.J. 2007. "Sociomaterial Practices: Exploring Technology at Work," *Organization Science* (28), pp. 1435-1448.
- Orlikowski, W.J. and Scott S.V. 2007. "Sociomateriality: Challenging the Separation of Technology, Work and Organization," *The Academy of Management Annals* (2:1), pp. 433-474.
- Qu, Y., Huang, C., Zhang, P., and Zhang, J. 2011. "Microblogging After a Major Disaster in China: A Case Study of the 2010 Yushu Earthquake," In *Proceedings of CSCW*, Hangzhou, China, pp.25-34.
- Smith, C. 2011. "Egypt's Facebook Revolution: Wael Ghonim Thanks The Social Network," The Huffington Post, http://www.huffingtonpost.com/2011/02/11/egypt-facebook-revolution-wael-ghonim_n_822078.html Retrieved 2012-04-23.
- Starbird, K. and Palen, L. 2012. "(How) Will the Revolution be Retweeted?: Information Diffusion and the 2011 Egyptian Uprising," in *Proceedings of Conference on Computer Supported Cooperative Work*, Seattle, WA, USA, February 11-15.
- Suh, B., Hong, L., Piroli, P., and Chi, E.H. 2010. "Want to Be Retweeted? Large Scale Analytics on Factors Impacting Retweet in Twitter Network," In *Proceedings of IEEE International Conference on Social Computing*, Washington, DC.
- Turner, R., and Killan, L. 1957. *Collective Behavior*, Englewood-Cliff, NJ: Prentice-Hall.
- Vieweg, S., Hughes, A., Starbird, K., and Palen, L. 2010. "Micro-blogging During Two Natural Hazards Events," in *Proceedings of CHI*, Atlanta, GA.