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Assessing the Carrying Capacity of Twitter and Online News

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Communication theorists have long presumed that the capacity of mass media was essentially fixed. This study investigates the relevance of this assumption in the digital environment, where production and broadcasting capacities have become nearly infinite. Examining 2 years of data from Twitter and electronic databases of news articles revealed some differences in the nature of constraint in the two environments. The daily volume of Twitter was more variable than online news coverage once cyclical factors were controlled. Interestingly, the volume of Twitter did not always increase in response to key events.

The total volume of daily news coverage has traditionally been regarded as, more or less, constant. Constrained by budgeting, staff, printing costs, and the number of hours in a day, “all the news that’s fit to print” could be conveniently packaged up to arrive daily on readers’ doorsteps. When

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a major event occurred, “breaking news” would displace “nonessential” items (Berkowitz, 1992). Hence, whether a news organization had 30 minutes, 20 pages, or 24 hours to fill, the amount of content communicated was essentially static from day to day.

The proliferation of social media sites and online informational platforms in the last two decades has the potential to challenge the traditional constraints of the mass media (Bruns & Burgess, 2012; Hermida, 2013; Papacharissi & De Fatima Oliveira, 2012; Shirky, 2008). In contrast to the constant bandwidth that characterized previous media environments, the digital revolution slashed the costs of publishing and offered Internet users virtually unlimited space to generate, customize, and exchange information (Pavlik, 2013). In theory, the spectacular “what-a-story” events that capture the public’s attention no longer must displace other news; they may instead add to the overall volume of content generated (Mitchelstein & Boczkowski, 2010). If events in the contemporary media environment expand public attention without having to sacrifice public attention to other issues, the implications for communication theory could be profound. In particular, it is necessary to reconsider the mechanisms behind media agenda setting, which proposes that that mass media direct public attention by focusing coverage on some issues at the expense of others (Geip, 2011; Iyengar & Kinder, 1987; James & Oneal, 1991; McCombs & Shaw, 1972; Zhu, 1992).

In practice, it has been commonly assumed that the technological affordances of new media have resulted in broadened creation and transmission of public information. Public attention may be directed in ways similar to earlier eras if content produced online is driven (directly or indirectly) by institutional actors or reflects traditional journalistic practices. Perhaps the key limit to the information that people can receive was never the size of the media pie per se but instead the cognitive resources necessary to process and attend to the information (Zhu, 1992). In these ways, it is possible that the digital revolution has changed the form but not the substance of the news.

Despite two decades of scholarship on online news dissemination, media scholars continue to have little idea of how digital practices change the relevance of long-standing assumption that the capacity of mass media is essentially limited. This study aims to fill this important gap by measuring the total volume of informational content produced daily on Twitter and in the online news media over the course of 2 years and assessing whether discussion of key events indeed alters the total volume of content generated. In particular, we examine whether notable events in the new media environment displace other informational content or whether they instead expand the total amount of information transmitted.

LIMITED CAPACITY IN A TRADITIONAL MEDIA ENVIRONMENT

Literature on journalism and agenda setting has indicated that mass media have limited carrying capacity (McCombs & Zhu, 1995, Zhu, 1992). This assumption has been widely accepted mainly because the limits on media's (a) production and (b) broadcasting capabilities were too obvious. The constrictive influence on production capacity stems from the fact that news organizations are largely governed by the market principle—seeking high profit with low cost. From the management perspective, it is expected that a limited number of journalists would produce high-quality news stories with the resources that have been allocated, and within the given time frames (Berkowitz, 1992). As time, money, and labor are nearly always in short supply (Epstein, 1973), the production of news tends to follow safe newsgathering routines to focus on news events that are commonly reported by other news media. The similarity in news content across news outlets further attests to this limited production capacity.

Mass media outlets have traditionally been constrained not only by their production capacity but also by their ability to disseminate information. The amount of media content that can be published is constant given the limits of column space and airtime. Although the rise of cable channels has increased the volume of news coverage to a certain extent, a news channel cannot broadcast more content than will fit into 24 hours. The 24-hour outlets also must fill the entire day with content, regardless of how unimportant a day's events may be (cf. Lewis, Cushion, & Thomas, 2005). Therefore, it seems unlikely that the production and broadcasting capacity of news organizations would be highly flexible. Even on the occasions when real-world events disrupt news routines and force resource reallocations, it is hardly the case that the size of “news hole” becomes much larger (Bennett, 1990; Glasser, 1999; Ryfe, 2006). Instead, news outlets have long padded their story lists with items that could be replaced if and when bigger news broke (Gans, 1979, p. 109).

The assumption of media's limited carrying capacity has not received much empirical assessment, and those studies that have attempted to test this capacity have been unable to distinguish limits on public attention from constraints on the information broadcast (McCombs & Zhu, 1995). For example, Brosius and Kepplinger (1995) found that most people could identify only about five issues. McCombs and Zhu (1995) also showed that despite the technical developments and educational enhancement between 1954 and 1994, there was no significant increase in the public's carrying capacity over the four decades. Although these studies identified another important constraint—limits on the news audience's attention—they did not directly test the assumption that media channels had a limited bandwidth. Hence, previous research

suggests that the total volume of public information transmitted via traditional news media was limited and constant over time due to some unknown combination of the media's broadcasting capacity and the attentional capacity of the audience. Given the inability to disentangle these pathways and the fact this research was largely conducted before the digital revolution, it is hard to know the extent to which similar constraints apply today.

CHALLENGES TO MEDIA'S LIMITED CAPACITY IN A DIGITAL ERA

In the emerging media environment, limits on content generation and dissemination appear to have lost their binding force. First, overall production capacity expanded with the rise of the Internet and participatory digital culture (Napoli, 2011). By blurring previously established divisions between information producers and consumers, the Internet—and social media in particular—undermines the monopoly that traditional outlets once held on information control (Deuze, 2008; Lewis, Holton, & Coddington, 2014; Neuman, Guggenheim, Jang, & Bae, 2014). Ordinary users have been empowered to create and publish information online, bypassing the gatekeeping role of elite news organizations (Goode, 2009; Shoemaker & Vos, 2009). As Singer (2014) noted, "People who work inside a newsroom now produce and publish only a fraction of mass-mediated news" (p. 55). These changes enlarge the amount of information that can be generated in the digital arena by giving the public a voice in the construction of public agendas (Maratea, 2008).

Broadcasting capacity has also become almost unlimited. The traditional constraints on the carrying capacity of communication channels (e.g., broadcasting time and newspaper size) no longer apply (Bruns, 2005; Hamilton, 2004). The amount of information that can be transmitted over the web is far greater than can be conveyed with either a daily newspaper or 24 hours of airtime (Hilbert & Lopez, 2011). Hence, the online platform may be able to accommodate the full panoply of issues without having to prioritize some matters over others. In particular, an increasing number of tweets or online news stories about one issue need not come at the expense of information about other topics. In this way, the digital media environment could afford endless agendas and choices, allowing for the inclusion of the "long tail" of potentially relevant information (Anderson, 2006; Jang, 2014). Together, traditional limits on capital and personnel, coupled with constraints on broadcasting space, may not pertain much to digital production and broadcasting.

Absent the pressures that defined the previous generation of media outlets, it is reasonable to predict that digital arenas could accommodate a breadth of issues as expansive as the public sphere could handle. It is also

expected that the total amount of public information transmitted via this new generation of media should fluctuate more, particularly when extraordinary events occur. For example, when presidential elections or Super Bowls draw increasing attention from the public, members of the public who post on social media may produce a growing body of information about that topic; in turn, the total amount of information transmitted would be expected to increase. If this is true, an increase in the amount of information available about one issue should not necessarily correspond with a decrease in the amount of information available about other issues, thus obviating the zero-sum principle of issue competition in the digital era.

However, there is an alternative possibility. Although the digital environment seems to provide almost an infinite bandwidth, it cannot change the fact that people have finite amounts of time and limited attention spans (Maratea, 2008). Even when digital spheres invite digital crowds to produce and broadcast terabytes of information, human beings with limited attentional capacity may not be able to make full use of these digital offerings. Indeed, researchers studying citizen competence note that most people, having managed their more immediate concerns of family, job, and leisure, have little energy left to follow relatively distant and fleeting social issues (Converse, 1964; Iyengar & Kinder, 1987). As the cost of being well informed is substantial, people presumably focus on, at most, only a few issues (Krosnick, 1990). Much of the psychological research has reiterated this view. The limited capacity model suggests that human beings have a finite number of cognitive resources to absorb and process information (Lang, 2000). Fiske and Taylor (1991) characterized humans as "cognitive misers" indicating that people are seldom motivated to engage in a mental task unless it is an urgent matter. This psychological constraint may pose a significant barrier to the expansion of the information pie. Although technological advancements increase production and broadcasting capacities, the breadth of unique information that individuals receive may remain static due to the limits of human attention. In this manner, breaking news may still set the agenda and displace other topics not because the media are limited but because their consumers are.

AN ASSESSMENT OF THE NEW MEDIA ENVIRONMENT

The current study represents an initial assessment of the extent to which limits on production, broadcasting, and attention continue to restrict information transmission in the new media environment. We examine modern-day constraint by looking at the total volume of content generated across two types of media outlets: social media (as instantiated in Twitter)

and online news. For each of these outlets, we examine a relatively simple question: Is the amount of information transmitted responsive to the presence of newsworthy topics? Our premise in this analysis is that an unconstrained environment should generate more total information when there is more information worth broadcasting.

When compared to traditional broadcast media, social media appear to remove production and broadcasting constraints on the amount of media content. Twitter provides an ideal environment for assessing the extent to which the volume of content on social media is responsive to news events: Twitter content is generated by a diffuse group of users (Kwak, Lee, Park, & Moon, 2010), most tweets are publicly visible, making them accessible to researchers (Bruns & Burgess, 2012), and Twitter appears to function much like a news outlet in facilitating the spread of information (Pentina & Tarafdar, 2014; Vis, 2013). Some media scholars have even highlighted the “ambient” function of Twitter as a reporting device (Bruns & Burgess, 2012; Hermida, 2010). Although the Twitterverse is often filled with banal chatter, when there is an important news story, Twitter appears to play a significant role in producing and spreading raw information across the world (Parmelee & Bichard, 2011). These factors, in combination with firehose access that enables us to index every tweet from the site, make Twitter ideal for assessing whether removing limitations on production and broadcasting capabilities results in a more responsive information environment. If these limitations, rather than audience attention, are the central constraints on information transmission, we might expect the following:

H1a: The daily volume of content on Twitter will vary even when holding aggregate trends constant.

H1b: The daily volume of content on Twitter will be responsive to the presence of noteworthy news events.

In contrast to social media, online versions of traditional media are still limited by journalistic norms and routines. Constraints on broadcasting, however, have largely been lifted. There are theoretical reasons to think that either of these processes could be the relevant bottleneck. Observational accounts of the newsroom provide reason to hold contradictory expectations. For one, journalists produce a small number of disposable stories that can be displaced when bigger news arrives (Berkowitz, 1992); these could potentially be broadcast at nominal additional cost in the current environment. Alternatively, limitations on journalist’s time are unchanged, and these appear responsible for many newsgathering practices (Mitchelstein & Boczkowski, 2010). Further, the editing process might streamline what

gets reported even when space is not a limiting factor. Together these forces lead us to expect that online news would fall somewhere between broadcast news and social media in its responsiveness. We thus view the level of elasticity in the online news environment as an open research question:

RQ1a: How much does the daily volume of content on traditional online news vary when holding aggregate trends constant?

RQ1b: How responsive is the daily volume of content on traditional online news to the presence of noteworthy news events?

METHOD

Data

Data for the current study were collected using the Sysomos Media Analysis Platform. Sysomos is a private company providing tools for social media analytics and traditional media monitoring. It is important to note that the company has a contract with Twitter that enables customers to access the full “firehose” of all public tweets that are produced on the site, not just the subset that can be accessed through the free Application Programming Interface. Sysomos also collects full data from online outlets of traditional media sources, including newspapers, television outlets, news magazines, and web-only outlets at both the national and local levels (e.g., *nytimes.com*, *foxnews.com*, *businessweek.com*). Together these sources provide a comprehensive portrait of the media environment that is ideal for assessing aggregate changes over time.

Both social and traditional online media data were collected for a 2-year period spanning from June 5, 2012, to June 4, 2014. We restricted both tweets and online traditional media to information from the United States that was published in English. Sysomos also removes “spam” tweets (e.g., Twitter bots) so that the tweets searched represent active accounts run by real people. In total, 46.3 billion public tweets and 194.0 million traditional news stories were assessed in the current analysis.

Outcome Variables

Daily volume of tweets. Access to the full Twitter firehose allowed us to measure the total volume of tweets. We aggregated the volume of tweeting on a day-to-day basis. On average, 63.4 million tweets were generated in the United States on a typical day of our field period ($SD = 11.3$ million). The daily volume of Twitter content was recoded to range from 0, representing

a day where no tweets would be generated, to 1, for the maximum number of tweets observed on a single day (92.5 million on February 2, 2014). The overall volume of tweeting on each date is indexed by the black line in Figure 1.

Daily volume of online news. We also aggregated the total number of news stories produced and disseminated on a daily basis. On average, around 266,000 news stories were generated from the U.S. news outlets examined on a typical day of our field period ($SD = 108,000$). The daily volume of news content was recoded to range from 0, representing a day where no news stories would be generated, to 1, for the maximum number of stories observed on a single day (497,000 on June 3, 2014). The overall volume of online news on each date is indexed by the gray line in Figure 1.

Predictors

Key events. In the terminology of this study, key events refer to those that lead to a “sharp and continuous increase of reporting on a specific issue

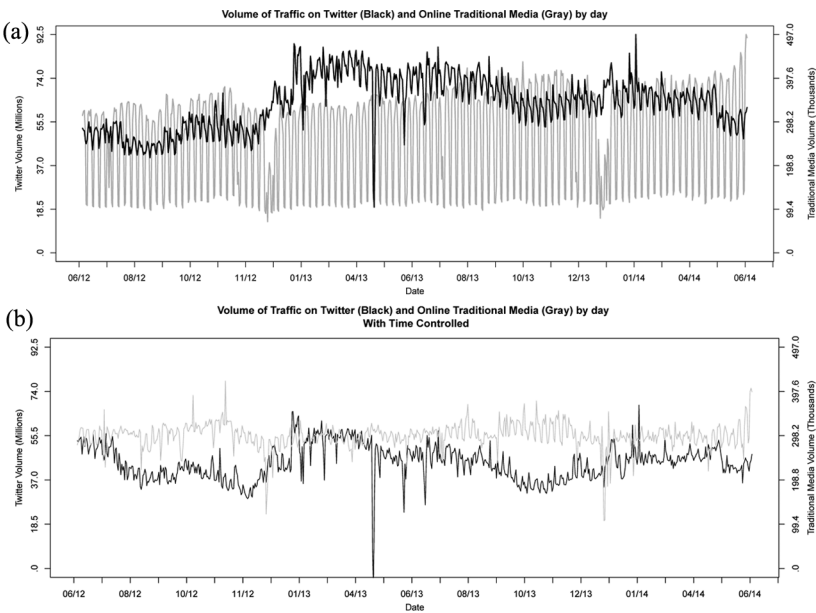


FIGURE 1 Volume of information on Twitter and online traditional media by day (a), and with temporal factors controlled (b).

for a limited period of time” (Geip, 2011, p. 272). Brosius and Kepplinger (1995) referred to these as “killer issues” to stress the role of key events in occupying news coverage and crowding out what they call “victim issues.” They identified six attributes of killer issues: personal relevance, danger and threat, change in knowledge, feedback, relatedness, and symbolic value. The literature has suggested that human/natural disasters, staged political events, scandals, and sporting events tend to hold these characteristics (Dearing & Rogers, 1996; Kepplinger & Habermeier, 1995). Following these considerations, occurrences of 12 types of news event were selected as key events in this study: the 2012 presidential election, presidential debates, Republican primaries, mass shootings (in Aurora, Newtown, and the Washington Navy Yard), the Boston Marathon bombing, the George Zimmerman trial, natural disasters (hurricanes, storms, and tornadoes), the Olympic Games (the 2012 Summer Games in London and the 2014 Winter Games in Sochi), the 2013 and 2014 Super Bowls, the election of Pope Francis, the birth of Britain’s Prince George, and international crises (the Ukraine crisis, Syrian civil war, and North Korea missile threats).

To quantify the daily presence of these key events, we needed to assign a value for the presence or absence of an event on a particular day. One approach is to simply assign a 1 or 0 to each event for each of the 730 days in our examination period based on whether that event was happening or not. For example, we could put 1 for November 6 and November 7 for the 2012 presidential election and 0 for the other 728 days. However, the problem with this method is that a key event did not necessarily have a definite beginning and end. Given that news coverage of and public attention to the presidential election begins much earlier than Election Night and lasts longer than 1 or 2 days, it is hard to determine the length of a key event in a binary manner. Further, as Guggenheim and Pasek (2013) have noted, keywords indexing events frequently return to the news when they are resurrected by successive related events, such as when President Obama visited Newtown, Connecticut, following the Sandy Hook shooting. To compensate for the limitations of the binary nominal scale, we developed a continuous measure to represent the salience of key events on a daily basis. We used the amount of online news coverage associated with keywords for each key event as a measure of its daily prevalence.¹ Data on the presence of key events in the news comes from a keyword search of traditional media using

¹This meant that keyword presence was, by definition, closely related to coverage of events in online traditional media. This is not an instance of selecting on the dependent variable, however, as it is not necessarily the case that the overall volume of coverage will relate to the volume of events within that coverage.

the Sysomos archive. Like the Lexis/Nexis database, Sysomos provides an electronic catalog of traditional media stories that can be searched. This study acknowledges that automated keyword analysis often yields misleading returns by failing to locate relevant content or including extraneous texts especially when it comes to complex issues or sentimental analysis (Stryker, Hornik, & Yanovitzky, 2006). However, we believe that this study is not susceptible to such concerns. Keywords used to represent key events in this study have strong face validity in signifying the presence of the key real-world issues.

We obtained the daily volume of news articles that referenced the keywords pertaining to each event. We limited ourselves to news stories that were written in English and from media institutions in the United States. For each event, we carefully derived a set of search queries identifying words or phrases unique to that event. To determine the relevance of search terms, we looked into at least a sample of 200 tweets for each event. We finalized our search terms after ascertaining that they do not include significant noise (i.e., tweets irrelevant to key events). These Boolean search terms were “presidential election” OR “2012 election” for the 2012 presidential election, “presidential debate” for the 2012 presidential debates, “GOP primaries” OR “Republican primaries” for the 2012 Republican presidential primaries, “shootings AND (Colorado OR Aurora OR Newtown OR “Sandy Hook” OR “navy yard”)” for mass shootings, “Boston bombing” for Boston bombing, “Trayvon OR George Zimmerman” for Zimmerman trials, “hurricane OR storm OR tornado” for natural disasters, “Olympic” OR “Olympics” for the 2012 Summer and 2014 Winter Olympics, “Super Bowl” for the 2013 and 2014 Super Bowls, “Pope Francis” for Pope Francis, “royal baby” OR “prince George” for the birth of royal baby, and Ukraine OR Syria OR “North Korea” for salient international crises. The daily volume of online news stories about each event is illustrated in Figure 2.

Although searches were not case sensitive, this filtering process based on Boolean keywords might exclude potentially relevant tweets about key events. We are not particularly concerned about this possibility, however, as the goal of keyword searches was to index the relative prevalence of media mentions of each key event on some days as compared to other days (cf. Jungherr, 2014). We elected to include retweets in our assessments, as prior literature suggests that they are an effective indicator for the extent to which messages are considered important in the network (Larsson & Moe, 2012). A partial replication excluding retweets yielded similar results. For each event, the daily volume of online news coverage was rescaled to range from 0 when an event received no coverage whatsoever to 1 for the date with the largest volume of coverage.

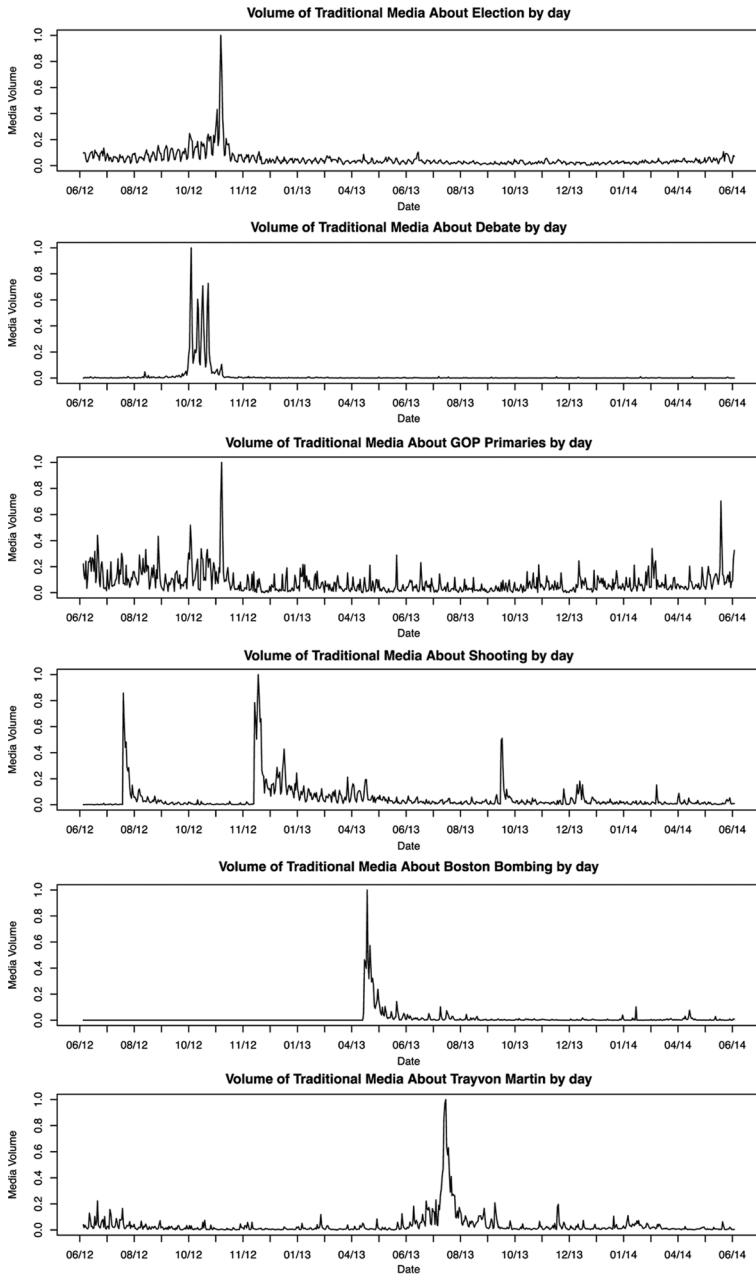


FIGURE 2 Traditional media volumes associated with key events.

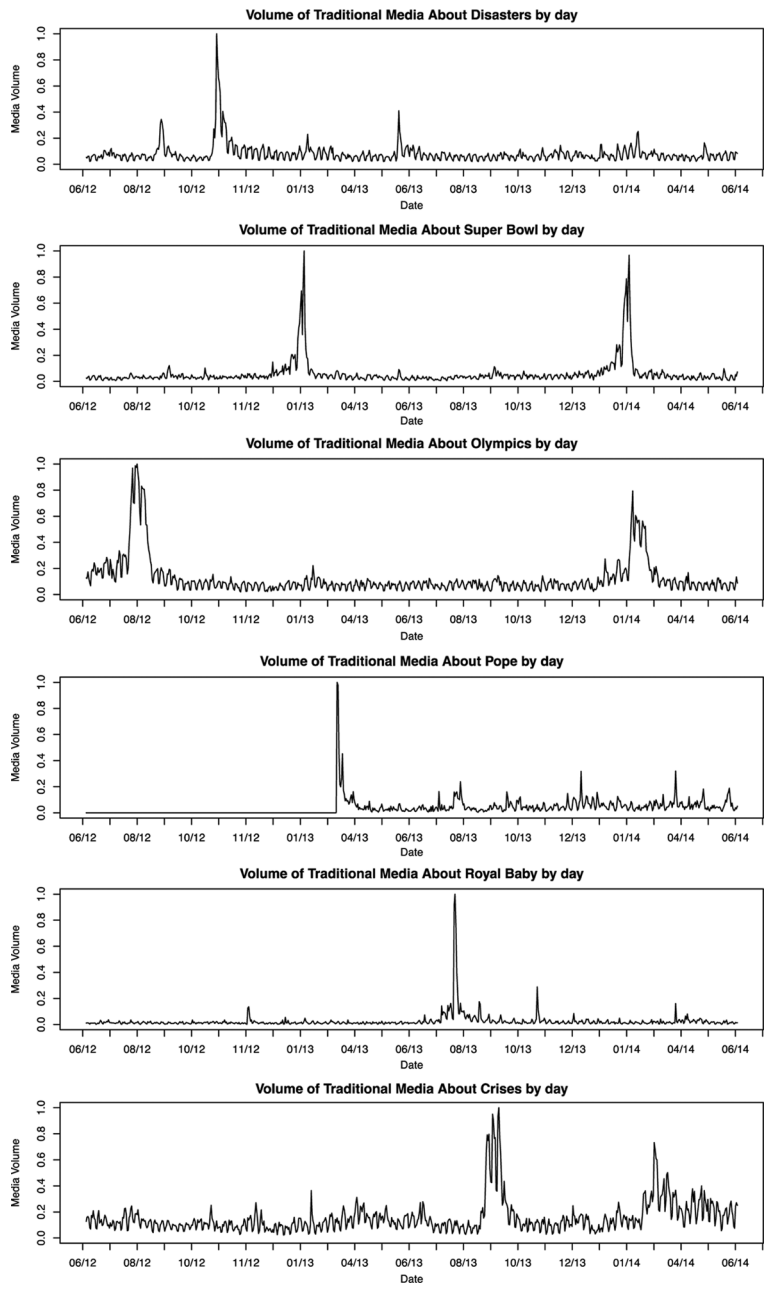


FIGURE 2 Continued.

Covariates

In line with earlier research, we expected that the total volume of content in both media would be a function of both key events and exogenous cyclical variations in production habits. In particular, Neuman et al. (2014) identified strong periodicity in weekly tweeting behavior. Twitter has also grown notably over time (Smith & Brenner, 2012). For this reason, it was important to control for long-term trends and cyclical processes that might alter patterns of behavior both on Twitter and in the traditional online media. To capture these processes—and thereby exclude these daily variations from our assessment of the relevance of events—we controlled for days of the week and holidays in all regression analyses. Each day of the week was treated as a dummy variable for all analyses. A holiday variable was coded 1 for the presence of a national holiday and 0 otherwise. Ten national holidays were included: New Year's Day, Martin Luther King Day, Presidents' Day, Memorial Day, Independence Day, Labor Day, Columbus Day, Veterans Day, Thanksgiving Day, and Christmas Day. Finally, we accounted for long-term changes in Twitter use over the period of the study with both a linear and quadratic variables for time (coded to range from 0 for the first day of the field period to 1 for the last day of the field period).

Analysis

To understand the sensitivity of both Twitter and traditional news media to key events, we conduct two comparisons. First, we explored the extent to which temporal factors alone accounted for variations in the volume of content produced in each medium. We then assessed whether key events were associated with expansions in the total amount of information generated by regressing daily media volume figures onto the time variables and daily prevalence of key events.

RESULTS

Both Twitter and online news content displayed consistent weekly patterns (Figure 1). In general, the largest volume of tweeting occurred on Mondays, with users producing 4.6% more tweets than average; the fewest tweets were generated on Saturdays, which averaged 9.3% fewer tweets than the average day. News coverage showed even stronger weekly cycles. The daily volume of news articles on weekends was barely one third of that on a typical weekday (35.2%) Slightly less news content was produced

on Fridays than on other weekdays. The total amount of media content that met our parameters (U.S.-based, English language, and not spam) increased over the course of our examination period both on Twitter and in the online traditional media, reflecting the growing popularity of social media and online news websites.

Time Constraints on Media Content

To assess how much of the variation in Twitter volume was attributable to temporal factors, we regressed the daily volumes of Twitter and news coverage onto the variables for day of the week, holidays, and over-time trends. If a large portion of the variance in the volume of media content is explained by these temporal variables, we might conclude that routines of production are constraining the amount of information produced. As shown in Table 1, the regression results about Twitter and news media were strikingly different. For Twitter, temporal variables explained 60.9% of the variance in the volume Twitter traffic (H1a).

TABLE 1
Variance in Media Content Explained by Temporal Factors

	<i>Twitter</i>		<i>Online News</i>	
	Coeff.	SE	Coeff.	SE
Time	1.140***	(.039)	.041	(.029)
Time squared	-.980***	(.038)	.074**	(.028)
Tuesday	-.006	(.011)	.071**	(.008)
Wednesday	-.011	(.011)	.073***	(.008)
Thursday	-.026*	(.011)	.057***	(.008)
Friday	-.078***	(.011)	-.080***	(.008)
Saturday	-.096***	(.011)	-.413***	(.008)
Sunday	-.004	(.011)	-.418***	(.008)
Holiday	-.015	(.023)	-.224***	(.017)
Tuesday * Holiday	-.009	(.045)	-.224***	(.033)
Wednesday * Holiday	-.002	(.050)	-.269***	(.037)
Thursday * Holiday	-.038	(.050)	-.151***	(.037)
Friday * Holiday	-.080	(.059)	.029	(.043)
Intercept	.476***	(.011)	.601***	(.008)
Initial <i>SD</i> .		.121		.216
Residual <i>SD</i>		.075		.056
<i>R</i> ²		.609		.934
<i>N</i>		730		730

Note. No holidays occurred during weekends over the period examined. Monday is the base-line category. Coeff = coefficient. **p* < .05. ***p* < .01. ****p* < .001.

When predicting the volume of online news content, 93.4% of the variance was attributable to temporal variables. The results suggest that the work of news production and broadcasting, even when published online, is greatly influenced by time constraints (RQ1a). On weekends, for example, there are fewer journalists on duty and correspondingly, there is less news to report (e.g., the stock markets are closed). Our results echo the notion that the news production cycle is controlled by daily resources and prescribed journalistic routines (Berkowitz, 1992). At the same time, Twitter activities do not appear to be dictated by the same temporal burdens. Almost 40% of the variance in the volume of Twitter content was not explained by the temporal factors we examined, indicating much more room for the flow of information to vary in response to information availability.

Responsiveness to Key Events

To assess the importance of key events in determining the level of traffic on Twitter and traditional media, we regressed the daily volumes of Twitter and news coverage onto the prevalence of key events after controlling for temporal variables. Key events were related to changes in the volume of information transmitted on both Twitter and in traditional media. When news coverage of the 12 key events was included in the regression models, this accounted for an additional 3.1% of the variance in Twitter volume beyond temporal factors, $F(12)=5.0$, $p<.001$ (Table 2, column 1) and an additional 0.6% of the variance in online versions of traditional news, $F(12)=5.6$, $p<.001$ (Table 2, column 2). Specifically, Twitter traffic increased in response to news related to Trayvon Martin, the Super Bowl, and the Pope (Table 2, column 1). Online news increased when additional news was published about elections, the Boston Marathon Bombing, the royal baby, and international crises (Table 2, column 2).

Notably, the pattern of relations linking the presence of news events with Twitter postings did not comport with the notion that broadcasting would always expand the overall volume of coverage. Among the 12 events examined, two demonstrated statistically significant negative relations between the presence of a newsworthy topic and Twitter volume (election news: $b=-.14$, $SE=.06$, $p=.03$ and debate news: $b=-.08$, $SE=.04$, $p=.04$). Coverage of shootings, disasters, and the royal baby also trended in a negative direction. This may be indicative of a more complex pattern of decisions among Twitter users, who might decide not to tweet about other matters when certain types of news stories occur.

TABLE 2
Variance in Media Content Explained by Temporal Factors and Events

	<i>Twitter</i>		<i>Online News</i>	
	Coeff.	SE	Coeff.	SE
Election	-.140*	(.064)	.098*	(.047)
Debate	-.080*	(.039)	.046	(.029)
GOP Primaries	.064	(.042)	.053	(.031)
Shootings	-.034	(.028)	-.043*	(.020)
Boston Bombing	.078	(.045)	.068*	(.033)
Trayvon Martin	.096*	(.035)	.035	(.026)
Disasters	-.045	(.046)	.029	(.034)
Super Bowl	.112***	(.029)	-.012	(.021)
Olympics	-.027	(.022)	.019	(.016)
Pope	.165***	(.043)	-.003	(.031)
Royal Baby	-.041	(.048)	.090*	(.035)
International Crisis	.025	(.025)	.076***	(.018)
Time	1.048***	(.048)	.087*	(.035)
Time squared	-.926***	(.045)	.031	(.033)
Tuesday	-.005	(.011)	.067***	(.008)
Wednesday	-.011	(.011)	.070***	(.008)
Thursday	-.027	(.011)	.056***	(.008)
Friday	-.078***	(.011)	-.077***	(.008)
Saturday	-.093***	(.011)	-.395***	(.008)
Sunday	-.002	(.011)	-.402***	(.008)
Holiday	-.010	(.022)	-.214***	(.016)
Tuesday * Holiday	-.012	(.044)	-.207	*** (.032)
Wednesday * Holiday	-.005	(.049)	-.254	*** (.036)
Thursday * Holiday	-.033	(.048)	-.142	*** (.036)
Friday * Holiday	-.078	(.057)	.034	(.042)
Intercept	.495***	(.016)	.560	*** (.012)
Initial <i>SD</i>	.121	.216		
Residual <i>SD</i>	.072	.053		
<i>R</i> ²	.640	.940		
Change in <i>R</i> ²	.031	.006		
<i>F</i> test vs. temporal model	5.0	(<i>df</i> =12)***	5.6	(<i>df</i> =12)***
<i>N</i>	730	730		

Note. No holidays occurred during weekends over the period examined. Monday is the baseline category. Coeff = coefficient. **p* < .05. ***p* < .01. ****p* < .001.

DISCUSSION

Previous literature indicates that the technical limitations of mass media as well as the limits of the audience's attention have kept the size of the news coverage pie constant over time. The main goal of this study was to conduct an initial empirical investigation of whether this assumption is still relevant

to the emerging information environment in which production and broadcasting limitations have largely been eliminated. The applicability of this assumption was evaluated by assessing whether social media and online versions of traditional media varied over time and were responsive to key events.

Overall, we found results suggesting that the total amount of traffic on social media was responsive to events, whereas online versions of traditional media only wavered slightly in the amount of content they disseminated (H1a and RQ1a). Because these two types of media content were similarly unconstrained by the low cost of broadcasting information and were both limited in the competition for audience attention, differences between these media likely stemmed from the production of information. The results are in line with the notion that user-generated content has highly elastic production capabilities, whereas newsroom practices and limited journalistic resources continue to constrain the production of news coverage, even when information is broadcast online (Mitchelstein & Bockzkowski, 2010). Evidence that production is a central constraint for online versions of traditional news outlets was particularly apparent from the overwhelming influence of temporal dynamics on online news volume, where weekends and holidays accounted for the vast majority of the variation in content produced.

The presence of news events did not necessarily have the impact on Twitter volumes that was predicted, however (H1b). Instead of evidence that newsworthy happenings drove additional coverage on Twitter, we found that the amount of total social media content generated sometimes increased and sometimes decreased when key events occurred. These responses suggest that the volume of content is responsive to events while presenting a puzzle: Why would Twitter traffic sometimes decrease when there is more news to report? And why were only some of the events related to changes in information volume?

We propose that the explanation may be attributable to the constraints of an individual's attention. In particular, it is possible that individuals, when fixated on a major news story, sometimes do so at the exclusion of other types of information. Further, in an environment where users generate the content, the news dissemination function of social network sites may rely disproportionately on the few creators of original content in the network. In this context, the volume of available information in some domains may not expand when events happen if users have little to add. The combined effects of increased attention (at the cost of other issues) and static news availability could sometimes result in a reduction in the size of the news environment, much like what was observed.

Another reason that not every key event increases Twitter traffic might be attributed to the structural assimilation of traditional media into social

media information streams (Ausserhofer & Maireder, 2013; Coddington & Holton, 2014; Maratea, 2008). Not only do Twitter users commonly reproduce and redistribute news content, but professional journalists also create news reports based on tweets (Murthy, 2013). Further, social media have also developed a hierarchical structure where only a few elite Twitter users draw large numbers of daily followers. To the extent that the ability to guide public attention is limited to these high-impact users, differences between social media and traditional media could be muted (Maratea, 2008). When social media conversations largely mirror mass media content produced by professional journalists, the relative silence on issues or events covered in the news may be reflected on social media. In this case, events that receive less news coverage may also tend to be less discussed in digital arenas, replicating the zero-sum dynamics and agenda setting roles of the traditional media in the new environments (Lee, 2007; Meraz, 2009; Parmelee, 2013).

Limitations and Future Directions

The current study represents a high-level examination of the potential for online social and traditional media outlets to circumvent the constraints that limit broadcast outlets. It relies, however, on a number of important assumptions. For one, we treat Twitter as if it is principally occupied by messages about real-world issues and key media events such as elections, mass shootings, sporting events, and natural disasters. But Twitter is at least as much a medium for social and personal interchange as for public expression (Colleoni, Rozza, & Arvidsson, 2014; Jang, Lee, & Park, 2014; Kwak et al., 2010). For this reason, it may not be ideal to make a direct comparison between tweets and traditional news content. This is especially true if the presence of some news events may cause individuals to act differently when producing other types of content.

Future research would be enlightened by considering the specific nature of the content that seems to be increasing or decreasing as events unfold. Specifically, to the extent that changes in the volume of content are due to increases in references to key event within tweets, it would be valuable to determine the extent to which the content that users are sharing began from traditional news sources or was user generated. This might itself depend on the nature of the event and the access that users have to novel information, perhaps because they are geographically proximal to events of interest.

Because the current analysis considers only the total volume of media content, it does not tell us about *how* attention is allocated across various news agendas. Our conclusions about attention as a key constraint rely on the assumption that the amount of content generated corresponds with the

public's attention to that content. This may not always be true. It is possible that the elites who generate news content or the Twitter users who disseminate information differ in notable ways from the public that encounters that information. Hence, the total number of tweets or news stories might be systematically more or less responsive to the presence of high-profile events than public attention to those stories. This difference between media and public attention may itself vary across issues. For some issues, such as stock market performance, a continuous flow of information is available regardless of public interest in the issue on a particular day. In contrast, stories about mass shootings might be more closely associated with public attention, as they tend to appear only when in the presence of a major event. To elucidate this process, future research should examine how the generation of issue-related content relates to public attention across various social issues.

A final concern stems from the aggregated nature of the data we consider. Because the aggregated data do not allow us to link our results with individual characteristics, it is difficult to explain why the volume of information on Twitter varies in case of some key events (Mahrt & Scharkow, 2013). Twitter traffic could increase either because these events brought in additional users or because the events caused a limited number of influential users to generate more tweets. Further, the current analysis was unable to disentangle whether the tweets we observed represent institutional accounts (or professional journalists' accounts) or those of ordinary users. To clarify this possibility, the collection and analysis of individual-level data would yield important insights into the dynamics of traffic surrounding key events.

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