RUNNING HEAD: Building Buzz

BUILDING BUZZ: (SCIENTISTS) COMMUNICATING SCIENCE IN NEW MEDIA ENVIRONMENTS

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Abstract

Public communication about science faces a set of novel challenges, including the increasing complexity of research areas and the erosion of traditional journalistic infrastructures. This poses new challenges for scientists to play a more active role in communicating directly with various publics. Although scientists have traditionally been reluctant to engage in public communication at the expense of focusing on academic productivity, our survey of highly cited U.S. nano-scientists, paired with data on their social media use, show that public communication, such as interactions with reporters and being mentioned on Twitter, can also contribute to a scholar's scientific impact.

Keywords: public communication, online buzz, academic productivity

Introduction

For many researchers, communicating with a broader public rarely entails more than a press release through their institution's public relations division, and possibly a follow-up interview with a journalist. Only a minority of scientists have been actively engaged in communicating science through popular media outlets. Among them are prominent and highly visible researchers, such as Carl Sagan, Richard Smalley, and Neil deGrasse Tyson.

In spite of these visible exceptions, there continues to be a normative assumption among scientists that public communication does not contribute to advancing a career within the so-called "ivory tower" of the academy. As a result, most believe scientific findings are best shared in peer reviewed publications, and scientists are expected to be dedicated to their research rather than trumpeting their works in popular media (Shortland and Gregory 1991). The rewards of communicating science through traditional media are thus believed to compromise a scientist's integrity and authority (Mellor 2010, Ecklund, James, and Lincoln 2012). In fact, the term "Sagan-ization" is often used to describe scientists who "become popular enough as an explainer of science to risk the contempt of more 'serious' researchers" (Kennedy 2010, p. 9). It is a reference to the widely held notion that the popular Cornell astrophysicist, Carl Sagan, was denied admittance to the National Academy of Sciences because of his publicly televised series, *Cosmos* (Dean 2009). On the other hand, many scholars have argued that scientists have the obligation to communicate their research findings with the public (Petersen et al. 2009, Eron 1986, Glass 1993, Weigold 2001) and the science culture is giving renewed attention to scientists' role in communicating science outside the "ivory tower." Discussion about the factual impact of the media outreach thus far has been however limited.

With social media and Web 2.0-type tools, the boundaries of communication that exist between scientists, journalists, and public audiences become blurrier. Through (micro)blogging services and social media, such as Facebook and Twitter, scholars now have the opportunity to communicate about their work directly with various publics without the traditional journalistic intermediary. However, there is little empirical research that examines if and how scientists' public communication about research influences their academic career. Are such public communication behaviors beneficial for scientists in terms of scientific impact? Specifically, do online communication behaviors affect the impact of scientists' traditional media outreach on their academic career, if any? We attempt to provide the first empirical examination of the roles that scientists can play as public communicators and the impacts of these communication efforts.

The changing nature of mass communication and science journalism

The Internet has fundamentally changed our modern media environment and audiences' media consumption habits (Brossard and Scheufele 2013, Anderson, Brossard, and Scheufele 2010). In the modern media landscapes, information flows across a range of media platforms (Jenkins 2004). For instance, the majority of mainstream newspapers, such as *The New York Times* and *The Washington Post*, now offer both print and online content (Pew Research Center 2012). Moreover, these news organizations commonly use social media, such as Facebook and Twitter, for news updates and engagement with audiences.

This changing media environment more broadly has also had significant impacts on science journalism. The volume of content about science and technology in traditional news outlets has been ebbing due to significant declines in readership and subscriptions. In turn, these declines have forced media corporations to decrease the number of journalists who specialize in communicating scientific issues (Dudo, Dunwoody, and Scheufele 2011). In 1989, there were 95 weekly science sections in newspapers in the U.S. However, by 2005, less than a third of these remained, and that number has plunged to 19 in 2012 (Morrison 2013). Meanwhile, the public is increasingly turning to the Internet for scientific information. According to the most recent *Science and Engineering Indicators* published by the Natinal Science Board (2012), almost half of the public turn to online sources for information on science and technology. Among Internet users, approximately 70% go online to search for explanations to scientific phenomena or answers to specific scientific science questions. Overall, the evidence suggests the public is heavily reliant on various types of media to follow developments in scientific fields. For instance, individuals who get science news from reading the print version of *The New York Times* can also visit the newspaper's electronic equivalent to read a science blog or search for information on a particularly interesting topic. Conversely, an individuals' attention might be captured by a news article written by a science journalist from a mainstream media outlet but posted online via social media, such as Facebook or Twitter.

The contemporary information environment is assumed to have important implications on how scientists monitor science development and communicate about their research. For example, American neuroscientists now rely on traditional journalistic outlets (e.g., newspapers, magazines, radio, and television), blogs, and social networks to keep abreast of new research (Allgaier et al. 2013). In general, the value of using integrated media outlets to communicate scientists' research to public audiences and to promote scientific findings can be assumed to be important for the scientific endeavor. However, due to the lack of empirical evidence, researchers have yet to agree on the impacts of communicating one's work through popular media, both online and offline, on scholars' advancement within the ivory tower. Our study fills this gap in literature by exploring whether scientists' public outreach efforts through the combined use of different communication channels impact their academic career. In other words, we hope to provide a comprehensive examination on whether and how public outreach via traditional and online media can boost scholars' academic career. Specifically, we attempt to explore how new media may amplify the impacts of traditional public outreach on scholars' scientific impact.

Scientific impact[1] meets public buzz

In academia, the impact of a scholar's work is linked to the number of citations their articles receive and the importance of other articles that cite it. This idea of scientific impact, a type of "academic buzz," is not unique to scholarly work. In fact, the algorithm used by the online search engine Google was originally based on this concept. In 1996, Google co-founders Larry Page and Sergey Brin, then graduate students at Stanford University, developed the algorithm PageRank, which was based on observations they had made of the faculty (Pariser 2011). Professors count the number of citations their work receives as a rough estimation of their impact. In academia, articles that receive more attention from other scholars in terms of citations are generally considered more important and prestigious, but the relative importance of the other articles that cite it also plays a role in determining its impact. Similarly, PageRank positions webpages referenced by many other popular sites as more important, and thus higher in the results of a search. Online webpage importance using PageRank is based on the same logic as peer-reviewed article importance and scholars' academic impact, but on a much larger scale.

One popular measure of an individual scholar's scientific impact is physicist Jorge Hirsch's h-index, which captures both the volume of one's publications and citations those publications received(Hirsch 2005). According to Hirsch, "a scientist has index h if h of his or her Np papers have at least h citations each and the other $(Np-h)$ papers have $\leq h$ citations each"

[1] Throughout this article, we use academic and scientific impact as analogous terms.

(p. 16569). The *h*-index has been gaining traction as an improved indicator of research performance compared to more traditional citation-based metrics, such as simple citation counts, and has been used in previous research to evaluate the significance of scientific output of individual researchers (e.g., Acuna, Allesina, and Konrad 2012, Ball 2005). Previous studies show that the *h*-index is affected by factors, such as a scholar's gender, scientific age (the number of years since his or her first publication), disciplinary field, number of publications in prestigious journals, and the number of distinct journals in which his or her work has been published (Gaughan and Ponomariov 2008, Hirsch 2005, Kelly and Jennions 2006, King 1987, Kokko and Sutherland 1999).

Scientists' interaction with mass media and lay publics

Despite the critiques, communication barriers, and discrepancies between scientists and journalists (Colson 2011, Hartz and Chappell 1997), the scientist-journalist relationship has been improving and scientists continue to interact with reporters more frequently and smoothly than previously assumed (Peters et al. 2008). Thirty-nine percent of scientists have one to five interactions with journalists in a three year period, while 29% have six or more interactions in the same time frame (Dunwoody, Brossard, and Dudo 2009). This is perhaps due to increased professionalism in the current landscape of science journalism, more efficient communication strategies of science toward the traditional media, and scientists' modified criteria for satisfaction with the quality of media coverage on scientific issues (Peters et al. 2008).

Scientists are often concerned with the rewards and consequences associated with their interactions with the media (Dunwoody, Brossard, and Dudo 2009, Dunwoody and Ryan 1985). Factors that influence a scholar's frequency of interaction with the media include the perception of public visibility held by peers and funding agencies and the impacts on their scholarly reputation. As science journalism has shifted from traditional to online media platforms, science journalists have increasingly begun to quote peer-reviewed articles in their stories as a way to gain credibility and readers' trust (Colson 2011). Frequent interactions with reporters can, therefore, increase the visibility and popularity of a scientist and his/her work as they may be referenced in journalistically mediated narratives, either offline or online. Such narratives can boost the information transmission from scientific literature to the scientific community at large. As demonstrated by Phillips et al. (1991), medical journal articles that were covered in *The New York Times* garnered significantly more scientific citations in each of the ten years after publication than articles that did not receive such coverage. Similarly, daily newspapers coverage of articles published in four elite scholarly journals, *American Medical Association, Nature, The New England Journal of Medicine,* and *Science* was found to be associated with more frequent subsequent citations of those articles by fellow scholars (Kiernan 2003). On the individual level, scholars who have frequent media contact tend to be more academically active (Jensen et al. 2008). Yet, contrary to the above findings, the perception of "Sagan-ization" is still prevalent in academia. While it seems reasonable to assume that concordant relationships between scientists and journalists could translate into greater impacts within academia for researchers, the possibility of critical reactions from peers may weaken the potential career rewards of such interactions (Dunwoody, Brossard, and Dudo 2009). Due to a paucity of empirical evidence exploring whether interactions with journalists are impactful for scholars' careers, we propose the following research question:

RQ1: Other factors held constant, do scientists' interactions with reporters affect their scientific impact?

In addition to media interactions, scientists' dissemination activities to engage lay publics can be wide-ranging, including popularization and outreach activities such as public speeches, school presentations, and collaborations with other non-academic institutions. Such activities are viewed as important in promoting public understanding and public opinion of science (Poliakoff and Webb 2007). However, many scientists still perceive research performance, publishing in scientific journals, and attending conferences as the only keys to academic success, and refrain from outreach activities because of the potential for "Sagan-ization" and the accompanying assumption that they are not successful in their academic careers.

Contrary to this assumption, scientists who actively participate in outreach are academically more active and associated with higher academic research performance. Jensen and colleagues' study (2008) showed that scientists who engaged in more dissemination activities published more peer-reviewed articles and were cited more times per year over their research career compared to those who were not active in public communication. Given that the existing data demonstrate a positive relationship between lay outreach activities and academic activity, we put forth the following hypothesis:

> **H1:** Other factors held constant, scientists' interactions with non-scientists are positively correlated with their scientific impact.

Science blogging

Blogs are Web 2.0-type tools which allow the public to learn about scientific developments (Jones and Himelboim 2010) and provide opportunities for scientists to have interactive conversations with the public. In addition, blogs offer an open space for the exchange of knowledge and peer evaluation among scientists from different disciplines (Colson 2011). There have been over 26,000 blog entries posting about peer-reviewed research on various science subjects on the Research Blogging[2] platform (Fausto et al. 2012). Blogs have become influential online niches for science and technology information (Bonetta 2007). For example, Pharyngula[3], a popular science blog, attracts over 1.5 million readers and thousands of comments each month (Batts, Anthis, and Smith 2008).

Unlike being in a scientist-journalist relationship, scientists as science bloggers, have higher levels of individual autonomy in determining how their scientific developments are communicated to the public. Science blogging has often been used by scientists to circumvent traditional media outlets when they highlight their own recently published work and communicate with peers (Brossard 2012, Colson 2011). Additionally, scientific blogs play a significant role in shaping mainstream news coverage by directing the attention of mainstream media to issues that are not yet popularized (Cacciatore et al. 2012). As fellow scientists rely on scientific blogs to maintain a certain level of surveillance over his or her academic environment (Allgaier et al. 2013), consistently and regularly updating blogs with scientific achievement helps scientists popularize their published research while increasing its visibility among peers.

In addition to being an open marketplace for scientific exchange, researchers can expand their professional networks through online activities. Evidence suggests that scholars who connect through online environments, including personal blogs, also collaborate on projects offline (Colson 2011). Although studies on scientists' online behaviors are relatively few, those that exist provide support for a positive association between online activities and popularity and visibility of a scientist's research, which can be interpreted as his or her scientific impact. On the basis of this reasoning, we put forth the following hypothesis:

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[2] http://www.researchblogging.com
[3] http://freethoughtblogs.com/pharyngula

H2: Other factors held constant, scientists blogging about science is positively correlated with their scientific impact.

Twitter activity

Twitter, the U.S. second largest social networking platform with 16% of all Internet users being users (Pew Research Center 2013), provides unique opportunities for scientists to exchange user-generated content with a limit of 140 words and "various degrees of social presence/ media richness" (Kaplan and Haenlein 2010, p. 61). In contrast to other online social sites (such as Facebook) that control information sharing only with approved "friends," public Twitter posts (the default setting) allow live dialogues visible to anyone unless the user switches it to a protected account. The social influence of certain opinion leaders can be enormous, notably some prestigious science writers. For example, every single tweet (Twitter posts) from Carl Zimmer instantly reaches over 146,000 followers and further audiences when retweeted by these followers.

Based on a non-probability sample survey of higher education professionals, researchers found academic use of Twitter has increased among scholars, with 35.2 % of surveyed college faculty members using Twitter in 2010 compared to only 30.7% in 2009 (Faculty Focus 2010). In particular, scholars on Twitter were found to be discussing academic conferences and articles (Young 2009) and some were "live tweeting" on the spot within conference sessions (Bonetta 2007, Shiffman 2012). Discussions on Twitter are considered to be legitimate, interactive, wide-ranging, and cross-disciplinary conversations that are reflective of academic impact (Priem and Costello 2010). Being cited or mentioned on Twitter could be a new signal of one's academic impact (Priem and Hemminger 2010). In more recent work, Eysenbach (2011) showed the practical impact of this approach by mining tweets that mentioned published articles on a medical journal (i.e., tweets with reference to the title and URL of journal articles) and found journal articles that were highly mentioned on Twitter were more likely to be frequently cited by other scholars. The current study takes a similar approach to examining mentions of scientists on Twitter, which are measured as tweets that include scientists' names and their research with links to information on other websites. On the basis of previous findings, we assume that scientists' being mentioned on Twitter promotes the visibility of their research and further reflects the underlying impact of their work:

H3: All other factors held constant, being mentioned on Twitter will be positively correlated with scientific impact.

In the modern communication landscape, scientists' traditional forms of public communications, primarily their interactions with the media through journalists, can be disseminated widely through Web 2.0-type tools. For example, a journalistic article posted on a news organization's website can be tweeted to followers on Twitter, and linked to in blogs. The public at large relies on mixed media across both traditional and online platforms for science news and information (Su et al. 2012, April). Therefore, in addition to traditional communication behaviors undertaken by researchers, it is reasonable to assume that multiple online social channels can assist with online information dissemination and amplify researchers' scientific impact. On the other hand, in a reflection of "Sagan-ization," some scholars may argue that the colleagues who are too actively engaged (e.g., tweet too often), would suppress the impact of other forms of outreach (e.g., engagement with traditional news media, science blogging, or public communication). Researchers have yet to provide empirical evidence that such interactions between "old" and "new" forms of outreach exist. We therefore put forth the following research question:

RQ2: Do different forms of communication activities (i.e., interactions with journalists or other non-scientists, science blogging, and being mentioned on Twitter) moderate each other's effect on scientific impact?

Method

Data collection

Data for the study were collected in two parts. First, a nationally representative survey of leading U.S. nano-scientists was collected by mail. The survey was fielded in four waves between June and September 2011, following Dillman's Tailored Design Method (Dillman, Smyth, & Christian, 2008). The final response rate was 31.6%, following American Association for Public Opinion Research's (AAPOR) method of Response Rate 3 (RR3, for a full discussion of response rates see the Standard Definitions of AAPOR 2011). In order to minimize the potential confounding effects of seniority on the *h*-index (Kelly and Jennions 2006, Hirsch 2005), our sample consists only of the most highly cited nano-scientists to minimize the variance of respondents' scientific age. We identified a sample of 1,405 scientists who were cited no less than 39 times in a two-year period (2008-2009) from a total of 189,014 nanotechnology publications in the ISI Web of Knowledge database (Porter et al. 2008). The mail survey yielded 444 completed questionnaires. We surveyed respondents' interaction with journalists, lay publics, and science blogging for outreach.

In order to examine links between scientists' self-reported public communication efforts and indicators of their productivity, we allowed respondents' *h*-indices to accumulate over a period of 15-18 months following our survey and collected the second part of our data in December 2012. We collected *h*-indices for all respondents from the ISI Web of Knowledge database and recorded their research mentioned in others' tweets. Respondents' curriculum vitae, obtained online from the institutions with which they were affiliated, were used to refine our *h*-index search. Our analysis focused only on scientists in tenure-track faculty positions while scientists associated with private industry and in federal government positions (e.g., U.S. Department of Agriculture, U.S. Environmental Protection Agency) were excluded due to the lack of accessible curricula vitae. Our final sample was 241 U.S. nano-scientists.

Measures

Our analyses controlled for gender, professional factors (scientific age and whether the respondent was tenured), and structural factors (disciplinary field) because of sensitivity of the *h*-index to these factors (Gaughan and Ponomariov 2008, Hirsch 2005, Kelly and Jennions 2006, Kokko and Sutherland 1999, Stack 2004, King 1987).

Dependent variable. We used the *h*-index (M = 37.1, SD = 23.7) as a measure of the breadth and depth of a researcher's scientific impact.

Independent variables. To obtain a measure of scientists' *interaction with reporters*, participants were asked, on a 4-point scale (1 = "Never," 4 = "Often"), how often they spoke to reporters about new research (M = 2.6, SD = 0.9). Participants were asked a similar question to assess *interactions with other non-scientists* (M = 3.1, SD = 0.7). *Science blogging* was measured by asking participants the following question, "How often, if ever, do you write for a blog about science?" Responses were coded on a 4-point scale (1 = "Never," 4 = "Often") (M = 1.3, SD = 0.6). We defined mentions on Twitter as tweets from other Twitter users that referred to respondents' name and research with hyperlinks to detailed information. Due to the low number of tweets that mentioned respondents' research, we chose a dichotomous variable to indicate whether the participant's research had been *mentioned on Twitter* (14.1% were mentioned on Twitter).

Control variables. We collected participants' *gender* (85.9% male), *scientific age* (M = 21.2, SD = 10.7), *tenure* (whether they were tenured faculty members; 73.8% tenured), and their *disciplinary field* in which they received their doctoral degrees (33.1% chemistry, 17.2% physics, 17.6% engineering, 14.2% materials sciences, and 17.9% biology and other sciences). The disciplinary variables were entered in the regression model as a series of dummy variables, with biology and other sciences as the reference group.

Data analysis

We tested our hypotheses and research questions using a hierarchical ordinary least squares (OLS) regression model. The variables were entered in blocks according to their assumed causal order. In the model, the blocks were ordered as follows:

1. Demographics and professional status (*gender, scientific age, tenure*)
2. Disciplinary field (*chemistry, engineering, physics, materials sciences*)
3. Science communication (*interactions with reporters, interactions with non-scientists, science blogging, mentioned on Twitter*)
4. Two-way interactions

The final block included interaction terms that were created by multiplying standardized versions of the variables to minimize multicollinearity between the interaction terms and their components in the model (Cohen et al. 2003).

Results

Overall, our model fit the data well, accounting for 60% of the variance in *h*-index. Most of the variance was accounted for by demographics and professional status (35.1%), while science communication variables accounted for 6.5% of the variance in *h*-index (Table 1).

[Insert Table 1 about here]

Scientific age ($\beta = .54$, $p \leq .001$) and tenure ($\beta = .14$, $p \leq .05$) were both positively correlated with scientific impact. Senior researchers, i.e. those who had published their first paper earlier relative to others in the sample, had higher *h*-indices. Tenured scholars also had higher *h*-indices than those who were not tenured.

Our first research question (RQ1) related to scientists' communication efforts through more traditional means, measured by their interaction with reporters. We found that interaction with reporters was positively associated with scientific impact ($\beta = .22$, $p \leq .001$). Our results implied that scholars who had more interactions with reporters had greater scientific impact compared to those who had fewer interactions with reporters. We expected to find positive associations between *h*-index and interactions with other non-scientists (H1) and science blogging (H2). However, the main effects of both these variables were not significant in our model (Table 2).

[Insert Table 2 about here]

As hypothesized (H3), scientists whose research was mentioned on Twitter had significantly higher *h*-indices ($\beta = .13$, $p \leq .01$) compared to their peers whose research was not mentioned on Twitter (Table 2). In response to our last research question (RQ2) on the moderating effects of Twitter activities and more traditional forms of public communication on *h*-index, we found two significant interactions (Table 2). The interactive effect between scientists' interaction with reporters and being mentioned on Twitter was positive ($\beta = .14$, $p \leq .05$). The *h*-indices of scientists who interacted with reporters were significantly higher if their work was also mentioned on Twitter (Figure 1). Being mentioned on Twitter also amplified the effect of interactions with other non-scientists on *h*-index ($\beta = .11$, $p \leq .05$). In other words, the *h*-indices of scientists who interacted with other non-scientists were higher if they had been mentioned on Twitter compared to scholars who had not (Figure 2).

[Insert Figure 1 about here]

[Insert Figure 2 about here]

Discussion

In this study, we surveyed the most highly cited and active scientists in the fields associated with nanotechnology research and explored the effects of scientists' various active public communication behaviors on their scientific impact as measured by the *h*-index. Our analysis provides evidence that active public engagement, such as interaction with reporters and being mentioned on Twitter, can be rewarding for one's career by promoting his or her scientific impact. Most prominently, online buzz (e.g., being mentioned on Twitter) amplifies the impact of interaction with journalists and other nonscientists on a scholar's *h*-index.

It is important to keep in mind several aspects of our data when interpreting the results. First, while this study supports the idea that a scientist's various communication behaviors are positively associated with his scientific impact, our results do not allow us to conclude a causal relationship. Some confounding factors, such as scientists' educational institutions, professional status, and *h*-index they have accumulated along the previous years, could be highly correlated with one's communication behavior and *h*-index in the following years. In other words, these scientists were likely from elite educational institutions (which is indeed the case in the sample) and have been fairly well-known in their field and therefore they were more likely to adopt various media outreach. Such alternative interpretations could confound the evaluation of the effects of various communication behaviors on one's scientific impact.

In this study, we minimized the issue of endogeneity through the following three solutions. First, we collected the data at two time points. Individual scientist's *h*-index was collected 15-18 months after surveying their communication behaviors. Second, we selected the most productive and most active scientists in a given field, and we further narrowed down our sample to those holding tenure-track faculty positions to minimize the confounding career effects. Third, we controlled for the possible factors that might be correlated with both scientists' communication behaviors and their scientific impact, e.g., one's gender, professional status (scientific age and whether the respondent was tenured, and disciplinary field). In particular, we observed a significant and positive association between active communication behaviors and *h*-index only 15-18 months after their communication activities. It is reasonable to assume that the strength of the observed associations would increase if we adopted a longer time period to allow *h*-index to accumulate following various communication behaviors. We are interested in exploring a more fine-grained picture of how different patterns of communication behavior in sequence affect scholar's scientific impact in future studies when study design includes more time points to collect longitudinal data of each communication behavior.

Our present sample design includes only university-based scientists, which does not allow us to compare subgroups of scientists based on their affiliations with industry or other non-academic institutions. However, this sample design is also a strength since it attenuates potential concerns about endogeneity by limiting our analyses to a group of already highly visible scientists. We encourage future studies to compare the impacts of outreach activities for scientists with different affiliations (such as industry-based, government-based versus university-based comparison) and in other research disciplines.

It is also important to take into account the nature of our operationalization of activities on Twitter. Ideally, we would have liked to include continuous measures of both active and passive Twitter activity, i.e. scientists tweeting research updates to their followers as well as being mentioned in others' tweets. However, too few scientists were active Twitter users to include either active Twitter use or a continuous measure (as opposed to our dichotomous indicator) of Twitter mentions. The limited number of respondents using Twitter was unsurprising, given that tweeting about scientific research is a relatively recent phenomenon within academia and only 16% of the general population are on Twitter (Pew Research Center 2013). Our results about positive association between scientists' research being mentioned on others' tweets and their scientific impact also align with Eysenbach's study (2011) that shows that tweets are correlated to citation counts. Future studies should attempt to obtain continuous variables and use more fine-grained analysis to measure the impact of social media (such as Facebook, Twitter, and Google plus) on scientists' career.

With these considerations in mind, the following contributions of the study are especially noteworthy. First, our study provides one of the first comprehensive empirical examinations on the impact of media outreach on scientists' academic career that combines survey data with data on Twitter usage. We provide empirical evidence that building buzz and having open conversations with lay audiences via "old" and "new" media outlets are indeed beneficial for scholars' academic careers. Our findings regarding potential positive impacts of scientist-journalist interactions show a continued role for mass media in boosting the information transmission from scientific literature to the scientific community (Kiernan 2003, Phillips et al. 1991).

Second, our study offers a new and more complex look at interactions between scientists and journalists at a time when science journalism and mass communication have experienced tremendous transformations. In this evolving media landscape, collaborations between scientists and journalists are increasingly frequent (Dunwoody, Brossard, and Dudo 2009). This may due to the mutual benefits for both collaborators. Almost all of the 2,000 members of the National Association of Science Writers work as freelancers at least at some of the time and therefore depend on ongoing working relationships with individual scientists as information sources (National Association of Science Writers 2013). At the same time, as we demonstrate here, scientists also benefit from the scientist-journalist interactions as they translate into increased scientific impact, potentially amplified by social media.

Our study also refines our understanding of the role of online social media in communication exchanges about science in modern media landscapes. Many scholars have suggested that social media are supplementing instead of supplanting conventional journalistic channels, such as newspapers and television, for scientific information (Allgaier et al. 2013, Morrison 2013). For the moment, this may be true; we found social media play a significant role in amplifying the impact that traditional media can have. This further highlights the important role of social media in closing science-public gaps and—at the same time—as important components of scholarly productivity. As a result, some scholars have even called for social media to be used to supplement traditional approaches of measuring scientific impact (Priem and Hemminger 2010).

However, current online social media environments also have potential pitfalls for science communicators. Open and interactive dialogues inherent to 2.0 environments enable audiences to repurpose and translate scientists' research findings into their own interpretation and debate them on Twitter, Facebook, and other social media (Brossard and Scheufele 2013). The very social networks that provide the amplification effects identified in our analyses can also help spread potential misinterpretations of scientific findings quickly among large audiences.

Most recently, some scholars have raised concerns, for example, that readers' uncivil online comments following scientific information can polarize perceptions of the risk associated with the technology itself (Anderson et al. 2013).

In addition to not being able to control the way information is repurposed or contextualized, social media may also present the scholarly community with new challenges related to traditional metrics of success. In academic circles, book blurbs from well-known scholars or book reviews by prestigious media outlets are generally considered more impactful than those from less well-known colleagues. A similar logic applies to social media. In fact, social media metrics are in many ways much more precise than academic reputation. If a scientist's work is tweeted about by prominent science reporters (such as Andrew Revkin, who has more than 50,000 followers on Twitter), scientists (such as Neil deGrasse Tyson with more than 1, 250, 000 followers on Twitter), or media outlets (such as *Science Friday* with over 345,000 followers on Twitter), it is likely to attract more attention and have a larger impact, even within academic circles, than a study that was only published in a peer-reviewed academic outlet (even for elite outlets, such as *Nature* and *Science* with impact factors of 36.28 and 31.2, respectively). The connections we found between researchers' willingness to engage in public scholarship—both offline and online—and their scientific impact may eventually force academics to think more carefully about defining academic impact in a world of sites, such as Google Scholar and ResearchGate.com, which combine social media metrics with indicators of scholarly productivity to measure the broader impact of academic work. Based on the findings presented in this study, the outcome for science communication will be a positive one: more public communication about science contributes to scientists' academic impact.

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Table 1. Unique variance explained by each block in the OLS regression model predicting *h*-index.

	R^2 (%)
Demographics and professional status	35.1***
Academic discipline	.8
Science communication	6.5***
Shared variance (%)	17.6***
Total variance (%)	60.0***

***$p \leq .001$.

Table 2. OLS regression model predicting *h*-index (N = 241).

	Zero-order	β
Block 1: Demographics and professional status		
Gender (female=1)	-.08	.02
Scientific age	.70***	.54***
Tenure (tenured =1)	.54***	.14*
Incremental R^2 (%)		*51.2****
Block 2: Disciplinary field		
Chemistry	.04	-.02
Engineering	-.13	-.10
Physics	.04	-.05
Material Science	-.06	-.07
Incremental R^2 (%)		*.2*
Block 3: Science communication		
Interaction with reporters	.34***	.22***
Interaction with other non-scientists	.18**	.02
Science blogging	-.03	-.06
Mentioned on Twitter (mentioned =1)	.23***	.13**
Incremental R^2 (%)		*6.5****
Block 4: Two-way interactions		
Interaction with reporters × Interaction with non-scientists	–	.08
Interaction with reporters × Science blogging	–	.01
Interaction with reporters × Mentioned on Twitter	–	.14**
Interaction with non-scientists × Science blogging	–	.03
Interaction with non-scientists × Mentioned on Twitter	–	.11*
Science blogging × Mentioned on Twitter	–	.04
Total R^2 (%)		*60.0*

***$p \leq .001$, **$p \leq .01$, *$p \leq .05$. Cell entries are final standardized regression coefficients for Blocks 1, 2, 3, and before-entry standardized regression coefficients for Block 4.

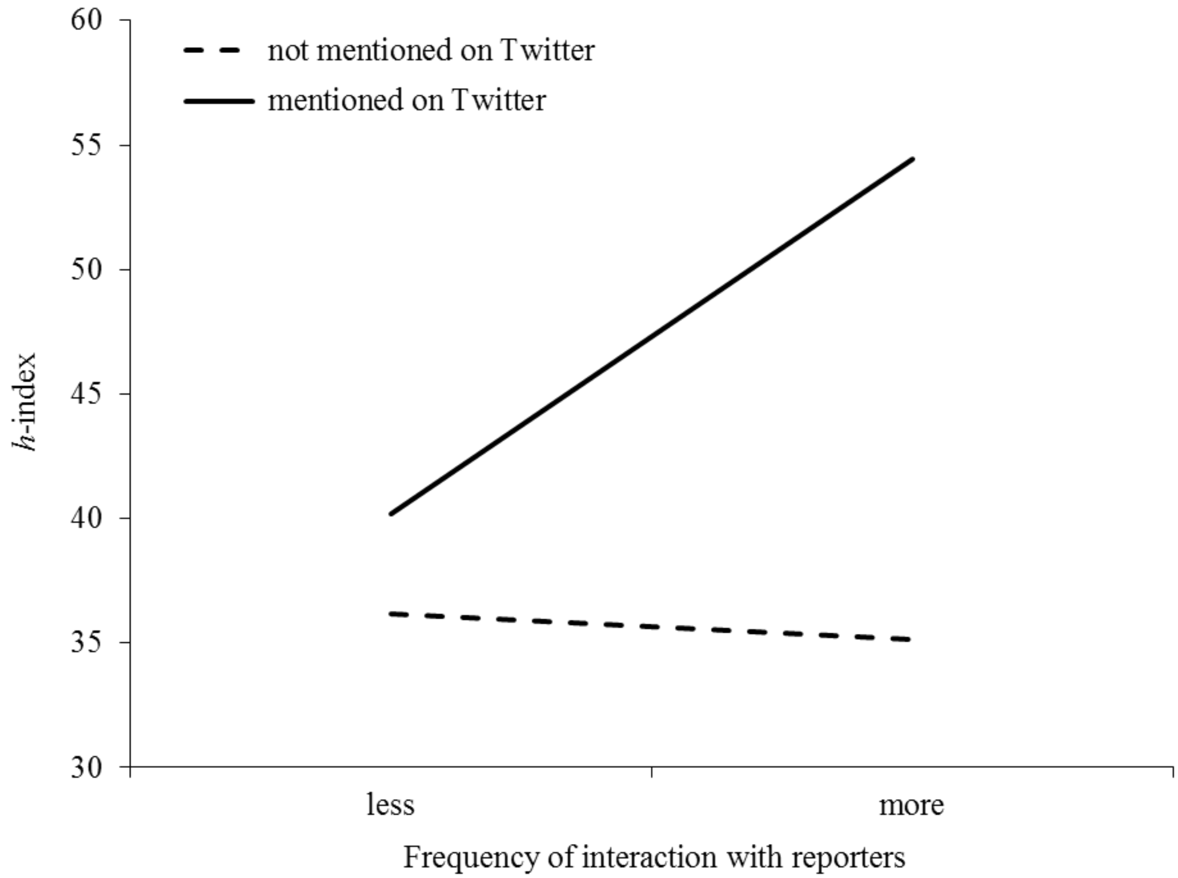

Figure 1. Interactive effect between frequency of interaction with reporters and being mentioned on Twitter on *h*-index. *Note*: Scale on y-axis is only partially displayed.

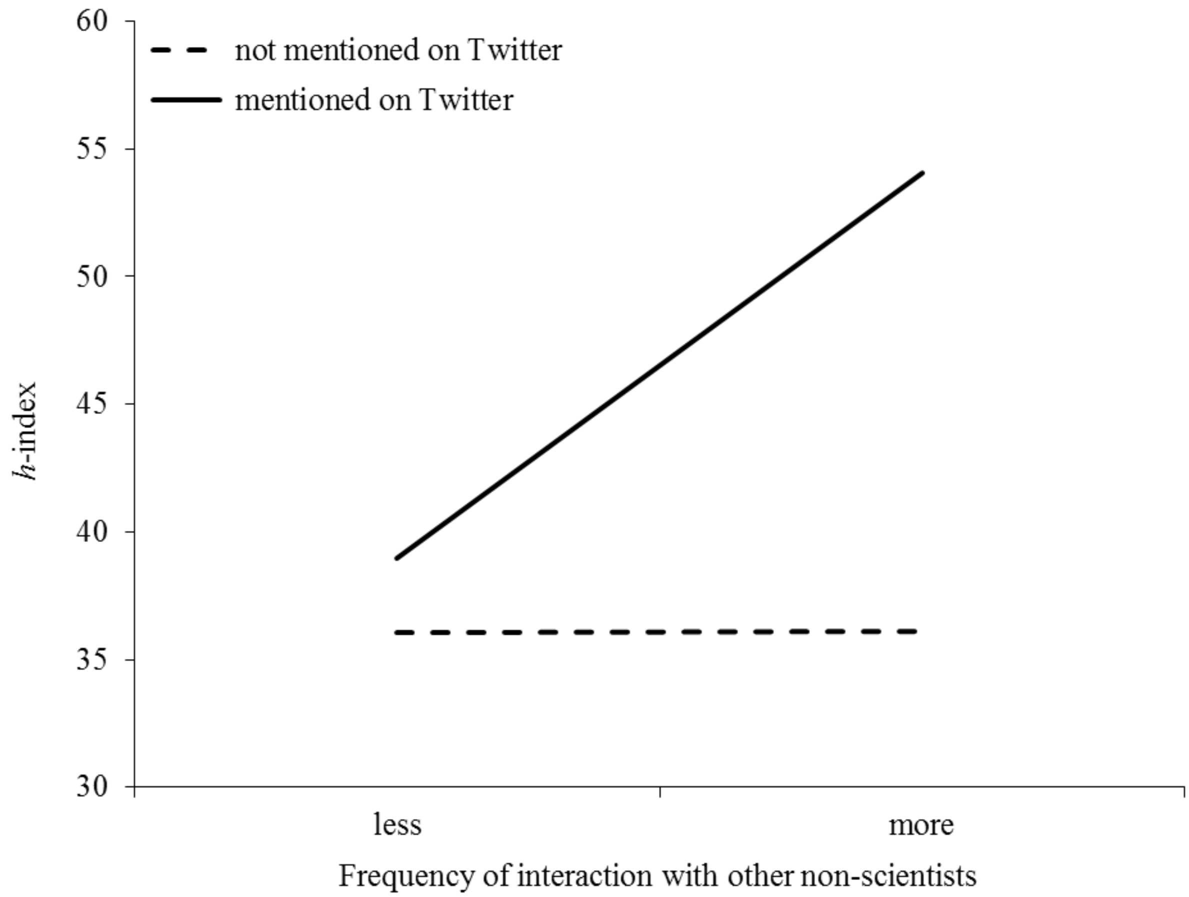

Figure 2. Interactive effect between frequency of interaction with other non-scientists and being mentioned on Twitter on *h*-index. *Note*: Scale on y-axis only is partially displayed.