

# Understanding Scientists' Willingness to Engage

Science Communication

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## Abstract

A set of parallel surveys of scientists from multiple scientific societies finds that the most consistent predictors of willingness to take part in engagement activities with the public are a belief that she or he will enjoy the experience (attitude), make a difference through engagement (response efficacy), and has the time to engage. Age, sex, scientific field, what a scientist thinks about the public, perceived personal engagement skill (self-efficacy), and what a scientist thinks about her or his colleagues (normative beliefs) are inconsistent predictors. Research may be needed to find how to shape scientists' engagement views in ways that are both effective and acceptable.

## Keywords

scientists, theory of planned behavior, public engagement, science communication, norms, efficacy

The current study represents the most comprehensive attempt yet to assess what may motivate scientists to engage with the public in the United States. Unlike past studies, it includes data from multiple scientific societies that represent a range of fields as well as responses specifically focused on three

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different potential modes of engagement, including face-to-face engagement, engagement through the news media, and online engagement. The data—which include responses from about 4,700 scientists—were collected just prior to the election of the current president. It thus represents a baseline for understanding the factors that may have been driving scientists' views about engagement prior to a potential increase in attention to engagement as represented by activities such as the April 2017 "March for Science."

The practical reason for studying scientists' willingness to engage the public is that recent years, even prior to the election of the current U.S. presidential administration, have seen a range of calls for scientists to communicate with nonscientists about science (Cicerone, 2006; European Union, 2002; Holt, 2015; Jia & Liu, 2014; Leshner, 2007; National Academies of Sciences, Engineering, and Medicine, 2016; National Research Council, 1989; The Royal Society, 1985). As applied research, the current study treats public engagement by scientists as planned behavior that might be changed through efforts to affect available drivers of that behavior. Recent past studies in this area have similarly treated scientists' engagement as a planned behavior (e.g., Besley, 2014; Dunwoody, Brossard, & Dudo, 2009; Poliakoff & Webb, 2007), but the current study is novel in its use of a relatively broad data set that allows for a discussion of whether there are differences in engagement across scientific societies from a variety of scientific fields and, more importantly, across engagement modes. The question of what may motivate scientists to engage also clearly remains a salient issue for many people interested in advancing science. At a theoretical level, as discussed below, the work seeks to advance the idea that the choice of whether or not to engage should be understood and studied as planned behavior (Ajzen, 2017; Besley et al., 2017), consistent with the integrated behavioral model (Yzer, 2012). While this approach seems to be the most common, conceptualizing public engagement as a set of behaviors opens up the possibility of studying the myriad choices around science communication—from big-picture questions about quantity of engagement to specific tactics (message content, formats, channel, etc.) that might affect the engagement quality—using a range of different behavior change theories that are sometimes used in the health and environmental communication literature, among others. There are many similarities across these models while also putting the focus on different potential drivers of behaviors (Davis, Campbell, Hildon, Hobbs, & Michie, 2015).

As research that relies on a set of large-sample surveys, the current study adopts a relatively broad understanding of public engagement. For the current research, public engagement is understood to include any effort that might see members of the scientific community trying to engage, primarily through communication, with people outside of their area of research. It is

fully recognized that much of this communication is likely to be one-way communication that does not live up to normative standards of public engagement as meaningful, multiparty dialogue as described by scholars focused on public deliberation (Delli Carpini, Cook, & Jacobs, 2004) or two-way symmetric communication (Grunig & Grunig, 2008). Nevertheless, while the question of engagement quality is important to science communication research, so too is the question of what gets scientists out from behind their computer screens and lab benches.

Below, we first briefly describe what past research tells us about the factors that scholars have found to be associated with scientist engagement with an emphasis on the theory of planned behavior (TPB). This literature review is used to describe the primary variables in the analyses and suggest hypotheses and research questions. The method section describes the underlying surveys, the measurement of the variables analyzed, and the analytical procedures. The results flow from this analysis. The concluding section attempts to summarize the current state of knowledge while highlighting limitations of the current study as well as opportunities for future work. The current study does not seek to provide an overview of studies on scientists' views on public engagement (see, instead, Besley & Dudo, 2017a; Besley & Nisbet, 2013; Peters, 2013; Yeo & Brossard, 2016) but, rather, seeks to understand how such views shape engagement willingness. In this regard, the focus is on differences in the relationships between variables, not differences in point estimates.

## Literature Review

Studies from a range of countries have assessed factors associated with scientists' communication activities, and it is becoming clear that scientists' engagement decisions should be understood and studied as planned behavior. Some studies have focused only on demographic predictors, while others have included a broader range of variables. These additional variables have often been drawn from the TPB, including attitudes, normative beliefs, and efficacy beliefs (Ajzen, 2017). The logic of drawing on the TPB is that engagement activities are behaviors that scientists choose and that TPB includes a set of known drivers of intended behavior. This common use of similar variables across studies of behavior has been recognized by Fishbein (2009), for example, in his articulation of an integrated behavioral model (Yzer, 2012). Building on past work, the current study focuses on 10 potential predictors of engagement willingness, including three demographic variables (sex, age, and scientific field) and seven variables related to attitudes, normative beliefs, and efficacy beliefs. Each of these is described in turn

within the context of justifying their use in a model aimed at predicting willingness to engage. Past engagement is used as an additional control. Similar to past research (Besley, 2014), we justify the inclusion of past engagement as we are interested in future willingness and past engagement seems likely to affect various engagement views but it should not be assumed that the fact that someone has shown a behavior in the past would mean that he or she would be keen to show the behavior again. As with most communication relationships, we would expect that there will be a cyclical relationship between past experiences, current views, and future behaviors. At a practical level, similar models run without past engagement (not shown) provide similar substantive results.

Whereas most research focused on the TBP emphasizes behavioral intent as the mediator between the desired behavior and associated attitudes, norms, and efficacy (e.g., Poliakoff & Webb, 2007), the current study focuses on willingness to engage as the criterion variable. This is consistent with past work in this area (e.g., Besley, 2014) and reflects the fact that engagement behavior is different from something like smoking or recycling where the desired behavior is frequent. Many university scientists may have substantial freedom to engage, but such behavior may also depend on having opportunities that present themselves. Furthermore, whereas a scientist might have a general willingness to engage, specific intent to engage would be expected to depend on the features of specific opportunities (e.g., timing, expected audience, etc.) and it seemed impractical to attempt to capture such dynamics in the current survey. More generally, there is a pragmatic argument that willingness and intent may be conceptually different (Gibbons, Gerrard, Blanton, & Russell, 1998) but that they are also similar enough to be seen as nearly equivalent ways to express a "readiness to engage in a behavior" (Fishbein & Ajzen, 2010, p. 43). That being said, it would be helpful to test if scientists who express greater engagement willingness are, in fact, more likely to agree to take part in engagement activities. Furthermore, as a cross-sectional study, we treat past engagement as a control in predicting willingness, rather than as an outcome. The key research related to demographics and TPB predictors is described below in the context of presenting hypotheses and research questions.

## *Demographics*

Past research from various countries suggests that older scientists are generally more likely to engage than younger scientists (Bentley & Kyvik, 2011; Besley, Oh, & Nisbet, 2013; Crettaz von Roten, 2011; Kreimer, Levin, & Jensen, 2011; Kyvik, 2005; The Royal Society, 2006; Torres-Albero, Fernandez-Esquinas,

Rey-Rocha, & Martin-Sempere, 2011). This might make sense inasmuch as older scientists are more likely to hold leadership positions that would lead to a demand or expectation of engagement activity (Rödger, 2012). One exception was France, wherein junior scientists were more likely to say they were involved in science communication activities (Jensen, 2011). The current study does not include a measure of academic experience, academic rank, or publications because these are very highly correlated with age. Nevertheless, past research has highlighted experience as being associated with engagement activity (Bentley & Kyvik, 2011; Besley et al., 2013; Crettaz von Roten, 2011; Dudo, 2013; Dunwoody et al., 2009; Jensen, 2011; Kyvik, 2005; Marcinkowski, Kohring, Fürst, & Friedrichsmeier, 2013; Torres-Albero et al., 2011). There is also some evidence that after initial early career increases, engagement decreases for older scholars (Besley & Oh, 2013).

One important wrinkle in past research is that work focused on online engagement has indicated that young scientists are more engaged online while older scientists prefer off-line engagement (Besley, 2014; Besley et al., 2013; Rainie, Funk, & Anderson, 2015). The current study includes a focus on three different modes of engagement (face-to-face, through the media, and online). This will make it possible to assess whether the age-engagement pattern varies by mode of engagement in the context of a single study.

**Hypothesis 1:** Age will be a positive predictor of face-to-face and news media engagement willingness and a negative predictor of online engagement willingness.

**Research Question 1:** Is there a point where older scientists are less likely than relatively younger scientists to be willing to engage face-to-face or through the media?

Regarding sex, it appears that men are usually more willing to engage (Bentley & Kyvik, 2011; Besley, 2014; Besley et al., 2013; Crettaz von Roten, 2011; Kreimer et al., 2011; Torres-Albero et al., 2011). Only a small sample study of American scientists (Ecklund, James, & Lincoln, 2012) and a large survey of French scientists found the opposite pattern (Jensen, 2011). Another study found that French-speaking female scientists in Switzerland were more likely than French-speaking male scientists to express interest for funding to support the time and resources needed to engage (Crettaz von Roten, 2011).

**Hypothesis 2:** On average, male scientists will report higher levels of engagement willingness than female scientists.

Researchers have also examined the degree to which a scientist's field is likely to affect engagement willingness. Peters (2013), for example, has shown descriptive evidence of differences between fields for the amount of media contact, but other studies have found only limited evidence that academic area is a primary driver of engagement behavior. Nevertheless, it seems clear that those in the social sciences (Bentley & Kyvik, 2011; Jensen, 2011; Kreimer et al., 2011; Kyvik, 2005; Peters, 2013; Rainie et al., 2015) and the environmental/earth sciences (Jensen, 2011; Rainie et al., 2015; Torres-Albero et al., 2011) appear somewhat more likely to engage than those in other fields. Some studies have also found that biologists or medical researchers may be relatively high engagers (Besley et al., 2013; Marcinkowski et al., 2013; Torres-Albero et al., 2011), although this may not always be the case (Ecklund et al., 2012). There is some evidence that environment and health topics might be of somewhat higher interest than other areas of science (National Science Board, 2016, chap. 7), and there is some evidence that scientists are most likely to engage when they believe that the public is interested in their subject (Rainie et al., 2015).

The current study includes researchers from seven different professional scientific societies as a way to try to capture some of the differences that the past research suggests may exist across fields. We include a general scientific society within which about half of the members are biology focused, two different biological societies, a chemistry society, a geology society, a geophysical society, and an ecological society. We would like to have also included a physics society but were unable to form a survey partnership. We elected not to include a social science society because we felt more comfortable comparing across the natural sciences. We expect, however, that there may be interesting differences to be explored in a study focused on such comparisons. Also, rather than posit a hypothesis, we propose a general research question.

**Research Question 2:** To what degree is scientific society a predictor of engagement willingness, if at all?

Race is one potential demographic predictor of willingness that is not included in the current study. The underlying survey included data for this variable, but initial analyses (not shown) suggested that there were too few differences in the response patterns between groups to merit further analysis. In other words, in terms of descriptive statistics, we saw no evidence of a substantive difference between White (non-Hispanic), Black (non-Hispanic), and Hispanic scientists such that adding race to the model would provide any meaningful information.

## *Attitudes, Efficacy, and Norms as Predictors of Engagement Willingness*

It seems important to recognize that the choice to engage largely represents the choice to take part in a planned behavior. Indeed, one could argue that, for a strategic communicator, many communication choices involved in public engagement should be planned. For example, for face-to-face engagement, a strategic communicator would choose a setting, format, and speaking points that seem most likely to allow the communicator to have the desired interaction. This recognition means that it should make sense to draw on the planned behavior literature when we seek to understand why some communicators—scientists in the current case—may make specific engagement decisions.

The current study specifically draws on the TPB and its focus on attitudes, normative beliefs, and efficacy beliefs. Past science-focused research that addresses each of these constructs is discussed, in turn. More general research that speaks to the importance of the underlying constructs (i.e., attitudes, normative beliefs, and efficacy beliefs) is not discussed here as these are well-known among communication and behavior change scholars (Armitage & Conner, 2001; Conner & Armitage, 1998; Fishbein, 2009; Fishbein & Ajzen, 2010). In discussing the variables below, it should also be recalled that one reason why the TPB variables are so important is that they may be amenable to change through targeted communication efforts. For example, if evidence suggests that having scientists believe that their communication efforts are likely to make a difference then it might make sense to ensure that those seeking to promote scientists' engagement highlight evidence of the response efficacy of engagement.

## *Attitude Toward Engagement and Audience*

First, past research suggests that scientists who have more positive views about engagement conduct more engagement. This has been found when assessing attitude as a general, direct measure of positive affect toward engagement (Poliakoff & Webb, 2007) and enjoyment (Dudo, 2013; Dunwoody et al., 2009). Scientists also engage more when they see benefits from engaging (Besley et al., 2013; Marcinkowski et al., 2013). These benefits may include the sense of accomplishment associated with contributing to the public good or fulfilling a moral duty (Besley et al., 2013; Dudo, Kahlor, AbiGhannam, Lazard, & Liang, 2014; Sharman & Howarth, 2016; Tsfati, Cohen, & Gunther, 2011). In general, scientists also report that their engagement experiences, at least when it comes to journalists, have generally been positive (Lo & Peters, 2015; Peters, 2013; Peters et al., 2008).

Given such findings, the current study includes an assessment of the degree to which the responding scientists felt that engagement would be an enjoyable or pleasant experience to capture a broad sense of whether the respondent has positive or negative expectations for how engaging would feel.

**Hypothesis 3:** Scientists who have a relatively more positive attitude toward engagement will be more willing to engage, regardless of mode.

The original survey includes questions focused on the benefits and harms of engagement, but these turned out to be relatively highly correlated with the measures of response efficacy discussed below and were therefore dropped. The correlation between benefit and harm makes sense conceptual and response efficacy makes conceptual sense inasmuch as both concepts are about the likelihood of engagement impact (whether good or bad).

Beyond general attitudes about engagement itself, it also seems possible that scientists' attitudes toward the public might shape engagement willingness. One review of past research found that many qualitative studies reported that scientists saw the public and the media as both chronically deficient in scientific knowledge and ability (Besley & Nisbet, 2013). Some limited evidence further found that scientists' who had negative views about their expected audience might be less willing to engage online (Besley, 2014). These findings are generally consistent with a much broader literature focused on trust (Fiske, Cuddy, & Glick, 2007; Fiske & Dupree, 2014) and fairness (Besley & McComas, 2014; Colquitt, Greenberg, & Zapata-Phelan, 2005) that suggests that how we view others will shape our desire to interact. The following attitude-focused hypothesis is therefore proposed.

**Hypothesis 4:** Scientists who have a relatively more positive attitude toward those with whom they would likely engage will be more willing to engage, regardless of mode.

The term *audience* is used in the current study with a recognition that it fails to capture the idea of two-way engagement. Alternative terms such as *expected interlocutor* and *fellow citizens* were considered but deemed cumbersome.

### Perceived Norms

The current study considers two types of normative beliefs (Lapinski & Rimal, 2005), including what scientists think their colleagues are doing (i.e.,



descriptive norms) and what they think their colleagues would support (i.e., injunctive or subjective norms).

For descriptive norms, there is some evidence that scientists who believe their colleagues engage were more likely to say they intend to engage in the future (Poliakoff & Webb, 2007), although another study found no such relationships (Besley, 2014). Nevertheless, it seems plausible to expect that scientists who see their colleagues engaging more would be more likely to be willing to engage themselves.

**Hypothesis 5:** Scientists who perceive that their colleagues are engaging will be more willing to engage themselves, regardless of mode.

Questions about the effect of injunctive norms and associated normative sanctions—the so called Carl Sagan Effect—are more common in the literature. The idea is that astronomer Carl Sagan was looked down upon by his colleagues and that the academic community dismisses scientists who take time from the research work to try to engage broader audiences (Ecklund et al., 2012; Fahy, 2015; Gascoigne & Metcalfe, 1997). Past research, however, has not found that scientists' engagement behavior is associated with beliefs about colleagues' views (Besley, 2014; Besley et al., 2013; Dudo et al., 2014; Poliakoff & Webb, 2007). Nevertheless, given the ubiquity of the idea and the importance of norms to the TPB, it seemed important to consider injunctive norms in the current study. The hypothesis is framed in a positive way to make it consistent with the other hypotheses.

**Hypothesis 6:** Scientists who perceive that their colleagues would have positive normative beliefs about those who engage are more likely to engage, regardless of mode.

### *Self- and Respondent Efficacy*

The current study considers three types of beliefs in the context of efficacy, including scientists' sense of their own skill at engaging, scientists' belief that engaging can have a beneficial effect, and scientists' sense that they have the time to engage.

For skill, understood as self-perceived self-efficacy (similar to internal efficacy in political contexts) of the responding scientist, previous studies have found that scientists who believe they could do a reasonable job at public engagement are more willing to engage (Besley, 2014; Besley et al., 2013; Dudo et al., 2014; Dunwoody et al., 2009; Poliakoff & Webb, 2007). Similarly, one study found that scientists who thought their work was easy to explain

were more likely to engage while those who thought their work was hard to explain were less likely to engage (Kreimer et al., 2011). Other studies showed that engagement training increased engagement and it may be that the effect was a function of increased skill (Dudo, 2013; Dunwoody et al., 2009).

**Hypothesis 7:** Scientists who perceive that they have the ability to engage skillfully, understood as self-efficacy, are more likely to engage, regardless of mode.

Beyond skill, while the hypothesis has not been widely tested, the belief that engagement will have a positive effect on the real world—response efficacy (similar to external efficacy in political contexts)—may also drive engagement (Besley, 2014). It makes sense, in this regard, that scientists who think they can help bring about positive outcome through an activity are more likely to pursue that activity. Similarly, research has shown that scientists who see a benefit from engagement, which might be understood as a positive effect, are more likely to engage (Besley et al., 2013). Positive outcomes could include policies that reflect the best available science, for example, as well as outcomes such as ensuring research for important areas of funding (e.g., Koh, Dunwoody, Brossard, & Allgaier, 2016).

**Hypothesis 8:** Scientists who perceive that engagement has the ability to have a positive impact, understood as response efficacy, are more likely to engage, regardless of mode.

Finally, it should be expected that scientists who feel too constrained by time pressures will be less likely to say they are willing to engage. This is not a traditional efficacy measure but seems important within this context and is consistent with the idea of subjective behavioral control. Although Poliakoff and Webb (2007) did not find that perceived time pressure was associated with engagement, a later project found that time was relatively important as a predictor of online engagement (Besley, 2014). Other research also found that scientists who believe they need communication help express less willingness to engage (Besley et al., 2013), and this help could decrease the time required to engage.

**Hypothesis 9:** The less time scientists perceive that they have for engagement, the less willing they will be to engage, regardless of mode.

To summarize, this study builds on past research and the idea of public engagement as planned behavior to predict two research questions and nine

hypotheses. For demographics, relatively higher age (Hypothesis 1) and being male (Hypothesis 2) are expected to be associated with more willingness to engage. However, it is not clear if there is a point in age that this pattern no longer holds (Research Question 1), and it is also not clear if there will be differences in the predictors for willingness between societies (Research Question 2). Beyond demographics, willingness should also increase, on average, with increases in positive attitudes toward engagement (Hypothesis 3) and expected engagement audiences (Hypothesis 4), as well as perceptions of positive descriptive norms (Hypothesis 5), injunctive norms (Hypothesis 6), internal efficacy (Hypothesis 7), and response efficacy (Hypothesis 8). Scientists who feel they have too little time to engage should be expected to express less engagement willingness (Hypothesis 9).

## Methods

### *Survey Implementation and Design*

The current study uses data collected from members of seven scientific societies during the fall of 2015 and winter/spring of 2016 (Table 1) (Michigan State University Institutional Review Board # x13-854e and University of Texas, Austin Institutional Review Board #2013-08-0061). Each society was surveyed at a time convenient to society collaborators. For each survey, multiple attempts were made to obtain cooperation from member scientists with slightly different appeals in each attempt (Dillman, Smyth, & Christian, 2009). The number of attempts varied by society because of different levels of organizational willingness to e-mail members. The societies themselves sent the surveys from their own membership departments on behalf of the research team because societies indicated that they did not feel comfortable providing contact information outside of the organization. All responses were sent directly to the primary investigators to ensure respondent confidentiality consistent with the intuitional review board approval for the project. We do not name the societies because we assured the participating societies that our goal was not to rank or rate societies or fields.

The survey itself typically took respondents between 15 and 25 minutes to complete. It began with questions about past public engagement and future willingness to engage. These initial questions included a definition of engagement. Depending on the size of the society, respondents might have been randomly assigned to questions in the context of face-to-face communication, communication with the public through news media, or online communication (i.e., engagement channel). For example, a single respondent assigned to the face-to-face condition would have been asked about

**Table 1.** Survey Timing and Sample Size.

Society	Survey dates (mm/dd/yy)	Number of attempts	Total respondents	Response rate <sup>a</sup> (%)	Eligible respondents <sup>b</sup>	F2F cond.	Media cond.	Online cond.
General science	10/15/15 to 11/10/15	5	1,263	9	1,109	385	333	391
Biology I	10/26/2015 to 11/20/15	4	513	9	375	375	n/a	n/a
Biology II	4/25/16 to 6/2/16	4	1,167	6	696	356	n/a	340
Chemistry	11/12/15 to 12/21/15 and 5/10/16 to 5/19/16	5/3	1,919	8	501	184	160	157
Geophysical	1/25/16 to 3/8/16	4	2,419	10	918	316	323	279
Geological	3/8/2016 to 4/1/2016	4	1,103	10	754	259	249	246
Ecological	3/25/2016 to 4/16/2016	3	860	16	350	350	n/a	n/a
Total			9,244			2,225	1,065	1,413

Note. F2F = face-to-face; cond. = condition; n/a = not available.

<sup>a</sup>After accounting for email bounce-backs due to bad or blocked addresses, as well as full inboxes. <sup>b</sup>Number of respondents with a PhD and working at an American university. The number of eligible respondents is different from the number of total respondents because not all participating societies had the same ability to prescreen respondents based on study criteria.

engagement attitudes, norms, and efficacy only within the context of that specific form of engagement. Societies with smaller memberships may have received only one of two options, or a single option. Partner societies indicated the type of engagement they were interested in learning about prior to the survey. Demographic information was collected at the end of the survey.

The goal was to obtain 383 respondents for each engagement channel who had a PhD and were based at an American university, which would provide a sampling margin of error of at least  $\pm 5\%$  for medium to large societies. Based on research literature that used online surveys to study scientists (Besley, Dudo, & Storksdieck, 2015; Dudo & Besley, 2016), the project team expected about a 10% response rate and set initial sample size accordingly, where possible. In some cases (e.g., the chemistry and geological societies), it was necessary to start with somewhat larger samples because the societies could not differentiate in their initial sampling between those who fit our study criteria and those who did not. Ultimately, the final response rate in four of the societies was similar to past online survey projects for several societies (Besley, 2014) and somewhat lower than hoped, and there were more noneligible members than expected. The current study is therefore cautious about using the data to describe specific societies. However, it still seems reasonable to use the data to speak to the relationships between variables in the context of our hypotheses based on the substantial variance that exists with the data. In this regard, while we might expect that respondents with negative views about communication might be less willing to complete a survey about communication (or more willing, if they felt current discussions about engagement were a threat), but we do not have any reason to think that the pattern of relationships explored would be different as a function of survey response. An analysis (not shown) was also done to see if respondents were systematically different across early and late waves with the logic that differences would suggest that harder-to-reach respondents would respond late. These analyses found that late respondents were largely similar to early respondents. The American Association for Public Opinion Research (2017) also warns that response rate should probably not be used as a measure of survey quality. Higher response rates could be obtained using additional paper mail sampling (Dudo, 2013; Pew Research Center for the People and the Press, 2009) but was not feasible due to prohibitive costs associated with the large scale of the project.

## *Measurement*

The core constructs studied here were typically measured with no more than two questions that were added together and divided by the number of

questions. Although not ideal, additional questions were not included because of concerns about survey length and because the constructs the project sought to assess seem relatively straightforward, especially given respondents' high education levels. This would be expected to reduce measurement error. The high correlation between the items reported below supports this view.

Also as with past research on scientists' engagement behavior (Besley, 2014; Dudo et al., 2014; Poliakoff & Webb, 2007), the current study uses a direct measurement approach, rather than an expected value approach (Fishbein & Ajzen, 2010), to attitudes, normative beliefs, and efficacy beliefs. The attitudes assessed were also drawn from the literature rather than from a qualitative elicitation phase.

**Willingness to Engage.** The outcome variable was measured by asking respondents to indicate how willing they were to engage in three different types of engagement using a 7-point scale anchored by "not all willing" to "very willing." The three engagement types included "face-to-face engagement where you discuss science with ADULTS who are not scientists (e.g., giving a public talk or doing a demonstration)," "interviews with a journalist or other media professional (e.g., from a newspaper, television, or online news site, documentary film, etc.)," and "[o]nline engagement through websites, blogs, and/or social networks (e.g., Facebook, Twitter) aimed at communicating science with ADULTS who are not scientists."

**Past Engagement Behavior.** This variable used the same engagement channels as the willingness variable but respondents were asked to indicate how often they had participated "within the last year" using one of seven response categories ranging from "never" to "daily." This variable was used as a control and not as the subject of a hypothesis or research question.

**Attitude Toward Engagement.** This variable was measured with two questions using 7-point semantic differential scales. Respondents were asked to indicate whether they think participating in engagement would be enjoyable or pleasant experience by selecting a point between unenjoyable and enjoyable, as well as unpleasant and pleasant ( $r = .83$ ,  $p < .00$ ). The question included piped text that asked the respondents to specifically answer in the context of the type of engagement to which they were randomly assigned (i.e., face-to-face, media, or online engagement).

**Attitude Toward Audience.** This variable was measured with two questions that asked respondents to use a 7-point scale to indicate how likely they thought it was that the audience with whom they would engage would "listen to what

[they] have to say” and “treat [them] with respect.” The scale was anchored by “not at all likely” and “very likely” ( $r = .92, p < .00$ ). This question also used piped text related to mode. Using all the available data, the two attitude questions’ composites are also correlated with each other ( $r = .48, p < .00$ ).

*Perceived Descriptive Norms.* This variable was measured with two statements that asked respondents the degree to which they agreed or disagreed that their colleagues “commonly practiced” the type of engagement to which they were randomly assigned, and whether they thought a “majority of [their] colleagues participate in [that] type of public engagement regularly.” They did so using a 7-point, “strongly disagree” to “strongly agree” scale ( $r = .82, p < .00$ ).

*Perceived Injunctive Norms.* This variable was measured with two statements that asked respondents the degree to which they agreed or disagreed that their colleagues “would respect someone who participates” in the type of engagement to which they were randomly assigned and whether they thought their “colleagues do not approve of” such engagement (reversed).” They did so using a 7-point, “strongly disagree” to “strongly agree” scale ( $r = .58, p < .00$ ).

The two norms questions’ composites are also correlated with each other ( $r = .48, p < .00$ ).

*Perceived Self-Efficacy.* This variable was measured with two statements that asked respondents the degree to which they agreed or disagreed that they “were skilled” at the type of engagement to which they were randomly assigned and whether they thought their engagement was “difficult for [himself or herself]” (reversed). They did so using a 7-point, “strongly disagree” to “strongly agree” scale ( $r = .66, p < .00$ ).

*Perceived Response Efficacy.* This variable was measured with two statements that asked respondents the degree to which they agreed or disagreed that the type of engagement to which they were randomly assigned “can make a difference in the world” and whether they thought their engagement was “probably a waste of scientists’ time]” (reversed). They did so using a 7-point, “strongly disagree” to “strongly agree” scale ( $r = .57, p < .00$ ). The two efficacy variables are also correlated with each other ( $r = .33, p < .00$ ).

## Survey Analysis

As noted, scientists indicated their willingness to engage using a 7-point scale and the mean was well above the scale midpoint (Table 2). The ordinal nature of the variable led us to use a cumulative link model (e.g., Agresti,

**Table 2.** Descriptive Statistics for Model Variables ( $n = 4,073$ ).

Mode	General Scientific Society			Biological Society I			Biological Society II			Chemistry Society			Geophysical Society			Geological Society			Ecological Society	
	F2F	Media	Online	F2F	F2F	Online	F2F	Media	Online	F2F	Media	Online	F2F	Media	Online	F2F	Media	Online	F2F	
Engage willingness																				
Not all willing (1)	3%	6%	19%	4%	2%	14%	3%	9%	15%	1%	3%	10%	2%	5%	15%	1%				
(2)	3%	5%	12%	3%	2%	7%	6%	7%	10%	2%	4%	8%	2%	5%	12%	1%				
(3)	3%	5%	8%	3%	2%	7%	3%	5%	9%	2%	4%	7%	2%	5%	6%	1%				
Neutral (4)	11%	16%	20%	13%	10%	19%	15%	26%	23%	8%	16%	19%	8%	19%	20%	6%				
(5)	17%	19%	14%	20%	17%	16%	17%	16%	14%	14%	17%	17%	14%	18%	13%	14%				
(6)	27%	23%	13%	24%	29%	16%	25%	19%	14%	29%	26%	17%	25%	20%	14%	26%				
Very willing (7)	36%	27%	15%	33%	39%	21%	31%	18%	15%	44%	32%	22%	47%	29%	20%	50%				
Past engagement <sup>a</sup>	2.64 (1.57)	2.10 (1.27)	2.32 (1.88)	2.20 (1.37)	2.46 (1.58)	2.42 (1.87)	2.33 (1.39)	1.61 (0.86)	2.04 (1.66)	2.78 (1.51)	2.25 (1.27)	2.71 (2.00)	3.05 (1.58)	2.08 (1.17)	2.64 (2.06)	2.97 (1.43)				
Male	69%	72%	66%	59%	52%	56%	66%	68%	68%	62%	68%	61%	64%	64%	65%	57%				
Age, years																				
18-30	1%	1%	1%	2%	2%	1%	2%	3%	3%	3%	2%	5%	2%	5%	5%	1%				
31-40	8%	9%	5%	17%	19%	20%	27%	27%	19%	26%	21%	27%	16%	9%	16%	19%				
41-50	8%	5%	8%	24%	22%	19%	25%	21%	30%	20%	24%	21%	18%	20%	11%	18%				
51-60	18%	22%	22%	28%	25%	25%	15%	21%	19%	24%	26%	19%	17%	22%	31%	21%				
61-70	33%	40%	34%	17%	17%	22%	24%	17%	20%	24%	23%	23%	25%	23%	18%	26%				
71-80	24%	18%	24%	9%	12%	11%	7%	11%	9%	2%	4%	5%	16%	14%	14%	12%				
81+	9%	5%	7%	5%	4%	2%	0%	0%	1%	1%	1%	1%	6%	6%	5%	3%				
Attitude: Toward engagement	5.61 (1.23)	4.90 (1.47)	4.53 (1.40)	5.30 (1.32)	5.64 (1.07)	4.82 (1.46)	5.39 (1.34)	4.61 (1.44)	4.54 (1.39)	5.53 (1.21)	4.96 (1.30)	4.56 (1.42)	5.59 (1.24)	4.69 (1.40)	4.38 (1.61)	5.39 (1.24)				
Attitude: Toward audience	5.70 (.90)	5.19 (1.03)	4.79 (1.19)	5.43 (1.04)	5.57 (1.01)	4.78 (1.23)	5.45 (1.00)	4.76 (1.12)	4.58 (1.17)	5.53 (0.96)	5.26 (1.01)	4.52 (1.30)	5.50 (1.05)	5.14 (1.10)	4.53 (1.26)	5.59 (.93)				
Perceived norms: Descriptive	3.93 (1.47)	3.80 (1.42)	3.65 (1.37)	3.66 (1.42)	3.91 (1.43)	3.62 (1.35)	3.88 (1.48)	3.29 (1.36)	3.48 (1.21)	4.21 (1.36)	4.33 (1.39)	3.93 (1.35)	4.12 (1.44)	3.96 (1.51)	3.83 (1.42)	4.23 (1.45)				
Perceived norms: Injunctive	5.40 (1.10)	5.21 (1.10)	4.83 (1.19)	5.26 (1.11)	5.31 (1.20)	4.96 (1.16)	5.51 (1.03)	5.08 (1.06)	4.85 (1.16)	5.48 (1.16)	5.41 (1.20)	4.97 (1.09)	5.30 (1.26)	5.23 (1.16)	4.94 (1.23)	5.33 (1.24)				
Perceived efficacy: Self	4.70 (1.44)	4.19 (1.50)	3.69 (1.51)	4.25 (1.38)	4.59 (1.40)	4.03 (1.54)	4.41 (1.40)	3.74 (1.36)	3.70 (1.36)	4.69 (1.45)	4.16 (1.41)	3.77 (1.49)	4.80 (1.44)	4.20 (1.51)	3.79 (1.58)	4.52 (1.50)				
Perceived efficacy: Response	6.05 (.92)	5.90 (1.01)	5.28 (1.24)	5.83 (1.09)	6.03 (.06)	5.31 (1.30)	5.74 (1.06)	5.59 (1.18)	5.03 (1.21)	5.99 (1.04)	5.93 (1.02)	5.17 (1.34)	6.05 (1.03)	5.83 (1.01)	5.21 (1.30)	6.03 (1.00)				
Perceived efficacy: No time	3.23 (1.55)	3.38 (1.55)	3.66 (1.55)	3.70 (1.63)	3.59 (1.5)	3.89 (1.51)	3.85 (1.57)	3.91 (1.41)	4.27 (1.49)	3.66 (1.52)	3.44 (1.61)	3.83 (1.64)	3.45 (1.64)	3.46 (1.53)	3.79 (1.64)	3.59 (1.56)				

Note. F2F = face to face. Values are presented as percentages or means (standard deviations).

<sup>a</sup>Past engagement: measured using a 7-point scale from *never* (0) to *daily* (7).



2010) to address the research questions and hypotheses. It may sometimes make sense to take advantage of the robustness of linear regression techniques to treat normally distributed ordinal responses as ratio responses, but the distribution that can be seen for willingness in Table 2 led us to use statistical techniques specifically designed for ordinal data. A statistical consultant from an on-campus statistical consulting group conducted the analyses in consultation with the other authors and joined the manuscript as an author. The model used assumes an underlying continuous latent variable for the response that makes use of the logit link. In this type of model, the parameter estimates for the predictor variable effects are invariant for the dependent variable categories ( $j \in 1, \dots, J$ ). Thus, the beta coefficients for the independent variables apply to all  $J - 1$  cumulative logits where the parameter,  $j$ , is the estimated threshold for each cumulative logit.

$$\logit[P(Y \leq j|x)] = \theta_j - X\beta$$

In other words, using this model, the coefficient estimates presented in Table 3 can be understood as the amount that willingness goes up with a 1-unit change in the predictor variable on the log-odds scale. Also reported are odds ratios meant to communicate the relative impact a change in each predictor variable has on a particular outcome variable. Odds ratios can be understood as the effect size for a change in predictor variable on the outcome variable. When the odds ratio is higher than 1, higher values for the predictor variable imply that a higher score on the outcome variable is more probable. Values less than 1 mean that the predictor variable would be expected to be associated with a lower score on the outcome variable. The odds ratio is therefore frequently used to describe the impact the occurrence of an event will have on the outcome variable. For example, if the odds ratio for a particular predictor is 1.5:1, the interpretation would be that when the predictor increases by 1 unit, the respondent is 1.5 times (50%) more likely to select the next higher response option for the predictor compared with someone who did not have the higher predictor value.

The decision was made to look at each engagement mode (e.g., face-to-face) on its own and provide only qualitative comparisons because not all of the participating societies had enough eligible members to make it possible to allocate a meaningful number of respondents to each of the three modes. Comparisons between the three modes can thus be thought of as replications where similarities are seen as additional confirmation of the underlying relationship and differences need to be discussed as opportunities for future research. The decision not to use a multilevel or mixed model was driven by the relatively small number of societies included in the analysis and the fact

**Table 3.** Final Estimates for Cumulative Link Model for Willingness to Engage (Ordinal;  $n = 2,225$ ).

	Face-to-face willingness					Media interview willingness					Online willingness				
	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )
Past engagement	<b>0.36</b>	<b>1.43</b>	<b>0.03</b>	<b>10.77</b>	<b>.00</b>	<b>0.69</b>	2.00	<b>0.06</b>	<b>11.05</b>	<b>.00</b>	<b>0.62</b>	1.85	<b>0.04</b>	<b>16.94</b>	<b>.00</b>
Pseudo $R^2$ (block only)	.14					.24					.38				
Age, years (18-30 is reference)															
31-40	0.33	1.39	0.34	0.98	.33	<b>0.98</b>	2.65	<b>0.39</b>	<b>2.51</b>	<b>.01</b>	-0.07	0.93	0.37	-0.19	.85
41-50	0.11	1.11	0.34	0.31	.76	0.67	1.96	0.39	1.74	.08	-0.19	0.83	0.37	-0.51	.61
51-60	-0.15	0.86	0.33	-0.45	.65	0.56	1.76	0.38	1.48	.14	<b>-0.81</b>	<b>0.45</b>	<b>0.36</b>	<b>-2.24</b>	<b>.03</b>
61-70	-0.52	0.59	0.34	-1.56	.12	0.60	1.83	0.38	1.58	.12	<b>-0.97</b>	<b>0.38</b>	<b>0.36</b>	<b>-2.68</b>	<b>.01</b>
71-80	<b>-1.14</b>	<b>0.32</b>	<b>0.35</b>	<b>-3.25</b>	<b>.00</b>	0.17	1.19	0.41	0.42	.68	<b>-1.37</b>	<b>0.25</b>	<b>0.38</b>	<b>-3.60</b>	<b>.00</b>
81+	<b>-2.05</b>	<b>0.13</b>	<b>0.39</b>	<b>-5.23</b>	<b>.00</b>	-0.27	0.76	0.50	-0.55	.59	<b>-1.89</b>	<b>0.15</b>	<b>0.48</b>	<b>-3.97</b>	<b>.00</b>
Male (female is reference)	0.03	1.03	0.09		0.34	<b>0.56</b>	<b>1.76</b>	<b>0.14</b>	<b>4.10</b>	<b>.00</b>	-0.12	0.89	0.11	-1.06	.29
Society (general is reference)															
Biology I	0.01	1.01	0.15	0.10	.92	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biology II	0.22	1.25	0.15	1.50	.13	n/a	n/a	n/a	n/a	n/a	0.18	1.19	0.15	1.19	.24
Chemistry	-0.26	0.77	0.18	-1.43	.15	-0.36	0.70	0.20	-1.83	.07	-0.18	0.84	0.19	-0.96	.34
Geophysical	0.10	1.11	0.15	0.67	.50	<b>0.38</b>	<b>1.46</b>	<b>0.16</b>	<b>2.32</b>	<b>.02</b>	-0.07	0.93	0.16	-0.45	.65
Geological	0.26	1.30	0.16	1.60	.11	0.17	1.19	0.17	1.02	.31	0.08	1.09	0.17	0.50	.62
Ecological	<b>0.68</b>	<b>1.98</b>	<b>0.15</b>	<b>4.49</b>	<b>.00</b>	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

(continued)

**Table 3. (continued)**

	Face-to-face willingness					Media interview willingness					Online willingness				
	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )	Est. <sup>a</sup>	Odds ratio <sup>b</sup>	SE	z	Sig. (> z )
Pseudo R <sup>2</sup> (block only)	.29					.19					.19				
Attitude: Toward engagement	<b>0.61</b>	<b>1.83</b>	<b>0.04</b>	<b>14.36</b>	<b>.00</b>	<b>0.74</b>	<b>2.09</b>	<b>0.06</b>	<b>13.12</b>	<b>.00</b>	<b>0.62</b>	<b>1.86</b>	<b>0.05</b>	<b>12.65</b>	<b>.00</b>
Attitude: Toward audience	<b>0.12</b>	<b>1.13</b>	<b>0.05</b>	<b>2.43</b>	<b>.02</b>	-0.01	1.00	0.07	-0.07	.95	0.01	1.01	0.05	0.15	.88
Perceived norms: Descriptive	<b>-0.08</b>	<b>0.92</b>	<b>0.04</b>	<b>-2.30</b>	<b>.02</b>	<b>-0.14</b>	<b>0.87</b>	<b>0.05</b>	<b>-2.78</b>	<b>.01</b>	0.01	1.01	0.04	0.23	.82
Perceived norms: Injunctive	-0.02	0.98	0.04	-0.43	.67	<b>0.14</b>	<b>1.15</b>	<b>0.06</b>	<b>2.19</b>	<b>.03</b>	0.08	1.08	0.05	1.41	.16
Perceived efficacy: Self	<b>0.22</b>	<b>1.24</b>	<b>0.06</b>	<b>3.41</b>	<b>.00</b>	0.02	1.02	0.09	0.18	.86	-0.03	0.97	0.08	-0.38	.70
Perceived efficacy: Response	<b>0.37</b>	<b>1.45</b>	<b>0.05</b>	<b>7.94</b>	<b>.00</b>	<b>0.13</b>	<b>1.14</b>	<b>0.07</b>	<b>2.03</b>	<b>.04</b>	<b>0.21</b>	<b>1.24</b>	<b>0.05</b>	<b>4.22</b>	<b>.00</b>
Perceived efficacy: No time	<b>-0.29</b>	<b>0.75</b>	<b>0.03</b>	<b>-9.29</b>	<b>.00</b>	<b>-0.19</b>	<b>0.83</b>	<b>0.04</b>	<b>-4.43</b>	<b>.00</b>	-0.06	0.95	0.04	-1.53	.13
Pseudo R <sup>2</sup> (block only)	.32					.37					.39				
Final pseudo R <sup>2</sup>	.35					.46					.41				
n	2,225					1,065					1,413				

Note. Est. = estimate; SE = standard error; Sig. = significant. Bold values indicate significant relationships for coefficients related to the hypotheses. Significance tests are two-tailed. Adding an additional block of interactions between society and the attitude, normative belief, and efficacy beliefs questions would increase the pseudo R<sup>2</sup> by .02 in the F2F model, .02 in the media interview model, and .03 in the online willingness model. Estimates for societies for which there is no data are marked as n/a.

<sup>a</sup>Estimates represents the expected change in willingness to engage associated with a 1 log odds change in the predictor on a scale. <sup>b</sup>The odds ratio represents the odds ratio for a 1-unit change in the predictor being associated with a 1-unit change in willingness.

that the societies were selected based on availability rather than probabilistically. Finally, the study only looks at the main effects of the predictor variables rather than looking at interactions between, for example, society and each of the predictors. This is partly because initial investigation (not shown) suggested that adding such interactions would only explain an additional 2% to 3% of the variance in willingness, but primarily because there was no consistent pattern in the results or theory that would allow for meaningful predictions. A more parsimonious main effect model is thus reported. Consistent with journal publishing guidelines, quantitative results reported in the tables are generally not repeated in the text.

## Results

### *Past Engagement Behavior*

The analysis controlled past, mode-specific engagement behavior given the expectation that past behavior would be likely to predict future willingness. The modeling showed that a unit increase in past behavior changed the outcome by between 0.36 log odds for face-to-face willingness to 0.69 log odds for news media willingness (Table 3). The interpretation using the odds ratios is that an individual who is 1 unit higher on the past engagement measure would be between 1.43 times (43%) and 2.00 times (100%) more likely to be 1 unit higher on willingness to engagement than an individual who was 1 unit lower on the past engagement measure. The result for past online engagement on future online engagement willingness was similar to the past news media engagement result.

Past engagement, as might be expected, explained a fairly substantive amount of variance in all the models (measured as pseudo  $R^2$ ), and it could be argued that including this variable hides some of the effect of predictors because past engagement is, by definition, also likely driven by the same predictors. An additional set of models (not shown) was therefore run without past engagement, and these found that including past engagement measures reduced the overall variance explained but did not substantively affect the pattern of relationships described below. In other words, it seems possible to talk about future willingness as something that occurs beyond past choices and the decision was thus made to keep past engagement in the model.

### *Demographics as Predictors of Scientists' Willingness to Engage*

Prior to analyzing attitudes, norms, and efficacy measures, it was important to assess the degree to which demographic variables need to be considered as important predictors of willingness to engage.

The relationship between age (Hypothesis 1 and Research Question 1) and willingness varies somewhat by mode of engagement (Table 3). For face-to-face engagement, it appears only that scientists in the top age-groups are somewhat less likely to be willing to engage but that, otherwise, age makes little difference. For engagement through the news media, it appears that those in the middle age-groups are more likely to be willing to engage when compared with the youngest and the oldest age-groups. For online engagement, the results suggest that relatively younger scientists are more willing to engage. The first significant difference is that the 51- to 60-year-old group is .45 times as likely to be one category lower in their willingness to engage online as those 30 years and younger.

For sex (Hypothesis 2), it appears that male scientists are somewhat (1.76 times) more willing to interact with the news media, but otherwise, there are few other differences (Table 3).

For society (Research Question 2), there are only a few differences (Table 3). Ecological scientists might be somewhat more willing to engage face-to-face and geophysical scientists might be more willing to engage through the news media. The aforementioned model (not shown) that did not include a measure of past engagement behavior also found that the chemistry society respondents were somewhat less willing to engage through the news media.

Overall, the model that includes sex, age, and society explains 19% to 29% of the variance.

### *Attitudes, Norms, and Efficacy as Predictors of Scientists' Willingness to Engage*

Several of the TPB variables are substantial and consistent predictors of future willingness to engage. The overall attitude and efficacy measures appear to be particularly important predictors of engagement.

For attitude (Hypothesis 1), as might be expected, positive attitude toward the engagement experience appears to be a more consistent predictor of willingness than attitude toward one's expected audience (Table 3). Specifically, it appears that a 1-unit shift in attitudes toward the engagement experience was associated with about a  $\frac{2}{3}$ -unit log odds increase in willingness to engage, no matter what mode was asked about. The reported odds ratios can be interpreted to suggest that a scientist who gave 1-unit higher response on attitude toward engagement (for any mode) was about twice as likely to have given a 1-unit higher response on willingness. In contrast, attitude toward the audience was only a significant predictor of willingness in the face-to-face model and the size of the relationship was small.

Perceived descriptive (Hypothesis 5) and injunctive (Hypothesis 6) norms appear to be relatively limited predictors of willingness to engage, contrary to some past work (Table 3). Even where these are significant predictors, the reported odds ratios suggest relatively modest differences between those who perceive positive and negative norms.

Efficacy beliefs—particularly response efficacy beliefs (Hypothesis 8)—were relatively consistent predictors of engagement willingness (Table 3). The degree to which scientists felt they had the skill needed to engage effectively (Hypothesis 7) was a significant predictor in face-to-face engagement though not in other forms of engagement. In contrast, scientists' belief that engaging through a specific mode would make a difference in the real world was associated with all forms of engagement. A lack of perceived time (Hypothesis 9) to engage was associated with less willingness for face-to-face and news media engagement. The odds ratios for the efficacy beliefs, even where significant, seem less substantive than those associated with attitude toward engagement.

Overall, the TPB-related variables predicted between about a third of the available variance on their own (pseudo  $R^2$  between .32 and .39) and somewhat more (pseudo  $R^2$  between .35 and .46) when combined with the other variables in the model. The fact that demographic variables and the TPB variables seem to explain a similar proportion of the variance in the face-to-face model is also noteworthy. This is suggested by the fact that both blocks explain about a third of the variance on their own and continue to predict about the same variance when combined together.

## Discussion

Consistent with the idea that scientists' engagement decisions should be understood and studied as planned behavior, the current research suggests that overall willingness to engage may be driven primarily by attitude toward engagement and scientists' engagement-related efficacy beliefs, controlling for past engagement. Furthermore, these predictors of willingness seem to work relatively well when looking at any of the three engagement modes (i.e., channels) and across any of the types of scientists studied here. The other variables in the model were only sometimes significant predictors, and only some of these relationships seemed qualitatively substantive. Each of the variables will be discussed in turn in the context of the hypotheses and research questions above and what they may mean for those such as trainers or organizations who want to get scientists to engage more frequently. Together, the results might be understood as providing the most comprehensive look to date on the factors that are associated with scientists' willingness to engage.

First, the finding for the past engagement variable is unsurprising but important. In this regard, it would be expected that those who are engaging more often through a given channel would be more willing to continue to engage in the future. The positive implication from this finding is that it could be interpreted to mean that those who are engaging generally want to continue engaging. And, while not surprising, it is possible to imagine a situation where those who were already participating might reject further engagement. The value of continued willingness to engage should not be taken lightly.

For age, the fact that engagement willingness drops after a certain age (Research Question 1) also seems fairly understandable. It also seems reasonable that the most junior scholars, relative to midcareer scholars, may be a little less willing to engage through traditional news media given the added potential stress associated with larger audiences. Similarly, the fact that willingness to engage online decreases with age may simply reflect comfort and interest in the available tools (Hypothesis 1). Practically, the results suggest the potential value of training and the possibility that we will see changes over time as current younger cohorts age.

The fact that men are more willing than women to engage through the media (Hypothesis 2), although consistent with past research, is potentially troubling and it is interesting that this pattern is not reflected in online willingness. Future research should explore this pattern, and increased energy might be directed by groups such as university media relations offices toward empowering and encouraging engagement among female scientists. On the other hand, the fact that the data do not suggest that women and men are different in their willingness to engage face-to-face and online seems positive.

For the society variables (Research Question 2), the fact that ecological society members may be somewhat more willing than members of other societies to engage in face-to-face contexts (noting that this group was not asked about news media or online engagement) may reflect the nature of their more direct focus on issues, like climate change, that are prevalent in U.S. social and political discourse. It may also possibly reflect a longer tradition of engagement among ecologists (Nelkin, 1977). The fact that few other differences emerged, however, is also important as it speaks to the idea that the drivers of engagement willingness are common, rather than unique, to specific fields. Recognizing the limits of the current data, the findings on age, sex, and field should also cause us to at least question arguments that some specific types of scientists are substantively different from others in how they think about science communication (e.g., Ecklund et al., 2012).

For attitudes, it appears that expected quality of the experience (i.e., enjoyable and pleasant, Hypothesis 3) was a more consistent and substantive predictor than what scientists think about their likely audiences' treatment toward

them (Hypothesis 4). To some extent, the attitude about the experience may be more all-encompassing than the specific attitude toward the audience, but the pattern is still important because it suggests the potential value of integrating content such as scientists' stories about past positive engagement experiences into training. It is also important because it suggests that despite some past emphasis on scientists' negative views about the public (Besley, 2014; Besley & Nisbet, 2013) the results do not suggest that such views are likely to drive communication willingness. Future research could explore additional types of feelings (or emotions) that scientists might anticipate would occur with engagement activities (e.g., frustration, panic, humiliation, pride, excitement, boredom, etc.).

For norms, the data suggest that, scientists' perceptions about their colleagues' behavior (Hypothesis 5) and attitudes toward engaged scientists (Hypothesis 6) are not substantive statistical drivers of willingness to engage. While some early work (Poliakoff & Webb, 2007) and some discussion (Fahy, 2015) highlight concerns about how colleagues react, the current study confirms recent empirical results that suggest that normative beliefs related to colleagues may not be as important as some think. This is important because it means the communication training community, for example, can devote time to addressing other potential beliefs rather than trying to convince scientists that their colleagues value engagement. Future research should, however, explore questions such as whether certain levels or types of engagement might result in social norm concerns and whether beliefs about noncolleagues' expectations may drive engagement willingness. It may be, for example, that scientists value a certain amount of engagement from colleagues but would question any engagement that took time away from important research or engagement that was done inappropriately (e.g., see discussion about norms for dealing with journalists in Peters, 2013). It may also be that faculty are concerned and focused on how they perceive the desires of groups such as key actors in their organizations or funders (Marcinkowski et al., 2013) or see engagement activity as the purview of people in certain leadership positions (Rödger, 2012).

The results for efficacy (Hypotheses 7 to 9), in contrast, suggest several proactive steps that are likely to motivate scientists to engage. The results for self-efficacy also suggest a potential problem with current engagement efforts. Each efficacy measure is discussed in turn.

For self-efficacy (Hypothesis 7), scientists' perception of their own skill at communicating is only associated with face-to-face willingness. This would suggest that willingness could be boosted by increasing skill. The fact that this relationship is not bigger and a more consistent predictor might be important as it could be taken to mean that scientists are willing to engage,



regardless of their own beliefs about their engagement skills. It should also be surprising because several past studies pointed to self-efficacy as an important drive of engagement (e.g., Besley, 2014; Besley et al., 2013; Dudo et al., 2014; Dunwoody et al., 2009; Poliakoff & Webb, 2007), and a key goal of communication training is to increase scientists' self-efficacy (Besley & Dudo, 2017b). One could also argue that, if high quality engagement is desired, a goal of communication training could be to better couple scientists' beliefs in their own skill with the degree to which the scientists are willing to put themselves in contact with real audiences. In other words, the lack of relationship between self-efficacy and willingness might be a problem. Alternatively, it may be that we might prefer that scientists with lower skills remain willing to engage but choose engagement with lower visibility or stakes.

For response efficacy and efficacy related to time, it seems clear that it could be helpful to show scientists that engagement can make a difference. This was not a large effect, but it is still meaningful and speaks to the need to ensure that we find ways to track engagement impacts. For the time-focused efficacy variable, the results suggest the need to think about ways in which we can either show scientists that they can engage within their current time constraints or find ways to relieve time-related engagement burdens. Those who want to promote more scientist engagement could, for example, experiment with providing help on time-consuming tasks such as logistics, presentation design, and evaluation. In some ways, this suggests that the science community may need to find ways to treat scientists who we want to communicate more in a way similar to how we treat other "executives." It would be unusual for corporate, governmental, or nongovernmental institutions to expect a "principal" to conduct many of the logistical tasks that we seem to expect scientists to manage on top of their research. From a societal point of view, it would also seem beneficial to maximize scientists' research time while recognizing that we need scientists to engage meaningfully, not just as figureheads.

### *Limitations and Future Research*

The current study is novel in its focus on multiple scientific disciplines and multiple modes of engagement, but it is not without limitations. As with any study, not all potential predictors of the outcome—willingness in the current case—were considered. The constructs that were considered could also have been measured with more depth or operationalized differently. The degree to which scientists perceive personal benefits and risks, in particular, seem like potential constructs that deserve more attention but were addressed here only

inasmuch as they overlap with the idea of attitude toward engagement and response efficacy. Another outcome that might have been considered is willingness to engage with policymakers, rather than citizen audiences. Similarly, while more U.S. scientists were surveyed than in previous projects, not all fields were covered. Social scientists and physicists, for example, are missing from the current study. It also only focuses on university scientists in the United States, and response rates were low. From a modeling perspective, the focus here was on main effects without substantive consideration of mediation or moderation. The pseudo  $R^2$  scores, particularly for face-to-face engagement, suggest that mediation may be at work. Finally, the research focused on overall engagement willingness (although across three modes), and it is interesting to question whether we would receive similar results if we focused on willingness to engage in more specific types of communication. Nevertheless, given the results, attention to attitudes and efficacy beliefs of scientists seem particularly important because these are potential outcomes that groups such as trainers could actually address. Future research could address how to effectively and ethically instill such beliefs in scientists through activities such as training. While ethics are not a core component of the current work, it seems clear that any effort to reshape engagement practice should be done in ways that are acceptable to the scientific community.

More generally, the focus of this study is on engagement quantity rather than on engagement quality. Both quantity and quality are important, but at some point, it may make more sense to think about how to recruit *specific* scientists to communicate and then focus on how to make these selected scientists effective. One useful thing to recognize about treating engagement behavior as planned behavior is that, while the current study focused on overall willingness to engage, similar models could be used to understand willingness to prioritize specific objectives (Besley, Dudo, & Yuan, 2017) or specific tactics. On tactics, an area that does not seem to have been studied, research might, for example, seek to assess what motivates participation in science cafés in comparison to more traditional public lectures or more elaborate deliberative events. It might equally be helpful to understand why some scientists are motivated to put more time toward carefully crafted communication (i.e., writing editorials), while others prioritize producing higher volumes of communication with lower quality (i.e., writing Tweets). Some of this research could be done using surveys (i.e., those used in this study), but other research should use methods such as experiments that, for example, explore if describing engagement in specific ways makes engagement more or less enticing. As noted above, when introducing the concept of willingness, validation research might also be helpful to assess whether scientists

who say they are more willing to engage are actually more likely to take opportunities to take part in engagement activities when presented.

From an applied standpoint, the results suggest a need to a shift in focus toward identifying groups of scientists that, for one reason or another, seem likely to have an advantage in achieving specific goals. For example, it may be that it makes sense for science organizations to focus on getting scientists in specific geographic locations or with expertise in specific areas more engaged. It will also be important to ensure that individuals from underrepresented groups are adequately supported and encouraged. On the other side, some effort could go to finding ways to get some scientists to engage less. For example, those who want to improve overall attitudes toward science may find it useful to find ways to demotivate scientists who are verbally aggressive (i.e., rude, condescending) or who might reinforce unhelpful stereotypes. Overall, the results suggest that future research and efforts seem most likely to benefit from several areas. This could include identifying specific factors that make scientists more likely to expect a positive experience from their engagement efforts, both in terms of personal and societal impacts. While gaining access to scientists as research subjects can be difficult, there is a range of research opportunities open to those who want to help increase the frequency and quality of public-scientist interactions.

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