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What Factors Predict Scientists' Intentions to Participate in Public Engagement of Science Activities?

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There is a drive for more scientists to engage with the lay public. The authors used an augmented version of the theory of planned behavior and identified three factors that predicted scientists' intentions to participate in public engagement activities, over and above their past actions: attitude (whether participation was regarded as positive), perceived behavioral control (beliefs about whether participation was under their control), and descriptive norms (whether scientists believe their colleagues participate). Factors such as career recognition and time constraints did not significantly predict intentions. These findings will contribute to the design of interventions to promote public engagement.

Keywords: *public engagement; theory of planned behavior; scientist participation; descriptive norm; moral norm; perceived behavioral control*

Since the Wolfendale Committee (1995) concluded that scientists receiving public funding for their research have a duty to communicate their research to the public, there has been an impetus to increase the number of scientists engaging with the lay public. Indeed, the Council for Science and Technology (2005) has recently launched a universal ethical code of conduct for scientists, which suggests that scientists should "seek to discuss the issues that science raises for society" (p. 4). Scientists are now asked about their public engagement plans when applying for research funding (Pearson, 2001), and funding

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bodies have launched a variety of funding schemes to promote public engagement. To give two examples, the Engineering and Physical Sciences Research Council runs Partnerships for Public Awareness projects, and the Wellcome Trust's Engaging Science grant program offers £3 million per year to raise public awareness of biomedicine.

Given the importance of engaging the public in science and the prevalence of initiatives to encourage public engagement (Pearson, 2001), it is perhaps surprising that there has been so little research investigating the factors that influence scientists' decisions to take part (or not to take part) in public engagement activities. Much of the research to date has focused on the best way to engage the public (e.g., Office of Science and Technology and the Wellcome Trust, 2001; Winter, 2004) or on how to influence policy making at an national or organizational level (e.g., Pearson, 2001) rather than what motivates individual scientists to participate in engagement activities. One exception is the Wellcome Trust (2000) commissioned survey (*The Role of Scientists in Public Debate*) in which 1,540 scientists were interviewed about their attitudes toward science communication and, in particular, about the importance of the public understanding the social and ethical implications of scientific research. More than half of the scientists had participated in science communication activities in the previous year, and 56% wanted to spend more time on this.

In a follow-up study, 1,485 scientists were asked what science communication they do and what factors they believe facilitate or inhibit science communication (*Survey of Factors Affecting Science Communication by Scientists and Engineers*, Royal Society, 2006). In terms of factors that inhibit science communication, 64% of these scientists identified the need to spend more time on research and 20% thought that scientists who engage are viewed less well by their peers. However, while these surveys are invaluable for identifying possible motivators and barriers to scientists' participation in public engagement activities, they are largely descriptive and have been carried out without an underlying theoretical framework. This makes it difficult to identify which of the factors are most important. In addition, although scientists might say that they would participate in public engagement activities if they had, for example, more time, often people lack the insight to understand the causes of their actions (e.g., Zacharakis & Meyer, 1998; Dunning, Johnson, Ehrlinger, & Kruger, 2003), are influenced by post hoc rationalization and recall biases (Rutter, Maughan, Pickles, & Simonoff, 1998), and may even reconstruct events to suit a particular interpretation (e.g., Smith, 1999; Wegner & Wheatley, 1999). In an effort to address these concerns, the present study does not ask scientists to reflect on why they choose to participate (or choose not to participate) in public engagement activities. Instead, an augmented version of the theory of

planned behavior (Ajzen, 1991) is used to measure scientists' beliefs about public engagement and to examine the relationships between these beliefs and participation decisions.

In this research, we define public engagement as any scientific communication that engages an audience outside of academia. Scientific communication refers to "the use of appropriate skills, media, activities and dialogue to produce one or more of the following personal responses to science: awareness, enjoyment, interest, opinion-forming and understanding" (Burns, O'Connor, & Stocklmayer, 2003, p. 183). Examples of public engagement activities would be appearing on radio, giving a public lecture, designing activities for children, and so on. To give a specific example, Café Scientifique is a growing initiative (founded by an independent TV producer in 1998 and now supported by the Wellcome Trust) that organizes monthly public lectures by eminent scientists in coffee houses and bars around the United Kingdom (Clery, 2003). It is important that scientists participate in public engagement activities for a number of reasons. First, and perhaps most obviously, science is at the core of many of the issues facing global society today—terrorism and violence, economic productivity, sustainable development, and health—and this centrality "bestows an obligation on the scientific community to develop different and closer links with the general population" (Leshner, 2003, p. 977). Second, there may be a discrepancy between the way that the media portrays science and actual scientific findings. For example, a survey found that 7 out of 10 adults think that the media sensationalizes science issues (Office of Science and Technology and the Wellcome Trust, 2000). Third, public engagement activities are important because they can change the public's perception of scientists (Hughes, 2001; Poliakoff, Baraas, Cotton, & Schiessl, 2004) and may lead to the public being more supportive of scientific research (Greenwood & Riordan, 2001). Finally, public engagement activities can be enjoyable for those who take part, and may enrich peoples' lives (Greenwood & Riordan, 2001). Indeed, enjoyment can be seen as a valid learning outcome of an activity such as visiting a museum (Hofstein & Rosenfield, 1996).

The Theory of Planned Behavior

The theory of planned behavior (Ajzen, 1991) is perhaps the dominant social-cognition model used to predict human behavior; 14 years after its conception more than 490 studies had been conducted applying and refining the framework (Conner & Sparks, 2005). The model suggests that the proximal determinant of a person's behavior is his or her decision about how to behave (or *behavioral intention*). Intentions are usually measured by endorsement of items such as "I intend to do X!" and indicate how hard one

is prepared to try, or how much effort one will exert, in order to achieve desired outcomes (Gollwitzer, 1990; Ajzen, 1991; Webb & Sheeran, 2005). Thus, according to the theory of planned behavior, the best predictor of whether a scientist will take part in a public engagement activity is the direction (shall I/shan't I) and strength (how much do I want to/not want to) of their behavioral intention.

According to the theory of planned behavior, there are three predictors of intention: attitude, subjective norm, and perceived behavioral control. *Attitudes* reflect the individual's enduring evaluation—positive or negative—of engaging in a particular behavior (Eagly & Chaiken, 1993). The evidence to date suggests that most scientists have a positive attitude toward participating in public engagement activities. In the Wellcome Trust (2000) survey, 97% of scientists said that they could see benefits to public communication, and 38% said that they could see no disadvantages to public communication. When predicting scientists' participation in public engagement activities, these salient behavioral beliefs may also include *perceived suitability of research* (e.g., "My research is too controversial for a public engagement activity") and *recognition of participation* (e.g., "Taking part in a public engagement activity would benefit my career"; Gascoigne & Metcalfe, 1997; Jacobson, Butterill, & Goering, 2004; Royal Society, 2006; Wellcome Trust, 2000). Indeed, 76% of scientists in the Royal Society (2006) survey agreed that they would be encouraged to get involved in public engagement if it helped their own career. *Subjective norms* refers to beliefs about whether a specific referent group would approve or disapprove of one engaging in the focal behavior (e.g., "My academic colleagues would disapprove of my taking part in public engagement activities"). Because multiple referent groups may conflict in their opinions about the same behavior (Hyman & Singer, 1968), it may be useful to distinguish the normative influence of academic colleagues from that of friends and family. For example, friends and family may be more supportive of public engagement activities than academic colleagues because they represent the user group who are likely to benefit. Finally, *perceived behavioral control* is similar to Bandura's (1977) concept of self-efficacy and reflects beliefs about whether one has the necessary resources, abilities, or opportunities to perform the behavior successfully. Thus, although people may have positive attitudes and subjective norms, they may still not intend to perform a particular behavior because they believe that the focal action is out of their control. For example, although scientists may have a positive attitude toward participating in public engagement activities and believe that significant others would approve of their taking part, they may not feel confident about their ability to engage with the public. In support of this idea, the Wellcome Trust (2000) survey reported that a fifth of scientists

spontaneously commented that "scientists lack communication skills" (see also Weigold, 2001). In addition, they found that scientists who felt that they had the necessary skills, or who teach as well as do research, were more likely to have participated in public engagement activities. Similarly, the Royal Society (2006) survey found that scientists who had received communication training were more likely to have participated in public engagement activities. Furthermore, in a survey of scientists' attitudes toward media communication in Australia, Gascoigne and Metcalfe (1997) reported that lack of training was seen as a major obstacle to participation.

The theory of planned behavior has received widespread support as a model of behavior. For example, Conner and Sparks (2005) conducted a meta-analysis of existing meta-analyses to date. Significant moderate- to large-sized correlations (Cohen, 1992) were found between attitude and intention ($r_+ = .51$, $k = 497$, $N = 111{,}558$), subjective norm and intention ($r_+ = .34$, $k = 472$, $n = 109{,}111$), and perceived behavioral control and intention ($r_+ = .43$, $k = 386$, $n = 95{,}877$). Behavior was significantly predicted by both intention ($r_+ = .43$, $k = 420$, $n = 82{,}712$) and perceived behavioral control ($r_+ = .35$, $k = 241$, $n = 55{,}444$). However, to date no study has applied the theory of planned behavior to understand scientists' participation in public engagement activities despite the success of the theory of planned behavior in predicting other participation behaviors (e.g., leisure choice, Ajzen & Driver, 1992, and collective action, Kelly & Breinlinger, 1995), public communication in other samples (e.g., teachers, Crawley, 1990; Burak, 1994; Haney, Czerniak, & Lumpe, 1996, and general practitioners, Kinket, Paans, & Verplanken, 1992), scientists' communication with professional users (Breslin, Li, Tupker, & Sdao-Jarvie, 2001), and users' adoption of communicated information (Paulussen, Kok, Schaalma, & Parcel, 1995).

Augmenting the Theory of Planned Behavior: Descriptive Norms, Moral Norms, Fear, Past Behavior, and Environmental Constraints

A number of authors have suggested that the theory of planned behavior may usefully be supplemented by additional constructs. For example, Chassin, Presson, Sherman, Corty, and Olshavsky (1984) suggest supplementing subjective norms with descriptive measures that refer not to perceptions of what others *think* one should do but to perceptions of what others *actually* do (Cialdini, Kallgren, & Reno, 1991; see also Grube, Morgan, & McGree, 1986; Nucifora, Gallois, & Kashima, 1993; White, Terry, & Hogg, 1994; Sheeran & Orbell, 1999). *Descriptive norms* are typically measured by asking participants to think

about the five people that they know best and to indicate how many of them engage in the behavior (e.g., "Of the 5 colleagues you know best, how many take part in public engagement activities?"). In a study of intentions to purchase lottery tickets, Sheeran and Orbell (1999) found that descriptive norms had a significant additional influence on intentions over and above attitude, subjective norm, and perceived behavioral control. A second body of research suggests that *moral norms* should be included alongside subjective and descriptive norms (see Manstead, 2000, for a review). Moral norms reflect the individual's perception of the moral correctness or incorrectness of performing a behavior (Ajzen, 1991; Sparks, 1994). Participation in public engagement activities is likely to constitute a morally relevant situation for many scientists who may feel a duty to take part in public engagement activities because (a) they feel they have privileged access to information that should be in the public domain and/or (b) because taxpayers' money ultimately may fund their research. Indeed, the Wellcome Trust (2000) survey found that 84% of scientists agreed that scientists have a duty to communicate their research findings to the public. In a study of dishonest actions, Beck and Ajzen (1991) showed that moral norms ("Cheating on a test or exam goes against my principles") predict intentions and behavior over and above the theory of planned behavior constructs (see also Randall & Gibson, 1991). Finally, protection motivation theory (Rogers, 1983) and the health belief model (Rosenstock, 1974) suggest that *fear* is a very powerful motivating influence on behavior. In the context of public engagement activities, scientists may fear (a) being taken less seriously by scientific colleagues (Royal Society, 2006; cf. Gascoigne & Metcalfe, 1997; Weigold, 2001), (b) that they will be misunderstood (Wellcome Trust, 2000) or misquoted (Weigold, 2001), or (c) repercussions following communication of potentially sensitive research (e.g., from animal rights groups; Wellcome Trust, 2000).

The theory of planned behavior suggests that all influences on behavior are mediated by the theory of planned behavior constructs (namely, attitude, subjective norms, perceived behavioral control, and intention). However, researchers regularly find that a measure of *past behavior* has an independent influence on future behavior (see Conner & Armitage, 1998; Ouellette & Wood, 1998, for reviews). Ajzen (2002) suggests that researchers should include a measure of past behavior to improve the prediction of future behavior but acknowledge that the construct lacks explanatory value. That is, knowing that a scientist did not participate in any public engagement activities last year does not explain why they do not intend to participate in the following year.

The majority of the constructs considered so far have been intraindividual—that is, they reflect individual beliefs about participation in public engagement activities. However, behavior is likely to be the result of a complex interplay

between the individual and his or her environment (Mischel & Shoda, 1995). The theory of planned behavior argues that the impact of environmental factors on behavioral decisions will be mediated by the putative cognitions. However, it is important to measure possible environmental constraints. For example, scientists may perceive that there are too many *time constraints* and *money constraints* that prevent their participation in public engagement activities, and this may influence the amount of control that they possess over participation. Indeed, the Wellcome Trust (2000) survey found that 60% of scientists agreed that the day-to-day requirements of their job left them with little time to communicate about their research to others, and 23% said that the time taken was a disincentive to participating in public engagement. Time was also identified as a barrier by the Royal Society (2006) survey. To give an anecdotal example, in a recent letter to the British Association for the Advancement of Science, John Warren (2006) writes,

> Many of us are more than delighted to talk with the public about our science, but it has to be appreciated that this takes time and effort, and distracts from our research and teaching for which we are primarily paid. (p. 2)

Rationale for the Present Research

Despite the importance of being able to predict and understand scientists' participation in public engagement activities, there has been a lack of theoretically motivated research on this issue. The present research investigates whether an augmented version of the theory of planned behavior can predict scientists' decisions to participate in public engagement activities in the next 12 months. We predicted that decisions would be based on attitude, normative beliefs, control beliefs, fear, and perceived environmental constraints.

Method

Participants and Design

This study adopted a questionnaire design and was carried out with scientists at the University of Manchester. The university is based in the northwest of England and has a high level of research and teaching activity. In 2004-2005, 35,655 students were registered at the university (26,460 undergraduates and 9,195 postgraduates), and across all subject areas there were more than 5,000 academics and research staff. $N = 1{,}000$ questionnaires were distributed

in August 2005 to randomly selected academic staff ($n = 851$) and postgraduates ($n = 149$) from the three science faculties (medical and human sciences, life sciences, and engineering and physical sciences). One hundred sixty-nine questionnaires (16.9%) were returned. The majority of participants were male (69%), 26-55 years old (89%), which is similar to the entire population of scientists in these faculties (64% male and 88% aged 26-55). All career stages were adequately represented: 9% of the sample were students, 30% were postdoctoral, 12% were lecturers, 22% were senior lecturers or readers, and 18% were professors. Comparison with the proportion of scientists at the different career stages for the entire population (57% students and postdoctoral researchers, 15% lecturers, 14% senior lecturers and readers, and 13% professors) reveals that our sample population slightly overrepresented scientists at higher career levels.

Measures

Questionnaire measures were taken of the 12 constructs: attitude (including separate measures of perceived suitability of research and recognition of participation), subjective norm, descriptive norms, moral norms, perceived behavioral control, intention, fear, time constraints, money constraints, and past behavior. All items were responded to on 7-point *strongly disagree* to *strongly agree* scales unless otherwise stated. Where possible, items were adapted from published guides on the development of theory of planned behavior questionnaires (e.g., Conner & Sparks, 2005; Ajzen, 2006) and previous research on peoples' attitudes toward public engagement and science (e.g., Poliakoff, 2005), as well as through consultation with a science communicator. In addition to these measures, participants were also asked if they had any further comments about participation in public engagement activities or the questionnaire.

Attitude was measured using the stem "Taking part in a public engagement activity would be" followed by six semantic differential 7-point scales: bad-good, unenjoyable-enjoyable, pointless-worthwhile, unpleasant-pleasant, foolish-wise, harmful-beneficial (Cronbach's $\alpha = .85$).

Perceived suitability of research was measured with one item: "My research is too complex for a public engagement activity."

Recognition of participation was measured with two items: "Taking part in a public engagement activity would help me to gain research funding" and "Taking part in a public engagement activity would benefit my career" ($r = .59$).

Subjective norms were split into two referent groups, academic colleagues and friends/family. *Subjective norm (academic colleagues)* was measured with "My academic colleagues would approve of my taking part

in a public engagement activity." *Subjective norm (friends/family)* was measured with "Most people who are important to me (e.g., family/friends) would approve of my taking part in a public engagement activity."

Descriptive norms were measured with two items: "Of the 5 colleagues you know best, how many take part in public engagement activities?" (0, 1, 2, 3, 4, or 5) and "Of the people in your school, how many take part in public engagement activities?" (none–all) ($r = .58$).

Moral norms were measured with two items: "It is important to take part in public engagement activities because taxpayers' money funds research" and "I have a duty as a scientist to take part in public engagement activities" ($r = .44$).

Perceived behavioral control was measured with four items: "I feel confident that I could prepare the necessary materials to participate in a public engagement activity," "For me to participate in a public engagement activity would be . . ." (difficult-easy), "I feel confident that I could answer questions posed to me by the public," and "I do not have enough training to participate in public engagement activities" (Cronbach's $\alpha = .79$).

Intention was measured with three items: "I intend to participate in a public engagement activity in the next 12 months," "I do not plan to participate in a public engagement activity in the next 12 months" (recoded), and "It is likely that I will participate in a public engagement activity in the next 12 months" (Cronbach's $\alpha = .94$).

Fear was measured with three items: "I would fear repercussions if I took part in a public engagement activity," "I fear that I would not be taken seriously by the public if I took part in a public engagement activity," and "My research is too controversial for public engagement activities" (Cronbach's $\alpha = .62$).

Time constraints were measured with "I do not have enough spare time to participate in public engagement activities."

Money constraints were measured with "I would participate in public engagement activities if there was money to support participation."

Past behavior was measured using two items: "Have you ever participated in a public engagement activity?" (yes/no) and "How many public engagement activities have you taken part in during the last 12 months?" We combined these items into a single scale with three categories (never taken part in public engagement, taken part in public engagement but not in last 12 months, taken part in public engagement in the last 12 months).

Procedure

Participants were sent a questionnaire through the internal post along with a cover letter, participant information sheet, and consent form. The

cover letter and information sheet invited participants to take part in a study investigating why people choose to participate in public engagement activities. It was made explicit that the study was not part of any initiative to increase, decrease, or otherwise influence participation in engagement activities and that data would be treated in the strictest confidence. Public engagement activities were defined as "any scientific communication that engages an audience outside of academia. For example, appearing on radio, giving a public lecture, or designing activities for children." As an incentive for taking part, participants were entered into a prize drawing to win one of two £25 book tokens.

Results

Table 1 shows the mean, standard deviation, and correlations between the variables. In general, scientists had a positive attitude toward participating in public engagement activities ($M = 5.66$) and believed that colleagues and friends/family approved of their participation (Ms = 5.35 and 5.96, respectively). However, scientists did not believe that many colleagues actually took part in public engagement activities ($M = 2.93$). Perceptions of fear associated with participation were low ($M = 2.24$), and most scientists felt that their research would be suitable for a public engagement activity ($M = 5.67$). Most scientists had taken part in a public engagement activity, but not over the last 12 months ($M = 2.05$), and had moderate intentions to participate over the next 12 months ($M = 4.33$). Perceptions of moral norm, perceived behavioral control, recognition, and time and money constraints were all around the midpoint (Ms = 4.81, 4.77, 4.63, 4.22, and 3.91, respectively).

In terms of the correlations, intention had moderate ($.30 < r\text{s} < .59$), positive correlations with attitude, descriptive norm, moral norm, perceived behavioral control, and past behavior. Intention was also negatively correlated with time constraints ($r = –.36$). Attitude had moderate ($.31 < r\text{s} < .46$), positive correlations with all normative beliefs (subjective, descriptive, and moral), perceived behavioral control, and past behavior. Attitude was negatively correlated with fear ($r = –.30$) and time constraints ($r = –.33$). Twelve other correlations exceeded $r = .30$. Subjective norm (academic colleagues) was positively correlated with descriptive norms ($r = .46$) and recognition ($r = .35$). Subjective norm (friends/family) was positively correlated with moral norms ($r = .30$) and negatively correlated with time constraints ($r = –.35$). Descriptive norms were positively correlated with perceived behavioral control ($r = .34$) and recognition ($r = .34$)

Table 1
Descriptive Statistics and Correlations Between the Study Variables

Variable (V)	*M*	*SD*	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
V1 Intention	4.33	1.94												
V2 Attitude	5.66	0.91	.50***											
V3 Sub. norm (colleagues)	5.35	1.39	.19*	.34***										
V4 Sub. norm (other)	5.96	1.07	.17*	.41***	.23**									
V5 Descriptive norm	2.93	1.14	.38***	.31***	.46***	.22**								
V6 Moral norm	4.81	1.46	.30***	.45***	.18*	.30***	.06							
V7 PBC	4.77	1.29	.53***	.46***	.27***	.25**	.31***	.13						
V8 Fear	2.24	1.07	–.19*	–.30***	–.20**	–.24**	–.22**	–.09	–.49***					
V9 Suitability	5.67	1.43	.29***	.22**	.11	.05	.12	.12	.35***	–.29***				
V10 Recognition	4.63	1.70	.01	.08	.35***	.13	.34***	.18*	–.14	.08	–.02			
V11 Time constraints	4.22	1.77	–.36***	–.33***	–.18*	–.35***	–.33***	–.22**	–.33***	.15	–.38***	–.26**		
V12 Money constraints	3.91	1.50	.10	.08	.11	.17*	.10	.25**	–.01	.12	–.02	.13	–.02	
V13 Past behavior	2.05	0.83	.59***	.32***	.10	.09	.21**	.27***	.44***	–.17*	.23**	–.06	–.26**	.00

Note: Sub. = subjective; PBC = Perceived behavioral control. All variables were measured on 7-point scales except past behavior, which was measured on a 3-point scale.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2
Hierarchical Multiple Regression of Public Engagement Intentions on Putative Predictors

Step	Variable Entered	β	β	β
1	Past behavior	.58***	.40***	.35***
2	Attitude		.28***	.24**
	Perceived behavioral control		.23**	.23**
	Subjective norm (academic colleagues)		–.07	–.11
	Subjective norm (friends/family)		–.05	–.08
	Recognition		.11	.02
	Perceived suitability of research		.03	.02
3	Descriptive norm			.20**
	Moral norm			.08
	Fear			.08
	Time constraints			–.07
	Money constraints			.04
	ΔR^2	.34	.15	.04
	ΔF	81.97***	7.19***	2.67*
	R^2	.58	.70	.73
	Model F	81.97***	20.63***	13.81***

*$p < .05$. **$p < .01$. ***$p < .001$.

and negatively correlated with time constraints ($r = –.33$). Perceived behavioral control was positively correlated with perceived suitability of research ($r = .35$) and past behavior ($r = .44$) and was negatively correlated with fear ($r = –.49$) and time constraints ($r = –.33$). Finally, perceived suitability was negatively correlated with time constraints ($r = –.38$).

Hierarchical multiple regression was used to predict intentions to participate in public engagement activities over the next 12 months (see Table 2). The independent variables were entered in three blocks: past behavior was entered in Step 1, the theory of planned behavior variables—attitude (including perceived suitability of research and recognition of participation), subjective norms, and perceived behavioral control—were entered in Step 2. Finally, the proposed extensions to the theory of planned behavior—descriptive norms, moral norms, fear, and time and money constraints—were entered in Step 3. All variables were standardized prior to analysis.

At Step 1, past behavior was a significant predictor of intentions to participate in public engagement activities ($\beta = .58$, $p < .001$) and accounted for 34% of the variance in behavioral intentions. The addition of the theory

of planned behavior variables at Step 2 led to a significant increase in the variance explained in intentions (R^2 change = .15, F change = 7.19, $p < .001$). In addition to past behavior ($\beta = .40$, $p < .001$), attitude ($\beta = .28$, $p < .001$) and perceived behavioral control ($\beta = .23$, $p < .01$) were significant predictors of participation intentions at Step 2. The addition of the proposed extensions to the theory of planned behavior at Step 3 further increased the variance explained (R^2 change = .04, F change = 2.67, $p < .05$). Inspection of the individual beta weights revealed that the increase in explained variance was attributable to descriptive norms ($\beta = .20$, $p < .01$). In the final regression equation, the variables under consideration were able to explain 73% of the variance in intention, $F(12, 159) = 13.81$, $p < .01$. Attitude, perceived behavioral control, and descriptive norm emerged as significant independent predictors of scientists' intentions to participate in public engagement activities over and above past behavior.

Discussion

This research investigated the determinants of scientists' intentions to participate in public engagement activities. In contrast to previous research in this area (e.g., Wellcome Trust, 2000; Royal Society, 2006), we applied an established model of reasoned action—namely, an augmented version of Ajzen's (1991) theory of planned behavior. Our results suggest that four factors influenced scientists' intentions to participate in public engagement activities over the following 12 months: past behavior (extent of previous participation in public engagement activities), attitude (whether scientists regard participating in public engagement activities as positive), perceived behavioral control (whether scientists feel capable of participating in public engagement activities), and descriptive norm (how much scientists perceive that their colleagues are participating in public engagement activities). In contrast, subjective norm, moral norm, perceived suitability of research, career recognition, and time and money constraints did not significantly predict participation intentions.

Past behavior was clearly the most powerful predictor of behavioral intentions. This finding suggests that generally speaking, scientists who already participated in public engagement activities intended to continue doing so and scientists who have not participated in public engagement events did not intend to start. However, as noted in the introduction, past behavior lacks explanatory value (Ajzen, 2002); knowing that a scientist who participated in six public engagement activities last year intends to participate in six public engagement activities next year does not explain why that scientist

participates. Instead, it attests to the routinized nature of behavioral decisions; intentions may simply reflect how the person has behaved in the past rather than a behavioral decision (Bem, 1972). However, the impact of past behavior on intention was attenuated (although remained significant) when cognitions were included in the prediction. Thus, although routines influence intention, it is important to also consider scientists' thoughts about their participation (or not) in public engagement activities.

The present findings provide clear support for the theory of planned behavior as a model of scientists' intentions to participate in public engagement activities; attitude and perceived behavioral control were important determinants of intention over and above past behavior. The finding regarding attitudes concurs with the finding from the Royal Society (2006) that there was a positive correlation between number of science communication activities and perceived importance of public engagement. However, despite the importance of general attitude toward participating in public engagement activities (e.g., "Taking part in a public engagement activity would be pleasant"), specific beliefs to do with career recognition or the suitability of one's own research did not predict intentions. In other words, some scientists did not intend to participate despite recognizing potential career benefits and some intended to participate despite recognizing few potential career benefits. The latter group fits with the notion of the "civic scientist" who chooses to contribute to wider society for personal rather than professional reasons (Office of Sciences and Technology and the Wellcome Trust, 2001), acting "as a citizen rather than as a scientist" (Greenwood & Riordan, 2001, p. 30). Interestingly, 40% of the current sample scored below the midpoint on the career recognition scale. That is, they did not see significant career benefits to participating in public engagement activities. For example, one of our participants commented at the end of the questionnaire, "The RAE [Research Assessment Exercise] places no credit on public engagement. Effort expended towards it cannot contribute to career enhancement. It's a good idea, but can't pay the rent." This concurs with qualitative findings from the Royal Society (2005) survey in which there was disagreement about whether public engagement could confer career benefits. Furthermore, comments from several other participants indicated that public engagement is seen as an "optional extra" (see also Gascoigne & Metcalfe, 1997). The implication of this for organizations interested in promoting scientists' participation in public engagement activities is that many scientists are unaware of the potential career benefits of participating in such activities. However, it is possible that those who participate in public engagement activities for personal reasons, without regard for career benefits, may not welcome a more strategic approach to public engagement (cf., Office of Sciences and

Technology and the Wellcome Trust, 2001; Royal Society, 2006). For example, research on self-determination theory (Deci & Ryan, 1985) shows that rewarding intrinsically motivated participants for performance of the focal behavior actually decreases motivation and self-reported interest (Deci, Koestner, & Ryan, 1999).

The importance of perceived behavioral control as a predictor of participation supports the findings of both the Wellcome Trust (2000) and Gascoigne and Metcalfe (1997). That is, a scientist's perception of his or her own ability to participate in a public engagement activity has a significant effect on his or her intention to participate. This finding speaks to the importance of the public communication and media training programs offered by research councils (Pearson, 2001) and universities. Indeed, one of our participants commented, "I presume, or would like to think that there is some sort of media training course or public engagement training." On the other hand, participating in activities may constitute training in itself, and scientists have indicated that additional training would be unnecessary and time-consuming (Pearson, Pringle, & Thomas, 1997). Indeed, in an evaluation of a Brain Awareness Week (BAW) activity (Poliakoff, 2005), one scientist commented,

> I think I used this as a training exercise—I learned a lot about how to talk to the public about my work and the brain. I would be more confident next time around. But I don't think specific training courses would necessarily work (I wouldn't have wanted to devote my time to that). Instead, I think it is helpful to have events like BAW where people can help out for a few hours and learn as they go along by watching other people.

It is worth noting that despite the importance of perceived behavioral control, fear did not influence participation decisions. Generally speaking, scientists in this study were not anxious about participating in public engagement activities. However, comments from a few scientists suggest that fear may be an important factor for a minority of scientists. For example, one of our participants noted that "I think the 'unknown-ness' of public engagement is what puts people off from taking part" and another commented that "I do feel quite anxious about the prospect of public engagement work."

It is notable that subjective norms (what others think) did not emerge as a significant determinant of participation intentions. There may be a number of possible explanations for this finding. This study measured scientists' perceptions of what others would want them to do, but not motivation to comply with these beliefs. Thus, it is possible that although scientists believed that academic colleagues and important others would approve or disapprove of their participation in public engagement activities, they were not motivated to comply

with the wishes of these groups. However, this explanation seems unlikely because although motivation to comply with the referent is often used to weight normative beliefs, weighted and unweighted norms show similar associations with outcomes (Gagné & Godin, 2000). Alternatively, there may be a conceptual explanation for the weak effects of subjective norm. Perhaps, despite thinking that their colleagues and significant others would approve of their taking part, other factors were simply more important with regard to their intentions to participate. For example, Trafimow and Finlay (1996) distinguished between individuals whose actions are driven primarily by attitudes and those whose actions are driven primarily by subjective norms. It seems that at least in relation to participation in public engagement activities, scientists in this sample were motivated by attitudes rather than subjective norms. This may be a consequence of the traditionally solitary nature of academic work that means scientists rely on their own, rather than others', judgment.

This research also investigated a number of extensions to the theory of planned behavior. However, only the addition of descriptive norms (what others do) increased the predictive utility of the model. In the context of public engagement, it seems as though what others actually do is more important than what they think. Indeed, the Royal Society (2006) survey also found that colleagues participating had a positive influence on public engagement. To date, descriptive norms have typically been investigated as determinants of health behaviors such as safe sex (Nucifora et al., 1993; White et al., 1994) and smoking (Chassin et al., 1984; Grube et al., 1986). The present findings demonstrate the importance of descriptive norms in another domain (see also Sheeran & Orbell, 1999). It is notable that the mechanism by which descriptive norms influence behavior has received little attention. Although we can only speculate here, it is possible that the number of colleagues perceived to be participating in public engagement may be indicative of the support (financial or otherwise) for and culture surrounding public engagement in a person's local working environment. Alternatively, the behavior of colleagues may serve as a model on which to base one's own behavior (Bandura, 1982).

Given the importance of descriptive norms, it is perhaps surprising that moral norms did not influence participation intentions. However, it is possible that perceived moral obligation influenced attitude rather than intention. For example, Kaiser and Scheuthle (2003, Study 1) found that for ecological behaviors, the correlation between attitude and moral norms was extremely high (r = .92) and concluded that "moral norms have a considerable, but presumably only indirect impact (mediated by attitude) on people's intention"

(p. 1040; see also Raats, Shepherd, & Sparks, 1995; Sparks, Shepherd, & Frewer, 1995). In support of this idea, the present research found a large positive correlation ($r = .45$) between attitude and moral norms. Alternatively, it may be that communicating science to the public is not viewed as a morally relevant activity. Scientists in this study had only moderate perceptions of moral obligation, and evidence suggests that the importance of moral norms is likely to increase as a function of the "moral relevance" of the behavior (Hart, 1961; Gorsuch & Ortberg, 1983; Kurland, 1995; Manstead, 2000).

It was also notable that perceived environmental constraints on participation (such as lack of time and/or money) did not influence intentions to participate. Interestingly, perceived lack of time was associated with more negative perceptions of participating in public engagement activities (except money constraints and fear). Thus, the impact of time constraints on participation decisions may be mediated by social-cognitive constructs specified by the theory of planned behavior. Alternatively, the causal direction may be the opposite way around; negative perceptions of participating in public engagement activities may lead scientists to perceive more time constraints. For example, if friends and family disapprove of one's participation (subjective norm), and colleagues are not participating (descriptive norm), then there is conflict about how one's own time should be spent. This finding suggests that time constraints may be used as an excuse to mask other concerns about participating in public engagement activities.

Our findings that perceived environmental constraints (lack of time and/or money) did not predict intentions to participate in public engagement may seem at odds with conventional wisdom. Indeed, key recommendations in the Royal Society (2006) report include creating greater reward and recognition for public engagement work and a more effective support system for public engagement. However, it is possible that these factors play a role in the translation of scientists' positive intentions to participate in public engagement into actual participative behavior. That is, overcoming barriers may represent a volitional issue rather than a motivational one (Heckhausen & Gollwitzer, 1987, Schwarzer, 2001). Future research should measure participative behavior alongside engagement intentions in order to investigate these ideas. If lack of time and/or money represent volitional control, then they should moderate the relationship between intentions and behavior such that intentions only translate into action when there are sufficient resources and/or opportunities to perform the behavior (Webb & Sheeran, 2006).

This research has important implications for interventions designed to increase the number of scientists who want to participate in public engagement

activities. Specifically, interventions should target scientists' attitudes, perceived behavioral control, and descriptive norms. A targeted intervention could present information and persuasive arguments (e.g., Ajzen, 1971) about the benefits of public engagement, skill-based training to foster perceived behavioral control (e.g., Kalichman & Hospers, 1997), and messages to increase awareness of colleagues' participation in public engagement activities (for a review of interventions based on the theory of planned behavior, see Hardeman et al., 2002). Recent experimental evidence suggests that modifying intention in this way can have a positive, albeit relatively small, effect on behavior (Webb & Sheeran, 2006), but also that the effects of motivational interventions on behavior might be strengthened by inclusion of incentives for behaving or remaining in the program (e.g., Mowen, Middlemist, & Luther, 1981; Bamberg, 2002) and by forming if-then plans that specify when, where, and how to act on positive intentions (Gollwitzer, 1999; Milne, Orbell, & Sheeran, 2002; Gollwitzer & Sheeran, 2006).

Conclusion

This research represents the first application of a theoretical framework for understanding scientists' intentions to participate in public engagement activities. Four factors were found to be important: past behavior, attitude, perceived behavioral control, and descriptive norm. In other words, scientists who decide not to participate in public engagement activities do so because (a) they have not participated in the past, (b) they have a negative attitude toward participation, (c) they feel that they lack the skills to take part, and (d) they do not believe that their colleagues participate in public engagement activities. These findings suggest that interventions to promote public engagement might usefully target these factors in an effort to encourage scientists to participate in public engagement activities and to promote public understanding of science. Contrary to expectations, factors such as time constraints, money constraints, and (lack of) career recognition did not influence participation intentions.

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