Intentions and Willingness for Public Engagement with Science

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Abstract

As advancements in science implicate more than just those within the scientific community, public engagement with science (PES) – scientific communication that engages an audience outside of academia (Poliakoff & Webb, 2007) – has come to attention in recent years. In psychology literature, the Theory of Planned Behavior (TPB; Ajzen, 1991) has been used to study intents for PES participation, where attitude and self-efficacy have been identified as predictors of intention and willingness for PES (Poliakoff & Webb, 2007; Besley, 2014). While intention and willingness are suggested to be similar constructs in PES literature (Besley et al., 2008), they have not been formally compared in one model. Due to this, and the distinction made between intention and willingness in health psychology literature (Gerrard et al., 2008), the current research examines whether PES intents of intention and willingness arise differentially from attitude and self-efficacy. The study additionally examines whether manipulation of construal levels, the abstractness at which an event is processed (Trope & Liberman, 2011), can moderate prediction of intents by attitude and self-efficacy. Findings show both intent types to be similarly and significantly predicted by attitude and self-efficacy in scientists (n = 152). When construal levels were manipulated, attitude and self-efficacy significantly predicted willingness at both high and low levels while intention was only significantly predicted by these factors at the high level, suggesting these intent types to derive from distinct pathways at low level. Limitations: this study was conducted when COVID-19 measures meant academics had to work remotely.

Keywords: public engagement with science, science communication, theory of

planned behavior, construal level theory, temporal framing

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Now more than ever, science and technology have assumed a prevailing presence in modern life. From medical advancements to environmental challenges, these areas have increasing impact on quality of life and decision-making at the individual, industry, government, and global level. To use the current Coronavirus crisis as an example, amidst this pandemic, politicians and policy-makers have relied increasingly on scientists to update the publics on the virus and to deliver evidence-based guidance on prevention measures, as well as to advise on governmental decisions regarding Public Health (Abo-Hamed, 2020)

Because knowledge of and advancements in science impact more than just those in the scientific community, it is important that this information is communicated to the public sphere (Dudo & Besley, 2016). Furthermore, much of research is conducted with the general public in mind as the presumed beneficiaries and users of the resulting scientific and technological advancements. This makes public engagement with science (PES) a key aspect to involving end-users in the process of scientific research and science innovation as well as in disseminating crucial information to the publics. Indeed, there is a growing requirement for PES plans when applying for research funding (Poliakoff & Webb, 2007), and the importance of public engagement has been further underlined by the launch of funding schemes specifically for PES projects in the past decade, with one of the world's largest funders of scientific research awarding more than £30 million to dedicated public engagement projects over the 2005-2018 period (Haenssgen, 2019). Due to the rising interest in and need for PES, this paper aims to investigate the factors predicting planned and reactive intents (termed intention and willingness in this paper) for the five most common PES activities amongst scientific researchers (Hamlyn et al., 2015)¹.

PES, in its broadest definition, refers to 'any scientific communication that engages an audience outside of academia' (Poliakoff & Webb, 2007, p.244). To date, a substantial amount of qualitative studies have examined scientists' view of public engagement and the public sphere (e.g. Besley & Nisbet, 2013; Gascoigne & Metcalfe, 1997; Kyvik, 1994; de Cheveigne, 2000; Martinez-Conde, 2016). These qualitative studies have founded the basis upon which quantitative studies on PES intents are built. Being a relatively new area of study in psychology and communication science, intents for PES have not been investigated extensively using quantitative methods as of yet. However, in the studies that have examined PES intent, Ajzen's (1991) Theory of Planned Behavior (TPB) has been particularly popular and has been used to determine factors that lead to intentions and willingness for PES in individual scientists. The following section does not aim to exhaustively examine all previous TPB literature on PES, but will highlight the most relevant majority of the studies that have examined PES through the TPB model.

Having been applied and refined in more than 490 studies (Conner & Sparks, 2005), TPB is one of the most widely used social-cognition models for mapping attitudes and cognitions to behaviors. TPB proposes that behavior intention is the most

¹ Note that PES activities listed in Research Councils UK's Concordat definition of PES have been excluded as the study was conducted during a worldwide Coronavirus lockdown, and activities such as 'giving a public lecture' would have been difficult to partake in

immediate precursor to behavior, and is predicted jointly by three factors: 1) Subjective norm, which can be understood as whether an individual thinks others would approve of an action, 2) Attitude, as how favorably an individual views an action and 3) Perceived behavioral control or self-efficacy (as it is called in PES literature), as an individual's perception of his or her ability to perform an action (Ajzen, 1991). Prior quantitative studies examining PES views among scientists have found support for these variables in predicting intention, as well as in predicting willingness and prioritization for PES.

In using the TPB model to examine PES, intention and willingness have been suggested to be similar constructs whereby both indicate a 'readiness' for engaging in behavior (Besley, Dudo, Yuan, & Lawrence, 2018). However, in health psychology, it is only willingness that implies readiness for action, whereas intention connotates planning and deliberation for action (Gibbons, Gerrard, Blanton, and Russell, 1998). Given this, it seems important that a distinction be made between the two. To illustrate their differences, consider the statements: *"I intend to donate \$100 to charity"* versus *"I am willing to donate \$100 to charity."*

Indeed, intention has been found to be more so predictive of planned behavior while willingness more so of engagement in behavior given an opportunity or context (Rivis, Sheeran, & Armitage, 2006). This distinction may give possible insight to why selfefficacy has been consistently found as one of the strongest and most consistent predictors of intention (Poliakoff & Webb, 2007; Besley, Oh, and Nisbet, 2013; Robertson Evia, Peterman, Cloyd, & Besley, 2018; Dermentzi & Papagiannidis, 2017), but not of willingness (Besley et al., 2018). This may also explain why attitude, instead, was found to be the more consistent predictor of willingness across different modes of public engagement in Besley et al.'s (2018) study.

The differences between planned intention and reactive willingness found in health psychology literature show that intentional behavior requires cognitive thinking and deliberation while reactive behavior depends more on affective evaluations (Lawton, Conner, & McEachan, 2009; Gerrard et al., 2008). As self-efficacy arises from cognitive evaluation of one's abilities through deliberative pathways (Bandura, 1977; Roberston Evia et al., 2017), the strong predictive ability of self-efficacy for intention makes sense. Similarly, as reactive behaviors and undeliberated willingness depend more on affective processing, the consistent association between attitude and willingness found in Besley et al.'s (2018) study also makes sense. Indeed, previous studies looking at how value judgments arise have found that those with reduced affect due to brain damage cannot make decisions on importance and value as well as nonbrain damaged individuals (Damasio, 1996; Batson, Engel, & Fridell, 1999). Given these possible differences between intention and willingness, it may be of interest to examine the two intent types simultaneously and to compare how these precursors to behavior draw on self-efficacy and attitudinal value judgments. As the third TPB predictor of subjective norms has not received as much support as a predictor for PES intents (Sheeran, Norman, & Orbell, 1999; Poliakoff & Webb, 2007), this paper will not delve further into this factor.

Because judgments of self-efficacy are supposedly more cognitively evaluated and attitudinal value judgments supposedly more affectively evaluated, it is predicted that

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scientists' intentions for PES would depend heavier on self-evaluations of PES skills while willingness for partaking in PES would depend heavier on value judgments – here on referred to as 'attitude' – of the importance of PES. These predictions are visualized in Figures 1 and 2 and formalized below:

H1. Intention for PES will be significantly associated with (a) attitude and (b) self-efficacy (Figure 1).

H2. Willingness for PES will be significantly associated with (a) attitude and (b) self-efficacy (Figure 1).

H3. The Attitude—Willingness association will be significantly stronger than the Attitude—intention association (Figure 2).

H4. The Self-efficacy—Intention association will be significantly stronger than the Self-efficacy—Willingness association (Figure 2).



Figure 1. Conceptual model showing hypothesized relationships between TPB predictors and PES intents. H1 and H2 are illustrated by black arrows while moderation effect of construal level on predictor—intent relationships are illustrated by grey arrows.



Figure 2. Graphed visualization of H3 and H4. The stronger Attitude—Willingness compared to Attitude—Intention association in H3, and stronger Self-efficacy—Intention compared to Self-efficacy—Willingness association in H4 are shown.

Additionally, the present research will examine whether manipulating participants to think about future PES events at different construal levels of abstraction can alter intent for PES, and whether this can strengthen or weaken attitude's and self-efficacy's associations with intention and willingness.

Construal Level Theory (CLT; Trope & Liberman, 2011) proposes that mental construals – one's perception, comprehension, and interpretation of the world – involve processing concepts at different 'levels.' The higher the construal level, the more abstract and less concrete the idea; the lower the construal level, the less abstract and more concrete the idea (Liberman, Sagristano, & Trope, 2002). To illustrate, moving houses processed at a high construal level may be thought of as 'a fresh start' and at a low construal level as 'packing my belongings into boxes.'

Construal levels may have moderating effects on how attitude and self-efficacy relate to intent as they have been found to affect evaluations of future events (Ledgerwood, Trope, & Chaiken, 2010). When individuals process events at a high construal level, evaluations tend to be based heavily on ideological values, such as whether the action is important (Liberman, Sagristano, & Trope, 2002) or why the action should be done (Knowles and Riner, 2005). On the other hand, when events are considered at a low construal level, evaluations tend to be based more heavily on feasibility, such as whether one can carry out the action (Liberman & Trope, 1998; Liberman et al., 2002) and how it can be done (Vallacher & Wegner, 1987; Eyal et al., 2009). Previous studies using temporal framing to manipulate construal levels support this – decisions for events presented in a distant time (high construal level) weighed the favorability of choices more heavily whereas decisions for events presented in a proximate time (low construal level) weighed feasibility and ease of the choices more heavily (Liberman & Trope, 1998; Liberman, Sagristano, & Trope, 2002; Eyal, et al., 2004; Eyal et al., 2009).

As proposed by Freitas, Salovey, and Liberman (2001), high-level thinking draws on importance and desirability of an action whereas low-level thinking draws on how easily one can accomplish an action. Following from this, it reasons that attitude would be more strongly associated with intent for PES in the far future rather than the near, and self-efficacy would be more strongly associated with intent for PES in the near future rather than the far. The moderator analyses in the current study therefore aim to examine whether construal levels – as manipulated through temporal framing where PES events are presented to occur in either a week or a year (based on previous CLT studies; Liberman & Trope, 1998; Ledgerwood, Trope & Chaiken, 2010; Fessel, 2011) – moderate relationships between TPB predictors and intents. It should be noted that previous CLT studies have not explicitly differentiated between the effect of construal

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levels on task acceptance versus task seeking; therefore, no predictions of differences in temporal framing's effect on predictor—intention versus predictor—willingness associations are made though there is evidence that they may be affected similarly (Liberman & Trope, 1998). Additionally, this study is only interested in the moderating effects of construal level on predictor—intent relationships and hence will not be comparing differences in how intentions and willingness are predicted by attitude and self-efficacy (though this may be interesting for future research). Predicted findings are visually represented in Figure 3 and formalized below:

H5a. The association of Attitude—intention will be significantly stronger at a high construal level compared to low.

H5b. The association of Self-efficacy—Intention will be significantly stronger at a low construal level compared to high.

H6a. The association of Attitude—Willingness will be significantly stronger at a high construal level compared to low.

H6b. The association of Self-efficacy—Willingness will be significantly stronger at a low construal level compared to high.



Figure 3. Visualization of H5a, H5b, H6a, & H6b. Figure shows attitude—intent relationships to be stronger at the high construal level than the low for both intention

(H5a) and willingness (H6a); and self-efficacy—intent relationships to be stronger at the low construal level than the high for both intention (H5b) and willingness (H6b).

The examination of willingness in the TPB model alongside intentions may lend insight into promoting PES in the academic community, as a majority of previous psychological studies on PES have looked to understand the relation of attitude, selfefficacy and other predictors (e.g. norms) with intention (e.g. Poliakoff & Webb, 2007). Bolstering intention is valuable as many scientists have the freedom to choose whether to participate in PES; however, much of PES also depends on presented opportunities (Besley et al., 2018), and many universities are beginning to offer organized PES opportunities for scientists to partake in (Featherstone & Owen, 2020). In this case, examining willingness in addition to intention allows a more fine-grained look at how planned intention and reactive willingness depend on scientists' attitude towards the importance of PES and their confidence in their public engagement abilities.

The additional examination of construal levels also gives practical insight into how attitude and self-efficacy are weighed up when making decisions regarding future PES participation scheduled to start at various times. For example, if self-efficacy is more influential for decisions to partake in PES in the near future, Public Engagement Units may do well to encourage participation in soon-commencing activities amongst researchers confident in their public engagement skills. Likewise, if attitude is more influential for decisions to partake in PES in the far future, this would also have implications for increasing uptake of PES opportunities in scientists new to public engagement or those that are less confident in their skills. For example, scientist who value the importance of PES but have lower confidence in their own skills may be less inclined to take up PES opportunities if it occurs soon, but may be much more willing to do so when approached earlier on by Public Engagement Units and offered training to build public engagement skills as time draws near to the PES task. Additionally, as PES is currently not a central responsibility for researchers at many institutions (Hamlyn et al., 2015), main career responsibilities such as teaching and conducting research may take precedence over PES despite intentions for it. In this case, it may be useful for Public Engagement Units to approach scientists with opportunities and increase PES rates this way.

From a theoretical perspective, testing the associations of attitude and selfefficacy with intention and willingness simultaneously will allow direct comparisons of these relationships with predictors and determine whether these two factors should be differentiated in PES research. Examining potential moderating effects of construal levels will lend additional insight into whether the abstractness or specificity at which PES events are processed can alter how intention and willingness arise from attitude and self-efficacy. The model tested in this study is presented in Figure 1, and will control for demographic factors of age and gender, as well as for past PES participation. This is in accordance with past PES research (Poliakoff & Webb, 2007; Besley 2014; Besley et al., 2018) as past behavior has bearing on one's intent for repeating that behavior in the future (Ajzen, 2002).

Method

Design and Procedure

This study employed a questionnaire design and was conducted in collaboration with the organization AESIS (Network for Advancing and Evaluating the Societal Impact of Science). All participants answered the same set of questions on the online survey software Qualtrics (Provo, UT, 2018). Participants were taken to the study after reading an information sheet (appendix A), indicating consent, and confirming their employment as scientific researchers; those that disconfirmed were taken to the end of the study. The demographic questionnaire was presented, followed by the General Intention, Intention in a Year, and Intention in a Week questionnaires, the General Willingness, Willingness in a Year, and Willingness in a Week questionnaires, the Attitude and Self-efficacy questionnaires, and finally the Past PES Participation questionnaire. A question on how participants came across the survey was used to monitor success rate of recruitment channels in order to optimize recruitment strategy in the one-month data collection period (see appendix B for recruitment texts).

Participants

203 participants were recruited in total for the study. 51 non-scientific researchers were excluded from analyses, leaving a final sample of 152 scientific researchers (female = 94, male = 55, other = 3) with an average age of 38.63 (*SD* = 12.10). Most participants were employed in the United States (48%), United Kingdom (23.7%) or other European countries (15%) at the time of this study. Scientific discipline comprised most largely of the natural sciences (46.7%) followed by the social sciences (37.5%). For research position, doctoral students (34.9%) were the largest group followed by professors (19.7%; see Appendix C for demographics table).

Measures

Demographics

The demographics questionnaire asked for age, gender, country of residence, scientific discipline, research position, and institute of employment and how participants came across the survey. Answer choices for questions are shown in the demographics questionnaire in Appendix D.

Variable measures

TPB predictors of attitude and self-efficacy, PES intents (in general, a week, and a year) of intention and willingness, and past PES experience were measured by rating five items of popular PES activities: 1) communication of my research via social media, 2) writing books about my research for the public, 3) writing articles about my research for the public, 4) engagement with policy-makers through my research, 5) engagement with non-government organizations through my research. For intention, willingness, attitude, and self-efficacy, the five items were rated using 7-point Likert scales in accordance with Ajzen's (2006) recommendation, while past PES experience was measured dichotomously with 'yes'/'no' (see appendix E for full questionnaire).

For **General Intention** (Cronbach's $\alpha = .79$), **Intention in a Year** ($\alpha = .79$), and **Intention in a Week** ($\alpha = .81$), scientists rated their intention for each PES activity ranging from 1=*definitely don't intend to*, to 7=*definitely intend to*. For **General Willingness** ($\alpha = .87$), **Willingness in a Year** ($\alpha = .85$) and **Willingness in a Week** (α = .88), scientists rated their willingness to partake in each PES activity if given the opportunity, 1=*very unwilling to*, to 7=*very willing to*. Other measures followed a similar format, with **Attitude** (α = .77) ratings measuring scientists' judgment of each PES activities' importance ranging from 1=*very unimportant*, to 7=*very important*; and **Self-efficacy** (α = .83) ratings measuring scientists' confidence in performing each PES activity ranging from 1=*very unconfident*, to 7=*very confident*. For **Past PES Experience**, participants answered 'yes' or 'no' to having participated in each activity in the past. This gave a totaled score out of 5 for each participant as an indicator of their experience in PES (means and standard deviations for each variable are shown in Table 1).

Measures	Mean	SD
General Intention	5.07	1.18
Intention in a Year	4.73	1.33
Intention in a Week	3.04	1.48
General Willingness	5.94	1.13
Willingness in a Year	5.80	1.17
Willingness in a Week	4.86	1.56
Attitude	5.61	0.98
Self-efficacy	5.13	1.16
Past PES Participation	2.52	1.39

Table 1. Means and standard deviations for variable measures.

Analyses

Main Analyses

Two hierarchical regressions were used to determine the association strengths between PES predictors (attitude and self-efficacy) and PES intents (intention and

willingness) while controlling for age and gender in Step 1, and past PES experience in Step 2. A repeated-measures ANCOVA with intent type (intention/willingness) included as the within-subjects variable, intent rating as dependent variable, and attitude as continuous covariate looked for interaction effects of attitude and intent type on intent ratings to test H3. A second repeated-measures ANCOVA with intent type included as the within-subjects variable, intent rating as dependent variable, and self-efficacy as continuous covariate looked for interaction effects of self-efficacy and intent type on intent ratings to test H4.

Moderator Analyses

To determine moderating effects of construal level on the associations between predictors (attitude and self-efficacy) and intents (intention and willingness), four repeated-measures ANCOVAS with construal level (high and low) as the within-subjects variable, intention (or willingness) ratings as the dependent variable, and attitude (or self-efficacy) as continuous covariate, tested for interaction effects of:

- Timeframe and attitude on intention ratings for Hypothesis 5a.
- Timeframe and self-efficacy on intention ratings for Hypothesis 5b.
- Timeframe and attitude on willingness ratings for Hypothesis 6a.
- Timeframe and self-efficacy on willingness ratings for Hypothesis 6b.

To examine the simple slopes of significant interactions, regressions controlling for age, gender, and past PES experience were run to determine strengths of associations between predictors and intention, and predictors and willingness.

Results

Main Analyses

General Intention.

Examining general intention as the dependent measure, Step 1 showed demographics did not significantly explain the variance in the model, $R^2 = .02$, F(2, 149)= 1.15, p = .321 adjusted $R^2 = .002$, with age nor gender being significant predictors. In Step 2, the addition of past PES experience ($\beta = .54$, p < .001) significantly improved the model, F(3, 148) = 16.62, p < .001; adjusted $R^2 = .24$, and accounted for an additional 23% of variance. The effect of age became significant ($\beta = .184$, p = .005) with the addition of past PES experience in Step 2. Step 3 showed that the addition of attitude (β = .37, p < .001) and self-efficacy ($\beta = .29$, p = .001) further improved the model and explained an additional 29% of the variance, $R^2 = .54$, F(5, 146) = 34.16, p < .001; adjusted $R^2 = .52$, thus providing support for H1a and H1b. Beta- and p-values for each predictor taken from the final model are shown in Table 2.

General Willingness.

Examining general willingness as the dependent measure, Step 1 showed demographics did not significantly explain the variance in the model R^2 = .03, F(2, 149) = 2.21, p = .113; adjusted R^2 = .02., although gender was found to be a significant

predictor (β = .17, p = .041). In Step 2, the addition of past PES experience (β = .32, p < .001) significantly improved the model R^2 = .12, F(3, 148) = 6.42, p < .001; adjusted R^2 = .10, and accounted for an additional 12% of the variance. The effect of gender became non-significant when past PES experience was added to the model. Step 3 showed that the addition of attitude (β = .337, p < .001) and self-efficacy (β = .35, p < .001) further improved the model and explained an additional 29% of the variance, R^2 = .41, F(5, 146) = 20.65, p < .001; adjusted R^2 = .39, thus providing support for Hypotheses 2a and 2b. The addition of attitude and self-efficacy in Step 3 reduced the effect of past PES experience to non-significance, while age became a significant predictor (β = -.17, p = .023) in the final model. Beta-values and p-values for each predictor taken from the final model are shown in Table 2.

	General Intention			General Willingness			SS	
	β	p	R ²	ΔR ²	β	p	R ²	ΔR ²
Step 1			.02	.02			.03	.03
Age	18	.005			17	.023		
Gender ^a	03	.647			.06	.405		
Step 2			.25**	.23**			.12**	.09**
Past PES Experience	.35	<.001			.12	.133		
Step 3			.54**	.29**			.41**	.30**
Attitude	.37	<.001			.34**	<.001		

Table 2. Final regression models for general intention and general willingness.

Self-efficacy	.29	.001	.35** <.001
Beta is taken from ΔR^2 indicates characteristic and the set of $a^0 = male, 1 = from p < .05$. ** $p < .05$.	om the final r nange of R ² w emale	nodel, R ² ind ith each new	icates the variance accounted for by variables in each step, step of the regression.

Comparison of Predictor—Intent Associations

Two two-way repeated-measures ANCOVAs were conducted with intent type (intention/willingness) as the within-subjects variable, intent rating as dependent variable, and attitude as continuous covariate for the first analysis, and self-efficacy as continuous covariate for the second analysis. Four and three outliers were detected for the first and second analyses respectively as assessed by studentized residuals greater than ±3 (Fields, 2005); removal of outliers did not materially affect the results of the first analysis and led the interaction in the second analysis to reach significance². After consulting the raw data, outliers were deemed to be genuine as answers for the five items of PES activities per scale tended to followed a general pattern (e.g. if item-1 had the highest score for the first scale, this pattern tended to appear for the following scales), suggesting that participants read the questions and items and that answers were not due to random clicking. Outliers that did not follow such a pattern were those that scored uncharacteristically high or low on most scales (tending to be all 1s or 7s); however, these were likewise assessed to be genuine data as low-scorers tended to have little to no PES experience while high-scorers tended to have abundant PES experience. Therefore, data from outliers were kept in the analyses. With outliers kept

 $^{^{2}}$ *F* (1, 147) = 4.08, *p* = .045

in, main effects of intent type on intent ratings were significant when controlling for both attitude, F(1, 150) = 5.75, p = .018, and self-efficacy, F(1, 150) = 14.35, p < .001, with willingness (M = 5.94, SD = 1.13) significantly higher than intention (M = 5.07, SD =1.18). The analyses did not yield significant interaction effects of attitude and intent type on ratings F(1, 150) = 0.30, p = .584, nor of self-efficacy and intent type on ratings F(1, 150) = 2.02, p = .157, in contradiction to H3 and H4 (see Figure 4).



Figure 4. Comparison of H3 and H4 with found predictor—intent associations. Figure shows interaction of predictor—intent associations hypothesized in H3 and H4 in upper images, and non-interacting associations found in the study in lower images.

Moderator Analyses

For the moderator analyses, two two-way repeated-measures ANCOVAs were

conducted for each intent type to determine interaction effects of timeframe and TPB

predictor on intent rating. Intention was the dependent measure for the first two

ANCOVAs, and willingness for the last two; timeframe was included as the withinsubjects variable, and attitude and self-efficacy included in separate analyses as continuous covariates. One and three outliers³ were respectively detected for the ANCOVAs examining the prediction of intention by attitude, and by self-efficacy, as moderated by timeframe. Three outliers each were detected for the ANCOVAS examining the prediction of willingness by attitude, and by self-efficacy, as moderated by timeframe. Rerunning the analyses without outliers did not materially affect results except for the interaction of self-efficacy's prediction of willingness as moderated by timeframe which now reached significance⁴. However, outliers were kept in as they were deemed to be genuine responses (see main analyses for more detailed explanation). Regressions were run to determine strengths of predictor—intention associations ANCOVAs revealed significant moderations by timeframe. For visual comparison of predicted versus found relationships, see Figure 5.

Moderation of Predictor—Intention Associations

Construal level manipulation was not found to have exerted a significant main effect, whereby intentions for PES events presented to occur in a year (high construal; M = 4.73, SD = 1.33) were not significantly different from intentions for events presented to occur in a week (low construal; M = 3.04, SD = 1.48). This occurred when controlling for both attitude, F(1, 150) = 0.59, p = .444, and self-efficacy, F(1, 150) = 2.54,

 $^{^{\}rm 3}$ Assessed by studentized residuals greater than ±3, as with the main analyses

 $^{^{4}}$ *F*(1, 147) = 3.23, *p* = .03.

p = .113. The repeated-measures ANCOVA revealed a significant interaction effect of timeframe and attitude on intention ratings, F(1, 150) = 17.40, p < .001, whereby the regression analyses revealed attitude to be a significant predictor of intention in the high construal-level condition ($\beta = .39$, p < .001) but not the low ($\beta = .16$, p = .084). The repeated-measures ANCOVA also found a significant interaction effect of timeframe and self-efficacy on intention ratings, F(1, 150) = 6.90, p = .01, whereby the regression analyses revealed self-efficacy to be a significant predictor of intention in the high construal-level condition ($\beta = .30$, p < .001) but not the low ($\beta = .19$, p = .066).

Moderation of Predictor—Willingness Associations

Construal level manipulation exerted significant main effect on willingness ratings, whereby willingness was significantly higher when activities were presented to occur in a year (M = 5.80, SD = 1.17) as opposed to a week (M = 4.86, SD = 1.56). This occurred when controlling for both attitude, F(1, 150) = 4.21, p = .042, and self-efficacy, F(1, 150) = 15.87, p < .001. Repeated-measures ANCOVA did not reveal a significant interaction effect of timeframe and attitude on willingness ratings, F(1, 150) = 0.11, p = .746, indicating that the association between attitude and willingness was not significantly different for low versus high construal levels. Similarly, repeated-measures ANCOVA did not reveal a significant interaction effect of timeframe and self-efficacy on willingness ratings, F(1, 150) = 3.16, p = .077, indicating that the association between self-efficacy and willingness was not significantly different for low versus high construal levels.



Figure 5. Comparison of H5a, H5b, H6a, and H6b with found predictor—intent associations. Upper images show hypothesized associations and lower images show found associations.

Discussion

Main analyses

The aim of the main analyses was to establish the prediction of intention and willingness by attitude and self-efficacy and to compare the predictor—intent associations. Attitude and self-efficacy were found to be significant predictors of both intent types (beyond age, gender, and past experience), thus supporting H1a, H1b, H2a, and H2b (shown in the final model in Figure 6) and is consistent with findings from previous research (Poliakoff & Webb, 2007; Besley, 2014). Willingness ratings were significantly higher than intention suggesting that in general, scientists are more willing to participate in PES through accepting offers than they are to have planful intentions to participate. Attitude and self-efficacy predicted both intent types to similar extents when compared, contradicting H3, which predicted the Attitude—Willingness association, and H4, which predicted the Self-efficacy—Intention association to be stronger than the Self-efficacy-Willingness association, and H4, which

Intention association. These contradictory findings to H3 and H4 were unexpected and are expanded on below.

Initially, the hypothesized stronger prediction of willingness by attitude rather than self-efficacy, and stronger prediction of intention by self-efficacy rather than attitude, were based on Health Psychology literature that distinguished between planned and reactive pathways (Lawton, Conner, & McEachan, 2009; Gerrard, Gibbons, Houlihan, Stock, & Pomery. 2008). Results from the current study however did not support this. A potential explanation for this may be that the distinction between planned and reactive pathways and behaviors in Health Psychology literature cannot be readily generalized to PES. While willingness is understood in both Health and PES literatures as openness and readiness to engage in behavior, calling for context or opportunity to translate intent into action, there is a key difference between willingness as studied in Health Psychology and in PES literature – willingness is used in Health Psychology to understand impulsive, in-the-moment behavior. In light of this, literature from Health Psychology may be less generalizable to PES as choosing whether or not to participate in PES when an opportunity is given is, while reactive, not impulsive.

The findings from the main analyses provide support for previous research (e.g. Poliakoff & Webb, 2007; Besley, 2014; Papagiannidis & Dermentzi, 2017; Besley et al., 2018) and has practical implications in showing that both attitude and self-efficacy can be used to boost intents for PES participation, and that both are drawn on similarly regardless of intent type. However, although both intents depending similarly on attitude and self-efficacy, the significant difference between intention and willingness

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ratings do suggest them not to be 'nearly equivalent' concepts (Besley et al., 2018, p.562) as had been suggested in PES literature. Institutions therefore are advised to exercise care in choosing which intent type to use in predicting PES participation rates of their researchers. For example, for a university that does not offer PES opportunities and where scientists have to seek out opportunities, willingness measures may overpredict participation rates; likewise, for a university that frequently offers scientists PES opportunities and where scientists do not need to seek these opportunities out, intention measures could underpredict participation rates.

In addition to the main effects suggesting intention and willingness as separate constructs, the moderator analyses further support a distinction between the two intent types. When construal levels are manipulated through presenting PES events in different timeframes, predictor—intention associations undergo moderation while predictor—willingness associations remain stable (see Figure 6). This suggests an event more clear-cut distinction between the two intent types.



Figure 6. Final conceptual model showing found predictor—intent associations and moderation of predictor—intention associations. Shown values are β from the final regression model.

Moderator Analyses

The moderator analyses aimed to examine whether altering construal levels by presenting PES activities as occurring in the far versus near futures could strengthen or weaken predictor—intent associations. In support of H5a, the prediction of intention by attitude was significantly stronger at the high construal level (where PES activities were presented to occur in a year) compared to at the low (occurring in a week). Unexpectedly, this stronger association at the high construal level was also found for self-efficacy's prediction of intention, contradicting H5b. Both attitude and self-efficacy ceased to be significant predictors of intention when PES events were brought near in time at the low construal level. For willingness, construal level manipulation did not seem to exert moderation effects on attitude nor self-efficacy's prediction in contradiction to H6a and H6b, thus showing a distinction between predictor—intention and predictor—willingness associations.

Regarding the moderation of predictor—intention associations, the stronger prediction of intention by attitude at a high construal level is unsurprising as this pattern has been found consistently in past CLT literature (Liberman & Trope, 1998; Eyal et al., 2004). However, the stronger prediction of intention by self-efficacy at the high construal level contradicts H5b and previous findings, which have suggested a stronger prediction of intention by self-efficacy at the low level (Liberman & Trope, 1998). An explanation to this may be because self-efficacy can change over time (Sheeran, Orbell, & Tramifow, 1999). Specifically, those who are already less confident in their abilities tend to experience diminishing self-efficacy as time to the task draws near (Gilovich, Kerr & Medvec, 1993; Savitsky, Medvec, Charlton & Gilovich, 1998).

It is possible therefore that the stronger relation between self-efficacy and intention in a year was due to self-efficacy being measured generally and abstractly (how confident do you feel in your ability to perform ...) and not with a specified timeframe (how confident do you feel in your ability to perform ... in the next week) in this study. As self-efficacy was measured at a general level, the stronger prediction for intentions in a year makes sense as distant intentions are also construed in the abstract. Had self-efficacy been measured for PES activities at specific timeframes, it is possible that the association between self-efficacy in a week and intentions in a week would be stronger than that of self-efficacy in a year and intentions in a year. While by the same logic it can be argued that the stronger attitude—intention association at the high construal level is due to attitude being measured at a general level, this is likely not the case. Attitudes of value judgments (as measured in this study) are higher level factors and therefore tend to stay relatively consistent (Liberman & Trope 1998; Eyal, et al., 2004). For example, students may feel lessening confidence regarding an exam as it draws near, but their valuation of succeeding on the exam likely remains unchanged whether at the start of the term or one day before the exam (Trope & Liberman, 2010).

Different from findings for intention and in contradiction to H6a and H6b, the moderator analyses did not find construal level manipulation to moderate Attitude—

Willingness and Self-efficacy—Willingness associations. This means that when given the chance to participate in future PES activities, scientists' willingness to accept the opportunity depended similarly on attitude regardless of whether the event commenced in a week or a year; the same was found for self-efficacy. This is interesting as moderation effects were present for predictor—intention relationships. A possible explanation for why moderation was present for predictions of planned intent but not reactive intent could be due to the factor of situation controllability.

Situation controllability has been suggested as a contributing factor to the differential weighing up of attitudinal values and judgements of feasibility in near and far timeframes (Trope & Liberman, 2010). Given that willingness is considered for when opportunities are given and intention for when opportunities need to be created, the controllability of intention and willingness are naturally different. Specifically, the change in timeframe for when PES events are set to occur should not have the same effect on intention and willingness due to controllability. This is because controllability is decreased when time for opportunity creation is narrowed (Ivanova, Treffers, & Langerak, 2018); however, since willingness does not require consideration of opportunity creation, controllability would not change for willingness as it would for intention.

The amount of controllability one has over opportunity creation is a plausible explanation for why attitude and self-efficacy ceased to predict intention in the proximate timeframe but remained predictive of willingness regardless of time, as controllability also shapes expectancies of outcome success; after all, it seems intuitive

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to disregard one's attitudes and abilities when success in creating PES opportunities is uncertain (Ivanova et al., 2018). However, since one cannot know the controllability of a situation and judgments of controllability are subjective, it is really *perceived* controllability that thus shapes expectancies of outcome success (Bandura, 1977). This brings the discussion then back to the TPB model, as the factor of perceived behavioral control, not self-efficacy, was one of the three predictors of intention in the model (Ajzen, 1991). Self-efficacy was measured in place of perceived behavioral control in the current study because efficacy measures are more frequently used in PES literature (e.g. Poliakoff & Webb, 2007; Besley et al., 2018; Robertson Evia, 2018) instead of perceived behavioral control. However, if it is the case that self-efficacy relates to intentions through perceived control, it may be necessary to distinguish between the two factors. Indeed, in a review of studies on perceived behavioral control, Ajzen (2002) suggested self-efficacy to be a sub-component of perceived behavioral control, and that selfefficacy relates to intention through perceptions of controllability.

Given this information, it reasons that changes to perceptions of controllability over creating PES opportunities for oneself would affect how factors influencing intentions are weighed up. To illustrate, if perceived controllability over acquiring an opportunity within a week is low, expectations of success in acquiring the opportunity would also be low. Naturally, when one does not expect an opportunity with certainty and expects low controllability over the situation, it becomes pointless to base intentions on the task's importance and one's confidence in task-performance, as the task may not even occur. On the other hand, if the timeframe for acquiring the

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opportunity is longer, perceived controllability over the situation and expectations of success would subsequently be higher. Naturally then, when expectation of opportunity is more certain, one's decision for participation would depend heavier on task importance and confidence in performing the task. Indeed, in contexts of higher perceived controllability, such as when PES opportunities are offered or when the timeframe for finding opportunities is longer, attitude and self-efficacy were found to be predictive of intents. Future research may look further into how perceived controllability over opportunity creation affects PES intentions as behaviors, as this factor has been identified as a predictor for proactiveness and success in business creation in entrepreneurship research (Rauch & Frese, 2007; Ivanova et al., 2018).

As the current research shows predictor—intention relationships to be moderated by timeframe manipulation while predictor—willingness relationships are not, this may have theoretical implications regarding interpretation of previous PES research on intentions, and practical implications in increasing PES participation in institutions.

Regarding research on PES intentions, previous studies have predominantly examined the prediction of intentions by TPB factors at a distant timeframe (e.g. in a year; Poliakoff & Webb, 2007) or at a general level without a timeframe (e.g. Dermentzi & Papagiannidis, 2017). As the current study shows distant and proximate intentions to arise from different pathways, it is likely that the factors identified to predict intentions in previous PES studies may not be predictive of proximate intentions. Given that it is concretely processed low-level plans that are more likely to translate into action than distant, high-level plans (Owens, Bowman, & Dill, 2008), it may be useful to identify factors that predict proximate intentions. To illustrate, an abstract intention and plan of *'educating the public through my writings this year'* is not as likely to cue action as the more concrete *'writing an outline for a blogpost on topics x, y, and z, and sending it to the Public Engagement Unit for advice this week'* (van Eerde, 2000). Therefore, further research should investigate the predictive variables for proximate PES intentions so they may be targeted and enhanced.

Additionally, as predictor—willingness relationships remain stable regardless of timeframe, approaching scientists with PES opportunities may be a highly effective approach, particularly after public engagement trainings when self-efficacy and attitude are at high levels. In stepping towards a more scientific-minded society and a more society-engaged scientific community, an increasing amount of universities and institutions are creating Public Engagement Units focused on helping researchers gain public engagement skills and increasing PES uptake through various strategies. In targeting scientists' willingness for PES, offering opportunities of ready-made public engagement programs led by Public Engagement Units to researchers (such as done at Bath University; Featherstone & Owen, 2020) could be a good way of increasing PES rates. The problem with this of course is that these programs are labor intensive and costly to run, and therefore thought should be put into which researchers to approach and how programs should be run in order to mitigate dropout and maximize benefits.

Conclusion

To conclude, the main analyses showed intention and willingness for PES to arise from attitude and self-efficacy judgments similarly; however, results from the moderator analyses show this to only be the case at the most general level of processing. Timeframe manipulation revealed that when PES events drew near and construal level was lowered, attitude and self-efficacy ceased to be predictive of intention. A suggested explanation for this is situation controllability. Results support this as, in contexts where controllability is higher, such as when PES opportunities are offered or when the timeframe for finding opportunities is longer, attitude and self-efficacy remain predictive of intents.

Altogether, these findings suggest that although PES intentions and willingness arise similarly from attitude and self-efficacy at the general level, they are not similar constructs that can be used interchangeably. Therefore, care should be taken in selecting which measure to use in predicting participation rates. Results from the moderator analyses also suggest that as proximate and distant intentions arise from distinct pathways, predictors of general PES intention identified in previous studies may not predict proximate intention. Additionally, as willingness remains stably predicted by attitude and self-efficacy over time, approaching scientists with PES opportunities particularly when attitude and self-efficacy are high may be an effective strategy in increasing PES participation rates.

As this study was conducted during the time of a worldwide pandemic, findings from this research should be seen in light of this limitation. During the period which the study questionnaire was live, – from April to May 2020 – many countries had only just begun lockdown or issued stay-at-home orders, which meant that universities, schools, and research institutes were closed, and scientists were working from home. Additionally, the closing of schools meant parents had to take care of and homeschool children who were constantly at home, an incredibly time-consuming undertaking. These COVID-19 measures were put in place for most European countries, Great Britain, and the United States, where most participants for this study resided in, around the end of March ("COVID-19 Pandemic Lockdowns", n.d.). This meant that participants took part in the questionnaire just as they were just getting used to a new life routine. As the questionnaire items in this study asked about intents for additional responsibilities at such an unpredictable time, it is hard to imagine that answers to these questions would not be affected by the drastic change COVID-19 measures put on daily routines, change in work and home responsibilities, and reshuffling of schedules and plans. This may resultingly limit the generalizability of findings from this study to future contexts, when scientists are no longer working remotely, and schedules and responsibilities have shifted back to how it was prior to the pandemic. The fact that data for this study was collected during the corona pandemic may also make comparison of results from the current research to those of studies done prior to the pandemic hard to interpret, as prior studies were done under drastically different situations, and work environments and home responsibilities were much different. Future studies could therefore

reexamine the pathways to PES intentions and willingness investigated in this study, once work situations have returned to normal, to gauge whether results from this study may be applicable to 'normal times.'

An additional limitation is that this study looked at a fairly diverse sample of participants from different countries. The problem herein is that intentions and willingness for PES participation likely depend on the Public Engagement culture and infrastructure at the scientist's place of work, which varies from institution to institution. The current study was unable to control for variance between scientists from different countries and institutions due to questionnaire length; however, future PES studies with an international sample should control for variance that may be caused by inter-national and inter-institutional differences. Factors to control for could include whether there are requirements for public engagement at the scientist's institution, whether public engagement participation is taken into consideration for promotion and tenure, whether PES opportunities are frequently offered to scientists at the institution, whether the institution has a Public Engagement Unit, and whether funding is available for public engagement projects at the scientist's institution or the scientist's country of residence/employment, to name a few.

In conclusion, this study answered questions regarding similarities and differences between planned and reactive intent for PES, where the two were found to be distinct constructs that arose from similar pathways, and construal level was found to moderate predictor—intention relationships but not predictor—willingness relationships. The generalizability of this conclusion should be seen in light of limitations – specifically that this study was conducted approximately one month after COVID-19 measures shut down universities globally, and that the study did not account for inter-institutional and international differences regarding PES. Future studies may address these limitations by reexamining intentions and willingness for PES once COVID-19 measures allow academics to return to work physically. Additionally, future studies using a diverse, multinational sample to examine PES should account for differences between countries and institutions.

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Appendix A

Information sheet

A Study on Public Engagement with Science

You are invited to participate in a study examining scientific researchers' attitudes, intentions, self-efficacy, and willingness regarding engagement with the lay public about science, such as through social media (e.g. Tweeting) or writing an article for a magazine to give just a few examples. This communication and interaction with the general public about science is termed 'Public Engagement with Science' (PES) in science communication literature and has been a topic of discussion in recent years. Through this study, the international network for Advancing and Evaluating the Social Impact of Science, AESIS, seeks to gain further insight into PES participation and how PES is viewed in the scientific community.

About AESIS

AESIS is an international, open community that brings together various types of professionals working on stimulating and demonstrating the impact of science on economy, culture, and well-being.

Terms and Conditions. By consenting to the study, you agree to participate in a 10-minute survey consisting of questionnaires about attitudes, self-efficacy, willingness and intentions regarding science communication and the public engagement of science. Participation is entirely voluntary and you may withdraw from participation at any time without explanation. This is done by exiting the survey, and will not lead to negative consequences. Surveys in which multiple questions are left blank will be discarded and excluded from final analysis. Personal data collected in this study (age, gender, institution and country of employment) will be used to report demographic information of the participant sample in this study. All data is kept confidentially and anonymously, and is securely stored and only accessible to the AESIS researcher and research supervisors. There are no anticipated risks associated with this study. If you have any questions regarding this study, please contact Bonita Liu (b.liu@aesisnet.com)

Appendix B

Recruitment texts



A study on Science Communication is currently being run by <u>AESIS</u>, the network for Advancing and Evaluating the Societal Impact of Science. This study aims to gain insights into researchers' attitudes, intentions, beliefs, and self-efficacy regarding **Public Engagement with Science** – engagement in communication of science with those outside of academia. We have developed a short 10-minute survey, and we would love for any researchers or PhD students to partake

Your answers will help us learn more about how researchers view engagement with the lay public about science. For researchers interested in societal impact, science communication connects science with the broader society and the information you provide may help uncover deeper insights into how the impact of science may be advanced. You may take the survey via: <u>https://bit.ly/33me9Ow</u>

The results of this study will be published in the August edition of the AESIS newsletter and you may sign up as a member to view the results if you wish.

Appendix C

Demographics table

Demographic Variable	Number (%)
Condor	
Male	55 (36 2%)
Fomalo	DJ (50.2%)
Othor	2 (2%)
Other	5 (270)
Scientific Discipline	
Natural sciences	71 (46.7%)
Social sciences	57 (37.5%)
Medicine and health sciences	9 (5.9%)
Technology and engineering	6 (3.9%)
Formal sciences	3 (2%)
Other	6 (3.9%)
Research Position	
Doctoral student	53 (34.9%)
Post-doctoral researcher	18 (11.8%)
Junior researcher/lecturer	17 (11.2%)
Senior researcher/lecturer	22 (14.5%)
Professor	30 (19.7%)
Independent or commercial researcher	5 (3.3%)
Other	7 (4.6%)
Country of Employment	
United States	73 (48%)
United Kingdom	36 (23.7%)
European countries	24 (15.8%)
Asian countries	6 (4%)
Other countries	13 (8.5%)
Institution of Employment	
Brandeis University	19 (12.5%)
Other universities/institutions	133 (87.5%)
Channel of Recruitment	
Electronic mailing list = 69 (45.1%)	69 (45.1%)
Email from colleague/friend = 56 (36.6%)	56 (36.6%)

Social media post = 17 (11.1%)	17 (11.1%)	
AESIS newsletter = 5 (3.3%)	5 (3.3%)	
Other/Unknown = 5 (3.3%)	5 (3.3%)	
Past PES Experience		
0 activities	14 (9.2%)	
1 activity	22 (14.5%)	
2 activities	40 (26.3%)	
3 activities	33 (21.7%)	
4 activities	33 (21.7%)	
5 activities	10 (6.6%)	

Appendix D

Demographics Questionnaire

Age: [fill in]

Gender:

- Male
- Female
- Other

Scientific Discipline:

- Natural sciences (e.g. physics, chemistry, biology...)
- Formal sciences (e.g. mathematics, statistics...)
- Social sciences (e.g. anthropology, psychology, economics...)
- Technology and engineering (e.g. mechanical engineering...)
- Medical and health sciences (e.g. medicine, psychiatry...)
- Other

Career stage (Please note that due to job title differences between countries, not all research roles are presented. Please select closest option.)

- Doctoral student
- Post-doctoral researcher
- Junior researcher/lecturer
- Senior researcher/lecturer
- Professor
- Independent/commercial researcher
- Other

Country of employment: [drop down menu]

Institution of employment: [fill in]

How did you come across this study?

- AESIS newsletter

- Social media posting
- Email from colleague/friend
- Online mailing list
- Other

Appendix E

Questionnaire for Variable Measures

Intention Questionnaires

Response choices: (Definitely intend to//Intend to//Somewhat intend to//Neither intend nor don't intend to//Somewhat don't intend to//Don't intend to//Definitely don't intend to)

General Intention. This questionnaire asks about how strongly you intend to participate in the following activities. Please select the choice that best matches your intention for the following activities:

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public
- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

Future Intention. This questionnaire asks about how strongly you intend to participate in the following activities in the future. Please select the choice that best matches your intention for the following activities in the following times:

In the next year

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public
- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

In the next week

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public
- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

Willingness Questionnaires

Response choices: (Very willing to//Willing to//Somewhat willing to//Neither willing nor unwilling to//Somewhat unwilling to//Unwilling to//Very unwilling to)

General Willingness. This questionnaire asks about how willing you are to participate in the following activities **if you are given the opportunity.**

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public

- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

Future Willingness. Imagine that right now, you are given the opportunity to participate in the following activities, taking place in a week or a year. Please select the choice that best matches your willingness for participation in the below activities in the following times:

In the next year

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public
- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

In the next week

- Communicate with the public about my research via social media
- Write a book about my research for the public
- Write an article about my research for the public
- Engage with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research

Attitude

Response choices: (Very important//Important//Somewhat important//Neither important nor unimportant//Somewhat unimportant//Unimportant//Very unimportant)

Please indicate how important the following activities are to you

- Communicating with the public about scientific research via social media
- Writing books about scientific research for the public
- Writing articles about scientific research for the public
- Engaging with policy makers as a scientist through my research
- Engaging with non-government organizations as a scientist through my research

Self-efficacy (PBC)

Response choices: (Very confident//Confident//Somewhat confident//Neither confident nor unconfident//Somewhat unconfident//Unconfident//Very unconfident)

Please indicate how confident you feel in performing the following activities

- Communicating with the public about my research via social media
- Writing a book about scientific research for the public
- Writing an article about scientific research for the public
- Engaging with policy makers as a scientist through my research
- Engaging with non-government organizations as a scientist through my research

Past Participation

Response choices: (Yes//No)

Please select whether you have participated in the following activities in the past

- Communicated with the public about my research via social media
- Written a book/books about my research for the public
- Written an article/articles about my research for the public
- Engaged with policy makers as a scientist through my research
- Engage with non-government organizations as a scientist through my research