Perceived efficacy and attitudes towards genetic science and science governance

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Abstract

Arguments for public involvement in science and technology are often based on ideas of developing a more capable public and the assumed effects this may have for science. However, such a relationship is yet to be sufficiently explored and recent work indicates that a more involved public may have counterintuitive effects. Using nationally representative survey data for the UK and Northern Ireland, the effects of the publics own beliefs about involvement are explored. Developing the concept of 'belief in public efficacy', findings suggest those who believe that the public might be able to affect the course of decision making have less approving attitudes towards future applications of genetic science, however, an individual's political efficacy does not significantly influence these attitudes. Furthermore, political efficacy and belief in public efficacy have some distinct and opposing relationships with the principles of governance people prefer. Overall, findings provide support for suggestions that it is simplistic to consider increasing public involvement as a way of increasing the approval of risky new technologies.

Keywords

Public involvement; genetic science; efficacy; science governance

1. Introduction

Science and a more involved public

Interest in science is increasing in the UK, with approximately eight out of ten people ‘moderately’ or ‘very interested’ in new inventions, technologies, and scientific discoveries; and, as many as nine out of ten similarly interested in new medical discoveries (People Science & Policy Ltd/TNS, 2008b). Survey data suggest that the UK public are mostly supportive of science, with nearly half believing the benefits of science outweigh any negative consequences (European Commission, 2005). However, the UK public also have reservations about the role and remit of science and technology; with 61% agreeing that “science and technology are responsible for most of the environmental problems we have today;” and, only 14% agreeing that science and technology can “sort out any problem” (European Commission, 2005: 62, 60).

The UK public are uneasy about the spontaneity and speed of scientific developments that appear to outpace consultation processes (House of Lords, 2000) and in response the UK Government has called “on all public bodies to be more open and responsive to the needs of the citizens they serve” (HM Government, 2005: 2). The answer to this call has principally been viewed as increased public participation in science and technology (Leshner, 2005; Willsden & Willis, 2004; DEFRA, 2001).

Genetic science provides a particularly pertinent opportunity to investigate the role of public involvement. Reported interest in genetic science is very high (People Science & Policy Ltd/TNS, 2008a) and it is an area where attempts to involve the public have already been made (DTI, 2003). Yet, the public are mostly unimpressed with the role of government and industry in this area (Gaskell et al., 2003) and attitudes mostly take a sceptical although not overly hostile quality (MORI, 2005).

National surveys indicate that the public are generally dissatisfied with the level of seriousness with which the Government considers their views. Almost half of the UK public feel that public involvement in science and technology is not adequate, and confidence in consultation processes is low (MORI, 2005; People Science & Policy Ltd/TNS, 2008a). Demand for timely information and greater acknowledgement of the interest of the public in science and technology is high, with as many as 78% of the public agreeing they "ought to hear about potential new areas of science and technology before they happen, not afterwards" (People Science & Policy Ltd/TNS, 2008a: 20). Despite the Government's awareness of its need to "demonstrate that it has listened to the public's views and taken them seriously" (HM Government, 2005: 4), the public engagement activities organised by or on behalf of Government continue to include desires to increase the public's trust (People Science & Policy Ltd/TNS, 2008b; Petts, 2008). For example, the Science and Trust Expert Group proposed action plan will in part aim to "develop new mechanisms to increase public trust in science and engineering" (Department for Business Innovation and Skills, n.d.). Even where governments do appear to be trying to take the lead by increasing public participation in scientific debate through enforcing their own definitions of participation and involvement any alternative action by the public (such as protests or boycotts) is likely to be undervalued. The significance of this is supported by empirical research showing that political participation in the UK is moving beyond traditional party affiliation and vertical dialogues (Li & Marsh, 2007; Bang, 2005). In fact, such participation is increasingly taking on new forms which have been found to relate to levels of efficacy (Li & Marsh, 2007). Thus, it becomes ever more likely that people's beliefs in their own and their collective's efficacy will make significant contributions to their preferred approaches to science governance and regulation.

A more efficacious public?

The origins of the field of study known as 'public understanding of science', to some degree at least, has its roots in the democratisation of the public. Much of its early impetus was based on raising the 'scientific literacy' of publics to levels which meant they could represent their interests as the role of scientific and technological innovations were becoming more increasingly important (Sturgis & Allum, 2004; Bodmer, 1985). However, the primary motives for increasing scientific literacy, as well as more recent attempts to increase public understanding and involvement in science, have even stronger roots in the government and business agendas of 'selling science' (Sturgis & Allum, 2004; OST & Wellcome Trust, 2001; Nelkin & Lindee, 1995). The success of both agendas is arguably poor: scientific knowledge is often found to be low (Jowell et al., 1997; Durrant, Evans & Thomas, 1989) and there has been both rising scepticism and diminishing conviction in the benefits of science (Gaskell et al., 2001; Hargreaves, 2000; House of Lords, 2000; Miller, Pardo & Niwa, 1997; Touraine, 1985). Despite the Government rhetoric that supposes greater public involvement may smooth the introduction of new or 'risky' technologies, suggestions thus far are that a more efficacious public may actually lead to a more critical approach to potentially risky technologies rather than overly legitimising attitudes (Barnett, Cooper & Senior, 2007) and that this more critical stance may actually be more desirable (Pidgeon, Poortinga & Walls, 2007).

In reality, little is known about the effect of formal public participation initiatives insofar as there are rarely evaluations of processes or, more particularly, of outcomes (see Petts (2008) for a recent discussion of this area). More generally, empirical research into the relationship between efficacy and public participation in politics has found that people who have both a strong belief in the power of their collective voice and are trusting of their systems of governance are more likely to take an active role in political activities (Bandura, 2000). Also, when trust in governing systems is low but belief in a collective voice remains high, political action outside conventional channels is preferred (ibid.). While there appears to be increasing public interest and desire for more public involvement in science, there only appears to be a low proportion of the public displaying a 'belief in public efficacy'; less than one in three in the case of genetic science (Barnett, Cooper & Senior, 2007). This has parallels with other areas of public participation where those with little confidence in the ability to affect governing systems, whether in themselves or a collective, may turn to silence through disaffection rather than lack of concern (Marris et al., 2001; Bandura, 2000).

A large body of research has identified a wide range of factors, values, views etc, which influence the public's attitudes towards science, these include: political and scientific knowledge, "culture, economic factors, social and political values, trust, risk perception, and worldviews" (Sturgis & Allum, 2004: 58). Along with knowledge, the role and influence of institutional trust on attitudes to science and technology has received extensive attention, largely because of the widespread findings that publics have low trust and confidence in many of the institutions and actors involved in science practice, policy and governance

(MORI, 2005; Poortinga & Pigeon, 2004; House of Lords, 2000). Plus, higher trust has been seen to reduce the differences between expert and lay opinion, while its absence may intensify concern or threaten future developments (House of Lords, 2000; Earle & Cvetkovich, 1995). Recent research has suggested that trust and belief in public efficacy appear to work in opposite directions in relation to people's permissiveness and favourability towards modern genetic science (Barnett, Cooper & Senior, 2007). However, the relationship between political efficacy and attitudes towards science is yet to receive attention. Investigation into the influence of political efficacy on attitudes towards science is felt to be particularly relevant because "the ways in which science is practiced, regulated, and deployed in society is still essentially a "political" matter" (Sturgis & Allum, 2004: 60).

Political efficacy is quite distinct from *belief in public efficacy* as discussed above. Political efficacy provides a measure of people's confidence in making demands of governing systems and getting adequate responses from that system. Within the political system, political efficacy has a positive association with trust in the government to look after the needs of the country (Bromley et al., 2001). So, a positive association between political efficacy, trust and satisfaction with science governance may be expected. Though science governance is not measured in terms of satisfaction in this study, empirical research is suggesting that higher political efficacy will be related to attitudes which allow experts to make decisions.

Some sections of the public have been found to desire a greater say in the principles on which science is governed. More than half of the European public are happy to go along with the "status quo" of decisions being made by experts on the basis of scientific evidence (Gaskell et al., 2005). Overall, nearly two-thirds opt for a scientific basis to decision making and three-quarters opt for experts to do the decision making. However, there remains a sizeable minority opting for alternative governance principles. More than a third would like moral and ethical issues to be considered over scientific evidence, and a quarter would prefer the public to make such decisions (ibid.). This study will explore the relationship between the public's views of their own agency and their preferred principles of science and technology governance.

Researching efficacy and its relation to attitudes towards genetic science and science governance

In summary, a situation where public agency is seemingly being fostered has been described. However, it has also been shown that little is known about what effect a more agentic public could have; and indications so far, are that a more confident and engaged public does not necessarily equate to a 'science-loving' public (Barnett, Cooper & Senior, 2007). Utilising social-cognitive theory, in which people's perceptions of their own efficacy is taken to be the foundation of human agency (Bandura, 1997), this study investigates how individuals' perceptions of agency, vis-à-vis *political efficacy*, influence their approval of genetic science and the principles of science governance they opt for. Furthermore, we argue that there is good reason to believe that both personal and collectivist concerns should be considered when addressing people's motivations for civic participation (Barnett, Cooper & Senior, 2007; Simmons & Burchell, 2005; Bandura, 2000). Therefore, this study extends the metrics of efficacy, and builds on previous research (Barnett, Timotijevic, Vassallo & Shepherd , 2008; Barnett, Cooper &

Senior, 2007) by incorporating a measure of people's *belief in public efficacy* into the investigation.

Political efficacy is defined as people's belief that they can make demands of governing systems and get adequate responses from these systems. *Belief in public efficacy* is defined as people's belief that the public can play a role in the governance of science and technology and affect the course of decision making. Barnett, Cooper and Senior (2007) have suggested that a belief in public efficacy may have similar attributes to Bandura's (1997, 2000) concept of *perceived collective efficacy*. In social-cognitive theory, perceived efficacy is taken as a key influence on an individual's or collective's actions, including: their choices; the amount of effort they exert; their resilience; their vulnerability; and, their accomplishments (Bandura, 1997). As such, increasing efficacy can be seen to be at the core of increasing agency.

The aim of this research is to gain further insight into the roles of political efficacy and belief in public efficacy as predictors of people's approval of future genetic science applications and attitudes to science governance. The review of literature and current understanding leads to the following hypotheses:

1. Greater belief in public efficacy is associated with less approving attitudes to genetic science.
2. Higher political efficacy is associated with attitudes which prefer experts to make decisions about science governance.

This research will also investigate how belief in public efficacy influences people's attitudes to science governance and how political efficacy influences people's approval of genetic science. Current literature does not highlight any information on these relationships so this part of the work is exploratory.

2. Method

Survey and respondents

This study's research questions were addressed by secondary analysis of Eurobarometer survey data. The data are from the Eurobarometers: 'Europeans, Science and Technology' (63.1: number 224) and 'Social Values, Science and Technology' (63.1: number 225) which were conducted together during November 2004. The surveys were conducted in all European Union countries and used a multi-stage random sampling procedure to provide statistically representative samples of national residents aged 15 and over. Though the content of the surveys was unique, these surveys were part of a range of standard and specific Eurobarometer surveys conducted since 1973. These surveys have widely been used by European Governments and academics for research in this time. The analyses in this study only use data obtained in the UK and Northern Ireland. The total samples for the UK and Northern Ireland were 1002 and 305 respectively. In this paper all inferential statistics are unweighted, while univariate descriptive statistics are weighted by the population sizes of the UK and Northern Ireland.

Analyses

The theoretical aims of this study are specifically addressed by two regression analyses. These statistical models test the hypotheses by providing information on the direction and magnitude of the effects of efficacy on attitudes towards genetic science and science governance. The first analysis uses linear regression to assess the role of two types of efficacy in predicting attitudes to genetic science. The second analysis uses multinomial logistic regression to explore the role of two types of efficacy in predicting people's choices of four different principles of science governance.

Survey measures

A number of the key variables used in these analyses were presented to only half of the survey respondents as part of the Eurobarometer survey's split ballot method. As some of these variables are included in the final regression analyses, these analyses include less than half (once missing values are accounted for) of the original sample. To increase the sample size for these analyses data from the UK and Northern Ireland are combined for analyses. This is less than ideal, but previous research has identified similar attitudes among the Northern Irish and UK publics (Springer et al., 2002) and this approach is in line with many of the analyses which explore attitudes to science at the EU level (e.g. Gaskell et al., 2005; Gaskell et al., 2004). To assess the effect of this amalgamation, a dummy variable measuring the effect of *Nation* was included in all multivariate analyses.

Ten questionnaire items in the survey dataset were identified as potential measures of efficacy. The domain specific nature of efficacy means that two of these items that appeared to be assessing a generic personal efficacy were not retained for further analyses (Bandura, 1997). The remaining eight items were believed to be related to the domain of science, technology and/or public involvement in decision making processes. Where appropriate, response items were recoded so that high scores indicate more efficacious beliefs. All respondents were asked to respond in (dis)agreement to six propositions: *'I am interested in what is going on in politics and current affairs'* (political interest); *'I feel well informed about what is going on in politics and current affairs'* (politically informed); *'People like me have too little influence in what the Government does'* (influence on Government); *'People should involve themselves more in politics and current affairs'* (attitude to political involvement); *'I think I have something to offer in decisions about politics and current affairs'* (contributing to political decision making); *'I know how to get my voice heard when it comes to politics and public affairs issues'* (getting heard in politics). For these analyses, responses to these items were coded as: 1= *'strongly disagree'*; 2= *'tend to disagree'*; 3= *'tend to agree'*; 4= *'strongly agree'*; *'don't know'* responses were coded as missing. Two efficacy items were presented to only half of all respondents (as part of the split ballot); they were asked to respond in (dis)agreement to two propositions: *'For people like me it is not important to be involved in decisions about science and technology'* (Importance of public involvement (S&T)) and *'The public is sufficiently involved in decisions about science and technology'* (Satisfaction with public involvement (S&T)). For these analyses, responses to these items were coded as: 1= *'strongly agree'*; 2= *'tend to agree'*; 3= *'neither agree nor disagree'*; 4= *'tend to disagree'*; 5= *'strongly disagree'*; *'don't know'* responses were coded as missing. The first analysis section below further reviews the operationalization of these efficacy variables and also the operationalization of other relevant independent and dependent variables used in the analyses.

3. Analysis I - operationalization of measures

Efficacy

A correlation matrix was produced to find out whether responses to the eight efficacy variables co-relate (N = 512). Five items, *political interest, politically informed, attitude to political involvement, contributing to political decision making* and *getting heard in politics* show highly correlated ($p < .001$) responses and together appear suggestive of a potential latent factor measuring political efficacy.

The two items assessing public involvement in decisions about science and technology (S&T) are highly correlated ($r = .39$; $p < .001$). The item labelled *importance of public involvement (S&T)* tests agreement with the proposition 'For people like me it is not important to be **involved** in decisions about science and technology' (emphasis added), and it is perhaps unsurprising that responses to this item also correlate most significantly with the two items which most precisely ask for respondents views on involvement in political processes - *attitude to political involvement* and *contributing to political decision making*. There are also significant ($p < .001$), though weaker ($r = .14$ and $r = .15$, respectively), correlations between these items and respondent's satisfaction with the level of public involvement in science and technology (*satisfaction with public involvement (S&T)*).

Responses to the *influence on Government* item do not correlate with the other items identified as measuring political efficacy and as such this survey measure was not a candidate for further analysis. This lack of correlation may be due to question wording and specificity. The item specifically refers to government decisions, while other questions ask about "politics and public affairs" so incorporate a wider range of opportunities for people to consider their own efficaciousness when responding to such items.

Exploratory Factor Analysis (Maximum Likelihood extraction; eigenvalues > 1), with oblimin rotation, was conducted to explore the underlying structure of the remaining seven items (Table 1). As expected from the correlation matrix discussed above, the factor loadings show two correlated, yet distinct factors. The second factor, which includes the two items relating to public involvement in decisions about science and technology, contains only two items[1] and therefore individual-level composite scores were computed based on the mean values for these two items. These items formed the basis of a tentative latent factor measuring Belief in Public Efficacy (BPE) in decisions about science and technology. This two-item measure is not ideal, neither is it as robust a measure as one with a greater number of indicator variables; however, this cannot be avoided as the Eurobarometer survey from which this data has come from was not designed specifically to measure public efficacy.

--- Table 1 about here -----

The Factor Analysis (Maximum Likelihood extraction; eigenvalues > 1; N = 1135) was rerun with only the variables that were believed to represent political efficacy. The results indicated a one-factor solution fits well (χ^2 (5) = 115.556, p < .001), all factor loadings were sufficient (> .5) and the factor accounts for 42% of the shared variance in these five items (extracted eigenvalue = 2.111). These five items form a reliable scale measure (Cronbach's α = 0.78). Individual level factor scores were computed to act as measures of PE in regression analyses.

Other Independent Variables for Analysis

Other items included in the Eurobarometer dataset were operationalized to provide measurements of key constructs widely used as predictors of attitudes to science and technology in the research literature. Of these, some of the most prevalent and widely discussed are attentiveness to science, trust in agents involved in science and technology and scientific knowledge. Analyses also include items measuring three demographic variables often included in such analyses: age, gender and education.

Attentiveness to science was based on responses to five items selected from the survey. Three of these items asked how interested respondents were in ‘new medical discoveries’, ‘new inventions and technologies’ and ‘new scientific discoveries’. Relevant responses to these items were on a three-point scale and were reverse coded from the original data to aid interpretation in later analyses, where: 1 = *‘not at all interested’*; 2 = *‘moderately interested’*; 3 = *‘very interested’*. The additional two items asked respondents how often they read about science and spoke to their friends about science and technology. Relevant responses were recoded to indicate more frequent behaviours with higher values where: 1 = *‘never’*; 2 = *‘hardly ever’*; 3 = *‘occasionally’*; 4 = *‘regularly’*. For all five items *‘don’t know’* responses were excluded from analyses. These five items were strongly correlated ($p < .001$) and found to form a reliable scale (Cronbach’s $\alpha = 0.81$). Factor Analysis (Maximum Likelihood extraction; eigenvalues > 1; N = 1292) indicated a one-factor solution fits well (χ^2 (5) = 345.354, $p < .001$), all factor loadings were sufficient (> .5) and the factor accounts for 48% of the shared variance in these five items (extracted eigenvalue

= 2.422). Individual level factor scores were computed to act as measures of *attentiveness* in later regression analyses.

As a measure of scientific knowledge a seventeen–point scale (Cronbach's $\alpha = 0.67$) was constructed from responses to one item querying respondent's understanding of what it means to study something scientifically (one point was added for each of four responses taken to be accurate descriptions of scientific study) and one point was allocated for each of 13 correctly answered textbook-style science questions with true or false response options (e.g. 'The Sun goes around the Earth' and 'It is the mother's genes that decide whether the baby is a boy or a girl'). This type of scale has been widely used to measure scientific knowledge in survey data analysis (Gaskell et al, 2004; Sturgis & Allum, 2004; Durrant, Evans & Thomas, 1989).

Trust has received a large amount of attention from researchers and although it is not a key variable of substantive importance in the work here, its relationship to PE and BPE in the context of attitudes to science and technology and to the governance of science and technology is of interest. Unfortunately, no items in the Eurobarometer dataset directly queried respondents' perceptions of trust in agents involved in science and technology; however, items asking for respondents' beliefs about the effects (whether they are positive or negative) of many stakeholders and groups involved in science and technology were included in the survey. For this study's purposes these work as suitable proxies for trust. Past research identifies trust in public authorities, scientists and industry as particularly relevant to attitudes towards science and technology (Gaskell et al., 2004) and the domain specificity of these agents is immediately apparent. Again, the Eurobarometer dataset is not ideal in this regard. Its split ballot method means that the trust-proxy items were split and between the two halves of the sample. As the BPE measure is also limited by the split ballot design, analyses were already limited to the trust items in split 'A' of the survey. This is unfortunate as the three items testing trust in public authorities all lie in split 'B'. On face validity, the most relevant item within split 'A' measuring trust in science and technology governance asks what effect "industry developing new products" has on society. This item was operationalized as a *trust in industry* measure for further analyses and was recoded so that high value responses indicate higher trust where: 1 = *'very negative effect'*; 2 = *'fairly negative effect'*; 3 = *'fairly positive effect'*; 4 = *'very positive effect'*. This single measure is not an ideal method of modelling the effects of trust in agents involved in science and technology but acts as a satisfactory proxy to observe the relationship between trust and efficacy measures in further analyses[2].

For the regression analyses, *age* is measured in whole years. Dummy variables were created to measure *gender*, with females acting as the reference category in all analyses. In PUS research based on survey data, education is often measured as those with degree level or science qualifications compared to those without. The Eurobarometer dataset records the age at which people finished their education, this variable acts as an interval variable to indicate *education*. A dummy variable was created to measure *nation*, with the UK acting as the reference category in all analyses.

Dependent variables

A measure of attitudes to genetic science was constructed from responses to six items measuring the approval of six possible future applications of genetic science. Respondent's were asked under what circumstances they would approve: '*Cloning animals such as monkeys or pigs for research into human diseases'*; *'Cloning human beings so that couples can have a baby even when one partner has a genetic disease'*; *'Developing for children a genetic test that would identify their talents and weaknesses'*; *'Developing genetic treatments to get rid of people's bad habits like smoking or alcoholism'*; *'Developing genetically modified bacteria that could clean up the environment after environmental catastrophes';* and *'Storing everyone's genetic data so that criminals can be caught easily'*[3]. The four-point response scales were reverse coded so that high values are indicative of more approving attitudes to genetic science applications, where valid responses were: 1 = *'never'*; 2 = *'only in exceptional circumstances'*; 3 = *'only if it is highly regulated and controlled'*; 4 = *'in all circumstances'*. Factor scores were computed on the basis of a single factor solution to Factor Analysis (which was chosen as the simplest structure). All variables showed statistically significant correlations with each other ($p < .01$), scale reliability was adequate for exploratory work of this nature (Cronbach's $\alpha = 0.68$), factor loadings were sufficient (> .4) and the chi-square statistic indicated good fit (χ^2 (9) = 44.355, $p < .001$; N = 556). The factor explains 27% of the shared variance in the items (extracted eigenvalue = 1.604).

To investigate the effect of efficacy on attitudes towards science governance, this study replicates a measure used by Gaskell et al. (2005) to classify public attitudes of how, and by who, decisions about science and technology should be made. Respondents were asked which of two views were closest to their own in two forced-choice items. First, should decisions about science and technology be based primarily on an analysis of the 'risks and benefits' *or* the 'moral and ethical issues' involved? Second, should these decisions be based primarily on the risks and benefits 'as advised by experts' *or* 'as viewed by the general public'? Four groups each representing a distinct preference to science governance can be created based on the responses to these two items: *scientific elitists* opted for decisions based on expert advice and scientific evidence (i.e. risk-benefit analyses); *moral elitists* opted for decisions based on expert advice on moral and ethical criteria; *scientific democrats* opted for decisions based on the public's views of the scientific evidence; *moral democrats* opted for decisions based on the public's views of the moral and ethical issues. In the Eurobarometer sample (N = 1148) these views were distributed as 54%, 22%, 11% and 13% of the sample, respectively.

4. Analysis II - modelling the effects of efficacy

Modelling the effect of efficacy on attitudes towards genetic science

A hierarchical linear regression analysis was performed with *attitude to genetic science* as the outcome measure. Of the split sample of 640 respondents, 442 valid cases were entered into the models.

Predictor variables were entered into the model in a controlled order that was based on their theoretical relevance; control variables were entered earlier and those of more substantive interest to the current study were added later. Predictor variables were selected by their importance as based on previous literature and research.

Four demographic variables, *age*, *gender*, *education*, and *nation* were entered first as they are causally prior to any other predictors. The next three variables were entered separately: first, *attentiveness to science*; second, *scientific* *knowledge*; and, third, *trust in industry*. Finally, the two efficacy variables were entered one after the other: first, *political efficacy (PE)*; second, *belief in public efficacy (BPE)*.

This hierarchical regression method calculates the variance attributable to the four demographic variables together, then of each of the additional variables separately. Therefore, if BPE accounts for any significant percentage of variance in *attitudes to genetic science*, it is after all other variables have been introduced. The same applies for PE, but minus BPE.

Table 2 shows the results of all six regression models predicting attitudes towards genetic science. Model diagnostics showed no indications of multicollinearity (Mean VIF = 1.21; lowest tolerance value of .78 for BPE).

--- Table 2 about here ---

The model shows that the measure of PE does not account for a significant amount of variance in attitudes to genetic science over trust in industry, scientific knowledge, attentiveness, education, gender, age and nation (R^2 change = .003, $F(8, 433) = 1.487$, $p = .223$). The BPE measure does, however, account for a small but significant amount of variance over and above that explained by all other variables in the model (R^2 change = .010, $F(9, 432) = 5.158$, $p = .024$).

As expected, the four demographic variables account for a reasonable and significant amount of variance (R^2 change = .071, $F(4, 437) = 8.358$, $p < .001$); as does scientific knowledge (R^2 change = .016, $F(6, 435) = 7.537$, $p = .006$) and trust in industry (R^2 change = .041, $F(7, 438) = 34.318$, $p < .001$). By comparing R^2 values it is possible to see that BPE (1%) uniquely accounts for about two thirds of the proportion of unique variance accounted for by scientific knowledge (1.6%) and about a quarter of the unique variance accounted for by trust in industry (4.1%).

The parameters of the final model in the hierarchical regression (Table 3) show that PE is not a significant predictor of approval of genetic science (p = .361). Greater belief in public efficacy is associated with less approval of genetic science (p = .024). Higher BPE has a negative effect on approval of genetic science (*Beta* = -.11) that is of similar magnitude to the positive effect of higher attentiveness (*Beta* = .13)[4]. Scientific knowledge is often argued to have a low, but positive, correlation (Gaskell et al., 2004) with attitudes to science so it is interesting to note that in this model higher levels of scientific knowledge have a negative effect on genetic science approval. It is less surprising to see that greater BPE has the opposite effect on approval as that of greater trust in industry (*Beta* = .20). It is also possible to see that the magnitude of effect BPE has on approval is just over half that of trust in industry, gender (*Beta* = .20) and age (*Beta* = -.19).

--- Table 3 about here ---

Modelling the effect of efficacy on attitudes towards science governance

A multinomial logistic regression model was fitted to assess what influence PE and BPE have on people's preferred principles of science governance (how, and by who, decisions about science and technology should be made). Of the split sample of 640 respondents, 438 valid cases were entered into the model. Of these there were 213 scientific elitists, 45 scientific democrats, 107 moral elitists, and 73 moral democrats. Two models were fitted. The first replicated the variables used by Gaskell et al. (2005)[5] along with the nation, attentiveness and scientific knowledge variables. In the second model the measures of PE and BPE were added. This 'nested' approach allows assessment of the unique variance associated with the addition of the two new variables, PE and BPE. For both models, the majority group (those opting for scientific elitism) were entered as the reference category.

Comparing the -2 log likelihood test statistics from the models with and without the two efficacy variables shows that their inclusion in the model as predictors of science governance trends towards significance, but over the whole model they do not seem to increase explanatory power compared to the first model without them (χ^2 (6) = 11.113, p < .080). Pseudo R^2 measures indicate that approximately 2 percent of the variation in governance can be explained by the addition of PE and BPE to the model.

The likelihood ratio tests for the independent variables show that neither PE (χ^2 (3) = 5.77, p = .123) nor BPE (χ^2 (3) = 3.38, p = .095) offers significant improvements to, and over, the entire model when considering all other associated parameters simultaneously. However, a comparison of chi-square statistics associated with BPE and PE indicates that they respectively rank 5th and 6th in magnitude of effect in the final model of ten variables so may be candidates for inclusion if this research were searching for the simplest and most parsimonious model. However, as the current aim is to investigate the relevance of efficacy in relation to other more established variables this approach was not taken.

--- Table 4 about here ---

Turning to the role of the independent variables in the final model[6] (see Table 4) shows that a single standard deviation (s = 1.02) increase in BPE results in a 60% increase in the proportional odds of opting for scientific democracy rather than scientific elitism, all else held equal[7]. The coefficients also show that for one standard deviation (s = 0.86) increase in PE the proportional odds of opting for scientific democracy decrease by 39%, all else held equal. In other words people in the scientific democrat group are more likely to have a strong belief in public efficacy and feel less politically efficacious, as well as being less attentive to science and have less scientific knowledge. And accordingly, the majority of people, i.e. the scientific elitists, are more likely to believe less in public efficacy while feeling more politically efficacious in themselves, as well as being more knowledgeable and be more attentive to science and technology.

Odds ratio plots (Figure 1) show that lower PE is associated with scientific democrats to a greater degree than any other group. This means that those people who feel they are more politically efficacious are more likely to be moral elitists, scientific elitists or moral democrats than scientific democrats. However, higher PE does not significantly distinguish between these three groups. Although in terms of statistical significance, BPE only predicts the difference between scientific elitists and democrats discussed above; it also shows a trend where increased BPE is again most characteristic of the difference between scientific democrats and all other groups.

--- Figure 1 about here ---

5. Discussion

One of the aims of this study was to provide insight into the influence of political efficacy and belief in public efficacy on people's approval of future genetic science applications. Controlling for a range of socio-demographic characteristics and other well known influences on scientific attitudes, the findings outlined above show that those who believe in a more involved public are less approving of genetic science, confirming the study's first hypothesis. Exploratory analyses found that variation in political efficacy does not significantly influence people's approval of genetic science. As discussed in the introduction to this research, much of the impetus for public involvement in science comes from the 'selling science' agenda (Sturgis & Allum, 2004; OST & Wellcome Trust, 2001; Nelkin & Lindee, 1995). For anyone subscribing to an agenda that only wishes to advance the interests of science the results presented here may suggest public agency should not be developed, in particular, those results that suggest increasing agency will reduce approval of risky science applications. While those with an interest in making science more democratic may need to accept that with increased agency may come increased critique. This effect may be comparable to that of "critical trust", which has shown that it is possible to be critical of an application without rejecting it (Poortinga & Pidgeon, 2003; Walls et al., 2004). It has been argued elsewhere that this democratisation of science is not only in the best interests of social justice but also science itself (Allen & Bassett, 2004).

The above findings support previous research and further suggest the value of a measure of belief in public efficacy (Barnett, Cooper and Senior, 2007). However, the reliance on only two-items limits the measures face validity. For example, it could be argued that it would still be possible to agree that 'it is not important for the public to be involved in science and technology' and also agree that 'the public is sufficiently involved in science and technology' without lacking a belief in public efficacy. However, the combination of these measures offers a vast improvement over using only one measure, as has been done in previous research (ibid.). Still, there may be some apprehension about the measures of efficacy used in this study. Although informed by previous research (ibid.), the argument for *two* distinct forms of efficacy was primarily based on results from a factor analysis. However, the findings from this study now provide further substantial support for an assertion of two forms of efficacy and for two reasons. First, the addition of a measure of belief in public efficacy to the model predicting approval of genetic science added unique and significant variance over and above a model that was already controlling for political efficacy. Second, the two forms of efficacy were seen to have opposing effects in the model predicting people's favoured principles of science governance. These findings highlight not only statistical but substantive differences between the influences of these two forms of perceived efficacy. The first of these differences is: an increase in belief in public efficacy has a negative influence on attitudes to genetic science, while political efficacy has no significant influence. The second difference is: higher belief in public efficacy is associated with preference for principles of governance based on the *public's* understanding of scientific evidence, while higher political efficacy is associated with preference for principles of governance based on *expert's* understanding of scientific evidence. This provides some support for the study's second hypothesis that higher political efficacy is associated with attitudes which prefer experts to make decisions about science governance. However, the null hypothesis is not rejected because political efficacy had no effect in distinguishing between those opting for principles of moral democracy and either of the two options preferring experts to make decisions. It is also interesting to note that the Northern Irish public are more likely to opt for scientific democracy over scientific elitism. This may be unsurprising considering the long-term tensions between the public and the state in Northern Ireland. After centuries of UK rule in Ireland, Northern Ireland remained under the rule of the United Kingdom when the rest of Ireland gained independence in the 1920's. Northern Ireland's affiliation with the UK, self-rule and its relationship to the independent state of Ireland has been a divisive and violent topic for most of the last century. Conflict has only shown signs of abating in recent years alongside the establishment of a devolved power-sharing government made up of both unionist (UK facing) and nationalist (Ireland facing) political parties. A speculative explanation would be that this struggle has led the Northern Irish public to value democratic decision making to a stronger degree than the UK public. Most importantly, this finding suggests it would be prudent to look at the relationship between efficacy, public involvement and nation in future research.

The findings presented here reiterate the well established opinion that with higher trust come more positive attitudes. However, they also find that increased scientific knowledge has a negative influence on approval. This negative association is counter to prevailing understanding that suggests more knowledge results in more favourable attitudes. However, it is not the first instance in which a negative influence has been found (e.g. Sturgis, Cooper and Fife-Schaw 2005). Without wanting to place too much emphasis on this peripheral finding, it does nevertheless undermine the view: 'to know science is to love it'. For the current case of future genetic science applications, it may be that more knowledgeable persons are sceptical because they also know of the limitations of current scientific understanding regarding genomics.

This study also aimed to understand how political efficacy and belief in public efficacy influence people's attitudes to science governance. Beyond the earlier discussion of this study's hypotheses, the type of science governance people opt for was found to be influenced by efficacy in a simple but interesting way. That is, it is simple at a statistical level but the practical implications may be more complicated. This study has found that the effect of raising efficacy is determined by the governance principles people begin with. Raising political efficacy is only likely to have an effect on people's choice of governing principles for those who start with a preference for a scientific democratic system of governance. This means, raising political efficacy may result in someone moving from scientific democratic principles to any of the other type of principles (though most likely a variant of elitism) but this will not have any effect on those originally opting for any other type of principles. Whereas any successful attempts to raise belief in public efficacy will only invoke a shift in principles for scientific elitists. This presents a situation where increasing agency has very specific effects depending on *whose* agency is being raised and also what *type* of agency is being raised. In its broadest terms, the implications for policy and practice are thus: raise political efficacy if you want science to continue to be governed by experts; raise belief in public efficacy if you want to increase public involvement in decision making and/or want less permissive attitudes. This is where the practical complications mentioned above become apparent. Firstly, how can efficacy be raised? Secondly and even more problematical, how can one type of efficacy be raised without the other? These are questions for both practice and research. Evaluation of public involvement initiatives is still sparse and embryonic (for some examples and discussion see: Rowe et al., 2005; Einsiedel, 2002) but the findings presented here support the inclusion of the measurement of participant's efficacy in such evaluations. This may then allow the mechanisms underlying attitudinal change to be better understood. The measures of efficacy used here do appear to be relevant to the study of attitudes towards genetic science and science governance. However, there is a need to develop valid, reliable and more comprehensive measures of efficacy, of which examples are available in other research areas (e.g. Bandura, 1997, 2000, Fernandez-Ballesteros et al., 2002), and to incorporate these into future research, monitoring and evaluation.

This study has built on previous exploratory work to show that it is important to consider perceived efficacy in its different forms as these are likely to relate to attitudes towards science in unique ways. Also, findings indicate the effects of increasing efficacy may result in a whole array of outcomes depending on whose and what type of efficacy is being increased. Overall, the findings here provide further support for suggestions that it is simplistic to consider increasing public involvement as a way of increasing the approval of risky new technologies (Barnett, Cooper & Senior, 2007). The findings also show that more needs to be understood about the nature of the effects associated with public participation, perhaps by evaluating public involvement activity at the psycho-social level to uncover what change underlies any attitudinal shift. As discussed in the analysis sections, the measure of trust used in this study is partial and there is scope to further investigate the relationships discussed here with a more comprehensive measurement of this important variable. Additionally, the role of efficacy should be considered for other technological and scientific applications. Though belief in public efficacy plays a greater role than political efficacy in predicting this study's quite general measure of attitudes to genetic science, it is uncertain whether this would be true for all types of genetic science application. Datasets containing more robust measures of attitudes to specific applications and also more robust efficacy measures would allow greater analytical scrutiny. Finally, further understanding of the role of efficacy could be obtained through research which identifies the structural pathways and, if possible, causal pathways linking efficacy and the publics formation of attitudes towards science and technology.

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Notes

[1] According to G. David Garson (n.d.) and Andy Field (2005) current opinion suggests at least three variables be used to compute factor scores.

[2] Data obtained from our *trust in industry* item correlate well with other data collected from respondents' perceptions on the effects of: newspapers & magazines reporting on S&T ($r = .364$, $p < 0.001$); TV & radio reporting on S&T ($r = .385$, $p < 0.001$); scientists in universities ($r = .390$, $p < 0.001$); consumer organisations testing new products ($r = .297$, $p < 0.001$). A composite of these four items with our trust in industry item would provide a reliable scale (Cronbach's $\alpha = 0.75$) but the substantive value of combining perceptions about

such disparate groups was felt inappropriate for this study's aims. It was therefore concluded to progress with a single item measure of trust in pursuit of greater face validity.

[3] In light of the earlier discussion regarding the face validity of combining dissimilar trust measures it is appropriate to consider the selection of variables chosen here. The ensuing analysis and discussion will make reference to findings in terms of attitudes towards and/or approval of genetic science and it is important to remember that in reality attitudes and/or approval may vary considerably between applications. However, in this exploratory work with a dataset of limited options this combination of applications is felt reasonable as even though the applications differ in applied terms they can all clearly be seen to be grounded in genetic science.

[4] These comparisons of Beta (or *Standardised B*) values indicate the number of standard deviation changes in the 'attitudes to genetic science' variable that result from a single standard deviation increase in the relevant predictor variable. It is important to note that this is only true when all other variables in the model are held constant.

[5] Minus income as it was not available in the dataset.

[6] Please contact the authors for more details of both nested models.

[7] This interpretation can be made for any of the odds ratios shown in Table 4. An interesting and simplified example to draw attention to is: the odds of being a scientific democrat for people in Northern Ireland are 2.8 times the odds of being a scientific elitist.

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Table 1. Factor Loadings of Seven Efficacy Items, After Oblimin Rotation

Item	Factor	
	1	2
Political interest	**0.72**	0.03
Politically informed	**0.68**	-0.10
Attitude to political involvement	**0.51**	0.22
Contributing to political decision making	**0.68**	0.17
Getting heard in politics	**0.63**	-0.13
Importance of public involvement (S&T)	0.15	**0.64**
Satisfaction with public involvement (S&T)	-0.09	**0.62**

Notes: N = 512; Factor loadings higher than 0.40 are in bold; χ^2 (8) = 63.356, $p < .001$; factors are correlated: r = 0.22; factor interpretations: 1 = PE; 2 = BPE.
Source: Eurobarometer 63.1, 2005; UK & Northern Ireland.

Table 2. Ordinary Least Squares Regression Models Predicting Attitudes Toward Genetic Science

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.510 * (.204)	0.550 ** (.204)	0.914 *** (.243)	-0.132 (.331)	-0.194 (.334)	0.087 (.355)
Age (years)	-0.007 *** (.002)	-0.007 *** (.002)	-0.008 *** (.002)	-0.008 *** (.002)	-0.008 *** (.002)	-0.008 *** (.002)
Gender: male	0.347 *** (.077)	0.322 *** (.078)	0.360 *** (.079)	0.347 *** (.077)	0.344 *** (.077)	0.328 *** (.077)
Education (by age)	-0.017 † (.009)	-0.019 * (.009)	-0.015 † (.009)	-0.011 (.009)	-0.009 (.009)	-0.008 (.009)
Nation: Northern Ireland	0.044 (.090)	0.048 (.090)	0.042 (.090)	0.037 (.090)	0.041 (.090)	0.033 (.090)
Attentiveness		0.074 † (.043)	0.105 * (.044)	0.074 † (.044)	0.093 * (.046)	0.118 * (.047)
Scientific Knowledge			-0.045 ** (.016)	-0.040 * (.016)	-0.037 * (.016)	-0.030 † (.016)
Trust in industry				0.289 *** (.064)	0.284 *** (.064)	0.283 *** (.064)
PE					-0.058 (.048)	-0.044 (.048)
BPE						-0.094 * (.041)
R^2	.071	.077	.093	.134	.137	.147
Adjusted R^2	.063	.067	.081	.120	.121	.130
Standard error of the regression	.803	.801	.795	.778	.778	.774
Statistical significance of change in R^2	---	.085	.006	.000	.223	.024

† p < .10; * p < .05; ** p < .01.; *** p < .001

Notes: Standard errors in parentheses. N = 442

Source: Eurobarometer 63.1, 2005. UK & Northern Ireland.

Table 3. Regression of Age, Gender, Education, Nation, Attentiveness, Scientific Knowledge, Trust in Industry, PE and BPE on Attitude to Genetic Science

Variables	B	SE	Beta	T	Sig T
Age (years)	-0.01	0.002	-.19	-3.96	.000
Gender: male	0.33	0.077	.20	4.24	.000
Education (by age)	-0.01	0.009	-.04	-0.90	.366
Nation: Northern Ireland	0.03	0.087	.02	0.38	.707
Attentiveness	0.12	0.047	.13	2.50	.013
Scientific Knowledge	-0.03	0.016	-.09	-1.86	.064
Trust in industry	0.28	0.063	.20	4.46	.000
PE	-0.04	0.048	-.05	-0.91	.361
BPE	-0.09	0.041	-.11	-2.27	.024
Constant	0.09	0.355		0.24	.807

Notes: Adj r^2 =0.13, $F(9, 432) = 44.691$, Sig. $F = 0.000$.

Source: Eurobarometer 63.1, 2005. UK & Northern Ireland.

Table 4. Multinomial Logistic Regression Predicting Governance Choice with Scientific Elitists as Reference Category (Odds Ratios)

	scientific democrats	moral elitists	moral democrats
Age (years)	1.00 (ns)	1.01 (ns)	1.00 (ns)
Education (in years)	0.98 (ns)	1.05†	0.99 (ns)
Religiosity	1.02 (ns)	1.14*	1.11†
Trust in industry	0.73 (ns)	0.66*	0.75 (ns)
Attentiveness	0.50**	0.77 (ns)	0.74†
Scientific Knowledge	0.81**	0.89*	0.85**
PE	0.61*	1.07 (ns)	1.00 (ns)
BPE	1.60*	1.17 (ns)	1.19 (ns)
Gender: Male	1.84†	1.57†	1.37 (ns)
Nation: Northern Ireland	2.81*	1.30 (ns)	1.71 (ns)

† $p < .10$; * $p < .05$; ** $p < .01$.

Notes: N = 438; Cox and Snell = .161; Nagelkerke = .176.

Source: Eurobarometer 63.1, 2005. UK & Northern Ireland.

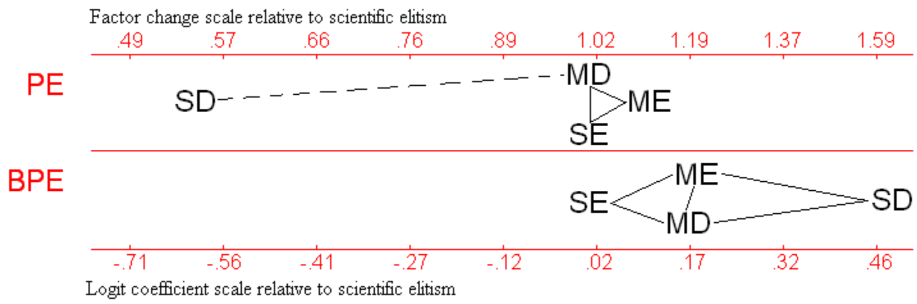

Figure 1. Odds Ratio Plots for Predicting Science Governance Choice (with Scientific Elitists as the Reference Category)

Full line p > .10; dotted line p < .10; no line p < .05.
Notes: SE: scientific elitists; SD: scientific democrats; ME: moral elitists; MD: moral democrats.
The plots show the change in the proportional odds of opting for SD, MD or ME rather than scientific elitism for a single standard deviation increase in PE or BPE, when all else is held equal. The lines or absence of lines in the plots also show the significance of PE and BPE as predictors of all other comparisons of science governance categories.

Source: Eurobarometer 63.1, 2005. UK & Northern Ireland.