AUTHOR VERSION

Public Attitudes to Genomic Science: An Experiment in Information Provision

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Abstract

We use an experimental panel study design to investigate the effect of providing ‘value-neutral’ information about genomic science in the form of a short film to a random sample of the British public. We find little evidence of attitude change as a function of information provision. However, our results show that information provision significantly increased drop-out from the study amongst less educated respondents. Our findings have implications both for our understanding of the knowledge-attitude relationship in public opinion toward genomic science and for science communication more generally.

Key words: deficit model; public attitudes; genetic science; genomics; information

INTRODUCTION

A key, perhaps definitional, fault-line in the inter-disciplinary field of public understanding of science (PUS) derives from dissensus regarding the importance of factual scientific knowledge in forming and maintaining public attitudes to new and emerging technologies. A fascination with the knowledge-attitude nexus in the study of science in society has emerged for two primary reasons. First, industrialists, scientists, and policy makers have historically attributed citizen resistance to techno-scientific progress to ignorance and misunderstanding of the underlying ‘facts’ (Irwin and Wynne 1996; Wolpert 1992). Second, since systematic measurements of public attitudes towards science and technology first began in the middle of the last century (Withey 1959), the empirical record throughout the world has consistently shown that citizens’ evaluations of scientific developments tend to be correlated with their level of ‘textbook’ scientific knowledge (Allum et al. 2008; Miller 2004). Information, then, appears to have some bearing on public evaluations of the utility and moral acceptability of scientific research programmes. Within this research tradition, however, whether retention of scientific information is associated with greater support or opposition, is an empirical question to be addressed within each particular context. It is not an *a priori* assumption (cf. Evans and Durant 1995; Sturgis, Cooper and Fife-Schaw 2005).

Thus we have, on the one hand, an *hypothesis* advanced by, often vested, interest groups and on the other an *empirical regularity* in need of a convincing theoretical explanation. At times these linked but nonetheless distinct influences on the development of theory and research in PUS have been conflated in the form of the by now infamous “deficit model” – the idea that ‘to know science is to love it’ or, by implication, that to be ignorant of science is to hate it. As has been argued elsewhere, this elision is unfortunate because, by characterising research into the informational bases of scientific attitudes as propounding the

deficit model, researchers have been discouraged from potentially fruitful avenues of research (Bauer, Allum and Miller 2007; Sturgis and Allum 2004).

The weight of evidence from over fifty years of cross-national research now leaves little room for doubt that, in the majority of contexts, there exists a small but robust correlation between ‘textbook’ scientific knowledge and evaluations of the usefulness and acceptability of scientific programmes and their associated technologies. Sometimes this relationship is positive, other times it is negative. Having resolved the question of *whether* attitudes are related to what people know about science and technology, it is now time for PUS research to focus attention on an elucidation of how this correlation comes about. Does information about the ‘facts and processes of science’ (Miller 1998) exert a direct causal influence on attitudes, or is the association a function of some unmeasured variable(s)? If the relationship is spurious, what is the variable that has so often been omitted from existing studies? If the relationship is causal, what is the mechanism underlying the effect? Under which conditions can we expect the effect to be manifested and which not? When should we expect scientific knowledge to lead to more favourable and when to more negative evaluative tendencies?

The goal of this paper is to take a step toward addressing some of these questions. We present the results of a study in which a random sample of the British public were randomly assigned to experimental conditions which manipulated the provision of ‘value-neutral’ information about genomic science in the form of a short educational film. We compare the experimental groups on a range of attitudes toward different aspects of genomic science before and after viewing the film to a control group who were not shown the films.

The idea that information about science, no matter how apparently factual it may be, can be considered completely neutral with respect to core human values and beliefs is itself problematic. The balance of factual information one selects for inclusion and exclusion may,

for instance, reflect existing ideological positions.ⁱ While full consensus on the complete neutrality of scientific information of the sort used in this study is never likely to be achieved, however, we contend that this type of factual information can be distinguished from un-evidenced claims and argumentational discourses which generally characterise scientific controversies. Furthermore, when resistance to controversial technologies *is* blamed on public ignorance, it is generally ignorance of the underlying science to which protagonists refer. Thus, although we explicitly disassociate our approach from any simple linear deficit model, this study can also be seen as a test of its central claim; that more factual scientific information will lead to more favourable attitudes.

Our choice of genomics as the focus of our analysis in this study is quite deliberate. It is a controversial area of modern science in which public knowledge is generally low and public opinion often polarized into camps of trenchant supporters and opponents. A strong candidate, therefore, for claims – and counter-claims – that public attitudes towards its associated applications and technologies have, at least to some extent, an informational basis. By focussing on a specific area of modern science, rather than science in general, we can also be more confident that our findings relate to real citizen preferences toward the practices which together constitute the field of modern genomics, as opposed to symbolic responses to some abstract notion of ‘science’.

The paper proceeds as follows. We begin with a review of existing studies into the relationship between knowledge and attitude in the area of genomic science. We then describe the design of our study and detail how the experimental manipulation of information provision was implemented via a short film, integrated within a face-to-face survey interview. Next we set out the results of our analyses, before concluding with a consideration of our results for our understanding of the mechanism linking knowledge of genomic science with expressed preferences.

KNOWLEDGE OF AND ATTITUDE TOWARD GENOMIC SCIENCE

In this section of the paper, we review existing quantitative investigations of the relationship between scientific knowledge and attitudes to modern genetic science and its associated technologies in general populations. We restrict our attention to quantitative studies of general populations because, while valuable, qualitative and other non-probability-based methods do not - and are not intended to - come to an unequivocal determination of the direction and magnitude of relationships between variables and are limited in the extent to which results may be generalised to the general population, which is our focus here.

Several studies report significant and positive associations between knowledge and engagement with biotechnology, variously conceived, and attitudes toward different aspects of genomic science. In an analysis of the 2000 Eurobarometer survey Gaskell et al. (2003) find what they refer to as the 'engaged public' to be significantly more likely to endorse a range of biotechnological applications as both morally acceptable and useful for society. A similar pattern is reported by Pardo et al in the 1996 round of the same survey, where public knowledge and awareness of biotechnology were unrelated to the perceived risks of biotechnology but showed a moderate, positive correlation with an index of perceived benefits (Pardo, Midden and Miller 2002).

Using British data, Sturgis et al (2004) show knowledge of genetic science to be positively associated with more favourable attitudes across a broad range of genomic applications. While, in the United States, Miller and Kimmel (2001) report their index of biomedical literacy to be positively related to optimism about biomedical science. Nisbet (2005) and Brossard and Nisbet (2007) also find more knowledgeable American respondents to hold more favourable attitudes toward stem cell research and agricultural biotechnology respectively, though both of these latter studies are careful to emphasise that the effects were

small in relation to other predictors, and strongly moderated by existing religious and ideological positions.

Most recently, in a meta-analysis of over nearly 200 surveys across 40 countries over a period of 15 years, Allum et al (2008) find knowledge of science in general to be unrelated to attitudes toward both GM crops and food and biomedicine. However, when matched with a measure of knowledge of biotechnology, a positive and significant association was found across the studies examined.

While the idea that knowledge of genomic science fosters a more positive outlook finds consistent empirical support in these studies, then, there is also evidence that the relationship may work in the opposite direction. Pardo et al (2002), for instance, find that, while better informed members of the European public perceived the benefits of biotechnology most favourably, they were also less convinced of the potential it has to improve individual quality of life in the future. Similarly, Midden et al. (2002) find better informed European publics to be more likely to hold negative expectations about the likely outcomes of biotechnology over the ensuing twenty years. Singer et al (2004; 2005) also report negative associations between knowledge and attitude within the American public. In an initial study, they show that, although black and Hispanic respondents were less knowledgeable than whites about genetic testing, they were also more in favour of its use, both pre-natally and amongst adults. In their subsequent study, the authors demonstrate factual knowledge of genetics to be broadly unrelated to attitudes toward genetic testing, though more knowledgeable respondents were both more optimistic *and* more pessimistic in their evaluations of the future influence of genetic testing in society.

All of the studies reviewed thus far are based on cross-sectional surveys and, as we argued at the outset, are therefore limited in their ability to yield insight on questions of causal ordering. An exception to this general rule is an ambitious panel study conducted in Britain by

the National Centre for Social Research (Stratford, White and Park 2001). The study interviewed a random sample of the British public on three occasions during 1999 and 2000, during which time respondents were provided with information about gene therapy, first in the form of a magazine and then, some months later, via a film sent to them on vide tape and by group discussion.

The authors report that knowledge of biotechnology increased over the course of the study and that respondents who attended group discussions and watched the video became more positive about human genetic research. However reservations about specific applications of gene therapy, such as germ-line therapy, and treatment of ‘cosmetic’ conditions such as male-pattern baldness were also found to increase for the same respondents. A limitation of this study, however, is that it did not include a control group against which to compare those exposed to the various information interventions. This means that attitude change deriving from information and deliberation cannot be distinguished from maturation in the broader population.

A second study employing an information intervention is reported by Sanderson et al (2005). Using a postal survey of residents of Oxfordshire in England, they randomly assigned sample members to either receive, or not receive an information leaflet about genetic testing alongside a self-completion questionnaire. They demonstrate that respondents in the group receiving the information leaflet were significantly more knowledgeable about and interested in genetic testing, as well as being more positive and holding fewer negative attitudes, relative to the control group.

In sum, then, our review of existing studies into the relationship between public knowledge and attitude in the area of modern genetic science can be characterised as showing a mix of negative, positive and non-significant results. However, the pattern of findings is not evenly distributed across these categories; significant positive relationships are the most

frequently observed by some margin. While the relationship is clearly, then, not a straightforward one, our review of the extant literature provides some *prima facie* evidence of a causal relationship between knowledge of and attitude toward genomic science.

RESEARCH DESIGN

Our data for this study is a three wave experimental panel survey, where the experimental treatment is the provision of information about genomic science, in the form of a short film. The first wave of the panel was the 2003 British Social Attitudes survey, which achieved a response rate of 60%, yielding 3270 achieved interviews (see Park et al (2004) for methodological details and Sturgis et al (2004) for substantive findings). Interviews were conducted face-to-face via Computer Assisted Personal Interview (CAPI) between July and November 2003. As part of the first wave interview, respondents were asked if they would be willing to be re-interviewed at a later date, with 1940 (59%) giving their consent.

Interviewing for wave 2 took place 4-9 months later, during March and April 2004. A stratified random sample of 1200 respondents was selected for re-contact from amongst the 1940 wave 1 respondents who had agreed to be re-contacted. Complete interviews were achieved with 867 respondents, yielding a wave 2 response rate of 72% (dropping to 34% if wave 1 respondents who declined to be re-contacted at wave 2 are included in the base). Wave 2 respondents were randomly allocated to one of three conditions: group 1 were shown a film about genomic science (the 'short' film); group 2 were shown the same film about genomic science, plus an additional film covering aspects of regulation of genomic science in the UK and Europe (the 'long' film); group 3 were shown no film.

All 3 groups were administered the same set of attitude questions covering 7 different aspects of genomic science that had also been administered at wave 1. They were also administered a question eliciting their interest in modern genetic science and a 4 item genetic

knowledge quiz (question wordings provided in the appendix). Additionally, groups 1 and 2 were administered a number of questions at the end of the wave 2 interview eliciting their perceptions and evaluations of the films they had seen. For the 2 treatment groups the film was shown prior to administering the questionnaire on the laptop computers used to conduct the interviews.

A third wave of interviewing took place during August and September 2004 via Computer Assisted Telephone Interview (CATI). Interviews were attempted with all wave 2 respondents and a response rate of 53% was achieved, yielding 458 complete interviews. Respondents were administered the same questions as were administered at waves 1 and 2. The third wave of interviewing enables us to assess the longer-term duration of any attitude change observed between waves 1 and 2 and to detect attitude change occurring subsequent to the wave 2 interview.

THE FILM

The film shown to respondents in the wave 2 interview was produced by members of the research team in conjunction with an independent television production companyⁱⁱ. The script was written with the aim of providing ‘value-neutral’ factual information in a manner that would be comprehensible to members of the general public about the science, technological applications and regulation of key areas of modern genomics. The film covered the following overlapping areas, which were selected to match the areas surveyed in the wave one interview and to cover the core principles and some primary technological applications of modern genetic science: genetic transmission of DNA via sexual reproduction; genetic testing, genetic modification of animals and plants, animal and human cloning; stem cells; and the legal and regulatory framework of genomic science.

Two versions of the film were produced, one with and one without the material covering the legal and regulatory framework of genomics. The shorter version of the film lasted for 5 minutes and 40 seconds, the longer version for 9 minutes exactly. Drafts of the script and accompanying footage were considered for accuracy, neutrality and comprehensibility on 2 separate occasions by the project advisory board which included members from academic, industry and stake-holder organisations.ⁱⁱⁱ The film can be obtained from the UK Economic and Social Data Service (study number_SN5147).

MEASURES AND ANALYSIS

Our analysis focuses on 7 multi-item attitude scales that were administered at all 3 waves of the study, covering the following areas of modern genetic science:

- General attitude to genetic science (3 Items)
- Attitude toward genetically modified crops and foods (6 items)
- Attitude toward Pre-implantation Genetic Diagnosis (4 items)
- Attitude toward Human Cloning (4 items)
- Attitude toward Gene Therapy (4 items)
- Trust in modern genetic science (3 items)
- Attitude toward the construction and use of genetic databases (3 items)

The 27 items were analysed as 7 multi-item scales rather than as individual items in order to protect against measurement error and to mitigate the effects of multiple hypothesis testing in assessing the effect of viewing the film on attitude change. It should be noted, however, that analysing each of the 27 items separately provides essentially the same pattern of results as we present here. An additional 3 item scale intended to tap beliefs about the balance between genes and the environment in determining human traits and behaviours was dropped from the

analysis presented here. This is because we encountered irresolvable convergence problems in estimating a common latent factor for these 3 items across all waves. Full question wordings for all 27 items are provided in the appendix.

Given the specification of our attitude measures as latent variables, a structural equation modeling (SEM) framework is appropriate to test for changes in the means on the attitudes across groups over time. For each attitude, we specify a latent variable measured at 3 time points by the same multiple indicators. The factor loading for the first item in the scale is set to 1 at each wave for purposes of identification and to set the scale of the latent variable (Bollen 1989). This means the scale of the latent variable is taken from this reference item. We constrain the factor loadings and intercepts for the same indicator to be equal over time in order to ensure that the meaning and interpretation of the items is consistent across groups and over time (Meredith 1993). Error variances for the same indicator variable and the disturbances of the endogenous variables are permitted to covary across waves (Finkel 1995). A schematic version of the model with 3 indicator variables is presented as a path diagram in Figure 1 (error covariances are not shown in figure 1).

FIGURE 1 HERE

We use a multiple group model (Hayduk 1987), with the groups defined by the experimental and the two control conditions. The mean of the latent attitude variable is constrained to zero for the control group at the first wave of measurement, for purposes of identification. In this model specification, the means of the latent variables for the remaining conditions are the *difference* between each group at each time point and the mean for the control group at time 1 (Sorbom 1974). Significant differences in latent means within and between groups can be

tested for by comparing the (log) likelihood of this model to that obtained from a model in which the latent means are constrained to be equal across groups.

The latent attitudes are specified as endogenous to 4 covariates, measured at wave 1, which are predictive of dropout between waves 1 and 2 and waves 2 and 3. These are age in years, highest educational qualification, self-reported interest in genetic science and knowledge of genetic science. Introducing predictors of dropout as covariates in the mean structure model enables us to correct for differential dropout across groups. We use a direct maximum likelihood estimator^{iv} which is unbiased and efficient assuming data to be missing at random (MAR)^v, conditional on the covariates which are predictive of missingness (Arbuckle 1996; Bollen and Curran 2006; Wothke 1998). Global measures of model fit, which demonstrate that the models provide a good fit to the data by conventional standards (Hu and Bentler 1999), are provided in table A1 in the appendix. All models are estimated using Amos 7.

RESULTS

Before presenting our analysis of the effect of viewing the film on the 7 attitude measures, we first consider the influence that presentation of the film had on retention rates between waves 2 and 3 of the study. Our initial motivation for conducting this analysis was to describe and correct for differential nonresponse in our analysis of attitude change. It transpires, however, that the pattern of dropout from the study is informative in substantive, as well as in methodological ways. Table 1 presents the results of a logistic regression, where the dependent variable is a binary indicator, coded zero for respondents that remained in the study for waves 2 and 3 and coded 1 for respondents who completed waves 1 and 2 but dropped out in wave 3. The two experimental conditions are combined in table 1 for the sake of

parsimony, as the coefficients for the 2 groups were not significantly different from one another (with $p < 0.05$).

TABLE 1 HERE

The coefficients in table 1 show that, as we might expect, dropout is higher amongst those with less interest in genomic science and amongst those who scored lower on a genetic science knowledge quiz. Younger people are also more likely to drop out between waves 2 and 3. Of greater substantive interest, however, is the significant negative interaction between experimental condition and the educational level of the respondent. Individuals at the lower end of the qualifications distribution have a significantly lower probability of providing an interview at wave 3 if they viewed the film, compared to those with the same level of education in the control group and those with higher qualifications who also viewed the film. This can be seen more clearly in Figure 2, which plots, separately for treatment and control groups, the predicted probability of dropout between waves 2 and 3 by highest educational qualification.

FIGURE 2 HERE

The film is clearly deterring less well-educated respondents from continuing to participate in the study; amongst those with no qualifications nearly two thirds dropped out by wave 3 if they were shown the film, compared to only 40% of those in the control group. Given that it is precisely this type of individual that public engagement and information programmes are primarily aimed at, this finding has some rather pessimistic implications. That is to say, providing this type of factual information – even in the comparatively accessible medium of a

narrated documentary film - may serve to exacerbate rather than diminish existing informational asymmetries within general populations.

Next we consider respondents' own evaluations of the comprehensibility, accuracy, and neutrality of the films they were shown. On the whole, these evaluations were positive with only 2% of respondents describing the film as either 'not very' or 'not at all' accurate, 90% reporting that they understood at least half of the film, or more and only 16% describing the material in the film as 'not relevant' to the questions they had subsequently been asked. For the most part, respondents also found the film interesting to watch, with 79% describing it as either 'very' or 'fairly' interesting, 10% as 'neither interesting nor uninteresting', and 9% as 'not very' or 'not at all' interesting. On the other hand, most respondents had only a rather dim recollection of the film when interviewed at wave 3, with only 19% reporting that they could remember about half or more of the film.

These are, of course, subjective accounts which are susceptible to the well-known biases and errors of recall and judgement (Tourangeau, Rips and Rasinski 2000). We do, however, have some more objective indices of how interesting and informative respondents found the film. Table 2 shows, for treatment and control groups at all 3 waves, the means for self-reported interest in genetic science, the 4 item factual knowledge quiz on genetic science, and number of Don't Know (DK) responses on the attitude items. There is an increase in interest in genetic science amongst the groups shown the film, which is significantly different from that observed in the control group. However, this difference had disappeared by the time respondents were re-interviewed some 4-6 months later. Given that the interest in genetic science question at wave 2 was administered immediately after respondents in the treatment groups were shown the film, this is hardly impressive evidence of a durable increase in interest in the subject matter.

TABLE 2 HERE

Scores on the factual knowledge battery showed a similar elevation in the treatment groups after viewing the film. However, this increase was also observed in the control group, so cannot be attributed as an effect of the film. It is not clear from the data why knowledge scores in the control group increased between the first and second waves of the panel, although it is likely to result from the increased awareness and attention respondents pay to the subject in the intervening months, as a result of the cognitive stimulus provided by the questions in the first wave interview (Traugott and Katosh 1979). Whatever its cause, the increase in factual knowledge was still evident when respondents were interviewed for a third time, between 3 and 5 months later.

The same general pattern is observed for DK responses; we see a reduction in non-substantive responses between waves 1 and 2 amongst those shown the films but, somewhat counter to expectation, the same reduction is also observed amongst the control group. Presumably, the same stimulus to internal reflection and increased attention to genomic issues in the media as a result of the first wave interview underlies this reduction in DK responses in the control group. For DKs, however, the effect did not persist into the third wave of the panel for either the treatment or control conditions. Whatever the cause of these changes, they highlight the importance of including a control group in studies incorporating an intervention. Without the control condition, we would wrongly attribute the changes in the treatment groups to viewing the film.

From more objective measures of the effect of the films on engagement and understanding, then, a more ambiguous picture emerges – what little respondents in the film conditions appear to gain in knowledge of and engagement with genetic science is either matched by those in the control group, or has entirely dissipated less than 6 months later.

Turning now to our primary focus on the effect of information on attitudes, table 3 presents means and standard errors for the 7 latent attitude variables for the 3 experimental groups across the 3 waves of the panel. These are the estimates from the structural equation models described on page 13 and displayed graphically in figure 1. The first thing to note about table 3 is the paucity of significant effects, both within and across treatment groups.

TABLE 3 HERE

On 4 of the attitude variables – those toward GM foods, pre-implantation genetic diagnosis, human cloning, and gene therapy, there is no change at all. Two attitude variables – general attitude to genetic science, and attitude to genetic databases show significant shifts in their means over time at the 95% level of confidence. However, while these temporal changes are not uniform across the treatment groups, none of them can be attributed to the effect of the film, as we are not able to reject the null hypothesis of zero difference between control and treatment groups at waves 2 and 3 at conventional levels of confidence.

The only significant experimental effect is found for trust in genetic scientists, where the group shown the short film became somewhat more trusting (an increase of 0.42 units relative to the control group at time 1) after seeing the film. The pattern of difference between the treatment and control groups persists on this attitude at the third wave, though by this time it has become non-significant. In sum, then, table 3 shows little evidence of an influence of either the short or the long version of the film on attitudes toward these different aspects of genomic science, immediately after the film was seen, or some 3-5 months later.

DISCUSSION

We began this article by emphasising the need for PUS research to move beyond correlation-based, cross-sectional studies in order to more adequately address its most persistent explanandum - how knowledge of the facts and processes of science conditions opinion toward different areas of science and technology. In this study we have employed an innovative experimental panel study design which enabled us to manipulate the provision of value-neutral information about genomic science and its regulation to a random sample of the British public. Respondents who viewed short educational films about genomic science showed no real evidence of increased knowledge and interest in genomics, relative to respondents who were provided with no information at all. In terms of effects on attitudinal outcomes, only one significant difference between treatment and control groups was observed; the group receiving information about genetic science alone became more trusting of genetic scientists, relative to the control group after viewing the film in wave 2 of the study. However, this was a small difference in substantive terms and did not persist until the third wave of the study. For the six remaining attitudes examined, no significant differences were found between experimental and control conditions at any wave.

We found no effects of information provision as a function of the *type* of information provided. That is to say, the group that received information about the regulation of genetic science showed no significant differences from the group that were provided with information about genetic science only. There is growing consensus that what constitutes knowledge of science in advanced democracies, extends well beyond the simple learning of accumulated ‘facts’. What has been referred to as the ‘contextual’ model of public understanding of science (Jasanoff 2000; Sturgis and Allum 2004; Yearley 2000) highlights the importance of other knowledge domains that may be equally, or even more important, determinants of public attitudes to science than formal learning of the scientific canon (Bauer, Petkova and Boyadjieva 2000). A lack of public awareness about the regulation of genetic technologies

has been highlighted in this context as potentially undermining public trust in institutions and actors such as government, genetic scientists and food producers (Priest, Bonfadelli and Rusanen 2003). Our results provide no support for this hypothesis, even on the ‘trust in genetic scientists’ attitude scale, which one would expect on a priori grounds to be most susceptible to change as a function of information about the legal and regulatory framework within which genomic research is conducted. Though the ‘trust in genetic scientists’ variable was the only one on which a significant difference between treatment and control groups was observed, this effect was only found for the group shown the short film about genomic science only.

Though we have been careful to differentiate our analysis of the informational basis of techno-scientific attitudes from the simple linear deficit model, the analysis we have presented here can nonetheless be construed as a test of its central tenet – that more information about the facts and processes of science will lead to more favourable attitudes. Our results provide no support for this contention. It is generally unwise, however, to take the results of complex empirical investigations at face value. Let us consider some alternative explanations of our failure to detect much of an influence of information on attitude before concluding that existing correlational evidence is spurious.

The first of these relates to the high differential dropout from the study at each wave. There were at least 4 points during the study at which eligible sample members were able to drop out. This means that, for our estimates of attitude change between waves 1 and 2 of the panel, we achieved a net response rate of 43%. Respondents completing all 3 waves of the study represent just 23% of those eligible to participate. Furthermore, we know from our attrition analysis that dropout was not random: younger people, those with less interest in and understanding of genomics, and those with less formal education were significantly more likely to drop out at each wave.

Thus, those most likely to drop out of the study are also those who are potentially most susceptible to information effects. By progressively selecting themselves out at each stage, the pool of ‘low information’ respondents steadily diminishes, reducing the scope for detecting attitude change in response to the information provision. Although our analyses make statistical adjustments which mitigate this nonresponse bias to a degree, we cannot discount the possibility that more non-zero effects, and effects of greater magnitude might have been observed, had higher response rates been achieved.

While generally regarded as little more than a statistical nuisance, differential dropout from a longitudinal study of this nature can also be substantively interesting. The fact that dropout between waves 2 and 3 was highest amongst those with low educational qualifications who were shown the film highlights the primary problem with ‘didactic’ approaches to science communication. It is often assumed, from a science communication perspective, that an effective way of changing attitudes toward different areas of science and technology is to inform the public through various forms of science education initiative (Bodmer 1985; Wolpert 1992). Our findings provide a caveat to this view; the effect of providing information may result in the least informed and engaged members of the public ignoring or avoiding the medium of communication altogether, leading to the classic ‘information paradox’, where the provision of information exacerbates rather than ameliorates knowledge and attitude asymmetries in the general public.

Another possible reason for our failure to detect experimental effects in this study relates to the issue of statistical power. That is to say, was our sample of sufficient size to detect differential attitude change across treatment and control groups? Analyses conducted prior to data collection suggest that our statistical tests have sufficient power to detect even small differences across groups.^{vi} Unless we are talking about very small changes indeed,

then, our failure to reject the null hypothesis of zero change in the majority of the tests we have performed is not a matter of under-powered tests.

Other important objections to the ‘no effect’ conclusion are likely to relate to the rather ‘weak’ nature of the intervention we have used. A documentary film lasting less than 10 minutes, one might reasonably contend, is never going to increase the average person’s knowledge and understanding of a complex area like modern genomics by anything other than a trivial amount. Thus, finding no experimental effect of the film should not lead us to conclude that attitudes to genomics do not have an informational basis. This argument holds some force and it would certainly be generalising considerably beyond the evidence at hand to conclude from this study alone that scientific knowledge plays no part in the formation of attitudes to genomics. What our results do tell us, however, is that efforts to ‘educate the public’ about science and technology are often likely to have little or no impact on public opinion or, for that matter, scientific knowledge. For a short documentary film is the way in which most people might realistically come across this type of information in the modern world (Eurobarometer 2007). If an adequate understanding of science in mass publics can only be achieved via dedicated study over long periods, it is always likely to remain elusive.

The ‘weakness of treatment’ argument must also be viewed against the back-drop of the vast body of research showing that seemingly trivial aspects of questionnaire design can often have large effects on survey responses (Schuman and Presser 1981). If simply reversing the order in which 2 questions are administered can substantially alter the marginal distributions of each variable, an intervention in the form of a 10 minute film appears anything but weak. Of relevance in this regard are the results of Sanderson et al (2005) who report significant differences in interest in, understanding of, and attitudes towards genetic testing in groups randomized to receive or not receive an information leaflet about genetic testing along with a self-completion questionnaire in a postal survey. This would seem a

weaker intervention than the film used in the present study, at least insofar as there is no way of telling what proportion of the treatment group actually read the leaflet.

A possible explanation of these anomalous findings is that what Sanderson and colleagues observed might not have been attitude change but differential dropout across the treatment and control conditions as a function of the information leaflet. As was discussed earlier, our own analysis showed that individuals with lower educational qualifications were more likely to drop out of the study after viewing the film than similar individuals in the control group. Information provision, then, appears to discourage those with less cognitive and emotional engagement in the subject matter from further participation in the study. This makes intuitive sense. To the extent that propensity to drop out of a study when provided with information interventions is correlated with knowledge, interest, and attitude this dropout mechanism will give rise to sample composition differences across treatment and control groups that are indistinguishable from mechanisms of attitude change. Future investigations involving provision of information within the context of a survey would be well advised to incorporate this knowledge in research designs.

Although the results we have presented here have largely failed to detect effects of viewing a film about genomic science on subsequent opinions, our findings should not, we have argued, be interpreted as demonstrating that public attitudes toward genomic science have no informational basis. Our results relate specifically to the reception in general populations of factual information about genomic science, which was produced with the specific intention of being neutral with respect to core values and beliefs. It is, in our view, probable that different kinds of information – such as argumentational discourses around the potential risks, advantages and disadvantages of genetic science for individuals and society – would lead to potentially sizeable shifts in the attitudes we have focused on here. This would be a useful focus for future investigations in this area.

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Endnotes

ⁱ This is amply demonstrated by the UK government's public consultation on nuclear energy in September 2007 in which advocates and opponents of nuclear power, as well as those professing to be undecided, could not agree on the neutrality of the briefing information to be provided to participants.

ⁱⁱ Glasshead Limited (<http://www.glasshead.co.uk/content/>).

ⁱⁱⁱ Advisory board members are listed in the appendix. Although Advisory board members made many helpful comments on the content of early versions of the film, this should not be taken to imply their endorsement of the claim that the film is 'value-neutral'.

^{iv} This is also referred to as the Full Information Maximum Likelihood (FIML) estimator.

^v In Little and Rubin's terminology, data is missing completely at random (MCAR) when missingness on the outcome, Y , is uncorrelated with covariates, observed or unobserved. Data is missing at random (MAR) when, conditional on observed covariates, nonresponse in Y becomes MCAR. Nonresponse in Y is 'nonignorable' when the propensity to be missing on Y is itself correlated with Y (Little and Rubin 2002).

^{vi} For instance, our tests have a power coefficient of 0.8 to detect a difference in means across treatment and control groups of just 0.2, with equal standard deviations of 0.9 in each group at the 95% level of confidence. By way of illustration, this would be equivalent to 50 out of 300 respondents in the treatment group increasing their attitude score by just one unit (from say 'agree' to 'strongly agree') with respondents in the control group showing no change.