Religious Beliefs, Knowledge about Science and Attitudes Towards Medical Genetics

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Abstract

The use of genetics in medical research is one of the most important avenues currently being explored to enhance human health. For some, the idea that we can intervene in the mechanisms of human existence at such a fundamental level can be at minimum worrying and at most repugnant. In particular, religious doctrines are likely to collide with the rapidly advancing capability for science to make such interventions. The key ingredient for acceptance of genetics, on the other hand, is prototypically assumed to be scientific literacy - familiarity and understanding of the critical facts and methods of science. However, this binary opposition between science and religion runs counter to what is often found in practice. In this paper, we examine the association between religiosity, science knowledge and attitudes to medical genetics amongst the British public. In particular, we test the hypothesis that religion acts as a 'perceptual filter' through which citizens acquire and use scientific knowledge in the formation of attitudes towards medical genetics in various ways.

Introduction

The use of genetics in medical research is one of the most important avenues currently being explored to enhance human health. On the one hand, there are new therapeutic applications for genetics being developed, notably for illnesses such as Parkinson's disease (Feng & Maguire-Zeiss, 2010). On the other, there is a raft of new kinds of genetic test that can detect or predict serious diseases that have a genetic basis. Some of the most well established and most well known to the public are tests concerned with human reproduction. Pre-implantation genetic diagnosis (PGD) is routinely conducted during assisted fertility treatment, to identify embryos that will give the best chances for a viable pregnancy and healthy child. Embryos that are not selected for implantation are either stored or destroyed. Prenatal genetic testing (PGT) is used during pregnancy to screen the foetus for genetic diseases and conditions. Positive results may lead to termination of the pregnancy.

There is great potential for human health to be enhanced through medical genetics but there are also reasons to think that developments in this field will not progress without some public resistance. The science of genetics cuts to the core of how we understand the origins of life. For some, the idea that we can intervene in the mechanisms of human existence at such a fundamental level can be at minimum worrying and at most repugnant. In particular, religious doctrines are likely to collide with the rapidly advancing capability for science to make such interventions. Hence one of the most powerful bases for opposition to medical genetics, where it exists, is likely to be from religious institutions and from citizens who hold strong religious beliefs. Arguments about human dignity, the sanctity of life and the appropriateness of humans meddling with nature have all featured in such religious debates over genetics (United States Conference of Catholic Bishops, 2011).

If religious belief, or even pre-enlightenment thinking, might be one of the bases of resistance to medical genetics, the key ingredient for acceptance is prototypically assumed to be scientific literacy - familiarity with and understanding of the critical facts and methods of science (Bodmer, 1985). Armed with such knowledge and a scientific, rationalist worldview, citizens should be no more concerned with developments in the field of medical genetics than they are about antibiotics or modern heart surgery. However, this binary opposition between science and religion runs counter to what is often found in practice. Religious faith and scientific understanding are not mutually exclusive and can, and do, co-exist. This begs an interesting question about the ways in which people of differing religious commitment attend to scientific information and utilise their understanding to form attitudes towards science and, in the present case, medical genetics.

Thus far, most research on the relationship of religion to public attitudes about science has taken place in an American setting, where religion plays what seems to be an increasingly important role in public policy, politics and public opinion. In this paper, we examine the association between religiosity, science knowledge and attitudes to medical genetics amongst the British public. In particular, we are interested in the idea that strong religious commitment might act as a 'perceptual filter' (Brossard & Nisbet, 2007 ; Brossard et al., 2009) through which citizens acquire and use scientific knowledge in the formation of attitudes towards medical genetics.

Genetic research and public opinion

Since the early 1990s, there have been signs that public support for genetic research is not always automatically forthcoming, although levels are generally quite high. Many studies have estimated the degree to which publics in various countries support medical genetics across a range of substantive applications. For the general population of the USA in 2005, Hudson et al. (2005) cite the rate of approval as 67%, whilst the National Science Board (2010) positions it at 58%. Time series comparison using data from the VCU Life Sciences Survey indicates that whatever the absolute level, support for genetic research has generally increased with time (National Science Board, 2010). In Europe, medical genetics, insofar as gene therapy is concerned, has also enjoyed the support of majorities of publics, albeit accompanied by some moral concerns (Gaskell et al., 2011). Around 63 percent of Europeans support gene therapy, provided it is adequately regulated, while only around 54 percent expressed support in 2005 (Gaskell et al., 2010). Gene therapy commands the support of sizeable swathes of European publics but some other aspects of medical genetics are more likely to generate controversy.

Genetic testing and religion

Pre-implantation and prenatal genetic testing in particular (alongside embryonic stem cell research) have stimulated ethical debates regarding the status of the embryo and foetus (Ehrich et al., 2008 ; Lynch, 2009): whether or not these should be regarded as human beings and, therefore, what rights they may be entitled to. Objection to conducting tests and research on embryos, stem cells and very early-aged humans is therefore often rooted in entrenched positions on abortion and the status of human embryos, as the result of testing can be the destruction of embryos or foetuses (Parens & Knowles, 2003). The basis of these positions is very often religious. Some religious groups adhere to the belief that life begins at a particular time before birth – at conception, implantation or another time during gestation (such as when the heart begins beating or when brain function can be detected). In addition, people with higher levels of religiosity may be more inclined to subscribe to the 'sanctity of human life' ethic – thus making them disinclined to favour any technology that results in the destruction of even clusters of cells with the potential to become a human being.

The Catholic Church promotes the view that human life begins at conception (United States Conference of Catholic Bishops, 2011). Since the late 1970s, the views of many American evangelical churches also coalesced around an anti-abortion position that implies an antipathy towards genetic testing and research (Evans & Hudson, 2007).

Public opinion research on the connection between religion and reproductive genetics has clearly shown that attitudes to medical genetics and genetic testing have been voiced with reference to religious beliefs (Alikani, 2007 ; Doolin & Motion, 2010 ; Evans, 2006 ; Lynch, 2009 ; Nisbet & Mooney, 2007). Two studies that asked respondents to evaluate the status of the embryo report that approximately one quarter to one third of respondents regard the embryo as having minimal status (e.g. the same as that of a cluster of cells) and a similar proportion regard it as having status equal to that of a human being (Hudson et al., 2005 ; Pardo & Calvo, 2008). A substantial minority of respondents feel there is a moral difference between using 'spare' embryos from assisted fertility treatment, versus embryos specially created for stem cell research: Slightly fewer respondents support research using specially created embryos (Hudson et al., 2005). In multivariate analyses, religious attendance and strength of religious belief have demonstrated significant negative associations with attitudes towards stem cell research (Ho et al., 2008 ; Nisbet, 2005 ; Pardo & Calvo, 2008). Finally, a recent study examining the intentions of US citizens in relation to obtaining personal genetic tests for screening purposes finds that those who are more religiously involved have more negative attitudes to genetic testing and are less likely to themselves be tested (Botoseneanu et al., 2011). Although there is so far rather little evidence from Britain until now, we might expect to see the same general associations between genetics and religiosity hold in the present study.

Scientific knowledge

The role of scientific knowledge in the formation of attitudes towards science and technology has long been debated by scholars of public understanding of science (PUS). Certainly it is the case that the starting point for these debates was the notion propounded by the science community that underpinning lack of support for science was lack of understanding on the part of the public (Bauer et al., 2007). On the one hand, there are those that regard science knowledge or literacy as largely irrelevant to the polarity of attitudes, while other factors, for example trust, risk perception or political values are more important (Priest et al., 2003). On the other hand, a majority of empirical studies linking attitudes and knowledge tend to find modest correlations between these variables, albeit ones that differ according to the type of scientific or technological issue at hand (Allum et al., 2008). Sometimes education is used as a proxy for science knowledge, other times in combination with direct measures. Attitudes to stem cell research, for example, are positively associated with level of education (Nisbet & Goidel, 2007), issue-specific awareness (Nisbet, 2005) and attention to media reports of scientific issues (Ho et al., 2008 ; Nisbet & Goidel, 2007). Education has also demonstrated a significant positive association with openness to prenatal genetic testing (Singer et al., 1999) and pessimism about biotechnology (Simon, 2010). It is not clear whether scientific knowledge acquisition alone leads to more positive attitudes. It may be that the acquirement of information over a period of time tends also to be accompanied by the development of favourable normative beliefs about science that are unobserved in retrospective survey measures. For instance, learning about genetics at school may well confer passion for the subject from an enthusiastic teacher, irrespective of knowledge gained. Whatever the mechanism, we would expect to see some association of knowledge with attitudes to medical genetics in the current research.

Religion as a perceptual filter: motivated reasoning

Though knowledge is demonstrably relevant, it is clearly more than just a case of 'ignorance breeds contempt', and more recently scholars have focused on the social psychological context within which knowledge and information may lead to attitude change, reinforcement or formation. More sophisticated theories of science and technology attitudes draw on the notion of low-information rationality (Brossard & Nisbet, 2007 ; Popkin, 1991) and motivated reasoning (Kahan et al., 2008). Low information rationality takes as axiomatic that people are cognitive 'misers', expending only as much effort as is necessary in forming opinions. Cues that might act as a shortcut in place of more effortful cognitive engagement will suffice, even for 'rational' citizens. However, we know that populations vary in their level of science literacy and therefore have divergent cognitive resources at their disposal. Motivated reasoning, and associated theories, document the functional interaction between affective and cognitive processes, resulting in rationalisation that is biased in favour of one's own values and preferences (Mooney, 2011). A high level of investment in ideological beliefs can make one resistant to ideas that challenge (threaten) those values (Kahan et al., 2008 ; Whitmarsh, 2011). In the present case, it is proposed that religious beliefs may act as just such a 'perceptual filter' to determine which pieces of information are attended to and retained (Brossard et al., 2009). Attitudes and beliefs that come about through more intensive deliberation or reasoning processes are likely to be stronger and more resistant. Hence, we might expect that those more knowledgeable individuals with ideologies incompatible with some of the implications of medical genetics will form attitudes that are reinforced in their antagonism, compared to those relying only on low-information cues. In practice, this implies a statistical interaction between science knowledge and religiosity in the formation of attitudes towards genetic testing.

There is empirical evidence for this contention in the recent literature on the related issue of attitudes to stem cell research. Nisbet (2005) observes a negative interaction between issue-specific awareness and the strength of religious belief. Low awareness is associated with low support for stem cell research across all levels of religious belief. For those with a high level of religious belief, support does not increase with awareness, whilst for those with a low level of religious belief support for stem cell research does increase with awareness. Ho et al. (2008) noted a more extreme finding: for respondents with a high level of religiosity, a higher level of scientific knowledge is associated with lower support for stem cell research. Ho and colleagues observe a similar effect for the interaction of scientific knowledge with political ideology – for more liberal respondents, a higher level of knowledge is associated with higher support for stem cell research, whilst for those who are more conservative, a higher level of knowledge is associated with reduced support. In contrast, Nisbet (2005) found that, irrespective of ideology, low levels of awareness are associated with lower support for stem cell research and increased awareness is related to increased support. However, this effect is stronger amongst those with more liberal views. While these examples do not directly concern genetic testing, there is good reason to think that the same social psychological processes may be at work.

The present research

In this paper, then, we develop this emerging body of work which examines the joint effects of religiosity and science knowledge by evaluating its claims in the context of medical genetics and genetic testing. Almost all of the previous research has taken place using respondents from the USA, where religion plays a vastly different role in public and private life compared to Britain. We use new data to analyse the joint effects of knowledge and religiosity on attitudes to genetics amongst a representative sample of British adults. We have some general expectations about the results, given the foregoing theoretical and empirical review. Firstly we expect to see religious beliefs associated with more negative attitudes towards genetic testing and other related biomedical applications and research, along all or some of the three dimensions of religion captured in our data: frequency of attendance at services, self identification as belonging to a particular denomination and belief in a creationist account of the origins of life. Secondly, we expect scientific knowledge to be associated with attitudes to genetic testing. Citizens that possess more scientific knowledge and demonstrate more understanding of scientific process and method have tended in the empirical literature to be more positive and optimistic about science in general and sometimes in specific contexts. We would expect to see this relationship reproduced in the present context of medical genetics such that more knowledge is associated with more positive attitudes. Thirdly, the motivated reasoning perspective implies that an individual's pre-existing values and dispositions can affect the ways in which information is processed and the way that knowledge is acquired and deployed. In line with this perspective, we expect that religion might moderate the association of knowledge with attitudes towards genetic medicine. In terms of the possible direction of this moderating effect, it may be that a perceptual filter like religiosity could lead to a psychological 'downgrading' of the role of factual information in how judgments about genetic testing are made. Conversely, it may mean that those who hold more strongly religious beliefs are more likely to attend to relevant information, subsequently using that to bolster doctrinal opposition. Or it may simply be that more deeply religious citizens who possess greater scientific knowledge and understanding are likely to have arrived at a more sceptical position on genetic medicine as the result of deeper and more deliberated reasoning compared to those who are low in such knowledge and information.

Data and Methods

We use data from the first wave of the Wellcome Trust Monitor Survey. The Wellcome Trust Monitor is a cross-sectional, triennial survey of UK adults and young people, designed to track public attitudes and beliefs about biomedical science. For the present study, we use only the adult sample, which consists of 1179 respondents. Individuals were selected using a stratified probability design from households across the UK and interviewed face to face in early 2009. The response rate was 49.3% using AAPOR Response Rate 3 (American Association for Public Opinion Research, 2011). Full details of the sampling and other aspects of the survey design can be found in Butt, Cleary, Abeywardana and Phillips (2009). Our analytic strategy is to fit a series of regression models that relate our key explanatory variables of religiosity and science knowledge, along with their interactions, to beliefs and attitudes about medical genetics.

Dependent variables

The Wellcome Monitor includes several questions designed to tap beliefs, attitudes and behavioural intentions in relation to genetic testing and medical research based on genetics more generally. We fit models for four separate outcome variables. The questions, along with their univariate distributions are shown in Table 1.

Table 1 HERE

Looking at the first question, opinion is somewhat ambivalent over support for genetic testing of unborn babies, with one fifth of respondents neither agreeing nor disagreeing with the statement, although a small majority are supportive. There is stronger willingness for respondents themselves to undergo genetic diagnostic tests for serious diseases but ‘do it yourself’ testing kits are not widely supported, although there is a sizeable minority that does not entirely reject the idea. The final question taps into general optimism about the potential for medical advances through genetic research. Here, UK citizens are overwhelmingly positive, with 86 percent saying they are either somewhat or very optimistic.

Principal explanatory variables

Science knowledge is measured with a combination of survey items. Nine are factual, 'textbook' quiz questions. Allum et al. (2008) have shown that the correlation between knowledge and attitudes tends to be stronger when knowledge and attitudinal domains are matched. The items included in the Wellcome Monitor are ideal for our purposes, as most of them have a biology and genetics emphasis, as well has having been validated in previous surveys (e.g. Gaskell et al., 2011 ; National Science Board, 2008).

Figure 1 HERE

Nine statements are presented and respondents are invited to say whether they think each is definitely true, probably true, probably not true, definitely not true, or that they don't know. Responses are recoded so that correct answers (either probably or definitely) are scored as one while incorrect and 'don't know' are scored as zero. Two further survey questions are used to tap respondents' understandings of scientific methods. The first evaluates understandings of controlled experimentation:

"Suppose a drug used to treat high blood pressure is suspected of having no effect. On this card, there are 3 different ways scientists might use to investigate the problem. Which one do you think scientists would be likely to use? "

1. Talk to those patients that have used the drug to get their opinion?
2. Use their knowledge of medicine to decide how good the drug is?

3. Give the drug to some patients, but not to others, then compare the results for each group?

The second item measuring understanding of scientific process is concerned with probability. Respondents are presented with the following scenario:

"Now think about this situation. A doctor tells a couple that their genetic makeup means that they've got a one in four chance of having a child with an inherited disease…"

1. Does this mean that if their first three children are healthy, the fourth will have the illness?
2. Does this mean that if their first child has the illness, the next three will not?
3. Does this mean that each of the couple's children will have the same risk of suffering from the illness?
4. Does this mean that if they have only three children, none will have the illness?

In both cases, option three is the correct choice. The distribution of correct answers to these and all of the true/false items, along with their wordings, is shown in Figure 1. Finally, we sum all of these responses to form a scale running from 0-11. The resulting scale has a Cronbach's alpha of 0.63, which is in line with its performance in previous studies (Evans & Durant, 1995). All items have positive correlations with the total scale score and no item if removed from the scale would improve its reliability.

Religion is measured along three dimensions: denomination or affiliation, attendance at religious services and beliefs. In contemporary empirical work, these three dimensions are becoming conventional (Voas, 2009). Each of them, though, has different bases and may be expected to relate differentially with other variables. Affiliation cannot of itself be taken as an indication of strong religious commitment, as for some people it may be simply an inherited category that has no substantial effect on their behaviour (McAndrew & Voas, 2011). For this reason, we do not have firm expectations about how religious denomination relates to attitudes but we include it in the analysis.

Belief in God and in religious scriptures can be reasonably regarded as fundamental to most religions and very often this is accompanied by behaviour such as attending services and praying. Thus we should probably expect these two indicators of religiosity to be correlated to some degree. From a psychological perspective, the most widely cited approach to understanding religious belief and behaviour is due to Allport (1950), who distinguishes between extrinsic and intrinsic religious motivations (Allport & Ross, 1967). Intrinsic refers to faith and firmly held beliefs while extrinsic orientations speak to more instrumental motivations for being religious, such as going to church for social or status reasons. Thus both affiliation and attendance at religious services might depend on a variety of motivations (see also Voas, 2009) whereas beliefs might perhaps be expected to act as a purer indicator of religious conviction.

We operationalise affiliation by collapsing an original variable that included 18 categories of declared religious denomination into five: Catholic, Church of England, other Christian, other non-Christian and no religion. Given our sample size, it is not possible to drill down in any more detail into the less common religious affiliations, interesting though that would be. Respondents who say that they belong to a religion are also asked how often they attend services connected with religion, excluding weddings, funerals and baptisms. We create a dummy variable representing those respondents who report attending services at least once per month, from an ordinal indicator. This coding decision was made for three reasons.

Firstly, the observed distribution is non-normal. Secondly, there is a large substantive gap between 'at least once per month' and 'at least twice per year', which are adjacent response alternatives in the questionnaire. Thus it makes sense to separate individuals on each side of this interval. Thirdly, once a month is 'regular' attendance and this, we believe, connotes a firmer commitment to religious participation than occasional, irregular churchgoing.

Our last religiosity indicator differentiates people's beliefs by their responses to a question about the origins of life on earth, by agreeing with the statement: "Humans and other living things were created by God and have always existed in their current form". Obviously this is not the only aspect of belief that one could have measured and it is a relatively extreme one, at least in the British context. However, we wanted to be able to tap strong religious beliefs and this question does allow us to accomplish this. The distribution of answers to this question is cross tabulated with the religious services variable and shown in Figure 2.

Figure 2 HERE

There is considerable heterogeneity in beliefs about the origin of life on earth. For instance, even amongst those who regularly attend religious services, less than half reject evolution altogether and take a creationist view. Along with the conceptual reasons outlined earlier, the heterogeneous distribution of creationist beliefs in the sample means that we consider it as a separate indicator of religiosity.

Control variables

We control for several variables that could act as confounders for the key associations in which we are interested. We suspect that older people are likely to be more religious, due to cohort differences in religious upbringing, and also that attitudes to genetics will vary with age. We therefore include dummy variables for three age bands, with people below the age of

35 as the reference category. Gender tends to be related to religiosity, both in terms of church attendance and creationist beliefs, with women tending towards more religious views and behaviours, at least in respect of Christian denominations (Loewenthal et al., 2002). It has also been shown that women tend to be less optimistic about genetics and other new science and technology (Ipsos-MORI, 2011). Hence we control for this with a dummy variable indicating whether or not a respondent is female.

Higher levels of education and social class, as well as being male, tend to be associated with higher science knowledge and with attitudes towards science and technology (Allum et al., 2008 ; Durant, 1992) so we control for all of these with dummy variables. For social class we use a three-level version of the NS-SEC, contrasting routine and managerial occupations with intermediate occupations as the reference group (Harrison, 2010). For education we control for having an undergraduate degree and whether or not someone has studied for a science qualification.

Finally, we elected to control for one psychological variable concerning the respondent's view about when human life begins - at conception, birth, or somewhere in between. We use a dummy variable indicating belief that life begins at birth. The rationale for this is as follows. One of the outcome variables, concerning tests on unborn children, has a wording that mentions termination of pregnancy. We want to ensure that we are estimating the effect of religiosity on people's views about genetic testing rather than on generalised attitudes to abortion, which are themselves likely to be associated, but not coterminous, with religiosity. Although perhaps the likeliest causal path is one which flows from religion to beliefs about sanctity of life, it is also possible that religiosity may be endogenous on the latter; one could imagine a situation where someone with strong beliefs of this kind could be drawn to become more religious over time. By including an indicator that we assume directly taps such attitudes, we can be more confident that the residual association between attitudes to genetic testing and religiosity will have been purged of this potential confound.

Regression Models

The dependent variables are all ordinal, Likert-type scales. Their distributions approximate normality and we therefore elected to use ordinary least squares regression to fit the models.[1] We estimate two equations for each of the four outcomes. The first shows main effects for the key predictors and control variables. In the second, we add to these models interactions between knowledge and the creationist belief and church attendance variables to examine whether there are moderating effects present.

Regression results

Eight sets of unstandardised OLS estimates are shown in Table 2, two for each of the four outcomes of interest, namely support for testing of unborn children, willingness to take a personal test for potential serious disease, support for such tests being publically available as 'do it yourself' kits and, finally, general optimism about genetics in medical research. The bottom two rows of the table show the estimated interaction effects from the second model.

Genetic testing of unborn children

Model 1 examines support for the testing of unborn children on the basis of our independent variables. We expected that more religious citizens might be more sceptical about this kind of testing and this expectation is confirmed in the case of church attendance, with a significant negative coefficient of -.40, and also for creationist beliefs with a coefficient of -.21.

[1] We also estimated models using ordered probit regression. We obtain the same results whichever estimator is employed but we prefer to present OLS estimates for ease of interpretation, particularly in relation to interaction terms.

Of the denominational variables, it is striking that Catholics are less likely to support genetic testing compared to the non-religious, whereas other types of Christian are no more or less likely to support than non-religious citizens. We also note that our control for anti-abortion attitudes is strongly associated with support, in the expected direction. Those that think that life begins at birth, rather than some prior point in time, are more relaxed about supporting tests that may result in a termination.

Table 2 HERE

Science knowledge has no significant effect on support for testing unborn children in the main effects model but becomes statistically significant and positive when the interaction variables are introduced. The coefficient of .07 means that for people who neither hold creationist views nor attend services at least monthly, more knowledge is associated with more support. Interestingly it is older people that seem to support testing of this kind more strongly, traditionally that part of the population with less education and scientific knowledge, and that is more religious in general.

What of the possible moderating effect of religiosity on the relationship between knowledge and support? We find that the interaction between knowledge and churchgoing is statistically significant (-.08). It is negative, which means that the positive association between knowledge and support for less religious people is attenuated for religious citizens. The interaction with creationist beliefs is not significant, although it follows the same pattern. These interactions are more easily interpreted graphically and can be seen in the top panels of Figure 3.

Figure 3 HERE

The top panels show line plots with predicted scores for genetic testing attitude on the y-axis and science knowledge quiz score on the x-axis. Lines are plotted separately for those holding creationist beliefs and those regularly attending services. Other variables in the model are held at their mean. As can be seen from the dashed lines, for those who are more highly religious, the more knowledge and information they have, the less likely they are to support genetic testing. For the less religious, represented by the solid lines, the association between knowledge and support is positive, which is the more familiar finding in the literature. Recall that the interaction term for creationist beliefs was not statistically significant in the model, but the same pattern is evident for both types of measured religiosity. These reverse-gradient lines of course explain why we do not see a significant main effect of knowledge: because pooling the religious and non-religious samples washes out the now-demonstrated opposite effects for each group.

Personal willingness to take genetic tests

The picture for attitudes to taking a personal genetic test is slightly different. The main effects coefficients for religiosity are in the same direction as for the previous outcome but they do not reach statistical significance. However, once the interaction terms are introduced, we see that the less religious, more knowledgeable citizens are more likely to say that they would take a genetic test to detect potentially serious illness for which there are treatments available. There is also a significant, negative, interaction between knowledge and church attendance, which means that, as was the case for the testing of unborn children, we find that the positive association of knowledge with attitude to testing is attenuated for those who are more strongly religious, at least as far as it is measured by church attendance. This pattern can be seen in the second row of panels of Figure 3. There is a clear difference in the slopes of the dashed and solid lines comparing those who do and do not attend church at least monthly, with the less religious group becoming more positive about taking a genetic test at higher levels of knowledge.

Publically available genetic tests

Looking at the fifth column of estimates, we find scant evidence of support for any relationship between religiosity, knowledge and attitudes to publically available genetic tests. Both religiosity variables and scientific knowledge have small and insignificant coefficients in both models. There are no significant interaction effects. This is shown clearly in the third row of panels in Figure 3, where the dashed and solid lines are almost parallel. Interestingly, as well as general lack of support for the idea of allowing members of the public to administer their own tests (nearly two thirds are opposed to it), there is even more scepticism from women and older citizens.

Optimism about medical genetics

The most accurate predictions of opinion about science can usually be made when the outcome is a more generalised attitude or belief (Allum et al., 2008). Optimism about genetics is just such a variable. Here, people who hold creationist beliefs are less hopeful about genetics. Those with greater scientific knowledge, conversely, are more optimistic. In the bottom panels of Figure 3 we see that the solid lines slope upward, indicating that more knowledgeable citizens tend to be more optimistic about genetics but there is little difference when churchgoers and creationists are considered separately. Confirming this picture, there are no significant interaction effects shown in the final column of Table 2.

Discussion

The use of genetics in medicine and in particular in relation to testing for heritable disease is developing apace. While there are generally high levels of public support in Britain for medical research of all kinds, the use of genetics in medicine generates some religious antipathy. While this has been articulated by some, although not all, religious elites, less is known about how religious belief amongst ordinary citizens affects attitudes towards genetic medicine and how such beliefs interact with other factors. What we have shown in this study is that citizens' religious beliefs do, to some degree, reflect religious elites' concerns about genetics and genetic testing in particular. In Britain, Catholics, as well as those who attend church often, are less likely to support the genetic testing of unborn babies. Those who adhere to creationist beliefs are less optimistic about the prospects held out for the future by developments in genetic medicine. When it comes to personal willingness to take genetic tests and support for testing kits being available to the public, we find no clear relationship to religious belief. Perhaps the testing of unborn babies strikes a particular chord with the religious whereas adults' consenting use of testing technology is seen as a matter of individual conscience.

Of course religion is just one of many factors that play a role in determining public opinion on these issues. We examined the relationship of one such factor, science knowledge, with attitudes to genetic medicine. In line with much previous research we find that those who are more knowledgeable are often more optimistic. We also find that these people are also more prepared to take genetic tests themselves.

One of the primary aims of the paper was to investigate the possibility that religion can act as a 'perceptual filter' that moderates the ways in which knowledge affects attitudes. We find evidence that this is indeed the case for some attitudes towards genetic testing, although not for general optimism about genetic medicine. Strongly religious people who are also highly knowledgeable about science tend to have more negative attitudes to genetic testing than those who are less scientifically literate. We observe this effect in two out of the four outcome variables we examined in our analyses. This provides mixed support for the conclusions of Ho et al. (2008) and Mooney (2011) in respect of the general notion that citizens deploy knowledge in different ways according to their pre-existing interests and motivations. We believe these findings are also broadly consistent with the cultural cognition perspective of Kahan and colleagues (Kahan, 2012). The particular (religious) culture we examine is far removed from the cultural typology that these researchers use, but the notion that people's predispositions can, in certain circumstances, affect the way in which information is assimilated and knowledge deployed is the conclusion we would reach on the basis of the present study.

What practical implications can be drawn from the results presented here? Firstly, although there is generally strong support for medical research of all kinds amongst the British public, the more religious may be less persuaded by the potential benefits of some of this research regardless of how attractive they may seem. Nevertheless, even the typical strongly religious citizen is broadly supportive, so one should not equate elite religious rejection of genetics with the views of ordinary people. Secondly, although it is the case that on average more scientifically literate citizens show more support for genetic testing and research, this is not always so for strongly religious people, where the reverse is true in some cases. One possible implication here is that those who might wish to encourage more support for genetic research by imparting more information and trying to enhance public understanding of the underlying science might find that this strategy will fail amongst precisely the group most likely to object in the first place. If anything, it may serve to harden opposition. Of course this interpretation is conditional on our cross-sectional models approximating what might happen to attitudes when knowledge changes over time within individuals, rather than describing, as we do here, how they vary amongst better or worse informed individuals. Thirdly, a distinction can be drawn between genetic testing that is the result of free citizen choice and that which is 'imposed' on an unborn child. It appears that religious objection dissipates when free choice is exercised. The implication for communication strategies for those who might wish to garner support for genetic medicine would be to emphasise these consensual, choice-based applications rather than those that might be seen as disempowering individuals or, indeed, those not yet born.

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TABLES

Table 1 Distribution of responses for dependent variables

Question wording	Response scale	%
TESTUNB "Please say whether you agree or disagree with the following statement: I would support the genetic testing of unborn babies for any serious diseases they might get in the future, if the discovery of a serious disease could lead to a decision to terminate a pregnancy."	Strongly disagree	9
	Disagree	15
	Neither agree nor disagree	20
	Agree	39
	Strongly agree	18
TREATEST "Please say how likely you would be to take a genetic test to detect any serious disease you might get in the future if there were treatments or other ways of greatly reducing the risks of developing any diseases detected?"	Not at all likely	5
	Not very likely	14
	Quite likely	43
	Very likely	38
PUBTEST "Genetic tests are now available directly to the public, without a having to go through a doctor or other medical practitioner. This might be done, for example, by ordering a test from a website, taking a swab and sending if off in the post and then receiving results directly by post or in an email. Generally speaking, please tell me whether you think that making genetic tests available to the public in this way is a good idea or a bad idea?"	Definitely a bad idea	29
	Probably a bad idea	34
	Probably a good idea	26
	Definitely a good idea	12
GENOPT "Are you very optimistic about the possibility of medical advances as a result of genetic research, somewhat optimistic, not too optimistic or not at all optimistic?"	Not at all optimistic	4
	Not too optimistic	10
	Somewhat optimistic	60
	Very optimistic	26

Table 2 *OLS estimates for four questions about genetics (unstandardised coefficients)*

	Unborn Child Test				Personal Test				Public Test				Genetics Optimism			
	Main Effects		Interaction		Main Effects		Interaction		Main Effects		Interaction		Main Effects		Interaction	
Constant	2.15	(.19)	1.84	(.21)	1.96	(.13)	1.87	(.15)	1.78	(.15)	1.79	(.17)	1.53	(.11)	1.48	(.12)
Other Christian	-0.03	(.10)	-0.01	(.10)	0.08	(.07)	0.09	(.07)	-0.13	(.08)	-0.13	(.08)	0.04	(.06)	0.04	(.06)
Catholic	**-0.27***	(.13)	-0.25	(.13)	0.09	(.10)	0.10	(.10)	-0.11	(.11)	-0.11	(.11)	0.06	(.08)	0.06	(.08)
C of E	0.06	(.10)	0.09	(.10)	0.07	(.07)	0.09	(.15)	-0.10	(.08)	-0.10	(.08)	**0.12***	(.06)	**0.12***	(.06)
Other non-Christian	0.12	(.21)	0.11	(.21)	-0.10	(.15)	-0.10	(.23)	-0.10	(.17)	-0.10	(.17)	-0.02	(.12)	-0.02	(.12)
Attends church monthly	**-0.40*****	(.10)	0.18	(.31)	-0.12	(.07)	0.36	(.22)	0.06	(.08)	0.00	(.26)	0.02	(.06)	0.04	(.18)
Creationist	**-0.21***	(.10)	0.30	(.30)	-0.11	(.07)	-0.24	(.22)	-0.06	(.08)	-0.06	(.26)	**-0.13***	(.06)	0.04	(.18)
Science knowledge	0.03	(.02)	**0.07****	(.02)	**0.04****	(.01)	**0.05****	(.02)	-0.03	(.02)	-0.03	(.02)	**0.07*****	(.01)	**0.08*****	(.01)
Female	0.00	(.07)	0.01	(.07)	**-0.12***	(.05)	**-0.12***	(.05)	**-0.12***	(.06)	**-0.12***	(.06)	**-0.09***	(.04)	**-0.09***	(.04)
35-49	0.12	(.10)	0.12	(.10)	-0.03	(.07)	-0.03	(.07)	-0.10	(.08)	-0.10	(.08)	0.03	(.06)	0.03	(.06)
50-64	0.20	(.11)	0.19	(.11)	0.02	(.08)	0.02	(.08)	**-0.27****	(.09)	**-0.27****	(.09)	0.03	(.06)	0.03	(.06)
>=65	**0.49*****	(.11)	**0.47*****	(.11)	-0.10	(.08)	-0.10	(.08)	**-0.38*****	(.09)	**-0.37*****	(.09)	0.05	(.06)	0.05	(.06)
Degree	0.16	(.11)	0.15	(.11)	0.05	(.08)	0.06	(.08)	-0.13	(.09)	-0.13	(.09)	0.02	(.06)	0.02	(.06)
Science degree	0.14	(.15)	0.14	(.15)	0.11	(.11)	0.11	(.11)	0.19	(.12)	0.19	(.12)	**0.30*****	(.09)	**0.30*****	(.09)
Routine occupation	**-0.19***	(.09)	-0.17	(.09)	-0.06	(.06)	-0.05	(.06)	-0.02	(.07)	-0.02	(.07)	**-0.20*****	(.05)	**-0.20*****	(.05)
Managerial occupation	-0.09	(.10)	-0.08	(.10)	0.00	(.07)	0.00	(.07)	-0.11	(.08)	-0.11	(.08)	-0.05	(.06)	-0.05	(.06)
High income	0.05	(.10)	0.04	(.10)	-0.07	(.07)	-0.08	(.07)	-0.07	(.08)	-0.07	(.08)	**0.15***	(.06)	**0.15***	(.06)
Life begins at birth	**0.33*****	(.11)	**0.34*****	(.10)												
Knowledge*Creationist			-0.08	(.04)			0.02	(.03)			0.00	(.04)			-0.03	(.02)
Knowledge*Church attender			**-0.08***	(.04)			**-0.07***	(.03)			0.01	(.03)			0.00	(.02)
R sq	.08		.09		.04		.04		.04		.04		.14		.14	
N	1153				1166				1150				1149			

FIGURES

Figure 1 Correct answers to science knowledge items

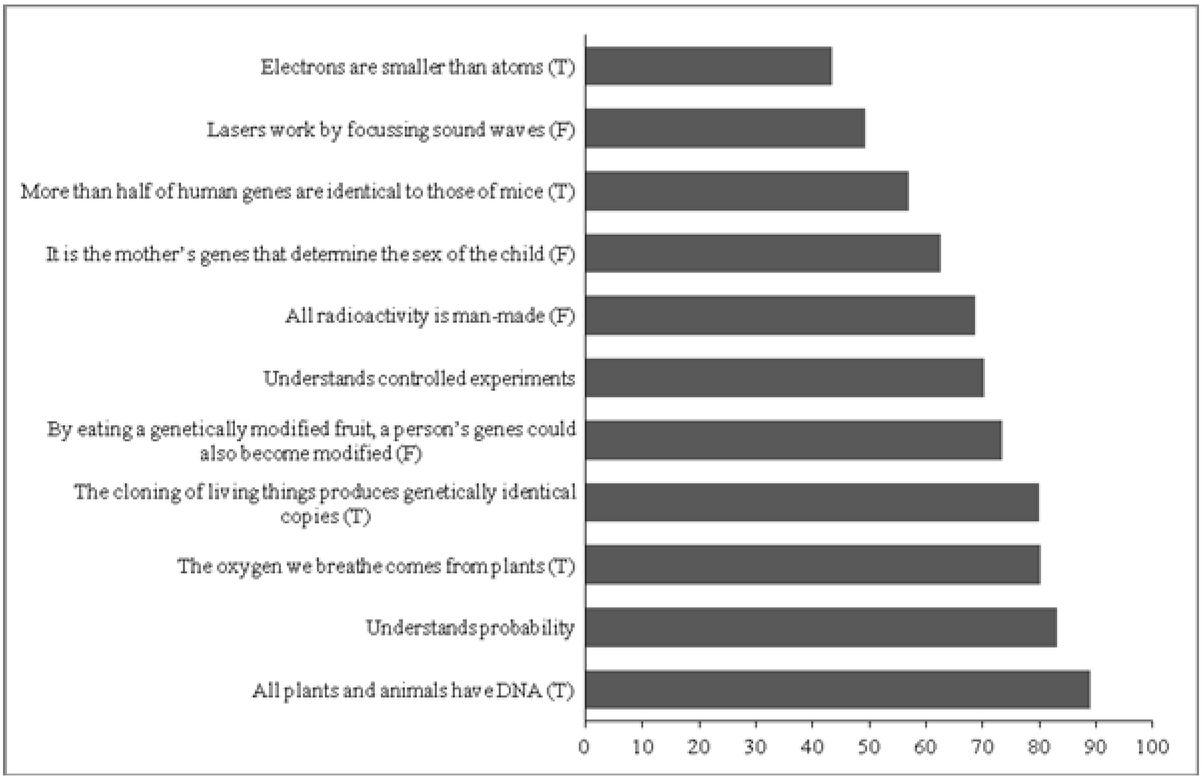

Figure 2 Probability of belief about origins of life by religious service attendance

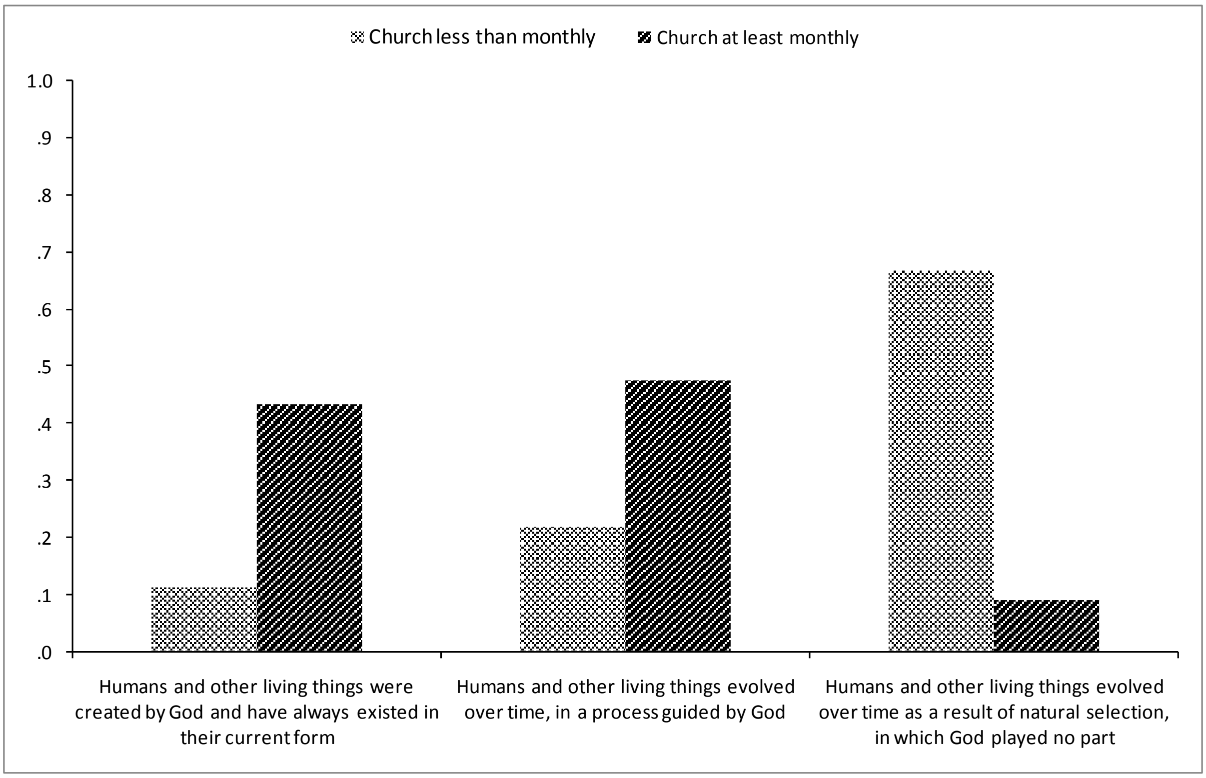

Figure 3 *Model predicted attitude scores by level of science knowledge, creationist beliefs and church attendance*