Religious Beliefs, Knowledge about Science and Attitudes Towards Medical Genetics

Nick Allum[1*], Elissa Sibley[1], Patrick Sturgis[2] and Paul Stoneman[2]

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.

1. Department of Sociology, University of Essex

2. School of Social Sciences, University of Southampton

* To whom correspondence should be addressed

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 baby. 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 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 found 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 test the hypothesis that religion acts as a 'perceptual filter' (Brossard et al 2007, 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 they should class as a human being 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 the abortion and the status of human embryos, as the result of testing can be the destruction of embryos or fetuses (Parens and 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 United States Conference of Catholic Bishops 2011). Since the late 1970s, the views of

many American evangelical churches have coalesced around an anti-abortion position that implies an antipathy towards genetic testing and research (Evans and Hudson 2007). The somewhat sparse public opinion research on religion and reproductive genetics has indeed shown that attitudes to medical genetics and genetic testing have been voiced with reference to religious beliefs (Alikani, 2007; 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 (Pardo & Calvo, 2008; Hudson et al, 2005). 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 (Nisbet, 2005; Pardo & Calvo, 2008; Ho et al, 2008). Overall, then, we know that religion, (generally operationalised as strength of religious belief), is associated with more negative attitudes towards genetics. We therefore might expect to see the same relationship in the specific case of medical genetics and genetic testing in Britain, which is the focus of 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 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 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.

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. 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 (Whitmarsh, 2011; Kahan et al, 2008). 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 hypothesise 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 SC 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 SC 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 SC research. Ho et al (2008) 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 SC research, whilst for those who are more conservative, a higher level of knowledge is associated with reduced support (similar findings have been observed regarding the acceptance of climate change; Mooney, 2011). In contrast, Nisbet (2005) found that at low levels of awareness, all ideologies are associated with lower support for SC research and increased awareness is related to increased support amongst members of all ideological persuasions. However, the effect is stronger for those with more liberal views. Whilst these examples do not concern genetic testing, there is every 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 to test three hypotheses that we derive from the foregoing review.

H1: Past research provides evidence that strong religious beliefs are associated with more negative attitudes towards genetic testing and other related biomedical applications and research. We expect the same to be the case here, along the three dimensions of religion captured in our data: frequency of attendance at services, self identification as belonging to a particular religion and belief in creationist account of origins of life.

H2: Citizens that possess more scientific knowledge and demonstrate more understanding of scientific process and method have tended in the 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: those with more science knowledge will have more positive attitudes towards medical genetics.

H3: Motivated reasoning 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 will moderate the association of knowledge with attitudes towards genetic medicine. Specifically, we would expect religion to attenuate any positive effect of knowledge perhaps because those who hold religious beliefs are more likely to attend to information that could bolster doctrinal opposition, or because 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.

Data and Methods

To evaluate our research questions and hypotheses, we use data from the first wave of the Wellcome Trust Monitor Survey (to which we will henceforth refer as the Wellcome Trust Monitor). 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 et al (2009). Our analytic strategy is to fit a series of regression models that relate our key explanatory

variables of religiosity, 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 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

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 significant 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, most of them having a biology and genetics emphasis, as well has having been validated in previous surveys (e.g. Gaskell *et al.*, 2011 ; National Science Board, 2008). 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 score as one while incorrect and DK 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:

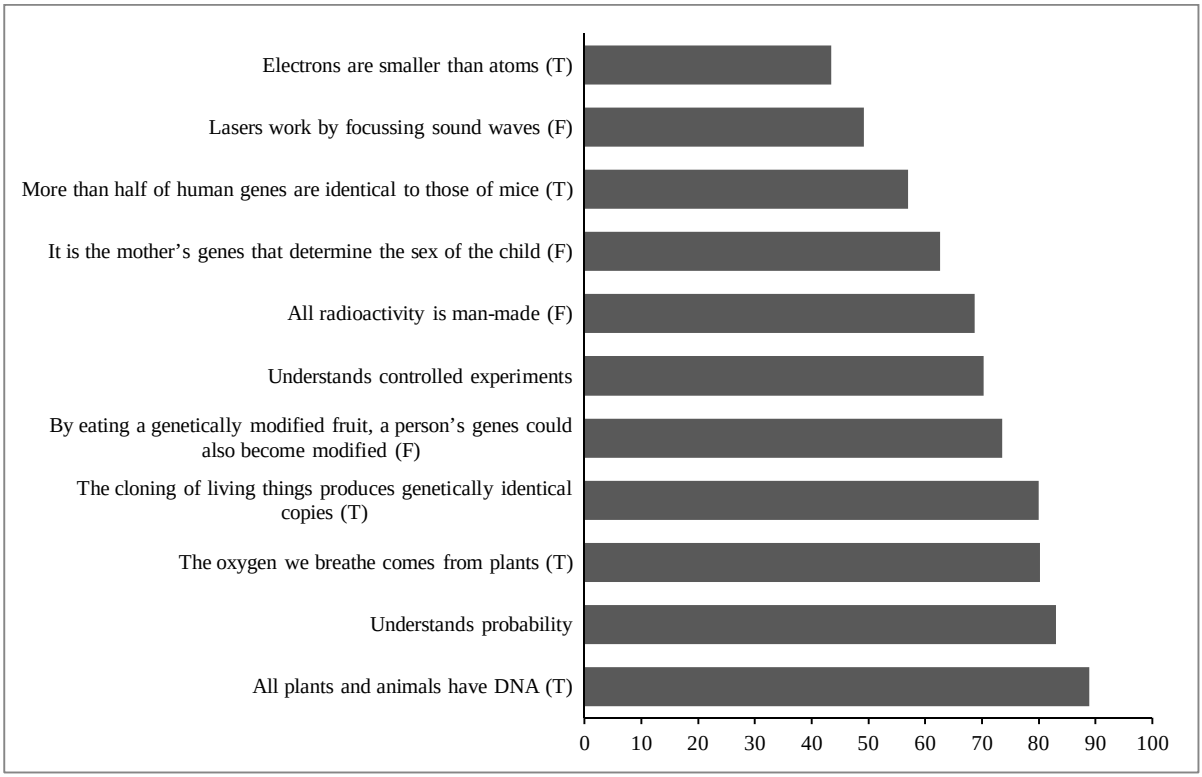
"Now think about this situation. A doctor tells a couple that their genetic makeup means that they've got a one in four chance of having a child with an inherited disease…"

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. This scale is reasonably reliable, with a Cronbach's alpha of 0.63.

Figure 1 Correct answers to science knowledge items

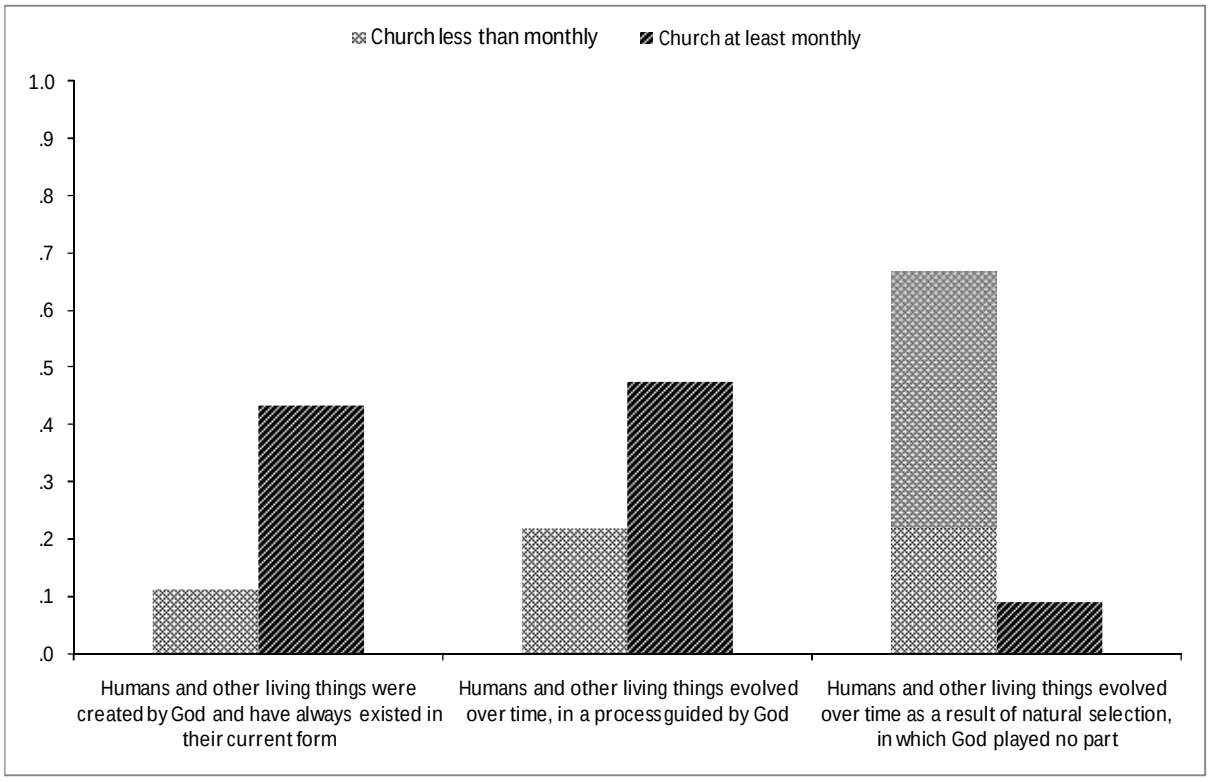


Religion is measured along three dimensions: denomination or affiliation, attendance at religious services and beliefs. In contemporary empirical work, these three dimensions have become the convention. Each of them, though, have different bases and may be expected to relate differentially with other 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 and Voas 2011). 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 and 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 on the basis of the observed distribution and because this would probably be regarded as 'regular' by most citizens. Finally, we differentiate 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 Probability of belief about origins of life by religious service attendance



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 religious upbringing, and also that attitudes to genetics will vary with age. We therefore include dummy variables for three age bands, with younger people, below the age of 35, as 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 (Lowenthal et al 2002). It has also been shown that women tend to be less optimistic about genetics and other new science and technology [reference]. 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 with routine and managerial occupations contrasted with intermediate 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 the 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 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. We therefore elected to use an ordered probit estimator to fit the models. The ordered probit model assumes a continuous unobserved variable underlying the observed categorical responses, which, in the case of attitudes and beliefs, seems to be a reasonable assumption. We estimate two equations for each of the four outcomes. The first tests our first two research hypotheses and accordingly features 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 test our third hypothesis about the moderating effects of religiosity on knowledge.

Regression results

Eight sets of probit 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 predicts support for testing of unborn children. Our first hypothesis states that religiosity will be negatively associated with support. This expectation is confirmed in the case of church attendance, with a significant negative coefficient of -.34, and also for creationist beliefs with a coefficient of -.18.

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. There is no impact of being both a church-goer

and holding creationist beliefs. 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.

In regard to H2, it science knowledge has no significant effect on support for testing unborn children in the main effects model but becomes significant when the interaction variables are introduced. 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.

H3 postulates a moderating effect of religiosity on the relationship between knowledge and support. Although the main effect of knowledge is, as we have seen, not significant, we find that the interaction between knowledge and churchgoing is. It is negative, which is the expected direction as it essentially means that any positive association between knowledge and support is attenuated or even reversed for religious citizens. The other interaction, with creationist beliefs is not significant, although follows the same pattern. These interactions are more easily interpreted graphically and can be seen in the top panels of Figure 3. Predicted probabilities of selecting the most positive supportive response according to science knowledge are shown, with separate lines for those holding creationist beliefs and those regularly attending services. Other variables are held at their mean. As can be seen from the solid 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 irreligious, represented by the broken 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

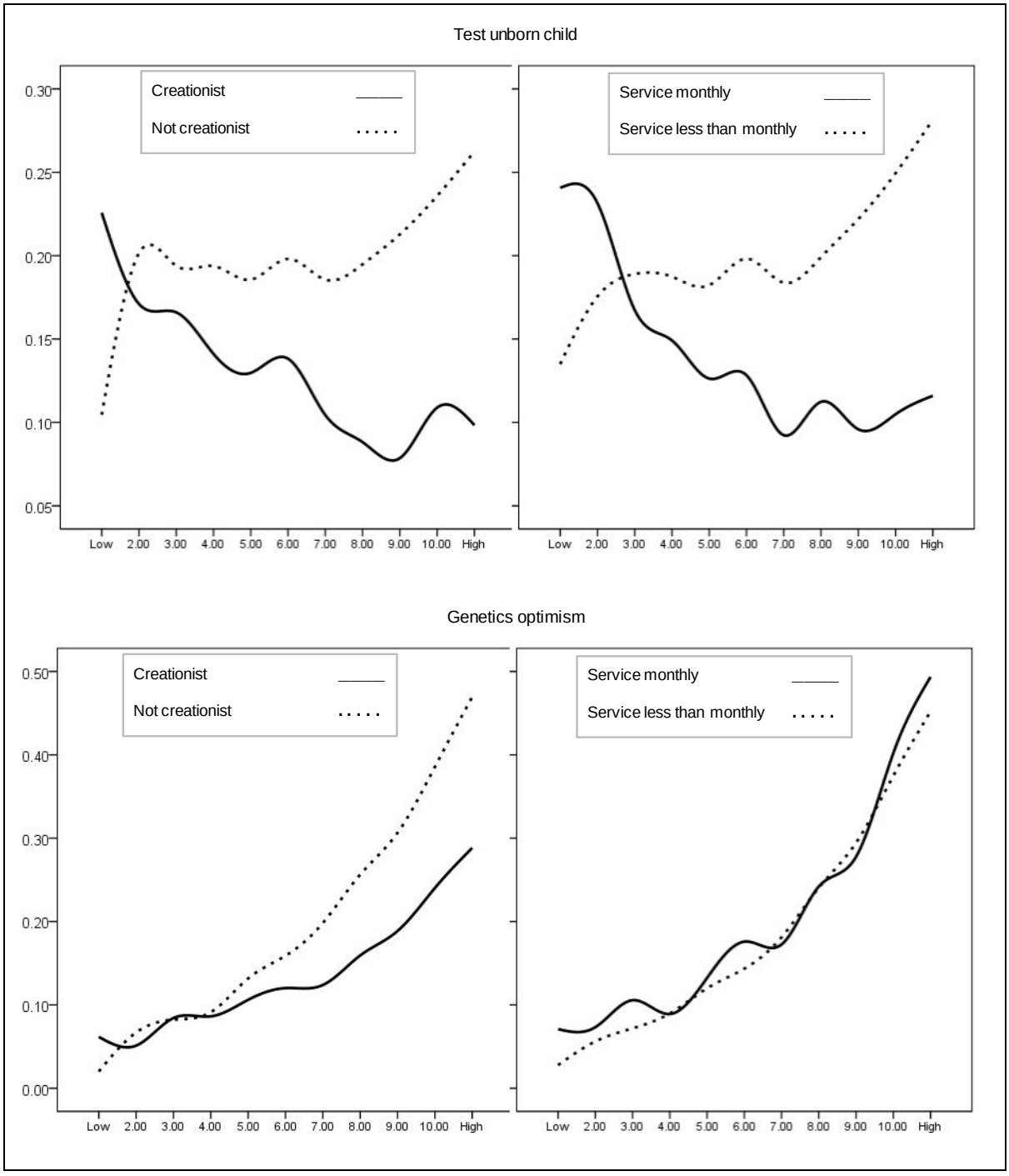
Table 2 Ordered probit estimates for four questions about genetics

	Unborn Child Test		Personal Test		Public Test		Genetics Optimism	
	Main Effects	Interaction	Main Effects	Interaction	Main Effects	Interaction	Main Effects	Interaction
Other Christian	-0.04	-0.02	0.11	0.13	-0.15	-0.15	0.08	0.09
Catholic	-0.24*	-0.23	0.12	0.14	-0.14	-0.14	0.10	0.10
C of E	0.03	0.06	0.10	0.12	-0.11	-0.11	0.18	0.19
Other non-Christian	0.14	0.13	-0.09	-0.10	-0.12	-0.12	-0.04	-0.05
Attends church => monthly	-0.34***	0.19	-0.15	0.44	0.08	0.01	0.02	0.07
Creationist	-0.18*	0.21	-0.13	-0.25	-0.07	-0.05	-0.20*	0.15
Science knowledge	0.03	0.06**	0.05**	0.06**	-0.03	-0.03	0.12***	0.14***
Female	0.03	0.04	-0.15*	-0.15*	-0.14*	-0.14*	-0.18*	-0.18*
35-49	0.11	0.11	-0.02	-0.02	-0.11	-0.11	0.05	0.05
50-64	0.19*	0.18	0.05	0.05	-0.30**	-0.30**	0.04	0.03
>=65	0.47***	0.46***	-0.10	-0.10	-0.44***	-0.43***	0.10	0.10
Degree	0.16	0.15	0.09	0.10	-0.15	-0.15	0.04	0.03
Science degree	0.14	0.14	0.20	0.20	0.20	0.20	0.61***	0.61***
Routine occupation	-0.17*	-0.15	-0.07	-0.06	-0.02	-0.02	-0.34***	-0.34***
Managerial occupation	-0.08	-0.08	0.00	0.00	-0.12	-0.12	-0.10	-0.10
High income	0.06	0.05	-0.10	-0.10	-0.08	-0.08	0.28**	0.28**
Life begins at birth	0.32***	0.34***						
Knowledge*Creationist		-0.06		0.01		0.00		-0.05
Knowledge*Church attender		-0.07*		-0.08*		0.01		-0.01

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

measured religiosity. These reverse-gradient lines go some way to explaining why we do not see a significant main effect of knowledge, because pooling the religious and non-religious samples cancels out the now-demonstrated opposite effects for each group.

Figure 3 *Predicted probability of selecting most positive response by level of science knowledge, church attendance and creationist beliefs: testing unborn children and optimism about genetics*



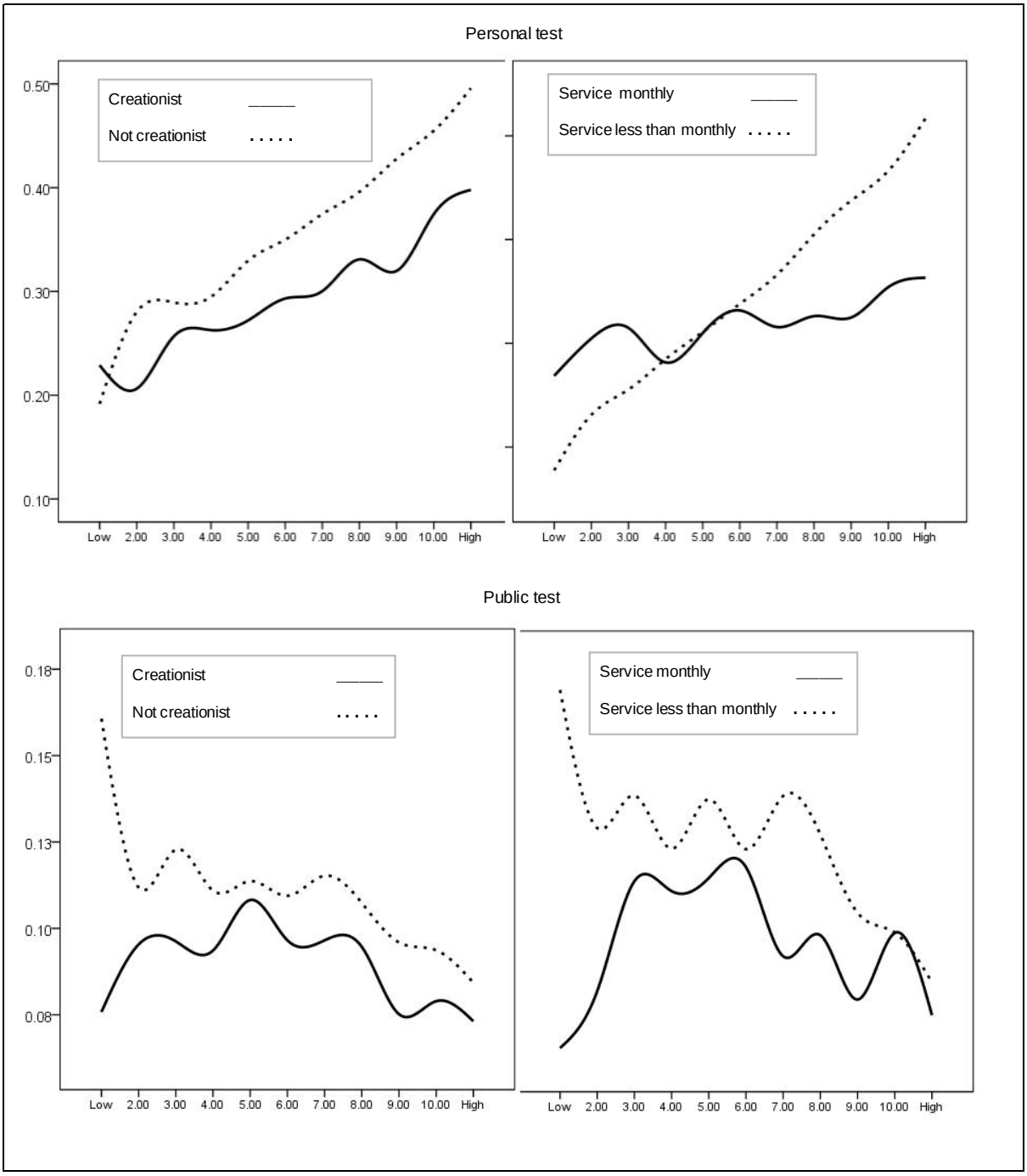
Personal willingness to take genetic tests

The picture for attitudes to taking a personal genetic test is rather different, and H1 is not supported. Although the coefficients for religiosity are in the expected direction, they do not reach statistical significance. H2, however, does receive support. 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. As it was in the case of testing for unborn children, we again 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.

Publically available genetic tests

Looking at the fifth column of estimates, we find scant evidence of support for any of our hypotheses. Both religiosity and knowledge have small and insignificant coefficients, with the estimate for knowledge even being reversed compared to the expected positive direction. There are no significant interactions between religiosity and knowledge. 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 more scepticism from women and older citizens.

Figure 4 *Predicted probability of selecting most positive response by level of science knowledge, church attendance and creationist belief: personal and public genetic tests*



Optimism about medical genetics

In line with what is often reported in similar studies, the most accurate predictions of opinion can be made when the outcome is a more generalised attitude or belief (Allum et al., 2008). There is support for Both H1 and H2, with people who hold creationist beliefs being less hopeful about genetics. Those with greater scientific knowledge, conversely, are more

optimistic. H3 suggests that the effect of knowledge will be moderated by religiosity, and this is, again, what we see for generalised optimism about genetics. The effect of knowledge is attenuated for those who hold creationist beliefs.

The knowledge-religiosity interactions for these outcomes are shown in Figure 3 and Figure 4. In the lower panel of Figure 3, we see that the hatched lines slope upward, indicating that more knowledgeable citizens who do not regularly attend services or reject evolution tend to be more optimistic about genetics. For the more religious citizens, higher knowledge is still associated with more positive attitudes, but the relationship is weaker. This general pattern is repeated in the top panels of Figure 4, where the slopes for the more religious are slightly flatter than they are for the less religious in relation to personal testing. For the public test variable, shown in the bottom panel of the figure, there is no linear relationship, no interaction and there is a great deal of variability in the slopes.

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, but 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 citizen's religious beliefs do to some fair 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 a 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 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 attitudes to genetic medicine. Strongly religious people who are also highly knowledgeable about science have more negative attitudes to genetic testing and genetic research in general than those who are less scientifically literate. We observe this effect in three out of the four outcome variables we examined in our analyses. This bolsters the conclusions of Ho et al (2008) and Mooney (2005) 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 affect the way in which information is assimilated and knowledge deployed is exactly 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 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 so for strongly religious people, where the reverse is true. The obvious corollary of this 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. 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.

References

Alikani, M. (2007). Commentary: The debate surrounding human embryonic stem cell research in the USA. Reproductive Biomedicine Online, 15(Suppl. 2), 7-11.

Allport, G. W. (1950), The individual and his religion, New York, Macmillan

Allport, G. W., & Ross, M. J. (1967). Personal religious orientation and prejudice. Journal of Personality and Social Psychology, 5, 432-443.

Allum, N., Sturgis, P., Brunton-Smith, I., & Tabourazi, D. (2008). Science knowledge and attitudes across cultures: a meta-analysis. Public Understanding of Science, 17(1), 35-54.

American Association for Public Opinion Research. (2011). Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys.

Bauer, M., Allum, N., & Miller, S. (2007). What can we learn from 25-years of PUS research? liberating and expanding the agenda. Public Understanding of Science, 16 (1), 79-95.

Bodmer, W. (1985). The Public Understanding of Science. London: Royal Society.

Brossard, D., & Nisbet, M. C. (2007). Deference to scientific authority among a low information public: Understanding American views about agricultural biotechnology. International Journal of Public Opinion Research, 19(1), 24-52.

Brossard, D., Scheufele, D. A., Kim, E. & Lewenstein, B. V. (2009). Religiosity as a perceptual filter: examining processes of opinion formation about nanotechnology. Public Understanding of Science, 18(5), 546-558.

Butt, S., Clery, E., Abeywardana, V., & Phillips, M. (2009). Wellcome Trust Monitor Survey Report: National Centre for Social Research.

Durant, J. (1992). Biotechnology in public. London: Science Museum.

Evans, J. H. & Hudson, K. (2007). Religion and reproductive genetics: Beyond views of embryonic life? Journal for the Scientific Study of Religion, 46(4), 565-581.

Ehrich, K., Williams, C. & Farsides, B. (2008). The embryo as moral work object: PGD/IVF staff views and experiences. Sociology of Health & Illness, 30(5), 772-787.

Feng, L. R., & Maguire-Zeiss, K. A. (2010). Gene therapy in Parkinson's disease: rationale and current status. CNS Drugs, 24(3), 177-192.

Gaskell, G., Allansdottir, A., Allum, N., Castro, P., Esmer, Y., Fischler, C., Jackson, J., Kronberger, N., Hampel, J., Mejlgaard, N., Quintanilha, A., Rammer, A., Revuelta, G.,

Gaskell, G., Stares, S., Allansdottir, A., Allum, N., Castro, P., Esmer, Y., Fischler, C., Jackson, J., Kronberger, N., Hampel, J., Mejlgaard, N., Quintanilha, A., Rammer, A., Revuelta, G., Stoneman, P., Torgersen, H., & Wagner, W. (2010). Europeans and biotechnology in 2010: winds of change? : European Commission.

Harrison, E. (2010). Measuring social class. In M. Bulmer, J. Gibbs, & L. Hyman (Eds.), Social measurement through social surveys: an applied approach. Farnham: Ashgate.

Ho, S. S., Brossard, D. & Scheufele, D. A. (2008). Effects of value predispositions, mass media use, and knowledge on public attitudes toward embryonic stem cell research. International Journal of Public Opinion Research, 20(2), 171-192.

Hudson, K. L., Scott, J. & Faden, R. (2005). Values in Conflict: Public Attitudes on Embryonic Stem Cell Research. Washington DC: Genetics and Public Policy Center.

Kahan, D.M. (2012). Cultural Cognition as a Conception of the Cultural Theory of Risk. in Handbook of Risk Theory: Epistemology, Decision Theory, Ethics and Social Implications of Risk. Hillerbrand, R., Sandin, P., Roeser, S. & Peterson, M. (eds) 725-760. London. Springer.

Kahan, Dan M., Donald Braman, Paul Slovic, John Gastil and Geoffrey L. Cohen. 2008a. "The Future of Nanotechnology Risk Perceptions: An Experimental Investigation of Two Hypotheses." Harvard Law School Program on Risk Regulation Research Paper No. 08-24.

Loewenthal, K. M., MacLeod, A. K., & Cinnirella, M. (2002). Are women more religious than men? Gender differences in religious activity among different religious groups in the UK. Personality and Individual Differences, 32(1), 133-139

Lynch, J. (2009). Stem cells and the embryo: Biorhetoric and scientism in Congressional Debate. Public Understanding of Science, 18(3), 309-324.

Mooney, C. (2011). The Science of Why We Don't Believe Science. http://motherjones.com/politics/2011/03/denial-science-chris-mooney?page=1, accessed on 26 September 2011.

National Science Board. (2010). Science and Engineering Indicators 2010. Arlington, VA: National Science Foundation (NSB 10-01).

National Science Board. (2008). Science and Engineering Indicators - 2008. Arlington, VA: National Science Foundation.

Nisbet, M. C. (2005). The competition for worldviews: Values, information, and public support for stem cell research. International Journal of Public Opinion Research, 12(1), 90-548.

Nisbet, M. C. & Goidel, R. K. (2007). Understanding citizen perceptions of science controversy: Bridging the ethnographic – survey research divide. Public Understanding of Science, 16(4), 421-440.

Nisbet, M. C. & Mooney, C. (2007). Framing science. Science, 316, 56.

Pardo, R. & Cardo, F. (2008). Attitudes toward embryo research, worldviews, and the moral status of the embryo frame. Science Communication, 30(1), 8-47.

Popkin, J. (1991). The Reasoning Voter: Communication and Persuasion in Presidential Campaigns. Chicago: University of Chicago Press.

Priest, S. H., Bonfadelli, H., & Rusanen, M. (2003). The "Trust Gap" Hypothesis: Predicting Support for Biotechnology Across National Cultures as a Function of Trust in Actors. Risk Analysis, 23(4), 751-766

Simon, R. M. (2010). Gender differences in knowledge and attitude towards biotechnology. Public Understanding of Science, 19(6), 642-653.

Singer, E., Corning, A. D. & Antonucci, T. (1999). Attitudes toward genetic testing and fetal diagnosis. Journal of Health and Social Behavior, 40(4), 429-445.

Parens, E. & Knowles, L. P. (2003). Reprogenetics and Public Policy: Reflections and Recommendations. A Special Supplement to the Hastings Center Report. Hastings Center Report, 33(4), S1-S25

Stares, S., Torgersen, H., & Wagner, W. (2011). The 2010 Eurobarometer on the life sciences. Nature Biotechnology, 29, 113–114.

United States Conference of Catholic Bishops. Human Life and Dignity, http://www.usccb.org/issues-and-action/human-life-and-dignity/, accessed on 26 September 2011.

Voas, D. (2009) The rise and fall of fuzzy fidelity in Europe, European Sociological Review 25(2): 155-68

Whitmarsh, L. (2011). Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. Global Environmental Change, 21, 690-700.