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# Public Perceptions of Genetically Engineered Foods: “Playing God” or Trusting Science? \*

Michael D. Mehta\*\*

## Introduction

Recent developments in the field of genetic engineering have created many opportunities for designing novel foods. Such developments have led to plants that produce their own pesticides (i.e., Bt corn), crops like canola and soybean that are resistant to herbicides such as Glyphosate (i.e., Roundup Ready™), and grains like rice enriched with beta carotene (i.e., Golden Rice™).

The technology for transferring and inserting genes from other species, including unrelated plants, fungi, and bacteria, has created a revolution in agricultural biotechnology. However, in spite of these developments, public concerns about the safety of genetically engineered foods have been growing in many parts of the world.<sup>1</sup> In addition to the human health concerns associated with consuming these foods, concerns are being expressed about the impacts of agricultural biotechnology on the environment, concentration of corporate power among large multinational players in the biotechnology sector, and the social and economic impacts of agricultural biotechnology on farming, in both the developed and developing world.<sup>2</sup>

\* I would like to thank my graduate student, Kelly Bronson, for assistance in developing, pilot-testing and aiding in the distribution of the questionnaire used in this study. Additionally, I would like to thank the peer reviewers for their insightful comments.

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<sup>1</sup> Robin Grove-White et al., *Uncertain World: Genetically Modified Organisms, Food and Public Attitudes in Britain* (Centre for the Study of Environmental Change, Lancaster University 1997); Thomas J. Hobin, *Consumers' Acceptance of Biotechnology: An International Perspective*, 15 *Nature Biotech* 232 (1997).

These developments in science represent a significant change in how life is understood. In essence, recombinant DNA technology allows for the shuffling of genes between organisms that cannot normally exchange genetic material. In conventional breeding within species, “vertical transfer” of genes takes place. However, genetic engineering allows for “horizontal transfer” of genes across species. Few would argue that such advancements do not represent a revolution in the biological sciences.

These changes coincide with a historically low level of trust in science by the public.<sup>3</sup> Notable technological failures including Bhopal, Chernobyl, and Seveso have left many anxious about the dangers associated with living in a world dominated by high technology.<sup>4</sup> Some express concerns about the ability of modern forms of governance to adequately regulate technologies that generate risks that transcend both time and space.<sup>5</sup> Others see a world becoming increasingly concerned with managing the risks ushered in by industrial modernity.<sup>6</sup> Others are concerned that developments in genetic engineering, especially as applied to reproductive technology, have crossed a line demarcating morally acceptable from unacceptable uses of technology. As trust in modern science suffers due to the alienation it sometimes engenders in the public, other considerations — including those typically categorized as moral and ethical — may gain ground. This study assesses the relationship between public perceptions of genetically engineered foods and attitudes individuals hold toward science (scientism) and the strength of their religious convictions (religiosity).

We propose the following hypotheses for consideration:

(1) Individuals with high levels of religiosity will be less supportive of genetically engineered foods. These individuals may believe that

<sup>2</sup> Michael D. Mehta & Julie J. Gair, *Social, Political, Legal and Ethical Areas of Inquiry in Biotechnology and Genetic Engineering*, 23 *Tech. in Socy.* 241 (2001).

<sup>3</sup> Ron Westrum, *Fear of Science-Trust in Science: Conditions for Change in the Climate of Opinion*, 10 *Contemporary Sociology* 805 (1981).

<sup>4</sup> Charles Perrow, *Normal Accidents: Living with High Risk Technologies* (Basic Books 1985).

<sup>5</sup> Michael D. Mehta, *Risk Assessment and Sustainable Development: Towards a Concept of Sustainable Risk*, 8 *Risk: Health, Safety & Environment* 133 (1997).

<sup>6</sup> Ulrich Beck, *Ecological Politics in an Age of Risk* (Polity Press 1995).

such interventions are not morally acceptable uses for technology and that using recombinant DNA technology to create new plants is akin to “playing God.” Additionally, such individuals may respond negatively to this technology due to concerns that it transgresses natural boundaries and fails to consider the complexity and majesty of a “grand design.” It is also possible that individuals with high levels of religiosity may object to this technology because it represents a radical departure from traditional breeding techniques and symbolizes an unprecedented break with natural processes.

(2) Individuals with high levels of scientism will be more trusting of science and more likely to perceive the risks from consuming genetically modified foods as low and less worrisome.

(3) Individuals with high levels of scientism will be more likely to evaluate the benefits arising from genetically engineered foods more positively and more likely to choose such foods if deemed safer than non-genetically engineered substitutes. This hypothesis is based on an assumption that most people are relatively satisfied with the safety of the food they consume. For some, the introduction of genetically modified food represents an unnecessary change in the way food is produced. One of the arguments being put forward for the adoption of this technology is that plants modified to produce their own pesticides (i.e., Bt corn) generate benefits by requiring less pesticide usage.<sup>7</sup> In order to facilitate greater consumption of these new foods, consumers will have to be convinced that such foods are safer than alternatives, rather than simply as safe as alternatives.

(4) Individuals with high levels of scientism are more likely to believe that consuming genetically engineered foods is voluntary. Not only are individuals with high levels of scientism more likely to trust science, they are probably more likely to take a proactive position on the consumption of food in general and therefore believe that they can exercise choice with respect to the food they eat.

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<sup>7</sup> I would like to thank Dr. William Leiss (President, The Royal Society of Canada) for noting that this logic creates a problem with the consistency of messages over time. For years scientists reassured us that consuming foods with pesticide residues was safe. Now with the advent of genetically modified foods, and the promise of using less pesticide for particular applications, we are being warned that pesticides are perhaps unsafe, or at least undesirable.

### Literature Review

Research in the field of risk perception has progressed in two distinct directions. One arm of research is devoted to elaborating on and expanding the utility of the psychometric paradigm.<sup>8</sup> Studies on a wide range of hazards have considered the influence of several dimensions commonly assumed to affect individual perceptions of risk. Researchers have looked at various relationships, including those between costs and benefits, voluntary exposure, perceived controllability, time frame, familiarity, dread, and trust.<sup>9</sup> It is common for psychometric studies of risk perception to also include an analysis of demographic variables. Sex, level of education, age, marital status, number of children, and occupation are frequently used variables.<sup>10</sup> Several studies have also examined differences in expert and lay perceptions of risk. The common observation is that expert and lay perceptions are often very different.<sup>11</sup> Many studies assume that experts perceive risk based on quantitative information, including the probability of harm and assessment of impacts.<sup>12</sup> However, studies show that there is considerable disagreement between experts.<sup>13</sup> When scientific experts are compared with each other, notable differences emerge between experts trained in the life sciences and those trained in the so-called "hard" sciences of physics, chemistry, and engineering.<sup>14</sup> This observation suggests that particular visions of science, and norms internal to a discipline, influence the perception of risk by trained scientists. By contrast, lay perceptions of risk are assumed to contain

<sup>8</sup> Paul Slovic, *Perception of Risk*, 236 *Sci.* 280 (1987).

<sup>9</sup> Richard G. Peters, Vincent T. Covello & David B. McCallum, *The Determinants of Trust and Credibility in Environmental Risk Communication: An Empirical Study*, 17 *Risk Analysis* 43 (1997).

<sup>10</sup> Michael D. Mehta & Paul Simpson-Housley, *Trait Anxiety and Perception of a Potential Nuclear Power Plant Disaster*, 79 *Psychol. Rpts.* 291 (1994); Michael D. Mehta & Paul Simpson-Housley, *Perception of Potential Nuclear Disaster: The Relation Between Likelihood and Consequence Estimates of Risk*, 79 *Perceptual & Motor Skills* 1119 (1994).

<sup>11</sup> Paul Slovic et al., *Rating the Risks: The Structure of Expert and Lay Perceptions*, 21 *Env.* 14 (1979); Bernice Tsang et al., *Perceptions and Attitudes About Blood Transfusion Safety and Blood Donation*, 96 *Blood* 112 (2000).

<sup>12</sup> See e.g. David H. Lee, Michael D. Mehta & Paula James, *Differences in Risk Perception Between Laypeople and Physicians*, *Canadian Med. Assoc. J.* (under review) (article on file with authors).

<sup>13</sup> Richard Barke & Hank Jenkins-Smith, *Politics and Scientific Expertise: Scientists, Risk Perception, and Nuclear Waste Policy*, 12 *Risk Analysis* 425 (1993).

<sup>14</sup> *Id.*

elements that are more consonant with a qualitative appreciation of a hazard. Lay perceptions of risk are often disparagingly treated as irrational and based on ignorance, phobia, or NIMBY (“not in my backyard”) responses. This observation incorrectly assumes that lay perceptions of risk are illegitimate and therefore not of value to risk analysis or the development of public policy.

Psychometric studies have putative strengths including the ability to generate readily compartmentalized data that can be modeled and built on. However, critics of this approach claim that treating risk perceptions as the product of cognitive processing is overly reductionist and ignores the larger social context in which risks are evaluated by individuals.<sup>15</sup>

The second arm of research in the area of risk perception follows the work of Mary Douglas and Aaron Wildavsky.<sup>16</sup> Instead of treating individuals as atomized processors of risk information, this perspective considers the influence of culture in shaping our understanding of nature and the role that worldviews play.<sup>17</sup> It is argued that attitudes toward science and technology can be understood through an examination of the role played by these worldviews and by cultural biases. Studies have looked at a variety of categories including egalitarianism, hierarchy, individualism, sectarianism, and monetarianism.<sup>18</sup> From a sociological perspective, this arm of research views individual perceptions of risk as socially constructed responses to structural relationships.<sup>19</sup> It opens the door to a consideration of how institutions like the media construct public perceptions of risk. Additionally, this arm of research has been used to understand how value orientations like egoistic, social-altruistic, and biospheric values are

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<sup>15</sup> Eugene A. Rosa et al., *Perceiving Risks: Rational Actor or Social Actor?* (paper presented at a meeting of the International Sociological Association 1994)(paper on file with the author).

<sup>16</sup> Mary Douglas & Aaron Wildavsky, *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers* (University of California Press 1983).

<sup>17</sup> Karl Dake, *Myths of Nature: Culture and the Social Construction of Risk*, 48 J. of Soc. Issues 21 (1992).

<sup>18</sup> Bernd Rohrmann, *Risk Perception of Different Societal Groups: Australian Findings and Cross-National Comparison*, 46 Australian J. of Psychol. 150 (1994).

<sup>19</sup> Jonathan Gabe, *Health, Medicine and Risk: The Need for a Sociological Approach*, in *Medicine, Health & Risk: Sociological Approaches* (Blackwell 1995).

related to norms that influence not only individual perceptions of risk, but also how they underpin social movements.<sup>20</sup>

Notably absent from the literature on risk perception are studies that attempt to reconcile these two arms of research. Perhaps a disciplinary divide explains why the psychometric and cultural approaches have grown along different paths. The psychometric approach is quantitative in nature. It assumes that individual perceptions of risk can be pieced together by assessing a range of indicators that purportedly reflect an underlying perceptual complex. Psychologists and others who work in the cognitive sciences have been most supportive of this approach. Researchers who use this approach rely heavily on questionnaires and exercises that ask individuals to rank risks. By contrast, the cultural approach to risk tends to use qualitative tools and modes of analysis. Sociologists and anthropologists are generally responsive to this approach and use a variety of techniques including focus groups and depth interviewing. Instead of constructing scales that reflect underlying cognitive processes or instruments for assessing personality characteristics, those who work with the cultural approach attempt to construct indicators that reflect value orientations. These two approaches, although different, can be considered complementary. To more fully understand how individuals perceive risk, a convergence of these methodologies is needed.

An analysis of how the public perceives genetically engineered foods is suited for this kind of investigation. From a psychometric perspective, studies on public perceptions of food safety have shown that characteristics of the hazard under consideration often combine with demographic variables to influence perceptions.<sup>21</sup> For a wide range of hazards, women express higher levels of concern than men.<sup>22</sup> The evidence with respect to age is less obvious and consistent and is often mixed with other variables including level of education. A study comparing Japanese and American perceptions of food safety found

<sup>20</sup> Paul C. Stern & Thomas Dietz, *The Value Basis of Environmental Concern*, 50 *J. of Soc. Issues* 65 (1994).

<sup>21</sup> Chris Fife-Shaw & Gene Rowe, *Public Perceptions of Everyday Food Hazards: A Psychometric Study*, 16 *Risk Analysis* 487 (1996).

<sup>22</sup> William A. McIntosh et al., *Public Perceptions of Food Safety*, 31 *Soc. Sci. J.* 285 (1994); Susan L. Cutter et al., *En-Gendered Fears: Femininity and Technological Risk Perception*, 6 *Indus. Crisis Q.* 5 (1992).

that age and education explained little of the variance and that concerns about food safety were primarily about maintaining a healthy diet.<sup>23</sup> The evidence with respect to level of education and perception of risk is also inconclusive. A study on food safety practices shows that better educated women were more likely to report a willingness to change their cooking practices to reduce the risk of food-borne pathogens associated with undercooked hamburger meat.<sup>24</sup> Another study concluded that level of education had little influence on the perception of risks associated with biotechnology.<sup>25</sup>

Since many studies under the psychometric paradigm generate inconclusive or conflicting results, perhaps other modes of analysis can help explain perceptions of risk. In the case of genetically engineered food, degree of religiosity and attitudes toward science may help complete the picture.

For some, genetic engineering is akin to “playing God.”<sup>26</sup> By “playing God,” scientists are assumed to be showing disrespect to the Creator and arrogantly assuming a role they are not capable of managing.<sup>27</sup> Individuals with highly religious convictions may be more likely to see genetic engineering as a morally questionable enterprise. Religiosity is a measure of how likely people are to defer to religiously-based moral concerns and how significant a role religious practices play in their lives.<sup>28</sup> Religiosity is sometimes defined as a tendency to adhere to Biblical (or Cabbalistic, Koranic, etc.) literalism, theological orthodoxy, and a belief that sin is ubiquitous.<sup>29</sup> Studies

<sup>23</sup> Raymond A. Jussaume & Lorie Higgins, *Attitudes Toward Food Safety and the Environment: A Comparison of Consumers in Japan and the U.S.*, 63 *Rural Sociology* 394 (1998).

<sup>24</sup> William A. McIntosh et al., *Perceptions of Eating Undercooked Meat and Willingness to Change Cooking Practices*, 22 *Appetite* 83 (1994).

<sup>25</sup> Dieter Urban & Thomas J. Hoban, *Cognitive Determinants of Risk Perceptions Associated with Biotechnology*, 40 *Scientometrics* 299 (1997).

<sup>26</sup> Cf. Barbara K. Rothman, *A Sociological Skeptic in the Brave New World*, 12 *Gender & Society* 501 (1998).

<sup>27</sup> See Vatican Pontifical Academy, *Animal and Vegetable Bio-Technology: New Frontiers and New Responsibilities* <[http://www.vatican.va/roman\\_curia/pontifical\\_academies/acdlife/index.htm](http://www.vatican.va/roman_curia/pontifical_academies/acdlife/index.htm)> (October 12, 1999) (concluding that the genetic engineering of plants does not constitute “playing God” and suggesting that religion and science need not be in conflict with each other).

<sup>28</sup> G. Adamson et al., *An Integrated Approach for Assessing Reliability and Validity: An Application of Structural Equation Modeling to the Measurement of Religiosity*, 29 *Personality & Individual Differences* 971 (2000).



show that religiosity increases with age and that women report higher levels of religiosity than men.<sup>30</sup> Other studies show how religiosity acts as a protective mechanism, where individuals with high levels of personal religious commitment not only feel protected from immediate and long-term stressors, but also draw upon their religious beliefs to control hypertension.<sup>31</sup>

General attitudes toward science influence how the public perceives risk.<sup>32</sup> Some studies show that overall levels of scientific knowledge are related to attitudes toward science.<sup>33</sup> Higher levels of distrust in science are found in individuals with lower levels of scientific knowledge.<sup>34</sup> Studies show that women have less trust in science and that this distrust may be a function of the traditional societal roles assigned to women and historical impediments to participation found in male-dominated sciences.<sup>35</sup> Scientism is a measure of how much faith an individual has in science and is an indication of the role that individuals believe science should play in public policy debates on the development of new technologies such as genetic engineering. Although religiosity and scientism are not necessarily opposites,<sup>36</sup> debates on the social acceptability of new technologies are sometimes polarized along these dimensions. This study deals with uncovering the relationships that may exist between scientism and religiosity by exploring linkages between psychometric and cultural approaches to risk.

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<sup>29</sup> Christopher G. Ellison & Marc A. Musick, *Conservative Protestantism and Public Opinion Toward Science*, 36 *Rev. of Religious Research* 245 (1995).

<sup>30</sup> Anne Bergan & Jasmin T. McConatha, *Religiosity and Life Satisfaction*, 24 *Activities, Adaption & Aging* 23 (2000).

<sup>31</sup> Carolyn M. Brown, *Exploring the Role of Religiosity in Hypertension Management Among African Americans*, 11 *J. of Health Care for the Poor & Underserved* 19 (2000).

<sup>32</sup> Susanna H. Priest, *Information Equity, Public Understanding of Science and the Biotechnology Debate*, 45 *J. of Commun.* 39 (1995).

<sup>33</sup> Martin Bauer et al., *European Public Perceptions of Science*, 6 *Intl. J. of Pub. Op. Research* 163 (1994).

<sup>34</sup> Edna F. Einsiedel, *Mental Maps of Science: Knowledge and Attitudes Among Canadian Adults*, 6 *Intl. J. of Pub. Op. Research* 35 (1994).

<sup>35</sup> Michele L. Trankina, *Gender Differences in Attitudes Toward Science*, 73 *Psychol. Rpts.* 123 (1993).

<sup>36</sup> Frederick Grinnell, *Complementarity: An Approach to Understanding the Relationship Between Science and Religion*, 29 *Persps. in Biology & Med.* 292 (1986); Oskar Gruenwald, *Science and Religion: The Missing Link*, 6 *J. of Interdisciplinary Stud.* 1 (1994).

### Study Design

In July 2000, 538 participants were surveyed in Kingston, Ontario, Canada. Participants were recruited from several parts of the downtown core of the city using a random number table. Random time slots and locations were picked to ensure greater representativeness. This study was exploratory. Respondents represented a convenience sample and not a random sample from a known population. Additionally, the relatively small sample size limited the generalizability of the data.

Participants completed a survey that included questions dealing with their perceptions of genetically engineered foods. Questions used a five-point Likert scale to ascertain perceptions of risk, worry, voluntary exposure, perceived benefits, and whether or not participants would be more inclined to consume genetically engineered foods if they were deemed safer than non-genetically engineered substitutes.

Following this set of questions, participants completed a short questionnaire on their attitudes toward science. In an earlier pilot testing phase, several questions were subjected to reliability analysis to generate a reliable, short scale. Participants in the main study answered questions using a five-point Likert scale represented in the Scientism Scale below.

#### Scientism Scale\*

- 
- I believe that science can eventually solve most of the problems facing the world.
  - I believe that science creates more problems than it solves.
  - I am willing to accept new ideas if provided with sufficient scientific proof.
  - I am cautious about using new technologies.
  - I believe that science is more constructive than destructive.
- 

\* Responses included strongly disagree, disagree, no opinion, agree, strongly agree.

Participants were then administered a short questionnaire to measure their level of religiosity. Based on pilot testing of a larger set of questions, participants answered several Likert-scaled questions that assessed how much their religion meant to them, whether they believed in the power of prayer, whether they attended religious services on a regular basis, whether they donated to their church, and whether they considered themselves to be very religious. The Religiosity Scale is represented as follows:

### Religiosity Scale\*

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My religion means a great deal to me.  
I believe in the power of prayer.  
I attend religious services on a regular basis.  
I usually donate to my church.  
I consider myself a very religious person.

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\* Responses included strongly disagree, disagree, no opinion, agree, strongly agree.

The last set of information elicited from participants was demographic details including their sex, age, and level of education. On average, participants needed approximately ten minutes to complete the entire survey.

### Methods

The survey yielded three kinds of information (perceptions of genetically engineered foods, scientism scale, and religiosity scale) and three demographic indicators (sex, age, and level of education). Each question from the perception of genetically engineered foods portion of the questionnaire was compared with the demographic variables to reveal any significant relationships as ascertained by the Pearson  $\chi^2$  statistic. Traditionally, this is the kind of analysis carried out under the psychometric paradigm. Next, each question from the genetic engineering portion of the questionnaire was analyzed with respect to totals for both scientism and religiosity scales. This analysis is closer to the cultural approach to understanding individual perceptions of risk. Lastly, scores on the scientism and religiosity scales were compared to the demographic data.

### Results

The response rate for participation was around 60%. From the sample, 56.4% were female and 43.6% were male. Respondents were well educated, with 70.8% receiving some form of college or university education, 27.5% had some high school education, and 1.7% had less than grade 9 education. Age ranged between 13 and 89 with a mean of 38.62 and a standard deviation of 16.67. A comparison of these demographic variables with census data (1996) from Statistics Canada

is available in Table 1. With respect to age and sex ratio, the sample is very close to the reported census data. However, for level of education the sample is biased towards the more highly educated.

Table 1  
Comparison of Demographic Characteristics with Census (1996) Data  
from Statistics Canada for the City of Kingston

	<i>Study</i>	<i>Census</i>
Female	56.4%	55%
Male	43.6%	45%
Mean Age	38.62	38.60
Level of Education:		
Some College or University	70.8%	56%
High School	27.5%	42%
Grade 9 or less	1.7%	2%

Analysis shows that the demographic variables are related to some questions in the perception of genetically engineered foods questionnaire noted in Table 2 below. The following results represent statistically significant relationships and not strength of relationship. Perception of risk is significantly related to sex. Female respondents (mean risk score=3.28) were more likely to assess the risks associated with genetically engineered foods as higher than males (mean risk score=2.95) ( $\chi^2=27.63$ ,  $df=4$ ,  $p<.0001$ ). They were also more likely to express higher levels of worry (female=3.21; male=2.76) associated with consuming genetically engineered food ( $\chi^2=24.22$ ,  $df=4$ ,  $p<.0001$ ). Older respondents believed that the consumption of genetically engineered foods was less voluntary than younger respondents did ( $\chi^2=28.95$ ,  $df=8$ ,  $p<.0001$ ). Respondents with higher levels of education expressed less worry about genetically engineered foods ( $\chi^2=9.98$ ,  $df=4$ ,  $p=.04$ ) and paradoxically were less likely to believe that genetically engineered foods provide benefits ( $\chi^2=11.52$ ,  $df=4$ ,  $p=.02$ ). However, if genetically engineered foods are proven safer than non-genetically engineered substitutes, respondents with higher levels of education were more likely to accept them ( $\chi^2=11.91$ ,  $df=4$ ,  $p=.02$ ). Although all of these relationships are statistically significant, the first

three were relatively strong ( $p < .0001$ ), while the latter three were weaker ( $p < .05$ ).

Table 2  
Significant Relationships Between Demographic Variables  
and Perceptions of Genetically Engineered Foods

Sex x perceived risk	$\chi^2=27.63$ , $df=4$ , $p < .0001$
Sex x degree of worry associated with consuming genetically engineered food	$\chi^2=24.22$ , $df=4$ , $p < .0001$
Age x belief that consuming genetically engineered food is voluntary	$\chi^2=28.95$ , $df=8$ , $p < .0001$
Level of education x degree of worry associated with consuming genetically engineered food	$\chi^2=9.98$ $df=4$ $p=.04$
Level of education x perceived benefits of genetically engineered food	$\chi^2=11.52$ , $df=4$ , $p=.02$
Level of education x choose genetically engineered food if proven safer than non-genetically engineered substitutes	$\chi^2=11.91$ , $df=4$ , $p=.02$

When subjected to reliability analysis, the scientism score has a Cronbach  $\alpha=.80$ . The range of scores fell between 9 and 23 with a mean of 17.46 and a standard deviation of 2.82. Scores from the scientism scale are related to several questions in the perception of genetically engineered foods questionnaire noted in Table 3 below. Respondents with high scores on this scale were more likely to assess the risks associated with genetically engineered foods as low ( $\chi^2=36.56$ ,  $df=8$ ,  $p < .0001$ ). High scoring respondents were less worried about consuming genetically engineered foods ( $\chi^2=18.56$ ,  $df=8$ ,  $p=.02$ ) and more likely to believe that their consumption is voluntary ( $\chi^2=19.22$ ,  $df=8$ ,  $p=.01$ ). High scoring respondents also ascribed more benefits to genetically engineered foods ( $\chi^2=35.03$ ,  $df=8$ ,  $p < .0001$ ) and were more likely to choose them if proven safer than non-genetically engineered substitutes ( $\chi^2=115.63$ ,  $df=8$ ,  $p < .0001$ ).

The religiosity scale yielded a Cronbach  $\alpha=.91$ . Scores ranged between 5 and 25 with a mean of 12.82 and a standard deviation of 6.51. Scores on the religiosity scale were not significantly related to any of the questions from the perception of genetically engineered foods questionnaire.

Table 3  
Significant Relationships Between Scientism and  
Perceptions of Genetically Engineered Foods

Scientism score x perceived risk	$\chi^2=36.56$ , df=8, p<.0001
Scientism score x degree of worry associated with consuming genetically engineered food	$\chi^2=18.56$ , df=8, p=.02
Scientism score x belief that consuming genetically engineered food is voluntary	$\chi^2=19.22$ , df=8, p=.01
Scientism score x perceived benefits of genetically engineered foods	$\chi^2=35.03$ , df=8, p<.0001
Scientism score x choose genetically engineered food if proven safer than non-genetically engineered substitute	$\chi^2=115.63$ , df=8, p<.0001

The only demographic variable significantly related to scores on the scientism and religiosity scales was age. Older respondents were more likely to have high scores on the scientism scale ( $\chi^2=11.64$ , df=4, p=.02). They were also more likely to score high on the religiosity scale ( $\chi^2=44.74$ , df=4, p<.0001). Using the Pearson correlation coefficient, scientism was positively correlated with age ( $r=.18$ , p<.01, two-tailed) and religiosity was positively correlated with age ( $r=.31$ , p<.01, two-tailed). There was no relationship between score on the scientism scale and score on the religiosity scale.

### Discussion

Public perceptions of genetically engineered foods can be understood by examining attitudes toward science and demographic variables like sex, age, and level of education. Based on our data, sex and age are the strongest predictors of perceptions associated with genetically modified foods. Females perceive the risks associated with genetically modified foods as greater and are more worried about consuming foods produced with this technology. This finding is consistent with a large volume of studies that show females to be more risk averse than males. Since females do not differ from males in scores for scientism or religiosity, it may be possible that there is something unique about the socialization of females and males that explains these differences. Perhaps females derive less direct benefits from the introduction and use of new technologies. What is clear from this study

and others is that more work is needed to help explain these consistently strong sex differences.

When we consider the age variable, explaining why older respondents are less likely to believe that consuming genetically modified foods is voluntary is equally speculative. Perhaps older respondents have become jaded about the food system. They have lived through several changes in the food production and processing industry. Older respondents are more likely to recall debates about the use of food irradiation and on the safety of exposure to pesticides. These experiences may lead some to believe that food production is beyond their control. Consequently, they may influence perceptions associated with voluntary consumption of newer food modifications like those ushered in by the revolution of genetic engineering.

The relationships between level of education and perception are weaker than the relationships for sex and age. Level of education is positively associated with less worry, the belief that genetically modified foods provide fewer benefits, and the willingness to consume genetically modified foods if proven safer than alternatives. Since education is not significantly associated with scientism or religiosity, it may be a surrogate for other value orientations and concerns. More educated individuals may feel that they can exercise some control over any perceived risks associated with exposure to genetically modified foods by buying organic foods, thus reducing worry. More educated individuals may be more critical of messages touting the benefits of genetically modified foods. Lastly, more educated individuals may be more sensitized to both risk and benefit. In this regard, if they can be convinced that genetically modified foods are indeed safer than alternatives, they may be more willing to consume them. It is possible that the results reported here reflect the highly educated sample taken from the study area. Future studies should consider using quota sampling to help minimize any biases that may be introduced.

Based on the data, religiosity does not explain differences in perception. As such, the first hypothesis that high levels of religiosity are associated with less support for genetically engineered foods is not supported. Although religiosity is positively related to age and being female, this concept is not linked to the risk dimensions assessed in the study. Perhaps the arguments made for including religiosity fit better

when assessing public perceptions of reproductive technology or when investigating areas like xenotransplantation (animal to human organ transplantation). Concerns about genetically engineered foods seem to be health-based. As the world's major religions clarify their positions on genetic engineering, it is likely that Jewish laws on Kosher foods, Moslem guidelines for Halal, and Buddhist interpretations of Ahimsa (non-harming) may have an influence on perceptions of these new food products among strict adherents.

By contrast, an analysis of attitudes toward science is fruitful. Individuals with high levels of scientism are more likely to assess the risks associated with genetically engineered foods as low, thus supporting the second hypothesis. This reflects a higher level of trust in science where less worry about the foods consumed is expressed. Individuals with high levels of scientism were more likely to believe that genetically engineered foods provide important benefits and that consumption of such foods is voluntary, thus supporting the third and fourth hypotheses respectively.

It is interesting to note that although scientism is associated with perceptions of genetically modified foods, it remains independent of sex and education. It is possible that the kind of education received influences this pattern. Future studies should consider not only the level of education of respondents, but also respondents' type of education on a post-secondary level such as whether the respondent was educated in the arts and humanities or in the natural sciences. These educational tracks, which are strongly related to sex, may independently influence perceptions.<sup>37</sup> Additionally, more educated individuals may have greater access to alternative sources of information and may accept the authority of science yet be more critical of its assumptions, methodologies, and sources of support.

The exploratory nature of this study means that the actual strength of relationships between variables under consideration is less important than the theoretically significant relationships uncovered. As such, this study identifies fruitful variables for future and larger scale research. Moreover, the study may lay the foundation for research that more comprehensively explores convergence of the psychometric and cultural

<sup>37</sup> I would like to thank one of the peer reviewers for pointing this out.



approaches to risk. In this vein, researchers may wish to consider using focus groups and depth interviews in conjunction with questionnaires and risk ranking exercises. Some analysis of the strengths and weaknesses associated with combining these approaches is also needed.

Research on public perceptions of different genetic engineering applications is a necessary step towards understanding how social and structural variables like sex, age, and education interact with the different dimensions commonly associated with how risks are processed and socially understood. Such an understanding can be used to improve communication between policymakers and the public and can be helpful in predicting public responses to new technologies. At the moment, assessing public attitudes toward science is an important tool for understanding perceptions of genetically modified foods. As genetic engineering extends into other areas including genetic testing for birth defects, “designer babies,” and transgenic animals, factors like religiosity are likely to play an important role in understanding how risks are understood. Social scientists should continue to work on exploring the rich connections that exist between the psychometric approach and the cultural approach to risk. In fact, new technologies like genetic engineering may be stimulating this convergence.

