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Risk and Culture: Is Synthetic Biology Different?

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Abstract

“Cultural cognition” refers to the influence that individuals’ values have on their perceptions of technological risk. We conducted a study to assess the cultural cognition of synthetic biology risks. Examining the attitudes of a large and diverse sample of Americans ($N = 1,500$), we found that hierarchical, conservative, and highly religious individuals—persons who normally are most *skeptical* of claims of environmental risks (including those relating to nuclear power and global warming)—are the persons most *concerned* about synthetic biology risks. We attribute this inversion of the normal cultural profile of risk perceptions to the seemingly anti-religious connotations of synthetic biology. We discuss implications of this finding for future study and for risk communication.

Were Franklin Roosevelt alive today, he might well advise proponents of synthetic biology that the only thing they have to fear is fear itself. Its immense range of potential applications—scientific, commercial, and medical—marks synthetic biology as one of the most promising new forms of applied science. Its future, however, will depend not just on anticipation of its likely benefits but also on concern about its possible risks. If members of the public react with alarm toward this novel technology, a stringent regulatory climate—or simply the expectation of one on the part of anxious investors—could stifle development of this nascent science¹. We conducted a study to gauge public predispositions toward the risks associated with synthetic biology. The results suggest that synthetic biology has the potential to arouse concern not only among persons who tend to worry about environmental and technological risks generally, but also among a group whose members typically do not: conservative, highly religious, white males who hold hierarchical and individualistic values.

Many psychological influences other than the best available scientific information contribute to the public's perception of risks. Studies have documented a host of biases and heuristics that can result in the systematic under- and over-estimation of environmental and technological risks².

Among the most potent of these influences are *cultural predispositions*. The “cultural cognition of risk” refers to the tendency of persons to conform their beliefs about the consequences of a putatively dangerous activity to their cultural evaluations of that activity. There are a variety of mechanisms, but simply put, it is more comforting for individuals to believe that conduct that they view as honorable is also socially beneficial, and conduct that they view as wicked is also socially detrimental, than vice versa³.

How might cultural cognition influence the public's perceptions of synthetic biology? One possibility is that synthetic biology risk perceptions will be shaped by the same cultural dy-

namics that inform perceptions of other environmental and technological risks. The assertion that commerce and industry threaten human health implies the incompetence and corruption of existing elites, whose authority is symbolized by those activities. Historically, this connotation has made concern over environmental risks (e.g., those associated with nuclear power^{4,5}, climate change⁶, and food additives⁷) congenial to persons with egalitarian values, who resent commerce and industry as sources of disparity in wealth and power. The same cultural resonances have generated environmental-risk skepticism in persons with more hierarchical (basically, pro-authority) and individualistic values—particularly white males with those outlooks—because they are the persons whose social roles and status are most tightly tied to commerce and industry⁸. Famously articulated by Douglas and Wildavsky⁹, this account finds strong empirical vindication in the work of Leiserowitz, who labels as “environmental risk naysayers” a segment of society whose members are disproportionately white and male, politically conservative, and highly religious, in addition to being culturally hierarchical and individualistic⁶. One might surmise, then, that synthetic biology will provoke a similar division in public opinion.

Alternatively, the development of synthetic biology might trigger a different cluster of cultural meanings, and hence a different cultural alignment of risk perceptions. More than any other form of science, synthetic biology highlights the injection of human agency into the *creation* of particular forms of life. This prospect excites exhilaration in some people, who see it as a singular token of human understanding of, and mastery over, nature. But for others, it provokes a profound unease, a sense that human beings are interfering with a more fundamental cosmic ordering—or “playing God,” thereby denigrating divine agency. In those who feel it most intensely, this sensibility is likely to be of a piece with resentment toward other practices—from cloning to stem cell research to the teaching of Evolution in public schools—all of which symbolize the threat that science is sometimes viewed as posing to *religious* authority¹⁰.

People who experience such resentment, cultural cognition theory predicts, are the ones most likely to see synthetic biology as posing significant societal risks. Indeed, both in public focus groups¹¹ and in a comprehensive comparative media study¹², researchers have found that the “playing God” objection is often voiced in the same breath as concerns about risks that synthetic biology might pose to human health and to the environment.

Based on casual observation, there seems little reason to expect persons who see synthetic biology as denigrating religion to subscribe to an egalitarian and solidaristic or communitarian worldview. On the contrary, they are more likely to hold relatively hierarchical outlooks due to the affinity between traditional religious values and hierarchical roles and norms. Similarly, whereas individualism usually predicts technological-risk skepticism, with regard to synthetic biology this predisposition is likely to be muted and possibly even inverted among persons who hold values that are *simultaneously* individualistic and hierarchical. White males who are politically conservative, highly religious, and who subscribe to hierarchical, individualistic values are no less likely to form this risk concern than other hierarchical individualists. Indeed, they might be even more prone to it because of the role that hierarchical and religious norms are likely to play in sustaining the status of white males in communities that reflect a highly traditional, and highly stratified, form of social organization. In sum, it is at least conceivable that synthetic biology might stand Leiserowitz’s “naysayers” on their heads, filling them with anxiety.

We’ll call these possibilities—that synthetic biology risk perceptions will conform to the conventional cultural pattern, and that they will instead reflect something closer to the opposite of it—the “standard” and “cultural inversion” hypotheses, respectively. We conducted a public opinion study to test them.

The study was based on an online survey of a nationally representative sample of 1,500 U.S. adults. We collected data on the respondents’ cultural worldviews, which were measured with two independent scales, Hierarchy-Egalitarianism (or simply, “Hierarchy”) and Individualism-Communitarianism (“Individualism”), used in studies of the cultural cognition of risk^{13,14}. We also collected data on various demographic and other individual characteristics pertinent to our two hypotheses. And finally we solicited the respondents’ perceptions of various environmental and technological risks, including those associated with synthetic biology.

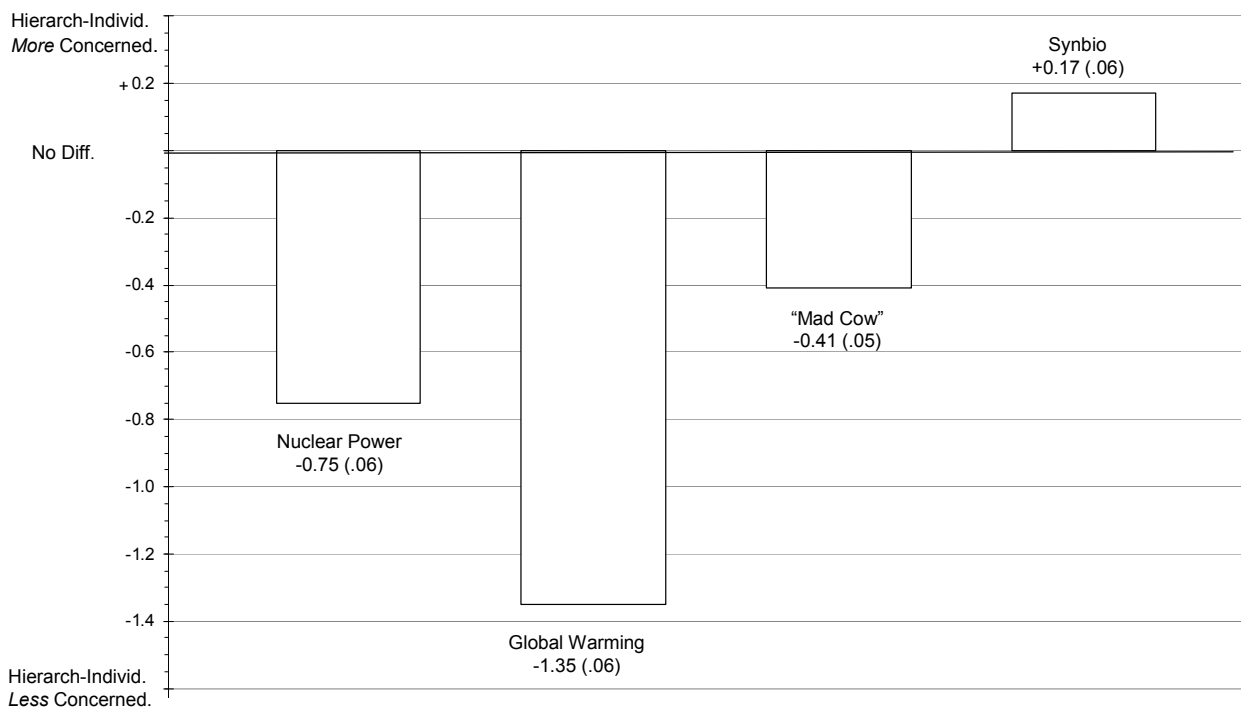


Figure 1. Difference between risk perceptions of Hierarchical Individualists and others. $N = 1,500$. Risk perceptions measured with 5-point scales; differences computed by subtracting mean score of subjects possessing Hierarchical and Individualistic cultural values (as determined by median splits), on the one hand, from mean scores of remaining subjects. Standard errors in parentheses. All differences significant at $p < .01$.

The results furnished strong support for the “cultural inversion” hypothesis. For environmental and technological risks *other* than those associated with synthetic biology, the results of the survey displayed the “standard” alignment. Respondents whose values were simultaneously hierarchical and individualistic were significantly less concerned about global warming, nuclear power, and “mad cow disease” than were respondents who held other worldviews (Figure 1).

Multivariate regression showed that for each of these risks being male, being hierarchical, and being individualistic all significantly predicted less risk concern, as did being white in the cases of nuclear power and mad cow disease, and regular church attendance in the case of global warming (Table 1).

But for synthetic biology, the results were markedly different. Far from being the least concerned, respondents holding hierarchical and individualistic values were significantly *more* concerned than other respondents (Figure 1).

<i>Predictor</i>	Global Warming	Nuclear Power	Mad Cow Disease
Male	-0.25 (0.11)	-0.96 (0.10)	-0.46 (0.10)
White	-0.07 (0.12)	-0.31 (0.11)	-0.54 (0.11)
Age	0.01 (0.00)	0.00 (0.00)	0.01 (0.00)
Income	-0.04 (0.02)	-0.08 (0.02)	-0.06 (0.02)
Education	-0.02 (0.04)	-0.19 (0.04)	-0.17 (0.04)
Democrat (vs. Nondemocrat)	0.36 (0.13)	0.07 (0.12)	0.14 (0.12)
Conservatism	-0.37 (0.07)	-0.09 (0.07)	0.00 (0.06)
No Religious Affiliation	-0.18 (0.15)	-0.30 (0.14)	-0.25 (0.14)
Regularity of Church Attendance	-0.14 (0.05)	0.06 (0.04)	0.02 (0.04)
Hierarchy	-0.91 (0.08)	-0.45 (0.07)	-0.22 (0.07)
Individualism	-0.53 (0.08)	-0.28 (0.07)	-0.19 (0.07)
McKelvey & Zavoina's R^2	0.46	0.26	0.13

Table 1. Multivariate ordered logistic regression analysis of other risk perceptions. $N = 1,500$. Ordered-logit coefficients. Dependent variables: 5-pt risk perception measures. Standard errors in parentheses. Bolded denotes significance at $p < .05$.

A multivariate regression analysis displayed an even sharper inversion of the usual risk-perception influences (Table 2). Thus both political conservatism and regular church attendance predicted *greater* concern with synthetic biology risks relative to benefits. So did the combined effect of hierarchy and individualism (Table 2). Being simultaneously egalitarian and individualistic, in contrast, significantly predicted *less* concern. Indeed, taking account of these worldviews and of their interaction with each other and with gender, the *aggregate* effect of being white, male, politically conservative, hierarchical and individualistic—the characteristics that jointly characterize Leiserowitz’s environmental risk “naysayers”—predicted a 16.9% *decrease* in the likelihood of seeing the benefits of synthetic biology as outweighing its risks (Figure 2).

Controlling for all other influences, being female predicted a moderate decrease (4.1%), and being white, had no significant impact.

<i>Predictor</i>	<i>B</i>
Male	3.83 (1.77)
White	0.17 (0.13)
Age	0.00 (0.00)
Income	0.02 (0.02)
Education	-0.07 (0.04)
Democrat (vs. Nondemocrat)	0.14 (0.14)
Conservatism	-0.24 (0.08)
No Religious Affiliation	0.15 (0.17)
Regularity of Church Attendance	-0.13 (0.05)
Self-reported Knowledge of Synbio.	0.15 (0.08)
Concern with Other Risks	-0.75 (0.09)
Hierarchy	1.14 (0.39)
Individualism	0.93 (0.32)
Hierarch x Individualist	-0.33 (0.09)
Hierarchy x Male	-1.23 (0.50)
Individ x Male	-0.83 (0.45)
Hier. x Ind. x Male	0.28 (0.12)
McKelvey & Zavoina's R^2	0.13

Table 2. Multivariate logistic regression analysis of synthetic biology risk-benefit perceptions. $N = 1,500$. Logit coefficients. Dependent variable: dichotomous, Benefits > Risks. Standard errors in parentheses. Bolded denotes significance at $p < .05$.

Interestingly, a greater concern with other environmental risks (nuclear power, climate change, and mad cow disease) also predicted a greater likelihood of perceiving synthetic biology's risks as exceeding its benefits (Table 2 and Figure 2). When all other influences were controlled for, being moderately concerned about other environmental risks predicted a 15.7% decrease in the likelihood of perceiving synthetic biology benefits as outweighing its risks.

Consistent with previous public opinion examinations¹¹, most of our respondents (82%) reported knowing only "little" or "nothing at all" about synthetic biology. Nevertheless, the level of reported knowledge had no significant impact on risk perceptions once other influences were controlled for (Table 2), suggesting that increased exposure to information about synthetic biology does not offset the impact of cultural worldviews and other characteristics.

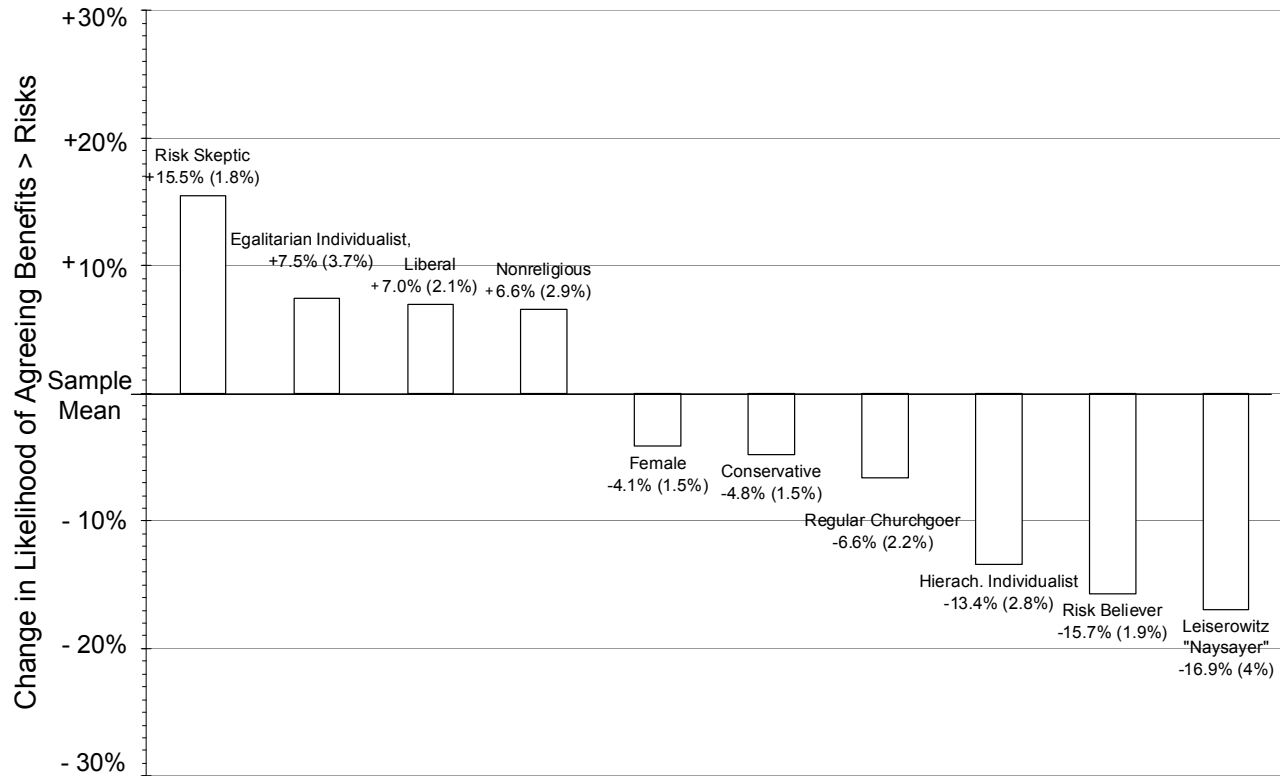


Figure 2. Individual characteristics' effect on probability of perceiving synthetic biology benefits outweigh risks. $N = 1,500$. Derived by statistical simulation from logistic regression analysis.¹⁵ The predicted change in probability reflects the impact of the indicated characteristic when all other characteristics are held constant at the sample mean. Standard errors in parentheses. All predicted changes significant at $p < .05$. "Leiserowitz's 'naysayer'" reflects values of white for race, male for gender, "several times a month" for church attendance, 0 or adherence to a religious faith for "no religion," one standard deviation toward conservatism on liberal-conservative scale, and one standard deviation from mean toward "hierarchy" and toward "individualism" on worldview scales.

We draw two conclusions from these results. The first is that a distinctive form of cultural conflict over the risks of synthetic biology is indeed a realistic possibility. Consistent with the cultural-inversion hypothesis, the pattern of risk concerns we observed among our subjects suggests that highly religious, conservative persons who hold hierarchical and individualist values—including white males who do—are poised to experience considerable anxiety toward the risks of synthetic biology.

Moreover, they are not the only ones. Because concern over other environmental risks *also* predicts concern with synthetic biology risks, opposition to development of synthetic biology might well feature an unusual alliance between those who are normally most disposed and

those who are normally *least disposed* to fear environmental and technological hazards generally.

Although this is a pattern unlike that found in previous studies of technological risk perceptions, it underscores the importance of cultural cognition. Indeed, it is fully consistent with Leiserowitz's basic claim that risk perceptions are determined by what technologies symbolize about the values of different "interpretive communities"⁶. It is also consistent with work showing that religious beliefs act as a perceptual "filter" in policy matters generally, including those relating to novel technologies,¹⁶ and thus reinforces Scheufele et al.'s call for "a more nuanced investigation of the role of religiosity in public perceptions about technological and environmental risks"¹⁷.

The second conclusion supported by our study is the critical importance of research aimed at fashioning effective risk communication strategies for synthetic biology. At the same time that it documents the importance of cultural predispositions in the formation of risk perceptions, existing research suggests techniques for minimizing their biasing potential.³ The goal of such strategies is not to induce any particular conclusion about the acceptability of the risks associated with a given technology, but rather to assure that persons of all cultural outlooks are able to make that assessment on the basis of the best available scientific information.

The current study, however, suggests that fitting such strategies to synthetic biology is likely to be a challenging task. The risk-communication techniques developed to counteract cultural cognition all presuppose the familiar tendency of egalitarianism toward risk-sensitivity and of hierarchical individualism toward risk-skepticism. Because synthetic biology appears to interact with cultural predispositions in a strikingly different way, additional study (particularly by experimental and related methods¹⁸) will be necessary before these strategies can be confidently adapted to it.

The time to initiate such studies is now. Existing work suggests that first impressions of the hazards associated with a new technology not only tend to be lasting but also self-reinforcing. Studies show that people form instantaneous assessments of technological risks based on visceral or emotional reactions, the valence of which is shaped by individuals' cultural outlooks¹⁹. Such assessments are likely to intensify over time because of people's disposition to search for and interpret information in a manner supportive of their existing views¹⁴. Thus, strategies aimed at averting cultural polarization are most likely to succeed if devised and implemented *before* awareness of synthetic biology has become widespread and opinions about it have hardened.

We are witnessing accelerating progress in our ability to fabricate novel biological systems that can be used to enhance human health and welfare. But for the benefits of this rapidly developing science to be fully realized, our understanding of how to communicate scientifically sound risk information within culturally diverse democratic polities will need to advance at just as dramatic a pace.

Methods

The sample consisted of 1,500 U.S. adults recruited to be members of a nationally representative on-line panel by Polimetrix, a firm that specializes in academic and commercial public opinion research. The study was conducted using Polimetrix's on-line facilities. For information on Polimetrix's sampling and testing methods, see <http://www.polimetrix.com/documents/YGPolimetrixSampleMatching.pdf>.

In addition to standard demographic data, the study collected data on respondents' cultural values. The scales, used in various previous studies of cultural cognition of risk^{13,14}, assessed respondent values along two dimensions: "Hierarchy-Egalitarianism" and "Individualism-Communitarianism." The scales were reliable ($\alpha = .86$ and $\alpha = .88$, respectively) and were designed to measure discrete latent factors representative of the "worldviews" described in Douglas

(1970).²⁰ For purposes of means analyses (Figure 1), respondents were deemed “hierarchical individualists” if their scores exceeded the median score on both scales. For purposes of the regression-based simulation (Figure 2), the culture variables for “hierarchical individualists” and for Leiserowitz “naysayers” were set at values one standard deviation from the mean toward the hierarchy and individualist ends of the those scales; the culture variables for “egalitarian individualist” subjects were set at values one standard deviation from the mean toward the egalitarian and individualist ends of those scales.

The survey instrument used a four-point scale (“almost never or never,” “less than once a month,” “a few times a month,” and “once a week ore more”) to measure church attendance. In addition, respondents who indicated “none” in response to a religious affiliation item were assigned a “1,” while those identified themselves with some religious denomination were assigned “0,” for the variable “no religion.” For purposes of the regression-based simulation (Figure 2), church attendance was set at “almost never or never,” and “no religion” at 1 for “non-religious,” while church attendance was set at “once a week or more” and “no religion” at 0 for “regular churchgoer.”

The survey instrument contained a number of items relating to synthetic biology. All respondents read an introductory statement indicating that “synthetic biology is a novel form of science that will allow scientists to design and build new biological organisms.” They then answered a self-reported knowledge item that stated, “How much have you heard about synthetic biology before today?,” and permitted the responses, “Nothing at All,” “Just a Little,” “Some,” “A Lot.” Respondents were also instructed to indicate the level of their agreement (“strongly disagree,” “moderately disagree,” “slightly disagree,” “slightly agree,” “moderately agree,” “strongly agree”) with the statement, “On the whole, the benefits of synthetic biology will outweigh the risks synthetic biology will outweigh the risks.” To make them commensurable with

responses to the other risk-perception items, responses to this item were reverse coded and transformed to a five-point scale in the means analysis reported in Figure 1. The item was collapsed to a dichotomous “benefits outweigh risks” variable for purposes of the logistic regression analysis (Table 2) and regression-based simulation (Figure 2).

We also collected data on respondents’ perceptions of a set of other environmental risks. Respondents were asked to indicate on a five-point scale (“almost no risk,” “slight risk,” “moderate risk,” “high risk,” “extremely high risk,”), “How much risk do you believe each of the following poses to the safety or health of people in our society?”: “Global Warming,” “Mad Cow Disease,” “Nuclear Power.” These items were combined into a single scale for purposes of the of the logistic regression analysis (Table 2); for purposes of the regression-based simulation (Figure 2), the value for “Risk skeptic” was set one standard deviation toward less concern, and the value for “Risk believer” one standard deviation toward more concern, on this scale.

In multivariate analyses, missing data were imputed through multiple imputation using Stata’s ICE module²¹. Monte Carlo simulations were performed with Stata using Clarify¹⁵.

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