DEFERENCE TO SCIENTIFIC AUTHORITY AMONG A LOW INFORMATION PUBLIC: UNDERSTANDING U.S. OPINION ON AGRICULTURAL BIOTECHNOLOGY

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ABSTRACT

This study uses the contemporary debate over agricultural biotechnology to conceptualize a theoretical model that can be used to explain how citizens reach judgments across a range of science and technology controversies. We report findings from a mail survey of New York State residents that depicts a 'low information' public relying heavily on heuristics such as value predispositions, trust, and schema to form an opinion about agricultural biotechnology. Science knowledge does play a modest role, with the news media serving as an important source of informal learning. Contrary to expectations and past research, we do not find any direct effects for news attention on support for agricultural biotechnology. Deference to scientific authority is a central value predisposition shaping support for agricultural biotechnology. Positively correlated with education, deference to scientific authority is the strongest influence on support for agricultural biotechnology in our model. Part of the variable's influence is direct, but part of it is also indirect, as deference to scientific authority is a key predictor of both trust in the sponsors of biotechnology and generalized reservations about the impacts of science.

Over the past decade, a growing number of studies have examined public opinion within the context of science and technology conflicts. These debates offer valuable opportunities for exploring opinion processes since they typically include developments remote from ordinary citizen experience, and are characterized by highly technical discourse. Public reaction is an important social dimension in these conflicts, with citizen opinion shaping the trajectory of scientific development and technological adoption. In post-industrial societies where issues ranging from stem cell research to climate change have at times come to dominate transnational agendas, and where expertise and knowledge

have evolved as major sources of economic power and political persuasion, it is increasingly important to understand how citizens reach judgments about the complexities of science and technology.

Perhaps no single science-related topic has generated as much speculation, concern, and research as the cross-Atlantic divide over agricultural biotechnology. As outlined in the introductions to a recent special issue of this journal (Bauer, 2005b; Peters, 2005), the technology raises fundamental questions about social values, nature, technological development, citizen input, international competitiveness, property rights, and economic justice. As chief exporters of agricultural biotechnology products, a majority of American scientists, industry members, and political leaders believe the technology offers great promise for improving world nutrition, increasing sustainability, and benefiting trade. However, public opinion in Europe, the largest market for U.S. ag biotech products, runs against the technology, creating major economic tensions with the European Union. In contrast to the European public, Americans remain largely unaware of the issue, yet when asked, are positive in their views of the technology.

This paper is not a direct comparison of the complex set of factors leading to very different patterns of public acceptance of agricultural biotechnology between the USA and Europe. Instead, the study uses survey data collected in the USA in 2001 to outline a conceptual approach to testing different accounts that researchers have put forward to explain opinion formation on the topic. The purpose is to present a parsimonious model integrating major variables highlighted by past research. We begin by noting general assumptions relative to how citizens make up their minds about complex policy issues, and then describe key influences that past research has highlighted specific to agricultural biotechnology. Using American attitudes about genetically engineered plants and food as a test case, our goal is to articulate a generalizable model that incorporates previous theorizing and findings, and that can serve as an analytical tool for understanding opinion formation across a range of science and technology controversies.

HOW CITIZENS MAKE UP THEIR MINDS ABOUT BIOTECHNOLOGY: GENERAL ASSUMPTIONS AND PAST RESEARCH

A Low Information Public

As part of human nature, individuals are cognitive misers or at least satisficers, who collect only as much information about a topic as they think is necessary to reach a decision (Fiske & Taylor, 1991). Faced with daily demands for their time and attention, it is impossible for citizens to be well informed about all policy issues; instead citizens look for short cuts in processing information and reaching social judgments about complex policy debates (Popkin, 1991). The fact that

citizens may be relatively uninformed about an emerging technological debate does not mean that they are unable to make decisions or judgments about a technology (Scheufele & Lewenstein, in press). A low information public is likely to rely heavily on their underlying value orientations in combination with a 'convenience sample' of just those interpretations or definitions of an issue most readily available from the mass media. Recent research examining public views of science and technology debates has highlighted the strong heuristic role played by value predispositions and media content in shaping general views about science (Nisbet et al., 2002), embryonic stem cell research (Nisbet, 2005), nanotechnology (Scheufele & Lewenstein, in press), and, as we will discuss, agricultural biotechnology (Besley & Shanahan, 2005).

The emphasis on a low information public runs counter to a still widely held belief among many scientists and decision makers that scientific literacy—understanding the facts behind the science in a debate—is the key factor shaping public views about science. The popular assumption is that increasing science literacy boosts public acceptance of the scientific worldview. In other words, if the public knew more about science, then scientists would be granted greater influence over important policy decisions, and controversies would likely go away (Bodmer, 1985).

This narrow focus on science literacy has been heavily criticized. For example, a recent meta-analysis of the results of nearly 200 surveys conducted in 40 countries revealed that the more people knew about science, the more likely they were to have favorable attitudes toward science. Yet knowledge only explained a small amount of the variance in their views, whereas other factors such as moral values, religious beliefs, and political views were much stronger predictors (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2005). Consistent with models of heuristic processing, various studies employing focus group, consensus conference, and survey methods in the United States, Germany, Canada, Australia, and the United Kingdom have found that citizens are generally more likely to rely on social values, generalized attitudes about science, and estimations of trust to guide their judgments about agricultural biotechnology (Einsiedel, Jelsøe, & Breck, 2001; Hempel, Pfenning, & Peters, 2000; Gaskell, Allum, & Stares, 2003; Priest, 1995, 2001), though knowledge appears to still play a limited role in promoting more positive views of the technology (Brossard & Shanahan, 2003; Hallman, Hebden, Aquino, Cuite, & Lang, 2003; Priest, 2001).

A view of 'miserly citizens' who rely primarily on values, readily available media interpretations, and estimations of trust to reach social judgments, however, is just a model, in other words it is meant to describe overall social patterns (Scheufele & Lewenstein, in press). There are exceptions to these patterns across society, as some individuals, particularly the so-called 'issue public' for science, are likely to be relatively well informed about the technical dimensions of the ag biotech debate, and to rely on this knowledge in formulating views about the issue.

For these citizens, press coverage likely plays a key role relative to knowledge. Media coverage may shape views about agricultural biotechnology directly through how the issue is interpreted or framed (Bauer, 2005a; Besley & Shanahan, 2005; Nisbet et al., 2002; Scheufele & Lewenstein, in press), but also indirectly, as news coverage serves as an important source of informal learning about the topic (Bauer, 2005b; Bonfadelli, 2005; Nisbet et al., 2002). The more citizens pay attention to agricultural biotechnology in the press, the more knowledgeable they are about the issue. The more knowledgeable the citizen, the less they perceive risk in the technology, though as discussed, the impact of knowledge is likely to be weaker in its effects than other competing influences (Brossard & Shanahan, 2003).

An Integrated Model

Past research therefore paints a view of a majority of citizens who rely on information shortcuts such as value orientations, available media interpretations, generalized attitudes towards science, and estimations of trust in shaping views of agricultural biotechnology, and a smaller segment of citizens who use their knowledge of the science linked to the debate to make sense of the issue. What is needed then is a conceptual and analytical approach that is able to integrate these multiple 'routes' to opinion formation in a parsimonious way. In general theoretical terms, the emphasis on predispositional values and media processes that shape opinion formation directly—but also indirectly via intervening and mediating factors such as knowledge and trust—is in line with a growing body of research that applies Markus and Zajonc's (1985) Orientation–Stimulus–Orientation–Response (O–S–O–R) model from social psychology to explain opinion formation and political behavior across a diversity of public issues and contexts (Besley & Shanahan, 2005; Holbert, Kwak, & Shah, 2003; Holbert, Shah, & Kwak, 2003; Moy & Pfau, 2000; Moy, Xenos, & Hess, 2005; McLeod, Scheufele, Moy, Horowitz, et al., 1999; McLeod, Scheufele, & Moy, 1999; Nisbet et al., 2002; Nisbet & Goidel, under review; Scheufele, Nisbet, & Brossard, 2003; Scheufele, Nisbet, Brossard, & Nisbet, 2004).

As conceptualized, 'O_1' represents long-term socialized value predispositions. The 'S' represents the stimulus of media consumption and attention across types of news outlets and other information sources. 'O_2' signifies intervening orientations or behaviors between stimulus and outcome, such as knowledge and trust, or generalized reservations about science. The 'R' represents the final outcome of both sets of orientations and the communication stimuli, in this case, public views about agricultural biotechnology. These variables are typically classified as 'endogenous' variables with primary emphasis in theorizing and analysis on the inter-relationships among these factors, and their direct and indirect effects on the response or dependent variable of interest. Demographic predictors such as

TABLE 1 **An O–S–O–R model explaining support for agricultural biotechnology**

Exogenous	Endogenous			
Demographics	Orientation O_1	Stimulus S	Orientation O_2	Response R

Sex
Age
General
  education
Science
  education
Ideology
Income
	Deference to
	  scientific
	  authority
		Diversity of
		  biotechnology
		  information
		  sources
		Attention to
		  biotechnology
		  in newspaper
		  coverage
		Attention to
		  biotechnology
		  on national
		  TV news
			Science-related
			  knowledge of
			  biotechnology
			Trust in
			  biotechnology
			  sponsors
			Fewer reservations
			  about impacts
			  of science
				Support for
				  agricultural
				  biotechnology

age or gender are grouped as 'exogenous' variables, and are of secondary interest. (For additional discussion of the O–S–O–R model, see McLeod, Kosicki, & McLeod, 2002). We order, label, and categorize these influences in Table 1, and elaborate on them in subsequent sections of this paper.

DEFERENCE TO SCIENTIFIC AUTHORITY (O_1)

The first step in understanding opinion formation specific to a policy controversy is to identify the relevant institutional arrangements and value predispositions connected to the controversy, which serve as first order influences in our model as outlined in Table 1. A number of value predispositions likely shape opinion formation on agricultural biotechnology in the USA, but in this paper we focus on a key value predisposition, 'deference to scientific authority,' that we identify from an understanding of the institutional relationships surrounding the technology.

In Europe, individual-level green orientations have been linked to public resistance. These green opponents are for the most part non-religious, politically left, post-materialist, and risk averse. The green resistance takes shape within a European institutional framework that features multiple social carriers, including political parties that cultivate a left modernist worldview (Nielson, Jelsøe, & Öhman, 2002). Though this type of macro-level modernist opposition to agricultural biotechnology resides within certain niche subcultures of Americans, (for example, consumers who prefer to purchase exclusively organic foods), the value system is not nearly as sociologically deep in the USA as in Europe. Although acknowledging green values as a potential factor, we do not test this possibility in the current study. Instead of green orientations, it is more likely that American

public opinion about agricultural biotechnology is, to some extent, 'pre-shaped' by a strong deference to scientific authority, a basic value predisposition cultivated by the nature of the American educational system.

The driving logic of American science as an institution is based in its exceptionalism: When it comes to research, the scientific community believes it should be mostly free from direct regulation and political control (Bimber & Guston, 1995). This assumption on the part of the American scientific community that free inquiry is guaranteed differs remarkably from Europe, where scientists are more likely to view themselves as servants to the state, and subject to regulation (Jasanoff, 2005). Primary and secondary education in the USA serves an important role in cultivating the American public's belief in the exceptionalism of science. Via textbooks and lesson plans, science is generally portrayed as a politically neutral, unproblematic institution that systematically and objectively increases knowledge about the natural world (Irwin, 2001). While calls to include discussions challenging these positivistic conceptions of science in education curricula have been made for at least a decade (American Association for the Advancement of Science, 1989; Gaon & Norris, 2001; Kolstoe, 2000), mainstream education still tends to portray scientists as the ultimate conveyors of the truth. Unlike religious and political institutions, very little in history class is taught about the 'politics' of science, nor is much attention paid to scientific scandals or controversies, or how disagreements in science are resolved (Collins & Pinch, 1993). Students are for the most part taught that the only thing worth knowing about science are the 'facts' of scientific research and discovery (Bauer, Petkova, & Boyadjieva, 2000).

American deference to scientific authority is further strengthened by popularized discourse and rhetorical tools suggesting that scientists' actions and assertions are indisputably linked to observable characteristics of the natural world (Hilgartner, 1990). Such rhetorical tools imply that scientific experts' claims cannot be disputed, even when the issue under discussion involves risks that are hard to quantify and for which even experts disagree. Regulatory agencies routinely appeal to scientific authority as a way to maintain public confidence in their decision-making (Jasanoff, 1990). Agricultural biotechnology, for example generates controversy even among experts. Although risks linked to the use of the technology are potentially numerous, so also are the potential benefits. The exact scope of such benefits and risks is unclear and subjective, and scientific consensus does not exist in this matter for a number of issues, such as allergenicity (Franck-Oberaspach & Keller, 1997) or environmental benefits (Johnson & Hope, 2000), to name just two uncertain points. Yet, the United States Department of Agriculture (USDA) has stated that 'biotechnology food is safe based on all available science,' and the USDA has repeatedly invoked faith in the authority of science in assuring consumers about the safety of its food supply (Juanillo, 2001).

Science as a societal institution has been analyzed at length qualitatively and historically in the sociological literature,[1] however, public opinion research has seldom examined how the American public's belief in the exceptionalism of science might impact the way citizens feel about technical debates. If scientists are indeed perceived as the experts, even when controversial science is at play, and deference to scientific authority is a predisposition reinforced through the American educational system, it could translate into a relatively stable tendency among citizens. In other words, when science controversies do occur, regardless of the specifics of their social, legal, or ethical context, deference to scientific authority as a value predisposition serves as a strong and consistent opinion generator, 'pre-shaping' among Americans a pro-technology view. In some ways, this value predisposition is an authoritarian-like trait specific to technical debates: Deference to science follows from the idea that citizens should not develop their own ideas about what is good or bad relative to a scientific controversy because legitimate authorities have already laid down the rules (Altemeyer, 1996; for a discussion specific to science, see Brossard & Shanahan, 2003).

We conceptualize deference to scientific authority as a long-term socialized trait that guides citizens' responses to a range of technical controversies. Moreover, as we will demonstrate in our analysis, this value predisposition is likely to have indirect influences on opinion formation by way of its linkages to the more temporal and issue-specific heuristic of trust in the sponsors of a specific technology, as well as its influence on a citizens' more global and schematic evaluations of the impact of science on society. For example, in the current example of agricultural biotechnology, not only might deference to scientific authority shape citizen evaluations of the issue directly, but the value predisposition also likely works indirectly via its impact on second order orientations (O_2), enhancing citizen trust in the proponents of agricultural biotechnology, while also shaping views relative to the general impact of science on society. We return to the operationalization of these unique concepts in the methods section.

DIRECT AND INDIRECT EFFECTS OF THE MASS MEDIA (S)

As previously mentioned, it is likely that the news media has a direct impact on citizen's views of agricultural biotechnology via the interpretative packages or frames most readily available in coverage, but also an indirect impact for some citizens through the media's role as an informal source of learning about the science involved in the debate. In several recent studies, news attention has been linked to enhanced knowledge of science, and this enhanced knowledge has

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[1] See for example the peer-reviewed journals *Science, Technology, and Human Values* and *Social Studies of Science*.

contributed to more positive views of science and technology (Nisbet et al., 2002; Brossard & Shanahan, 2003).

Research on framing has diffused across the social sciences, and in this paper we focus on specific research that links the interpretative packages or definitions of an issue found in media coverage, with the ways in which the public view an issue. Media frames are the ideal information short cut as they provide an interpretative handle, label, or way of thinking about an issue in short hand that allows the public to reach judgments about the topic with little or almost no other information. Media frames are often most influential when they resonate or align with existing public values (Gamson & Modigliani, 1989; Pan & Kosicki, 1993; Scheufele, 1999).

Previous research on U.S. press coverage of agricultural biotechnology finds that journalistic interpretations of the technology have utilized frames that emphasize scientific progress and economic development, with these media packages often emphasizing greater benefits than risks, and featuring an evaluative positive tone (Gaskell, Bauer, Durant, & Allum, 1999; Nisbet & Lewenstein, 2002). Only in recent years have more negative images of biotechnology appeared in U.S. coverage, beginning with social protest and the Monarch butterfly study in 1999, and peaking in 2001 with the contamination of the American food supply by StarLink corn, a genetically modified variety not approved for human consumption. Despite the best efforts of opponents of agricultural biotechnology, powerful negative frames of an unethical and risky technology have not been prominent. In reaction to the StarLink affair, major news organizations did not consider the revelation worthy of the scandal label. Instead, the press characterized the controversy predominantly as an industry and regulatory matter, with coverage assigned to business and science reporters (Nisbet & Huge, under review). Outside of these analyses of press coverage of agricultural biotechnology in the United States, little is known about how much attention television news has paid to the issue, or how television news has interpreted or defined the topic.

In light of the positive framing of agricultural biotechnology in U.S. newspaper coverage, we might expect that attention to this issue among newspaper readers would be directly related to more positive views of the technology, based on a resonance between positive journalistic interpretations of the issue and the citizens' natural tendency to defer to the authority of science. Since we lack content data specific to television news, both in terms of level of attention and framing of the issue, we can offer few predictions concerning the direct effects of TV news on attitudes. Our expectations relative to newspaper attention are in line with past research employing the O–S–O–R model. In this case, we treat media effects as the result of medium to long-term exposure and/or attention to media content, estimating the influence of news attention as a central mediating influence between initial orientations such as values and second-order outcomes such

as knowledge and trust (Besley & Shanahan, 2005; Moy & Pfau, 2000; Nisbet et al., 2002; Scheufele et al., 2004; McLeod et al., 1999).

In addition to the likelihood of direct effects of newspaper coverage through journalists' selective interpretations of the issue, the significance of the press in informing the public about the science behind agricultural biotechnology cannot be overlooked. When formal education in science ends, media become the most available and sometimes the only source for the public to gain information about scientific discoveries, controversies, events, and the work of scientists (Nelkin, 1995). Even more so than press coverage, television news, perhaps, offers the best possibilities for broad access to various publics; given that people are spending a significant amount of time with television compared to other media, one might expect television news to provide the most opportunity for gains in terms of science-related knowledge (Nisbet et al., 2002). Again, this assumption is made without content data specific to the amount of attention paid to agricultural biotechnology by television news to date.

Yet even if television news outlets were covering the debate over agricultural biotechnology, it is likely that informal learning might be constrained by this medium in comparison to print coverage. In the political learning literature, newspaper readership consistently has been shown to be a better predictor of learning than television (for an overview, see Chaffee & Frank, 1996; also McLeod, Scheufele, & Moy, 1999). Overall, the political learning effects—and the scientific learning effects as well—from television are weaker than for newspapers, controlling for variables such as age, education, or income (e.g., Eveland & Scheufele, 2000; Nisbet et al., 2002).

SCIENCE KNOWLEDGE (O_2)

As previously mentioned, the relationship between science knowledge and support for agricultural biotechnology has been debated at great length. With few exceptions, where the relationship has been tested, a majority of studies point to a clear connection between science knowledge and science-related attitudes, yet this influence is likely to be weaker in comparison to other factors such as value predispositions and trust (Allum et al., 2005). Though a consistent (but sometimes weak) correlation between science knowledge and support for science appears across studies, scholars remain divided on the reason for the relationship. As discussed, the dominant view is that enhanced science knowledge allows citizens to sort through the misinformation and many claims made about science in public discourse, and to arrive at judgments about science more in line with scientists (Bodmer, 1985). Others hold that science knowledge is closely tied to an underlying science enthusiasm, and that citizens who score high on survey tests of science literacy do so because they believe science is important, and therefore should be followed and closely understood (Gaskell et al., 2001; Priest,

Bonfadelli, & Rusanen, 2003). According to this view, the most that can be claimed is that science knowledge, like political knowledge, is a resource that citizens can use to either oppose or support science and technology (Gaskell et al., 2001).

Leaving these competing explanations aside, studies in the USA and Europe appear to show a consistent link between biotechnology-related knowledge and support for agricultural biotechnology. For example, researchers analyzing Eurobarometer data have identified a positive, but sometimes weak link between knowledge and support for agricultural biotechnology (Pardo, Midden, & Miller, 2002; Gaskell et al., 2004; Priest et al., 2003). Studies in the USA have found similar positive effects for science knowledge on support for agricultural biotechnology (Besley & Shanahan, 2005; Brossard & Shanahan, 2003; Hallman et al., 2003; Miller & Kimmel, 2001; Priest, 2001). In sum, science knowledge is important, but contrary to popular assumptions, it is not a 'stand alone' explanation of support for ag biotech (Priest et al., 2003).

Moreover, part of the influence for knowledge on support for ag biotech is direct, and part of it is likely indirect, as mediated by a connection to general reservations about science and trust in science-related institutions. Citizens who are more informed about ag biotech hold fewer reservations about the impact of science on society, and as we will discuss, citizens holding fewer reservations about science are more likely to support biotechnology (Miller & Kimmel, 2001; Pardo et al., 2002). In addition, past research has shown that more scientifically knowledgeable societies (Priest et al., 2003), and more scientifically knowledgeable citizens (Besley & Shanahan, 2005; Brossard & Shanahan, 2003) are on average more trusting of scientists, industry, and regulatory institutions, and as we detail in the next section, enhanced trust is linked to increased support for ag biotech.

TRUST IN SCIENCE-RELATED INSTITUTIONS (O_2)

The role of trust in explaining public acceptance of agricultural biotechnology has also been debated at great length. In line with a cognitive miser view of opinion formation, in an increasingly complex world, trust enables citizens to act without knowledge of the technical nature of risks. As a substitute for information about a vast array of possible threats in everyday life, citizens are forced to rely heavily on the endorsement of regulators, officials, industry, scientists, and other experts. Instead of arriving at informed probabilistic accounts of which risks are to be feared, the miserly citizen, and 'smart heuristics user' (Gigerenzer, Tood, & ABC Research Group, 1999) relies instead on making choices about which institutions to trust (Priest et al., 2003). Based on theorizing from the field of risk perceptions, if trust is high in the industrial, governmental, and university sponsors of biotechnology, then citizens are less likely to worry about the unforeseen risks and costs of the technology (Freudenburg, 1992, 1993; Slovic, 1999).

Indeed, the tendency to rely on trust as a central heuristic is not exclusive to lay citizens. Even experts are often highly overconfident and tend to under-estimate organizational amplifications of risks (Freudenburg, 1992). In short, as a common human tendency, both the public and experts alike rely heavily upon social criteria such as trust to evaluate risk (Freudenburg, 1993). Empirical evidence supports these propositions. Several groups of researchers have detailed differences in trust between the USA and Europe as reasons for divergent citizen views relative to agricultural biotechnology, with Americans more trusting in regulators, scientists, and industry, and less trustful of consumer and environmental organizations than Europeans (Bonny, 2003; Priest et al., 2003). Using data specific to the USA, other researchers have shown that trust in institutions directly influences risk perception and fear, which in turn affects acceptance of biotechnology (Brossard & Shanahan, 2003; Siegrist, 2000).

The research is clear on two counts: that institutional trust varies nationally and seems to be related to acceptance of biotechnology, with greater levels of trust in science-related institutions generating greater citizen support. In addition, where trust has been compared directly to knowledge as an antecedent of variables such as fear of science or support for biotechnology, trust generally has stronger relationships. In the methods section, we return to aspects of conceptualization and measurement of institutional trust as a key variable in our model.

RESERVATIONS ABOUT THE IMPACTS OF SCIENCE (O_2)

As a final second-order orientation, a citizen's science-related schema are also likely to be influential in shaping support for agricultural biotechnology. 'Schema' is the metaphorical term adopted from social psychology to explain how members of the public integrate new information and experiences into coherent clusters (Markus & Zajonc, 1985). Schema are cognitive structures that help individuals organize their issue preferences (Lodge, McGraw, Conover, Feldman, & Miller, 1991).

Specific to science and technology, the schema 'scientific reservations' is an attitude construct identified in previous research as reflecting public concerns about the speed of change in modern life, and a sense that science and technology poses conflicts with traditional values or belief systems (Miller, Pardo, & Niwa, 1997). Previous research has shown that scientific reservations served as an important heuristic for citizens, with those individuals holding fewer reservations about science on average more likely to support agricultural biotechnology (Miller & Kimmel, 2001; Brossard & Shanahan, 2003; Pardo et al., 2002). This schema is also likely an important mediator of demographics and value predisposition. For example, citizens who are stronger in their deference to scientific authority, are likely to have fewer reservations about science, and this science-related schema in turn helps individuals assess and categorize the meaning of the

agricultural biotechnology issue. Schema therefore serve as 'principles of mediated inference' (Sniderman, Brody, & Tetlock, 1991), partially intervening between the value predisposition of deference to scientific authority, and a citizen's opinion about biotechnology.

METHOD

Data for our study came from a mail survey administered between June and July 2001 to a random sample of 1,500 New York State residents (excluding the 6 counties of New York City). The survey design and administration (including follow-ups) were based on the Total Design Method (TDM) proposed by Dillman (1978, 2000). However, due to cost constraints, TDM's 4th certified mailing of a packet (cover letter, survey and stamped returned envelope) was not included. Instead, a preliminary mailing announcing the study was sent before the three traditionally used in TDM. The survey was documented according to the AAPOR Standard Definitions for disposition codes. One hundred and fifty random phone interviews were also conducted post-survey among the non-respondents to determine the proportion of wrong addresses and/or deceased individuals in the remaining non-respondents' sample. The final corrected response rate (AAPOR standard formula RR 3) was 40.4 percent.

The variables used for the study can be categorized into three groups: exogenous variables (those not influenced by other variables in the model), 'antecedent' endogenous variables (those influenced by some variables in the model but that also influence other variables) and the 'consequence' endogenous variable.

Exogenous Variables

Respondents' *age* was assessed by an open-ended continuous item ($M = 54$, $SD = 15.5$). *Gender* was coded with female equal to 0, and male equal to 1 (66.5 percent). *General education* was an ordinal level measure with 8 categories that ranged from grade six or less of education (coded 1) to graduate/professional degree (coded 8) ($M = 5.27$, $SD = 1.84$). *Science education* was a continuous variable comprised of the number of science classes taken in college ($M = 1.3$, $SD = 6.02$). Finally, *ideology* was an additive index of two 7-point items ($M = 8.96$, $SD = 2.7$) that measured social and economic ideology by asking individuals to rate themselves from '1' very liberal to '7' very conservative on either social or economic issues.[2]

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[2] The population of the USA had the following characteristics in 2000: 48.2 percent of 20 year-old or older were males, i.e. slightly less than in our sample; the median educational attainment was a high school diploma, therefore comparable to our sample (Census Scope, 2005).

ANTECEDENT ENDOGENOUS VARIABLES

Deference to scientific authority was operationalized as an additive index (ranging from 0 to 16; $M = 7.96$, $SD = 2.84$) of four 5 point items (ranging from 0 = 'strongly disagree; 4 = 'strongly agree'). The items are a combination of items that had been used in previous research on social–political aspects of authoritarianism (Ray, 1971; Shanahan, 1998) and that were adapted to the specific context of science and agricultural biotechnology (see Appendix for question wording and political items). The scale is unidimensional, with a Cronbach α reliability coefficient of .69.

Attention to agricultural biotechnology on national television and *attention to agricultural biotechnology in the newspaper* were measured with 7-point scales (1 = little attention; 7 = very close attention). Attention to stories related to agricultural biotechnology on national television was relatively high, with 30 percent of the respondents reporting 1–3, and 70 percent 4–7. For attention to stories related to agricultural biotechnology in newspaper coverage, 40 percent of the respondents answered 1–3, and 60 percent answered 4–7. Finally, *heterogeneity of information sources* is based on a set of seven separate items, each asking how often a source provided the respondent with information about agricultural biotechnology (1 = never; 4 = very often). Each item was recoded in the following manner (never = 0; occasionally, often or very often = 1) and an additive item ranging from 0 to 7 was calculated with the recoded variables ($\alpha = .82$). The potential sources were: local newspapers, national newspapers, scientific magazines, television science programs, television news, non–profit organization web sites, university web sites, and activist-run web sites. This item was included as a rough summary measure of the total available information environment or message system surrounding the issue of agricultural biotechnology in the USA.

Factual scientific knowledge assessed respondents' understanding of the basic science related to agricultural biotechnology. It was measured with a scale developed specifically for the study. General themes to be covered by the scale were chosen on the basis of a concept mapping exercise described in Brossard (2001). An item representing each theme was developed and validated by a panel that included two plant geneticists and two social scientists working in science communication. The scale includes five 4-point Likert-type items (1 = 'strongly disagree; 4 = 'strongly agree'; 5 = 'don't know;' see Appendix). The items were recoded as True-False (1 = true; 0 = false), and the recoded items added in an additive index ranging from 0 to 4 ($M = 1.91$; $SD = 1.4$). The scale is unidimensional, with a KR-20 reliability coefficient of .52.

Reservations about impacts of science was measured with an additive index (ranging from 0 to 8; $M = 4$; $SD = 1.9$), of two 5-point items (1 = 'strongly disagree; 5 = 'strongly agree) developed specifically for the study: 'I feel scientific research often goes too far,' and 'I fear the potential impacts of scientific

research.' The two items were correlated at .43. In this case, the items were re-coded so that higher scores on this construct reflect fewer reservations about the impact of science on society and in personal life.

Trust in biotechnology sponsors was measured with three 5-point items for each of the following actors: industry representatives; government officials; and university scientists. These three institutions in the USA have played a unique role in developing, sponsoring, and managing the development of agricultural bio-technology, and are widely acknowledged as the most credible sources of author-ity on the science, benefits, and risks of the technology. As discussed in the literature review, the standing of these three institutions is in contrast to Europe where non-governmental activists have played a prominent role as a key source of information for the public (Priest et al., 2003; Jasanoff, 2005). The combined measure for trust was based on a modified version of Meyer's credibility scale (1988),[3] which asked respondents to rate each actor's level of trustworthiness (1 = can't be trusted at all; 5 = can be trusted completely); level of bias (1 = completely biased; 5 = not biased at all); and level of fairness (1 = not fair at all; 5 = com-pletely fair) specific to the issue of agricultural biotechnology. The items were combined into an additive index comprised of a total of 9 attitude measures ($M = 21.63$, $SD = 6.8$), with a Cronbach α reliability coefficient of .61.[4]

CONSEQUENCE ENDOGENOUS VARIABLE

Support for agricultural biotechnology, our dependent variable, was operational-ized as an additive index ($M = 14.39$, $SD = 4.76$) of five 5-point items assessing respondents' perception of the health risks versus benefits related to agricultural biotechnology, respondents' perception of environmental risks versus benefits related to agricultural biotechnology, and support or opposition for the use of biotechnology in agriculture and food production (see Appendix for item word-ing). The scale had a Cronbach α reliability coefficient of .85.

We tested the relationships among independent and dependent variables based on structural equation modeling analysis performed with LISREL. Struc-tural modeling has advantages compared with the use of other multivariate tech-niques. In particular, all the coefficients in the model are estimated at the same time: Any given coefficient therefore represents the relationship between two variables controlling for all other relationships and variables in the model. In addition, the technique accounts not only for all the links from exogenous and

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[3] Meyer's original credibility scale includes five items. However, earlier pilot test results showed that the scale could be limited to three items, which would allow us to shorten the survey without hurting explanatory power of the scale.

[4] Beyond face and content validity differences, a principal component factor analysis of the 'deference to scientific authority' items and the ag biotech-specific trust items loaded on two separate factors, supporting their conceptualization as two different measures.

endogenous variables to the dependent variable but also for the relationships among all exogenous and antecedent endogenous variables. By treating endogenous variables as both independent and dependent variables, structural equation modeling allows for the estimation of direct and indirect effects. An indirect effect is the influence of an independent variable on a dependent variable through one or more intervening or mediating variables. The assumed causal ordering and tested relationships among variables is based on the reasoning of the O–S–O–R model and reasoning outlined in the literature review and Table 1. The cross-sectional nature of the data, however, precludes making any final causal arguments about the nature of the relationships presented.

RESULTS AND DISCUSSION

The final model fit the data exceptionally well with a BIC statistic of –251. The Goodness-of-Fit-Index (GFI) was .98 and the Adjusted Goodness-of-Fit-Index (AGFI)—controlling for multivariate nonnormality—was .97. Our model accounted for 10 percent of the variance in knowledge, 20 percent of the variance in institutional trust, 30 percent of general attitudes toward science, and 45 percent of the variance in support for agricultural biotechnology.

EXOGENOUS VARIABLES

As reported in Table 2, older individuals tended to defer more to the authority of science, and by way of this stronger deference to science, age was positively related to trust in biotechnology sponsors, to fewer reservations about the impacts of science, and to support for agricultural biotechnology.

In comparison to women, men tended to score higher on deference to scientific authority. Men also reported a greater number of heterogeneous sources of information about agricultural biotechnology, and greater attention to biotechnology in the newspaper, and on television news. In an indirect relationship, men tended to score higher on the measure of science-related knowledge about biotechnology. (As we note shortly, much of this indirect effect on knowledge is likely attributable to the informal learning effects of the media sources. In comparison to women, men pay closer attention to news coverage about agricultural biotechnology, and this leads to greater knowledge.) Men also tended to hold greater levels of trust in biotechnology sponsors than females, with part of this total relationship explained by the indirect effects of higher scores on deference to scientific authority. Finally, as a combination of both direct and indirect effects, men tended to report stronger support for agricultural biotechnology than women, the second strongest influence in the model.

As expected, education was strongly related to deference to scientific authority. Highly educated citizens, whether measured in terms of general education or

TABLE 2 **Influence of exogenous variables on other variables**

	Age	Sex (m)	General education	Science education	Income	Ideology (lib-con)
Deference to	.11	.12	.15	.14	—	—
scientific	—	—	—	—	—	—
authority	.11	.12	.15	.14	—	—
Heterogeneity of	—	.20	—	—	.18	—
information sources	—	—	—	—	—	—
for biotechnology	—	.20	—	—	.18	—
Attention to	—	.25	.19	—	—	—
biotechnology in	—	—	—	—	—	—
the newspaper	—	.25	.19	—	—	—
Attention to	—	.31	.12	—	—	—
biotechnology on	—	—	—	—	—	—
national television	—	.31	.12	—	—	—
Factual science	—	—	—	—	—	—
knowledge about	—	.09	.04	—	.03	—
biotechnology	—	.09	.04	—	.03	—
Trust in	—	.13	—	—	—	—
biotechnology	.04	.05	.06	.05	—	—
sponsors	.04	.18	.06	.05	—	—
Fewer reservations	—	—	—	.11	.16	—
about impacts	.05	.05	.07	.06	—	—
of science	.05	.05	.07	.17	.16	—
Support for	—	.16	—	—	—	.13
agricultural	.05	.09	.08	.09	.04	—
biotechnology	.05	.25	.08	.09	.04	.13

Note: All coefficients (γ) shown are significant at $p < .05$.
Coefficients on the first row indicate direct effects, coefficients on the second row indicate indirect effects, and coefficients on the third row indicate total effects.

science education, were more likely to defer to the authority of science than their low education counterparts. Consistent with prior research, citizens with higher levels of general education also tended to pay closer attention to stories about biotechnology in the newspaper, and on television news. Interestingly, neither measure of education was directly related to factual science knowledge about agricultural biotechnology. Instead, general education was indirectly related to knowledge by way of media attention. It is likely that the emerging science of biotechnology is so new that few Americans have been exposed to the science via formal education, and are therefore reliant on media coverage for knowledge. Both general education and science education were also indirectly related to trust in biotechnology sponsors.

Importantly, it appears that greater trust is forged by way of the highly educated's tendency to defer to the authority of science, and it is this value orientation that acts as a heuristic in generating trust in the sponsors of biotechnology. In terms of fewer reservations about the impacts of science, general education only had an indirect relationship, whereas science education had both direct and indirect influences. Finally, and perhaps of greatest interest, was that neither measure of education was directly related to support for agricultural biotechnology, instead the influence of general education and science education was fully mediated by other endogenous variables in the model, resulting in significant indirect links.

Income was directly related to more heterogeneous sources of information about agricultural biotechnology, and as a result was indirectly related to factual science knowledge. Income was also positively related to fewer reservations about the impacts of science, and was indirectly related to support for agricultural biotechnology. Ideology, with conservatives coded high, was directly and positively related to support for agricultural biotechnology. It is likely that both of these variables tap the investor class of Americans, who see scientific and technology development as closely tied to economic performance, and therefore are inclined to support both science generally and agricultural biotechnology.

Endogenous Variables

Among the endogenous variables graphed in Figure 1 and detailed in Table 3, the results indicate that deference to scientific authority plays a key central role as an information short-cut for the miserly citizen in reaching judgments about agricultural biotechnology. Part of the value predisposition's connection to support for agricultural biotechnology is indirect ($\beta = .17$) via its strong link to trust in biotechnology sponsors ($\beta = .40$), and its relationship to fewer reservations about the impacts of science generally ($\beta = .46$). In agreement with past research, these two second-order orientations are important additional heuristics for the miserly citizen, with trust in biotechnology sponsors and fewer reservations about the impacts of science both positively related to support for agricultural biotechnology ($\beta = .17$ and $\beta = .22$ respectively). Deference to scientific authority is also directly positively related to support for agricultural biotechnology ($\beta = .32$), resulting in a total relationship of $\beta = .48$, by far the strongest influence of any variable in the model.

As discussed earlier, relying on social values, trust, and relevant schema as heuristics in order to form an opinion about agricultural biotechnology is just one route available to citizens. There are exceptions to the pattern of the miserly citizen across society, and one such exception includes a 'communication' path to opinion formation where the media serves as an important source of informal learning about an issue, and knowledge in turn affects opinion, at least to a degree. The results indicate that both heterogeneity of information sources and attention to newspaper coverage were important sources of science knowledge

FIGURE I **Relationships among endogenous variables**
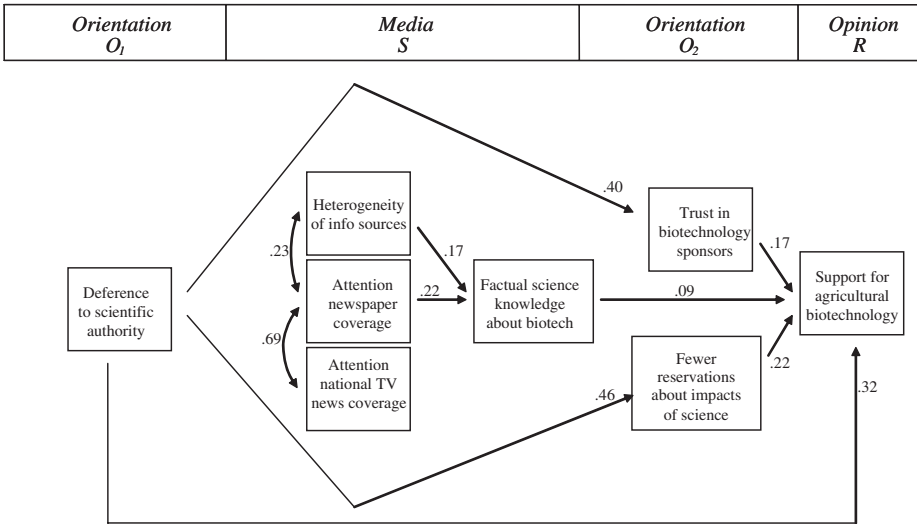
Note: Directional coefficients for direct effects are β's; for relationships between the media variables they are non-directional φ-coefficients.

about biotechnology, and knowledge in turn was positively related to support for agricultural biotechnology. (Though consistent with previous research, the impact of knowledge was modest in comparison to the influences of value predispositions, trust, and schema.) By way of this information route, heterogeneity of information sources and attention to newspaper coverage had weak indirect and total influences on support for agricultural biotechnology. If past research suggests that there are gaps based on education and motivation in how much citizens learn from the news media about biotechnology (Bonfadelli, 2005), and as we find in this paper informal learning is an important process promoting support for agricultural biotechnology, then future research should more closely examine the consequences of these knowledge gaps for opinion formation.

Television news had no direct or indirect influences in our model, though in a non-directional relationship, attention to TV coverage was positively related to newspaper attention (see Figure 1), suggesting perhaps a surveillance function for TV news (McLeod et al., 1999). In this possible scenario, citizens spot coverage of agricultural biotechnology on the evening news, then follow up the next day in the newspapers for more in depth information about the issue, and it is through print sources that learning occurs. Indeed, the null effects for learning found for TV news are not surprising in light of previous research relative to both politics and science that has highlighted the limitations of TV news in serving as a conveyor of complex information (e.g. Eveland & Scheufele, 2000;

TABLE 3 **Relationships among endogenous variables**

	1	2	3	4	5	6	7
Deference to scientific authority (1)							
Heterogeneity of information sources for biotechnology (2)	—						
	—						
	—						
Attention to biotechnology in the newspaper (3)	—	—					
	—	—					
	—	—					
Attention to biotechnology on national television (4)	—	—	—				
	—	—	—				
	—	—	—				
Factual science knowledge about biotechnology (5)	—	.17	.22	—			
	—	—	—	—			
	—	.17	.22	—			
Trust in biotechnology sponsors (6)	.40	—	—	—	—		
	—	—	—	—	—		
	.40	—	—	—	—		
Fewer reservations about impacts of science (7)	.46	—	—	—	—	—	
	—	—	—	—	—	—	
	.46	—	—	—	—	—	
Support for agricultural biotechnology (8)	.32	—	—	—	.09	.17	.22
	.17	.01	.02	—	—	—	—
	.48	.01	.02	—	.09	.17	.22

Note: All coefficients (β) shown are significant at $p < .05$.
Coefficients on the first row indicate direct effects, coefficients on the second row indicate indirect effects, and coefficients on the third row indicate total effects. The direct effects are also shown in Figure 1.

Nisbet et al., 2002). A similar non-directional link was observed between hetero-geneity of information sources and attention to newspaper coverage, again sug-gesting that citizens are not attending to or seeking out information about agricultural biotechnology exclusive to one medium or source.

Finally, somewhat unexpectedly, other than the learning effects for media, our findings do not indicate direct content effects for either newspaper or national TV news attention on support for agricultural biotechnology. This finding runs counter to our expectation that available media interpretations would likely serve as important heuristics for citizens in making up their minds about agricultural biotechnology. Although we do not have many survey-based media studies spe-cific to agricultural biotechnology with which to compare, our null results are at

least partially inconsistent with the findings of Besley and Shanahan (2005) who found promotional effects for these media sources. This particular study, however, used very different media attention measures than our project, combining into one measure attention not only to biotechnology news, but also attention to coverage of both science and the environment generally. More importantly, the study did not include a measure of science knowledge related to agricultural biotechnology, meaning that at least some of the indirect effects of media were not controlled. Still, the fact that in our current study, available media interpretations and images of the issue do not result in direct effects for news attention remains surprising, a question that future research should continue to explore.

CONCLUSION

Our goal in this paper was to use the contemporary debate over agricultural biotechnology as a test case for outlining a theoretical account that integrates key variables and reasoning from past research into a parsimonious model explaining opinion formation. We intend the model to serve as an organizing device for future research, explaining opinion formation relative to other science and technology debates by serving as a guide for researchers in conceptualizing, specifying, and testing relationships among variables.

THE MISERLY CITIZEN AND THE UTILITY OF THE O–S–O–R MODEL

As a first principle in our account, we emphasized the 'miserly' nature of citizens. Faced with many competing demands for their time and attention, most citizens lack the ability and/or the motivation to be fully informed about an issue, and instead rely heavily on information short-cuts such as values and trust in combination with the interpretations of the issue most readily available from media coverage to form an opinion. The results of our data are consistent with a diversity of public opinion studies relative to both politics and science that emphasize the key influences of heuristics such as values, trust, and schema. We also suggested, however, that heuristic reasoning is only a general social pattern, meaning that as exceptions to this pattern, some citizens do make relatively informed decisions about agricultural biotechnology, relying on their science knowledge to guide their opinions. As our data indicate, it is likely that media coverage plays an important indirect role, serving as a central vehicle for informal learning about the topic. According to our data, the more attention citizens paid to media coverage of agricultural biotechnology (with the exception of TV news), the more they knew about the science specific to the debate. And the more they knew about the science of agricultural biotechnology, the more supportive they were of the technology. Yet contrary to the still prevailing assumption of many scientists, journalists, and policy makers, science knowledge was not a stand alone influence on citizen judgments, and was in fact

relatively modest in its influence when compared to heuristics such as values, trust, and generalized feelings about the impacts of science.

As a way to integrate and think systematically about these many variables, we applied the O–S–O–R model developed in recent political communication studies. This model asserts that beyond basic demographic indicators, long-term social-ized predispositions such as values serve as first order orientations in shaping opinion. Overlaying these values are the stimuli of media exposure and attention, followed by a set of second order orientations such as knowledge, forms of trust, and relevant schema. Although the particular conceptualizations of relevant value predispositions, media sources, schema, forms of knowledge and trust may differ across policy controversies and issues, the opinion formation process outlined in this study is generalizable, and lends support to the utility of the O–S–O–R model in understanding the dynamics of a number of policy debates.

AMERICANS' DEFERENCE TO SCIENTIFIC AUTHORITY

As a first step in applying the model we identified the relevant value predisposi-tions connected to the controversy by studying clues from elite conflict surround-ing the issue in the USA. As discussed, in Europe, past research has highlighted green orientations as a key value predisposition shaping opinion, but in this study specific to the American context, given different institutional structures and elite arrangements, we expected that deference to the authority of science might be a key determinant 'pre-shaping' opinion towards agricultural biotechnology. Transmitted to citizens by the educational system and popular culture, deference to scientific authority as a value predisposition means that when science contro-versies do occur, deference likely generates among Americans an almost natural pro-science or pro-technology view. Indeed, the result of our study indicates that deference to scientific authority is the strongest total influence on support for agricultural biotechnology. Part of the variable's influence is direct, but part of it is also indirect, as deference to scientific authority is a key predictor of the second order orientations relative to trust and reservations about the impacts of science.

Our emphasis on deference to scientific authority does not mean that other values do not play a role in shaping American views of science, or agricultural biotechnology specifically. These other values might include green orientations as mentioned, but also possibly religious values. As discussed, however, with green orientations, the strong social carriers of this worldview do not exist in the USA as in Europe. Part of the institutionalized opposition to agricultural bio-technology in Germany, for example, derives from the active opposition of the Green Party. Similarly in the UK, during the early 1990s, initial opposition to agricultural biotechnology arose from the Green Alliance, an environmentalist branch of the Liberal Party (Jasanoff, 2005). In the USA, there has always been fairly uniform support for agricultural biotechnology among the elites of both

political parties, with the administrations of Presidents Ronald Reagan, George H. W. Bush, Bill Clinton, and George W. Bush, for example, all strong proponents of the technology. Moreover, while the issue has been a priority for Greenpeace, Friends of the Earth, and the Union of Concerned Scientists, agricultural biotechnology, has never been a central issue for the larger, more influential environmental organizations such as the Sierra Club or Nature Conservancy. Minus these elite cues and efforts on the green side in the USA, when compared to the strong institutional and cultural emphasis on the authority of science, green orientations likely play a role only among a smaller subset of Americans. Still future research should look at green orientations in the U.S. context, moving beyond the parsimony of the model presented here.

Finally, on many issues in the U.S. context, deference to scientific authority, if used as a general construct in predicting views about controversial science, is likely to be in conflict with religious predispositions, especially those of conservative evangelicals and Catholics. Conservative religious elites in the USA have not focused on the issue of agricultural biotechnology, yet on science-related issues like embryonic stem cell research, therapeutic cloning, and evolution that challenge the legitimacy of conservative doctrine, religious predispositions are likely to compete strongly with citizens' willingness to defer to scientific authority. (For more on religious orientations and the institutional sources of worldviews, see Nisbet, 2005.)

Chief among the limitations to this study is the cross-sectional nature of our data. The outlined processes suggest that future studies should take advantage of panel survey techniques to explore more carefully the possible causal ordering of relationships. In addition, the data analyzed in this paper are derived from a carefully conducted mail survey of New York State residents. If this study were concerned with estimating the parameters in attitudes among the national U.S. population, then our sample would not be suitable. However, our focus instead was on understanding the opinion formation process. The elaborate measures of value predispositions, different types of media use, issue-specific knowledge and trust related to agricultural biotechnology are not available in large national datasets such as the National Science Foundation's Survey of Public Attitudes about Science and Technology. The issue therefore becomes a trade-off between the population parameter generalizability of national samples vs. the quality of measurement and careful examination of social processes allowed by the state sample survey presented in the current study. In addition, given that we collected our data in the spring/summer of 2001, the patterns of influences that we identify in our study should be interpreted as the outcome of a particular informational and symbolic context. This contextual nature of the data is especially important when thinking about media effects. In the USA, Nisbet and Huge (2006) describe agricultural biotechnology as going relatively unnoticed by the news media for decades, until

the triggering events of social protest and the Monarch butterfly study in 1999, followed by historic peaks in media attention to the issue in 2000 and 2001 generated by the StarLink corn affair. Though these years constitute unprecedented spikes in media attention, the issue of agricultural biotechnology still rested relatively modestly on the overall media agenda compared to major issues during early 2001 such as the stem cell debate, the Chandra Levy disappearance, or energy prices and rolling blackouts, and even compared to other food-related issues such as bacterial food poisoning. As previously mentioned, this limited agenda status is attributable in part to the still dominant framing of the issue around scientific and economic considerations, rather than the type of moral and political strategy interpretations that often result in escalating news dramas (Nisbet, Brossard, & Kroepsch, 2003). If future events and their selective interpretations by political actors and journalists propel the issue towards higher media agenda status, morphing the image of agricultural biotechnology in the public eye, then it is possible that future opinion studies might observe differing media influences than those reported here, particularly the type of direct persuasive effects that can mobilize public opposition to the technology.

APPENDIX: QUESTION WORDING FOR DEPENDENT AND ENDOGENOUS VARIABLES

DEPENDENT VARIABLE: SUPPORT FOR AGRICULTURAL BIOTECHNOLOGY SCALE

1. Overall what are your feelings toward using biotechnology in agriculture and food production? (1 = strongly oppose; 5 = strongly support).
2. Some people say that genetically engineered crops *are good for the environment* because among other benefits, they can help decrease the use of pesticides. Others say genetically engineered crops are *bad for the environment* because, among other risks, they can affect existing plant or animals in nature.

    Do you think the benefits *for the environment* outweigh the risks, or do you think the risks outweigh the benefits? (1 = risks strongly outweigh the benefits; 5 = benefits strongly outweigh the risks).
3. Some people say that genetically engineered crops are *good for human health* because, among other benefits, they can be used to produce more nutritious foods. Others say genetically engineered crops are *bad for human health* because, among other risks, they can induce allergic reactions.

    Do you think the benefits *for health* outweigh the risks, or do you think the risks for health outweigh the benefits? (1 = risks strongly outweigh the benefits; 5 = benefits strongly outweigh the risks).
4. *Overall*, do you think the benefits of developing and growing new plants and crops through genetic engineering outweigh the risks, or do you think

the risks outweigh the benefits?. (0 = risks strongly outweigh the benefits; 4 = benefits strongly outweigh the risks).

5. *Overall*, would you say you oppose or support the use of biotechnology in agriculture and food production? (1 = strongly oppose; 5 = strongly support).

ENDOGENOUS VARIABLES

Deference to scientific authority

1. Scientists know best what is good for the public.
2. It is important for scientists to get research done even if they displease people by doing it.[5]
3. Scientists should do what they think is best, even if they have to persuade people that it is right.[6]
4. Scientists should make the decisions about the type of scientific research on agricultural biotechnology.

Heterogeneity of information sources, *Attention to newspaper coverage of agricultural biotechnology*, and *Attention to national TV news coverage of agricultural biotechnology* are described in the text.

Factual scientific knowledge about agricultural biotechnology

1. Genes are the cell's instructions for producing proteins. (True)
2. Through genetic engineering, scientists can produce genes that do not exist in nature. (True)
3. In nature, plants transmit their genes to unrelated kinds of plants through the process of pollination. (False)
4. Manipulation of genetic material in plants to produce better crops has been performed by plant breeders for centuries. (True)
5. Genetic engineers can use 'gene guns' or bacteria to transfer genes into an organism. (True)

Trust in biotechnology sponsors

Respondents were asked the following questions about each of the following actors: industry representatives, government officials, and university scientists.

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[5] Original item: It is important for a leader to get things done even if he must displease people by doing them (Ray, 1971).
[6] Original item: The government should do what it thinks is best, even if it's not what the people want (Shanahan, 1995, 1998).

1. How trustworthy do you think each of the following sources is about genetically engineered food and crops? (1 = can't be trusted at all; 5 = can be trusted completely).
2. How biased do you think each of the following sources is about genetically engineered food and crops? Please circle one response for each source. (1 = not biased at all; 5 = completely biased; recoded).
3. How fair do you think each of the following sources is about genetically engineered food and crops? Please circle one response for each source. (1 = completely unfair; 5 = completely fair).

Fewer reservations about impacts of science

1. I feel scientific research often goes too far. (Recoded; 1 = strongly disagree; 5 = strongly agree).
2. I fear the potential impacts of scientific research. (Recoded; 1 = strongly disagree; 5 = strongly agree).

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