

CULTURE AND TECHNOLOGICAL INNOVATION: IMPACT OF INSTITUTIONAL TRUST AND APPRECIATION OF NATURE ON ATTITUDES TOWARDS FOOD BIOTECHNOLOGY IN THE USA AND GERMANY

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ABSTRACT

Using 'general trust in institutions' and 'concepts of nature' as examples, the article analyzes the influence of cultural factors on sense-making of food biotechnology and the resulting public attitudes in the USA and Germany. According to the hypotheses investigated, different levels of trust and appreciation of nature explain part of the well-known differences in attitudes between both countries. The analysis of a cross-cultural survey of the general population shows that appreciation of nature is a predictor of attitudes in both countries. The higher appreciation of nature in Germany partly explains why attitudes towards food biotechnology are more negative in Germany than in the USA. The relationship between trust and attitudes is more

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complex than expected, however. Institutional trust is a moderate predictor of attitudes towards food biotechnology in the USA but not in Germany. To explain the varying effectiveness of trust in resolving innovation-related uncertainty we refer to differences in issue framing in both countries and to the higher degree of universalism and individualism in the USA. We conclude that the higher relevance of trust and the lower appreciation of nature make the U.S. culture more apt to assimilate technical innovations than the German culture.

Scholars have extensively studied international differences in public opinion and regulation of biotechnology both within Europe and between Europe and the USA (see e.g., Gaskell, Bauer, Durant, & Allum, 1999; Gaskell & Bauer, 2001; Epp, 2003; Jasanoff, 2005). One reason for this strong research interest (and the availability of research funding) is the cultural and economic impact of biotechnology on agriculture and food production, in particular its connection to regulatory problems on the transnational European level and to the issues of international trade. Cross-cultural analyses are a way to analyze international differences of public opinion and regulatory responses to innovative technologies. They are also—by means of comparison and contrast—a research strategy to uncover cultural resources of making sense of innovations.

Public opinion in Europe is ambivalent or critical towards food biotechnology (Gaskell, Allum, & Stares, 2003). In the USA, public attitudes seem to be more positive, although not unanimously so (Hallman, Hebden, Cuite, Aquino, & Lang, 2004). The few studies that directly compare European and U.S. public opinion on food biotechnology find more positive public attitudes in the USA than in Europe (cf. Gaskell et al., 1999; Worldviews, 2002). Such an attitude difference also exists between the USA and Germany. In a cross-national survey, 63 percent of the German respondents, but only 45 percent of their U.S. counterparts, said that they moderately or strongly oppose the use of biotechnology in agriculture and food production (Worldviews, 2002, p. 51).

Scholars frequently analyze subjectively assessed risks and benefits of genetically modified (GM) products or processes involving genetic engineering as major factors influencing attitudes (Siegrist, 2000; Wu, 2004; Durant & Legge, 2005). That attitudes towards different applications of biotechnology greatly differ—for example, medical applications generally being more positively evaluated than applications in food production (Bauer, 2005)—may be seen as strong supporting evidence. However, pointing to different perceptions of risks and benefits as the cause of inter-individual and intercultural attitude differences only shifts the problem of explanation. Why do different groups of people perceive risks and benefits of the same applications of biotechnology differently? Some answers in the rich literature

on public perception of biotechnology refer to personality traits, values and preferences, lifestyles, social roles, knowledge, credibility and trust, and media coverage.

In this article, we are interested in cross-cultural differences in public attitudes between the USA and Germany, in cultural explanations for these differences and, more fundamentally, in cultural roots for attitudes towards food biotechnology *per se*. We assume that individual and organizational sense-making of food biotechnology operates in a semantic space provided by the respective culture. According to Swidler's (1986) 'tool kit' model, cultures offer semantic resources for making sense of problems that require action or orientation. Referring to that model we assume that cultures provide contingent semantic relations between novel technologies and symbols, previous events, experiences, books, movies, knowledge, norms, values and generalized interpretation schemes. We further assume that these semantic references lead to the selection of the relevant risks, benefits and other evaluative aspects associated with the technology. Insofar as cultural inventories of sense-making tools differ, then the selection of relevant evaluative associations by the media, the population and the political-administrative system will also differ.

For our analysis, we focus on two aspects of culture: *trust in institutions* as a classical concept of (political) culture and *concepts of nature*, defined as beliefs about the boundary between nature and civilization, the characteristics of nature, and the relationship between nature and man. Previous research and theoretical reasoning suggests that both factors are predictors of attitudes towards biotechnology and that the U.S. and German culture differ with respect to both factors (see subsequently). Unlike previous studies, however, we treat both factors as cultural elements and test the assumption that cross-cultural variations regarding trust in institutions and concepts of nature explain part of the difference in public attitudes towards food biotechnology in the USA and Germany.

TRUST AS A COPING MECHANISM FOR INNOVATION-RELATED UNCERTAINTY

Innovations like food biotechnology can have a broad range of unintended consequences including health risks, environmental risks, and conflicts with social values. The response of science, technology, and politics to the problem of innovation-related uncertainty consists of scientific risk analysis, technology assessment, and regulatory processes for the implementation of innovations. These strategies reduce some uncertainties but also add new ones: Does the innovation process reflect the general populations' values and interests? Are technology developers, users and regulators competent enough to make

the right decisions? Will they honestly inform the public about risks and benefits or mislead it? Part of the uncertainty related to innovation thus is uncertainty about the performance of relevant social institutions and elites.

An important strategy to deal with situations characterized by ‘uncertainty and vulnerability’ is trust (Heimer, 2001, p. 43). There are numerous definitions of trust; we do not intend to elaborate, review and integrate the many sociological, psychological, and game-theoretical conceptualizations of trust (for overviews see Preisendörfer, 1995; Braithwaite & Levi, 1998; Cook, 2001). In our understanding, ‘trusting’ on the micro-level means expecting a ‘good’ performance of an actor in a specific situation without sufficient grounds, that is despite an inability to control, enforce or monitor that performance, and although there may be reasons to suspect an intentional or careless violation of one’s expectations.

According to Luhmann (1989) trust increases the tolerance of ambiguity (p. 16) and opens up new possibilities for action (p. 25–26), especially for cooperative interactions. Trust furthermore reduces the resources required to monitor others (Preisendörfer, 1995, p. 271). Hardin (2001, p. 28) argues that trust leads to a willingness to ‘delegate’ problems. Trust may finally be a factor contributing to deference to authorities (Tyler, 2001, p. 288–291)—deference, however, not based on formal hierarchies or power but on accepted authority (Luhmann, 1989, p. 57). The social effects of trust have led a number of scholars to consider general trust as part of the ‘social capital’ (Coleman, 1990; Putnam, 1995) and as an important element of political culture (Inglehart, 1999).

On the micro-level, people assign trust in a specific situation of uncertainty to a specific actor. We can derive more abstract forms of trust from this basic definition of situation-specific trust by generalizing the expectation of trustworthiness to classes of actors and to the meso- and macro-level of society. Trust in specific police officers, for example, may be generalized to trust in the police as institution. Important examples of such generalizations at the societal macro-level are *interpersonal trust* as the ‘default expectations of the trustworthiness of others’ (Yamagishi, 2001, p. 142) and *institutional trust* as the level of confidence in social institutions. We can furthermore distinguish forms of trust with respect to their thematic scope. We may trust government in general, for example, or differentiate our trust with respect to specific policy fields. For our analysis, we conceptually distinguish two levels: *general trust*, not limited to a specific thematic field, and *issue-specific trust*, limited to an issue or policy field. Preisendörfer (1995, p. 269) strongly supports the assumption that trust is not bound to specific situations but to a large extent is structurally, individually and culturally typified. In this article, we are only concerned with institutional trust on the general and issue-specific level.

Two arguments, the roots of which can already be found in the work of Arnold Gehlen (1957), support the idea that institutional trust affects attitudes towards innovative technologies:

1. Technologies are *socio-technical systems* consisting not only of hardware or technical processes but incorporating social institutions that develop, implement, operate, monitor, and regulate these systems (Bijker, Hughes, & Pinch, 1987). Trust in the performance of these institutions is an integral part of the evaluation of technologies (Rayner & Cantor, 1987; Earle & Cvetkovich, 1999). While trust in 'expert systems' is a ubiquitous requirement of modern societies (Giddens, 1991, p. 83ff.), it is particularly tricky for innovative technologies because the expectation of future performance of the relevant institutions and actors cannot be based on prior experience.
2. In the absence of personal experience and lacking expertise, lay people rely on information provided by science, politics, regulatory bodies, industry, environmental, and consumer organizations, and the media in their evaluation of innovative technologies. According to classical and modern persuasion theories, perceived trustworthiness of information sources partly determines which ones are used and which information is accepted as subjective knowledge (Hovland, Janis, & Kelley, 1953; Petty & Cacioppo, 1986). Which sources of information are considered trustworthy thus influences which risks and benefits are considered relevant for the evaluation of the technical innovations.

With innovations such as food biotechnology, we hypothesize that institutional trust will lead to a greater readiness to rely on judgments and accept the policies of the relevant institutions. A lot of empirical work relates positive attitudes towards genetic engineering to trust in government, industry, regulatory agencies, and scientific experts (e.g., Peters, 1999; Siegrist, 2000; Frewer, Scholderer, & Bredahl, 2003; Durant & Legge, 2005; Poortinga & Pidgeon, 2005). If people position institutions as pro- or anti-biotechnology, there is a clear relationship between attitude and kind of institution that one trusts. People with a positive attitude towards food biotechnology tend to trust institutions that approve food biotechnology; those with a negative attitude tend to trust institutions rejecting food biotechnology (Priest, Bonfadelli, & Rusanen, 2003).

That a correlation between trust and attitudes exists is clear. The direction of the causal relationship, however, is unclear. Does trust in certain institutions lead to a positive attitude towards food biotechnology or conversely, do existing attitudes towards food biotechnology determine the institutions one trusts? The assumption that trust influences attitudes is perhaps the intuitive and default expectation. But there is also some empirical

evidence of a reverse causality: an assessment of trustworthiness and credibility based on attitudinal (dis)similarity (Frewer et al., 2003; White, Pahl, Buehner, & Haye, 2003; Poortinga & Pidgeon, 2005). Contrasting the two possible directions of the influence may mean missing the point, however. The principle of congruity (Osgood & Tannenbaum, 1955) states that persuasive influences between semantically related evaluative concepts may flow in either direction. With respect to the assignment of trust that means, we tend to trust people and institutions who share our attitudes, and we tend to adjust our attitudes toward those people and institutions we trust. The mentioned correlations between trust in actors who are either pro- or anti-food biotechnology may thus simply reflect the principle of congruity.

We may even make a more general claim. Semantically related variables with an evaluative connotation—perceptions of risk and benefit, attitude towards the innovation, trust in actors promoting or opposing the innovation—may be considered a ‘syndrome’, a net of concepts that are tied together and vary jointly. Variables that are part of a syndrome influence each other to maintain or increase congruity. Because of the interdependencies, correlations among the variables of a syndrome are generally strong; one cannot say, however, that one variable ‘explains’ another.

Is ‘trust’ part of an attitudinal syndrome or is it a true (external) predictor of attitudes towards food biotechnology? It depends on the conceptualization and operationalization of trust. Issue-specific trust is part of an attitude syndrome and cannot *explain* other variables of this syndrome, such as risk perception and attitudes. The empirically well-established correlation between specific trust and attitudes is thus rather trivial. Correlations between attitudes and general trust would be essential. General institutional trust is a variable external to the food biotechnology attitude syndrome. We would not expect that attitudes towards food biotechnology have more than a minimal influence on general institutional trust. If a correlation between general trust and attitudes exists, it will be caused by the influence of trust on attitudes, not vice versa.

We do, thus, not agree with Siegrist and Cvetkovich’s (2000, p. 714) claim that measures of general trust as explanatory variables for risk perception are not of ‘much practical or theoretical value’. We also disagree with Sjöberg’s (2001, p. 193) similar claim made with reference to stronger correlations of risk perception with specific than with general trust. We contend that, although correlations between trust and attitudes are stronger for issue-specific than general trust, the possible correlation between general trust and attitude is the theoretically more interesting one. Such a correlation would connect specific attitudes to the general political culture and may explain cross-cultural differences in attitudes towards innovative technologies.

If there is an impact of institutional trust on attitudes, cross-cultural differences in the level of that trust would contribute to explaining why attitudes towards food biotechnology differ between the USA and Germany. We can indeed observe differences in institutional trust in recent international surveys. For example, the 1999/2000 World Values Survey and the 2004 International Social Survey Program (ISSP) both indicate higher levels of institutional trust in the USA than in Germany. Thirty-two percent of the U.S. respondents, but only 11 percent of the German respondents, in the ISSP 2004 agree to the statement 'Most of the time we can trust people in government to do what is right.' The World Values Survey further indicates small cross-cultural difference of trust in the Parliament but considerable differences of trust in the civil service and major companies. In each case, the U.S. population places more trust in these institutions than the German population.¹

CONCEPTS OF NATURE AS SENSE-MAKING 'TOOLS' FOR BIOTECHNOLOGY

As part of cultural evolution, food-related technologies including hunting weapons, agriculture, farming, food preservation, cooking, and food logistics have supplemented and supplanted 'natural' ways of provisioning food. The societal division of labor made food production a specialized and industrialized activity, increasingly alienated from everyday experience. Now, the mass-production of food shows many of the side effects of industrialization, in particular with respect to environmental impacts.

From a scientific standpoint, food biotechnology based on gene transfer is just another step in the cultural evolution of nutrition. In public perception, however, there seems to be a big difference in the 'naturalness' of more traditional methods and modern food biotechnology. First, GM food is a high-tech product, based on esoteric, scientific knowledge; the crucial processes happen in laboratories rather than in fields or barns. Second, at the beginning, even scientists were afraid of subjugating the natural evolution to the technical control of scientists through recombinant DNA technology (Wade, 1977). Food biotechnology thus seems to be a particularly large and alienating step in the cultural evolution of food provisioning. Moreover, it is a step done in a social context characterized by a scarcity not of food but of 'nature'.

¹Data of the World Values Survey is available online at <http://www.worldvaluessurvey.com/>, enabling the authors to make their own simple statistical analyses via the comfortable web-interface. The Centre for Survey Research and Methodology (ZUMA), Mannheim, and the Central Archive for Empirical Social Research (ZA), Cologne, provided ISSP 2004 data about trust in the USA and Germany prior to the official public release of the data sets (<http://www.issp.org/>). For methodological details consult the websites of both international survey programs.

How these technical interventions into nature—culminating in food biotechnology—are framed and evaluated depends partly on one's 'concept of nature'. Attitudes towards food biotechnology may be related to concepts of nature in at least three ways:

1. On a general level and concerning any application of genetic engineering, deliberately modifying the 'blueprint of life' has the connotation of 'playing god' and is sometimes viewed as an act of human hubris, exceeding natural and moral boundaries (Miah, 2005). This argument may be based on a religious belief in the sacredness of God's creation but also, in a secular variant, on an ethical position assigning 'nature' the status of a value in itself.
2. People may relate technical modifications of food such as food biotechnology to the perception of food quality in different ways. They might see the modifications as enhancing food quality by, for example, increased convenience or better nutrition. Conversely, people might see the modifications as lowering food quality because of, for example, increased allergy risks or increased Bovine spongiform encephalopathy (BSE) risk as the consequence of 'unnatural' feeding practices. Furthermore, for some consumers perceived 'naturalness' of food may be a quality criterion in itself.
3. Agricultural production has severe environmental impacts including changes in land use and the spreading of fertilizers and pesticides. People may interpret agricultural biotechnology as contributing to environmental depletion by posing risks for natural organisms and introducing new genetic material into ecosystems with unknown consequences.

Environmental ethics and cultural theory both suggest relevant distinctions between differing concepts of nature. Environmental ethics distinguishes between the *anthropocentric* and the *ecocentric* perspective as models of the relationship between humans and nature (Huber, 1989; Birnbacher, 1991; Döbert, 1994). The ecocentric perspective considers the value of nature as genuine, while the anthropocentric perspective derives the value of nature from its benefit for humans. Although nature might be valued from both points of view, when in conflict with the interests of humans the ecocentric perspective values protection of nature more than the anthropocentric perspective. Apart from these 'ideal types' mixed and modified positions can be found (Birnbacher, 1991; Knaus & Renn, 1998).

Cultural theory distinguishes between four 'myths of nature' that differ with respect to the perception of the stability of the ecosystems and imply different limitations to human interventions (Thompson, Ellis, & Wildavsky, 1990). The myth of a *benign nature* regards nature as robust and tolerant to human interventions. It assumes that nature will always find equilibrium and

implies few limitations to human actions affecting nature. The myth of a *perverse/tolerant nature* is somewhat more restrictive regarding human interventions. This myth regards nature as robust and tolerant but only within certain limits. The myth of a *capricious nature* sees nature as unpredictable. Human interventions always have an incalculable risk because we cannot anticipate nature's reactions. Finally, the myth of an *ephemeral nature* considers ecosystems highly fragile and sensitive to minor interventions. This position demands the strictest limits for human interventions into nature.

Both environmental ethics and cultural theory treat nature as socially constructed. Culture determines its value and function, the perceived relationship between humans and nature, and the attitudes towards nature. 'Societies exist in nature. Nature, however "exists" in our understanding. What nature is is determined by images, ideas, concepts, and models – in short, through the available semantic repertoire of a given culture' (van den Daele, 1992, p. 526). While nature-related beliefs may partly be the result of direct experience, culture forms and mediates these experiences.

Several recent qualitative and quantitative studies of public attitudes towards biotechnology identified 'nature' as an important factor. Zwick (1998) found that ontological associations, associations contrasting nature and culture, and appraising associations with the term 'nature' tend to go along with a negative attitude towards food biotechnology. In contrast, associations with nature as a productive resource, as a threat or a scientific view of nature were related to more positive assessments. Using the categories of cultural theory for an analysis of the population's concepts of nature, Kuckartz (2000) found a significant correlation with the perception of risks of genetic engineering. Those who believed that nature is 'ephemeral' assessed the risks of genetic engineering to be significantly larger than those who believed in a benign nature; people whose convictions resembled the myths of a 'capricious' or 'perverse/tolerant' nature took moderate positions with respect to risk perception. Wagner et al. (2001) identified 'nature' as an important category when exploring public perceptions of biotechnology in ten countries by means of focus groups. The analysis showed that participants often referred to nature to explain their rejection of biotechnology. Kniازهva (2002) used a grounded theory approach for analyzing in-depth interviews about consumer concerns. She found the category of 'naturalness' to be a frame of reference for consumer perception of GM food. In a study by Beckwith, Hadlock, & Suffron (2003) ecocentric and technocentric worldviews were related to rejection and support of plant biotechnology, respectively. Finally, Gill (2003) developed a typology of worldviews and concepts of nature from the history of ideas and applied it to the analysis of the British discourse on food biotechnology. He claims that a changing understanding of nature as

‘surprise’, ‘adventure’, and ‘longing’ drove the dynamics of the discourse on food biotechnology.

The different history and geography in the USA and Germany may have contributed to the development of different cultural concepts of nature in both countries. In a pilot study, Sawicka (2005) found clear differences in nature-related beliefs between U.S. and German elementary school teachers, indicating a higher appreciation of nature in Germany. The historically recent colonization of the USA strongly connects Americans to the experience of a ‘wilderness’ that had to be conquered and cultivated (Ott, Potthast, Gorke, & Nevers, 1999; Nash, 2001). Furthermore, patterns of land use differ strongly between the two countries. The USA has large areas that, at first glance, appear relatively unaffected by civilization while in Germany such ‘uncivilized’ areas are rare. Moreover, agriculture in Germany is less separated from other forms of land use such as housing, traffic, and recreation than in the USA.

SURVEY DESIGN AND METHODOLOGY

The data used for the analyses reported in this article stems from telephone surveys, conducted in May–June 2004 in the USA and Germany. The samples for both surveys were drawn from the general population in the USA and Germany using random digit dialing. Our cross-cultural study is the extension of a U.S. survey on food biotechnology (Hallman et al., 2004); we specifically developed several questions for the intercultural comparison and integrated them into the U.S. survey as well as a German ‘omnibus survey’.² In the U.S. survey, the questions used in this article were only asked in a split-half sub-sample of 601 of 1,201 interviews. In Germany 1,000 interviews were done. Because the U.S. sample included only respondents above the age of 17 years, we excluded the age group 14–17 years from the German sample. The data on which our analysis is based thus stems from 601 U.S.-American and 942 German respondents, representing the 18 and older populations in both countries.

Because our hypotheses refer to the impact of institutional trust and appreciation of nature on the attitude towards food biotechnology, the three key variables are *trust*, *nature*, and *attitudes*. These variables were operationalized by Likert-like sum scales consisting of eight items each to

²Commercial polling institutes conducted the field work. In the USA, Shulman, Ronca, and Bucuvalas, Inc. conducted an exclusive study for the Food Policy Institute of the Rutgers University; in Germany TNS Infratest Sozialforschung carried out the interviews as part of their omnibus survey ‘Infrasprint 2004’. Response rates according to the AAPOR RR2 definition are 26.2% (USA) and 46.3% (Germany). In both countries, weights were calculated to compensate biases with respect to regional and socio-demographic factors as compared to census data. For all statistical analyses reported in this article we used the weighted data.

TABLE 1 U.S.–German differences in trust in institutions, appreciation of nature and attitudes towards GM food

	USA		Germany		Diff. of means	Sign. of difference ^a p	Scale reliability Cronbach's α
	Mean	SD	Mean	SD			
Trust in institutions	0.32	4.02	-0.38	3.39	0.71	≤.01	.63
Appreciation of nature	3.57	3.63	4.25	2.85	-0.68	≤.01	.46
Attitude towards GM food	-1.91	5.09	-3.59	4.78	1.69	≤.01	.82

^at-test of significance of scale mean differences USA vs. Germany.

which respondents could express agreement or disagreement on 4-step scales. To compensate for a possible acquiescence tendency we constructed balanced scales: four items of each scale had a positive wording (i.e., agreement implied high trust, high appreciation of nature, and a positive attitude), four items were reverse in that respect. We use the variables *sex*, *age*, *educational level*, and *awareness* to control the possible mediating influences of socio-demographic factors and awareness of GM foods in our multivariate analyses (see online Appendix, <http://hdl.handle.net/2128/648>, Table A4).³

According to our conceptualization of *trust* as general trust in societal institutions, we first selected four social subsystems—politics, economy, law, and science—that are central to modern societies and appear to have similar functions in both countries. For each of these subsystems and without any reference to biotechnology we asked two questions about the trustworthiness of institutions that are part of those subsystems, referring to their perceived intentions ('try to do what is best for society') and their perceived (in)ability ('not competent enough to make the right decisions'). The eight ratings of the four institutions on the two trustworthiness dimensions can be combined into a fairly reliable general trust scale (Cronbach's alpha = .63, Table 1). While the level of trust in the institutions of the four subsystems differs considerably (Table 2), those who trust the institutions of one subsystem are also more likely trust the institutions of the other subsystems. It seems, thus, justified to combine the eight ratings into a single measure of general institutional trust, which we take as a feature of political culture.

The eight items of the scale measuring *appreciation of nature* represent four aspects in which concepts of nature might differ: priority, sensitiveness,

³We operationalized educational level by highest school qualification. For Germany, we used the following equivalences: low = a qualification of 'Volksschule/Hauptschule' or no formal qualification at all; medium = 'Mittlere Reife' or a qualification of the 'Polytechnische Oberschule'; high = 'Abitur' or 'Fachhochschulreife'. For U.S. respondents, we used the following categories: low = 'high school graduate', passed test of general educational development (GED) or less; medium = 'some college/2 year Associate Degree'; high = 'four year college degree' or 'post graduate'.

TABLE 2 Agreement to items used for the scales 'Trust in institutions,' 'Appreciation of nature' and 'Attitude towards GM food'

<i>Items (short form)^a</i>	<i>Agreement (%)^b</i>		<i>Significance of difference^c p</i>
	<i>USA</i>	<i>Germany</i>	
<i>Trust in institutions</i>			
Political institutions try to do what is best (+)	53.1	28.2	≤.01
Legal institutions try to do what is best (+)	68.8	67.6	NS
Economic institutions try to do what is best (+)	35.8	18.7	≤.01
Scientific institutions try to do what is best (+)	77.5	69.9	≤.01
Political institutions are not competent enough (-)	53.1	54.8	NS
Legal institutions are not competent enough (-)	43.3	43.8	NS
Economic institutions are not competent enough (-)	54.2	48.6	≤.05
Scientific institutions are not competent enough (-)	38.9	42.2	NS
<i>Appreciation of nature</i>			
Okay for humans to change nature (-)	35.4	29.6	≤.05
Nature should be left alone (+)	73.6	85.0	≤.01
Humans can easily destroy balance of nature (+)	90.2	93.4	≤.05
Nature finds ways to adopt to change (-)	70.4	65.7	NS
Humans are smarter than nature (-)	35.7	17.5	≤.01
Things in nature more perfect than those made by humans (+)	81.4	85.6	≤.05
Humans must control nature to protect themselves (-)	55.2	55.6	NS
Nature must be protected against humans (+)	90.3	91.6	NS
<i>Attitude towards GM food</i>			
GM food no danger for future generations (+)	28.4	20.5	≤.01
Safe to eat GM food (+)	52.9	23.2	≤.01
Would buy GM food if cheaper (+)	37.2	14.8	≤.01
Consumer should have the right to buy GM food (+)	91.4	80.7	≤.01
GM food threatens the natural order (-)	63.5	76.1	≤.01

(Continued)

TABLE 2 Continued

<i>Items (short form)^a</i>	<i>Agreement (%)^b</i>		<i>Significance of difference^c p</i>
	<i>USA</i>	<i>Germany</i>	
Serious accidents involving GM foods are bound to happen (–)	75.7	52.4	≤.01
Would pay more for non-GM food (–)	60.9	76.3	≤.01
Would be upset if served GM food in a restaurant (–)	70.6	76.1	≤.05
	(<i>n</i> = 601)	(<i>n</i> = 942)	

^aTables A1–A3 in the online Appendix show the exact item wording in English and German; see <http://hdl.handle.net/2128/648>.

^bAnswer categories ‘Strongly agree’ and ‘Somewhat agree’ were summarized for this table. Percentages were calculated on the basis of valid answers. For the detailed answer distributions see Tables A1–A3 in online Appendix.

^cDifferences in the proportions of agreement in both countries were tested for significance by a *t*-test; ‘NS’ means not significant, i.e. *p* > .05.

perfection, and threat. For each of these aspects two items were constructed, one with a positive, one with a negative wording. ‘Priority’ refers to a hierarchy in the human–nature–relationship: nature as a value of its own vs. nature as a means to serve human interests, reflecting the classical distinction in environmental ethics between an anthropocentric and an ecocentric concept of nature. ‘Sensitiveness’ is a simplified version of the distinction in cultural theory of how sensitive or robust nature reacts to human interventions, implying more or less need for protection. ‘Perfection’ captures the kind of association made by Kniazeva (2002) between the notions of quality and naturalness. Roughly, the opposite positions are: nature is perfect ‘by nature’ vs. culture is superior to nature. ‘Threat’, finally, refers to the different possible answers to the question of who is a threat to whom—nature for humans (e.g., by natural hazards or dangerous animals) or humans for nature (e.g., by environmental pollution). Approval and disapproval of these items expresses more or less appreciation of nature. For the following analysis, we simplify the semantic complexity of concepts of nature by focusing on the appreciation aspect, implicit in all items. The semantic heterogeneity of our items leads to a rather low reliability of the sum scale (Cronbach’s alpha = .46), indicating that the hypothesized appreciation dimension indeed does not exhaust the conceptual complexity. We use this scale nevertheless and justify this with its enormous predictive value (see ‘discussion’ section).

The scale for *attitudes towards GM food* (Cronbach’s alpha = .82, Table 1) comprised four items on possible benefits and risks of GM foods (i.e., ‘Genetically modified food presents no danger for future generations’)

as well as four items expressing consumer preferences for or against GM food under different conditions (i.e., 'I would buy genetically modified food if it were cheaper than ordinary food'). Some items resemble those used in previous surveys (Gaskell, et al., 2003; Hallman, Hebden, Aquino, Cuite, & Lang, 2003) but the wording of most was modified.

When developing the three scales our general goal was to find or construct items that have a similar meaning and are equally plausible for respondents in both countries. We developed the items simultaneously in both language versions, continuously checking between the U.S. and the German versions, and involving professional translators. The main challenge, however, was not the translation of the items but securing the cross-cultural equivalence of concepts we referred to in the items (see online Appendix, <http://hdl.handle.net/2128/648>, Tables A1–A3).

We also invested much effort into controlling the context effects of the questionnaire. To be able to interpret possible statistical correlations between our independent variables 'trust' and 'nature', and our dependent variable 'attitudes' as a true (causal) explanation of the latter by the first, it was crucial that institutional trust and appreciation of nature was measured without any 'semantic contamination' by the food biotechnology issue. As explained earlier, a correlation between attitudes and issue-specific trust is rather trivial and allows several interpretations. We thus made sure that respondents were asked the questions on trust and nature before introducing the topic of biotechnology in the interviews.

SURVEY RESULTS

ATTITUDES TOWARDS FOOD BIOTECHNOLOGY

This article examines the potential of institutional trust and appreciation of nature to explain why public attitudes towards food biotechnology are more positive in the USA than in Germany. As expected, our survey replicates this attitude difference.⁴ In seven out of eight items of our attitude scale, German respondents express a significantly more critical or less positive assessment of food biotechnology than the U.S. respondents (Table 2). The only exception

⁴One might suspect that the differences in attitudes towards food biotechnology as well as the differences in the two predictor variables institutional trust and appreciation of nature may be caused by a different degree of issue awareness and/or a different socio-demographic structure of the populations in both countries rather than by cultural differences. The main effect of 'country' as predictor of attitudes, trust, and appreciation of nature remains statistically significant in a variance analysis, however, even when including the variables sex, age, educational level, awareness and all their interactions as predictors in the model. This does not prove beyond doubt that the country differences regarding attitudes, trust, and appreciation of nature are due to cultural influences, but at least there is no *simple* alternative explanation pointing to a different age structure, for example.

is item A6 ('Serious accidents involving genetically modified foods are bound to happen') which, contrary to the general trend, finds significantly more approval in the USA than in Germany. We do not have a conclusive explanation for this untypical item characteristic but suspect that the item reflects the U.S. population's sensitivity to accidents after the terrorist attack on the World Trade Center on 11 September 2001. However, this item does not show a lower correlation with the total scale than the other items. Therefore, there is no reason to believe that this item is a less valid indicator for attitudes towards food biotechnology than the other items. Despite this outlier item, the mean value of the Likert scale 'attitudes towards GM food', based on the eight attitude items, is significantly lower for Germany than for the USA (Table 1).

GENERAL TRUST IN INSTITUTIONS

The items used to measure general institutional trust refer to four societal core institutions and two dimensions of trust—perceived intentions and competence. In both countries, respondents assess scientific and legal institutions as more trustworthy than political and economic institutions (Table 2). Furthermore, the difference in trust is much more pronounced in the 'intentions' than in the 'competence' dimension. In four of the eight items, German respondents express significantly less institutional trust than their U.S. counterparts did. The differences are moderate for scientific and legal institutions but large for political and economic institutions, in particular on the 'intentions' dimension. With respect to general institutional trust, Germany and the USA hence strongly differ, particularly in the perceived intentions of political and economic institutions. Consistent with the results of the World Values Survey and the ISSP 2004 mentioned earlier, our trust scale shows significantly more general institutional trust in the USA than in Germany (Table 1).

APPRECIATION OF NATURE

Five of the eight items of the 'appreciation of nature' scale show significant differences between the USA and Germany—and all differences are in the expected direction, indicating that appreciation of nature is higher in Germany than in the USA (Table 2). In particular, U.S. respondents agree more with the statement that 'humans are smarter than nature' and agree less with the statement that 'nature should be left alone'. The scale shows a significant difference of means between the USA and Germany (Table 1).

TABLE 3 Bivariate correlations of 'Trust in institutions' and 'Appreciation of nature' (items and scale) with 'Attitude towards GM food'

	<i>Correlation with scale 'Attitude towards GM food'</i>	
	<i>USA</i>	<i>Germany</i>
<i>Trust in institutions</i>		
Political institutions try to do what is best (+)	.13**	.00
Legal institutions try to do what is best (+)	.14**	-.01
Economic institutions try to do what is best (+)	.14**	.01
Scientific institutions try to do what is best (+)	.17**	-.02
Political institutions are not competent enough (-)	-.09*	-.03
Legal institutions are not competent enough (-)	-.11*	.00
Economic institutions are not competent enough (-)	-.16**	-.01
Scientific institutions are not competent enough (-)	-.16**	-.03
Likert scale 'Trust in institutions'	.24**	.03
<i>Appreciation of nature</i>		
Okay for humans to change nature (-)	.29**	.22**
Nature should be left alone (+)	-.21**	-.17**
Humans can easily destroy balance of nature (+)	-.13**	-.15**
Nature finds ways to adopt to change (-)	.09	.01
Humans are smarter than nature (-)	.14**	.15**
Things in nature more perfect than those made by humans (+)	-.25**	-.15**
Humans must control nature to protect themselves (-)	.11*	.10**
Nature must be protected against humans (+)	-.12**	-.19**
Likert scale 'Appreciation of nature'	-.33**	-.31**

* $p \leq .05$, ** $p \leq .01$.

APPRECIATION OF NATURE AND INSTITUTIONAL TRUST AS PREDICTORS OF ATTITUDES TOWARDS GM FOOD

In both countries, most bivariate correlations between the individual nature items and the 'appreciation of nature' scale with the attitude scale are

significant and all show the expected direction (Table 3). Within each country, higher appreciation of nature is related to more critical attitudes towards food biotechnology and vice versa. The correlations are moderate; it has to be kept in mind, however, that the nature items do not refer to biotechnology. Our measure of appreciation of nature thus is a true independent predictor. The correlation of $r = .33$ (USA) and $r = .31$ (Germany) between the nature and attitude scales means that about 10 percent of the attitude variance within each country can be explained by appreciation of nature. This is surprising because the nature scale is technically quite poor and has low internal reliability. Based on the presented results, we consider appreciation of nature to be an important predictor of attitudes towards GM food both in the USA and in Germany.

The correlations of institutional trust with attitudes towards GM food differ remarkably between the two countries. In the U.S. sample, every trust item correlates significantly with attitudes towards GM food in the expected direction: higher general trust in institutions of the four subsystems—politics, law, economy, and science—goes along with more positive attitudes. The correlation of the trust scale with the attitude scale is somewhat lower than the correlation found for the nature scale, but it is still considerable (Table 3). For Germany, however, all correlations between indicators of general trust and attitudes towards GM food are almost zero and not statistically significant. The same is true for the Likert scale ‘trust in institutions.’ General trust thus is a moderately important factor for attitude-formation in the USA, but not in Germany.

MULTIPLE ANALYSIS OF (Co)VARIANCE

To reduce the possibility that the results of the analysis of bivariate correlations are biased by correlations with socio-demographic variables and issue-awareness, we performed a multiple analysis of (co)variance for each of the two countries. We defined attitudes towards GM food as the dependent variable, nature and trust scales as covariates and sex, age, level of education as well as issue awareness as factors. The purpose of this analysis is to determine the predictive power of ‘appreciation of nature’ and ‘trust in institutions’ while controlling for the modifying influence of basic socio-demographic variables and awareness (Table 4).

To this end, we defined a base model (BM) that included as factors the mentioned three socio-demographic variables and awareness with all interactions (saturated model). We did not attempt to interpret the model parameters. This base model only serves as a reference to determine the specific contribution of trust and appreciation of nature, and their relative importance, by measuring the increase in explained variance by the trust and nature scale controlling for sex, age, level of education, and awareness.

TABLE 4 Multivariate linear model showing the single and combined effects of ‘Trust in institutions’ and ‘Appreciation of nature’ on ‘Attitude towards GM food’, controlling for sex, age group, educational level, and issue awareness

	<i>USA</i>			<i>Germany</i>			
	<i>Effective sample size: n = 499</i>			<i>Effective sample size: n = 896</i>			
	<i>Model</i>	<i>Explained variance (%)</i>		<i>Model</i>	<i>Explained variance (%)</i>		
	<i>Raw</i>	<i>Adjusted</i>	<i>Diff. to BM</i>	<i>Raw</i>	<i>Adjusted</i>	<i>Diff. to BM</i>	
Base model (BM) ^a	df = 82	23.5	8.4	df = 84	25.3	17.6	
BM + main effect ‘Trust’ ^b	df = 83	29.5	15.4	df = 85	25.5	17.7	0.1
BM + main effect ‘Nature’ + two-way interactions ‘Nature × Level of education’ and ‘Nature × Age group’ ^c	df = 88	36.1	22.4	df = 90	35.7	28.5	10.9
BM + main effect ‘Trust’ + main effect ‘Nature’ + two-way interactions ‘Nature × Age group’ and ‘Nature × Level of education’ ^d	df = 89	39.2	25.9	df = 91	36.1	28.8	11.2

^aBase model: Saturated model of variables ‘Sex’, ‘Age group’, ‘Level of education’, and ‘Awareness’ (main effects and all interactions).

^bMain effect ‘Trust’ only significant for the USA; no significant two-way interactions of trust with variables of BM in either country.

^cInteraction ‘Nature × Age group’ only significant for Germany.

^dMain effect ‘Trust’ only significant in the U.S. data; interaction ‘Nature × Age group’ only significant for Germany.

Because of the large number of degrees of freedom, we refer to the adjusted explained variance for the following argumentation. In models 2 and 3 we added the trust and nature scale, respectively, as covariates including the main effect and those interactions effects with the four factors of the base model that are significant in at least one country. We used the same models for both countries even if an effect is significant only in one country (see footnotes of Table 4 for details).

This multiple analysis of (co)variance generally confirms the results of the analysis of bivariate correlations. Compared to the base model that combines the explanatory power of the four control variables, the trust scale adds 7 percent to the explained variance in the USA but does not contribute anything to the explanation of attitudes towards GM food in Germany. The nature scale (main effect and two interactions with control variables significant in at least in one country) adds 14 percent to the explained variance in the USA and about 11 percent in Germany. Appreciation of nature thus is a quite good predictor of GM attitudes in both countries even when controlling for socio-demographic variables and issue awareness. Model 3 shows the combined effect of the trust and nature scale. Again, compared to model 2, general trust in institutions hardly increases the explained variance in Germany but contributes to the explanation of GM attitudes in the USA. However, appreciation of nature and trust in institutions are statistically related predictors; appreciation of nature and trust in institutions are negatively and weakly correlated in the USA ($r = -.22$, $p \leq .01$) and in Germany ($r = -.16$, $p \leq .01$). The difference in explained variance between models 2 and 3 for the USA is therefore smaller than that between the base model and model 1. Nevertheless, in the USA general trust in institutions increases the explained variance somewhat, even when controlling for socio-demographic variables, awareness, and appreciation of nature.

DISCUSSION

Our hypothesis concerning the relevance of concepts of nature for the sense-making of food biotechnology was clearly confirmed. In both countries, concepts of nature play an important role for attitudes although we only used a simple scale. This scale was based on the assumption, confirmed post hoc by the results of our analysis, that one relevant respect in which 'concepts of nature' differ is the degree of appreciation of nature implicit in them. We can attribute part of the attitude difference between the USA and Germany to the higher appreciation of nature in Germany. We assume, however, that we have not exhausted the explanatory potential of concepts of nature with this scale. Future multidimensional versions, based on a qualitative analysis of the

cultures' inventories of nature-related symbols, associations and experiences, would increase the concept's predictive power.

More difficult to interpret are the results concerning trust. We expected an influence of general trust on attitudes towards food biotechnology in both countries and a higher degree of institutional trust in the USA than in Germany. We did find the expected higher level of institutional trust in the USA than in Germany. However, we also found a cross-national difference in the statistical impact of general institutional trust on attitudes towards food biotechnology. While general trust was a moderate but significant predictor of attitudes in the USA, it did not explain attitudes towards food biotechnology in Germany. This is unexpected because it is usually the level, not the effect, of trust, that is seen as cause of varying perceptions of risk and different attitudes towards innovative technologies. Our striking result finds no easy and conclusive explanation but we distinguish between two principle accounts for this finding: more *context-specific differentiation of institutional trust* by the German than the U.S. population and/or higher *relevance of institutional trust* for the formation of attitudes towards GM food in the USA than in Germany.

In the following paragraphs, we attempt to identify possible causes for different context-specific differentiation and/or relevance of trust, referring (1) to the different political and semantic framing of the food biotechnology issue in both countries and (2) to the stronger universalism and individualism in the USA. We suggest five hypotheses that, in combination, provide a plausible explanation for the different efficiency of trust in resolving innovation-based uncertainty.

FRAMING OF THE FOOD BIOTECHNOLOGY ISSUE

The political framing and structure of the food biotechnology issue between Germany and the USA differs in several respects. We will outline these cross-cultural differences in the next paragraphs and then derive three hypotheses on the varying role of trust in Germany and the USA that make use of the different issue framing.

Issue scope. Jasanoff (2005) argues that the U.S. debate about, and regulation of, food biotechnology focuses narrowly on risk while in Europe (Germany in particular) broader value- and worldview-related aspects play a much more important role. Millstone, van Zwanenberg, Marris, Levidow, and Torgersen (2004) conclude the same based on their analysis of food-related issues in the USA and three European countries. In Germany, food biotechnology is linked to a broad spectrum of issues such as agricultural overproduction as a consequence of EU policy, other technological controversies such as the nuclear power debate, and the perceived economic imperialism of multinational companies and the USA (Peters & Sawicka, 2007). Of course, broader cultural connotations, such as to the issues of

consumer choice, also exist in the USA (Hallman et al., 2004, p. 11). We would argue, however, that concrete risks and cost–benefit considerations from a consumer point of view are relatively less important for decision-making and attitude formation in Germany than in the USA.

Technocratic vs. political regulation frame. We make a distinction between two types of societal problems: familiar problems for which responsible organizations, relevant regulations and established routines exist, and novel problems for which such institutions do not exist. The regulatory network usually deals with the former problems in a technocratic manner without much public visibility. The latter problems lead to public discourses, political conflicts, and the involvement of organizations of civil society. Several authors have characterized the regulation process regarding food biotechnology as more ‘technocratic’ in the USA than in Europe and Germany (Epp, 2003; Millstone et al., 2004; Jasanoff, 2005). From her analysis of the regulatory networks for food biotechnology, Epp (2003) concluded that food biotechnology in the USA was regulated by adapting the existing general food regulation system to the specific demands of the new technology, emphasizing the continuity in technological development of food production (p. 86ff.). In contrast, the novelty of food biotechnology was emphasized in Germany (as in Europe in general)—indicated by the name of the relevant EU regulation of 1997: ‘Regulation [...] concerning *novel foods* and *novel food ingredients*’ [emphasis added] (p. 78ff.). This result is in line with Jasanoff’s (2005) analysis of U.S. genetic engineering being ‘regarded as a supplier of familiar classes of products requiring familiar types of review—not as a unique technological process threatening society with uncertain or incalculable harm’ (p. 53).

Intensity of public controversy and involvement. Indicators of issue salience and public involvement could include the intensity and tone of media reporting on food biotechnology as well as measures of public awareness based on survey questions. It is remarkably difficult to find clear and conclusive empirical evidence for a difference in intensity of media coverage on food biotechnology between Germany and the USA.⁵ As we have shown, awareness of GM food is somewhat higher in Germany than in the USA (see online Appendix, <http://hdl.handle.net/2128/648>, Table A4). We assume that the intensity of public controversy about food biotechnology during the last decade was higher in Germany than in the USA.

Institutional structure of controversy. Mazur (1981, p. 43) and other authors describe controversies about risky technologies as conflicts between the

⁵ The scarce available comparative data (Gaskell et al., 2001; Kohring & Görke, 2000) is uncalibrated and based on only one or two elite papers in each country. It gives the impression that in the years before 2001 the German media reported slightly more often and somewhat less positive about food biotechnology than the U.S. media, but that the coverage is not as different as one might assume. A good media indicator of the intensity of public controversy, however, does not yet exist.

establishment, in most cases in support of technology, and a challenging protest movement. Accordingly, the public would view the established institutions of science, economy, politics, and law as supportive of the controversial technology. This may be true in the USA. However, in Germany technical controversies have moved into the established political-administrative system as well as into science. Politicians of the Green Party have been ministers in several German Federal and State Governments. Germany, for example, has made the co-founder and former executive director of Greenpeace Germany, Monika Griefahn, Minister of Environmental Affairs in the federal state of Lower Saxony. In the Federal Government and the North Rhine-Westphalian State Government, respectively, Green Party members Renate Künast (2000–2005) and Bärbel Höhn (1995–2005) were ministers responsible for agriculture and food, and stood for a clear anti-food biotechnology policy. In Germany, the controversy over food biotechnology is thus more institutionalized *within* the established subsystems than in the USA.

The mentioned German–U.S. variations in issue framing do not represent clear-cut alternatives but differences in degree. Furthermore, issues are dynamic and some observers see a time trend towards convergence of the European and U.S. framing of food biotechnology and of public opinion. Currently the food biotechnology issue seems to be represented differently in the political-administrative system and in the public sphere in the USA and in Germany, however. We suggest three hypotheses of how the cross-cultural differences in issue framing may contribute to explaining the different impact of general institutional trust for attitudes towards GM food in the USA and Germany:

1. Trust in institutions can resolve the uncertainty of citizens with respect to food biotechnology in the USA, because in the USA these institutions show a clear support of food biotechnology; this is not true in Germany because the support from these institutions is ambiguous or controversial. A trusting citizen would thus derive a clear signal in support of food biotechnology from the established institutions in the USA, but a mixed signal, neither clearly supporting nor opposing food biotechnology, from the equivalent German institutions. Consequently, in the German case institutional trust does not reduce the uncertainty in the individual assessment of food biotechnology, and hence appears rather irrelevant for attitude formation.
2. Because of the broader issue scope and the emphasis on the novelty of food biotechnology as a regulatory problem, routine technocratic ways of dealing with food biotechnology are perceived as less adequate by the German regulatory system and population. Consequently, the politicization of the issue is higher in Germany than in the USA. This calls for a more important role of public deliberation and citizen involvement

in Germany than in the USA. This hypothesis implies the more general assumption that institutional trust tends to be more relevant in 'technocratic' than in 'political' settings.

3. Since food biotechnology in the last decade was a more salient public issue in Germany than in the USA, more information about the food biotechnology issue is available to average German citizens and their issue involvement is higher. This resulted in the development of issue-specific expectations about the performance of institutions. People in the USA, in contrast, base trust judgments about the biotechnology domain on their default general trust expectations. Furthermore, because of their higher issue awareness, Germans are less prepared to rely on the assessments of biotechnology even by trusted institutions, preferring to generate their own assessments based on the available and subjectively relevant arguments. Congruent with this hypothesis, Brossard and Nisbet (2007) argue that in the USA 'deference to scientific authority'—a variable related to general trust in science—is a crucial predictor of attitudes towards agricultural biotechnology.

UNIVERSALISM AND INDIVIDUALISM

Besides issue framing and issue salience, cultural-specific ways of dealing with the uncertainty implicit in the assessment of innovative technologies may contribute to an explanation of the different relevance of trust for attitude formation. With respect to the role of trust, it would be appropriate to look at culturally different ways of aiming at goals and guiding behavior. Hofstede (2001, p. 1) refers to these approaches as 'mental programs'. Parsons' (1951) pattern variables provide a classical framework for this kind of analysis. This theory says that people make choices on five dimensions when considering how to act: affectivity vs. affective neutrality, self-orientation vs. collectivity-orientation, universalism vs. particularism, achievement vs. ascription, and specificity vs. diffuseness. Parsons and others have used these dimensions to categorize cultures (Parsons, 1951, pp. 180ff.; Trompenaars & Hampden-Turner, 1997). The assumption is that different cultures suggest different defaults for the selection of one side of each contrast.

Of Parsons' pattern variables, two are particularly relevant for our discussion of trust: universalism vs. particularism and self-orientation vs. collectivity-orientation. Universalism stands for a more rule-based approach, discounting particular relations to people and organizations. Trust is more germane when acting according to universalist principles because of an increased likelihood of dealing with impersonal actors and with people with whom no particular relationship exists. Cultures encouraging a universalistic orientation hence rely more on trust as mechanism to cope with uncertainty

than particularistic cultures that produce subjective certainty by building special relations and reciprocal commitment. Furthermore, since universalism tends more towards 'generalization' than particularism (Parsons, 1951, p. 62), the difference in the relevance of trust might be more pronounced for general than for specific trust.

We can make a somewhat related argument with respect to self-orientation vs. collectivity-orientation. Yamagishi and Yamagishi (1998) show that trust and commitment are functional equivalents for coping with uncertainty. In a collectivistic culture, in-group relationships are strongly favored over relationships with nonmembers. Within a group, however, uncertainty is reduced by the establishment of group norms and resulting commitment, rather than by trust. Hofstede (2001, p. 239) furthermore argues that in collectivistic cultures trust is mainly established in specific people, not impersonal actors. He also points to the fact that 'universalism vs. particularism' is statistically correlated to individualism: 'The individualist society tends to be universalist' (p. 212). Based on these arguments we conclude that trust, in particular context-exceeding general trust, is a more important mechanism for uncertainty reduction in universalistic/individualistic cultures than in particularistic/collectivistic cultures.

From a global perspective, both the USA and Germany are universalistic and individualistic countries. Large-scale cross-national surveys of corporate cultures by Trompenaars and Hampden-Turner (1997, pp. 33ff. and 50ff.) and Hofstede (2001, p. 215), however, show that they differ in the degree of universalism and individualism. The USA is more universalistic and individualistic than Germany. While these surveys demonstrate cross-national differences in the corporate culture, other studies suggest similar differences in the popular culture. Based on the World Value Surveys, representative for the general population, Inglehart and Welzel (2005, p. 63, Fig. 2.4) find the USA ranking clearly higher than Germany with respect to (individualistic) 'self-expression values'. Referring to this difference and making use of the arguments about the different mechanisms of coping with uncertainty in universalistic/individualistic vs. particularistic/collectivistic cultures, we suggest two further hypotheses to explain our empirical finding of a difference in relevance of trust for attitudes towards GM food in Germany and the USA:

4. Because of stronger universalism and individualism, U.S. culture favors 'trust' as the mechanism to cope with uncertainty and depreciates 'particular' social relations and commitment as possible functional equivalents. The hypothesis is not that universalism and individualism increase the level of trust but that they increase its relevance for decision-making and attitude formation. Trust in institutions responsible for the development, application and regulation and of food

biotechnology therefore is a more effective mechanism for the resolution of uncertainty about this technology in the USA than in Germany.

5. The generalization of trust from specific situations with specific interaction partners to higher levels depends on universalistic reasoning, abstracting from aspects of the social situation and from the specific actor. The lower universalism/individualism in Germany impedes this generalization of trust compared to the USA and causes a more context-specific variation of trust and a stronger reliance on trust in people rather than institutions. In Germany, general institutional trust, as measured in our survey, is therefore a more spurious and inconsequential concept than in the USA, where it is relevant for orientation in specific contexts.

CONCLUSIONS

Our analysis of the possible roots of U.S.–German differences in attitudes towards food biotechnology points to the importance of culture. Cultural factors appear statistically to be only moderately strong predictors. They are, however, analytically less trivial predictors than traditional risks and benefits because of their semantic distance from the phenomenon (cf. Sjöberg, 1998, p. 137).

We presented five hypotheses to explain the surprising finding of a different impact of general institutional trust on attitudes towards food biotechnology in the USA and Germany. These need to be further scrutinized but point to interesting issues regarding the ways societies deal with innovation-related uncertainty and how they differ in that respect. Our results suggest that it is not primarily the level of trust that explains the different social responses to biotechnology in the USA and Germany but its different effectiveness in dealing with uncertainty given the varying issue framing and culturally formed orientation patterns.

Institutional trust and concepts of nature are potentially relevant for other issues related to science, technology, and environment. Nanotechnology, stem cell research, and energy supply systems are examples of issues that are semantically linked to concepts of nature and introduce uncertainties into society. We should be cautious with generalization of our results, however. Cultures are in a constant flux. In the USA, as in many other countries, trust in government has decreased during the last decades (Dalton, 2005). If our analysis is true, this decline in institutional trust in the USA should be accompanied by a decreasing tolerance of innovation-related uncertainty. Furthermore, as Nisbet's (2005) analysis of support for stem cell research in the USA shows, other cultural aspects such as moral and religious beliefs are also relevant for making sense of scientific–technical innovations.

These cautions, however, do not detract from the general questions posed in our analyses. Do societies differ in their ability to absorb innovations? What role does culture play in this process? Our case study of food biotechnology suggests that the U.S. culture might be more apt to assimilate technical innovations than the German culture because of (a) a more efficient coping mechanism for innovation-related uncertainty and (b) a greater tolerance of human interventions into nature.

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