Gene Technology, Food Production, and Public Opinion: A UK Study

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ABSTRACT In this paper, dimensions of the debate surrounding the application of gene technology to food production are discussed and a study assessing perceptions of the technology among a sample of the UK public (n = 1499) is reported. The general picture that emerges from the study is one of people expressing low familiarity with the technology, with more people associating it with high risks than with low risks, and more people expecting it to provide low benefits than high benefits. Attitudes towards different applications vary significantly, as does trust in different potential sources of information about the technology. It is also shown that attitudes can be predicted not only by estimates of risks and benefits but also by perceptions of the involvement of ethical issues, by the perceived need for the technology, and by the perceived likelihood of improvements it is likely to bring to the quality of life in the UK. The results are discussed in the context of the need for greater public information about the technology and the realization that communication of risks takes place within a complex network of societal relationships.

Introduction

> It must be recognized that research on values and public choice is inherently more difficult than research in biotechnology itself. This, however, neither detracts from its importance nor indicates it should not be done.[1]

The potential benefits of gene technology in agriculture and food production are numerous, as many supporters of the technology are quick to emphasize; on the other hand, opponents and critics point to the possibility of detrimental consequences associated with its application. So much is to be expected. However, protagonists also highlight different aspects of particular issues. For example, where the environmental risks of the technology are under discussion, proponents are wont to emphasize the low probabilities of the risks, with critics more likely to stress the catastrophic potential of outcomes, *were they to occur.* Promoters of the technology defend against the suggestion that such risks from novel organisms are high: ". . . there does not seem to be any reason to expect greater problems arising from recombinant organisms in agriculture than from organisms produced through traditional practices".[2] Critics, opponents, and skeptics, on the other hand, are often less sanguine about

possible environmental effects, with many suggesting that, while the probabilities of adverse ecological consequences may be very low, these consequences could nevertheless be very severe. Among those calling for greater research into the possible ecological consequences of gene technology in agriculture, it is the perception of a lack of confidence in predicting which organisms might spread into the environment that fuels concern.[3,4]

Just as there are disputes about the risks of agricultural applications of gene technology, so too are there disputes about the benefits. For example, proponents cite the potential for recombinant BST (Bovine Somatotropin) to reduce the cost of milk to the consumer;[5] skeptics doubt whether such economic benefits would extend that far.[6] A number of ethical issues also feature strongly in the debate: for example, in relation to "tampering with nature" or "playing god", as well as in relation to the more utilitarian considerations associated with the perceived consequences of the application of the technology.

While the debate between opposing positions in the literature is generally carried out by relatively well-informed adversaries, the public debate about gene technology is less developed, despite the recognition of the role that public opinion is likely to play in the development of the technology and despite repeated calls for more information to be made available to the public. In this paper we sketch (i) how the issues are framed; (ii) the role of public opinion in influencing the development of the technology; and (iii) preliminary findings of recent survey work in the UK.

The terms of the debate

In tandem with disputes over the potential risks, benefits, pitfalls, and promise of the technology, attention has begun to be paid to how the technology is "framed" in the debate, how the agenda for discussion is being influenced by interested parties, and how power to manipulate the agenda has become a part of the debate itself.

Levidow and Tait,[7] for example, discuss how the rhetoric of proponents of the technology has shifted emphasis "from biological revolution to evolution". Other commentators also note how proponents are keen to emphasize continuity with the past by portraying it as "a benign, incremental technology rather than as a new and alien science".[8] This continuity is often emphasized through describing biotechnology as consisting of techniques "practiced for centuries".[9]

Critics and opponents of the technology use its purported catastrophic potential to contrast the technology with other, less potentially catastrophic, technologies and with the natural and industrial hazards faced by people in years gone by. Beck,[10] for example, suggests that the hazards of biotechnology (along with those of nuclear and chemical technologies) are both "political", in the sense that inequalities (in benefits and threatening outcomes) originate in decision-making, and are potentially irreparable in the way that the risks facing society in the past have not been. Giddens,[11] in discussing the global implications of technological hazards, talks in a similar vein of how "the risks of ecological catastrophe form an inevitable part of our horizon of day-to-day life".

Different parties to the debate thus not only focus on different issues but also select their metaphors in order to emphasize particular similarities and distinctions. That each side has the ability to do so itself forms part of the debate: for example, Davis[12] complains that "The agenda has been set for too long by apocalyptic activists", whereas Plein[13] suggests, "Today, biotechnology is largely characterized by economic themes such as patent rights, international trade, research funding, and regulatory policy . . .. These images of biotechnology have, in large part, been influenced by the efforts of a well-organized coalition to define biotechnology in positive terms".

The function of public opinion

There is widespread sentiment that public opinion will play a significant role in the development of gene technology.[14] Public information is consequently lauded as a necessary step in permitting the public to make informed judgments about the technology. At the same time, protagonists in the debate are obviously keen to present their arguments with maximum rhetorical appeal, leading to the call for information to be presented in the form of "neutral, nontechnical language".[15]

While much investment of effort has gone into "agenda-setting", survey research indicates that the public is not very well informed about gene technology. This general lack of knowledge about the technology makes it likely that people might seek to assess the trustworthiness or otherwise of the protagonists in the debate about gene technology in order to help them formulate relevant attitudes and opinions. Thompson[16] suggests (in a discussion of the "ice-minus" tests) that public opinion of the scientific community is an important variable in the judged acceptability/unacceptability of risks. However, a widely acknowledged decline in trust in the professions is mirrored by increasing concern about agricultural production. Harlander,[17] for example, talks of the "Erosion of public confidence in agriculture and food systems" and empirical work would seem to support the idea that consumption practices are affected by levels of confidence in the safety of the food supply.[18]

At a more general level, declining levels of trust in experts are suggested by Barber[19] as resulting from those experts becoming possessors of ever more powerful knowledge, from society taking on a more egalitarian ethos and from the public becoming increas-

ingly educated in scientific matters. Experimental research in social psychology suggests that expertise in the absence of trust is likely to have little communicative impact in persuasion settings.[20] This research would generally support the assertion by Thompson[16] that activists (in the biotechnology debate) will be seen as more trustworthy because their positions are less clearly influenced by self-interest than are those of "scientific proponents" of the technology. The business community may be seen as a paradigmatic example of self-interest.[21] Certainly, research exists in the area of biotechnology and gene technology that indicates low levels of trust in industry and political organizations and higher levels of trust in environmental and consumer organizations.[22]

Previous research

It is apparent from research into public attitudes that people generally report having little knowledge of biotechnology. On the one hand, an OTA survey reported two-thirds of a sample indicating that they understood the meaning of the term genetic engineering,[23] while Berrier[24] reports a survey in which 51% of a sample of 2000 adults expressed "no awareness" of genetic engineering and another in which 57% reported "little understanding" of DNA. (Lacy, Busch and Lacy[25] provide an intelligent discussion of these, and other, public surveys carried out in the US). Hamstra,[26] in research involving 870 Dutch consumers, reports 27% indicating never having heard about genetic engineering before they took part in the survey.

At the same time, negative attitudes are often elicited. In the first of the surveys reported by Berrier, "when its potential risks and benefits were explained, 28% said that its effects would be harmful, 22% thought biotechnology would be beneficial, and 29% foresaw mixed benefits and costs". Hamstra[26] reports negative attitudes towards a number of applications of genetic engineering (including in food production). On the other hand, a Eurobarometer report[22] indicated a majority in favor of the application of genetic engineering to microorganisms and plants in food production, although only a minority expressed approval of the application of the technology to farm animals.

Aims of the research

The purpose of the empirical work reported in this paper was to collect some preliminary information about attitudes towards the application of gene technology to food production in the UK. At the same time, we were interested in assessing the effects of presenting the technology to people *via* different terminologies: we therefore presented the term "gene technology" (the terminology suggested by the Food Advisory Committee for the labeling of certain foods produced using the technology) to some people; others were presented with the terms "genetic engineering", "genetic manipulation" (both of which have been described by Straughan[15] as having a "sinister ring") or "genetic modification". Given the importance attached to the concept of trust in the risk perception and risk communication literature[27, 28] we also sought to elicit people's ratings of how likely they thought they would be to believe information about the risks and benefits of the technology presented by different potential sources of information.

That public attitudes towards biotechnology are not yet well-formed is widely agreed. Despite the pitfalls of questioning people on subjects about which they have little knowledge, such research may be suggestive, if not indicative, of some likely foci of public debate in the future.

Methodology of the empirical study

A questionnaire was constructed to assess various facets of public opinion concerning the application of gene technology to food production. A copy was sent to 6000 randomly selected members of the general public in the UK. (excluding Northern Ireland), along with a covering letter and a prepaid return envelope. Three thousand of the questionnaires used the term "gene technology", 1000 used the term "genetic engineering", 1000 used the term "genetic manipulation" and 1000 used the term "genetic modification" (the greater number receiving questionnaires framed in terms of "gene technology" was due to the need to recontact a large sample for a longitudinal study of attitudes towards gene technology; this research will be reported in a separate paper). The covering letter introduced the questionnaire as part of a project "concerned with increasing our understanding of public opinion about food-related issues", and pointed out that although participation would make a valuable contribution to the research, there was no obligation for people to take part in the study.

One week before the distribution of the questionnaire, each person had been sent a card informing them that they would shortly be receiving a questionnaire, requesting their participation and promising a small donation to charity for each completed questionnaire returned.

The questionnaire

The questionnaire was prefaced with a short introduction to the subject matter of the research:

> Gene technology (alternatively: 'genetic engineering', 'genetic manipulation' or 'genetic modification') involves the transfer of genetic material from one living thing to another. These living things may be animals, plants or microorganisms (such as yeasts). There are potentially many uses for such techniques: in medicine and food production, for example.

Table 1. Questions about 'the use of gene technology* in food production'

Questionnaire item	response scale	mean	s.d	n
'Before you received this questionnaire, how much had you heard or read about ...?'	1= 'nothing'; 5 = 'a great deal'	2.12	0.87	1462
'How likely do you think it is that ... will improve the general quality of life in Britain?'	1 = 'extremely unlikely'; 7 = 'extremely likely'	4.02	1.91	1442
'How much need do you think there is for ... in Britain?'	1 = 'no need'; 5 = 'a very high need'	2.42	1.03	1448
'Please indicate your general opinion of the use in food production of animals altered by gene technology*'	1 = 'extremely unfavourable'; 7 = 'extremely favourable'	2.93	1.89	1443
'Please indicate your general opinion of the use in food production of plants altered by gene technology*'	1 = 'extremely unfavourable'; 7 = 'extremely favourable'	4.05	1.91	1438
'Please indicate your general opinion of the use in food production of microorganisms altered by gene technology*'	1 = 'extremely unfavourable'; 7 = 'extremely favourable'	3.52	1.85	1438
General attitude measure	(range = 3-21)	10.49	5.11	1431
'How concerned are you about any possible suffering of animals from ...?'	1 = 'extremely unconcerned'; 7 = 'extremely concerned'	5.81	1.66	1449
'How concerned are you about any possible harmful effects on human health from ...?'	1 = 'extremely unconcerned'; 7 = 'extremely concerned'	5.81	1.59	1446
'How concerned are you about any possible harmful effects on the environment from ...?'	1 = 'extremely unconcerned'; 7 = 'extremely concerned'	5.63	1.56	1450
'Do you agree or disagree that ... raises important ethical issues?'	1 = 'disagree strongly'; 7 = 'agree strongly'	5.41	1.70	1447
Questionnaire item	response scale	mean	s.d	n
'How great do you think the benefits from ... are likely to be?'	1 = 'none'; 7 = 'extremely high'	3.67	1.46	1432
'How great do you think the risks from ... are likely to be?'	1 = 'none'; 7 = 'extremely high'	4.50	1.41	1427
'How likely would you be to believe statements about the benefits and risks of ... made by each of the following:'				

Government Ministers	1= very unlikely; 7= very likely	2.18	1.14	1408
Greenpeace	1= very unlikely; 7= very likely	3.52	1.18	1411
The Department of the Environment	1= very unlikely; 7= very likely	2.94	1.25	1384
The Consumers' Association	1= very unlikely; 7= very likely	3.92	0.94	1399
The Ministry of Agriculture, Fisheries and Food	1= very unlikely; 7= very likely	2.98	1.28	1398
Friends of the Earth	1= very unlikely; 7= very likely	3.48	1.18	1385
The Department of Health	1= very unlikely; 7= very likely	3.23	1.25	1407
A TV current affairs programme	1= very unlikely; 7= very likely	3.54	1.08	1418
'Please indicate how strongly you agree or disagree with the following statement: *The social and environmental costs of continued technological growth and energy consumption are intolerably high.'*	1 = 'disagree strongly'; 7 = 'agree strongly'	4.92	1.82	1434
Age		49.36	16.19	1457

'From what sources have you read or heard about the use of gene technology* in food production?' friends/colleagues (11%); newspapers/magazines (50%); television/radio (53%); other (4%); none (25%)
Occupational group (n given; data is missing for many respondents)
Professional (152); Intermediate (308); Skilled manual (157); Skilled non-manual (204); Partly skilled (62); Unskilled (12)
* or 'genetic engineering', 'genetic modification', 'genetic manipulation'

In food production the use of gene technology could enable the transfer of desirable characteristics from one living thing to another (leading, for example, to less fatty meat production in animals, greater disease resistance in plants or improved yeasts for baking)

Following preliminary questions about age, occupation, and gender, the questionnaire sought to gather information about respondents and their views on the use of the technology in food production. Table 1 includes the main questions, response scales, and mean ratings. Finally, subjects were requested to list any newspapers that they read on a regular basis, were thanked for completing the questionnaires and were asked to check to ensure that they had answered all the questions before returning the questionnaire in the prepaid envelope provided.

Results

In this section, we shall first present some general findings from the questionnaire; we then illustrate some differences between sub-groupings within the sample based on the demographic information collected and on the different terminologies used to describe the technology.

Of the questionnaires sent out, 162 were returned uncompleted for one reason or another; of the remainder, 1499 (25.7%) were returned within the required time period. Twenty-six percent indicated that they had heard or read "nothing" about the use of the technology in food production, 44% indicated "very little", 25% "a moderate amount", 4% "quite a lot" and 1% "a great deal" (n = 1462). Of those people who indicated that they had read or heard about the use of the technology in food production, "television/radio" (53%) and "newspapers/magazines" (50%) were by far the most frequently endorsed categories, followed by 'friends/colleagues" (11%) and "other" (4%) (see Table 1).

Thirty-eight percent thought it unlikely that the use of the technology in food production would improve the general quality of life in Britain; 53% thought this to be likely. Fifty percent indicated that there was "no need" or "little need" for the use of the technology in food production in Britain; 36% indicated "a moderate need" and 14% indicated "a high need" or "a very high need".

On the questions dealing with applications of the technology, 64% were unfavorable about the use of animals, 50% about the use of microorganisms and 40% about the use of plants. Favorable attitudes were indicated by 28%, 37% and 50% of the sample, respectively. ANOVA (SPSS) indicated significantly lower scores for the use of animals (M = 2.92) than the use of microorganisms (3.52) and significantly lower scores for the use of microorganisms than the use of plants (4.05) ($F(2, 1429) = 363.29$, $p<.001$).

On the questions dealing with concerns about the possible consequences of the technology, 85% indicated concern about possible suffering of animals, 86% indicated concern about possible harmful effects on human health, and 84% indicated concern about possible harmful effects on the environment. Unconcern was indicated by 11% for each of these three categories. ANOVA indicated that there was more concern expressed about animal suffering (5.82) and human health (5.81) than about effects on the environment (5.63), although levels of concern were clearly high in each case ($F(2, 1443) = 21.37$, $p<.001$).

Seventy-three percent agreed that the use of the technology in food production raises important ethical issues; 13% disagreed. When asked about the benefits of the technology, 37% indicated that these were likely to be "none" to "low", 38% "moderate", and 25% "high" to "extremely high". When asked about the risks, 22% indicated that these were likely to be "none" to "low", 34% "moderate", and 44% "high" to "extremely high".

On the question dealing with how likely people were to believe statements about risks and benefits made by various potential sources of information, the Consumers' Association appeared the most likely to be believed (M = 3.92), followed by environmental groups, various government bodies and with Government Ministers (M = 2.18) considered least likely to be believed (the presentation of these items was made in a fixed order, so we do not present statistical tests of difference here).

The final statement about technology and energy consumption ("technology attitude") was disagreed with by 24% of the sample and agreed with by 65%. Correlations indicated a number of significant relationships between technology attitudes and the other measures (see Table 2).

In general terms, negative attitudes to technology (as expressed on this item) were associated with negative attitudes towards gene technology, with less trust in government bodies and with greater trust in environmental groups. By comparison, age and occupation status showed much lower, and often nonsignificant, correlations with these measures.

Although we cannot claim that the people participating in our study form a representative cross-section of the UK population (since the response rate was low), it is of interest to note differences within some of the social groupings for which we have data. For this purpose we have divided the sample into two age categories, (i) below 50 years of age and (ii) 50 and above, and two occupation groups ((i) occupation groups 1 and 2, and (ii) occupation groups 3, 4, and 5). These latter categories were derived from the OPCS Classification of Occupations.[29] Two (gender) x 2 (occupation) x 2 (age) analyses of variance were carried out on the questionnaire measures. Here, we first report the findings as they pertain to differences between the occupation groups; since occupation data were unavailable for a significant proportion of the sample, we then report gender and age differences based on 2 x 2 analyses in order to permit an increase in the sample size.

Table 2. Correlations of age, occupational status and technology attitude with other variables.

	Age	Occupational status	Technology attitude
Heard/read about	.03	-.17***	.00
Improved quality of life	-.02	-.05	-.29***
Need	-.03	-.01	-.28***
Involves ethical issues	-.08**	-.08	.32***
Attitude (animals)	.02	-.04	-.34***
Attitude (microorganisms)	-.04	-.05	-.33***
Attitude (plants)	-.02	-.08*	-.32***
Concern (animal suffering)	-.02	.06	.16***
Concern (human health)	-.02	.01	.19***
Concern (environmental damage)	-.04	.07	.21***
Benefits	-.11***	-.06	-.31***
Risks	.04	.03	.37**
Trust (Government Ministers)	.01	.05	-.19***
Trust (Greenpeace)	-.11***	.18***	.25***
Trust (Department. of Environment)	-.10***	.13***	-.11***
Trust (Consumers' Association)	-.09**	.04	.01
Trust (MAFF)	-.05	.11**	-.20***
Trust (Friends of the Earth)	-.13***	.19***	.28***
Trust (Department of Health)	-.02	.10**	-.17***
Trust (TV current affairs program)-	-.08**	.15***	.08**

*** = p<.001; ** = p<.01; * = p<.05. n varies for age (1372-1450), technology attitude (1366-1425) and occupational status (858-893).

Occupation group A (comprising subjects belonging to occupation groups 1 and 2) reported perceptions of greater benefits from the technology than did occupation group B (comprising subjects belonging to occupation groups 3, 4, and 5) (see Table 3); however, there was no difference in perceptions of the risks

Table 3. Differences in mean ratings between occupation, age and gender groups (only significant differences are shown; *** = p<.001; ** = p<.01; * = p<.05)

	Occupation group A	Occupation group B	
Involves ethical issues	5.58	5.28	**
Benefits	3.90	3.69	*
Trust (Greenpeace)	3.32	3.71	***
Trust (Department of Environment)	2.79	3.04	**
Trust (MAFF)	2.86	3.08	*
Trust (Friends of the Earth)	3.26	3.70	***
Trust (Department of Health)	3.11	3.29	*
Trust (TV current affairs program)	3.35	3.66	***
	Age group 1 (<50years)	Age group 2 (50years)	
Involves ethical issues	5.52	5.28	*
Benefits	3.78	3.55	**
Trust (Greenpeace)	3.63	3.38	***
Trust (Department of Environment)	3.02	2.86	*
Trust (Consumers' Assoc.)	3.99	3.85	**
Trust (Friends of the Earth)	3.58	3.35	***
Trust (TV current affairs program)	3.61	3.47	*
	Female	Male	
Improved quality of life	3.70	4.31	***
Need	2.29	2.55	***
Involves ethical issues	5.52	5.31	*
Attitude (animals)	2.61	3.22	***
Attitude (microorganisms)	3.24	3.78	***
Attitude (plants)	3.73	4.34	***
Benefits	3.43	3.87	***
Risks	4.63	4.38	**
Trust (Department of Environment)	3.11	2.81	***
Trust (Friends of the Earth)	3.55	3.41	*
Trust (Department of Health)	3.32	3.17	*
Attitude (technology)	5.15	4.72	***
Concern (animal suffering)	5.94	5.70	**
Concern (human health)	5.92	5.71	*
Concern (environment)	5.75.	5.51	**

Occupation group A incorporates (1) professional and (2) intermediate groups. Occupation group B incorporates (3) skilled, (4) partly skilled and (5) unskilled groups.

Table 4. A comparison of terminology effects on mean ratings

Questions:	Gene technology	Genetic engineering	Genetic manipulation	Genetic modification
Improvements to quality of life	4.06	4.05	3.84	4.06
Need	2.47	2.47	2.35	2.31
Attitude (animal applications)	3.01	2.98	2.75	2.80
Attitude (micro-organism applications)	3.57	3.60	3.33	3.46
Attitude (plant applications)	4.06	4.12	3.93	4.08
Benefits*	3.69	3.87^{a}	3.45^{a}	3.60
Risks	4.49	4.43	4.71	4.41
Attitude (technology)	4.85	4.81	5.20	5.00
Heard or read about***	1.99^{ab}	2.30^{a}	2.29^{b}	2.16

Ratings are taken from one-way ANOVAs;*** p<.0001;* p < .05 (n = 1427-1462). Within each row, mean scores with the same superscript are significantly different from each other

Table 5. Hierarchical regressions of general attitude measure on predictor variables (df = 1374; *** = p < .0001).

Perceived risks	-.56***	- .20***
Perceived benefits	.71***	.27***
Perceived need	.72***	.29***
Perceive involvement of ethical issues	-.32***	- .08***
Perceived improvements in quality of life	.68***	.20***
R^2 = .68		

involved. Occupation group A also agreed more strongly that ethical issues were involved and reported less likelihood of believing information provided by a number of potential information sources.

Compared to men, women indicated less need for the technology, gave lower ratings about improvements to the quality of life, reported lower benefits and greater risks, expressed less favorable attitudes towards all three applications, expressed greater concern, and agreed more strongly that ethical issues were involved.

Compared to younger subjects, older subjects reported lower benefits and agreed more strongly that ethical issues were involved (see Table 3). (There were also gender-age category interaction effects on the questions dealing with improvements to the quality of life in the UK, attitudes towards applications involving animals and plants and likelihood of believing information presented by Gov-

ernment Ministers, the Ministry of Agriculture, Fisheries and Food, and the Department of Health. We do not report these data in detail here, but the pattern of the findings was such that some "attitude" differences between male and female respondents were accentuated in the older age group while differences in the perceived likelihood of believing various information sources were attenuated in the older group).

The "framing" manipulation, in which the technology was presented using different terminology, led to relatively few differences. There was a main effect on the question dealing with perceived benefits ($F(3, 1428) = 3.45$, $p<.02$) with the benefits of genetic manipulation (mean = 3.45) being seen as significantly less than those of genetic engineering (mean = 3.87) (the multiple comparison tests used here are *Scheffé* tests). People also reported having heard or read less about gene technology (mean = 1.99) than about genetic manipulation (mean = 2.29) or genetic engineering (mean = 2.30) ($F(3, 1458) = 12.10$, $p<.0001$). Although these were the only significant differences found for the framing manipulation, the findings did fall into a pattern such that "genetic manipulation" (i) received the lowest score on the question concerning improvements to the quality of life in the UK, (ii) received the lowest score on all three attitude questions, and (iii) received the highest score on the question concerning risks (see Table 4).

Ratings on the three attitude items ($\alpha = .89$) were summed to form a "general attitude" measure. A multiple regression analysis was then carried out with this measure regressed on perceived benefits, perceived risks, perceived need, perception of related ethical issues, and perceptions about likely improvements to the quality of life in the UK. Each of the predictors contributed an independent influence on the prediction of attitudes (see Table 5). Risks and benefits had been expected to exert an influence, as had perceived need and ethics (given their prominence in the debate about biotechnology issues); the independent influence of perceived improvements in the quality of life in the UK was, however, somewhat surprising (given that risks and benefits had already been assessed). When age and occupation group were included as additional predictor variables, they contributed less than a 1% increase in variance explained (they also contributed less than 1% when included as the only predictor variables in a separate analysis).

Summary and discussion

The general picture of public perceptions of gene technology that emerges is one of more people reporting low benefits than high benefits, more people reporting high risks than low risks, more people reporting low need (in the UK) than high need, and a large number agreeing that ethical issues are involved. Perceived risks, perceived benefits, perceived need for the technology in the UK, perceived involvement of ethical issues, and perceptions of improvements that the technology would bring to the quality of life in the UK all contributed towards the prediction of attitudes towards the use of organisms modified by the technology. There was also some evidence of occupation, gender, and age differences in our sample.

"Framing" the technology in different terms led to few significant differences although there was some slight indication that the term "genetic manipulation" elicited less favorable responses towards the technology than did other terms (see Table 4). It is unclear whether a viable extrapolation can be made from such differences to public responses in "real-life" settings, however. In the reported study, we presented a fairly controlled situation in which different terminologies were accompanied by the same descriptive information about the technology: such a situation is unlikely to have a real-life analog. Usually, people would be exposed to different information than that presented here, or to no explicit information at all. We mention this only to serve a word of caution about the kinds of inferences that may validly be drawn from experimental findings concerning possible framing effects.

It is also necessary to address the issue of response bias since our response rate was low (25.7%). There is some indication that occupation groups 1 and 2 were overrepresented and that occupation groups 4 and 5 were under-represented in our sample. More men (54%) and fewer women (46%) participated in the study than would have been expected on the basis of UK population statistics (*cf.*[30]). It is therefore necessary to consider the total sample scores on questionnaire items with these asymmetries in mind, although the group differences presented in Table 3 give some indication of possible effects of any bias in the sample. Of course, the sample may well have been over-representative of people interested in the issues addressed in the questionnaire but we have no population statistics against which such speculation might be assessed.

A major issue raised by research such as that reported in this paper is that of the low level of public knowledge about the subject matter in question. This questionnaire, like others before it, necessitated a short description of the subject matter and the results of the research need to be considered with this in mind. Undoubtedly, people's responses are heavily colored by the way in which information is presented to them. However, we would suggest that such research is useful if the results are interpreted with potential pitfalls of the methodology in mind and in full cognizance of the growing literature on questionnaire context effects.[31, 32, 33] The findings here need to be assessed critically and in conjunction with other research in this area that has addressed similar issues.[22,23,26,34] We are, moreover, currently examining key issues in more detailed research.

Findings from questionnaire assessment of public attitudes need to be interpreted carefully and in full

awareness of the methodological details of the research. However, it is not the questionnaire method that is the prime cause of difficulties in assessing people's attitudes; it is rather the fact that attitudes are variable and influenced by context and function: they are not stable entities and they may be formed with minimal information. Furthermore, it is possible that attitudes towards gene technology in food production may be especially susceptible to context effects where there is some ambivalence towards the application of the technology in the first place.[32]

While the basic pitfalls of questionnaire research have long been recognized, it does at least afford the public some "voice".[35] We have to be careful however that such "voice" is not unduly prejudiced by the ways in which questions are asked. The nature of questionnaire items and of the information provided in questionnaires on such a sensitive issue becomes itself a matter of considerable ethical importance, not simply one of pragmatic, methodological concern. If aspects of public policy are influenced by the findings of such research, then this issue becomes even more acute. In the short description of gene technology in the questionnaire used in the study reported here, we have made explicit reference to some benefits but not to any risks: the results should be interpreted with this feature of the research design borne in mind.

For the public, the choices regarding gene technology are likely to be less than clear. They are asked to supply judgments on issues where it is widely acknowledged that there is a great deal yet to be learned. The risks of gene technology are, so it is said, largely unknown36, 37 and research would appear to suggest that public perceptions reflect this notion.[38] Johnson and Thompson[39] predict that as information about biotechnology increases, so too will there be a decrease in both "fear" and "undue optimism" on either side of the biotechnology debate. However, in situations characterized by a lack of information, it may be the case that people will turn more than they would usually to trusted sources for some guidance.[16]

Here, there exists something of a dilemma for proponents of the technology. On the one hand, they are aware of an increasing public lack of confidence in government and industry to present information in an impartial way: the need to be seen providing balanced information is therefore crucial. On the other hand, proponents of the technology are clearly concerned that information is presented in such a way that the technology is presented in a generally positive light, although public perceptions of self-interest on the part of proponents are likely to mitigate their communicative impact (Thompson, for example, warns that the scientific community needs to be seen to be putting forward views on biotechnology that "are not so blatantly self-serving").[40] The dilemma can be observed in some proposals from Harlander[41] who suggests that in order to achieve public acceptance (of biotechnology), scientists ought to "Be open and honest with the public" since "The public needs to be given both sides of the story and be allowed to make choices". However, she also suggests that scientists ought to "Focus on those areas of biotechnology that provide substantial benefits to society".

Gene technology has been described as a "mega" technology;[10] it arouses controversy because of disparate ideas concerning its benefits, costs/risks, and the ethical issues that surround its development and application. The research reported in this paper gives a "snapshot" of attitudes towards applications in food production in the UK at the end of 1991/early 1992. How public attitudes towards the technology will change over the course of time is likely to be influenced to a large extent by the values that people hold and what they believe the consequences of the application of the technology to be. This in turn is likely to be affected not only by "information provision" but by how the debate about the technology develops and how "information" is interpreted. Perhaps above all, the growing recognition in the risk communication area is that trust is likely to be a crucial issue;[27, 28] it is this facet of the relationship between the public and the promoters/critics of the technology that may hold the key to future developments, in so far as public attitudes remain an influential factor.

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