Article

GENETICALLY MODIFIED FOOD IN THE EYES OF THE PUBLIC AND EXPERTS

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Abstract

Risk perceptions and attitudes to genetically modified food (GMF) were investigated in a survey study of the public (N = 469) and experts (N = 49). The response rate was 47% for the public. For the experts, response rate was 60%. GMF technology was rated as the worst of 18 technologies by members of the public and highly replaceable. Experts had a very different view but also saw GMF as replaceable. Models of risk perceptions and attitudes with regard to policy and consumer intentions were fitted to data. It was found that a very large share of the variance, about 70%, was accounted for in the latter cases, while risk perception was somewhat harder to account for (about 50% was explained). Traditional explanatory dimensions such as Dread and Novelty were weak explanatory factors as compared to new approaches, which included Interfering with Nature, moral value of technology and epistemic trust. Experts were throughout much more positive to GMF than were members of the public. However, their attitudes and risk perceptions still showed dynamic properties similar to those found in the data from the public. The differences between experts and the public could be well explained in terms of the models tested. In comparisons with recent Eurobarometer studies of attitudes toward GMF, risk emerged in the present study as a more important factor in attitudes, equally important as benefits. The models formulated for the present data were about twice as powerful as those in published analyses of Eurobarometer data.

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Introduction

Gene technology has many and varied applications. People's reactions to it have been found to vary as well, depending on a number of factors, including area of application.[1] The reactions and attitudes of the public to gene technology constitute important areas of research due to their relation to acceptance or rejection of policies. Genetically modified food (GMF) is an important case in point – a technology that is not well received by the European public.

Siegrist and Bühlmann (1999) performed a multidimensional scaling of various gene technology applications and found two factors: type of application (food *vs* medicine) and plants *vs* animals. The first factor appeared to be the most important one for technology acceptance, which was low for food and high for medicine [cp. Zechendorf (Zechendorf, 1994)]. Positive attitudes to medical applications of gene technology are common (Berth *et al.*, 2002). Frewer *et al.* (1996, 1997) found low acceptance of GMF, perceived benefits counteracting this tendency, as well as perceived "naturalness". Frewer *et al.* stressed the variation of responses to different technologies. Fischhoff and Fischhoff (2001) also emphasized the varying responses to different types of biotechnology .

Other variables correlating with perceived risk and acceptance of gene technology were worldviews (Siegrist, 1999), gender and environmental attitudes (Siegrist, 1998), and moral concerns (Tanaka, 2004). Trust has often been mentioned as an important variable (Siegrist, 2000; Olofsson *et al.*, 2006). Eiser *et al.* (2002) found evidence against the notion of trust and/or risk being factors causally related to technology acceptance. They suggested that trust, risk and acceptance all reflected similar notions.

Siegrist's work on trust is interesting but his conclusions may be somewhat misleading. First, some of the work shows modest relationships between trust and risk perception, some 15–20% explained variance, which is quite in line with most other work on this issue (Sjöberg, 2008). Second, in some applications the amount of explained variance was much higher, but in those cases perceived risk and trust were both measured by attitude scale items that were formally similar, having the same response scale (agree–disagree, a Likert scale). In a special methodological study, I obtained the same result (Sjöberg, 2002b). When both perceived risk and trust were measured by rating scales, the usual methodology, the relationship was found to be modest, about 15% explained variance. When both dimensions were measured by means of attitude scale items using the same response format, the explained variance was drastically increased to 30%.

Skeptical attitudes to some applications of gene technology seem to be more common in Europe (Siegrist, 2003) than in the USA (Gaskell *et al.*, 1999; Madsen *et al.*, 2003). The US public is still relatively little concerned about gene technology (Loureiro and Hine, 2004). At the same time, increased negative media coverage, starting in the end of the 1990s seemed to be bringing out worry and concern among some sectors of the American public (Shanahan *et al.*, 2001). Madsen *et al.* point out that European consumers see little or no benefit to them from the use of GMF, while American producers may profit greatly. A large minority of farmers in New Zealand were found to be positively oriented towards the use of GM technology and intense production methods. Economic factors may benefit such farmers. Media reports about new hazards have also played an important role (Frewer *et al.*, 2002; Olofsson, 2002), possibly because they give rise to fear (Laros and Steenkamp, 2004).

Eurobarometer 46.1 reported that people had little knowledge about and were negative towards biotechnology (data collected in 1996) (Biotechnology and the European Public Concerted Action Group, 1997), and subsequent work (Eurobarometer 52.1) has verified these findings (Gaskell *et al.*, 2003). Moral issues, and "unnatural" risk, emerged as important aspects, and attitudes appeared to be declining (Bauer *et al.*, 2000).

The survey questions used in the Eurobarometer program may be partly hard to understand for the lay public who was expected to understand the meaning of such scientific terms as "stem cell" or "cloning." In addition, relatively few questions were asked and in-depth understanding of attitudes was consequently hard to achieve. Only a relatively modest level of explained variance of gene technology attitudes was reached.

Models

Pardo *et al.* (2002) suggested a broad approach to gene technology attitudes (perceived risks and benefits) but did not devise a model of attitudes. They did construct models of perceived benefits and risks. The risk models failed to explain perceived risk, not even gender appeared to be an important explanatory factor. Only 5% of the perceived risk variance was accounted for. The benefit model explained 33% of the variance, mainly based on level of education, knowledge, and general and specific technology optimism. Savadori *et al.* (2004) reported a higher level of explained variance of gene technology risks, based on risk dimensions of the type used in the Psychometric Model (Fischhoff *et al.*, 1978). Their models achieved, on the average, about 40% explained variance. However, the sample of non-experts was a small convenience sample of 58 persons (not described in any detail) and a regression model using 15 explanatory variables would seem to be questionable with such a small sample size.

Gaskell *et al.* (2004) reported models of attitude to GMF, based on Eurobarometer data, which reached a maximum of 27% explained variance. Their most powerful model included an interaction term reflecting a stronger effect of risk for respondents who saw a high degree of benefit of GMF. The main message of their article is that risk is not the major factor in GMF attitude, but that benefit is (cp. Chen and Li, 2007). However, both risk and benefit contributed to the explanation of attitude in their data, even if benefit was more important than risk.

The Eurobarometer work carried out in Sweden has been claimed to show that risk has no importance for the attitude to GMF (Öhman, 2002; Fjaestad *et al.*, 2003). Possibly, this is a question of cultural differences, but the lack of an effect of risk could also be due to the methodology used. Gaskell *et al.* (2004) give a recent analysis of the Eurobarometer data, and risk does make an important contribution to the modelling of attitudes in their working. It may be pointed out, in addition, that much previous work in other countries has shown that risk is important for GMF attitudes; see for example Rosati and Saba (2000). Risk is not the whole story, but it is an important part of it. I further investigate the issue of risks *vs* benefits in the present study.

It should also be noted that the Eurobarometer work, where it was claimed that risk has no or a very small importance, partly used self-ratings of the importance of various factors. Are people able and willing to give valid ratings of the weights they have given to various attributes in their assessments of technologies? This is a highly controversial issue, and psychologists have argued for decades, on good grounds, that people often cannot give valid judgments of what influenced their behavior (Nisbett and Wilson, 1977). The issue obviously needs further research. Barlas (2003) found clear evidence that rated importance did not give a valid picture of real reasons for choices. People used importance ratings to justify their choices in terms of socially desirable dimensions. It is quite possible that a dimension such as "morality" fits in well with the need to manage impressions, while "riskiness" may have connotations of lack of rationality and a tendency to be "subjective" and "emotional," hence a less popular alternative as a reason for choice.

In summary, previous attempts at modelling factors in risk perceptions and attitudes toward GMF have resulted in models of only moderate power, as measured by the amount of variance accounted for. The main reason for this fact is probably that several factors known to be of potential importance, based on previous work on other technologies, were not measured and applied in the models. I mention especially epistemic trust (Sjöberg, 2001), morality (Sjöberg and Winroth, 1986) and Interference with Nature (Sjöberg, 2000), a factor that borders on religious beliefs and New Age convictions (Sjöberg and af Wåhlberg, 2002). It is also possible that affective and cognitive risk perceptions call for different explanatory factors (Townsend, 2006; Leikas *et al.*, 2007).

Purpose

The purpose of the present study was to investigate attitudes towards GMF in depth, with a special focus on moral issues and risk attitudes. This work relies on our previous risk perception research, and it was designed to test and further develop the models of risk perception and attitudes, which have emerged in recent research.

It was important to study the opinions and beliefs of non-expert members of the public. It was also considered to be of interest to include a group of gene technology experts (Verbeke *et al.*, 2007). The common view of experts as objective and qualitatively different from non-experts has been found to be unjustified (Rowe and Wright, 2001; Sjöberg, 2002a). A study comparing experts and the public is called for, because a gap between the two groups constitutes the basis for serious policy conflicts. It was the purpose of the present study to investigate the possible gap between experts and non-experts in order to inform policy on this matter and to form the basis for further work on risk communication and policy.

There have been many comparisons between experts and the public, in several different fields of technology (Sjöberg, 1999); see for example studies of nuclear waste experts by Flynn *et al.* (1993) and Sjöberg and Drottz-Sjöberg (in press). The large gap between experts and that of public has been well documented in this area (Kugo *et al.*, 2005). Kraus *et al.* (1992) studied experts of toxicology, to name another example. The typical finding in such work is that experts judge risks as much lower than members of the public do. The difference is typically restricted to their area of expertise; they judge other risks in much the same way as members of the public. Furthermore, it seems that the difference is still more restricted than that: experts judged risks as small within their area of professional responsibility, not in their area of scientific expertise in general (Sjöberg and Drottz-Sjöberg, in press). Risk communication strategies must be carefully designed to take the gap between experts and the public into account (Beecher *et al.*, 2005).

Summing up, the present study was carried out in order to analyze aspects of risk perceptions and attitudes towards GMF, and to model these data in terms of driving factors at the level of individual respondents. Differences between members of the public and experts were investigated and it was expected that experts would be much more positive and see fewer risks of gene technology than members of the public. The explanatory constructs measured were based on our previous work, which has been oriented towards finding powerful factors behind risk perceptions. It was expected that similar factors would work well also in the case of GMF.

The following hypotheses were formulated

1. Perceived risk and attitudes towards GMF can be well accounted for by models including epistemic trust, morality and Interfering with Nature.
2. Experts differ strongly in quantitative terms from the public when it comes to perceived risk, but not qualitatively, in terms of how their risk perception can be explained.
3. Differences between experts and the public can be explained by models similar to those explaining risk perception and attitudes within the group of members of the public.

Method

Procedure

An extensive questionnaire,[2] 27 pages in A5 format, was mailed to 1,000 persons living in Sweden in September 2003. The names and addresses had been selected at random from the national population file administered by SPAR-DAFA. Incentives in the form of lottery tickets were promised to respondents. Two reminders were sent. The same questionnaire, minus a few sections and with some added background questions, was sent to 109 persons tentatively identified[3] as experts in the field of gene technology, in March 2004. Two reminders were sent, but no incentives were promised to the experts.

Questionnaire

The design of the questionnaire sent to the public was as follows:

- Eleven initial questions dealing with attitude to gene technology in general
- Ten sections dealing with different specific applications of gene technology:
    - Modification of animal genes in pharmaceutical industry
    - Modification of plant genes in pharmaceutical industry
    - Modification of animal genes in food industry
    - Modification of plant genes in food industry
    - Gene diagnostics in family planning when there are reasons to suspect injury
    - Gene diagnostics of a foetus to inform an abortion decision when there are reasons to suspect injury
    - Gene diagnostics of a foetus in connection with "test tube" reproduction, to inform a decision about inserting a foetus in the uterus
    - Modification of human body cells in order to counteract illness
    - Modification of human sex cells in order to counteract illness
    - The use of gene technology by the police in their work to find the perpetrator of a certain crime.

Each of these 10 sections asked for five ratings of the technology in question, on five-category scales. These ratings asked whether the technology was

  - Good, on the whole
  - Morally correct
  - Useful
  - Risky
  - Associated with acceptable risk

- A section calling for rating 46 hazards in terms of personal risk, on category scales from 0 (no risk at all) to 7 (a very large risk)
- The same 46 hazards rated in terms of risk to people in general
- Five sections calling for the assessment of 18 technologies in terms of:

  - Should they be used more or less or kept at the present level
  - Risk
  - Moral status (acceptable – unacceptable)
  - Utility
  - If they could be replaced by other technology or were irreplaceable

- A section calling for judging 19 aspects of GMF risks
- Fifty-five attitude statements concerning GMF
- Five items measuring Neophobia[4]
- Nine statements measuring New Age beliefs
- Six fact statements, to be judged as true or false, concerning genetics and gene technology
- Eight ratings of trust in various organizations or groups
- Thirteen statements measuring general suspiciousness
- Background questions, including interest in technology, GMF and illness experience, assessment of the environmental situation in the world and the role of technology in that connection, a question tapping attitudes to the precautionary principle, place of residence, vegetarianism, political preference, knowledge of Swedish, if the respondent was the person who had received the questionnaire, if he or she had answered individually, as instructed, and interest in taking part in further studies
- Ten dimensions for rating the quality of the questionnaire and the study
- Time needed to complete the questionnaire
- Space was finally provided for written comments

The questionnaire sent to the experts was quite similar to the one sent to the public, with three exceptions:

- The New Age questions were deleted
- The questions measuring general suspiciousness were deleted
- The questions about elementary facts were deleted

- A few background questions about academic credentials and degree of expertise were added, and some questions about willingness to take part in further studies, and the like, were deleted

The total number of items of the questionnaire was 383. The median time to fill out the questionnaire, by the public sample, was still not excessive, 40 minutes. The time reported by the experts (median) was 35 minutes. Only a subset of the results is reported in the present article. For a more complete account, see a technical report (Sjöberg, 2004b).

There were 10 questions about the quality of the questionnaire. The evaluations of the study and the questionnaire were positive. In particular, few aspects seem to have been missed, according to the views of the respondents, and the study was clearly seen as meaningful. The experts made similar assessments of the questionnaire, only somewhat less positive. It can be noted, in particular, that the experts were more prone to find some questions and formulations to be unclear. This is a common finding in a group of experts and is probably partly caused by their having much more, and much more detailed, knowledge of the field. They want nuances, which the public would not have appreciated. Exactly the same questions to experts and the public were a necessity, however, in order for meaningful comparisons to be made.

Respondents

Public

Filled out questionnaires were returned by 469 persons, yielding a response rate of 47.8%. (Nineteen addresses were unusable). There was also about 2% internal data loss since not all respondents answered to all questions.

There was an even gender distribution among the respondents in the public sample: 49.3% male and 50.7% female. The age distribution was quite similar to the national statistics, with a few percentage units too few in the youngest age groups. There was a bias with regard to education; 8 percentage units too many had college or graduate education. With regard to place of residence, there were a few percentage units too few respondents from the four largest cities and from purely rural areas. The proportion of vegetarians was 2%, as compared to 5% in the population. The political preferences of the respondents were in good agreement with polls conducted during the time period.

About 14% of the public sample answered a question about their knowledge of Swedish with some hesitation about how well they knew the language; this figure resembles the number of immigrants in the country, which was at that level. Only a few percent indicated that they were not the person the survey had been addressed to or that they had filled out the questionnaire after discussions with others.

A check was made on the importance of level of education, since this was the only salient source of possible bias. Educational level was scored in five categories, and correlated with attitude to gene technology (good–bad on a seven-step scale, see below), risk of gene technology (also a seven-step scale) and moral acceptability of gene technology (another seven-step scale). The resulting correlations were quite small: 0.20, 0.08 and 0.14, indicating that people with a higher level of education tended to be only a little more positive to gene technology than others, and to judge the risk as slightly lower. The effects were quite weak, so the education bias factor can probably be ignored. If any effect can be discerned it is that, the present sample gave a somewhat too positive picture of the general population's views regarding gene technology.

Experts

Sixty-five of the 109 experts answered, so the response rate in that group was higher than in the public: 59.6%. Of the 65 respondents, 16 were deleted because they checked, in a question about their degree of expertise, that they were not experts of gene technology. Hence, all data analysis of the expert group was based on 49 respondents.

Experts were predominantly male: 69%. They were also older than the public sample, the most common category being 55–64 years, and none younger than 35. Eighty-eight percent had a Ph.D. or its equivalent.[5] The year they got their Ph.D. varied between 1961 and 2000. Their faculty associations were dominated by Natural Science, Medicine and Veterinary Medicine. These categories comprised 87% of the respondents; the few remaining reported either Social Science or Humanities as their faculty association. Sixty-five percent had published 21 or more scientific articles; only two had no such publications. Twenty-nine percent reported formal competence as a "docent" (associate professor) and 46% as full professor.

Their self-assessed degree of expertise in some area of gene technology was rather or very large in 72% of the cases and their self-assessed degree of knowledge of the current scientific development of gene technology was reported as rather or very good by 96%.

Results

GMF risk perception

Both personal and general risks of GMF were rated in a context of 46 hazards. The public rated the personal GMF risk as no. 12 ($M = 3.34$). Experts rated the personal GMF risk as no. 45 ($M = 1.15$). The public rated the general GMF risk as no. 21 ($M = 3.46$), while the experts rated it as smallest of all 46 risks ($M = 1.17$). Distributions of personal and general risk ratings of GMF are given in Figure 1, which refers to the data from the public sample.

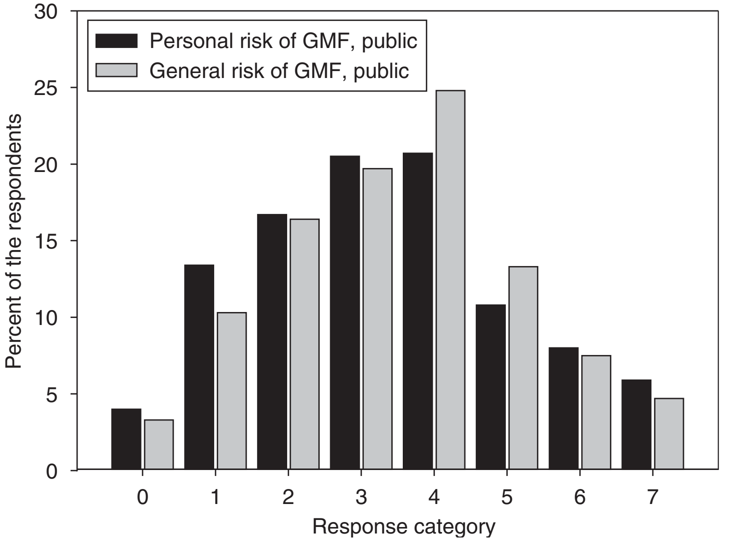

Figure 1 Ratings of personal and general risk, data from the public.

The two distributions are quite similar, suggesting that this is a risk beyond one's control and hard to protect oneself from, in agreement of results reported by Hunt and Frewer (2001). In connection with uncertainty of risk assessments, the perceived lack of control could be a cause of alarm and lead to seeing the risk as severe (Miles and Frewer, 2003).

The "non-finding" above should be stressed – there was no clear difference between personal and general risk. Large positive differences are often observed between general and personal risk. The same was true in the present study, for a large number of hazards (see Figure 2). These hazards were of the same type as in many previous studies, not related to gene technology.

The response distributions of experts and the public are compared in Figure 3 for general risk. Results for personal risk were very similar to those in Figure 3. The two groups were strikingly different in both cases, and the differences were highly significant according to chi-square tests.

The GMF risks were rated on 19 risk dimensions, on scales from 1 to 7. Some of the risk dimensions were based on the Psychometric Model (Fischhoff *et al.*, 1978) but several were added. The results were as shown in Table 1. It is clear that GMF technology was rated as very risky in most respects. The risk was considered new, Interfering with Nature, unfair and immoral. Interestingly, the most salient risk aspect was that there could be negative effects unknown today. This is an aspect of the limitations of scientific knowledge (Sjöberg, 2001).

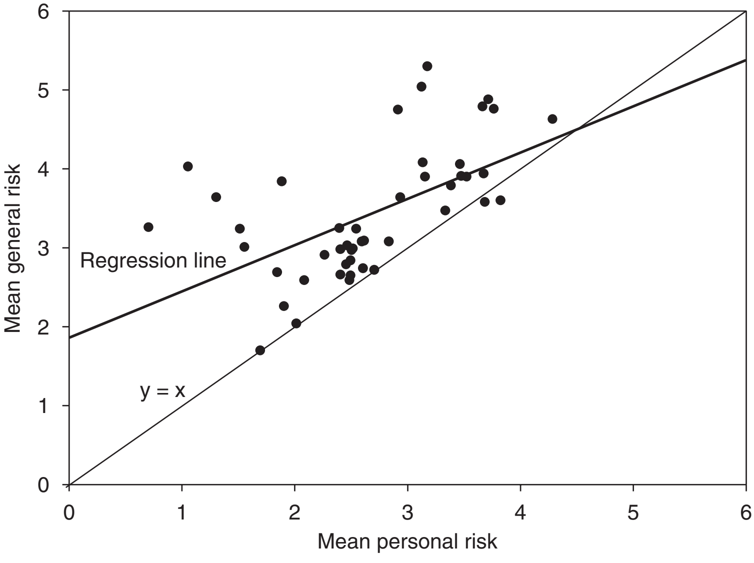

Figure 2 Plot of mean general *vs* mean personal risk of 42 hazards, data from the public.

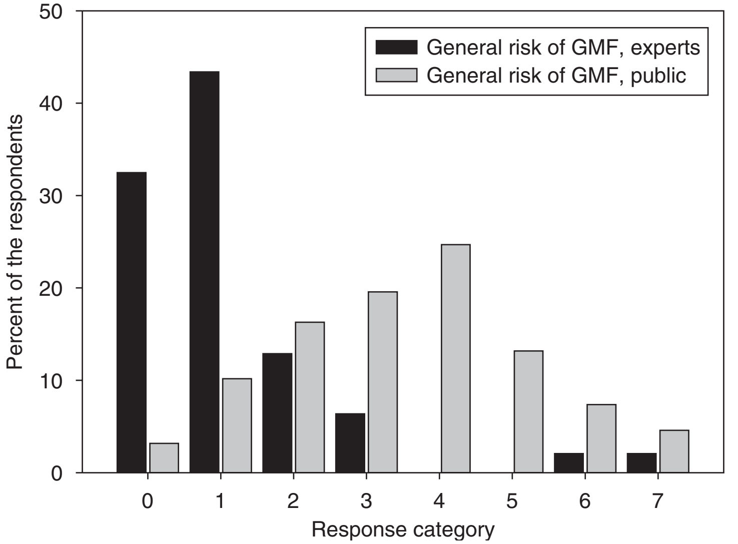

Figure 3 Ratings of general risk of GMF, data from experts and the public.

Table 1 shows dramatically large differences between experts and the public. The members of the public saw much larger risks in GMF than the experts, and they did so in all the studied aspects.

Table 1 Ratings of the 19 psychometric factors, means and standard deviations, and *t*-tests of differences between experts and the public

	Public		*Experts*		*Standardized difference*[a], *and outcome of t-test*
	Mean	*Std. deviation*	*Mean*	*Std. deviation*	
New and unknown	5.15	1.51	4.05	1.79	0.70***
Order of nature is disturbed	5.35	1.50	2.49	1.24	1.69***
Hard to understand	5.23	1.37	4.58	1.65	0.45**
Little known even to scientists	4.81	1.54	3.09	1.51	1.06***
Involuntary exposure	5.19	1.55	4.13	1.42	0.67***
Hard to avoid	5.18	1.46	3.64	1.53	1.01***
Immediate negative consequences	3.97	1.52	1.89	1.14	1.30***
Negative effects hard to reverse	4.62	1.54	2.47	1.17	1.32***
Strongly feared, dreaded	4.60	1.53	3.65	1.60	0.61***
"Unnatural" activity	5.22	1.62	2.60	1.57	1.47***
Will hurt children and future generations	4.61	1.68	2.02	1.08	1.44***
Unfair and immoral	4.77	1.75	2.31	1.30	1.33***
Creates great worry	5.18	1.25	4.33	1.17	0.67***
Human arrogance and hubris	4.90	1.67	2.07	1.19	1.56***
Disaster due to interference with nature	4.98	1.65	2.20	1.17	1.55***
Increasing effects over time	5.12	1.51	2.67	1.35	1.49***
Will lead to cancer	3.94	1.57	1.93	0.94	1.23***
An activity counter to nature	5.16	1.70	2.13	1.39	1.61***
Can have negative effects unknown today	5.71	1.37	3.29	1.42	1.57***

***$P<0.0005$, **$P<0.01$.
[a]Standardized to give all the variables a mean of 0 and a standard deviation of 1. This is done in order to make it possible to easily get a measure of the size of the differences, which is comparable across scales and studies. A difference about 0.6 on a standardized scale is considered "very large" (Cohen, 1988). Note that the present differences between the public and experts in most cases are much larger than that.

It is common to find very large differences between experts and the public when it comes to the level of perceived risk (Krystallis *et al.*, 2007), especially in domains where the experts have professional responsibility (Sjöberg, 1999). The present results are well in line with such findings.

In order to test models of GMF risk perception, the 19 risk aspects were used to construct five indices. The traditional Psychometric Model reduced the number of crucial risk factors to two overarching factors: Dread and new risk. The present design made it possible to measure three more factors: Interfering with Nature, immoral risk, and severity of consequences, yielding an Extended Psychometric Model. Thus, five factors were estimated in the form of indices; see Table 2 for their properties. Note that Dread was measured by emotion items only. Another explanatory variable was added: risk sensitivity. This is a variable measuring a general tendency to rate the risks as large.[6] It was estimated separately for personal and general risks as the average of all risk ratings, except the GMF risk. The alpha values of the two resulting indices are given in Table 2.

Table 2 Properties of five factors of the Extended Psychometric Model, public sample

Factor	*Coefficient alpha*	*Number of items*
Dread	0.76	2
New risk	0.84	4
Interfering with nature	0.91	4
Immoral risk	0.91	7
Severity of consequences	0.81	3
Risk sensitivity, personal risk	0.95	45
Risk sensitivity, general risk	0.96	45

Table 3 Models of GMF risk perception, standardized regression weights, public sample

Explanatory variable	*Personal risk*	*General risk*
Gender	−0.029	−0.064
Age	−0.040	−0.022
Level of education	−0.031	0.033
Risk sensitivity	0.441***	0.395***
Dread	−0.014	−0.011
New risk	−0.032	−0.091
Interfering with nature	0.108	0.164*
Immoral risk	0.328***	0.383***
Severity of consequences	0.127	0.066
Explained variance	0.510	0.497

*$P < 0.05$, ***$P < 0.001$.

The five risk factors, risk sensitivity, and demographic variables were used as explanatory variables in models of the perceived risk. The results are given in Table 3.

A high level of explained variance was achieved. The most important variable was risk sensitivity. It is interesting that the traditional factors of the Psychometric Model had no explanatory power when the new factors were added.[7] In particular, the factor immoral risk was an important explanatory variable.

Early in the history of risk perception and Psychometric Model research, it was asserted that experts make risk judgments on the basis of objective facts, while members of the public are affected by the various subjective factors of the model (Fischhoff *et al.*, 1982; Slovic *et al.*, 1985). This assertion has been challenged (Rowe and Wright, 2001; Sjöberg, 2002a). Table 4 shows correlations between personal and general risk judgments of GMF, and the factors of the Extended Psychometric Model, for both experts and members of the public.

The table shows that for personal risk, the correlations were similar for experts and the public. For general risk, data from experts gave lower correlations, especially for the two traditional psychometric factors of new risk and Dread.

It is interesting to note that the low correlations between perceived risk and psychometric factors are found for (a) general risk, and (b) the two traditional basic psychometric dimensions. When personal risk and/or a broader sample

Table 4 Correlations between risk perception ratings and the psychometric factors for the public and experts

Explanatory variable	*Personal risk*		*General risk*	
	Public	*Experts*	*Public*	*Experts*
Dread	0.40	0.43	0.19	0.01
New risk	0.44	0.51	0.31	−0.06
Interfering with nature	0.47	0.53	0.47	0.08
Immoral risk	0.51	0.56	0.61	0.38
Severity of consequences	0.50	0.54	0.47	0.08

of dimensions are studied, the picture is different. Experts no longer appeared to be unaffected by "subjective" factors.

Attitudes toward GMF

Attitude data were available in two formats: comparisons with several other technologies and ratings of GMF attitudes *per se*.

Attitudes toward GMF in a context of technologies

In this section, results are presented from ratings of 18 technologies on five dimensions. The results for GMF, as judged by members of the public and by experts, are given in Table 5.

These results show very clearly that for members of the public, genetic modification of food is a technology, which is rated in a very negative manner with low utility, high risk and as morally little acceptable. The experts had a more complex view. They thought that GMF should be used more, yet it was not judged as irreplaceable. They found its risk to be low, and that it was morally acceptable, yet it was relatively speaking low in utility. However, the latter impression may be somewhat misleading since they rated *all* technologies as very useful. It is possible that their assessments were partly because GMF is still a new technology and has yet to be put to large-scale use in Sweden.

GMF attitudes per se

The present section reports the results on the attitude questions regarding GMF, data from the public sample. Indices of various factors were mainly based on the set of attitude items. There were three dimensions used as dependent variables in the analyses:

- Overall attitude towards GMF
- GMF policy acceptance
- Consumer intention with regard to GMF

To measure attitudes towards GMF, the ratings of gene technology used for food production, plants and animals were combined (10 items). A few items

Table 5 Mean ratings of GMF in five dimensions, by members of the public and by experts

Variable	*Public*		*Experts*		*Standardized difference between experts and the public*
	Mean	*Rank in a set of 18 technologies*	*Mean*	*Rank in a set of 18 technologies*	
Use less, range 1–7	5.46	2	2.96	15	1.59***
Risk, range 0–8	5.65	3	2.68	17	1.66***
Moral unacceptability, range 1–5	3.71	1	1.98	14	1.48***
Utility, range 0–8	3.28	18	5.30	16	–1.07***
Substitutability, range 0–8	5.57	1	5.25	1	0.17 ns

***$P<0.0005$.

from other sections in the questionnaire were also added. Items measuring consumer intention expressed a will to buy and consume GMF, while policy items were about voting or not voting for a GMF friendly political party, or other aspects of GMF policy.

The explanatory variables were as follows

- The five factors of the Extended Psychometric Model (see the section on risk perception)
- Risks of GMF
- Benefits of GMF
- Trust in GMF science (epistemic trust)
- Social trust in GMF experts and regulators
- Neophobia
- New Age beliefs
- Suspiciousness.

Four Likert items and three risk ratings of GMF were combined, after standardization, to one risk index. Social trust was measured based on the ratings of trust and items in the list of Likert type attitude items. These items were combined to a measure of social trust.

Psychometric properties of all indices are given in Table 6. See Table 2 for corresponding information about the factors of the Extended Psychometric Model. Results of regression analyses are given in Tables 7 and 8.

The results show that all three models reached a high level of explanatory power. Demographic effects were weak, but there was a trend for women to be more negative. Demographics accounted for less than 5% of the variance of two of the dependent variables, 7% for in the case of attitudes to GMF. The traditional Psychometric Model factors contributed to some extent to policy attitudes, but significantly in only one of six tests. Moral acceptability and

Table 6 Properties of dependent and explanatory variables, public sample

Variable	*Coefficient alpha*	*Number of items*
Overall attitude to GMF	0.90	11
Acceptance of GMF policy	0.78	5
Consumer intention	0.95	9
Risks of GMF	0.86	7
Benefits of GMF	0.86	5
Epistemic trust	0.80	5
Social trust	0.86	12
Neophobia	0.75	3
New age beliefs	0.88	9
Suspiciousness	0.82	13

Table 7 Regression models of attitudes to genetically modified food (GMF), standardized weights, public sample

Explanatory variable	*Attitude to GMF*	*Acceptance of GMF policies*	*Intention to consume GMF*
Gender(Male=1, Female=2)	−0.094**	−0.016	0.004
Age	0.077*	−0.011	0.032
Level of education	−0.035	0.011	0.032
New risk	−0.045	0.107*	−0.072
Dread	0.048	0.075	0.008
Severity of consequences	0.027	0.009	0.065
Morally unacceptable risk	−0.033	−0.212***	−0.114*
Interfering with nature	−0.152*	0.032	−0.190**
Risks of GMF	−0.259***	−0.235***	−0.199***
Benefits of GMF	0.362***	0.273***	0.416***
Epistemic trust	−0.016	0.344***	0.024
Social trust	0.039	0.107**	0.099**
Neophobia	−0.029	−0.110***	0.003
New Age beliefs	0.018	−0.018	0.043
Suspiciousness	0.104*	−0.038	0.132***
Explained variance	0.496	0.681	0.698
Explained variance using only background data (gender, age, level of education)	0.070	0.043	0.044

* $P<0.05$, ** $P<0.01$, *** $P<0.0005$.

Interfering with Nature were the most important factors of the Extended Psychometric Model. They contributed strongly. Benefit was a very important explanatory construct, risk somewhat less but still important. Both epistemic trust and social trust had some impact, epistemic trust more than social trust for

Table 8 Reduced regression model of attitudes to genetically modified food (GMF), standardized weights, public sample

Explanatory variable	*Attitude to GMF*	*Acceptance of GMF policies*	*Intention to consume GMF*
Risks of GMF	−0.311***	−0.482***	−0.342***
Benefits of GMF	0.418***	0.318***	0.582***
Explained variance	0.485	0.548	0.637

***$P < 0.0005$.

policy attitudes. Moral value and trust in science were of particular importance for policy. Benefits, risks, Interfering with Nature and social trust were most important for consumer intention. For overall attitude, benefits, interference with nature and risks were the most important factors. Other variables contributed to some extent. Neophobia made a contribution in one case and suspiciousness in two others. In simple models, which eliminated all explanatory variables except demographics, risks and benefits, risks emerged as about equal in importance to benefits. The reduced models fitted almost as well as the full models in two cases, but somewhat less well in the case of policy acceptance.

Summing up, benefits and risks were the most powerful explanatory variables, followed by moral acceptability, Interfering with Nature, trust (both epistemic and social) and suspiciousness.

Comparison of experts and the public in GMF attitude dimensions

The experts were compared to members of the public with regard to attitudes toward GMF, acceptance of GMF policies and consumer intentions, as well as the explanatory variables used in the regression models applied to data from the public. All differences were highly significant. The standardized means are given in Table 9. The table shows that the mean differences were very large.

The differences between the two groups remained after controlling statistically for gender, age and level of education. Regression models were fitted and the resulting standardized residuals differed 1.08, 1.48 and 1.13 for attitudes, acceptance of policy and consumer intentions, respectively. The group differences remained highly significant. Then the explanatory variables from the regression analysis of the sample from the public were entered, see Table 6 for a list of explanatory variables. New Age attitudes and suspiciousness were deleted from these analyses since no data were available in the group of experts. The result was a drastic reduction in the differences between the two groups. The standardized residuals differed 0.062, 0.370 and 0.140 for attitudes, acceptance of policy and consumer intentions, respectively. The difference was significantly different from 0 only in the case of acceptance of policy ($p = 0.013$), but even in that case it was reduced to about 1/4 of the non-adjusted difference.

Table 9 Means of standardized variables for members of the public and for experts

Explanatory variable	*Public*	*Experts*	*d-value*	*t-value*	*Significance of difference*
Attitude towards GMF	−0.10	1.05	1.15	9.055	***
Acceptance of GMF policies	−0.14	1.45	1.59	12.532	***
Consumer intention	−0.11	1.14	1.25	8.373	***
New risk	0.11	−1.13	1.24	8.731	***
Dread	0.09	−0.93	1.02	9.200	***
Severity of consequences	0.13	−1.43	1.56	12.663	***
Morally unacceptable risk	0.13	−1.37	1.50	13.195	***
Interfering with nature	0.15	−1.61	1.76	15.612	***
Risks of GMF	0.15	−1.49	1.64	13.810	***
Benefits of GMF	−0.10	1.01	1.11	8.415	***
Epistemic trust	−0.11	1.10	1.21	7.021	***
Social trust	−0.06	0.65	0.72	4.401	***
Neophobia	0.02	−0.25	0.28	2.162	not significant

***$P < 0.0005$.

The significant explanatory variables were as follows, in order of importance:

- For attitudes: benefit, risk, gender, age
- For acceptance of policy: epistemic trust, risk, benefit, moral acceptance, new risk, social trust, Neophobia
- For consumer intention: benefit, risk, moral acceptance, Interfering with Nature, social trust

Hence, group differences were most accounted for by benefit and risk. Moral acceptance, epistemic trust, and Interfering with Nature were also important. The traditional explanatory variables of new risk and social trust had some importance, but they did not have a major influence. Dread was of no importance in these models.

Discussion

The hypotheses formulated in the Introduction were as follows:

1. Perceived risk and attitudes toward GMF can be well accounted for by models including epistemic trust, morality, and Interfering with Nature.
2. Experts differ strongly in quantitative terms from the public when it comes to perceived risk, but not qualitatively, in terms of how their risk perception can be explained.

3. Differences between experts and the public can be explained by models similar to those explaining risk perception and attitudes within the group of members of the public.

Hypotheses 1 and 3 were supported by the results. Hypothesis 2 was supported with regard to personal risk but not for general risk. In the latter case, and especially for Dread and Novelty, the traditional view that experts' risk perception is not affected by "subjective" factors was supported.

GMF was rated as a very undesirable technology in the present study by members of the public. This is by no means a unique finding, but there has been some discussion in the literature about just how unacceptable GMF is, and what factors account for attitudes towards it. Townsend *et al.* (2004) studied attitudes and risk perception of GMF in a context of other concerns, such as nuclear war and cancer. They found that GMF was not rated among the top concerns, an unexpected finding according to them. However, other work and the results of the present study do place GMF in the bottom of the list of *technologies*. This does not imply that it is also among the very worst concerns generally. Townsend, Clarke, and Davis did not compare GMF with other technologies.

One striking finding was that the risk of GMF was at the same level when rated as a personal or a general risk. Previous work on the risk of genetic engineering showed, on the contrary, a clear difference between personal and general risk (Sjöberg, 2004c). That finding could have been caused by differences in wording of the hazard. It is also possible that perceived control was different in the two studies. Anything we consume can be seen to be under control, as long as we know what we consume. A prime example is alcohol, where people typically give low ratings of personal risk and high ratings of risk to others (Sjöberg, 1998). It is possible that some people perceive the GMF risk as being under control. Yet, GMF could be in our food without our knowing about it. It would be interesting to study risk perception and perceived control under special conditions, such as explicit labelling of genetically modified food.

The group of experts studied here had dramatically different attitudes and risk perceptions than members of the public, except that they also tended to see GMF as a replaceable technology. The large differences between the public and the experts could be well explained by the attitudes and risk-related variables investigated here, in particular overall risks and benefits, morality, Interfering with Nature, epistemic and to some extent social trust. Demographics accounted for very little of the differences between the public and the experts.

Summing up the results of the model analyses, it was found that traditional factors used in many previous studies of risk perception, that is, Novelty and Dread, contributed little beyond the set of dimensions introduced here. Similarly, social trust – which is the dominating trust aspect studied in previous work by other researchers – had a relatively weak influence as compared to epistemic trust, defined in our previous work with regard to policy (Sjöberg, 2001).

The factors introduced here accounted for a very large share of attitudes and risk perceptions, approaching a full explanation if error variance is taken into account.[8] Other work with a similar orientation is scarce so far, but a study by Saba and Vassallo (2002) is interesting . They found that consumer intention was explained to 41% with their attitude models,[9] considerably less than the present results. Townsend and Campbell (2004) found, in an experimental study, that risk factors explained 46% of the variance of consumer intention. Eurobarometer work reported a lower level of explained variance (Gaskell *et al.*, 2004).

Statements about the importance of various dimensions for "acceptance" are found in the report by Fjaestad *et al.* (2003), being an analysis of Swedish Eurobarometer data, but no data analysis is described or otherwise reported. Among other things, they claimed that risk is unimportant. This statement seems to build upon data from a single dimension of "riskiness to society." This is a matter that needs careful consideration of what risk dimensions are investigated. Hunt and Frewer (2001), among others, have found very clearly that risk is an important factor in attitudes to GMF, just as in the present study.

It has been claimed that benefit is by far the most important factor in GMF attitudes and risk perceptions (Gaskell *et al.*, 2004). In the data reported here, we have also found that benefit dominated the picture for consumer intention and overall attitudes, but for policy acceptance, it was epistemic trust, which was most important. More powerful models were made possible by our design, which included about three times as many questions as the Eurobarometer design.

The often-stated conclusion from early risk perception research that experts make objective risk judgments not affected by the psychometric factors was not supported by the present data. The results suggest *why* that conclusion was suggested in the early work. Experts' risk judgments were not correlated with the traditional psychometric factors of Novelty and Dread as far as *general* risk was concerned. These were the factors studied in the seminal work of Fischhoff *et al.* (1978). The present results showed that experts' risk ratings had properties very similar to those of the public sample, when *personal* risk was studied and when the factors of the Extended Psychometric Model were considered, that is, morality, Interfering with Nature and severity of consequences.

There is of course a huge difference between experts and most members of the public when it comes to knowledge. However, this "knowledge gap" does not tell the whole story of the differences between the two groups, as argued by Dietrich and Schibeci (2003), Hansen *et al.* (2003) and Frewer (2004), and shown here. Previous work on experts and the public has shown that experts were likely to judge risks as smaller with regard to hazards within their area of responsibility (Sjöberg and Drottz-Sjöberg, in press; Sjöberg *et al.*, 1997).

A check on the present data showed that there were no significant risk judgments differences between experts and the public, within genders, for risks other than GMF.

Conclusions

GMF ranked very low in trust and attitudes and high in risk. Different demographic strata had similar views. Moral issues played a very big role. In addition, trust in science *per se* was of importance, and so was perceived benefit. In the present study, experts were much more positive than members of the public to GMF, in almost all respects. This was so in spite of their judgments of *other* risks being at the same level as the one given by the public sample.

In view of results such as the present ones, acceptance of GMF seems unlikely in the short or medium run. People doubt that science knows well enough the crucial properties of GMF, and beliefs about the dangers inherent in Interfering with Nature are widely spread. In addition, there are grave moral doubts as to the appropriateness of gene modification in the food processing industry.

The conclusions reached in other research are partially supported here, but new aspects appeared and explained variance doubled as compared to Eurobarometer work. In a policy-related discussion, notions as to the *benefits of technology* and *validity of science* must be carefully attended to and explained. In discussions of consumer behavior and preferences, social trust appears to be of some importance. However, this is a factor of limited importance, and it has been overrated in previous work. Moral issues are of primary importance, and the closely related notions about interference with nature play an important role as well. These are risk dimensions. Further research on the structure and dynamics of these beliefs could be of great importance for understanding the attitudes and beliefs of the public with regard to GMF.

The experts studied here differed sharply from the public as to the *level* of perceived risks and benefits, but not with regard to *structure* of their ratings of personal risk. In addition, their risk perceptions in other areas were much like those of the public. The dramatic difference between experts and the public was well accounted for by the models formulated and tested here, although some variance remained unexplained in the case of policy acceptance.

Notes

1 This study was supported by the Knut and Alice Wallenberg Foundation. Johnny and Lena Drottz and Caroline Nordlund contributed to the administration of the study.

2 Available at http//:www.dynam-it.com/institute (see tab “gene technology study”).

3 Names and addresses were obtained from several knowledgeable informants. Most of the people approached were associated with universities or government research institutes, but a few were

employed by industry. For reasons of respondent integrity, no data on institutional association were entered in the file, and all responses were anonymous.

4 Neophobia is the reluctance to eat unfamiliar foods, see for example Knaapila *et al.* (2007).

5 This number includes regular Ph.D.s and a few who had a "licentiate" degree, which is somewhere in between an M.Sc. and a Ph.D.

6 See Sjöberg (2004a) for further discussion of this variable, which has turned out to be very important in risk perception models.

7 Note that the Dread factor as defined here is purely emotional. In previous work on the Psychometric Model, severity of consequences has often been combined with a single emotion item, which has given its name to the mixture (Sjöberg, 2003).

8 It is likely that another 15%, approximately, is true variance, which could be accounted for if new constructs were to be introduced in the models. It is an interesting challenge to try to formulate hypotheses about such additional explanatory factors. One obvious possibility is that of political values and preferences. Some personality factors, especially emotional instability (Källmén, 2000), may also be of importance. Other work has found some evidence for the importance of control and self-identity (Sparks *et al.*, 1995). The effect, if any, of the latter variable was very weak, however. In future work, it would be interesting to also study questions about the nature/nurture controversy (Singer *et al.*, 1998).

9 They applied the Theory of Reasoned Action and the Theory of Planned Behavior (Ajzen and Fishbein, 1980; Ajzen, 1991), which seldom give better results than they achieved. These are common-sense models, which are not flexible enough to incorporate additional factors, which may be called for in special applications. Typical variance accounted for in food applications are 30% or less (Bagozzi *et al.*, 2000).

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