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GENE TECHNOLOGY IN THE EYES OF THE PUBLIC AND EXPERTS.

Moral opinions, attitudes and risk perception

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Abstract

Risk perceptions and attitudes to gene technology were investigated in a survey study of the general public (N=469) and experts (N=49). The response rate was 47 percent for the public, and data suggest that the results are applicable – with caution - to the population as a whole. For the experts, response rate was 60 percent. Gene technology was studied at increasing levels of detail, from global attitudes across 10 specific applications to in-depth investigation of genetically modified food (GMF). It was found that reactions to gene technology were quite diverse. Medical and forensic applications were well accepted, GMF much less so. Moral aspects emerged as the most important ones in attitudes to gene technology applications. GMF technology was rated as the worst of 18 technologies and highly replaceable. Experts had a very different view but also did not see GMF as irreplaceable. 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 percent, was accounted for in the latter cases, while risk perception was harder to account for (about 25 – 30 percent explained variance). Traditional explanatory factors such as Dread and New Risk were very weak explanatory factors as compared to new approaches, which included Interfering with Nature, Moral value of technology and Trust in Science. Emotion (affect) played a very marginal role in these data; the risk attitudes and technology beliefs, which were investigated, should therefore be seen as the result of ideological convictions, not emotions or ignorance. Experts were throughout much more positive to gene technology 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. In comparisons with recent Eurobarometer studies of attitudes towards gene technology, risk emerged in the present study as a more important factor in attitudes, even if it tended to be less important than benefits. The models formulated for the present data were about twice as powerful as those in published analyses of Eurobarometer data.

Key words: Gene technology, risk perception, policy attitude, consumer behavior, experts

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Introduction

The present report is an account of an empirical study of risk perception and related attitudes with regard to gene technology. Both the public and experts were investigated. The framework of the study builds upon our earlier extensive research on risk perception in other fields of application. Since this framework differs from the traditional one, some space in the introductory section is devoted to explaining the conclusions from earlier research and pointing out some of the shortcomings of traditional approaches.

Background in risk perception research

The controversies about modern technologies usually focus on risk, and it has been noted that experts and the public often have had very different notions as to risk, e.g. when it comes to food [20; 51; 131] . Experts tend to rate risks as lower when they refer to their area of responsibility [124] . Gene technology is no exception even if systematic research on experts' attitudes has so far been scarce or lacking. Current developments of gene technology tend to give rise to controversy, and the public is known to be very unwilling to accept some of the applications [8; 28; 32; 59] . Whether the risk focus is true also of GMOs remains to be seen. Recently published research based on Eurobarometer investigations tells a different story, putting the emphasis on benefits (or lack of them) rather than on risk [38] . Others have stressed risk perspectives [60] , personality in terms of general trust [90] , values [15] or cultural factors [22] . Be that as it may – the issue will be treated at some length in the present report - GAO's have given rise to a number of difficult questions when it comes to risk perception and policy attitudes [61] .

Social scientists, many of them psychologists, have conducted studies of technology risk perception and attitudes for about 25 years, but as of yet, there is no consensus on what is driving these attitudes, or how conflict resolution can be achieved. Conflict resolution is called for since there is a dramatic gap between experts' and managers' risk perceptions and those of the public, and of many – but not all - politicians[2]. Risk communication strategies are frequently proposed in order to solve the conflicts [30; 65] , but communication may have the effect of increasing risk awareness, no matter what its contents [79] . More knowledgeable people were found, in one study, to be more ambivalent about genetic testing [49] . Clearly, challenging and interesting questions abound when it comes to gene technology and risk attitudes.

More generally, political decisions in matters of risk tend to be overly responsive to what is believed to be the public demands, resulting in skew allocations of resources to various safety programs [64; 71; 133; 136] . This is so in spite of indications that people do not really demand, or accept, very skew resource allocations [72] . Politicians have, however, at times erroneous views of the public's beliefs and attitudes regarding risk [94] .

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[2]. Elite groups such as politicians at various levels and in various capacities, leading businessmen or journalists have rarely been studied, with the exception of natural science and technology experts who have been studied, in particular in the nuclear field. Rothman and Lichter studied a broad sampling of elite groups [74] . Sjöberg [107] and Rowe and Wright [75] provide further discussion of experts' risk perception and related attitudes. Politicians in Sweden were studied by Carter et al. [10] and by Sjöberg [94] , which are two of the few investigations of large and representative groups of politicians, at the municipal and regional level and specializing in risk management issues. They were found to have risk attitudes quite similar to those of the public.

Why should risk be important? We have repeatedly found risks to be more important than benefits [101; 116] . In related work, we found that people are more easily sensitised to risk than to safety [122] . Mood states have been found to be more influenced by negative expectations (risk) than by positive ones [93] . Tversky and Kahn man's Prospect Theory of decision making posits that monetary losses are more abhorred than corresponding gains are desired [52] . People seem to be more eager to avoid risks than to pursue chances.

Hence, policy making in matters of risk and hazard is very hard and it is to some extent governed by beliefs about the public's fear and volatility of beliefs, driven by such external events as foreign accidents and disasters. These political beliefs have seemingly been supported by social and behavioral research on the public's risk perception, carried out mainly in the USA, since the end of the 1970's. This work is described and discussed in the following sections.

The received view of risk perception

The field of risk perception research was given stimulation by the work by Tversky and Kahneman on heuristics [92; 139] and by a seminal paper by Fischhoff et al. in 1978 [25] . This paper established what was to become a paradigmatic approach to risk perception, called the Psychometric Model. The main conclusion from research using this model is that the public's risk perception is driven by emotional reactions (often referred to as dread or "gut feelings") and ignorance (judging the risk to be new and unknown). The view that emotions play a dominating role is still a major part of the received view of risk perception, as witnessed in a recent theoretical analysis by Loewenstein et al. [57] . In other work, it has become clear that general factors such as novelty carry little explanatory power and that more specific analysis is called in any modeling the perceive risk of any major hazard such as nuclear waste [115] or terrorism [119] .

Further main theses of the received view are that experts make "objective" risk judgments uncontaminated, as it were, by the "emotional" factors characteristic of the public's attitudes, and that risk perception directly drives risk policy attitudes [24; 128] . Indeed, a distinction between risk perception and policy attitudes is rarely made. It is commonly argued that the risk perception gap between experts and the public needs to be eliminated and to do so we must establish (social) trust [127; 130] .

In the original work on risk perception, and much of the later one as well, no risk target was specified. Respondents were simply asked to judge "risk", and were not told to whom the risk would pertain. It is clear, however, that risks are judged differently when pertaining to one's own person (personal risk) or to others (general risk)[3]. In most cases, personal risk is judged as smaller than general risk; a finding related to unrealistic optimism affecting health related beliefs, as documented by Weinstein [141; 142] . The two types of risk also have different correlates, general risk being related to policy attitudes especially for lifestyle hazards (smoking, drinking alcohol, etc) [112] .

Slovic and other researchers went on to formulate, in the 1980's, a "stigma theory" which posits that hazardous facilities or technologies create a stigma of an area, leading to loss of economic opportunities and also to people living there being ostracized in the wider society [27] .

[3] . When no target is specified, people seem to judge general rather than personal risks [112] .

The most recent work in the Psychometric Paradigm claims that "affect" is important in driving perceived risk [21; 57] .

Experts have been investigated, to a limited extent [24; 128] . On the basis of a very small sample of risk analysts (N=12), it was concluded that experts make "objective" risk judgments, unaffected by factors, which were found to be important in the case of the public (dread, novelty). This early work was critically assessed only recently [75; 107] . Apart from the sample being very small, the studied risk analysts could not have had expertise in all of the many and very varied topics investigated, from nuclear power plants to mountain climbing.

Summing up, risk perception work appeared to imply that the public reacts emotionally, and out of ignorance, with regard to their risk perceptions. Experts were said, in contrast to the public, to be objective and correct in their risk perceptions, which are not contaminated by emotions and other biasing factors. Trust in experts could re-establish the gap between the experts and the public; trust being a very important factor in perceived risk. This work has enjoyed a widespread credibility, in spite of serious weaknesses, which I now briefly review.

Critique of the received view

The present report relies on a different view of risk perception than the received one. There are several reasons for this choice of different theoretical and methodological framework. Eight critical points against the received view will be made here[4]:

1. The psychometric model seemed to be very powerful in accounting for perceived risk and risk acceptance, but that was an illusion, based on misleading data analysis [108] . Mean values were used in regression analyses. When raw data and individual differences were analysed, amount of explained variance dropped from about 70 to 20 percent [36] . Considerable improvement has been achieved by introducing new factors in the original model, such as Interfering with Nature [104] . Another important factor, related to Interfering with Nature, is that of moral value [126] . Man-made disasters are reacted to very differently from natural disasters, in part because there is nobody to blame for natural disasters [45] .

2. The original work on "dread" did not measure only emotion, but mainly judgments of the severity of consequences of an accident [114] . The dread item has turned out to have less explanatory value than the items measuring severity of consequences. Only recently, more emotion items have been introduced in the models [56] .

3. The notion that "new risk" is very important in accounting for perceived risk has not been supported in current research [110; 116] . Novelty of a risk is a very marginal factor in risk perception.

4. "Stigma" has never been established as a factor, except as a *post hoc* explanation of a few cases. Stigma theory cannot be used to predict events, nor can it explain the large prevalence of non-stigma cases (the vast majority with regard to nuclear facilities) [5; 9] .

[4] . Cultural theory of risk perception [14] could also be said to be part of the received view, since it is often mentioned as the background for "world views" being important determinants of perceived risk, see e.g. Peters and Slovic [69] . However, the explanatory power of Cultural Theory dimensions is minuscule [95] and I therefore chose not to discuss it at length in the present context.

5. Current beliefs that “affect” (emotion) is an important factor in risk perception are mainly based on the fact, well known in other literature [103; 105] , that attitude tends to be strongly correlated with perceived risk. Researchers within the Psychometric Paradigm chose to use the word affect for what is more appropriately called attitude, thus giving rise to the erroneous belief that they had shown that emotions influenced risk perceptions [120] .

6. The belief that risk policy attitudes are based on perceived risk misses at least two important qualifications. First, policy attitudes are based on perceived or expected consequences of e.g. an accident, not its risk (which is mainly interpreted as probability) [99; 102] . Probability tends to be ignored [134] . Second, attitude to a technology is largely based on beliefs regarding its benefits and whether it is indispensable or not, if viable alternatives exist [109; 114] .

7. Social trust is fairly marginal when it comes to accounting for perceived risk [100; 144] . Trust in the value of science is frequently more important [106] . People may well think that experts are honest and competent, yet that their scientific basis is insufficiently well developed [17; 18] , as Drottz-Sjöberg found in her work on attitudes, following the two local repository referenda that have been held in Sweden. More research is needed, in the eyes of many, or they even reject the value of science and opt for other notions of knowledge, such as those offered by New Age proponents. In studies especially oriented towards New Age beliefs and worldviews, it was found that such beliefs account for some 10-15 percent of the variance of risk perception [113; 121] .

8. While experts tend to give lower risks estimates than the public, in their own area of expertise and responsibility, the structure of their risk perceptions is similar to that of the public’s [107] .

Research on attitudes toward gene technology

Siegrist and Bühlmann [89] 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 [145] . Positive attitudes to medical applications of gene technology are rather common [6] . Frewer, Howard and Shepherd found low acceptance of genetically engineered food, perceived benefits counteracting this tendency, as well as perceived "naturalness" [31; 34] . Frewer et al. stressed the variation of responses to different technologies. Fischhoff and Fischhoff also stressed the varying responses to different types of biotechnology [23] .

Other variables correlating with perceived risk and acceptance of gene technology were worldviews [86] , gender and environmental attitudes [85] and moral concerns [135] . Trust has often been mentioned as an important variable [87] . Eiser, Miles and Frewer found evidence against the notion of trust and/or risk being factors causally related to technology acceptance [19] . They suggested that trust, risk and acceptance all reflected similar notions.

Siegrist's work on trust is interesting but his conclusions tend to be somewhat misleading. First, some of the work shows fairly modest relationships between trust and risk perception, some 15-20 explained variance, which is quite in line with most other work on this issue. 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 so-called Likert scale). In a special methodological study I recently obtained the same result [109] . When perceived risk and trust both are measured by rating scales, the usual methodology, the relationship was found to be modest, about 15 percent explained variance. However, when both dimensions were measured by means of attitude scale items using the same response format, the explained variance was drastically increased to 30. One may ask, of course, which methodology gives the most valid information about strength of relationship.

Skeptical attitudes to some applications of gene technology seem to be more common in Europe [88] than in the USA [39; 62] . The US public may still be relatively little concerned [58] . 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 Zeeland were found to be oriented towards the use of GM technology and intense production methods. Economic factors may benefit such farmers. Possibly, media reports about new hazards have also played an important role here [33; 67] , possibly because they give rise to fear [55] . At the same time, increased negative media coverage, starting in the end of the 1990's seemed to be bringing out worry and concern among sectors of the American public [82] .

Much of the work on gene technology is of the type opinion polling rather than attitude research, e.g. some of the Eurobarometer work sponsored by the EU. For example, Eurobarometer 46.1 reported that people had little knowledge about and were negative towards biotechnology (data collected in 1996) [7] , and subsequent work (Eurobarometer 52.1) has verified these findings [37] . Moral issues, and "unnatural" risk, emerged as important aspects, and attitudes appeared to be declining [40] .

The survey questions used in the Eurobarometer program may be partly hard to understand for the lay public who is apparently expected to understand the meaning of such scientific terms as "stem cell" or "cloning". In addition, relatively few questions are asked and in-depth understanding of attitudes is consequently hard to achieve. It should also be noted that only a relatively modest level of explained variance was reached.

Pardo, Midden and Miller [68] 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 came out as an important explanatory factor. Only 5 percent of the perceived risk variance was accounted for. The benefit model explained 33 percent of the variance, mainly on the basis of educational level, knowledge, and general and specific technology optimism. Savadori et al. [78] reported a higher level of explained variance of gene technology risks, on the basis of risk dimensions of the type used in the Psychometric Model. Their models achieved, on the average, about 40 percent 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 in their case.

Gaskell et al. reported models of attitude to GM food [38] , also based on Eurobarometer data, which reached a maximum of 27 percent 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 GM food. The main message of their article is that risk is not the major factor in GM food attitude, but benefit. However, both risk and benefit contributed to the explanation of attitude in their data, even if benefit was more important than risk. A qualitative approach was attempted by Verdurme and Viaene [143] .

Thus, the few previous attempts at modeling factors in risk perceptions and attitudes toward gene technology have thus resulted only in fairly 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, on the basis of previous work on other technologies, were not measured and applied in the models. I mention especially epistemological trust, morality and interference with Nature, a factor that borders on religious beliefs and New Age convictions.

The purpose of the present study was to investigate attitudes to gene technology 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 over the last three decades. In particular, we apply a conceptual structure different from the received view due to Slovic and others and show how risk attitudes emerge according to ideological rather than emotional or affective themes. Close attention to the many varieties of risk and worry questions is called for, since there are several dimensions of such questions which may have large effects not intuitively obvious [109] .

It was important to study the opinions and beliefs of the non-experts members of the general public. However, it was also considered to be of interest to include a group of gene technology experts. It was noted above that the received view of experts as fully objective and qualitatively different from non-experts has recently been found to be unjustified. However, we know of no previous study comparing gene technology experts with non-experts with regard to risk perception and related beliefs. Such a study 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.

Summing up, the present study was carried out in order to describe main aspects of risk perceptions and attitudes of gene technology, and to model these data in terms of driving factors at the level of individual respondents. The differences between members of the public and experts were investigated and it was expected that experts would be much more positive to 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 gene technology case.

Method

Procedure

An extensive questionnaire[5], 27 pages in A5 format, was mailed to 1000 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

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

identified[6] 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:

- 11 initial questions dealing with attitude to gene technology in general
- 10 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 5 ratings of the technology in question, on 5-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
- 5 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 psychometric aspects of GM foods
- 55 attitude statements concerning GM foods
- 9 statements measuring New Age beliefs
- 6 fact statements, to be judged as true or false, concerning genetics and gene technology
- 8 ratings of trust in various organizations or groups
- 13 statements measuring general suspiciousness

[6] . 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.

- Background questions, including interest in technology, GM food 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
- 10 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.

There was an unusually positive response to a question about taking part in a new study; about 60 percent said they would do so[7]. There were 10 questions about the quality of the questionnaire; positive and negative answers were distributed as in Table 1.

[7] . A new study was later sent to a subsample that had indicated willingness, about 80 percent responded (no reminder was used). The topic was quite different from the gene technology study.

Table 1. Quality assessments of the questionnaire and the study[1].				
Dimension	Percent positive		Percent negative	
	Public	Experts	Public	Experts
Do you find the study meaningful?	73.8	59.6	5.7	4.3
Were the questions clearly formulated?	73.3	52.3	7.8	13.6
Were the response alternatives clearly formulated?	78.9	55.5	5.5	8.9
Did the questionnaire bring up what is important in this context?	81.7	75.0	2.0	2.3
Do you feel that we tried, with the questionnaire, to influence your responses in a certain direction?	66.0	77.9	10.6	6.6
Has the questionnaire made you interested in getting more information about the topics?	39.4	4.4	28.7	62.2
Has the questionnaire made you worried about the risks, which it treats?	50.7	93.3	25.1	0.0
Was it an interesting task to fill out the questionnaire?	52.3	34.8	22.2	39.2
Were the text easy to ready and the layout clear?	78.6	71.8	7.8	13.1
Were there many questions, which you found unnecessary?	34.8	34.9	33.7	32.6

Note. 1. The columns do not sum to 100 because there was also a category of "doubtful" responses, see Appendix for these data.

The evaluations of the study and the questionnaire can thus be seen to be, overall, 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; see Table 1. 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 where the public would not have appreciated them. 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 percent. (Nineteen addresses were unusable). There was also about 2 percent 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 percent male and 50.7 percent female (see Appendix for this and subsequent response distributions). The age distribution was quite similar to 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 percent, as compared to 5 percent in the population according to our information. The political preferences of the respondents were in good agreement with polls conducted during the same time.

About 14 percent 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 is 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 educational level, since this was the only salient source of possible bias. Educational level was scored in 5 categories, and correlated with attitude to gene technology (good – bad on a 7 step scale, see below), risk of gene technology (also a 7 step scale), and moral acceptability of gene technology (another 7 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 somewhat more positive to gene technology than others, and to judge the risk as slightly lower. The effects were however quite weak, so the education bias factor can therefore be largely ignored. If any effect can be discerned it is that, the present sample gives 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 percent. 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 percent. 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[8]. The year they got their Ph. D. varied between 1961 and 2000. Their faculty association was dominated by Natural Science, Medicine and Veterinary Medicine. These categories comprised 87 percent 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), 46 percent as full professor.

Their self-assessed degree of expertise in some area of gene technology was rather or very large in 72 percent 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 percent.

[8] . 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.

Results

Interests and attitudes to the environment and technology

About 30 percent of the public sample indicated that they had little or no interest in science and technology in general; none of the experts did so. Many more, almost 60 percent, said they had no interest in gene technology; again, none of the experts chose those alternatives. On the other hand, few (19 percent) had no interest in the *risks*, or *benefits* (27 percent) of gene technology. A few of the experts (6 percent) had no interest in the possible risks; all of them were interested in the benefits.

The respondents were quite pessimistic about the global environmental situation. Almost half of the public said it was deteriorating drastically. Many of them, 63 percent, regarded technology as responsible. The experts were just as pessimistic about the environment and technology in general. This is interesting, confirming earlier work, which showed experts to be as concerned as the public about risks outside their own field of responsibility – but not necessarily inside their field of expert knowledge [123] .

Very few (14 percent) among the public saw it as acceptable to take rather or very large risks in order to profit from technology. Experts were more likely to accept some risks if benefits could be expected, see Table 2.

Hence, this version of the precautionary principle was more acceptable to the public than the experts, even if few among the public espoused it in its most extreme form.

Table 2. What is your general opinion of the risks and benefits of technology? Percent within groups

	GROUP	
	Public	Experts
No risks whatever should be taken. Regardless of benefits	13.7	4.5
Very small risks can be taken if there are benefits	35.3	25.0
Rather small risks can be taken if there are benefits	36.8	50.0
Even rather large risks can be taken if there are benefits	13.1	20.5
Even very large risks can be taken if there are benefits	1.1	0.0
Total	100.0	100.0

Questions about attitude, risk and morality of gene technology in general

Starting with gene technology questions, it should first be noted that respondents indicated that they had little knowledge about this technology, see Table 3. These data are in good agreement with American data, showing that about 20 percent of the population claimed, in 1996-97, that they were totally ignorant about genetic testing [91] . Experts naturally rated their knowledge at a much higher level.

Table 3. How large is your knowledge about gene technology? Response distributions in percent.

	GROUP	
	Public	Experts
Extremely large	0.4	14.9
Very large	0.6	44.7
Rather large	7.6	36.2
Neither large nor small	26.1	4.3
Rather small	31.1	0.0
Very small	20.7	0.0
None at all	13.4	0.0
Total	100.0	100.0

Attitudes, ratings of good vs. bad on 7-step scales, were quite different depending on whether technology was used to change genes or for diagnostic purposes, see Fig. 1 for gene modification and Fig. 2 for diagnostics ("studying the properties of genes in humans, animals and plants"). As can be seen in the two figures, there were very large differences in attitude between the experts and the public. The experts were clearly quite positive to gene technology, while most members of the public had a more reserved attitude (only rather positive or neutral), and some members of the public were outspokenly negative.

Almost half of the respondents from the public (47 percent) said they were worried about gene technology, at least to some extent. Only 9 percent of the experts had some degree of worry. Even more, 70 percent, of the public responded that there were rather large, or larger, risks of gene technology; for experts the figure was 21 percent. There is an interest in relating these two questions, since opinion polls often ask about worry rather than risk. The correlation was 0.58 for both the public and the experts - high and significant but by no means perfect, a common finding [77; 98] . In response to a question about utility, many respondents from the public (62 percent) stated that there was at least rather large utility of gene technology. For experts, the figure was 94 percent. A large minority among the public, 24 percent, found this technology morally unacceptable (none of the experts), at least to some extent, 67 percent found it frightening (9 percent of the experts). Fright, a more specific emotion than worry, correlated 0.63 with risk among the public, i.e. even higher than worry, with a lower value for the experts (0.47).

There was a sceptical attitude regarding the activities of authorities to protect us from possible risks of gene technology. Only small groups in the public were confident about regulations and the activities of the authorities (values for the experts within parentheses)

- 25 (71) percent were confident about the sufficiency of present Swedish laws and regulations
- 20 (60) percent were confident about the activities of Swedish authorities
- 12 (63) percent were confident about EU activities in this respect

It can be noted that the sceptical or outright negative views were hardly the result of direct personal experience. Only 4 percent suspected that they had become ill from eating genetically modified food. One expert stated having such a suspicion.

The present section can be summarized as follows:

- The members of the public had little self-assessed knowledge of gene technology, while experts were on the other hand quite confident about their knowledge of the field.

- The public had a slightly positive or neutral attitude towards gene technology, with large groups who were outspokenly negative. Experts were overwhelmingly positive.

There was, in the group from the public, much scepticism about the authorities, Swedish and European, and their ability to manage gene technology risks. Experts showed *some* scepticism, but the over-all picture was one of strong trust.

Fig. 1. Distributions of ratings of attitude to gene modification

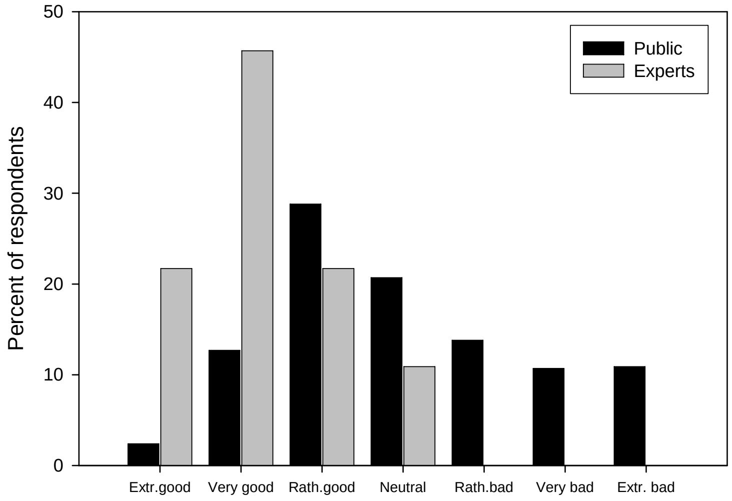
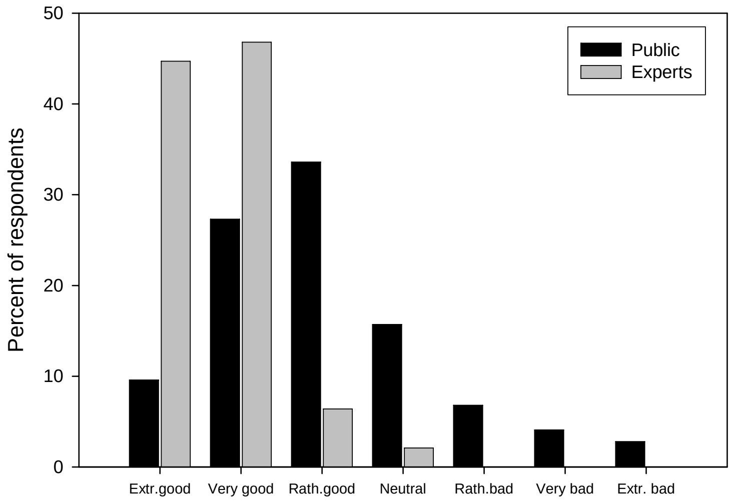


Fig. 2. Distributions of ratings of attitudes to gene diagnostics



Specific applications of gene technology

Ten applications of gene technology were studied, each of them judged in five dimensions. The data are available in detail in the table appendix. Here, the moral judgment results are reported in Tables 4-13. All chi-square tests for differences between experts and the public were highly significant, $p<0.0005$, except for modification of genes in sex cells and the use of DNA technology in police work, where there was no significant difference between the two groups.

Table 4. "There are now scientific methods to change the genes of animals. They can be used in the pharmaceutics industry. What is your opinion, overall, of that technology and its applications? Is it in your view morally correct?" Percent within groups.

	GROUP	
	Public	Experts
To a large extent	8.4	42.2
To a certain extent	22.6	46.7
Doubtful	37.6	4.4
Hardly at all	14.0	4.4
Absolutely not	17.4	2.2
Total	100.0	100.0

Table 5. "There are now scientific methods to change the genes of plants. They can be used in the pharmaceutics industry. What is your opinion, overall, of that technology and its applications? Is it in your view morally correct?" Percent within groups.

	GROUP	
	Public	Experts
To a large extent	23.7	68.9
To a certain extent	37.0	28.9
Doubtful	28.2	0.0
Hardly at all	3.8	2.2
Absolutely not	7.2	0.0
Total	100.0	100.0

In the case of the pharmaceutics industry, both experts and the public thus tended to accept that gene technology applications were morally acceptable, especially when applied to plants. Yet, the difference between the two groups was considerable, experts being much more accepting of this type of application.

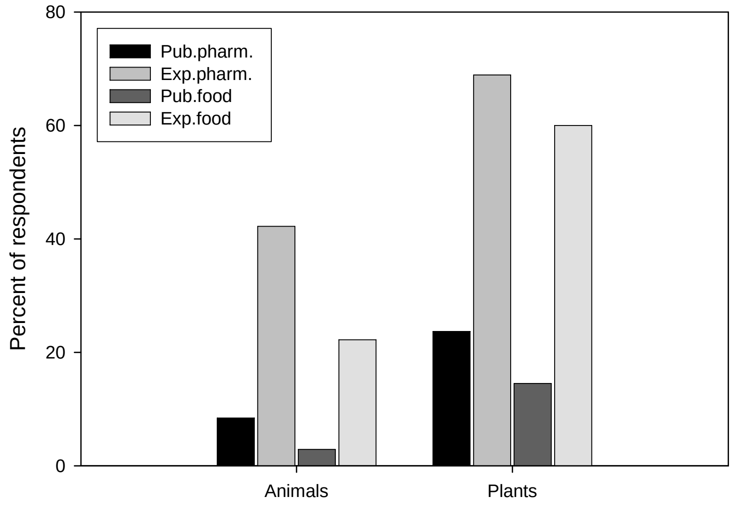
Table 6. There are now scientific methods to change the genes of animals. They can be used in the food industry. What is your opinion, overall, of that technology and its applications? Is it in your view morally correct?" Percent within groups.		
	GROUP	
	Public	Experts
To a large extent	2.9	22.2
To a certain extent	11.8	35.6
Doubtful	31.0	31.1
Hardly at all	17.0	6.7
Absolutely not	37.3	4.4
Total	100.0	100.0

Table 7. "There are now scientific methods to change the genes of plants. They can be used in the food industry. What is your opinion, overall, of that technology and its applications? Is it in your view morally correct?" Percent within groups.		
	GROUP	
	Public	Experts
To a large extent	14.5	60.0
To a certain extent	26.9	31.1
Doubtful	32.3	4.4
Hardly at all	8.9	2.2
Absolutely not	17.3	2.2
Total	100.0	100.0

In the case of the food industry, there were serious moral objections among the public, less so among the experts. The difference was, again, very large between the two groups. However, even the experts had some doubts as to the moral status of gene modification of animals in the food industry. It can also be noted that as many as about 40 percent of the members of the public sample apparently felt that gene modification of plants in the food industry was at least partly acceptable from a moral point of view.

For an overview of the results, see Fig. 3

Fig. 3. Proportions indicating full moral acceptance of gene technology in pharmaceutics and food industries, applied to animals and plants, respectively.



It is interesting to see that the same trend is true for both groups with regard to animal applications, but that the levels of acceptance were dramatically different. Experts were much more likely to see the applications as morally acceptable. For plants, experts were almost as likely to morally accept food as pharmaceutics applications. It should be noted that experts and the public ranked the four applications as to moral acceptability in the same way:

- Plants, pharmaceutics
- Plants, food
- Animals, pharmaceutics
- Animals, food

It can thus be said that the main factor in moral judgment is that which distinguishes plants from animals, while the specific use – pharmaceutics or food – is secondary.

Three applications had to do with reproduction and family planning:

Table 8. "What is your opinion about the use of gene diagnostics as a basis for counselling about planning to have a child, in cases where there is reason to expect damage? Is it in your view morally correct?" Percent within groups.

	GROUP	
	Public	Experts
To a large extent	13.5	54.3
To a certain extent	30.9	30.4
Doubtful	32.3	6.5
Hardly at all	10.5	4.3
Absolutely not	12.8	4.3
Total	100.0	100.0

Table 9. What is your opinion about the use of gene diagnostics of a foetus as a basis for deciding about abortion, in cases where there is reason to expect damage? Is it in your view morally correct? Percent within groups.

	GROUP	
	Public	Experts
To a large extent	13.3	47.8
To a certain extent	28.3	32.6
Doubtful	34.6	10.9
Hardly at all	9.3	4.3
Absolutely not	14.5	4.3
Total	100.0	100.0

Table 10. “What is your opinion about the use of gene diagnostics of a foetus in connection with "test-tube conception", as a basis for deciding about introducing a foetus in the uterus, in cases where there is reason to expect damage? Is it in your view morally correct?” Percent within groups.

	GROUP	
	Public	Experts
To a large extent	12.8	34.8
To a certain extent	25.4	30.4
Doubtful	32.5	26.1
Hardly at all	9.2	2.2
Absolutely not	20.1	6.5
Total	100.0	100.0

There was a higher level of acceptance in “normal” reproduction cases, see Tables 8 and 9. It was especially high among the group of experts, while the public showed much hesitation. In the “test-tube” case, even experts hesitated to some extent. The relation between what is natural and what is morally acceptable may be behind these data. It is possibly an example of a similar kind of thinking, which is behind notions as to “pure” and “impure” foods in religious beliefs [13] .

Two applications concerned the treatment and prevention of illnesses, see Tables 11 and 12.

Table 11. “There is a hope to mitigate some illnesses by introducing new genes in human body cells, which cannot be developed into sex cells. In such cases, the new genes will not be transferred to future generations. What do you think about such changes in human body cells? Is it in your view morally correct?” Percent within groups.

	GROUP	
	Public	Experts
To a large extent	17.8	71.7
To a certain extent	32.3	21.7
Doubtful	31.7	
Hardly at all	5.7	2.2
Absolutely not	12.5	4.3
Total	100.0	100.0

Table 12. "There is currently hope to cure some illnesses by introducing new genes in human sex cells. Such changes will be transferred to future generations. What do you think about such changes in human sex cells? Is it in your view morally correct?" Percent within groups.

	GROUP	
	Public	Experts
To a large extent	13.2	19.6
To a certain extent	25.9	26.1
Doubtful	30.9	26.1
Hardly at all	9.8	6.5
Absolutely not	20.2	21.7
Total	100.0	100.0

It is interesting to see that experts had some doubts when it came to introducing new genes in human sex cells. Otherwise, these medical applications were fairly well accepted.

The final specific application concerned forensic use of gene technology:

Table 13. "Gene technology can be used by police in their work to find the perpetrator of a certain crime (DNA analysis). What is your opinion about the police using that technology? Is it in your view morally correct?" Percent within groups.

	GROUP	
	Public	Experts
To a large extent	73.9	91.5
To a certain extent	20.2	8.5
Doubtful	4.8	0.0
Hardly at all	.7	0.0
Absolutely not	.5	0.0
Total	100.0	100.0

Clearly, both experts and the public found this use of gene technology to be quite acceptable from a moral point of view. The result is seemingly inconsistent with Eurobarometer results and will be further commented on in the concluding discussion section.

Summing up, there are several interesting trends in these data. First, food industry applications were seen as of little use, risky and morally questionable. Second, medical applications were much better accepted even if there were, even in that case, some second thoughts as to risk and morality. "Normal" reproduction (family planning and abortion) questions led to a higher degree of moral acceptance than a “test-tube” case. Finally, forensic use was *highly* acceptable.

Data on rejection of the technologies, i.e. the number of respondents who said that an application of gene technology was hardly or absolutely not good, varied greatly. However, even the highest value, for animal gene modification in the food industry, was less than a majority, only 39.2 percent.

Moral acceptance of the ten applications was related to utility, risk and acceptability of risk, see Tables 14 and 15 for the public and experts, respectively.

Table 14. Results of regression analyses of moral acceptability of the ten applications of gene technology, data from the public.

	Standardized regression coefficients			
Application	Utility	Risk	Risk acceptability	Adjusted R^2
Changing animal genes, in pharmaceutics industry	0.506	-0.287	0.185	0.492
Changing plant genes, in pharmaceutics industry	0.572	-0.266	0.225	0.579
Changing animal genes, in food industry	0.602	-0.204	0.175	0.546
Changing plant genes, in food industry	0.631	-0.201	0.182	0.616
Diagnostics of genes, for family planning	0.616	-0.188	0.134	0.525
Diagnostics of genes, for decision about abortion	0.616	-0.132	0.172	0.519
Diagnostics of genes, for deciding about “test-tube” conception	0.649	-0.137	0.181	0.584
Therapeutic use, body cells	0.700	-0.161	0.114	0.599
Therapeutic use, sex cells	0.683	-0.213	0.205	0.622
Use by police in finding criminals	0.600	-0.161	0.060 (ns)	0.430

The regression coefficients are all significant at the 0.001 level, with one exception noted in the table. The mean proportion of variance accounted for was 0.551.

Table 15. Results of regression analyses of moral acceptability of the ten applications of gene technology, data from the experts.				
	Standardized regression coefficients			
Application	Utility	Risk	Risk acceptability	Adjusted R^2
Changing animal genes, in pharmaceutics industry	0.289*	-0.301*	0.279*	0.273
Changing plant genes, in pharmaceutics industry	0.612***	-0.128	0.164	0.442
Changing animal genes, in food industry	0.691***	-0.178*	0.210	0.656
Changing plant genes, in food industry	0.832***	-0.050	0.105	0.767
Diagnostics of genes, for family planning	0.819***	-0.025	0.101	0.759
Diagnostics of genes, for decision about abortion	0.711***	-0.140	0.153	0.688
Diagnostics of genes, for deciding about "test-tube" conception	0.737***	-0.092	0.194*	0.735
Therapeutic use, body cells	0.878***	-0.005	0.068	0.850
Therapeutic use, sex cells	0.607***	-0.218	0.062	0.502
Use by police in finding criminals	0.822***	0.091	0.028	0.619

*** $p<0.0005$, *$p<0.05$

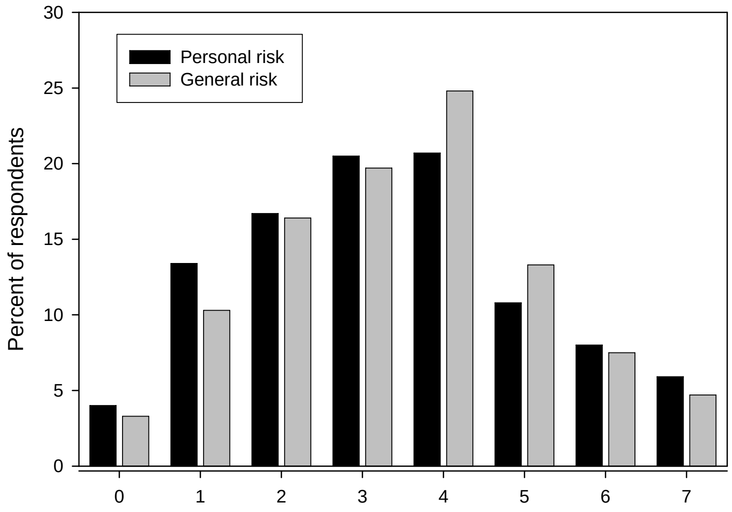
The mean share of variance accounted for in the expert group was somewhat higher than for the public, 0.629. It is interesting to note that the moral judgments by the experts were (a) easier to account for than those by the public, and (b) less affected by risk aspects, and more one-dimensional in the sense that utility was strongly dominating their morality judgments. The same tendency was found for members of the public but it was less pronounced and risk aspects also affected their judgments of morality.

Risk perception

Both personal and general risk of GMF was rated in a context of 45 other hazards. The public rated the personal GMF risk as no. 12 (M=3.34). Experts rated the GMF personal 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 genetically modified food are given in Fig. 4.

Fig. 4. Personal and general risk
of genetically modified food, public data



The two distributions are quite similar, suggesting that this is a risk beyond one's control and hard to protect oneself from. In connection with uncertainty of risk assessments, the perceived lack of control could be a cause of alarm and seeing the risk as severe [63] . It can be concluded that the personal risk was more salient than the general one, relatively speaking. The response distributions of experts and the public are compared in Figs. 5 and 6. They are strikingly different in both cases, and the differences were highly significant according to chi-square tests.

Fig. 5. Personal risk of GMF, experts and public

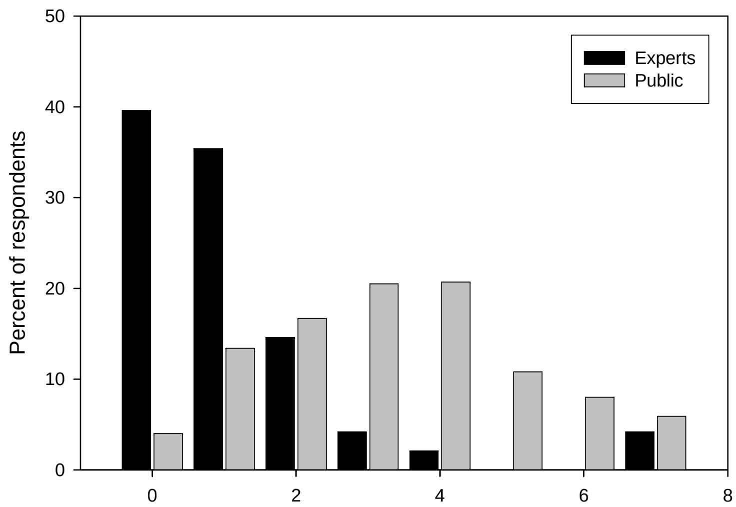
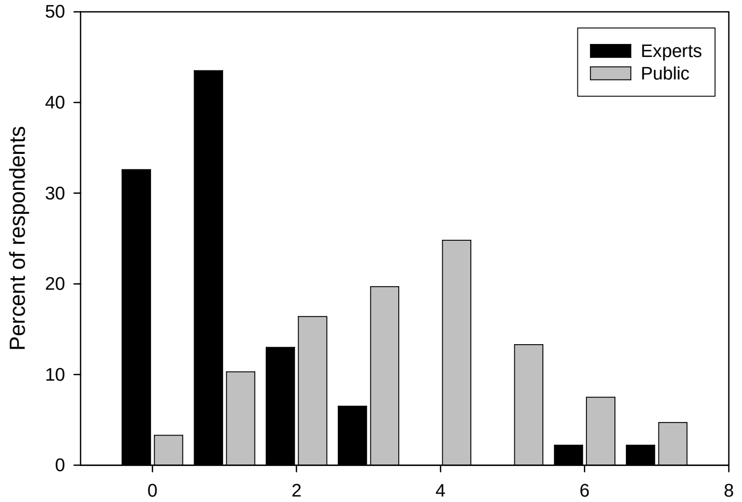
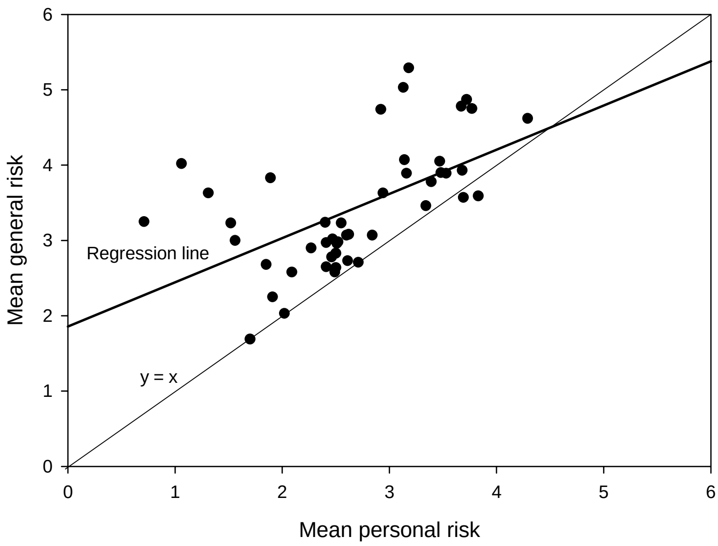


Fig. 6. General risk of GMF, experts and public



We wish to stress the “non-finding” above – 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 Fig. 7. These hazards were of the same type as in many previous studies, not related to gene technology.

Fig. 7. Plot of mean general vs. mean personal risk, public data.



The risk of GMF food was rated on 19 risk dimensions, on scales from 1 to 7. The results were as shown in Table 16. It is clear that the risk of GMF technology was rated highly in most respects. The risk was new, counter to 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 [106] .
Table 16 shows dramatically large differences between experts and the public. The members of the public saw much larger risk components in genetically modified food than the experts, and they did so in all the studied aspects.

Table 16. Ratings of the 19 psychometric factors, means and standard deviations, and tests of differences between experts and the public.

	Public		Experts		
	Mean	Std. deviation	Mean	Std. deviation	Standardized difference[9], and outcome of t-test
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

[9] . 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 to be “very large” [11] . Note that the present differences between the public and experts in most cases are much larger than that.

Attitudes toward technologies

In this section, 18 technologies were rated on 5 dimensions. The results for genetically modified food, as judged by members of the public, were as follows.

Use less: Mean=5.46 (SD=1.44), 2nd among the 18.
Risk: Mean=5.65 (SD=1.63), 3rd among the 18.
Morally unacceptable: Mean=3.71 (SD=1.10), 1st among the 18.
Utility: Mean=3.28 (SD=1.84), 18th among the 18.
Substitutability: Mean=5.57 (SD=2.23), 1st among the 18.

For experts, the results were:

Use more: Mean=2.96 (SD=1.48), 3rd among the 18.
Risk: Mean=1.42 (SD=2.68), 17th among the 18.
Morally acceptable: Mean=1.98 (SD=0.95), 4th among the 18.
Utility: Mean=5.30 (SD=1.63), 16th among the 18.
Substitutability: Mean=5.25 (SD=1.88), 1st among the 18.

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 that *it was not irreplaceable*. They found its risk to be low, and that it was morally acceptable, yet 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 due to the fact that GMF is still a new technology and has yet to be put to large-scale use in Sweden.

Attitude statements regarding GMF

Responses to the 55 statements reveal much the same picture as risk and attitude ratings already described. In order to get a more comprehensive picture of the attitudes of the respondents, the statements were factor analysed[10], using data from the public, and six factors were found to describe the data quite well:

[10] . Factor analysis can be used to group the items in homogenous groups, on the basis of their intercorrelations. In this way, a more comprehensive picture of the results is provided. At the same time, more reliable measures of the attitudes are provided by indices, which simply are based on the average response to all items in a group. The homogeneity of each group can be measured by the alpha index (also called Cronbach's alpha), which has a maximum value of 1.0 when all statements in a group correlate perfectly. Values above 0.7 are considered to be acceptable. Lower values mean that statements in the group tend to measure different dimensions and results are then unreliable.

Gene technology acceptance
- Gene technology rejection
- Social trust
- Trust in science
- Consumer intentions
- Policy acceptance

Data are reported here for the groups of items, public data, beginning with the factor of gene technology rejection, see Table 17. Note that the items of this table and the following ones have been used to form a number of more precise scales, measuring various aspects used in regression analyses reported below.

Table 17. Response distributions to items in the factor of gene technology rejection, percent of the respondents. Data from the public.

Item	Agree absolutely	Agree on the whole	Doubtful	Disagree on the whole	Disagree absolutely
Genetically modified food (GMF) only increases industry profit and is of no value to mankind at large (b)	21.9	32.7	26.9	14.6	4.0
Politicians should be more cautious about GMF (a)	45.2	29.7	15.4	6.2	3.5
GMF is an example of human illusions about what is possible and appropriate	25.9	30.8	30.1	8.6	4.6
GMF can be dangerous to people (d)	31.0	29.9	26.8	9.9	2.4
I would not vote for a party which wanted to permit the use of GMF in Sweden (a)	29.3	16.2	29.5	15.3	9.5
The supporters of GMF are naïve and gullible	10.4	16.2	42.5	23.5	7.5
People do not have the right to change genes of animals and plants for economic reasons (c)	46.0	22.3	15.3	11.5	4.9
The use of GMF should not be permitted (a)	23.7	15.7	34.4	16.2	10.0
Authorities cannot control sufficiently carefully what researchers and GMF industry are up to (a)	35.0	36.8	18.6	6.9	2.7
We are not protected sufficiently against importation of GMF in Sweden (a)	30.0	29.8	30.5	6.5	3.1
The cultivation of GMF crops would damage the environment	14.6	22.9	45.1	14.3	3.1
If researchers and experts are uncertain about the risks of GMF they must let the public know	66.7	23.8	6.2	2.0	1.3
Gene modification is morally unacceptable (c)	16.4	22.4	33.9	20.0	7.4

Notes. (a) Item used in forming the policy index.
(b) Item used in forming the benefits index
(c) Acceptance index item
(d) Risk item

These items all give the same picture, one of GMF rejection. On the average, only 16.8 percent of the respondents rejected statements negative to GMF. The two policy items gave rise to somewhat less pronounced rejection.

Table 18 summarizes responses to the GMF acceptance factor items.

Table 18. Response distributions to items in the factor of gene technology acceptance, percent of the respondents. Data from the public.

Item	Agree absolutely	Agree on the whole	Doubtful	Disagree on the whole	Disagree absolutely
I trust that GMF is a technology which can be well controlled by current regulations	4.0	16.7	29.3	24.7	24.9
It would be irresponsible not to develop and use GMF (c)	4.6	15.7	32.2	22.3	24.9
Those who are against GMF are ignorant reactionaries	4.6	8.1	30.4	22.0	34.6
Talk about risks of GMF are indeed rather ridiculous (d)	4.2	4.0	16.1	27.8	47.8
The risks of GMF should not be exaggerated (d)	9.1	24.7	24.4	20.2	21.3
GMF is a great step forward we should be grateful to (b)	4.6	17.2	34.9	20.5	22.5
It is morally right to exploit the possibility of GMF (c)	4.4	16.6	31.5	22.4	24.8
GMF is a technology which makes it possible to produce food to starving people (b)	10.2	24.7	36.3	14.7	13.8
GMF creates a higher quality of life	3.1	12.0	33.3	23.1	28.4
We should trust the experts, if they say GMF is safe then I believe it (e)	1.8	7.5	23.9	26.1	40.5
Corporations producing GMF are aware of their responsibility (e)	2.2	10.5	35.7	28.1	23.2
Opponents to GMF are emotional and irrational	2.4	9.6	31.8	28.1	27.8
On the whole, society profits from GMF (b)	4.2	17.7	39.2	19.3	19.3

Notes.
(b) Item used in forming the benefits index
(c) Acceptance index item
(d) Risk item
(e) Included in Social Trust 2

On the average, 18.8 percent of the respondents agreed to positively worded statements regarding GMF, very close to the corresponding percentage that rejected negatively worded statements. It is interesting to note that only 9.3 percent agreed that we should trust the experts and believe that GMF is safe if they say so.

A large group, about 30 percent, was doubtful about both the positive and negative items. Three statements measured social trust, see Table 19.

Table 19. Response distributions to items in the social trust factor, percent of the respondents. Data from the public.					
Item	Agree absolutely	Agree on the whole	Doubtful	Disagree on the whole	Disagree absolutely
I trust that authorities protect us against the risks of GMF	4.1	17.8	30.0	25.5	22.3
Membership in the EU gives us good support to exert control over GMF in Sweden	2.0	7.8	35.9	23.2	30.8
GMF builds upon technology which on the whole gives the same results as e.g. traditional plant breeding	1.8	12.4	50.1	18.5	16.9

The statements of Table 20 measures trust in Science.

Table 20. Response distributions to items in trust in science factor, percent of the respondents. Data from the public.					
Item	Agree absolutely	Agree on the whole	Doubtful	Disagree on the whole	Disagree absolutely
GMF can very well turn out to have effects unknown today	48.1	32.1	13.8	4.2	1.8
Scientific knowledge about GMF is probably still incomplete	44.1	32.3	17.6	4.0	2.0
Researchers behind GMF technology are hardly aware of all consequences of what they create	34.4	31.6	22.0	9.1	2.9
We do not know yet of all the possible long-term effects of GMF	52.3	31.1	8.9	4.5	3.1
There could be negative side-effects of GMF unknown today	53.9	28.5	14.0	1.8	1.8

Table 21 summarizes answers to the consumer intention statements.

Table 21. Response distributions to items in the consumer intention factor, percent of the respondents. Data from the public.					
Item	Agree absolutely	Agree on the whole	Doubtful	Disagree on the whole	Disagree absolutely
If GMF has better quality (e.g. taste, keeping quality) than usual food I would be quite willing to buy it, for the same price	4.8	14.0	30.2	15.3	35.2
Whenever possible I avoid buying GMF*	45.2	29.7	15.4	6.2	3.5
I have nothing against eating GMF	5.5	12.7	21.8	15.2	44.6
If GMF were to be about 20 percent cheaper than usual food, I would not hesitate to buy it.	4.2	12.7	24.4	22.2	36.2
I would buy GMF if it contained less fat than usual food	2.2	10.9	22.0	24.5	40.1
I would buy GMF if it was produced in a more environmentally friendly way than usual food	5.8	16.7	28.6	21.9	26.8
I would buy GMF if it was produced in a way more friendly to animals than usual food	7.8	18.7	27.2	19.8	26.3
I would buy GMF if it contained less pesticide residues than usual food	10.2	20.0	29.2	16.9	23.6
I would buy GMF if it tasted better than usual food	6.9	17.4	26.0	16.1	33.6

Note. * Reversed scoring.

Facts

Distributions of answers to six fact questions are given in Table 22.

Table 22. Distributions of answers to fact questions, percent. Data from the public.				
Item	True	False	Present study, incorrect answers including DK	Euro-barometer, incorrect
Ordinary tomatoes do not contain genes, but genetically modified tomatoes do.	<u>27.3</u>	72.7	29.6	45.1
Eating genetically modified fruit can affect the genes of a person.	<u>32.2</u>	67.8	34.7	42.8
It is only the genes of the mother, which decide if a child will be a girl.	<u>11.8</u>	88.2	15.1	31.1
Genetically modified animals are always larger than non-genetically modified animals.	<u>25.2</u>	74.8	27.9	45.1
More than half of human genes are identical with those of a chimpanzee.	76.2	<u>23.8</u>	27.7	27.2
It is impossible to transfer animal’s genes to plants.	<u>43.5</u>	56.5	46.9	58.9

A large minority apparently had confused views as to some basic facts. Compared to the Eurobarometer data, the present group still had better knowledge, even if the results were similar in 3 of the 6 questions. Part of the reason may be that the Eurobarometer study used an explicit DK category in this case, while the present study did not. (DK answers were scored as incorrect).

Trust

Distributions of ratings of social trust are given in Table 23. These items were trust ratings, to be distinguished from the Likert type social trust items of Table 19.

Table 23. Social trust ratings, percent.

Trustee		Not at all	Very little	Rather little	Rather much	Very much
EU authorities	Public	17.0	29.7	37.8	13.8	1.7
	Experts	10.4	4.2	31.3	41.7	12.5
National Food Administration	Public	3.1	11.3	23.3	52.1	10.2
	Experts	6.3	2.1	10.4	60.4	20.8
National Board of Health and Welfare	Public	7.5	14.3	36.2	36.0	6.1
	Experts	8,7	13.0	23.9	47.8	6.5
National Institute of Public Health	Public	3.5	9.9	25.0	52.6	9.0
	Experts	13.0	2.2	28.3	54.3	2.2
Researchers and experts at Swedish universities	Public	3.1	5.0	24.8	50.9	16.2
	Experts	4.2	2.1	4.2	60.4	29.2
Food processing industry	Public	12.6	24.2	41.8	19.0	2.4
	Experts	6.3	4.2	43.8	43.8	2.1
Physicians	Public	3.9	12.7	33.4	43.0	7.0
	Experts	4.2	16.7	27.1	52.1	0.0
The Government	Public	16.0	27.6	42.8	12.5	1.1
	Experts	10.4	29.2	31.3	29.2	0.0

The trust ratings varied a lot depending on who was the trustee. Among the group from the public, there was low trust in national and European politicians and the institutions of the EU, little trust in industry but high trust in Swedish authorities and experts. The experts showed high trust except for the National Institute of Public Health and they had some hesitation with regard to the Government.

Models

In this section, a number of regression analyses are reported, beginning with attitudes to gene technology in general. Then follow analyses of several applications of gene technology as well as attitudes to GMF.

Gene technology in general

There were two attitude questions, one concerning gene modification and the other pertaining to diagnostics. These two attitudes were related to a number of possible explanatory variables, see Table 24.

Table 24. Models of two global attitude ratings, standardized regression weights.				
Explanatory variable	Gene modification		Gene diagnostics	
	Public	Experts	Public	Experts
Self rated knowledge	0.021	0.153	0.023	0.218
Worry	-0.067	-0.161	-0.082	0.076
Social utility	0.205***	0.529***	0.374***	0.301*
Risk	0.029	0.312	0.078	0.003
Moral acceptability	0.360***	-0.141	0.268***	0.147
Fear	-0.207***	-0.138	-0.139*	-0.114
Swedish legislation	0.024	0.102	-0.003	0.335
Swedish authorities	0.022	-0.041	0.046	-0.294
EU authorities	0.001	-0.032	-0.046	0.005
Explained variance	0.485	0.284	0.402	0.105

* $p<0.05$ *** $p<0.001$

For the public, the results are quite similar. In both cases, a high degree of explanatory power was achieved, between 40 and 50 percent. In both cases, only three explanatory constructs contributed in a significant manner: social utility, moral acceptability and (negatively) fear.

The analysis for the data from the experts should be treated with some caution since the group was small in relation to the number of explanatory variables. It may be noted, however, that utility came out as important also in the group of experts. Correlations were low for the experts, except for utility. The two dependent variables correlated equally, and strongly, for experts and the public, however, at the 0.5 level. The results suggest that experts were mostly considering utility in their judgments of gene technology at the over-all level.

Specific applications of gene technology

Each of ten specific applications was rated as to over-all attitude and in four aspects, viz. moral acceptability, utility, risk and acceptable risk. The results are given in Table 25 for the public sample.

The results are quite similar with one exception, forensic use. A very high level of explanatory power was achieved, mainly on the basis of moral acceptability and social utility. Risk variables played an unexpected subordinate role in the models. It was also true that moral acceptability appeared to be the most important factor, except in the forensic application case, where utility was clearly more important. Note, however, that these statements are based on regression weights, which in turn reflect, among other things, intercorrelations of the explanatory variables. The raw correlations between risk and attitudes to gene technology were sizable, and statistically highly significant.

For the experts, the results were quite similar. Utility and moral acceptability dominated as explanatory variables. The level of explained variance achieved with experts was even higher than with the sample from the public.

Table 25. Models of attitudes to 10 specific applications of gene technology, standardized regression weights. Public sample.					
Application	Moral acceptability	Social utility	Risk	Acceptable risk	Explained variance
Animal gene modification, pharmaceutics industry	0.508***	0.354***	-0.028	0.071*	0.663
Plant gene modification, pharmaceutics industry	0.473***	0.385***	-0.080**	0.054*	0.705
Animal gene modification, food industry	0.559***	0.364***	-0.027	0.017	0.752
Plant gene modification, food industry	0.534***	0.378***	-0.054*	0.048*	0.799
Family planning	0.463***	0.447***	0.032	0.068*	0.724
Abortion	0.393***	0.507***	-0.012	0.047	0.726
"Test-tube" conception	0.500***	0.447***	0.003	0.014	0.787
Therapeutic use, body cells	0.479***	0.457***	-0.039	-0.001	0.778
Therapeutic use, sex cells	0.561***	0.380***	-0.042	0.017	0.801
Forensic use	0.165***	0.585***	-0.096**	0.058	0.539

The Extended Psychometric Model

The traditional Psychometric Models reduced the number of crucial risk factors to two over-arching 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. Thus, five factors were estimated in the form of indices; see Table 26 for their properties. Note that Dread is measured by emotion items only.

Table 26. 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	0.90	6
Severity of consequences	0.81	3

The five factors were used as explanatory variables in models of the perceived risk. The results are given in Table 27.

Table 27. Models of risk perception, standardized regression weights, public sample.		
Explanatory variable	Personal risk	General risk
Dread	-0.038	0.016
New Risk	-0.025	-0.078
Interfering with Nature	0.095	0.174*
Immoral risk	0.256**	0.292***
Severity of consequences	0.233**	0.176*
Explained variance	0.247	0.305

A fair level of explained variance was achieved, especially for general risk. It is interesting that the traditional factors of the Psychometric Model had no explanatory power when the new factors were added[11]. 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 [24; 129] . This assertion has only recently been challenged [75; 107] . To my knowledge, the present study is the first one where it can be checked on data from gene technology experts. Table 28 shows correlations between personal and general risk judgments of GMF, and the factors of the Extended Psychometric Model.

Table 28. Correlations between risk perception ratings and the psychometric factors for the public and experts.

	Personal risk		General risk	
Explanatory variable	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
Epistemological trust	0.24	-0.31	-0.27	-0.08
Social trust (Likert items)	-0.38	-0.42	-0.52	-0.30

For personal risk, the correlations were similar for experts and the public. For general risk, 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 of dimensions are studied, the picture is different. Experts no longer appear to be unaffected by “subjective” factors.

[11] . Note, however, that the Dread factor as defined here is purely emotional. In most previous work on the Psychometric Model, severity of consequences has been combined with a single emotion item, which has given its name to the mixture.

Attitudes toward technology

As already pointed out above, ratings of GMF technology were, relatively speaking, quite low. It was still of some interest to relate policy attitude regarding GMF (should it be used more or less) to the four other technology dimensions. A regression model fitted well, explained variance was 0.616. Standardized regression weights for risk, moral value, utility and substitutability were 0.244, 0.362, 0.293 and 0.019, respectively. All were statistically significant with the exception of the last value. Once more, the moral dimension appears to be dominating the picture, but it should be noted that risk also has a sizable regression weight.

For the experts, a similar analysis resulted in a somewhat less powerful model, explained variance 0.449, with risk as the only significant explanatory variable.

Acceptance/rejection, consumer intentions and policy attitudes

The present section reports the results on the attitude questions regarding GMF, data from the public sample. The analyses are used to construct psychometrically sound indices of various factors found in the set of attitude items. Data from the public and the experts are compared on these indices, since a detailed comparison at the item level would be hard to get an overview of. The reader who wants to check out the results at the item level is referred to the Appendix.

To measure attitude towards GMF, the attitude ratings of gene technology for food production, plants and animals, were combined (two items)[12]. Two more dependent variables were of interest, viz. Consumer Intention with regard to GMF, and Policy Acceptance. 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 party, to take an example.

The explanatory variables were the five factors of the Extended Psychometric Model, Trust in GMF Science, Social Trust in GMF experts and regulators, Neophobia, New Age beliefs and Suspiciousness. Social trust was measured both on the basis of the ratings of trust (Social Trust 1) and on the basis of items in the list of Likert type attitude items (Social Trust 2)[13]. Psychometric properties of these indices are given in Table 28. See Table 26 for corresponding information about the factors of the Extended Psychometric Model.

[12] . Note that these items belong to an earlier part of the questionnaire and not to the list of Likert attitude items.
[13] The reason for using both types of measures was that previous work, see introduction, had suggested that the response format was important and affected the predictive properties of the trust measures.

Table 28. Properties of dependent and explanatory variables.		
Variable	Coefficient alpha	Number of items
Overall Attitude	0.80	2
Acceptance of GMF policy	0.78	5
Acceptance of GMF	0.81	4
Consumer Intention	0.95	9
Trust in GMF Science	0.80	5
Social Trust 1	0.88	8
Social Trust 2	0.81	5
Neophobia	0.75	3
New Age beliefs	0.88	9
Suspiciousness	0.82	13
Risk level	0.66	3
Benefit of GMF	0.87	4

Results of regression analyses are given in Table 29.

Table 29. Regression models of attitudes to genetically modified food (GMF), standardized weights.			
Explanatory variable	Global acceptance of GMF	Acceptance of GMF policies	Intention to con-sume GMF
New risk	-0.028	0.113*	-0.067
Dread	-0.005	0.084	-0.001
Severity of Consequences	0.140	0.047	0.057
Morally unacceptable risk	-0.140	-0.308***	0.011
Interfering with Nature	-0.176*	0.058	-0.164**
Trust in Science	-0.016	0.379***	0.043
Social Trust 1 (trust ratings)	0.053	0.101**	-0.024
Social Trust 2 (Likert items)	-0.004	0.006	0.205***
Neophobia	-0.021	-0.118***	-0.036
New Age beliefs	-0.005	-0.032	0.011
General Suspiciousness	0.089*	-0.056	0.099**
Benefit	0.413***	0.303***	0.439***
Over-all risk level	-0.122*	-0.174***	-0.196***
Explained variance	0.437	0.685	0.738
Explained variance using only back-ground data (sex, age educational level)	0.109	0.043	0.044

The results show the following:

- All three models reached a very high level of explanatory power
- The traditional Psychometric Model factors contributed virtually no explanatory power
- Moral acceptability and Interfering with Nature were the most important factors of the Extended Psychometric Model
- Benefit was a very important explanatory construct.

- Both Trust in Science and Social Trust were important, Trust in Science clearly more than Social Trust. Social trust based on the Likert items was possibly more powerful as an explanatory concept than trust based on trust ratings

- Comparing the different independent variables, moral value and trust in Science were of particular importance for policy. Benefit, risk, Interfering with Nature and Social Trust were most important for consumer intention. For Overall Attitude, benefit, interference with Nature, and risk were the most important factors.

- Other variables, resembling personality factors, contributed little or nothing to the models, except that Neophobia made a small contribution, in one case and Suspiciousness in two others.

- Demographics accounted for less than 5 percent of the variance of the dependent variables, except for Overall Attitude

The role of risk perception is well covered in these models, but it might be of interest also to include global risk ratings, personal and general. When this was done, it was found that general risk contributed somewhat to policy attitude, personal risk to general acceptance of GMF. These results were interesting both for documenting the importance of perceived risk and for confirming earlier work where general risk, in particular, had policy implications for certain hazards [112] .

Previous work on data collected in Sweden has led to the unexpected conclusion that perceived risk has no importance at all for GMF attitude (acceptance) [26] . This finding gets no support in the present context. In order to delineate, in a clear manner, the roles of risk and benefit, models were estimated for the three attitude dimensions with level of perceived risk and benefit as the only explanatory variables. See Table 30.

Table 30. Regression models using only risk and benefit as explanatory variables, standardized weights.

Explanatory variable	Attitude to GMF	Acceptance of GMF policies	Intention to consume GMF
Benefit	0.494***	0.454***	0.568***
Risk level	-0.209***	-0.340***	-0.345**
Explained variance	0.422	0.512	0.685

This supplementary analysis shows that even very simple models can reach a high level of explained variance. More important, it shows that risk makes a very significant contribution, not only benefit.

Comparison of experts and the public in GMF attitude dimensions

All differences between experts and the public were statistically significant. Most of them were dramatically large. More specifically, experts as compared to the public, were

- More likely to feel that GMF is beneficial (1.08)[14]
- More likely to be in general accepting of GMF (1.62)
- More likely to accept GMF as a policy issue (1.53)
- More likely to trust scientific knowledge regarding GMF (1.21)
- Less likely to see GMF as posing a new risk (1.21)
- Less likely to regard the GMF risk as something dreaded (1.02)
- Less likely to see GMF as something interfering with Nature (1.73)
- Less likely to see GMF as morally unacceptable (1.49)
- Less likely to feel that GMF has risks with very severe possible consequences (1.56)
- More likely to trust experts and organizations (0.39 and 0.96)
- More likely to be willing consumers of GMF (1.22)
- Less likely to feel that GMF is risky (1.40)

These differences between the two groups could not be accounted for by differences in gender and age.

[14] . The numbers give differences in standardized scores.

Political preference, interest, technological pessimism and attitudes to GMF

The respondents in the public sample indicated which of 7 parties (+ “other”) they would currently vote for. Mean standardized values[15] in acceptance, policy attitude and consumer intention were computed for each party group, see Table 31. The differences were highly statistically significant. The F values were, for policy attitude, acceptance and consumer intention, respectively: 5.627 (7,389) $p<0.0005$, 4.682 (7,388) $p<0.0005$ and 4.700 (7,391) $p<0.0005$. These low p values are of course largely a function of the large sample size. It is more interesting to look at the span of standardized means in Table 31, which depicts a very dramatic variation between the extremes. At one end, we find supporters of the Liberals and Conservatives who were positive (relatively speaking) to GMF, at the other extreme the supporters of the Environmentalist Party who were very negative. The large social democratic block occupied a position in the middle of the range.

Table 31. Mean standardized values in three variables for supporters of the seven dominating parties in Swedish national politics.

Party	Policy attitude	Acceptance of GMF	Consumer intention
Environmentalists	-0.58	-0.57	-0.63
Center Party	-0.40	-0.17	-0.24
Left Party (communists)	-0.18	-0.22	-0.23
Christian Democrats	-0.17	-0.07	0.06
Social Democrats	0.05	0.03	-0.01
Conservatives	0.45	0.36	0.36
Liberals	0.37	0.52	0.45

It is important to stress that the political dimension correlated so strongly with attitudes across parties only partly coincided with the traditional left-right dimension. The Center Party, for example, is considered to be “non-socialist” in Swedish politics, and the Christian Democrats are decidedly so. Yet, the Social Democrats came out as more positive to gene technology than these two non-socialist parties. The Environmentalists often support socialist policies, but not always, and they are not adherents of traditional socialist thinking. The dimension of Table 31 can be best thought of as a dimension reflecting the attitude to economic growth and technology. This sort of variability of opinion is commonly found in other conflicts over technology, such as the siting of a nuclear waste repository [125] .

It may also be noted, in this section, that an analysis was done to define “the engaged public”, in the manner of thinking used in the latest Eurobarometer report on biotechnology [37] . There were 3 questions measuring interest in gene technology, its risks and benefits. However, relations to attitudes were very weak (see Table 32), as they seem to have been also in the Eurobarometer study. The political dimension was a much more powerful explanatory variable.

Another notion mentioned in the literature is that of technological pessimism [140] . One

[15] . 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 to be “very large” [11] . Note that the present span from Liberals to Environmentalists is much larger than that.

question in our questionnaire asked about the role of technology for the environment. It was correlated with the three attitude dimensions, see Table 32. The general pessimism factor had some promise in accounting for GMF attitudes, while interest did not. Siegrist found similar results with a scale measuring the value of Nature [85] .

Table 32. Correlations between attitudes to GMF, interest and technology pessimism.

Attitude dimension	Interest	Pessimism
Policy attitude	0.053	0.171***
Acceptance of GMF	-0.051	0.274***
Consumer intention	0.005	0.236***

Discussion

Representativeness

Public

The present response rate was somewhat lower than in several previous studies with equally long questionnaires. We have noted a tendency towards lower response rates over a 20-year period. One reason may be that the percentage of immigrants is steadily rising in the population, now about 15 percent. Linguistic problems may make it hard and unattractive for them to respond to long questionnaires.

In the present sample, 12.2 percent had names of non-Swedish origin. The response rate in that sub-sample was 30.3 percent, as compared to 48.9 percent in the rest of the sample. Since some people with a non-Swedish name are born in the country and speak perfect Swedish[16], the response rate of 30.3 percent is probably an overestimate of the likelihood that immigrants will take part in a study of the present type. The factor of increased immigration can be expected, hence, to decrease over-all response rate at least by 2-3 percent but other factors probably have the main responsibility of the drop from about 60 percent response rate in previous work. The length of the questionnaire is hardly a likely explanation since previous work also used long questionnaires and international research on that question suggests that the length of the questionnaire is not a major determinant of response rate [46] . Mailed surveys usually give a somewhat lower response rate than face-to-face interviews [41] , but the difference seems to be decreasing [47] . The cost of face-to-face interviews, per question, is usually prohibitive when a very large number of questions are needed to map the pertinent beliefs and attitudes, as in the present study.

In spite of the response rate problem, the present data showed that the respondents probably could be considered an approximately representative sample of the population with regard to important background data, with the exception of level of education. Demographic data accounted for only about 5 percent of the variance of important dependent variables. Analysis of the data also showed that the level of education was only weakly correlated with important response variables so there is reason to be optimistic also with regard to this factor. If any bias is present in the data, it probably means that the attitudes of the respondents are somewhat more positive than they are in the population as a whole.

[16] . Yet, there was a strong correlation between origin of name and self-rated knowledge of Swedish.

Some more information on representativeness can be obtained by comparing the results with Eurobarometer 58.0. Several qualifications must be mentioned, however.

- The Eurobarometer data were obtained in 2002, the present data one year later. This need not be an important factor, however.
- The Eurobarometer data were collected in in-home interviews, which probably means that a tendency towards social desirability response bias was present, in this context possibly producing a more positive attitude towards GMF and other biotechnology.
- It is well known that mailed surveys where a "doubtful" or "don't know" (DK) alternative is available will elicit more such responses than face-to-face interviews[17]. Interviewers are often instructed to cajole hesitant respondents into taking a stand. This is especially true with matters of high technical difficulty.
- A related issue emerges with regard to knowledge questions. In the present study, only two alternatives were presented and people were encouraged to choose "True" or "False". Only about 4 percent abstained from answering and were not counted as incorrect. In the Eurobarometer study, DK was a permitted alternative and was counted as incorrect. This may explain some of the differences between the two studies in this respect.
- The present data were collected with a response rate just below 50 percent. Inquiries about the Eurobarometer study failed to provide any information about their response rate in Swedish data.

In spite of these *caveats,* a comparison is of interest in 4 cases, where the same attitude statements were used in both studies, see Table 33. The present DK data are based on selections of the mid response alternative "doubtful", a practice with some research support [70] .

Table 33. Comparison of present and Eurobarometer 58.0 data on 4 attitude statements, percent.

Statement	Percent "agree"		Percent "Don't know'	
	Present data	Eurobarometer data	Present data	Eurobarometer data
I would buy GMF if it contained less fat than usual food.	12.6	22.0	21.1	5.6
I would buy GMF if it were produced in a more environmentally friendly way than usual food.	21.5	42.0	27.3	11.6
I would buy GMF if it contained less pesticide residues than usual food.	29.0	45.0	27.9	12.3
I would buy GMF if it tasted better than usual food.	23.2	32.0	24.7	8.9

[17] . When an explicit DK alternative is used, there will usually be a much larger number of respondents who choose it, as compared to the number who simply skip a question [80; 81] .

The expected difference with regard to DK answers occurred, and was large[18]. If the DK's can be divided evenly between Agree and Don't Agree, we observe a good agreement between present data and the Eurobarometer data in two cases, somewhat worse in two others. The two items with sizeable percent agreement with the Eurobarometer study were both concerned with generally embraced values such as being against pesticides and for the environment. It is possible that a social desirability bias was at play in the in-home interviews, as it often is. Hence, it is reasonable to assume that the present data give a truer picture of the public's opinion.

About 35 percent of the respondents in the present study answered, to the question about their knowledge of these topics, that it was very small or non-existent. The Eurobarometer data show – see Table 33 – that only about 10 percent said they did not know enough to answer the questions singled out here for comparative purposes. The DK proportion was about 25 percent in the present data, in much better agreement with self-rated knowledge. It is therefore very likely that the interviewers in the Eurobarometer study exerted some more or less subtle pressure on the respondents to take a stand. It is quite noteworthy that the data presented by the Eurobarometer report on acceptance of various statements may contain about 50 percent consisting of respondents who really felt that they did not know how to answer the questions. Such responses may of course still contain some information, but it is debatable how much value it has [53; 84] . At any rate, this issue needs more critical analysis and discussion.

It is particularly interesting that the present group was more knowledgeable than the Eurobarometer sample on 4 of the 6 fact questions, see Table 22. This may be the result of stronger self-selection among those who answered to the mailed questionnaire. They were probably more interested and hence were likely to have better knowledge. Persons that are more interested are found among so-called stakeholders, and they are more likely to take part in a survey with a societal interest [42] . At the same time, stakeholders tend to deviate from the population in being too extreme [111] .

Experts

There are a number of approaches to defining expertise [83] . One extreme type of definition would be to sample world famous researchers in the field or Nobel Laureates. It would obviously be difficult to obtain a sizable sample in that way. In addition, there is no support, as far as I know, for an assumption that leading researchers have different risk perceptions and attitudes as compared to well qualified academics in general in the field in question.

Although it can be seen as somewhat doubtful if all the experts taking part in the present study really were true experts of gene technology, the group as a whole gives a convincing yes in reply to that question[19]. Over-whelming majorities had a Ph. D. and were formally qualified at least at the level of associate professor ("docent"). Many had a large number of scientific publications. They had their academic basis in Natural Science or Medicine, with few exceptions. The fact that some of them still rated their level of expertise as fairly limited can perhaps be attributed to modesty prescribed by cultural values; at any rate, analyses of some of the data in relation to self-assessed level of expertise revealed few substantial relationships.

[18] . Very similar results were obtained in a study of nuclear waste attitudes, where it was also possible to compare interviews with response to a mailed survey containing some of the same questions in both cases [116] .
[19] A study by Savadori et al. [78] compared a group of the general population with "experts", some of which were only graduate students in biology. They did not state how many members of their group were students and how many were professors, nor how qualified the students were.

The response rate among those tentatively identified as experts was 60 percent. It should be noted that 16 of the respondents indicated that they were not gene technology experts; their data has not been used in the analyses of the present report. It seems likely that 60 percent is an underestimate of the response rate among the true experts of gene technology.
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Morality

The moral aspect was throughout quite important. It was a driving factor behind attitudes, or overall assessments, of the 10 types of gene technology studied. However, different kinds of gene technology were assessed in different ways as to morality. The use of gene technology in the food industry was judged as morally less acceptable than for medical use, and changing the genes of plants was more acceptable than doing the same in the case of animals. In human reproduction, the most "unnatural" kind of technological intervention – "test-tube babies" – was the least morally acceptable one. Moral judgment by itself could largely be accounted for by utility and risk; for experts utility was a clearly dominating factor in moral judgments. Medical applications were judged as more morally acceptable when applied to people living today than to coming generations.

Three principles can be discerned behind these results on morality judgments:

- Utility. What is useful is seen as morally correct.
- Risk. What is risky is seen as morally incorrect.
- Naturalness. What is "normal" and "natural" is seen as morally correct.
- Humanness. Animals are more similar to humans than plants are; hence, it is morally less acceptable to modify their genes.
- It is less acceptable to modify genes of coming generations than the present one, perhaps because people living now can have some influence over what happens to them.

These are tentative suggestions. It is, however, likely that the judgments of moral correctness or incorrectness are rather shallow, cp. the high degree of determination by utility in the morality judgments made by the experts. It is possible that moral choice dilemmas would bring out more sophisticated or at least multidimensional types of moral judgments and considerations. On the other hand, such dilemmas may not be of crucial importance for social policy, which is probably mostly determined by the kind of coarse dimensions studied here.

Attitudes

Gene technology as a whole was rated by the public sample in a moderately positive manner, but people indicated that they had little knowledge about it. Specific applications were rated in very diverse ways. Medical and forensic applications were well accepted while food industry applications were less so, especially gene modification of animals for food purposes. Genetic modification for food purposes was rated as the least accepted technology in a set of 18 technologies. It was seen as the most dispensable technology, morally unacceptable and risky. General and personal risks of GMF were close, suggesting that the hazard associated with genetically modified food was one, which was hard to avoid. It is an open question if these attitudes can change and, for example, if monetary incentives may counteract them and make people more willing to consume GMF [50] .

Townsend, Clarke and Travis [138] studied attitudes and risk perception of GMF in a context of other grave 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 a list of technologies. Yet, the finding by Townsend and Campbell [137] that 93 percent of an experimental sample willingly tasted an apple which was said to be genetically modified is puzzling. A much smaller percentage, 48 percent, said they would be willing to buy GMF in the future, but that percentage is still unexpectedly high. It would be interesting and important to follow up on these findings and check to what extent they are related to expectations of what is appropriate behaviour in an experiment of this type. After all, the participants had been recruited to take part in an experiment which, so were they told, would involve the tasting of apples.

The trends in attitude data from the experts were quite similar, but on a higher level throughout. They were much more positive to GMF, saw smaller risks and found it morally much more acceptable. The only exception is that they also found GMF to be less than indispensable.

Trust

Data on social trust showed that Swedish experts and authorities were rather highly trusted with regard to genetically modified food, industry and politicians less so. There was a demand for a more alert policy against the dangers of GMF. Experts showed similar trends, but exhibited throughout a higher level of trust. Frewer and Miles also found low trust for industry [35] , which they attributed to “food scares”, but low trust in industry may have deeper roots. Many people see industry as having a vested interest and giving priority to its own profits. Hence, basic political attitudes may play a role as they indeed did in the present study.

Models

Summing up the results of the model analyses, it was found that traditional factors used in many previous studies of risk perception, i. e. New Risk and Dread, had little or nothing to offer beyond the set of dimensions introduced here. Similarly, social trust – which is the dominating trust aspect studied in previous work – had a relatively weak influence as compared to the factor Trust in Science, defined in our previous work with regard to policy [106] . The four dominating factors behind attitudes to gene technology in general, to specific applications, and to GMF, which was studied in depth, were:

- Benefit
- Morally unacceptable risk
- Risk
- Lack of trust in Science

These factors accounted for a very large share of attitudes and risk perceptions, approaching a full explanation if error variance is taken into account[20]. Other work with a similar orientation is scarce so far, but a study by Saba and Vassalo is interesting [76] . They found that consumer intention was explained to 41 percent with their attitude models[21], considerably lower than the present results. Townsend and Campbell [137] found, in an experimental study, that risk factors explained 46 percent of the variance opf consumer intention. Recently published Eurobarometer work reported an even lower level of explained variance [38] .

In some cases, we also found associations with Social Trust, global risk ratings, New Risk and Dread. Emotional reactions were not found to be of importance, however, refuting the common assertion that "affect" is of major importance in risk perception [57] . This assertion is built upon terminological confusion, since "affect" is not used in its dominating sense in natural language (emotion) but as liking, or attitude [120] . Ideology is a more likely alternative as a basis for understanding risk perception and related attitudes [43; 118] .

Statements about the importance of various dimensions for "acceptance" are found in the report by Fjaestad et al [26] , being an analysis of Swedish Eurobarometer data, but no data analysis is described or otherwise reported. Among other things, they claim that risk is totally unimportant. This statement seems to build upon data from a single dimension of "riskiness to society". As noted above, this is a matter, which needs careful consideration of what risk dimensions are investigated. Hunt and Frewer, among others, have found very clearly that risk is an important factor in attitudes to GMF, just as in the present study [48] .

There is risk to society, but also personal risk and risk to people in general. These are all quite distinct risk aspects [16] . The traditional Psychometric Model risk factors are indeed weak as explanatory variables [96] but the theme of risk is much more complex and powerful than that. In particular, these researchers claimed that benefit was by far the most important factor. In our data, we have also found that benefit dominated the picture for consumer intention, but for policy acceptance, it was trust in Science, which was most important. Varying angles were made possible by our design which included about 3 times as many questions as the Eurobarometer design. The design we have used is built upon previous experience with new emerging dimensions in our risk perception research, and on a conviction that *consequences* of beliefs about hazardous technology need to be differentiated [99; 102] . Policy attitudes are one thing, consumer intention another, to take an example.

It is interesting to note that previous work on different trust measures was confirmed. A trust measure based on Likert type items of trust was somewhat more powerful as an explanatory variable than trust ratings, when the dependent variables were other Likert type measures.

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[20] . It is likely that another 15 percent, 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 [54] , may also be of importance. Other work has found some evidence for the importance of control and self-identity [132] . The effect, if any, of the latter variable was very weak, however. In future work, it would be interesting to study also questions about the nature/nurture controversy [91] .

[21] . They applied the Theory of Reasoned Action and the Theory of Planned Behavior [1; 2] , 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 would seem to be 30 percent or less [3] .

(This finding may be more general than that. In relation to risk ratings, the trust score based on ratings correlated about –0.25 while the Likert item based trust score correlated about –0.35, with both general and personal risk).

Experts

The results from the groups of experts showed very clearly that there were large, often dramatic, differences between experts and the public. These differences occurred in both specific and more general measures. Experts saw gene technology as more beneficial than the public did, and as more morally justified and less risky. Their judgments seemed to be more governed by benefits than any other factors. For example, the public's judgments of morality were driven by both risk and benefits, while the experts tended to reflect mostly benefits in their judgments. These results could not explained by restriction of range phenomena since the judgments made by the experts had enough variation to show large correlations in several other respects. The group of experts differed in gender and age from the distribution of the public sample but these factors could not explain the large differences between experts and the public.

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. However, the results suggest *why* that conclusion was suggested in the early work. Experts' risk judgments were not correlated with the traditional psychometric factors of New Risk and Dread as far as *general* risk was concerned. These were the factors studied in the seminal work of Fischhoff et al. [25] . The present data 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, i.e. morality, interfering with Nature and severity of consequences. The correlations between risk judgments and trust scores were quite similar for experts and the public, also supporting the thesis advanced elsewhere that experts and the public give risk judgments, which are qualitatively similar even if their levels differ [107] . There is of course a huge difference between experts and most members of the public when it comes to knowledge, but this "knowledge gap" does not tell the whole story of the differences between the two groups, as argued by Hansen et al., by Frewer and by Dietrich and Schibeci [12; 29; 44] , and shown here.

Previous work on experts and the public has shown that experts were likely to judge risks as smaller when with regard to hazards within their area of responsibility [123; 124] . 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.

Risk vs. benefit

Gene technology risks were studied in several perspectives in the present report. One striking finding was that the risk of GMF was at the same level when rated as a personal or general risk. Previous work on the risk of genetic engineering showed, on the contrary, a clear difference between personal and general risk [117] . That could have been caused by differences in wording of the risk. However, anything we consume can be seen to be under control. A prime example is alcohol, where people typically give low ratings of personal risk and high ratings of risk to others [97] . It would be interesting to study risk perception under special conditions, such as explicit labelling of genetically modified food.

The Eurobarometer work carried out in Sweden has been claimed to show that risk has *no importance* for the attitude to GMF [26; 146] . It now seems clear that this statement, important if it were true, is incorrect. Gaskell et al. [38] give the most recent analysis of the Eurobarometer data, and risk does make an important contribution to the modelling attitude in their work The present results, see e.g. Table 21, show clearly that perceived risk does play an important role in attitudes to GMF. It is likely that the false impression produced by previous work in this respect is due to the paucity of appropriate measures of risk – the measurement of perceived risk can proceed in many ways and not all will show the true story of how risk influences attitude. It may be pointed out, in addition, that much previous work in other countries has shown that risk is important for GMF attitudes; see e.g. Rosita and Saba [73] . Risk is not the whole story, but it is an important part of it.

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 the technologies? This is a highly controversial issue, and psychologists have for decades argued, on good grounds, that people cannot give valid judgments of what influenced their behavior [66] . The issue obviously needs further research. Barlas [4] is perhaps the most recent contributor to the issue, and she found clear evidence that rated importance *did not give a valid picture of real reasons for choices.* People used the 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.

Some qualifications to these conclusions are called for. First, regression analyses of the specific applications of gene technology gave very low weights for risk. This is in spite of sizable correlations between risk and the over-all assessment of the applications. A similar result was found for the global assessments of gene technology as such. Correlated explanatory variables sometimes result in misleading conclusions if only standardized regression coefficients are taken into account.

Another possible explanation of these anomalous results is the choice of verbal definitions of the rating variables. The respondents were asked to rate to which extent a certain technology was "risky"[22] or even, with a more appropriate translation, "highly risky". It would be interesting to check on these items with different wordings, for example by replacing the term corresponding to "highly risky" with a less demanding expression.

Further comparison with Eurobarometer results

The pessimistic picture of public opinion painted by the Eurobarometer results may be largely a function of how questions were worded[23]. It is true that, relatively speaking, gene technology was sometimes rated very low in the present study, especially food industry applications. However, even in this case, only a minority definitely rejected the application, and in other cases, the share of clearly negative respondents was small. In the case of forensic use, it was almost zero. How could such differences arise? There are at least two important explanations.

[22] . In Swedish "riskfylld".

[23] . The issue is quite complex, since the Eurobarometer work may have involved one or several factors working in the opposite direction as well. See the discussion above about social desirability factors at play in face-to-face interviews, and the practices of cajoling hesitant respondents to take a stand.

First, some of the Eurobarometer questions were formulated in a highly technical manner, using such terms as stem cells without further explanation. And an explanation would be quite difficult to provide, given that it must be both brief and correct. In the present study, we decided to avoid the term for this very reason.

Second, and more important, the Eurobarometer questions introduced, in a somewhat subtle manner, considerations, which seem to have guided the respondents in a negative direction. Take forensic applications as an example. The Eurobarometer researchers have claimed that there is not even a majority in Sweden in favour of forensic applications of gene technology [26] . That claim is based on responses to the following statement:

> "I would support that the police had access to genetic information of people[24] as a help in their work to solve crimes".

Compare with the present formulation:

> "Gene technology can be used by the police in their work to find who has committed a certain crime (DNA analysis). What is your opinion about police using that technology?"

Note that the Eurobarometer formulation suggests that use of a large "gene bank" which the police would have regular access to. This is very different from using genetic information in investigating single persons and a specific crime. The gene bank scenario is hardly a realistic one, while the use of DNA analysis is routine and apparently quite well accepted.

Conclusion

Gene technology gave rise to very varied reactions, depending on field of application. Medical applications were quite acceptable, a forensic application even more so. Genetically modified food ranked very low in trust and popularity, in spite of very few having had personal negative experiences of it.

Different demographic strata had similar views. Personality factors were probably of little importance as well. Moral issues played a very big role. In addition, trust, or lack of trust, in Science *per se* was of great importance, and so was perceived benefit. Gene technology is, thus, by no means rejected by the public as a whole. These results are in good agreement with previous work of ours, based on extensive population samples and re-analyzed for the purpose of the present project [117] .

In the present study, experts were much more positive than members of the public to gene technology including 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.

[24] . In Swedish: ”människors genetiska information”, which can be understood as the information people have about genetics, not information about their genetic properties. Possibly, many respondents still understood the statement as it was intended but some (perhaps many) may have understood it as it was formulated and could hence have missed the point altogether. Why should the police have access to people's knowledge?

Acceptance of GMF is unlikely in the short or medium time run. Social trust is indeed low, but on the other hand, social trust is not a crucial factor according to the present results. People doubt, instead, that Science knows well enough the crucial properties of GMF, and beliefs about the dangers inherent in tampering with Nature are widely spread. In addition, there are grave moral doubts as to the appropriateness of gene modification.

The conclusions reached in other research are partially supported here, but new aspects appear and explained variance doubled as compared to Eurobarometer work cited in the introduction.

In sum:

- 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.
- In both cases, 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 gene technology.
- In contrast, the received view on risk perception, which emphasizes emotion (dread, affect) and ignorance (new risk) was not supported by the present data.
- The experts studied here differed sharply from the public as to the *level* of perceived risks and benefits, but not with regard to quality or *structure* of their ratings. In addition, their risk perceptions in other areas were much like those of the public.

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