The stability of risk and benefit perceptions: a longitudinal study assessing the perception of biotechnology

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Abstract

The study of public perceptions is considered to be important for making sound policy decisions since the public decides which products will enter and sustain in the market. Stability of public perceptions is important for policy makers, only if public attitudes and perceptions remain constant policy-makers will be able to take them into account. The aim of the present study was to examine the stability of participants' risk and benefit perceptions of gene technology over a period of two years. In spring, 2008 and in spring, 2010, the same sample of participants filled out an identical questionnaire. Results of structural equation modelling show that risk and benefit perceptions of gene technology applications are moderately stable (r = 0.5 – 0.7). Furthermore, results show that people distinguish between medical, plant and food applications, and applications involving animals when evaluating the risk of gene technology. When evaluating the benefits, participants also take consumer-related benefits into account, such as enhancement of functional properties. Results of the present study suggest that risk research should regularly examine people's risk perceptions in order to gain a clearer picture of the dynamics of people's perception and preferences not only of novel technologies but also of **entrenched** technologies.

Key words: Stability – Risk perception – Biotechnology – Longitudinal

Introduction

There has been an increased interest in involving the public in decision-making processes about science and technology, especially with regard to issues concerning the management of environmental and health risks (Fife-Schaw and Rowe 2000; Horlick-Jones et al. 2006). Public involvement in policy matters is rooted in diverse reasons, but generally they are considered to derive from either a recognition of basic human rights regarding democracy and procedural justice (Perhac 1996) or simply from a practical point of view that implementing unpopular policies may result in widespread protest and reduced trust in

governing bodies (Kasperson, Golding, and Tuler 1992). However, the extent to which members of the public are interested and capable of being involved effectively in governance varies widely (Smiley, de Loe, and Kreutzwiser 2010). Since publics' perception of risk can compel or constrain political, economical, or social action to address particular risks (Leiserowitz 2006) studying publics' perceptions of risk **over an extended period of time (e.g. a period of one to three years)** is crucial for making sound policy decisions. However, there is a lack of studies that examined the stability of lay people's technological risk perception **over such an extended period of time**. **In furtherance to provide an insight of public perceptions of gene technology over an extended period of time the present study will investigate risk and benefit perceptions over a period of two years.** Lay people's perception of risks and benefits influences consumers' behaviour and decision-making, the acceptance of the technology, and the willingness to buy novel products (Siegrist 2000). Only when **public** attitudes and perceptions **relatively stable** over time preferences pronounced by the public be taken into account by the government (Siegrist and Visschers 2012). There are few studies that examined the stability of people's risk and benefit perceptions, however. To the best of your knowledge the stability of attitudes towards gene technology has not been examined, however. **Gene technology is a modern tool of biotechnology providing the opportunity to overcome shortcomings of traditional breeding methods e.g. long selection processes. Gene technology can be seen as a continuously developing tool of biotechnology which itself is an entrenched technology.**

Longitudinal studies on technological risk perception

The most important longitudinal studies on biotechnology perceptions are the studies conducted for the Eurobarometer. **However, it should be noted that not that the Eurobarometer studies use a repeated cross-sectional study design meaning that not the same group of people had answered the questions in the different years.** The first Eurobarometer study on biotechnology was conducted in 1991, followed by studies in 1993,

1996, 1999, 2002, 2005, and 2010. **The Eurobarometer** is based on a representative sample of 25,000 respondents, approximately 1000 in each EU member state. Results of the last Eurobarometer study in 2010 show that there are still **deeply rooted** views on GM food (Gaskell et al. 2010). **The Eurobarometer studies** provide a general overview about **people's** perceptions of biotechnology, knowledge, and preferences **and show** that people's perceptions change over time (Gaskell et al. 2010). Each Eurobarometer survey was further developed; more countries joined the European Union and further questions were added. The structure changed and the content evolved over the years and, therefore, it is rather difficult to directly compare the results over time. Due to the fact that **a cross-sectional design was** used in th**e Eurobarometer** studies, it is impossible to assess **the stability of individual's responses over time. Acceptance or risk perception of nuclear power seems to be the only technology for which studies with a longitudinal panel design exist.**

Several studies have examined the impact of a nuclear accident on people's perception and attitudes towards nuclear power utilizing a within subject design (Eiser, Spears, and Webley 1989; Verplanken 1989; Lindell and Perry 1990; Siegrist and Visschers 2012; Visschers and Siegrist 2013). Participants' attitude towards nuclear power was investigated before and after the Chernobyl accident in 1986 employing questionnaires (Eiser, Spears, and Webley 1989; Verplanken 1989; Lindell and Perry 1990) and a mixed method design of questionnaires and interviews (Verplanken 1989). These studies focused on mean changes of perceptions and attitudes towards nuclear power and not on associations between the two measurement times. Since there was a nuclear accident between the two measures that may have shaped people's responses at the second and following measurement times no assessment in regard to the stability of people's risk perceptions or acceptance of a technology can be made.

Associations between two or more measurement points were investigated after the Fukushima disaster in 2011 (Siegrist and Visschers 2012; Siegrist, Sütterlin, and Keller

2014). Acceptance, perceived risks and benefits and trust related to nuclear power stations were assessed 5 months before and directly after the disaster employing a within subject design (Visschers and Siegrist 2013). Visschers & Siegrist (2013) show that the acceptance and perceptions as well as trust were more negative after the accident than before. However, perceived benefits before the accident correlated with perceived benefits after the accident (r = .52). Additionally, the relations of the determinants for people's acceptance of nuclear power did not change after the accident indicating stability over time. Even after a severe accident, the public may still consider the benefits as relevant, and trust remains important for determining their risk and benefit perceptions (Visschers and Siegrist 2013).

Mean changes and correlations between three measurement points were also investigated in relation to the Fukushima accident (Siegrist and Visschers 2012). Results of this survey research show that the accident had a negative impact on the acceptance of Nuclear power. However, high correlations were observed between all three measurement points and the mean changes were only moderate. Participants showed rather stable attitudes towards nuclear power (Siegrist and Visschers 2012).

Perception of biotechnology applications

There are many studies that have investigated people's perceptions of biotechnology (see Lusk et al. (2005) and Frewer et. al (2013b) for a review). One of the main findings is that perceived risks and benefits are key factors in the acceptance of biotechnology (Frewer, Howard, and Shepherd 1997). **In their review and meta-analysis Frewer and colleagues (2013) suggest that risk and benefit perceptions associated with all aspects of genetically modified agri-food application have been increasing over time.**

It has been shown that people have varying attitudes towards biotechnology applications in different fields (Connor and Siegrist 2013, 2010). Medical and non-medical applications are perceived differently; medical applications are perceived to be highly beneficial, and consumers see considerable value in the development of new medicines to combat disease

e.g. (Frewer, Howard, and Shepherd 1997; Connor and Siegrist 2010; Magnusson and Hursti Koivisto 2002). However, it has also been shown that people disapprove of the use of human genetic testing and may have moral objections towards the manipulation of human DNA (Pardo and Calvo 2008). Thus, people not only distinguish between different categories of applications, but also within the same category of application the perception varies (Frewer, Howard, and Shepherd 1997).

Furthermore, Frewer et al. (1997) investigated people's perceptions of biotechnology applications including genetically modified (GM) microorganisms, plants, human DNA, and animals. The results of this study show that applications involving microorganisms and plants were perceived to be beneficial, advantageous, and necessary, whereas applications involving human DNA and animals were perceived to be unethical, harmful, and dangerous (Frewer, Howard, and Shepherd 1997). Another distinction is made between first-generation GM crops and second-generation GM crops. First-generation GM crops are associated with producer-related benefits like herbicide tolerance, insect resistance, and pathogen resistance. Although first-generation crop plants are seen to be useful, they are also perceived as risky and are not accepted (Gaskell 2000). Second-generation crop plants deliver consumer-related benefits, e.g. rapeseed with augmented functional properties. A study by Hartl and Herrmann (2009) investigated whether German consumers also rejected second-generation GM foods. Two different types of rapeseed, one that contains functional compounds such as long-chain omega-3 fatty acids and one that contains phytosterol, which translate into increased quality of oil derived from the crop, were investigated (Hartl and Herrmann 2009). Results of this study show that most participants were not interested in GM rapeseed oil. However, output traits **such as enrichment of oilseed rape with omega-3 fatty acids** increase the probability of the purchase of GM rapeseed oil (Hartl and Herrmann 2009).

A number of studies showed that perceived benefits and perceived risks are the main factors influencing acceptance of gene technology (Siegrist 2000; Prati,

Pietrantoni, and Zani 2012; Tanaka 2013). Consumers who perceive tangible benefits associated with this technology are more likely to accept gene technology compared with consumers who do not associate benefits with this technology. Risk perception was also found to influence attitudes towards gene technology. Results of these studies suggest, however, that benefit perception is a stronger predictor for attitude or acceptance than perceived risks.

Rationale of the present study

Numerous studies about lay people's risk perception have been published in recent years (Earle 2010; Frewer et al. 2011; Frewer et al. 2013b). **With the exception of nuclear power, little is known how stable people's risk perceptions are.** Recent studies on attitudes about nuclear power showed stable attitudes (Siegrist and Visschers 2012) and stable determinants for people's risk perception (Visschers and Siegrist 2013) **even after a nuclear accident. It is unclear whether the results observed for nuclear power can be generalized to other technologies, however.** It was the aim of the present study to investigate how stable perceptions of **gene** technology applications are. **Gene technology is an entrenched technology for which people had a chance to develop stable attitudes.** For technologies that are either well-known or well-established, we **expect strong correlations for the risk perception, and the benefit perceptions, respectively.** People may have acquired basic knowledge or have a fundamental underlying preference. **Gene** technology is a continuously developing technology, with newly emerging strains in the agricultural, food, and medical sectors. However, considering that **gene technology is a tool of the well-entrenched technology biotechnology** it is likely that people may have formed **well-founded** attitudes. The dimensions people use to make their evaluations of **gene** technology and its applications have been investigated at length throughout the last years; perceived risks and benefits are the important determinants (Frewer et al. 2013a) and will, therefore, serve as the subject matter for the present study. We do not expect great changes in people's risk and benefit perceptions

of biotechnology applications due to the knowledge and familiarity people may have acquired over the past years. This would be also in line with research conducted on nuclear power (Eiser, Spears, and Webley 1989; Verplanken 1989; Lindell and Perry 1990; Visschers and Siegrist 2013; Siegrist and Visschers 2012). We, therefore, hypothesise that people's risk and benefit perceptions of **gene** technology **are stable over a period of two years. The aim was to examine whether perceptions related to gene technology are as stable as reported for nuclear power or whether for a technology that is perceived as less risky compared with nuclear power (Flynn, Slovic, and Mertz 1994) risk and benefit perceptions are less stable.**

Methods

Participants

Data for the present study come from two surveys conducted in spring, 2008 and in spring, 2010 in a German-speaking Swiss community (Reckenholz) where nearby field trials with GM wheat plants were carried out. The survey started when the first plants were visible. In 2008, people were asked to fill out a questionnaire, and additionally people were asked whether they would agree to fill out a questionnaire in two years' time. The **questionnaire was returned by 999 persons and the** response rate was 42.5%. In 2010, these people received the exact same questionnaire, with two additional questions. The response rate was 62.4%. Only participants for whom the data for gender and birthday were the same in both years and had complete data sets were considered for the analyses. In total, 534 **(53.5%)** people fulfilled these requirements: 42% (n = 226) were female and 58% (n = 308), male. The mean age was 57 years (SD = 15). Only people 18 years or older were allowed to participate in the study. The self-reported educational level ranged from lower primary school (2%, n = 11), secondary school (7%, n = 37), professional school (45%, n = 244), high school (19 %, n = 103), to technical universities and universities (25%, n = 133). Fourteen participants (2%) did not report their educational level.

Questionnaire

The questionnaire was designed to measure risk and benefit perceptions of gene technology applications. For all questions, six response categories were used, with the two extreme points verbally depicted (1 = no benefit/risk, 6 = high benefit/risk). Twelve applications covering medical, nutritional, agricultural, and industrial, as well as animals, plants, and microorganisms, **were created based on a previous study conducted by Connor and Siegrist** (2010). These items are presented in Table I and Table II. Furthermore, socio-demographic characteristics such as gender, age, and level of education were recorded.

Data Analysis

In order to test the relationship between the repeated measures and the pattern of change over time, we applied structural equation modelling procedures (SEM). Firstly, SEM was applied to test the plausibility of the postulated **correlational** model. Parameters were estimated using the statistical software package AMOS 18. To calculate the SEM coefficients, the maximum likelihood method of estimation was applied. The assessment of the model fit was based on the Comparative Fit Index (CFI), the residual values, the root mean square error of approximation (RMSEA), and the meaningfulness of the model (Hu and Bentler 1995). CFI values higher than .90 represent an acceptable fit and values higher than .95, a good fit (Byrne 2010). RMSEA values lower than .08 also represent an acceptable fit and values below .05, a good fit (Byrne 2010). Parameters were added in consideration of substantive meaningfulness and parsimony. The significance level for hypothesis tests was set to $\alpha = .05$.

The analyses were conducted in three steps. First exploratory factor analyses were performed for each latent variable to test whether the postulated measurement model was appropriate for the data from the first wave. After establishing the measurement model, the observed data of both waves were fitted to the hypothesised model. The measurements components and the structural components were combined in one model. We also correlated the error terms of both measurement times in order to achieve reliable estimates of the

regression paths (Jöreskog 1979). The error terms for the same measurement tend to correlate when investigating the same sample, which applies to this longitudinal study. For example, the measurement error of an item that belongs to the latent factor "medical applications" in 2008 is related to the measurement error of the identical item in 2010. On account of simplicity, the correlations between the error terms of the indicator variables are, not shown in Figures 1 and 2.

The modification indices were used to identify parameter additions that would contribute to a better-fitting model. Lastly, the invariance of all factor loadings and correlations of both models (risk and benefit) was tested across the two measurement times.

Only participants who answered all questions were included for testing the model. Participants with incomplete data sets were deleted. Data analysis was based on 491 participants: 42% (n = 205) were female and 58% (n = 286), male.

Results

Model development

An exploratory factor analysis with principle components as the extraction method and oblimin rotation was used to detect the underlying structure of participants' risk and benefit perception of the 12 biotechnology applications. Results show that people distinguish between the applications. All applications can be found in Table I (benefit) and Table II (risk). For benefit, one component includes medical applications. The second component includes food and crop applications. The third component consists of applications that include animals. The last component includes applications where different products are improved independently of the type of application or the organism involved. All groups of applications have rather high correlations between the two measurement points: $r > .60$ (Table III). Between 2008 and 2010, people's benefit perception has only changed a little (Table III).

For risk, people distinguish between three different types of application. Similar to the benefit components, one component consists of the medical applications. The second component includes all food- and crop-related applications, and the third component includes all applications where animals are involved. People's risk perception of medical applications and food and crop applications increased from 2008 to 2010 (Table III), but the effect size is very small. The correlations of perceived risks in 2008 and 2010 are substantial **(.49 < r < .59)**, but a bit lower than the correlations for the benefit assessments.

General model of benefit perception

The initial model for benefit is shown in Figure 1 and represents the four factors, which are allowed to correlate with each other at both measurement times. Furthermore, Figure 1 also shows **the correlations and the path coefficients.** The initial model for benefit resulted in a suboptimal fit: $\chi^2 = 925.8$, df = 224, CFI = .92, RMSEA = .08. However, the modification indices suggested allowing additional correlations for both years between the error terms of the observed variables V9 and V10. This seems plausible as both applications involve genetically modified animals. Furthermore, the modification indices suggested adding a correlation for both years between the error terms of V6 and V11; both applications are improvements for people with allergies. The last added correlation is between the error terms of V2 and V3 for both years; these applications involve genetically modified microorganisms. All of these added correlations seem plausible. The initial and the revised model were nested, and the difference in χ^2, thus, was used for calculating the improvement in fit of the new model. For the revised model, χ^2 has dropped significantly ($\Delta\chi^2 = 266.5$, Δdf = 6, $p < .001$) and improved the overall fit ($\chi^2 = 659.3$, df = 218, CFI = .951, RMSEA = .064). The final model is presented in Figure 1. Estimates along each path represent standardised coefficients, which represent effect sizes. The structural model explains 54% of the variance in benefit perception of the improved food products. Furthermore, 48% of the variance is explained in the benefit perception of food and crop plant applications, and 53% of the variance is

explained in the benefit perception of applications involving animals. For the medical applications, 46% of the variance is explained by the structural model.

General model of risk perception

The initial model for risk is shown in Figure 2 and represents the three factors, which are allowed to correlate with each other at both measurement times and **the** path coefficients. The initial model for risk resulted in a good fit: $\chi^2 = 1004$, df = 231, CFI = .93, RMSEA = .083. However, the modification indices suggested allowing additional correlations for both years between the error terms of the observed variables V2 and V3, V2 and V1, V8 and V9, and V6 and V11. This seems plausible as V2 and V3 both concern genetically modified microorganisms. This is also true for V2 and V1. V8 and V9 are applications, which concern improved food products, and V6 and V11 are applications especially for people with allergies. The initial and the revised model were nested, and the difference in χ^2 was again used for calculating the improvement in fit of the new model. For the revised model, χ^2 has dropped significantly ($\Delta\chi^2 = 277$, Δdf = 8, $p < .001$) and improved the overall fit ($\chi^2 = 727.2$, df = 223, CFI = .956, RMSEA = .068). The final model is presented in Figure 2. Estimates along each path represent standardised coefficients, which represent effect sizes. The structural model explains 26% of the variance in the risk perception of food and crop plant applications. Furthermore, 23% of the variance is explained in the risk perception of applications involving animals. Twenty-four percent of the variance is explained in the risk perception of medical applications.

Invariance of the measurement models

The invariance of the measurement model was tested by comparing the baseline model with two constrained models. In the first model, all factor loadings were constrained to be equal. In the second model, correlations between the error terms, correlations between latent variables, and measurement weights were constrained to be equal for the two measurement points. Table IV shows the results for both the risk and benefit models. For both models, results show that

constraining the factor loadings at both measurement times to be equal does not result in worsening of the overall model fit. In other words, the factor loadings are equal across the two measurement points. Whereas, additionally constraining the structural paths of the CFAs to be equal results in worsening of the overall model fit. This implies that the correlations between the factors were not equal in 2008 and 2010.

Discussion

Since there has recently been increased interest in involving the public in decision-making processes (Rowe and Frewer 2000), it is necessary to evaluate how stable people's preferences towards **emerging technologies are**. Only when attitudes and perceptions are stable over time can governance and other policy-making agencies take preferences pronounced by the public into account (e.g. when deciding about the allowance of **gene** technology in food production in Europe or the ban of nuclear power). The present study is, to the best of our knowledge, the first longitudinal study assessing the stability of risk and benefit perceptions **of various gene technology applications** over two years.

Results of the present study show that people's risk and benefit perceptions of **gene** technology applications differ. When assessing the risks of **gene** technology applications, people take the genetically modified organism into account as well as the field of research from which the applications derive from. Confronting people directly with a set of applications where all aspects were considered (the type of application as well as the organism involved) results in participants distinguishing between medical applications, food and crop plant applications, and applications involving animals. Our results concur with results found in other studies, where people were confronted with applications involving GM microorganisms, plants, and human DNA (Connor and Siegrist 2010, 2013), as well as with studies that show a differentiation between medical and non-medical applications e.g. (Connor and Siegrist 2010; Frewer et al. 2013a). **Results of the present study also show that** when people evaluate the benefits of **gene** technology, they perceive applications that

represent an improvement of food products independent of all other applications, regardless of the type of application or the organism involved. These applications are comparable with the second-generation GM crop plants, which deliver consumer-related benefits such as the enhancement of functional properties (Hartl and Herrmann 2009). This, furthermore, indicates that people may think of themselves when evaluating benefits and therefore, perceive benefits in a more detailed way (Bredahl 1999). In contrast risks tend to affect a wide range of people and not just an individual (Fleury-Bahi 2008). Therefore, the distinction of **gene** technology applications on an individual level as present when evaluating the benefits is not present when evaluating the risks. Our results show that applications are perceived differently regarding risks and benefits, and are concurrent with other studies, although most of these studies do not include both dimensions: the field of application and the organism being manipulated (Frewer, Howard, and Shepherd 1997; Connor and Siegrist 2010; Frewer, Howard, and Shepherd 1995; Frewer et al. 1997; Hoban 1998; Magnusson and Hursti Koivisto 2002).

By applying structural equation modelling, we show how stable risk and benefit perceptions of **gene** technology applications are over a period of two years. Results of the structural equation modelling suggest that the perception of risks and benefits for all groups of applications are moderately stable ($r = 0.5 - 0.7$) **compared to high correlations ($r > 0.7$) found in a study on nuclear power, which has been conducted before and after the Fukushima accident (Visschers and Siegrist 2013)**. People's risk perception is less stable than their benefit perception of **gene** technology applications. This is not surprising since the benefits are clearly stated for the applications, i.e. 'Genetically modified micro-organisms that produce vaccines against infectious diseases.' However, the risks are not stated and people have to imagine the associated risk themselves, which means that they either need to have the necessary knowledge to estimate the risks or they need to rely on certain cues for providing their answers. It seems likely that participants relied on the affect heuristic (Finucane et al. 2000; Slovic et al. 2002) for providing their risk estimates. In other words, the affect heuristic

may have been more important for participants' risk perceptions compared with participants' benefit perceptions. **Since data collection took place in the vicinity of the field trials with genetically modified plants another possible explanation could be that people actively looked for information and therefore gained more knowledge about risks associated with gene technology. This may have constituted to the less stable risk perception between the two measurement points.** Results of the present study are also in line with Slovic's (1995) idea that people construct their preferences when they fill in a questionnaire. This could be a plausible explanation for the low correlations observed for risk perception. Participants may have been influenced by different associations across the two measurement points and as a result the measured risk perceptions had rather low correlations.

Only a few studies have directly addressed possible changes of preferences when people were confronted with exactly the same decision at two different time points. Some studies examined the test-retest reliability over a month and a year and found that between one quarter and one third of participants expressed different responses when confronted with the same choice twice (Camerer and Kunreuther 1989; Schoemaker and Hershey 1992). Other studies, which measured risk attitudes in different sessions, found small positive ($r = 0.36$) correlations over a one-year interval (Wehrung, Maccrimmon, and Brothers 1984). Higher correlations ($r = 0.45$) of risk attitudes were found in a study investigating 1000 Dutch farmers (Smidts 1997) over a one-year period. The results of laboratory experiments with a Danish population sample, where preferences for financial gains were investigated, show that the preferences were quite stable over seven-month and seventeen-month periods (Harrison et al. 2005; Andersen et al. 2008). Rather stable associations between several measurement points have been shown in a Swiss sample evaluating nuclear power before and after the Fukushima accident (Visschers and Siegrist 2013; Siegrist and Visschers 2012). It has to be noted, however, that the context within which people had to make their decisions differed between these studies and the present study. In contrast to afore mentioned studies,

participants in the present study had to evaluate biotechnology regarding perceived risks and benefits on predefined applications of which most stated the benefits. Compared with the previously mentioned studies the test-retest coefficients observed in our study correlate moderately.

Benefit perceptions were more highly correlated than risk perceptions. The applications and the stated benefits did not change in the description between the two years, which allowed people to assess exactly the same application. This is slightly different for people's risk perceptions. Our results show that people's risk perceptions are less stable than their benefit perceptions. Several factors may have played a role resulting in less stable risk perceptions. Firstly, people had to conceptualise the risks associated with **gene** technology themselves and may have relied on the affect heuristic for their evaluations. Secondly, due to the start of the scientific field trials with genetically modified wheat plants in 2008 and the randomly selected sample of the surrounding area participants of the present study were consequently highly aware of the field trials and biotechnology. Additionally, at the beginning of the field trials in 2008 the high level of media coverage about **gene** technology and the field trials may have shaped people's risk perceptions at that time. In 2010 however, at our second measurement time, media coverage was low. In 2010, media coverage about the field experiments was comparatively low and as a consequence people would have had to actively search for information about **gene** technology. It may have been difficult for people to conceptualise the same or similar risks associated with **gene** technology when they were not directly confronted by a perceived threat resulting in less stable risk perceptions. **In addition, measurement errors and random variations, which can't be accounted for may have constituted to the results obtained.**

To the best of our knowledge, there are no comparable studies that have examined the stability of technological risks or environmental hazards perceptions over a period of two years. The question is, therefore, whether the results found for **gene** technology can be

generalized to other technologies. **Since gene** technology as a tool of biotechnology is not a novel technology, but rather a **constantly** developing technology **with new tools emerging especially in areas of gene sequencing techniques** (Mardis 2011). People seem to have relatively stable benefit perceptions of the applications but less stable risk perceptions. **Owing to the results obtained in the present study**, one could expect that for common, recognised, or well-established technologies, people's perceptions are quite stable (e.g. nuclear power). People are to a certain extent familiar with **such** technologies and have been able to form an opinion over time. Nonetheless, for novel and emerging technologies **(e.g. nanotechnology)**, people's perceptions can change with new implications or developments. It seems plausible, therefore, that risk and benefit perception of nanotechnology, for example, are less stable **compared to perceptions of gene technology**. **On a continuum from well established and entrenched technologies to novel and emerging technologies we expect gene technology to lay somewhere in between depending on the type of technological tool which is represented. In general gene technology encompasses both, dimensions of entrenchment and establishment but also dimensions of novelty and development we therefore do not expect as stable perceptions as for nuclear power but more stable perceptions than we would expect for nanotechnology.** In the case of novel technologies **e.g. nanotechnology**, or new environmental hazards, it is rather likely that people construct their preferences when responding to questionnaires (Slovic 1995), and that irrelevant information could strongly bias these constructions. When people lack knowledge about such novel hazards and do not yet know which dimensions to use when evaluating these novel hazards, they may presume dangers when being asked about possible risks, which could in turn influence their perceptions.

In order to inform policy makers about the developments and dynamics of people's perceptions and preferences future research should, regularly examine people's risk perceptions not only for novel technologies but also for constantly developing

technologies, which are often tools of well-known and established technologies. It is important that in the future research not only repeated cross-sectional designs are used, but that panel designs are used to examine changes in people's risk perceptions of various technologies.

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