The effectiveness of a medical treatment should not predict its risk (highly effective treatments can be either safe or risky), however, people's use of heuristic shortcuts may lead them to judge a link between effectiveness and risk, typically a negative correlation. A particular concern is that experts might use such a strategy and that this is unlikely to provide an accurate judgement. This large-scale field-based experiment compares expert-relevant and non-expert-relevant contexts, for both expert and public judgements of risk and effectiveness in the context of blood-transfusion medicine. Postal questionnaires were distributed to anaesthetists (experts, N = 123) and a general public (non-expert) comparison group (N = 1153); half of the participants were cued with accompanying, general information about GM biotechnology and half received specific information about blood-product technologies. The blood-focussed information served to emphasise the medical-relevance of the questionnaire to the expert group. Regression analyses showed that generally perceived effectiveness predicted perceived risk for both experts and the non-experts, which suggests heuristic processing. However, although experts appeared to engage in heuristic processing for risk perceptions in certain circumstances, this processing is strongly affected by context. Experts who received the medically-relevant context rated perceptions of effectiveness independently of perceptions of risk, unlike those who received the GM context. This indicates a reduced reliance on a low-effort heuristic for experts given an expertise-relevant context. The results are considered in light of dual-process (rational- associative) accounts of reasoning.

Keywords: Expertise; Affect Heuristic; Risk perception; Context; Blood

Introduction

Do experts assess risk differently to non-experts? For many years it was believed that experts' risk perceptions were based on knowledge of mortality rates (there was a high correlation between actual number of deaths from hazards and expert-perceived risk). In contrast lay risk perceptions correlate with measures of affect including perceived dread of the hazard and only correlated moderately with actual number of deaths (Slovic, Fischhoff and Lichtenstein 1985). Although intuitively appealing, these findings have been challenged on the basis of research design (Rowe and Wright 2001). One problem is that expert groups have been small, and heterogeneous. For example, one study had 15 expert risk assessors including a lawyer, biologist and geographer (Slovic, Fischhoff and Lichtenstein 1985). One study which addresses these issues found overall little differences in risk perceptions between underwriters and a group of business students (Wright, Bolger and Rowe 2002). Underwriters were found to be slightly more accurate than than the students in estimating relative death rates, especially on tasks more similar to the context of their work, and expert accuracy was also found to positively correlate with years of experience (Wright, Bolger and Rowe 2002). Other research, however has found experts to have lower risk perceptions than lay people (Savadori et al. 2004).

The question, therefore, remains as to whether experts' knowledge alters the process of risk assessment within their domain of expertise. Prima facie it would be expected that experts would be less susceptible to contextual biasing forces and less reliant on heuristics. In addition, it is plausible that the greater knowledge of experts, and therefore familiarity with relevant hazards, would reduce perceived risk. It is known that experts and non-experts are equally susceptible to framing effects (Loke and Tan 1992), but it's possible that experts use of heuristics is more selective and effective than those of lay people (i.e. experience would

teach experts which strategies work and which do not) (Reyna 2004; Gätcher et al 2009). The present study investigated whether experts were more likely to use heuristics when judging risk and effectiveness in a non-relevant context than in an expertise relevant context. The premise being that cognitive resources can be conserved in low consequence circumstances. This would suggest that the use of risk judgement heuristics are contextually determined amongst experts. Following dual process models of decision making (Stanovich and West 2000), experts may be more likely to process information using 'System 1', which is characterised as being fast, automatic and associative in nature, when the context is irrelevant to their expertise and utilise 'System 2', the more effortful and cognitively intense system of processes when the context is relevant to their expertise. Given that the use of heuristics is theorised to occur primarily within 'System 1', experts would be expected to be more likely to utilise heuristics when in context irrelevant situations than in context relevant situations where 'System 2' is likely to be engaged and overrides potentially misleading heuristics.

The 'affect heuristic' is a key heuristic, observed when a judgement for perceived risk is negatively correlated with perceived benefit (Slovic et al. 2007). Real world hazards can suggest a link between risk and benefit in people's minds as they may believe that some things are high-benefit, low-risk (e.g. antibiotics) and some are low-benefit and high-risk (e.g. smoking), which may suggest that there should be an inverse risk-benefit link (Slovic et al. 2007). However, in reality the two characteristics are far more frequently either independent and uncorrelated, or possibly positively associated as people are willing to take greater risks for greater benefits.

The theorised mental association of risk and benefit stems from evidence that the manipulation of risks and benefits are interrelated; so the presentation of risk information is found to result in changes in perceived benefits and vice versa, regardless of topic (Finucane

et al. 2000). This is believed to be a System 1 process because the correlation is stronger under time-pressure, when cognitive resources are scarce. Also affective judgements (e.g., good-bad), theorised to relate to System 1 associations, predict the strength of the inverse relationship between risk and benefit. It is speculated that the negative risk-benefit correlations are cued by the representations of objects and events which are marked by positive or negative affective tags; these tags provide an easily available graded affective impression that can cue a judgement (Slovic et al. 2007). Although, the present study measures perceived effectiveness and not benefit, effectiveness would be the primary benefit within the domain of medical treatment. Effectiveness is of critical importance in the appraisal of medical risks because treatment efficacy and treatment risk combined allow a judgement of acceptability; a high risk, high efficacy treatment might be preferred to a low risk, ineffective treatment. Risk and effectiveness ought to be independent because the risk of a treatment is not a consequent, determinant or linked to its benefit, unlike, for example height and weight. Therefore risk and benefit should be uncorrelated (for example, insulin effectiveness varies by body size but risk will not covary with effectiveness) (Fleming et al. 2007). Effectiveness is also of particular interest in medicine as a predictor of acceptance of treatments (Chapman and Coups 1999). An additional advantage of effectiveness is that effectiveness is quantifiable (e.g. a treatment is successful 90% of the time) and that these quantities would be available to the experts, just as treatment risks are.

Previous studies have found mixed evidence of the affect heuristic in risk perception among experts. Siegrist et al. (2007) gave a group of 375 lay people and 46 experts in nanotechnology a questionnaire examining nanotechnology risks and benefits. The expert sample was small, mostly male (91%), and all but one had read scientific publications on nanotechnology. Both groups were provided with information about nanotechnology, its potential risk and potential benefits. There was evidence of the affect heuristic with a

significant negative correlation (r = -.48) between risk and benefit for the lay group, but no significant correlation for the experts (r = -.21). In contrast Savadori et al. (2004) found that, within the field of biotechnology, experts (an academic sample specialised in biotechnology research) perceived greater negative correlations between risks and benefits than lay people (a community sample).

This study significantly extends previous work in two ways. Our expert sample (of anaesthetists) was large and homogenous. Furthermore, a large non-expert group was sampled to control for demographic issues of age, gender and income; experts are often wealthier, male and better educated, all properties associated with reduced risk perceptions and the potential to confound studies in this area (Slovic 1999). Secondly, we added an expert-relevance manipulation to the experiment. Two different contexts were used to present the risk perception questionnaire, a medically-salient, blood-product context (more relevant to anaesthetists) and a non-medical GM-product (Genetically-Modified) context (less relevant to anaesthetists). Both contexts are equally relevant to one treatment for which perceptions were sought in our study, namely a GM-blood-substitute transfusion, but only the blood-product context highlights the medical-relevance to the expert anaesthetists. It is for this reason that both a GM and a blood transfusion context were used; they allow two different perspectives on GM-blood-substitute transfusion. Anaesthetists are responsible for blood transfusions in surgery and are therefore experts in this area and knowledgeable about the risks and effectiveness of transfusion technologies. Informational relevance is known to increase the depth of information processing (Petty and Cacioppo 1979), therefore greater relevance should lead to a reduced reliance on heuristics and a reduced risk-effectiveness correlation (i.e. more System 2 processing). In practical terms one would hope that although an expert might sometimes use System 1 heuristics to make judgements, when primed by a medically salient context they are capable of effortful (System 2) consideration of risk and

effectiveness judgements. We predicted, therefore, that risk-effectiveness correlations should be reduced for experts when risk judgements are made in an expertise relevant context.

This study examined whether expertise and contextual-information impacts risk perceptions and the risk-effectiveness correlation. We predicted the following:

H1 – expert risk perceptions will be lower than non-expert risk perceptions; this has previously been found for biotechnology risks (Savadori et al 2004).

H2 – perceived risk and perceived effectiveness will correlate negatively (suggesting the use of System 1 affective processing); a replication of previous findings (Savadori et al. 2004; Slovic et al. 2007; Finucane et al. 2000; Siegrist et al. 2007; Alhakami and Slovic 1994).

H3 – the negative risk-effectiveness association will be moderated by expertise. Specifically, the association will be attenuated for the expert group (suggesting experts make less use of System 1); a result indicated by some past work and explicable within a dual-processing framework (Siegrist et al. 2007).

H4 – the negative risk-effectiveness association will be further moderated by context-relevance in the expert group. Specifically it is predicted that this association will be lowest for experts in a medically-salient context; where experts should make less use of System 1 type processing when their expertise is salient (Petty and Cacioppo 1979).

Method

This study uses a subset of data obtained as part of the Eurobloodsubstitutes project (Ferguson et al. 2009). In this study the Dutch experts who took part form a homogenous group of experts (anaesthetists) whereas UK experts who were also sampled included a diverse range of medical personnel. The issue of expert homogeneity was highlighted above and it is for this reason that only Dutch experts are compared to the Dutch public in the

present study. All respondents were randomly assigned to one of two context conditions: medically-salient, blood transfusion information, or general GM information.

Participants

All participants were recruited by post in the Netherlands in 2005. Anaesthetists are responsible for blood products used and transfusing patients in medical procedures. It is their responsibility to be knowledgeable with respect to blood product risks. Dutch anaesthetists receive 6 years of initial medical training to obtain their medical degree. To become a registered anaesthetist the doctor must undergo a five-year assistant-in-training course, there are also annual update courses that are required. Some of the initial training and update courses are in advanced transfusion medicine. This expertise is supported by evidence that anaesthetists are more knowledgeable about blood transfusion than General Practitioners who are in turn more knowledgeable than blood donors (Ferguson et al. 2001). 1000 questionnaires were sent to all practicing members of the Dutch Society of Anaesthetists including approximately 30% who were assistants-in-training. Each questionnaire was accompanied by an invitation to take part via the Sanquin blood bank asking them to take part in a study on artificial blood and GM products. Recipients were able to request further questionnaires for their colleagues which occurred fewer than 10 times. The questionnaire was enclosed with addressed, pre-paid envelopes sent to the anaesthetist's place of work. Participants all responded by mail (they were offered the opportunity to respond by mail, email or telephone). 123 responded (approximately 12.3% response rate) with an average age of 47.8 years (SD 7.44). A further 6,000 questionnaires were sent by a market research company to a panel of potential non-expert survey candidates. The panel was formed from a subset of a volunteer sample of the Dutch population who are selected to be demographically representative and agree to be contacted with postal surveys by a market research company

(TNS NIPO). They were also sent questionnaires with pre-paid, addressed envelopes although the additional invitation letter was not included because they had already agreed to be contacted for survey research. 1153 responses were received (19.3% response rate) with an average age of 50.6 years (SD 16.35). The sample was predominantly white with 0.9% of respondents describing themselves as non-white. None of the public sample described their occupation as an anaesthetist. Participants were told the questionnaire would take 10-20 minutes to complete, and were given a three week deadline by which to return them, no responses were disqualified by the deadline.

(Insert Table 1 about here)

Demographic data for the participants can be found in Table 1. Education levels have been given in terms of time spent in Education – in the Dutch Education system there are course streams: Here the category for up to the age of 16 includes the VMBO qualification, 16-18 includes the VWO and HAVO qualifications and post-school education includes MBO, HBO and University qualifications.

Measures

All participants received a questionnaire and accompanying contextual information, half of the participants were randomly assigned to receive general GM technology information and half received specific, medically-salient, blood transfusion information that provided brief information about the development of blood substitutes. The difference between the contextual information was a two hundred word description which explained in simple terms why the biotechnology (blood substitutes or GM) was used and what it was (see Appendix 1).

This study examines the data on five of the 12 medical treatments examined in the original dataset. These treatments were selected as directly relevant to the anaesthetists' expertise and directly relevant to the two types of contextual information used. The treatments included four blood transfusion technologies: GM haemoglobin blood substitute (GM blood), Bovine haemoglobin blood substitute (Bovine blood), Perfluorocarbon-based blood substitute (Chemical blood), donated human blood (Donor blood), and one further medical GM technology (GM insulin). Responses were asked for as if the respondent was receiving the transfusion/injection (insulin). Each treatment was assessed for familiarity (to confirm that experts were more familiar than lay participants) and perceived Risk and Effectiveness. *Familiarity* was assessed with a simple indicative index ('Have you heard of this? Y / N'); *Risk* and *Effectiveness* were assessed on single item (Ganzach et al. 2008) 7-point Likert-type scales ('How risky/effective do you think this is?') with 1 being not at all and 7 being extremely (see Appendix 2 for question items, all questionnaires were presented in the same order). Single item measures are used as standard in research examining the affect heuristic (Finucane et al. 2000). There is some evidence that simple single item measures have equivalent utility to multi-item measures (Ganzach et al. 2008; Wanous, Reichers and Hudy 1997).

Analyses

Of the overall sample of 1376, a total of 98 members of the public and 17 anaesthetists stated that they did not read the accompanying experimental information or did not respond to the question asking them if they had read this information. These participants were excluded from the analyses as the effect of the contextual information cannot be assessed if it was not read). This left a usable sample of 1261 participants. Missing data was excluded listwise.

A 2 (contextual information: blood vs GM) by 2 (expertise: non-experts vs anaesthetists) by 5 (medical treatments: GM insulin, GM blood, Bovine blood, Chemical blood and Donor blood) mixed design ANOVA was used to examine perceived risk and effectiveness. Contextual information and expertise were between groups factors and medical treatment was a within subjects factor. Follow up analyses consisted of (Bonferroni corrected) t-tests to examine the main effects of context and expertise for each individual treatment. Treatment familiarity was tested by five between-group t-tests comparing non-expert with expert familiarity. Zero-order correlations between perceived risk and perceived effectiveness for each treatment grouped by expertise (non-experts and anaesthetists) and by context (GM and Blood) were calculated to illustrate the strength of the risk-effectiveness correlation. Regression models were calculated for each treatment to address the relationship between risk and effectiveness for each individual hazard but controlling for demographic variables. Demographic variables were included in order to control for the typical demographic differences between experts and non-experts (see above). For each treatment the model was tested with the demographic variables alone and with the experimental variables (context, effectiveness and expertise), in each case the model was significantly improved by the inclusion of experimental variables; only these latter regressions are reported here. Multiple regressions tested for two and three-way interactions between effectiveness, context and expertise; note that where these interactions were not significant these are not reported. The interactions between perceived effectiveness, context and expertise act as a measure of the moderating effect of context and expertise on the risk-effectiveness correlation i.e. do these variables increase or decrease the relationship between perceived risk and perceived effectiveness. A final model included a three-way interaction between context, expertise and perceived effectiveness; this tests the hypothesis that the risk-effectiveness

association will be lower for experts given the medically-salient context. The regression models offer the ability to control for demographic variables which have been problematic in previous studies of expertise (Rowe and Wright 2001). All continuous variables were mean-centred for the multiple regressions to reduce multi-collinearity within the interaction terms.

Results

Perceived Risks – Test of H1 (Lower expert risk perceptions)

Mean values for perceived risks and perceived familiarity of Experts and non-experts are given in Table 2.

(Insert Table 2 about here)

A 3-way mixed ANOVA found a main effect of treatment type (F (4, 3840) = 102.8, $p < .001$, *partial-*η^2=.097), but not of expertise or context, and therefore fails to give global support to Hypothesis 1. Differences between perceived risks of treatments were determined by post hoc Bonferroni-adjusted analyses ($\alpha = .005$); bovine blood was rated as most risky and donor blood and GM insulin as joint lowest in risk. Chemical blood and GM blood were rated jointly as lesser risks than bovine blood but greater risks than donor blood and GM insulin.

The 3-way mixed ANOVA also indicated significant interaction of treatment type x expertise (F (4, 3840) = 23.9, $p < .001$, *partial-*η^2=.024) and a significant interaction of treatment type x context (F (4, 3840) = 2.4, $p = .050$, *partial-*η^2=.002). To explore the nature of these interactions ten t-tests were performed with Bonferroni correction, two for each individual treatment. Table 2 marks the significant effects. Five t-tests compared experts and

non-expert risk ratings for each individual treatment. Experts expressed significantly lower (after Bonferroni-correction) perceived risks of GM blood (t (108.1) = 4.4, $p < .001$, $r = .39$) and GM insulin (t (1039) = 8.3, $p < .001$, $r = .25$) but there was no significant difference for the other three treatments. Therefore Hypothesis 1 is partially supported. The interaction of treatment type and context was explored with five further t-tests. The GM information was compared with the medically-salient blood information for each treatment. Bovine blood was reported as less risky for participants who received the blood information (t (1030) = 3.5, $p = .005$, $r = .11$) by contrast GM insulin was rated as less risky by those who received the GM information (t (997.6) = 2.8, $p = .045$, $r = .09$). There were no further significant differences. Finally, 5 between group t-tests found significantly greater familiarity for experts for all 5 treatments.

Matching analyses for perceived effectiveness were carried out (a description is provided for information in Table 3). The results closely mirrored the risk results in which higher perceived risk is presented as reduced perceived effectiveness. A full account of the results is provided in Appendix 3.

(Table 3 about here)

Risk Effectiveness Zero-Order Correlations – Indicators of H2– (Negative risk-benefit correlations), H3 and H4 (Correlations will be reduced for experts and by context-relevance among experts)

Correlations between perceived risk and effectiveness for each health technology are presented in Table 4. All correlations were negative. Significant negative correlations were found between perceived risk and effectiveness for every hazard for the non-expert sample in

both framing conditions, which supports Hypothesis 2. Significant negative correlations were also observed for the expert, anaesthetists group produced when presented with GM information (except for donor blood), but when presented with medically-salient blood information only one treatment type - donor blood - produced a significant correlation. This implies support for Hypotheses 3 and 4.

(Table 4 about here)

Factors influencing risk perceptions

Multiple regressions were used to predict risk perceptions for each of the five treatment types. During the regression analysis one case was excluded (standardised DFFIT > 1). In both cases the same expert respondent who received the GM context was excluded; scatterplots confirmed the case as an outlier.

Hierarchical multiple linear regressions were carried out initially with demographic variables, then with context, expertise and effectiveness variables and finally with interaction terms; only significant interaction terms were reported in the final analysis. Table 5 reports the coefficients for all five regressions.

(Insert Table 5 about here)

Demographics

Women rated bovine blood, GM blood and donor blood as more risky than men (significantly positive coefficients). There were also a significant effects of age (bovine blood was rated as less risky by older participants) and of education (college-educated participants rated donor blood as less risky than participants who left education by age 16). Finally, there was also an effect of income in that the highest paid group found Bovine blood riskier.

Context, Expertise and Effectiveness

There was a significant impact of context on bovine blood risk perceptions in that it was rated as being less risky when presented with blood information in comparison to GM information, (confirming the previous ANOVA results). Perceived effectiveness was a significant and negative predictor for all technologies, so in every case greater effectiveness was associated with reduced risk; the association was greatest for GM insulin and least for donor blood. This supports the theory that heuristic processing was used, as proposed by H2. Compared to the non-experts, the anaesthetist group was associated with lower risk ratings for one treatment type - for GM insulin; this provides partial support for H1.

Interestingly we also note an interaction effect; the type of context exposure interacted with the perceived effectiveness of the treatment type in predicting perceived risk for GM insulin. Simple slopes analysis carried out by Aiken and West's (1991) method revealed that whilst in both contexts, perceived effectiveness predicted perceived risk, this relationship was significantly stronger with GM information (B = -.515, SE = .041, p < .001) compared to the blood information (B = -.370, SE = .047, p < .001). A similar pattern can be seen in the zero-order correlations in Table 3 with higher correlations between perceived risk and effectiveness of GM insulin in the GM information compared to the blood information for both non-experts and anaesthetists.

Further to this, the association between perceived risk and effectiveness is moderated by expertise and context (a three way interaction) for GM blood. Simple slopes analysis indicated that the negative relationship between perceived risk and effectiveness was evident for both groups in the GM context but only for the non-experts in the blood context; for the majority of treatment types, anaesthetists in the blood context did not display the negative relationship between perceived risk and effectiveness (GM, Lay B = -.378, SE = .045, p < .001; GM, Expert B = -.571, SE = .146, p < .001; Blood, Lay B = -.465, SE = .049, p < .001;

Blood Expert B = -.135, SE = .172, p = .434). Figure 1 shows that the relationship between risk and effectiveness is weakest for anaesthetists in the medically-salient blood context. Hypothesis 3 was therefore not supported as the relationship between risk and effectiveness was not moderated overall by expertise. However partial support was found for Hypothesis 4 in that within one treatment type - GM blood – the negative relationship between risk and effectiveness was moderated by context specifically within the expert group. Again a similar pattern can be seen in the zero-order correlations in Table 3.

(Insert Figure 1 about here)

Discussion

This study utilised a large-scale field-based experiment in order to examine the role of expertise in risk perceptions and the use of heuristic processing such as that evident in the affect heuristic. Expertise was found to relate to lower perceptions of risk for some medical treatments. Elucidating previous mixed results on expert use of the affect heuristic however, we find that medical experts here only make use of affective processing in certain contexts. In expertise relevant contexts evidence for the application of the use of affect was much reduced. This implies that experts process pertinent information at a deeper level and are less prone to misuse of heuristics when making judgements in an expertise relevant context.

Expertise and risk perception (H1)

The mean risk perception scores show that the anaesthetists rated GM treatments (GM blood and GM insulin) as less risky than the public. The same pattern is observed with perceived effectiveness which is greater for these treatments in the expert group. It is interesting that it is only GM treatments which evidence differences in risk and effectiveness

perceptions between the public and experts. The GM treatments were neither the most risky nor the least familiar. GM seems to have a special quality in the mind of the public – it is often viewed negatively (Gaskell et al. 2000), and is subject to social influences (Fleming et al. 2007). It may be that anaesthetists, as medical practitioners, are more familiar with safe, positive applications of GM biotechnology which might influence their perceptions.

The experts also evidenced greater familiarity for all of the treatments; this is an endorsement of their expertise. The familiarity differences between experts and non-experts were especially large for chemical blood and GM insulin. Familiarity tends to encourage lower risk perceptions (Fischhoff et al. 1978), but given that the pattern of familiarity differences does not match the pattern of risk perception differences this would not appear to entirely explain this data. The uniqueness of GM in provoking differences in risk perception was confirmed in the regression analyses where there was a main effect of expertise in reducing GM insulin risk perception and an interactive effect of expertise on GM blood risk perception (over and above demographic characteristics).

Risk-effectiveness correlation (H2)

Risk-effectiveness correlations were observed for every treatment for both the non-expert and anaesthetist samples (albeit only significantly for experts within certain contexts); again this was confirmed in the regression analyses. No significant interactions were observed between the risk-effectiveness relationship and expertise indicating the pattern held for all participants (except for the expert group within the blood-context condition see below, section 4.3).

The anaesthetists, who are experts in blood transfusion, ought to be able to accurately assess risk and effectiveness for these treatments. Effectiveness is not a good predictor of risk and yet among both experts and the public those who rated donor blood less risky rated it

more effective and vice-versa. This pattern is very similar to research on the affect heuristic, characterised by a negative correlation between risk perception and benefit perception when the two are independent in reality (Finucane et al. 2000; Alhakami and Slovic 1994). The study reported here uses a larger sample and confirms the evidence of heuristic correlations for experts and non-experts (Savadori et al. 2004); it is possible therefore that Siegrist et al.'s (2007) findings (a non-significant correlation between risk and benefit among experts, r = -.21) might also have been significant given greater power.

Contextual Information and Expertise – Context relevance (H3 + H4)

It was predicted that the relevance of the context that judgements are made in would reduce affect heuristic use for experts. Here the relevance of the context was manipulated by presenting the questionnaire within the context of either GM or medically-salient blood transfusion technologies to anaesthetists (considered more relevant to this group). The results supported an effect of relevance. The zero-order correlations suggest that the anaesthetists' responses to all treatment types (except donor blood) show stronger risk-effectiveness correlations within the GM context than within the blood product context. However, regression analysis indicated that this trend was only significant for one treatment type – GM blood. Indeed GM blood is a special case as its relevance was reliant on its context – either as a GM biotechnology or as a blood transfusion technology dependent on the context. Among anaesthetists the blood product context produced a much lower association between perceived effectiveness and risk than the GM context indicating that the depth of processing was higher and the use of a heuristic approach was reduced within the blood product context.

There were other effects of context apparent in our results. GM insulin showed a similar difference between the two contexts, for both groups; there was a greater risk-effectiveness coefficient for those who read the GM context (β = -.63) than those who read

the blood context (β = -.42). GM insulin is not relevant to the blood context and that this difference occurred across both experts and the non-experts suggests a greater use of heuristics associated with GM biotechnology. As stated above GM seems to have a special quality which does not necessarily encourage rational consideration – the GM information may encourage a heuristic approach. Finally, the contextual information had a direct effect on risk and effectiveness perceptions; the blood product context reduced bovine blood substitute risk perceptions and increased perceived effectiveness. This itself has implications for the use of context in risk assessment and communication that is relevant across all risk domains.

A dual process model of Expertise, contextual-relevance and risk-effectiveness

The pattern of results observed here may be explained by System 1 and System 2 processing. System 1 processes are swift and automatic, but effortful System 2 processes ought to provide more accurate judgements because they do not rely on an algorithm but instead on the individual merits of the situation. There was considerable evidence for the use of System 1 heuristics in the pattern of responses. Judgements of risk largely mirrored judgements of effectiveness which supports the idea of affect heuristic-type processing. However, importantly we demonstrated that this can be reduced for experts when an expertise-relevant context is used.

It seems that experts do not, by default, use System 2 processes even to evaluate a risk that is highly relevant to their expertise; instead they may often rely on System 1 heuristics that provide an answer with less effort, only using System 2 processes in necessary contexts. This elaborates previous, more simplistic, theories that the public rely on affect whereas experts rely on factual knowledge (Slovic, Fischhoff and Lichtenstein 1985).

GM technology seems to encourage a heuristic approach (greater risk-effectiveness correlations) when presented in the context of the technology (rather than its application). This may be due to the controversial nature of the technology and a tendency for it to provoke extreme reactions (Fleming et al. 2007; Frewer, Howard and Shepherd 1998). Given that System 1 is associative (e.g., accumulation of positive and negative associations) the existence of these associations may make System 1 processes more available and so heuristics are used rather than relying on System 2 (Slovic et al 2007). However, when experts are making judgements on an expertise-relevant hazard *and* that hazard is presented in a relevant context they can find alternatives to heuristic processes.

An alternative explanation would be that the contextual information had a differential effect on information salience, i.e. medical information may elicit different memory representations in the experts compared to the non-experts – as we have not measured or manipulated affect it is possible that the presentation of medically salient contextual information has altered the construction of perceived effectiveness judgements. Further research should examine these relationships in conjunction with affective measures. Furthermore a multi-item measure of risk could potentially differentiate more nuanced patterns of variation between experts and lay people beyond the limited single-item measure of risk perception used here. A more sophisticated study could consider likelihood and severity separately or pursue a full psychometric approach.

Our findings may help to explain previously mixed results in this field. Overall, experts shared more similarities in risk perceptions than differences with non-experts. They both relied predominantly on System 1 processes. However, experts can be motivated to use System 2 resources if an appropriate context is provided. This is an important finding and has important implications for risk management within medical settings implying that specific contexts could be purposefully utilised in order to prompt more conscious deliberate

information processing. The generalisability of these findings should be explored in future research across different domains both within and beyond health, for example, within education or finance where expert decision making is of interest.

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Appendix 1

[GM condition]

We are conducting a study aimed at understanding more about people's beliefs about different risks. One of the things we are interested in is 'Genetically Modified' (GM) products.

Why modify plants or animals?

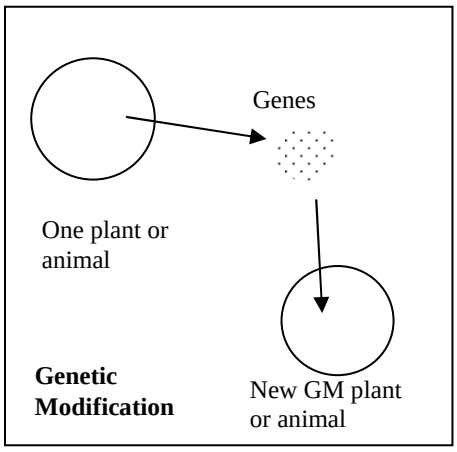
We use animals and plants for food and medicines. The animals and plants we use are bred to be good to eat or good for other things.

What is GM?

GM means taking genes from one plant or animal and adding them into another. This means that some features of the plants and animals can be chosen, or new features can be added. GM has been used with *food* to make plants grow better or taste better. GM *medicine* allows bacteria to make human medicines. Diabetics today use insulin from GM bacteria. GM food can be like medicine. GM rice is made that has extra vitamin A.

Facts about GM

- GM is quicker than breeding which takes years.
- GM is more accurate at choosing features because breeding needs luck.
- GM can make new types of animal or plant that couldn't be bred (e.g. bacteria that produce insulin).
- GM does not always work.
- GM is still being developed.



[Blood condition]

We are conducting a study aimed at understanding more about people's beliefs about different risks. One of the things we are interested in is 'artificial blood'.

Why is blood needed? Blood is used in hospitals. The blood used in hospitals comes from blood donors.

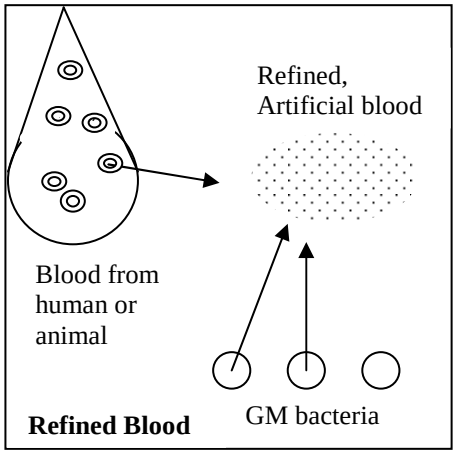
What is artificial blood? There are two types of artificial blood under development but neither is (yet) available for patients today:

Chemical blood: Blood from man-made chemicals.

Refined blood: Blood refined from natural blood. One type of artificial blood is made from refined human or cows' blood. Another type is produced by Genetically Modified (GM) bacteria.

Facts about artificial blood

- Donated blood is divided into different groups that must match the person receiving it. Artificial blood could be used by everybody.
- Artificial blood can be made when needed and stored for longer than donated blood.
- Some people hold beliefs that prevent them receiving donated blood but can receive artificial blood.
- Artificial blood is still being developed.



- Artificial blood only lasts in the body for 12 hours before new blood is needed.

Appendix 2

[Part of the original (translated) questionnaire]

Activity	**Have you heard of this?**	**How risky do you think this is?**	**Would you do this if recommended by a doctor?**	**How effective is this for good health for you?**
	Yes or No (circle your answer)	1 = not risky 7 = extremely risky	Yes or No (circle your answer)	1 = not effective 7 = extremely effective
Having a **blood transfusion** of **donated blood**	Y / N	1 2 3 4 5 6 7	Y / N	1 2 3 4 5 6 7
Having a **blood transfusion** of **artificial blood made from chemicals**	Y / N	1 2 3 4 5 6 7	Y / N	1 2 3 4 5 6 7
Having a **blood transfusion** of **artificial blood based on cow blood**	Y / N	1 2 3 4 5 6 7	Y / N	1 2 3 4 5 6 7
Having a **blood transfusion** of **GM blood**	Y / N	1 2 3 4 5 6 7	Y / N	1 2 3 4 5 6 7
Having an **insulin injection** from **GM insulin**	Y / N	1 2 3 4 5 6 7	Y / N	1 2 3 4 5 6 7

Appendix 3

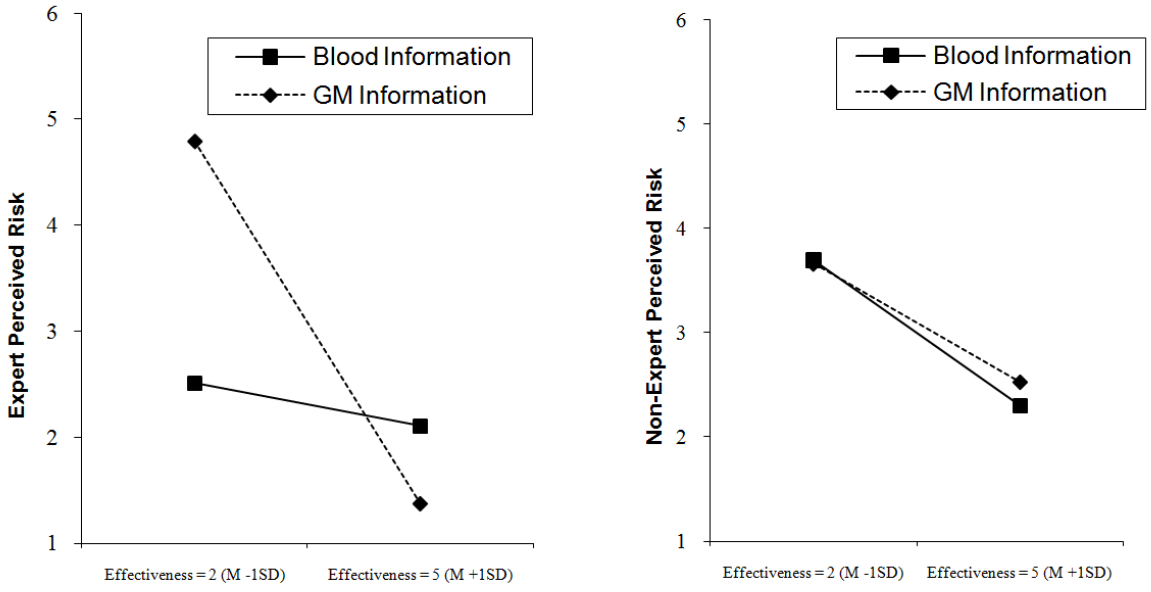
Effectiveness Results

A 3-way mixed ANOVA found a main effect of treatment type (F (4, 3904) = 74.6, p < .001, *partial-*η^2=.071), and of expertise (F (1, 976) = 4.4, p = .037, *partial-*η^2=.004) on perceived effectiveness but not context. Differences between perceived effectiveness of treatments were determined by post hoc Bonferroni-adjusted analyses (α = .005); bovine blood was rated as least effective and donor blood and GM insulin as joint highest in effectiveness. Chemical blood and GM blood were rated jointly as more effective than bovine blood but less effective than donor blood and GM insulin.

The 3-way mixed ANOVA found two other significant effects; a significant interaction of treatment type x expertise (F (4, 3904) = 27.8, p < .001, *partial-*η^2=.028) and a significant interaction of treatment type x context(F (4, 3904) = 1.6, p = .003, *partial-*η^2=.004). To explore the nature of these interactions ten t-tests were performed with Bonferroni correction, two for each individual treatment. Table 3 marks the significant effects. Five t-tests compared experts and non-expert effectiveness ratings for each individual treatment. Experts expressed significantly higher (after Bonferroni-correction) perceived effectiveness of GM blood (t (1033) = 3.9, p < .001, r = .42) and GM insulin (t (132.1) = 10.6, p < .001, r = .68) but there was no significant difference for the other three treatments. The interaction of treatment type and contextwas explored with five further t-tests. The GM context was compared with the medically-salient blood information for each treatment. Bovine blood was reported as more effective for participants who received the blood information (t (995.1) = 2.9, p = .003, r = .09) by contrast GM insulin was rated as more effective by those who received the GM information (t (1006.4) = 3.5 p < .001, r = .11). There were no further significant differences.

Figure 1. Plots of simple slopes of interaction terms, Panel A shows Experts' perceived risk by effectiveness for the Blood and GM contexts, Panel B gives the same information for the Non-Expert's perceived risk.

Note: Effectiveness values are plotted at one SD above and one SD below the mean.



Panel A Panel B

Table 1. Demographic data split by sample group

	Gender		Income (€)					Education		
	Male	Female	≤10,000	10,001 – 25,000	25,001 – 40,000	40,001 – 55,000	> 55,000	<16 yrs	16-18 yrs	>18 yrs
Non-Experts	47.2	52.8	15.3	37.7	29	11.3	6.7	19.1	14.6	66.3
Experts	75.7	24.3	0	0	2	3	95	0	0	100

Note: All statistics are stated as percentages of the total sample (1153 Non-Experts, 123 Experts).

Table 2. Mean risk perceptions (1=not at all risky, 7=extremely risky), standard errors and percentage hazard familiarity

Group	Non-Experts					Experts				
Contextual information		GM		Blood			GM		Blood	
	Familiarity					Familiarity				
Treatment Type	(%)	M	SE	M	SE	(%)	M	SE	M	SE
GM insulin	28	3.9[ab]	0.08	4.2[ab]	0.07	80	2.6[ab]	0.25	3.1[ab]	0.23
Bovine blood	13	5.0[b]	0.08	4.7[b]	0.07	30	5.2[b]	0.26	5.2[b]	0.23
GM blood	22	4.6[a]	0.08	4.6[a]	0.07	34	3.7[a]	0.24	4.0[a]	0.24
Chemical blood	34	4.5	0.09	4.3	0.08	88	4.5	0.30	4.6	0.24
Donor blood	98	3.2	0.07	3.1	0.07	100	3.5	0.26	3.2	0.21

a) Significant difference between Non-Expert and Expert (across both contexts) by post hoc comparison (t-test)

b) Significant difference between GM and Blood context (across Experts and Non-Experts) by post hoc comparison (t-test)

Table 3. Mean effectiveness perceptions (1=not at all effective, 7=extremely effective), and standard errors

Group	Non-Expert				Experts			
Contextual information	GM		Blood		GM		Blood	
Treatment Type	M	SE	M	SE	M	SE	M	SE
GM insulin	4.6[ab]	0.08	4.3[ab]	0.06	6.1[ab]	0.19	5.5[ab]	0.17
Bovine blood	3.7[b]	0.07	4.1[b]	0.07	3.9[b]	0.29	3.8[b]	0.18
GM blood	4.2[a]	0.07	4.0[a]	0.06	4.8[a]	0.25	4.6[a]	0.19
Chemical blood	4.4	0.07	4.6	0.06	4.2	0.29	4.2	0.16
Donor blood	5.4	0.07	5.4	0.06	5.5	0.24	4.8	0.19

a) Significant difference between Non-Expert and Expert by post hoc comparison (t-test)

b) Significant difference between GM and Blood context by post hoc comparison (t-test)

Table 4. Correlations between hazard risk and hazard effectiveness

Group	Non-Experts				Experts			
Contextual information	GM		Blood		GM		Blood	
	r		*r*		*r*		*r*	
GM insulin	-.49	***	-.39	***	-.43	**	-.16	NS
Bovine blood	-.36	***	-.33	***	-.47	**	-.28	NS
GM blood	-.37	***	-.46	***	-.67	***	-.09	NS
Chemical blood	-.37	***	-.31	***	-.57	***	-.25	NS
Donor blood	-.26	***	-.19	***	-.16	NS	-.29	*

* $p < .05$; ** $p < .01$; *** $p < .001$; NS $p > .05$

N's for Non-Experts 443-552; N's for Experts 37-53

Table 5. Standardised coefficients for multiple regressions

	GM insulin		Bovine blood		GM blood		Chemical blood		Donor blood	
	β		β		β		β		β	
Gender (male=0)	.022	NS	.081	*	.094	**	.051	NS	.089	**
Age	-.058	NS	-.125	***	-.033	NS	-.047	NS	-.028	NS
Education finished: <16 vs 16-18	.050	NS	.013	NS	.034	NS	.044	NS	-.055	NS
Education finished: < 16 vs >18	.042	NS	-.052	NS	.048	NS	-.046	NS	-.028	*
< 10,000 vs 10-25 000 Euro	-.022	NS	.001	NS	.045	NS	.022	NS	-.055	NS
< 10,000 vs 25-40,000 Euro	-.028	NS	.052	NS	.038	NS	.043	NS	-.063	NS
< 10,000 vs 40-55,000 Euro	-.074	NS	.044	NS	-.025	NS	.010	NS	-.030	NS
< 10,000 vs 55,000+ Euro	-.044	NS	.106	*	.082	NS	.045	NS	.027	NS
Contextual information (GM = 0)	.041	NS	-.077	*	-.031	NS	-.050	NS	-.029	NS
Effectiveness	-.490	***	-.340	***	-.355	***	-.346	***	-.233	***
Expertise (Non-Expert = 0)	-.143	***	.021	NS	-.150	NS	.024	NS	.001	NS
Effectiveness x Expertise					-.055	NS				
Effectiveness x Context	.088	*			-.055	NS				
Expertise x Context					.023	NS				
Effectiveness x Expertise x Context					.096	*				
Adjusted R^2	.252		.143		.179		.124		.061	
N	943		936		939		959		1045	

* $p < .05$; ** $p < .01$; *** $p < .001$; NS $p > .05$