Factors influencing the framing of probabilistic risk information

The way in which probabilistic information is framed has an effect on risky decision-making. Typically, the bias created through information framing in Asian disease-type problems results in risk-averse decisions associated with a negative frame and risk-seeking decisions associated with a positive frame. Three laboratory experiments are reported that investigate quantity of information and format of probabilistic information on risk perceptions and decision-making using Asian disease-type problems. Experiment 1 demonstrates an effect of quantity of information; however, the traditional framing effect only occurs using Tversky and Kahneman's (1981) original manipulation. In Experiment 2a, no effect is found when the information is provided in numerical form, but there is an effect for a verbal format. In Experiment 2b, participants chose the least risky, positively framed options more frequently than the negatively framed options when presented with all possible outcomes. In conclusion, the way in which probabilistic risk information is presented has the potential to influence perceptions of risk and decision-making.

Introduction

Decision-makers frequently encounter and evaluate likelihood/probability information with regard to the outcomes of behavioural choices (Smits & Hoorens, 2005). Indeed, probabilities are a standard way to describe situations of uncertainty and risk and it is often the case that people *need* to know the probabilities of risk-related events (Fischhoff & de Bruin, 1999). However, people's perceptions of risk and subsequent behaviour can be influenced to a large extent by the way probabilities are presented (Stone, Yates, & Parker, 1997). There is a particular susceptibility to the way in which the information is framed (e.g. positively [i.e. lives saved] or negatively [i.e. lives lost]) which influences the way individuals approach a risk, and biases the decisions they make (Edwards & Elwyn, 2001). By examining perceptions of risk and decision-making, the current series of experiments investigated the effect of a number of presentation factors on the framing of probabilistic risk information.

The term *framing effect* (or risky choice framing, see Levin, Schneider, & Gaeth, 1998) was initially employed by Tversky and Kahneman (1981) to describe the finding that simple changes in the wording of decision problems can lead to different preferences. For instance, they found in their seminal paper in which they introduced the Asian disease problem (see Figure 1) that despite all options being logically equivalent (but not transparently equivalent) with only the degree of risk inherent in the option differing, participants displayed a risk-aversion bias in the positive frame (72% choosing the certain option over the risky option). However, in the negative frame there was evidence of a risk-seeking bias (78% choosing the risky option over the certain option). Drawing on prospect theory (see Kahneman & Tversky, 1979) Tversky and Kahneman argued that the alternative wording makes people code the outcomes of identical options either as gains or as losses relative to a reference point.

Participants were asked to read the following short vignette, describing the decision problem

> Imagine that the US is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows.

They were then given two options either in a positive frame:

> If Program A is adopted, 200 people will be saved (CERTAIN OPTION)
>
> If Program B is adopted, there is 1/3 probability that 600 people will be saved and 2/3 probability that no people will be saved (RISKY OPTION)

Or in a negative frame:

> If Program C is adopted, 400 people will die (CERTAIN OPTION)
>
> If Program D is adopted, there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will die (RISKY OPTION)

And asked to select the option they preferred.

F*igure 1.* Tversky and Kahneman's (1981) Asian disease problem.

The framing phenomenon demonstrates that factors that are considered in the analysis of a decision problem and the relative importance of these factors (Druckman, 2001) may be affected by the form in which alternatives are presented, and not as a the product of a thorough analysis of the possibilities (Maule & Hodgkinson, 2002). Following recommendations in the literature (e.g. Kühberger, Schulte-Mecklenbeck, & Perner, 1999) a large body of work has investigated ways in which the framing effect disappears in order to identify the antecedent conditions that determine its occurrence. For example, providing justification for a choice (Stanovich & West, 1998) altering the decision-maker's perspective (Levin & Chapman, 1990) changing the context of the decision problem (Bless, Betsch, & Franzen, 1998) and changing the probability structure of the choice problems (Bohm & Lind, 1992) have all been found to influence the occurrence and strength of the framing effect. While these studies involve the manipulation of the decision context or the task, a number of other studies have investigated ways in which small changes in the presentation of the probabilistic risk information can influence the occurrence of the framing effect. These have included: the amount of information available (Kühberger, 1995; Mandel, 2001) and the format of the probabilistic information (Reyna, 1989; Welkenhuysen, Evers-Kiebooms, & d'Ydewalle, 2001). These last two issues will be the focus of the experiments reported here.

Most of the studies investigating the effect of framing on decision-making, often neglect the effect on processes that precede this stage (Dunegan, 1993). Despite the central role risk plays in risky choice framing, perceptions of risk are often overlooked. Rather, it appears to be generally accepted at a qualitative level that, for instance, the "risky option" will be

perceived as riskier than the “certain option”. Levin et al. (1998) noted that considering risk would only make it more difficult to extract the influence of the frame. However, Sitkin and Pablo (1992) proposed a mediated model of the determinants of decision-making under risk, which posits that the effect of a variety of exogenous variables (particularly framing) that were generally believed to have a direct affect on decision-making are mediated by two causal mechanisms, namely, risk perception and risk propensity (see Keil, Wallace, Turk, Dixon-Randall, & Nulden, 2000; Simon, Houghton, & Aquino, 1999; Sitkin & Weingart, 1995). However, it has been found that risk perception “*substantially* mediate the relationship between problem framing and decision-making’ (Sitkin and Weingart emphasis added p. 1586; see also Keil *et al*.). Hence, given the integral role of risk in the construction of an individual’s cognitive representation of the decision environment (Dunegan) it should be considered when analysing the effects of exogenous variables on decision-making (Sitkin & Weingart).

The three experiments reported here investigate the effect of quantity and format of information on the framing of probabilistic risk information through their effects on perceived levels of risk and decision-making, using Asian disease-type problems.

Experiment 1
Effect of quantity of information on framing

Many decisions must be made with incomplete or missing information (Johnson, 1987). However, there are mixed findings in terms of how people behave when confronted with such information. For instance, Jones, Frisch, Yurak, and Kim (1998) found that people only consider the alternatives explicitly stated in the problem context. In contrast, Cherubini, Mazzocco, and Rumiati (2003) found that individuals are able to consider relevant alternatives that are not made explicit in the decision problem. In general, much of the research examining the effects of missing information has investigated multi-attribute decisions in which information about one important attribute is present (e.g. price) and information about another attribute is not (e.g. quality). However, it has been suggested that even in the single-attribute cases associated with framing studies (e.g. number of lives saved or lost) missing information can influence choice (Mandel, 2001).

Kühberger (1995) noted that inspection of the Asian disease problem reveals an asymmetry in the quantity of information provided about the two option descriptions. For instance, while the risky option is completely specified (has both complements) the certain option is incompletely described (i.e. only has one complement). Consequently, it has been suggested that previous instances of the risky choice framing effect are likely to have been the result of asymmetries in amount of information provided option descriptions (Kühberger, 1995; Mandel, 2001). Two studies (Kühberger and Mandel) have investigated this possibility. Kühberger controlled for the asymmetry by providing completely described certain options, thereby making both complements available (additive method, see Mandel, 2001). For example, in the loss frame, participants read the statement: “If Program C is adopted, 400 will die and 200 people will not die”. In this condition, no framing effect was

found. However, when Tversky and Kahneman's (1981) original formulation was used, the framing effect was evident. In the other study, Mandel noted that the inclusion of both complements in the options represented equivalent descriptions of the same event, and that it should not matter which one is provided. As such, in the positive frame the risky option was presented as "If Program B is chosen, there is a 1/3 probability that 600 people will be saved". Under this condition, an exceptionally weak framing effect was found. The findings from both these studies would suggest that asymmetries in the quantity of information about an option may be an important antecedent to the occurrence of the framing effect.

The quantity of information provided about an option has the potential to influence the decisions people make in Asian disease-type problems in terms of the occurrence of the framing effect; however, nothing is known of the effect on perceptions of risk. The current experiment aims to replicate the various conditions used previously in order to undertake a complete investigation of the effects of the quantity of information on risk perception and decision-making thereby bringing the body of work together.

Method

Design

A repeated measures design was employed. The independent variables were the certainty of the option (certain vs. risky) quantity of information about the outcome option (fully described [both complements] vs. partially described [one complement]) and the frame (positive vs. negative). The two dependent variables were level of perceived risk associated with the options and choice of outcome option. The eight conditions were presented in two orders (Conditions 1 to 8 or 8 to 1). For each order, the positive and negative frames were alternated and each quantity of information condition was never followed by the corresponding frame of the same condition. Moreover, the order of the certain and risky options were alternated for each condition, with each group being presented with a different order for each condition. For instance, in Condition 1, one group was presented with the certain option before the risky option while the second group was presented with the risky option first. This order of presentation was revered for Condition 2.

Participants

One hundred and eight undergraduate psychology students participated for course credit. The sample consisted of 62 females and 46 males with an age range of 18 years 9 months to 40 years 5 months (M = 21 years 8 months, SD = 4 years 3 months).

Materials

Each of the eight scenarios involved Tversky and Kahneman's (1981) original Asian disease problem. Three of the quantity of information manipulations replicated that used by Tversky and Kahneman, Kühberger (1995) and Mandel (2001). The final manipulation reversed the asymmetry in Tversky and Kahneman's manipulation such that the certain option was fully described and the risky option was partially described.

Procedure

Participants were required to complete one condition each week over a period of 8 weeks. They were asked to read the scenario followed by the option descriptions, and to base their answers on the information they were provided with. Participants were required to indicate the level of risk they associated with each of the options by circling the score on a 7-point likert scale with the anchors “no risk” at 1 and “very risky” at 7. Following this participants were required to select which of the two available options they would choose. After the eighth week, participants were debriefed and given the opportunity to ask any questions.

Results and discussion

Table 1 shows the data for both perceived level of risk and option choice.

Table 1.

Descriptive and inferential statistics for perceived level of risk and option selection for quantity of information conditions

			Level of perceived risk			Option selection	
Frame condition	Option	Quantity of information	M	SD	*t*(107)	Freq.	$\chi^2(1)$
1. Positive	Certain	Partial	3.67	1.61	10.62***	65	4.48*
	Risky	Full	5.61	1.03		43	
2 Negative	Certain	Partial	4.01	1.74	7.88***	42	5.33*
	Risky	Full	5.53	1.13		66	
3. Positive	Certain	Full	3.57	1.55	11.62***	65	4.48*
	Risky	Full	5.56	1.03		43	
4. Negative	Certain	Full	3.79	1.65	9.65***	51	0.33
	Risky	Full	5.50	1.06		57	
5. Positive	Certain	Partial	3.35	1.60	10.75***	56	0.15
	Risky	Partial	5.23	0.98		52	
6. Negative	Certain	Partial	4.04	1.66	9.78***	62	2.37
	Risky	Partial	5.71	0.88		46	
7. Positive	Certain	Full	4.00	1.52	7.20***	43	4.48*
	Risky	Partial	5.30	1.10		65	
8. Negative	Certain	Full	3.57	1.60	12.60***	78	21.33**
	Risky	Partial	5.69	0.97		30	

*$p < .05$, **$p < .01$, ***$p < .001$

First, Conditions 1 and 2 replicated Tversky and Kahneman’s (1981) original formulation. In both the positive and negative frames the risky option was rated as significantly higher in risk than the certain option. However, in the positive frame significantly more people selected the certain option over the risky option, while in the negative frame significantly more people selected the risky option. This finding replicates Tversky and Kahneman's finding and confirms the bias toward risk-aversion in the positive frame and risk-seeking in the negative frame for their asymmetrical presentation of information about the outcomes.

Secondly, Conditions 3 and 4 replicated Kühberger (1995) formulation. Once again, for both the positive and negative frames the risky option was

rated as significantly higher in risk than the certain option. However, in the positive frame significantly more people selected the certain option over the risky option, while in the negative frame there was no difference in the numbers. Although, the findings support Kühberger's overall conclusion that providing complete information about the options removes the framing effect, his pattern of findings was not replicated.

Thirdly, Conditions 5 and 6 replicated Mandel's (2001) formulation. Once again, for both the positive and negative frames the risky option was rated as significantly higher in risk than the certain option. However, there were no differences in the numbers selecting the certain or risky option in either the positive or negative frame. This is in contrast to Mandel's finding of an exceptionally weak framing effect.

Finally, conditions seven and eight involved a novel formulation in which the asymmetry in Tversky and Kahneman's original formulation was reversed. Once again, for both the positive and negative frames the risky option was rated as significantly higher in risk than the certain option. However, in the positive frame significantly more people selected the risky option over the certain risky option (risk-seeking bias) while in the negative frame significantly more people selected the certain option over the risky option (risk-averse bias). It would appear that reversing the asymmetry of the information resulted in a reversal of the framing effect.

In summary, it would appear that despite a consistent pattern in the perceived level of risk associated with the option descriptions across all manipulations of the quantity of information, the presentation of the information resulted in different decision outcomes for each condition, in terms of the occurrence of the framing effect. These findings suggest that although participants should be capable of, for instance, inferring any missing information, they only appeared to consider the information explicitly stated in the problem context (Jones et al., 1998). This supports Mandel's (2001) assertion that the occurrence of the framing effect (using the Asian disease problem) would appear to be dependent on the provision of asymmetrical information in the option descriptions. More generally, when presenting probabilistic information, it would appear that both the frame and the quantity of information should be considered given the potential to influence perceptions of risk and decision-making.

Experiment 2
Effect of format of risk information on framing

Uncertainty/risk is commonly expressed through verbal probabilities (e.g. good chance, very unlikely, probable etc.,); however, numerical probabilities (e.g. 1/3 chance, 50% certain) have become a part of most people's vocabulary for probability and risk (Teigen, 1988). While a large body of work has investigated differences between various probabilistic formats, relatively few have incorporated a consideration of the framing effect. As such, the two experiments aim to investigate the effect of framing and information format on risk perception and decision-making.

A large number of verbal phrases are used to express degrees of uncertainty or risk (Moxey & Sanford, 2000; Teigen, 1988). However, the

numerical values which participants assign to verbal probability phrases display large ranges. For instance, Timmermans (1994) found that the interpretations of the term “very likely” ranged from 30% to 99%. As a result of this variability, verbal probabilities are often considered “vague”. While some view this from a negative perspective arguing that “… ambiguous probability statements are useless. They simply do not provide the information necessary to analyze a decision” (Behn & Vaupel, 1982, p. 78). Others perceive the flexibility and lack of precision as a positive attribute enabling various communicative functions (Teigen, 1988). For instance, it is believed that verbal probabilities are more representative of people’s intuitive thinking and how they feel about uncertainty (Windschitl & Wells, 1996). What is more, the degree of verbal-numerical discordance has been questioned when participants use a limited set of individualised/self-selected vocabularies (Wallsten, Budescu, & Zwick, 1993).

It is argued, however, that real-world decision-making requires some numerical ability (Peters et al., 2006). From a theoretical perspective it is believed that numerical probabilities have a number of advantages over verbal phrases, which make them the preferred mode of communication (Teigen & Brun, 2000): they are precise (Renooij & Witteman, 1999) everyone uses the same vocabulary (Wallsten et al., 1993) they are readily comparable (Teigen & Brun, 1999) and can be used in calculations (Hamm, 1991). Thus, it is believed that numerical probabilities are the best form of information (Windschitl & Wells, 1996) as they permit less ambiguous communication (von Winterfeldt & Edwards, 1986).

There are a number of limitations with numerical probabilities. First, they can influence the choices people make by indirectly conveying information about what is ‘normal’ (Moxey & Sanford, 2000). Secondly, people, even experts, are reluctant to express probabilities numerically as they do not feel sufficiently confident with the concept of probability (Henrion et al., 1996). Thirdly, there are concerns that numerical probabilities might wrongly imply an unjustified degree of precision (Timmermans, 1994). Finally, various numerical formats have differential effects on decision performance (Slovic, Monahan, & MacGregor, 2000).

When people reason using numerical probabilities, they tend to make errors: a large body of research has identified a susceptibility to cognitive biases or reliance on cognitive heuristics which has been attributed to a lack of statistical insight and computational competency in reasoning and risky decision-making (Evans, Handley, Perham, Over, & Thompson, 2000; Kahneman, Slovic, & Tversky, 1982). However, it is argued that the numerical information provided in these studies does not correspond to the way in which information is typically acquired(Gigerenzer & Edwards, 2003). For instance, Gigerenzer (1991) argued that for many domains, humans represent probabilistic information as frequencies. When information is expressed in this “user-friendly” format (Gigerenzer, 1996) there is an improvement in statistical reasoning abilities (see Cosmides & Tooby, 1996; Gigerenzer, 1996; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000). What is more, Brase (2002) found that of the three different numerical formats investigated (simple frequency [i.e. 1 in 10] relative frequency [i.e. 10%] and single-event probability [i.e. 0.1]) information presented as simple frequencies was perceived as the clearest and as providing the best and easiest understanding

of the situation, whereas information presented as single-event probabilities was considered the most difficult to understand and the least serious. While it makes little mathematical difference which numerical format is provided, it does, however, appear to make a psychological difference (Hoffrage et al.) which could influence perceptions of risk and decision-making.

In general, it has been found that participants are equally willing and able to use verbal and numerical expressions of probability over a range of tasks and paradigms (Budescu & Wallsten, 1990; Budescu, Weinberg, & Wallsten, 1988; Erev & Cohen, 1990). However, Erev and Cohen detected an interesting phenomenon, which they named the 'communication mode preference paradox' in which there appears to be a preference to receive precise, numerical probabilities, but to provide vague, verbal probabilities.

Due to the directionality of verbal descriptors (i.e. positive or negative connotations associated with a particular word/phrase, one commonality between numerical and verbal expressions of probability is that whenever they are presented they are necessarily framed (Moxey & Sanford, 2000). Nonetheless, there is a paucity of research in this area. Perhaps the first study to investigate the framing of verbal descriptors was undertaken by Reyna (1989) who found that using vague phrases rather than numbers in the Asian disease problem resulted in a much stronger framing effect. It was proposed that the use of numerical information tended to mask rather than amplify the framing effect. A further investigation directly compared the effect of framing verbal versus numerical (relative frequency) information, using a genetic counselling scenario. In their study, Welkenhuysen et al. (2001) provided information about the occurrence or recurrence risk of having a child with cystic fibrosis, the penetrance of the disease, or the likelihood that specific symptoms will occur. It was found that although a negative frame was dominant, decisions about having a prenatal diagnosis for a genetic disorder were influenced by the positive versus negative framing of a problem, but only through the use of verbal probabilities.

The aim of the two experiments reported here is to investigate further the influence of information frame and format on risk perception and decision-making using Asian disease-type scenarios.

Experiment 2a

The aim of Experiment 2a was to investigate the influence of probabilistic format on perceptions of risk and decision-making outcomes in terms of the occurrence of the framing effect.

Method

The method for experiments 2a and 2b are similar; however, where differences occur, they will be noted at the beginning of Experiment 2b

Design

A repeated measures design was employed. The independent variables were the format of information (simple frequency vs. relative frequency vs. single-event probability vs. verbal) and the frame (positive vs. negative). The two dependent variables were level of perceived risk associated with the options

and choice of outcome option. The eight conditions were presented in a partially counterbalanced order across two sittings. Each sitting contained only one frame from each information type and the four scenarios and the positive and negative frames were alternated. Consequently, four sequences were created for each sitting.

Participants

One hundred undergraduate psychology students participated for course credit. Of these, 39 were male and 61 were female with an age range of 18 years 5 months to 49 years and 1 month (mean = 21 years 4 months, SD = 5 years, 2 months). One requirement was that participants had not completed Experiment 1.

Materials

Four life-death, Asian disease-type problems were used that had, in the past, been found to result in framing effects of a similar magnitude to Tversky and Kahneman's (1981) original scenario. Each of the scenarios was assigned to a particular probabilistic format.

1. Asian Disease problem (Tversky & Kahneman) – Simple frequency
2. Chemical Spill/Civil Defence problem (Fischhoff, 1983) – Relative frequency
3. General's military problem (McKean, 1985) – Single-event probability
4. New strain of AID's problem (Levin & Chapman, 1990) – Verbal descriptor

In order to make the verbal-numerical assignment more straightforward, the probability structure was changed slightly from the original formulation (1/3 and 2/3) to 30% and 70% (or equivalent probabilistic format) respectively. Further, consistent with the ecologically valid approach used by Mandel (2001) only one compliment was provided for each option.

Procedure

The experiment was completed over two sittings at least one week apart. In the first week, participants began by assigning verbal descriptors to each numerical value ranging from, for instance 0% to 100%, in 10% intervals. The results at 30% and 70% were then used as the probability information in the verbal conditions. The participants were then given a booklet containing the four scenarios, separated by a number of filler tasks and questionnaires. When completing each scenario, participants were required to read the short vignette describing the decision problem and then rate the level of risk they associated with each of the outcome options on a 7-point likert scale. They were further instructed to rate each option independently, by considering only the information they were provided about the option and not how they had rated previous options. In order to minimise any order effects, the presentation of the certain and risky options were counterbalanced both within and across the two groups of participants. Finally, they were required to select the option they preferred. Participants were asked not to look back over any of their answers once they had completed each task (including the filler tasks).

Results and discussion

Table 2 shows the descriptive and inferential statistics for the perceived level of risk and option selection data.

Table 2.
Descriptive and inferential statistics for perceived level of risk and option selection for format of information conditions

			Perceived level of risk			Option selection	
Probability format	Frame	Option	Mean	SD	*t*(99)	Freq.	$\chi^2(1)$
Simple frequency	Positive	Certain	3.69	2.28	7.08***	47	0.36
		Risky	5.54	2.05		53	
	Negative	Certain	4.59	2.28	3.85***	53	0.36
		Risky	5.72	2.21		47	
Relative Frequency	Positive	Certain	4.23	2.10	6.02***	45	1
		Risky	5.52	1.90		55	
	Negative	Certain	4.53	2.41	4.97***	53	0.36
		Risky	5.98	2.20		47	
Single-event Probability	Positive	Certain	3.65	2.11	6.23***	44	1.44
		Risky	5.27	2.13		56	
	Negative	Certain	4.51	2.49	3.68***	43	1.96
		Risky	5.56	2.17		57	
Verbal	Positive	Certain	4.07	2.25	1.844	27	21.16**
		Risky	4.61	2.39		73	
	Negative	Certain	4.88	2.38	3.16***	40	4*
		Risky	5.88	2.34		60	

*p < .05, **p < .01, ***p < .001

For the three numerical formats, the risky option was rated as significantly more risky than the certain option in both the positive and negative frames; however, there was no difference in the number of individuals choosing either of the options. While these findings were consistent with the findings in Experiment 1 in which the probabilistic information was presented as a fraction, once again there was a failure to replicate the weak framing effect found by Mandel (2001). Further, given the potential differences between the different formats (e.g. Brase, 2002; Cosmides & Tooby, 1996) there was no evidence of this in the current results.

One possible reason why there were no differences between the numerical formats is that the nature of the framing tasks create a frequency-like scenario for each numerical format. For instance, participants were able to relate the probabilistic information back to the overall numbers of individuals being affected. This ability is usually associated with simple frequency information which inherently conveys base rate information, which is why it is widely acknowledged as being the superior and most natural form of numerical information (Gigerenzer, 1991). The nature of the task employed may not have demonstrated the natural advantage that frequency information often has over other numerical formats.

In contrast, the results for the verbal condition indicated a difference between the positive and negative frame. In the positive frame there was no difference between the perceived levels of risk for the certain and risky option; however, significantly more people chose the “risky” option over the certain

option. Conversely, in the negative frame, the risky option was rated significantly higher in risk than the certain option; however, significantly more people chose the risky option over the certain option. This result is somewhat consistent with Reyna's (1989) finding in which the use of vague verbal phrases resulted in a stronger effect than numerical information, and Welkenhuysen et al. (2001) who found an effect of framing only for the verbal phrases. Unlike these previous studies, however, participants in the current experiment were provided with self-selected verbal descriptors. Consequently, similar results would have been expected with the verbal format as the numerical format, particularly given the similarity between the numerical formats. However, this differential influence between verbal and numerical formats on the effect of framing probabilistic risk information in Asian disease-type problems could correspond to the communication mode preference paradox (Erev & Cohen, 1990) in which people prefer to receive numerical probabilities, but to provide verbal probabilities.

Experiment 2b

The aim of Experiment 2b was to further investigate the influence of probabilistic format on perceptions of risk and patterns of decision-making outcomes using Asian disease-type scenarios with all four outcome options available.

Method

This experiment was completed in one sitting and involved the same participants as in Experiment 2a. The first task required participants to assign numerical values to their original set of verbal descriptors, which were presented in a randomised order. Following this they were provided with a booklet containing the four scenarios (in counterbalanced order) with filler tasks and questionnaires separating each scenario. For each scenario all four options were presented. In addition, participants were asked to identify why they choose the particular option, and to select which probability format they considered the clearest, easiest to use and most informative.

Results and discussion

Simple frequency condition

Figure 2 shows the data for the mean perceived level of risk and frequency of option selection for each option.

The mean level of perceived risk data was analysed using a single factor repeated measures ANOVA. The sphericity assumption was not met ($W(5) = .57$, $p < .001$) so the Greenhouse-Geisser correction was applied ($\varepsilon = .74$); there was a main effect ($F(2.23, 220.29) = 14.80$, $p < .001$, MSE = 4.23, $\eta_p^2 = .130$). Post hoc paired comparisons were made using the Tukey test (critical values @ 5% = 0.76, @1% = 0.92). The certain-positive option (3.55) was rated lower than the risky-positive option (4.61, $p < .01$) the certain-negative option (4.62, $p < .01$) and the risky-negative option (5.18, $p < .01$).

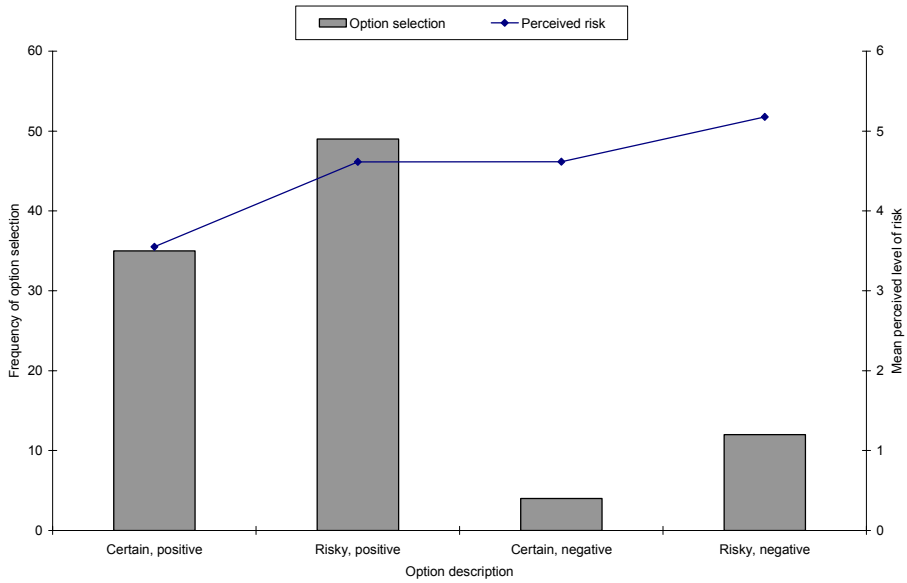

Figure 2. Perceived level of risk and option selection for the simple frequency condition

The frequency of option selection data was analysed using the chi-squared technique. Analysis indicated that the observed frequencies differed significantly from the expected frequency of 25 ($\chi^2(3) = 51.47$, $p < 0.001$). Post hoc follow-up tests (Bonferroni corrected alpha level = .44) revealed significant differences between the certain-positive option (35) and the certain-negative (4, $\chi^2(1) = 24.64$, $p < .044$) and the risky-negative options (12, $\chi^2(1) = 11.26$, $p < .044$). Moreover, there were differences between the risky-positive option (49) and the certain-negative ($\chi^2(1) = 38.21$, $p < .044$) and the risky-negative options ($\chi^2(1) = 22.44$, $p < .044$).

The analyses indicated that while the risky-positive option was rated as being significantly riskier than the certain-positive option, there was no statistical difference in the numbers selecting the options. Moreover, despite there being no difference between the perceived risk associated with the risky- positive and risky-negative options, the former was chosen more frequently.

Relative frequency condition

Figure 3 shows the data for the mean perceived level of risk and frequency of option selection for each option.

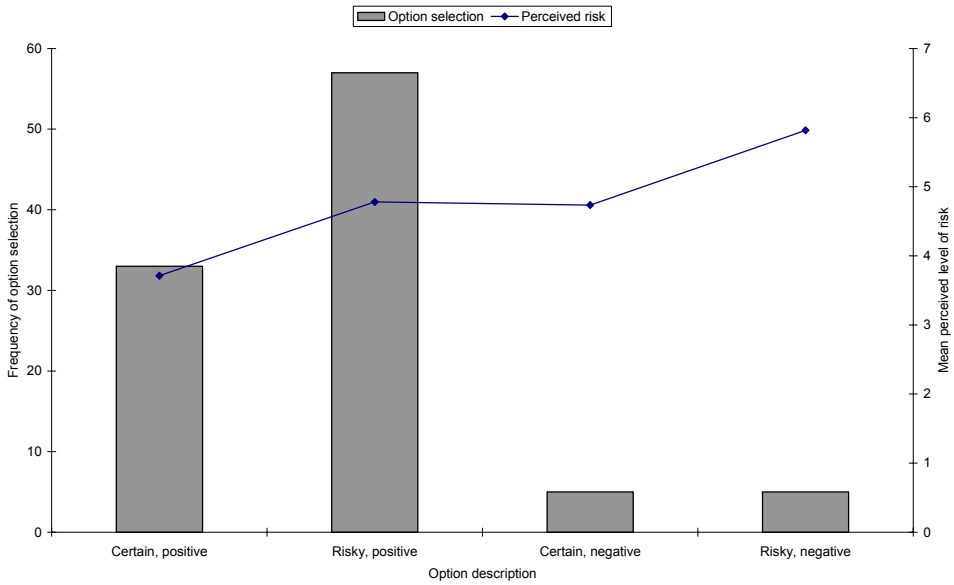

Figure 3. Perceived level of risk and option selection for the relative frequency condition

A single factor repeated measures ANOVA was conducted on perceived level of risk. The sphericity assumption was not met ($W(5) = .40$, $p < .001$) so the Greenhouse-Geisser correction was applied ($\varepsilon = .64$); there was a main effect ($F(1.91, 188.79) = 24.29$, $p < .001$, MSE = 4.79, $\eta_p^2 = .20$). Post hoc paired comparisons were made using the Tukey test (critical values @ 5% = 0.81, @ 1% = 0.99). The certain-positive option (3.71) was rated lower than the risky-positive option (4.78, $p < .01$) the certain-negative option (4.74, $p < .01$) and the risky-negative option (5.82, $p < .01$). Moreover, the risky-negative option was rated higher than the risky-positive option ($p < .01$) and the certain-negative option ($p < .01$).

The frequency of option selection data was analysed using the chi-squared technique. Analysis indicated that the observed frequencies differed significantly from the expected frequency of 25 ($\chi^2(3) = 75.52$, $p < 0.001$). Post hoc follow-up tests (Bonferroni corrected alpha level = .44) revealed significant differences between the certain-positive option (33) and the risky-positive option (57, $\chi^2(1) = 6.40$, $p < .044$) and the certain-negative (5) and risky-negative options (5, $\chi^2(1) = 20.63$, $p < .044$). Moreover, there were differences between the risky-positive option and the certain-negative and risky-negative options (χ^2 (1) = 43.61, $p < .044$).

The analyses indicated that the certain-negative and risky-negative options were the two least selected options, despite the latter being rated as significantly more risky. What is more, despite the risky-negative and risky-positive options being rated as equally risky, the former was the overall most selected option. This was in spite of the finding that the risky-positive option was rated as significantly riskier than the certain-positive option. Hence, there was evidence of a preference for the positively framed option presented as a relative frequency.

Single-event probability condition

Figure 4 shows the data for the mean perceived level of risk and frequency of option selection for each option.

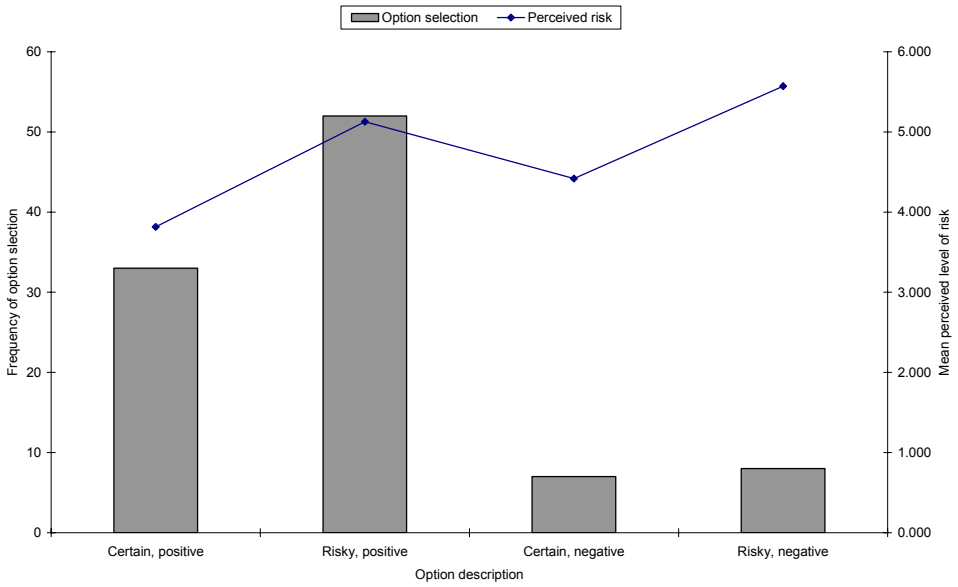

Figure 4. Perceived level of risk and option selection for the single-event probability condition

The mean level of perceived risk data was analysed using a single factor repeated measures ANOVA. The sphericity assumption was not met ($W(5) = .43$, $p < .001$) so the Greenhouse-Geisser correction was applied ($\varepsilon = .64$); there was a main effect ($F(1.93, 190.80) = 18.44$, $p < .001$, MSE = 5.07, $\eta_p^2 = .157$). Post hoc paired comparisons were made using the Tukey test (critical values @5% = 0.83, @1% = 1.01). The certain-positive option (3.82) was rated lower than the risky-positive (5.13, $p < .01$) and the risky-negative options (5.57, $p < .01$). Moreover, the risky-negative option was rated higher than the certain-negative option (4.42, $p < .01$).

The frequency of option selection data was analysed using the chi-squared technique. Analysis indicated that the observed frequencies differed significantly from the expected frequency of 25 ($\chi^2(3) = 53.92$, $p < 0.001$). Post hoc follow-up tests (Bonferroni corrected alpha level = .44) revealed significant differences between the certain-positive option (33) and the risky-positive (52, $\chi^2(1) = 9.33$, $p < .044$) the certain-negative (4, $\chi^2(1) = 20.16$, $p < .044$) and the risky-negative options (8, $\chi^2(1) = 5.49$, $p < .044$). Moreover, there was a significant difference between the risky-positive option and the certain-negative option ($\chi^2(1) = 47.61$, $p < .044$) and the risky-negative option ($\chi^2(1) = 26.80$, $p < .044$). Finally, there was a significant difference between the certain-negative and the risky-negative option ($\chi^2(1) = 6.25$, $p < .044$).

The analyses indicated that the risky-negative option was rated as the most risky and the least selected. The risky-positive option was the most preferred option despite being significantly more risky than the certain-positive option. As was the case in the previous two formats, the risky-positive and certain-negative options were rated as equally risky; however the former was selected more frequently. Hence, there was a preference for the positively framed option presented as a single-event probability.

Verbal condition

The results of the verbal-numerical classification task indicated that the majority of participants were unable to assign consistently the same numerical value to their own verbal descriptor (48 of the 100 participant's demonstrated verbal-numerical concordance at 30% and 70%). While the use of individualised vocabularies might facilitate performance on some tasks and has been used to question the degree of intra-individual verbal-numerical discordance (see Wallsten et al., 1993) under the current conditions, there was still a degree of discordance. Consequently, only the data for the 48 participants was analysed. Figure 5 shows the data for the mean perceived level of risk and frequency of option selection for each option.

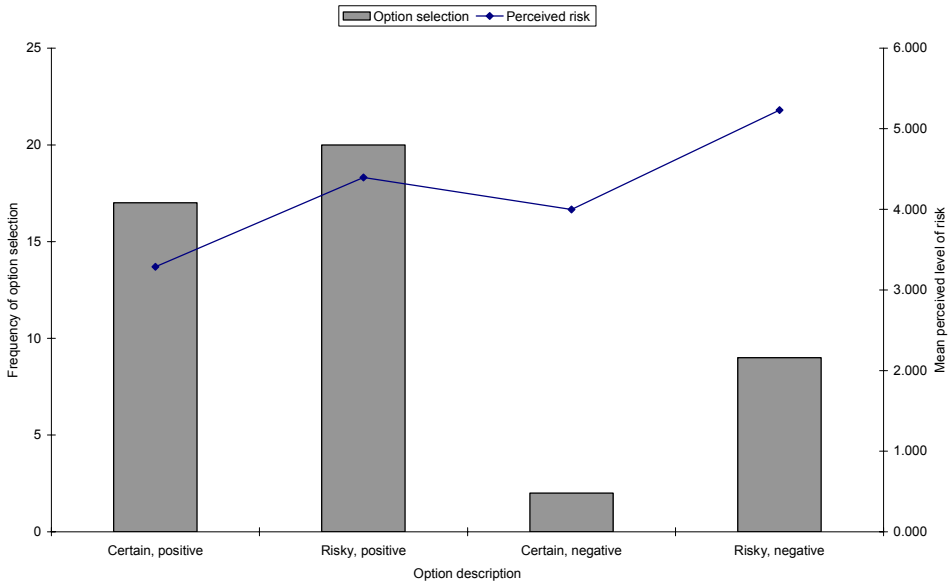

Figure 5. Perceived level of risk and option selection for the verbal condition

The mean perceived level of risk data was analysed using a single factor repeated measures ANOVA. The sphericity assumption was not met ($W(5) = .45$, $p < .001$) so the Greenhouse-Geisser correction was applied ($\varepsilon = .68$); there was a main effect ($F(2.03, 95.59) = 7.73$, $p = .001$, MSE = 6.02, $\eta_p^2 = .14$). Post hoc paired comparisons were made using the Tukey test (critical values @5% = 1.31, @1% = 1.59). The certain-positive option (3.29) was rated lower than the risky-negative option (5.23, p < .01) but not the risky-positive (4.40) nor certain-negative options (4.00).

The frequency of option selection data was analysed using the chi-squared technique. Analysis indicated that the observed frequencies differed significantly from the expected frequency of 12 ($\chi^2(3) = 16.50$, $p < .005$). Post hoc follow-up tests (Bonferroni corrected alpha level = 0.44) revealed significant differences between the risky-positive option (49) the certain-negative (4, $\chi^2(1) = 14.73$, $p < .044$) and risky-negative options (9, $\chi^2(1) = 4.17$, $p < .044$). Moreover, the certain-positive option (17) was significantly different from the certain-negative ($\chi^2(1) = 11.84$, $p < .044$) and the risky-negative options ($\chi^2(1) = 5.14$, $p < .044$).

The analyses indicated that the certain-negative and risky-negative options were equally rated in terms of perceived risk and were the least preferred. However, despite the certain-negative and risky-positive options

being rated as equally risky, the latter was selected more frequently. Indeed, the risky-positive and certain-positive options were rated as equally risky and were the most preferred options.

Comments made by participants indicated that while all four options were perceived as being statistically similar, the manner in which they were presented influenced the way the options “sounded”. This made them appear to present different chances of saving the most lives. Although there appears to be some influence of perceived levels of risk on option selection, as indicated by the most risky option generally being the least preferred, it was not generally the case that the least risky option was the most preferred. For Instance, there was a general positivity bias as the two positively framed options (risky-positive and certain-positive) were the most frequently selected (particularly in the simple frequency and verbal conditions). However, the finding that the risky positive option was the most frequently selected option in the relative frequency and single-event probability conditions would suggest that participants were willing to accept a greater degree of risk in order to save the greatest number of people, when presented in these numerical formats.

Despite the large body of evidence suggesting that frequentist information (particularly simple frequency) is the most ‘user-friendly’ format in which to provide probabilistic information, participants overwhelmingly favoured the relative frequency format when asked which format was easiest to use, clearest, and most informative. Taken more generally, this would appear to be consistent with Erev & Cohen’s (1990) communication mode preference paradox which proposes that people prefer to receive information in numerical format; however, the specific numerical format is open to debate.

In summary, Experiment 2b indicated that despite all possible information being available across the four options, in general participants still perceived the options as differing in terms of implied risk. Further, there were a number of differences in the pattern of results for the four formats. In general, there was evidence suggestive of a positivity bias in which participants were more influenced by the options that were positively framed; however, it was also evident that they were willing to accept a greater degree of risk in the relative frequency and single-event probability formats. Combined with the findings in Experiment 2a, this suggests that the format of the probabilistic risk information in addition to the frame should be considered, given participant preferences, and their potential to influence risk perception and decision-making.

Conclusions

All three experiments have indicated that the amount and format of information can influence the framing of probabilistic risk information in Asian disease-type scenarios. In particular, the findings of Experiments 1 and 2a support Kühberger’s (1998) finding that the larger the difference between a particular decision problem and the original Asian-disease problem, the smaller the framing effect with the new problem.

The effect of framing on the presentation of risk information is an important issue. A key question in the framing literature concerns the identification of the antecedent conditions that determine the occurrence of the framing effect (Kühberger, 1998; Levin et al., 1998). This highlights a

degree of tunnel vision, in which there is a general focus on demonstrating when framing effects occur, while instances of small or null effects are generally not made available through publication (Druckman, 2001). However, on the rare occasion when null or weak effects are reported they are often used to cast doubt on the reliability of the framing effect. What the findings here have actually achieved is to demonstrate the influence of a myriad of variables on framing probabilistic risk information, which are consequently able to affect decision-making.

Hence, given the close association between risk/uncertainty and probability, and the necessity to frame probabilistic risk information, providers of probabilistic risk information *need* to consider the different psychological routes through which risk communication occurs (Nelson, Oxley, & Clawson, 1997). This is important because of the potential effect that framing and other information manipulations can have on how people perceive a situation and their decision outcomes.

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