Using Means Objectives to Present Risk Information

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Abstract

When making decisions involving alternatives with risk, individuals are often unable to express or view the possible outcomes in terms of a fundamental objective. In many cases, using a means objective is more practical or more accessible. However, to apply information about a means objective correctly, a decision maker must first translate it into information about a fundamental objective. This paper presents and discusses the results of two experiments regarding decision makers' preferences and decision process when information is presented either in terms of a means objective or a fundamental objective. We find that individuals are somewhat more likely to choose a risky alternative when information is expressed in terms of means objectives than in terms of fundamental objectives, and that this difference is not significantly smaller among individuals with greater quantitative ability. Individuals are also better able to articulate their decision process when given information related to fundamental objectives than they are with information related to means objectives. In addition, we find that individuals who focus on the uncertainty involved in a decision are more likely to choose a sure thing, whereas individuals who focus on consequences are more likely to choose a gamble.

Keywords: means objectives, risk attitude, risk communication, risk information

1. Introduction

Individuals in society face many risks, and make decisions every day that impact exposure to and potential consequences of these risks. Experts are faced with the challenge of communicating information about risks to the public in a way that helps to improve the decisions made by individuals. Among these challenges is the difficulty of expressing possible outcomes in a manner that can be easily understood. In some cases, it may be more practical to express the outcomes in terms of a *means objective* rather than a *fundamental objective*. A fundamental objective is an objective that is inherently important to the decision maker; a means objective is an objective that is important to the decision maker only because of its "implications for the degree to which another (more fundamental) objective can be achieved" (Keeney 1992, p. 34). For example, *minimizing the concentration of radon in a home* (Smith et al. 1988) could be viewed as a means objective for the fundamental objective of *minimizing the likelihood of the occupants of the home developing lung cancer*.

It is often convenient to communicate risk information in terms of a means objective. In the radon example, the means objective is much easier to quantify and measure. However, presenting risk information in terms of a means objective requires individuals to perform a conversion from the means objective to the fundamental objective before acting rationally on the information given. If the relationship between these objectives is ignored, the decision maker may choose alternatives that are not in his/her best interest. In this paper, we explore the question of whether, and how, individuals make risky decisions differently depending on whether they are given information in terms of means objectives or fundamental objectives. We also explore the impact of the quantitative ability of the decision maker.

There are many decision problems in which the fundamental objective is not readily available to be measured or is challenging to assess. Therefore, we resort to using a means objective. In this paper, we consider a scenario in which officials are interested in decreasing the number of people developing gastrointestinal cancer in a given area. Consequently, they are

concerned about pollution levels, because they have evidence that high levels of a particular pollutant leads to an increase in the rate of gastrointestinal cancer. In this example, the fundamental objective is to *minimize the rate of gastrointestinal cancer in the area*. The means objective associated with this fundamental objective is to *minimize the level of the pollutant*. The relationship between the two objectives is nonlinear; specifically, the *gastrointestinal cancer rate* is increasing and concave in the *level of the pollutant*.

In the following sections, we describe two experiments regarding the relationship between subjects' risk attitudes over the fundamental objective and the means objective. We are interested primarily in how subjects' risk attitudes may (or may not) differ when outcomes are expressed in terms of a means objective versus a fundamental objective. When outcomes are expressed in terms of the means objective, we also provide the relationship between the means objective and the fundamental objective. Thus, if there were no biases or heuristics in play, and no limitations on subjects' cognitive abilities, we would expect to see identical results between the two cases, as it is quite clear that they differ only in the way in which they are framed However, as shown in several of the papers referenced in the next section, framing can have a variety of substantial effects on judgments and decisions; it would be a mistake to presume that the manner in which the outcomes are presented is irrelevant. Keeney and Raiffa (1976) state that the human mind lacks the cognitive ability to assess complex relationships between the means and fundamental objectives, which suggests that this particular difference in framing may have a meaningful impact. This leads us to make the following hypothesis:

Hypothesis 1: People exhibit different risk attitudes depending on whether they receive information describing fundamental objectives or information describing means objectives.

We hypothesize that even when people are presented with the relationship between the means and fundamental objective, they will exhibit different risk attitudes in the two cases, as they are unlikely to incorporate the relationship between the means and fundamental objective fully into their decision process. Instead, they will fixate to some extent on the means objective numbers themselves. Therefore, the risk preferences exhibited by those subjects receiving means objective

information would differ from the subjects receiving fundamental objective information, even though both groups are presented with the same alternatives and possible outcomes. The specific nature of this particular framing effect is unknown.

Due to the cognitive challenge involved with translating quantitative information about means objectives into fundamental objectives, it is possible that an individual's quantitative ability might influence the process. Therefore, we also examine whether numeracy and/or the quantitative background of the subjects affect their exhibited risk attitudes between the two cases. As explained in the following section, prior research indicates that numerate individuals are more likely to incorporate all of the relevant preference and outcome information when making a decision. This suggests that the difference proposed in Hypothesis 1 would likely be less pronounced for numerate individuals.

Hypothesis 2: A high level of quantitative ability reduces the difference observed in risk preferences between the fundamental objective and means objective settings.

In addition, we would like to gain insight into the process by which subjects are making their decisions, which could potentially shed light on any differences observed between the two settings. Therefore, in our second experiment, we also include an open-ended question asking subjects how they arrived at their decision. These responses will help explain the results observed in the two experiments.

We obtain information about subjects' risk attitudes by presenting them with a binary choice between two possible strategies for improving performance on an objective. The effectiveness of one of the strategies is uncertain, i.e. subjects must choose between a sure thing and a risky option. The study includes two different conditions, each of which involves such a binary choice. In one condition, the binary choice is stated in terms of the fundamental objective only. In the other condition, the binary choice is stated in terms of the means objective only, but a graph showing the nonlinear relationship between the means objective and the fundamental objective is also included. In both experiments, we also examine the impact of subjects' quantitative ability or background on the results. In addition, the second experiment includes

process variables that yield further insight about how subjects thought about the decision in each of the two conditions.

The remainder of the paper is organized as follows. In Section 2, we review related literature. We present the first experiment in Section 3, and the second experiment in Section 4. Finally, we conclude the paper with a summary of the analysis and ideas for future directions of research in Section 5.

2. Literature Review

It is well established that the manner in which information is presented affects the way individuals make decisions under risk. Tversky and Kahneman (1974) find that preferences differed significantly depending on whether the same information was expressed in terms of mortality or in terms of survival. This is an example of a *framing effect*, which is discussed further by Tversky and Kahneman (1981); many instances of it can be found in the literature on risky decisions. Starr and Whipple (1984) explore differences between the way people view financial risks, health, and safety risks. Fischhoff et al. (1978) explore many different characteristics of hazards and risks that affect the way individuals view them. Among other findings, they note that subjects who had performed a task requiring assessment of benefits were willing to accept more risk associated with those benefits than subjects who had not performed the task.

Given the complex nature of how individuals interpret and respond to information about risk, a large stream of literature has developed on exploring how to communicate this information to the public more effectively. See, for instance, Morgan et al. (1992), Atman et al. (1994), Chess et al. (1995), and Fischhoff (1995). Corso, Hammitt, and Graham (2001) test how subjects respond to mortality risk information when presented with different types of visual aids. In an analysis of public participation, Kasperson (1986) argues that effective risk communication requires providing the recipient(s) with the additional knowledge and resources necessary to make informed judgments about the risk. Merz et al. (1993) and Merz (1993) discuss the challenges of conveying the appropriate risk information to patients for informed medical consent, and Fischhoff

(2000) extends the discussion to consumers exposed to individual product risks and citizens exposed to broader risks. These authors recognize that simply providing all available risk information is not the solution, as decision makers often lack the expertise and/or desire to sort through all of the information and determine the relevant takeaways. Fischhoff (1995) suggests that presenting people with more information than they need to know would lead to additional bias and confusion. He recommends that when communicating risk information, or any quantitative information, it is important to focus on the numbers that really matter. In our experiments, the numbers that really matter are the fundamental objective outcomes. The means objective is meant to provide people with information that is innately easier to measure or estimate based on real world problems. This notion of focusing on the truly important numbers is central to the premise of our paper; the "numbers that really matter" are those conveyed directly as levels of fundamental objectives.

Fischer et al. (1987) test whether the directly assessed utility functions for a fundamental attribute *X* and a proxy *Z* are consistent with the expected utility model discussed by Keeney and Raiffa (1976), and find that decision makers consistently overweight the proxy attribute relative to the prescriptions of the expected utility model. Using a relative importance model, Fischer et al. find that subjects overweight proxy attributes because they treat the range of outcomes on the proxy *Z* as being equal in importance to the range of the outcomes on the fundamental attribute *Y*. This is related to our first hypothesis, as it suggests decision makers are not thoroughly translating means objective information into fundamental objective information. Keeney (2002) lists twelve mistakes commonly made in determining value tradeoffs, several of which involve shortcomings in measurement and/or the use of means objectives. In particular, he states that elicitations involving tradeoffs should be conducted using fundamental objectives, not means objectives. Keeney (1999) separates means and fundamental objectives in the context of preferences regarding internet commerce. Furthermore, he uses the set of fundamental objectives to provide the foundation for a quantitative model to measure consumer values. In this paper, we examine

specifically the impact of using means objectives in the context of risk; Hypothesis 1 posits that risky decisions, like tradeoffs, are affected by the use of means objectives.

Fundamental objectives are often discussed in the context of value-focused thinking, an approach to developing objectives that is commonly used in the decision analysis literature. It is motivated by a desire to ensure that decision makers base their decisions on the information that is of direct importance to them. Several recent papers apply value-focused thinking to obtain a set of fundamental objectives relevant to a particular decision context, including: Merrick et al. (2005) in watershed improvement, Feng and Keller (2006) in potassium iodide distribution, Merrick and Grabowski (2014) in oil tanker safety, and Simon, Regnier, and Whitney (2014) in defense energy decisions. Bond, Carlson, and Keeney (2010) explore methods of identifying a more complete set of fundamental objectives. Several of the preceding papers use means-ends networks to model the relationship between means objectives and fundamental objectives. The results of the experiments in our paper underscore the importance of a decision maker having a clear understanding of the fundamental objective(s) associated with a decision.

There is some work in the literature on the relevance of numeracy (i.e. comfort with and ability to use mathematical concepts) to risk communication. Peters and Levin (2008) find that numerate individuals are more likely to incorporate their preferences for all of the possible outcomes of a gamble when making a decision, whereas less numerate individuals are more likely to provide superficial responses and fall victim to framing effects. Dave et al. (2010) find that more complex methods of eliciting risk preferences are more accurate but noisier. They argue that the nature of the tradeoff differs depending on the level of individuals' quantitative ability; more complex methods are preferable for numerate individuals, while simpler methods are preferable for non-numerate individuals. The results of both Peters and Levin (2008) and Dave et al. (2010) motivate Hypothesis 2; they suggest that numerate individuals should be better able to process the relationship between a means objective and a fundamental objective in a coherent way. In addition, Reyna and Brainerd (2008) find that non-numerate individuals are more likely to suffer from several particular biases in judgment and decision making related to probabilities and

frequencies, and in the medical domain, Lipkus, Samsa, and Rimer (2001) find that even many well-educated individuals cannot correctly interpret basic information about health risks.

3. Experiment 1

3.1. Method

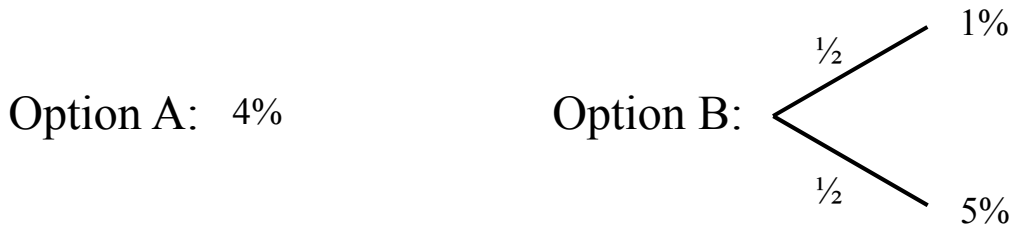
The first experiment uses a between-subjects design with 522 subjects. The subjects are undergraduate students at a large public research university on the west coast of the United States, and each received course credit for participating in the study. Subjects were randomly assigned to one of two conditions with equal likelihood: Fundamental or Means. They were then asked to choose between two available options that could be implemented to address the issue of high *pollutant levels* associated with an increase in the *rate of gastrointestinal cancer* in the population. One option was a sure thing; the subjects could be certain that a precise level of the objective would be achieved, while the other option involved uncertainty, where the subjects were given a 50/50 gamble over two potential levels. In the Fundamental condition, subjects chose between reducing the *gastrointestinal cancer rate* to 4% with certainty, and a 50/50 chance of reducing the *gastrointestinal cancer rate* to either 1% or 5%. The question presented to subjects in the Fundamental condition is shown in Figure 1. In the Means condition, subjects chose between reducing the *pollutant level* to 30 parts per million (ppm) with certainty, and a 50/50 chance of reducing the *pollutant level* to either 10 ppm or 50 ppm. Subjects assigned to the Means condition were also shown a graph depicting the (non-linear) relationship between *pollutant level* and *cancer rate*. The question and information presented to subjects in the Means condition are shown in Figure 2.

City officials are concerned about the level of a pollutant because it has been shown to lead to an increase in the rate of gastrointestinal cancer in the population. Two possible options for addressing the problem are presented below:

-Option A will reduce the gastrointestinal cancer rate to 4% with certainty.

-Option B will reduce the gastrointestinal cancer rate to:
1% with a ½ chance
5% with a ½ chance

The two options are illustrated below.



Which of the following best describes your preferences about these two options?

- o I prefer Option A.
- o I prefer Option B.
- o I am indifferent between Option A and Option B.

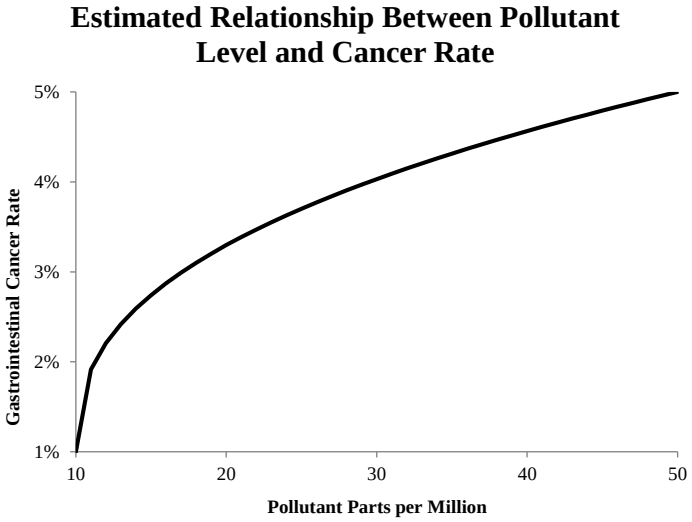
Figure 1. The question presented to subjects in the Fundamental condition of Experiment 1.

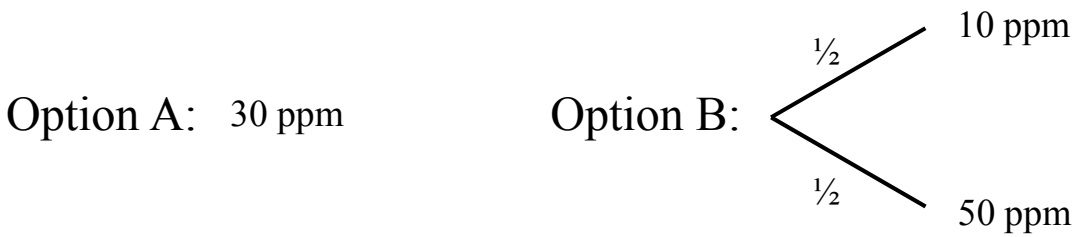
City officials are concerned about the level of a pollutant because it has been shown to lead to an increase in the rate of gastrointestinal cancer in the population. Two possible options for addressing the problem are presented below:

-Option A will reduce the pollutant level to 30 parts per million (ppm) with certainty.

-Option B will reduce the pollutant level to:
10 ppm with a ½ chance
50 ppm with a ½ chance

The relationship between the pollutant level and gastrointestinal rate, and the two options, are illustrated below.





Which of the following best describes your preferences about these two options?

- I prefer Option A.
- I prefer Option B.
- I am indifferent between Option A and Option B.

Figure 2. The question and information presented to subjects in the Means condition of Experiment 1.

Notice from the relationship shown in Figure 2 that at 30 ppm, the corresponding *gastrointestinal cancer rate* is 4%, and at 10 ppm and 50 ppm the corresponding *cancer rates* are 1% and 5%, respectively. Thus, as illustrated in Figure 3, if subjects prefer the sure thing in the Fundamental condition, they should also prefer the sure thing in the Means condition, and vice versa. The questions and the relationship between the two objectives were constructed such that if all subjects assigned to the Means condition performed a correct conversion from *pollution levels* to *cancer rates* and then treated their choice as if it were the Fundamental condition, we would expect to observe identical results for the two conditions.

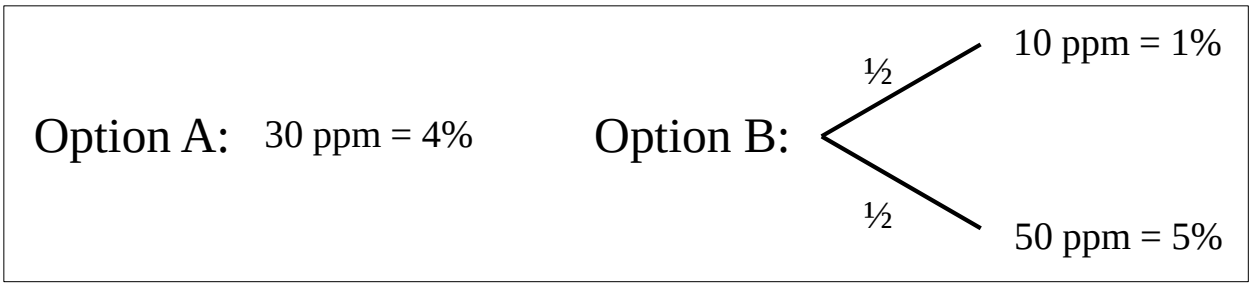


Figure 3. The correct conversion between the means objective and fundamental objective in Experiment 1 based on the relationship presented to subjects in Figure 2.

Subjects also stated their area of study. The area of study options were Business/Economics, Engineering/Math, Humanities, Natural Science (e.g. Biology, Chemistry), Social Science (e.g. Political Science, Psychology), and Other/Undecided. In our analysis, we condense the subjects' areas of study into "Quantitative," which includes Business/Economics, Engineering/Math, and Natural Science, and "Non-Quantitative," which includes Humanities, Social Science, and Other/Undecided. This categorization is not perfect, of course, but it is reasonable to assume that the average mathematical ability of the subjects categorized as quantitative is higher than the average mathematical ability of those categorized as non-quantitative (The College Board 2015). 20% of the subjects were quantitative, and 80% were non-quantitative. The imbalance was due to the survey being conducted through a group with a greater degree of access to social science students.

This study was conducted as an online survey. The median completion time for the entire survey was 2.6 minutes. 70% of subjects spent between one and five minutes on the survey.

3.2. Results and Discussion

The overall results of Experiment 1 are shown in Figure 4. Note that Option A is the "sure thing" option with certainty, while Option B is the "gamble." If subjects assigned to the Means condition were performing a correct conversion from the means objective to the fundamental objective, we would expect the proportions of responses to be equal for the two conditions. We find that subjects were more likely to be indifferent in the Means condition, and less likely to prefer the sure thing. The proportion of indifferent responses was the most pronounced difference between the two conditions. This result is not surprising, since the Means condition provided more information and thus required a greater level of cognitive processing. That is, differentiating between the sure thing and the gamble requires greater effort in the Means condition, leading to more subjects choosing the indifference option. The proportion of subjects preferring the gamble remained constant across both conditions. Thus, overall, we observe more indifference and a slight reduction in risk aversion when outcomes are expressed in terms of means objectives for this particular scenario.

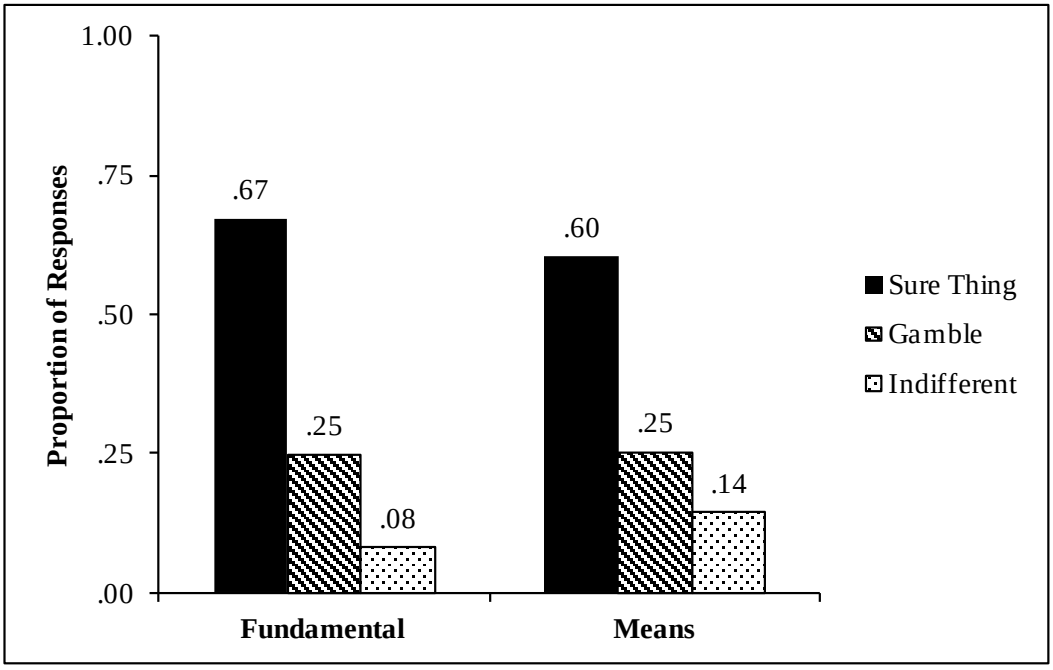


Figure 4. Overall results of the survey, showing the proportion of each response for each of the two conditions.

The results of the survey split by area of study are shown in Table 1, with the proportions illustrated in Figure 5.

	Quantitative			**Non-Quantitative**		
	Sure Thing	Gamble	Indifferent	Sure Thing	Gamble	Indifferent
Fundamental	30	20	5	143	44	16
Means	36	14	8	123	53	30
Total	66	34	13	266	97	46

Table 1. Survey results split by area of study.

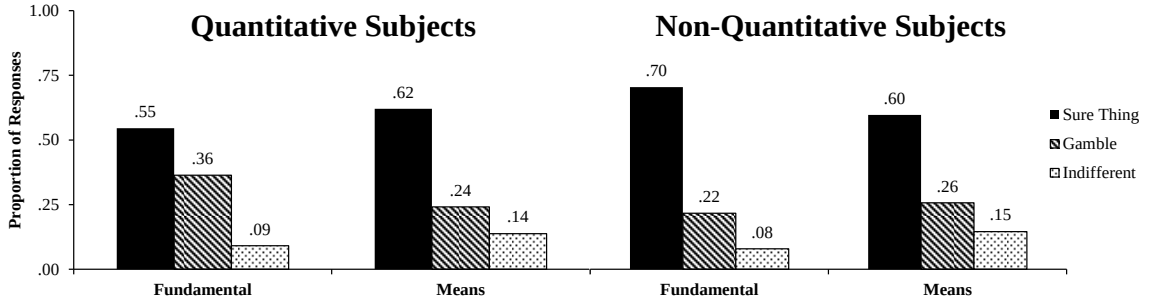


Figure 5. Proportions of responses for each condition, split by subjects' area of study.

Table 2 shows the results of an ordered logit model with the response as the dependent variable. The model includes the condition and the quantitative background of the subjects as independent variables, as well as an interaction term. A value of 0 for condition indicates the Fundamental condition, and a value of 1 indicates the Means condition. A value of 0 for Quantitative indicates a non-quantitative area of study, and a value of 1 indicates a quantitative area of study. The response variable is treated as ordinal, with the sure thing as the lowest level, and the gamble as the highest level, i.e. the indifferent response is treated as being between the two other responses. The main effects of condition and quantitative background are both significant. Subjects were more likely to prefer the sure thing in the Fundamental condition than in the Means condition, and non-quantitative subjects were more likely to prefer the sure thing than quantitative subjects. However, the interaction between the two factors was insignificant; that is, we did not observe strong evidence that quantitative and non-quantitative subjects performed the conversion from means to fundamental objectives differently, despite the differences visible in Figure 5.

Ordered Logit, using observations 1-522
Dependent variable: Response
Standard errors based on Hessian
Full model

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	0.509	0.206	2.476	0.013**
Quantitative	0.591	0.298	1.986	0.047**
Interaction	−0.686	0.422	−1.625	0.104

With interaction removed

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	0.364	0.139	2.620	0.009***
Quantitative	0.277	0.164	1.691	0.091*

*significant at 10% level
**significant at 5% level
***significant at 1% level

Table 2. Ordered logit results of Experiment 1.

4. Experiment 2

4.1. Method

The second experiment uses a between-subjects design with 510 subjects from the same university. As before, subjects were randomly assigned to either the Fundamental or Means condition with equal likelihood, and each condition involved a choice between a sure thing and a 50/50 gamble. The information presented to subjects in the Fundamental and Means conditions is shown in Figures 3 and 4, respectively. For the sake of ensuring robustness of the results, the numbers differ somewhat from those in Experiment 1, which leads to a small visual change in the curve shown in the Means condition. We also removed the word "estimated" from the title of the graph, to avoid having subjects read too much into the possibility of imprecision or error associated with the function.

There are three further changes from Experiment 1. First, the "indifferent" choice was removed. Second, a short assessment of quantitative ability was added at the end of the survey. The questions on the assessment were adapted from Schwartz et al. (1997) and Lipkus, Samsa,

and Rimer (2001). The reasons for and implications of these changes are discussed in Section 4.2. Finally, after subjects had chosen either the sure thing or the gamble, they were given the following prompt: "*As best you can, please describe the thought process you used to reach your decision. Whatever information you can provide will be very helpful*." These responses were coded by the authors according to three binary process variables: *uncertainty-focused, consequence-focused*, and *computation-focused*. A response was coded as uncertainty-focused if it suggested that uncertainty (or certainty) played a role in the subject's decision, e.g. "I prefer not to gamble." It was coded as consequence-focused if it made any sort of value judgment about any of the outcomes, e.g. "I don't think 6% is that much worse than 5%." It was coded as computation-focused if it referred to any mathematical treatment of the probabilities and/or outcomes, e.g. "The average of the levels in the gamble is 4.5%." Responses were not limited to one process variable; for instance, a response could be both uncertainty-focused and consequence-focused, e.g. "The better result isn't beneficial enough to justify taking a chance." Each author coded the responses independently; the few differences were then resolved on a case-by-case basis. The approach used to obtain data for the process variables is similar to that used by Kühberger and Wiener (2012).

Apart from these changes, the questions and information given to the subjects were identical to Experiment 1 in both content and appearance. The quantitative assessment included eight questions; the associated independent variable was defined as the number of correct answers. The list of questions is provided in the Appendix. As in Experiment 1, the vast majority of the subjects were in non-quantitative areas of study; only 11% indicated a quantitative major. The median completion time for the entire survey (i.e. including the process question and quantitative assessment) was 5.6 minutes. 70% of subjects spent between three and ten minutes on the survey.

4.2. Results and Discussion

The overall results of Experiment 2 are shown in Figure 6. As in Experiment 1, the Means condition appears to be associated with a lower proportion of subjects preferring the sure thing.

Note that the indifferent option was removed in Experiment 2. This was done to help establish the robustness of the results in Experiment 1; there may have been a few subjects, particularly in the Means condition, who chose the indifferent response simply because comparing the options carefully would require cognitive effort. This eliminates the option for the subjects to decline to choose between the gamble and the sure thing.

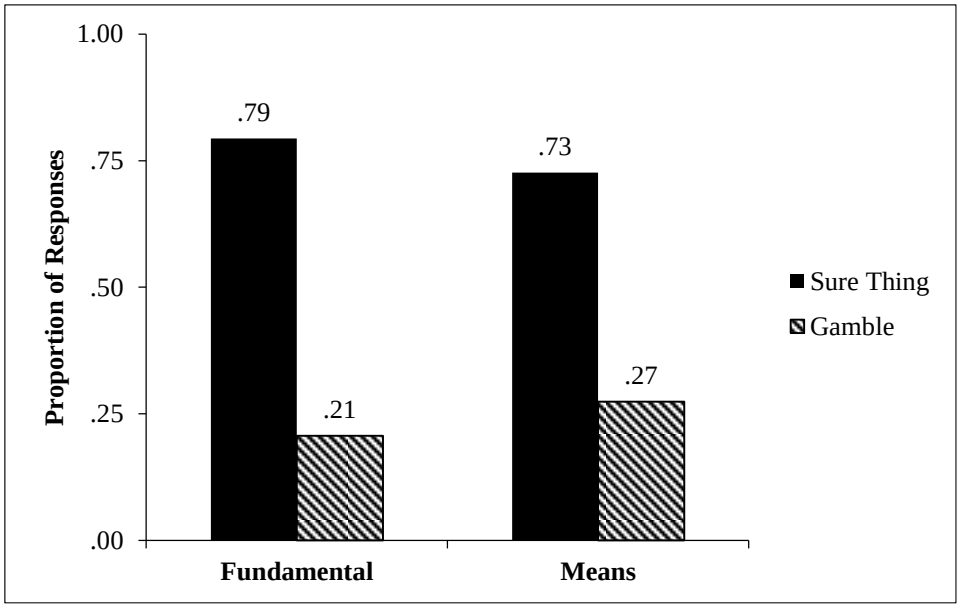


Figure 6. Overall results of the survey in Experiment 2, showing the proportions of each response for each of the two conditions.

The effect of quantitative ability of the subjects on the responses disappeared completely, whether measured by area of study or by score on the quantitative assessment. The results of a binary logit model are shown in Table 3. Thus, the specific relationship of quantitative ability to risk preferences given fundamental objectives versus means objectives remains unclear. Table 3 uses the assessment score as the measure of quantitative ability. The results are nearly identical if area of study is used instead. The two measures were clearly related; the average assessment score of subjects from non-quantitative areas of study was 5.83, while the average score of subjects from quantitative areas was 6.45 ($p = 0.0038$). If the insignificant interaction term is removed from the model, condition becomes significant at the 10% level. That is, the main

effect of condition is significant, but the conditional effect given assessment score is not. As in Experiment 1, subjects were less likely to choose the sure thing in the Means condition.

Logit, using observations 1-510
Dependent variable: Response
Standard errors based on Hessian
Full model:

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	0.704	0.734	0.959	0.338
Quantitative	0.004	0.094	0.045	0.964
Interaction	-0.057	0.120	-0.479	0.632

With interaction removed:

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	0.367	0.210	1.753	0.080*
Quantitative	−0.031	0.058	−0.529	0.597

*significant at 10% level

Table 3. Logit results of effects on subject response in Experiment 2.

Experiment 2 also included a text response in which subjects explained how they made their decisions, which allowed us to develop process variables to gain additional insights. Out of 510 subjects, 318 responses included an uncertainty focus, 117 included a consequence focus, and 32 included a computation focus. 26 subjects left the question blank, and a few responses were not meaningful or intelligible, e.g. “The risk of getting cancer.” In addition, some responses were vague or general, e.g. “it seemed more logical.” However, the vast majority of the responses included at least one of the three process variables.

Table 4 shows the results of three logit models with each of the three process variables as the dependent variable. Condition is the only independent variable. The purpose of these models is to determine the influence of using a fundamental objective or a means objective on the likelihood of a subject focusing on uncertainty, consequences, or computations when faced with a risky decision.

Logit, using observations 1-510
Standard errors based on Hessian
Dependent variable: UncertaintyFocus

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	−0.335	0.135	−1.824	0.068*

Dependent variable: ConsequenceFocus

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	−0.643	0.215	−2.996	0.003***

Dependent variable: ComputationFocus

	Coefficient	*Std. Error*	*z*	*p-value*
Condition	−0.906	0.392	−2.309	0.021**

*significant at 10% level
**significant at 5% level
***significant at 1% level

Table 4. Logit results of the relationship between condition and the occurrence of each of the three process variables.

The most striking process variable result is the negative coefficient and significant p-value of condition in all three models, meaning that the likelihood of subjects alluding to each of the three process variables was significantly higher in the Fundamental condition than in the Means condition. This suggests that subjects were better able to elucidate specific thought processes when making a decision based on information about fundamental objectives. In the Means condition, subjects tended to write less, and were more likely to provide blank, unintelligible, or vague responses. The clearly significant result for the consequence focus variable, in particular, supports the intuitive argument that subjects are less likely to focus on the consequences in the Means condition, in which their impacts are less salient.

We also examine the relationship between the process variables and the preference between the sure thing and the gamble using a logit model. The three process variables are used as the independent variables. The results are shown in Table 5. An uncertainty focus greatly increased subjects' probabilities of choosing the sure thing, and a consequence focus greatly increased subjects' probabilities of choosing the gamble. The relationship between an

uncertainty focus and preference for the sure thing is rather intuitive. The relationship between a consequence focus and preference for the gamble is perhaps less so. One possible explanation is that decision makers view the sure thing as a "default" choice, and tend to choose the gamble only if they can become convinced that its set of possible outcomes is more desirable. These results may be valuable for future studies on risky decisions.

Logit, using observations 1-510
Dependent variable: Response
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*
UncertaintyFocus	−2.167	0.259	−8.375	<0.001***
ConsequenceFocus	1.586	0.280	5.650	<0.001***
ComputationFocus	0.356	0.429	0.829	0.407

***significant at 1% level.

Table 5. Logit results of effects of subjects' reported decision process on their response.

5. Conclusion

We conducted two experiments to examine how subjects make choices between a sure thing and a gamble, depending on what information about objectives is provided. Some subjects were given information in terms of a fundamental objective, and others were given information in terms of a means objective, along with a graph showing its relationship to the fundamental objective. We observed differences in subjects' preferences depending on which information they received; in particular, subjects were more likely to choose the gamble when information was presented in terms of a means objective. This suggests the existence of a framing effect; people make risky decisions differently depending on whether information is presented in terms of fundamental objectives or means objectives. This may be due to the additional cognitive effort involved with converting from a means objective to a fundamental objective, a concept that itself merits further study.

We split the results according to whether or not the subject came from a quantitative area of study, and in Experiment 2, we also conducted an assessment of subjects' quantitative ability.

In Experiment 1, we observed a difference in responses by quantitative background; quantitative subjects were more likely to choose the gamble than non-quantitative subjects were. This result did not arise in Experiment 2 (using either area of study or assessment score as the measure of quantitative ability). Neither experiment yielded a significant interaction between condition and quantitative ability, suggesting that the difference in responses between the fundamental and means objectives conditions is not mitigated by quantitative ability. We believe the relationship between quantitative ability, fundamental and means objectives, and risky decision making is rather complex, and merits further study.

In Experiment 2, we asked subjects to explain the rationale for their decision, and coded the responses into process variables indicating a focus on uncertainty, consequences, and computation. All three focuses were more likely when subjects were presented with information in terms of fundamental objectives, suggesting that individuals are better able to articulate a specific thought process when dealing with fundamental objectives than with means objectives. We also observed very strong effects of two of the process variables on the choice between the sure thing and the gamble. Subjects who indicated an uncertainty focus were far more likely to choose the sure thing than subjects who did not, and subjects who indicated a consequence focus were far more likely to choose the gamble than those who did not. These relationships provide valuable insight into the processes behind risky decision making, and suggest possible underlying reasons for the observed differences between the fundamental and means conditions.

There are several possible directions for future research on this topic. First, the results of these experiments suggested a slight reduction in risk aversion when information was presented in terms of a means objective. However, this might be a consequence of the fundamental objective being concave in the means objective; it would be interesting to explore how this effect might change if the relationship were convex. Second, it might be valuable to explore other possible ways of presenting information about the relationship between means objectives and fundamental objectives. In this study, we simply showed graphs, but perhaps there are other approaches that might be more effective, particularly for non-quantitative decision makers. It might be possible to

provide other visualizations of the impact of potential outcomes that would make the means objective information less abstract. Third, it might be possible to train decision makers to convert means objectives information more accurately by having them practice and obtain feedback. That is, decision makers could answer a series of questions that includes intermingled pairs of identical decisions, where one is presented using fundamental objectives, and the other with means objectives. The decision maker would be informed of any inconsistencies at the end, and asked to reflect on how and why they arose. Fourth, it could be productive to explore the factors that lead decision makers to focus on the particular process variables. The results of Experiment 2 suggest that framing information in a way that draws attention to consequences, for instance, could lead to an increased probability of choosing a gamble. Finally, it could be enlightening to conduct similar studies in different domains. The scenario used in this study involved a societal risk; it is possible that different results might arise for scenarios involving more personal risks.

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Appendix

The quantitative assessment given to subjects in Experiment 2 is shown below. It is based on Schwartz et al. (1997) and Lipkus, Samsa, and Rimer (2001).

The last portion of this survey is a short quantitative assessment. Please answer the following eight multiple choice questions as best you can:

1. Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, what is your best guess for the number of times the die will come up even (2, 4, or 6)?
   - o 167
   - o 333
   - o 500
   - o 667

2. In the Mega Bucks Lottery, the chance of winning a $10.00 prize is 1%. What is your best guess for the number of people who will win a $10.00 prize if 1,000 people each buy a single ticket to Mega Bucks?

- 0
- 1
- 10
- 100

3. In the Super Monthly Sweepstakes, the chance of winning a car is 1 in 1,000. What percent of tickets to the Super Monthly Sweepstakes win a car?

- 0%
- 0.1%
- 1%
- 10%

4. Which of the following numbers represents the biggest risk of an accident occurring?

- 1 in 100
- 1 in 10
- 1 in 1000
- 1 in 50

5. Which of the following numbers represents the biggest risk of an accident occurring?

- 10%
- 0.5%
- 1%
- 5%

6. If Person A's chance of an accident this year is 1%, and person B's chance is double that of A's, what is B's chance?

- 10%
- 2%
- 1%
- 0.5%

7. If Person A's chance of an accident this year is 1 in 100, and person B's chance is double that of A's, person B's chance is 1 in ____.

- 1000
- 200
- 50
- 10

8. The chance of a semiconductor made by QuantumTech being defective is .0005. If QuantumTech produces 10,000 semiconductors, what is your best guess for the number of semiconductors that will be defective?

- 5
- 10
- 50
- 100