DOES LINGUISTIC AMBIGUITY EXPLAIN RISKY CHOICE FRAMING EFFECTS?: WHAT PEOPLE INFER ABOUT MISSING INFORMATION, AND HOW INFERENCES RELATE TO NUMERACY AND FRAMING BIAS

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Christina F. Chick

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ABSTRACT

Scholars have argued that framing effects are caused by assumptions about unstated information, such as assuming that the sure option is lower-bounded (e.g., assuming “at least” 200 will be saved; Mandel, 2013). We disambiguated missing information before presenting framing problems with either the traditional risky option (e.g., 1/3 chance 600 saved and 2/3 chance none saved) or a truncated risky option (e.g., 1/3 chance 600 saved). A manipulation check indicated that, following presentation of detailed instructions with worked examples, over 90% of subjects correctly interpreted missing information while completing framing problems. Contrary to the ambiguity hypothesis, subjects who did not mentally add “at least” to the sure option nonetheless showed a robust framing bias. Among the few subjects who showed ambiguity effects, framing and truncation effects still replicated. Although adding words can change interpretations of framing information, this manipulation does not account for the core mechanism of framing bias.

BIOGRAPHICAL SKETCH

Ms. Chick graduated from Phillips Exeter Academy in 2003 and from Dartmouth College in 2008 with a BA in Psychological and Brain Sciences. Her research, using both behavior and functional magnetic resonance imaging, has focused on how individual differences in reward response and inhibition interact with situational factors such as information about magnitude and probability. Her research interest is the neural mechanism of the interaction between emotional and cognitive processes, including motivation and self-control.

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In risky choice framing effects, people show opposite preferences for risk depending on whether objectively equal options are described as gains or losses. For example, imagine that 600 lives are at risk. Given the choice between (a) saving 200 people for sure and (b) taking a 1/3 chance that 600 people will be saved (with 2/3 chance that no one will be saved), most people choose to save 200 people for sure. However, if the options are presented as a choice between (a) 400 people dying for sure and (b) 1/3 chance that no one will die and 2/3 chance that 600 will die, people who chose the sure option in the previous example often opt, instead, to take a risk. Although individual differences in loss aversion and risk aversion are well documented as determinants of risky decision making (Christopoulos, Tobler, Bossaerts, Dolan & Shulz, 2009; Peters & Buchel, 2009), contextual modification of these preferences challenges core assumptions about decision making (Kuhberger & Gradl, 2013; Okder, 2012). The framing bias raises the question whether a decision maker brings preferences to the decision context, or the context brings preference to the decision maker. At stake is not only the stability of values and preferences, but the human propensity to make rational decisions (Mandel, 2013; Reyna, Chick, Corbin & Hsia, 2013).

Descriptive Invariance and the Stability of Preferences

This reversal of preferences for options of equal expected utility, first demonstrated by Tversky and Kahneman (1979), challenges the assumption that people make rational decisions. Specifically, the axiom of *descriptive invariance* holds that, for a decision maker to be rational, his or her preferences must be consistent across different descriptions of otherwise identical options (Kuhberger & Wiener, 2012). In other words, “the manner in which prospects are formulated should not influence their preference order" (Kahneman & Tversky, 1984). By defying descriptive invariance, framing effects call into question an even more basic assumption about the stability of preferences. As Tversky, Sattath and Slovic (1988) put it, "[I]f different elicitation procedures produce different orderings of options, how can preferences and values be defined? And in what sense do they exist?" (p. 383).

Hypothesized Ambiguity in the Framing Options

The prototypical risky choice framing problem is the Asian disease problem (Kuhberger & Gradl, 2013; Mandel, 2013; Tversky & Kahneman, 1981). In this problem, subjects are told that an unusual Asian disease is expected to arrive in the United States, and it is expected to kill 600 people. They are told that there are two proposed treatment programs, and they must select one. There are two versions of each program, one of which (gain frame) describes the outcomes in terms of lives saved, and the other (loss frame) in terms of lives lost. Subjects see only the gain or the loss version of the options for a given problem, as follows.

Gain frame:

> If Program A is adopted, 200 people will be saved.
>
> If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that nobody will be saved.

Loss frame:

> If Program C is adopted, 400 people will die.
>
> If Program D is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die.

In terms of expected utility, all of the options are equal, both within and between frames. Therefore, a rational actor who prefers either the sure option or the risky option in one frame should have the same preference in the other frame. However, most people prefer the safe option in the gain frame but the risky option in the loss frame, and this bias is widely documented both within and between subjects (Kuhberger, 1998).

However, there is an apparent loophole in the case against rational decision-making. Framing effects are said to be irrational because people show opposite preferences *for options of equal expected utility* when superficial aspects of the problem wording are changed. However, multiple scholars have questioned whether subjects really perceive the options to be equal:

> [T]he illusion of framing in the Asian disease problem arises owing to preconceptions on the part of the experimenters, who expect the decision makers to have the same schema as theirs when making decisions. (Okder, 2012, p. 65)
>
> [A]n important segment of the framing literature has been concerned with information non-equivalent descriptions. (Sher & McKenzie, 2006, p. 468)

The argument for ambiguity centers on the fact that, whereas the risky option is completely specified (i.e., both logical complements are stated), the sure option is incompletely specified (i.e., only one of the logical complements is stated). This has led to widespread speculation about what subjects assume about the unstated logical complement in the sure option.

> [T]he riskless option is ambiguous, and, presuming specific inferences, this option could be better (gain frame) or worse (loss frame) than the risky option, which is unambiguous because it is completely specified. (Kuhberger & Gradl, 2013, p. 116)
>
> [I]t is not obvious that people interpret saving 200 people as exactly 200 will be saved. (Kuhberger & Tanner, 2010, p. 316)

> The crux of the issue is the assumption that [when 600 lives are at stake] saving 200 lives is equivalent to losing 400 lives, and that losing 400 lives is equivalent to saving 200 lives. (Jou, Shanteau & Harris, 1996, p. 2)

We and others (e.g., Kuhberger & Tanner, 2010) know of no rationale for why the traditional version of the problem completely specifies the risky option but not the sure option.

Ambiguity as a Defense of Rationality

Scholars who argue that subjects do not perceive the options to be equal take this as evidence that framing effects do not challenge rational decision making. After all, if one option has a higher expected utility, then it would be irrational *not* to prefer it. This opinion is widespread, and it spans three decades of literature:

> Framing effects have long been viewed as compelling evidence of irrationality in human decision making, yet that view rests on the questionable assumption that numeric quantifiers used to convey the expected utilities of choice options are uniformly interpreted as exact values. (Mandel, 2013, p. 1)

> If framing effects appear only in descriptions that fail to be logically equivalent, but disappear in descriptions that succeed in being logically equivalent (i.e., in complete descriptions), one can no longer interpret risky choice framing effects as reflecting irrational decision behavior. (Kuhberger & Tanner, 2010, p. 325)

> There is no normative problem with logically equivalent but information non-equivalent descriptions leading to different decisions. (Sher & McKenzie, 2006, p. 487)

> These findings [i.e., risky choice framing effects] do not constitute convincing evidence that people violate the invariance principle in responding to the problem. (Mandel, 2001, p. 60)

> If subjects treat problems differently and state that there was an objective difference…then the problems, as interpreted by the subjects, actually were different, and therefore cannot be viewed as a violation of descriptive invariance. (Frisch, 1993)

In short, Okder (2012) summarizes the skeptical perspective as follows: “The quarter-century history of the research has accumulated the findings in the framing phenomena, but the underlying psychological processes are still in controversy” (p. 72).

In what follows, I argue that the published literature yield far less controversy than Okder’s (2012) quotation would indicate. I organize the debate by systematically reviewing and assessing theoretical arguments and empirical evidence for and against (a) the perception of ambiguity and (b) the effect of perceived ambiguity on framing behavior. First, I catalogue the theoretical frameworks that have been invoked as causal mechanisms for the perception of ambiguity. I assess the degree to which each framework makes coherent predictions that correspond to the empirical evidence. Next, I review empirical literature in order to identify the prevalence and type of ambiguity perceived by subjects, as well as the relationship, if any, between perceived ambiguity and framing effects. Then, I present new data testing the hypothesis that ambiguity is necessary to framing effects. By instructing subjects about how to interpret the options (so as to eliminate hypothesized ambiguities), and by documenting that they retained our instructions when making decisions, my research team and I show that framing effects are robust to linguistic disambiguation. I conclude that, while some subjects do interpret the options as ambiguous, ambiguity does not change the prevalence or direction of framing effects.

Theoretical Accounts of Ambiguity

Gricean pragmatics and conversational implicature. Appeals to the pragmatics of everyday language are common in justifying claims of ambiguity in framing options. Many have suggested that incompletely specified framing options are ambiguous because people find meaning in the mere fact that they are not fully specified. For example, Mandel (2001, pp. 59-60) writes:

> The ambiguity of the certain prospects may also have made it easier for linguistic norms to systematically bias the interpretation of the prospects. For instance, Macdonald (1986; see also Jou, Shanteau & Harris, 1996) proposed that people tend to implicitly add the term 'or more' to statements about quantities. Clearly, it would be easier to do so if the total number of relevant cases (viz., the 600 people in the disease problem) are not explicitly accounted for.

Macdonald (1986) elaborates on this point, summarizing the application of conversational pragmatics to risky choice framing problems:

> Tversky and Kahneman would seem to hold that subjects should convert the essence (as seen by the experimenters) of problems into formal propositions, ignoring stylistic variations, extra detail and the motivations behind the utterances. Presumably they see such a process as a model for ordinary decision making. In this way they are quite wrong: it is essential to take all these things into account in determining the meaning of natural utterances. (p. 26)

In addition to providing this background argument, Macdonald (1986) makes a specific hypothesis about the direction of the effect of ambiguity on framing behavior:

> What are subjects supposed to make of the phrase 'exact scientific estimates'? One might ordinarily regard the statement about A as being falsified if 199 cases live and 401

> die, and conversely for the statement about C; that is, ordinary language reads 'or more' into the interpretation of the statement. This has to do with the preferred level of description once more—it is unnatural to predict an exact number of cases. Programme A is therefore seen as better than programme C and this alone is enough to explain the results. (p. 24)

Thus, Macdonald uses conversational pragmatics to predict that subjects mentally add "or more" to the sure option.

The problem with the argument based on conversational pragmatics is that, notwithstanding the plausible hypothesis set forth by Macdonald and Mandel, it is difficult to derive a clear prediction about the direction of effects. For example, the following quotation from Macdonald (1986) might just as well be used to argue for the opposite of his point: "While it cannot be denied that natural language has a potential for ambiguity, utterances in context are rarely misunderstood and because different levels of meaning can be conveyed simultaneously it is a highly efficient vehicle of communication" (p. 26). One might take this to mean that there is reason to make inferences about missing information, since if there were any additional relevant information, the speaker would have included it. Consistent with this interpretation, Reyna and Brainerd (1991) write, "The second phrase of the gamble is merely the complement of the first. From the perspective of pragmatic norms of communication, one of the complements is superfluous, and would ordinarily be omitted in everyday language (e.g., Grice, 1975)" (p. 254).

Similarly, based on the maxim of relevance, it may be assumed that unstated information (the object of inference) is not pertinent, because if it were, the speaker would have made it explicit. In this vein, Kuhberger and Tanner (2010, p. 325) cite a classic text on relevance theory in order to speculate, “Based on pragmatic rules, subjects may make no inferences about the unstated information because ‘communication information comes with a guarantee of relevance’ (Sperber & Wilson, 1986, p. vi).” As one last example, Mandel (2001) also seems to unwittingly counter his own argument for ambiguity when invoking pragmatic norms:

> Also, because it is a norm of conversational pragmatics that people avoid redundancy in their statements (Grice, 1975, Hilton, 1995), they tend not to use multiple descriptions, especially if the descriptions are complements. It would be uncommon—perhaps even strange—to describe a wine glass as both half *empty* and half full. Doing so would violate Grice’s *maxim of manner* which stipulates that, among other things, interlocutors should be brief in their utterances. (p. 57)

What are we to make of these opposing uses of the pragmatic norms? Which of the maxims applies: Relevance? Manner? Both? There is no systematic hypothesis, even a disputed one, about how pragmatic norms of conversational implicature would impact interpretation of the framing problems. Among these inconsistencies, the clearest hypothesis is the one articulated by MacDonald (1986) and Mandel (2001, 2013), that the norms of conversational pragmatics cause subjects to mentally add “or more” to the sure option.

Information leakage. Information leakage is a variant of the pragmatics approach; as Sher and McKenzie (2008, p. 83, emphasis orignal) describe it, “The normative analysis of framing effects cannot be neatly separated from the phenomena of *pragmatics*—i.e., the ways in which speakers typically select utterances and convey meaning in human conversational environments.”

In short, information leakage implies a conventional understanding about the use of language to convey more than the surface meaning of an utterance. Though related, Gricean pragmatics and information leakage are distinct approaches. Whereas *Gricean pragmatics* are about conventions in the use of a particular language (such that a native speaker would understand, but a proficient foreigner would not), *information leakage* is an inference about the speaker's intention (as distinguished from the nuances of a particular language that allow for communication of that intention).

According to the information leakage hypothesis, listeners assume that speakers' valenced language cues additional, implicit information. That is, "psychologically salient properties recruit congruent linguistic terms" (Sher & McKenzie, 2006, p. 488). In particular, the valence of language used to describe an option is thought to signal a change relative to a reference point. For example, listeners may infer that a wine glass described as half full was previously half empty.

Sher and McKenzie (2008) have reported the only empirical test of information leakage in risky choice framing effects. In articulating the hypothesized mechanisms, they distinguish *logical* equivalence from *information* equivalence, arguing that two logically equivalent premises can nonetheless be conveyed in an information non-equivalent way. If A and B are logically equivalent and they are described as *'A'* and *'B,'* Sher and McKenzie (2008) argue that listeners assume the speaker's choice of words ('*A'* and *'B'*) reveals unstated knowledge about A and B, and listeners make inferences about A and B based on what they assume to be the speaker's implied knowledge. Sher and McKenzie (2008) apply this reasoning to risky choice framing effects as follows:

> In the typical framing experiment, the participant knows that A, assuming the participant trusts the speaker, only because the participant knows that the speaker has said '*A*'. *The speaker said 'A'* is a fact which is logically equivalent neither to A nor to B. It is

> certainly not logically equivalent to *The speaker said 'B'*. It is true, as the above argument notes, that no inferences can be drawn from A which cannot be drawn from B. But it is false that no inferences can be drawn from the fact that the speaker said *'A'* which cannot be drawn from the fact that the speaker said *'B.'* (p. 84)

Sher and McKenzie (2008) describe two preliminary experiments (statistics and sample sizes are not reported) that are consistent with this argument, although far from conclusive. Despite these suggestive preliminary results (described in the next section), Sher and McKenzie (2008, p. 89) describe the ambiguity question as an open one. They sum up the evidence as follows: "Is there important information leakage in risky choice framing problems? The short answer is: we do not know. The available evidence is too sparse and fragmentary to undertake a serious analysis at this point."

Whereas the evidence for information leakage in *risky choice* framing effects is sparse, there is compelling evidence for the information leakage effect in *attribute* framing. For instance, McKenzie and Nelson (2003) and McKenzie (2004) show that listeners can infer a speaker's reference point. In six experiments on attribute framing, Sher and McKenzie (2006) show that (a) speakers describe objects using language (an attribute frame) that is consistent with the valence of the attribute being described, (b) this information is relevant to choices when options are evaluative, and (c) listeners are sensitive to these subtle linguistic cues (i.e., the leaked information is absorbed).

At issue is whether the information leakage hypothesis can explain risky choice framing effects. Although information leakage has been demonstrated in attribute framing, its application to risky choice framing has not been rigorously tested. It is not obvious that an explanation for one type of framing bias also applies to another type, since the different types of framing effects (including goal, attribute, and risky choice) have different properties (Levin, Gaeth & Schreiber, 2002; Levin, Schneider & Geith, 1998). Indeed, the tests by Sher and McKenzie (2006), and the preceding experiments from the same group, applied to attribute framing, not risky choice framing.

Sher and McKenzie (2006) speculate on the application of the information leakage hypothesis to risky choice framing effects, but they conclude that this application is unwarranted. In general, they warn, "[W]hile information leakage explanations are not confined to reference points and implicit recommendations, they do not cover the framing literature exhaustively" (p. 490). In particular, they contend that information leakage is only possible when there is an asymmetry of information between two frames. If choice-relevant information can be inferred from the speaker's choice to use one frame but not the other, then the frames are not information-equivalent. Given that information leakage is only possible when two frames are information non-equivalent, Sher and McKenzie (2006) make the following hypothesis about Kahneman & Tversky's (1979) risky choice framing task with a monetary endowment: "Though the two frames are not logically equivalent, we believe that they are, under usual conceptions of choice-relevance, information equivalent. Hence, information leakage does not account for this [risky choice] framing effect" (p. 490).

Despite the lack of conclusive evidence, recent experimenters have speculated that information leakage may cause risky choice framing effects. For instance, Kuhberger and Tanner (2010) suggest that information leakage may account for risky choice framing effects. They write,

> [S]ince in the classic framing task the program to combat the disease is phrased in terms of people saved (positive frame), it is possible that listeners tacitly infer that the number

> of people being saved does increase by choosing this program, making the sure option more attractive. In contrast, when the program is described as people dying (negative frame), listeners may intuitively infer that the number of people dying is increasing, making the sure option less attractive. (p. 327)

After suggesting this mechanism, Kuhberger and Tanner (2010) admit that there is no evidence to support it. They acknowledge, "We can only speculate that such inferences may have been involved in the various task formulations reported here. To our knowledge, an empirical test of the information leakage account of risky choice framing effects has not been done so far" (p. 327).

Kuhberger and Gradl (2013) also cite information leakage as a possible explanation for risky choice framing effects. Their results suggest that risky choice framing effects are driven primarily by evaluations of the sure option, with evaluations of the risky option differing little between frames. They speculate that information leakage might be the mechanism for the asymmetry in evaluations of the sure and risky options, since the sure option is incompletely specified. They argue that "speakers are more likely to choose higher than expected utilities as anchors for description" (p. 116). They flesh out the argument as follows:

> Describing an option in terms of people saved may thus communicate that the number of people being saved is increasing by choosing this program, rendering the riskless option more attractive. In an analogous way, describing an option in terms of people dying may communicate that the number of people dying is increasing. We did not elicit such inferences and it might be difficult to explicitly elicit these, but it is not unlikely that people may indeed form such inferences in an implicit way. (p. 116)

Kuhberger and Gradl (2013) acknowledge that "additional assumptions are necessary to predict the direction of the effect" (p. 116). They point out that there is no evidence for specific inferences such as adding "or more" to the sure option: "To our knowledge, explicit inferences of this type have not yet been demonstrated" (p. 116).

Thus, although Kuhberger and Gradl (2013) and Kuhberger and Tanner (2010) cite information leakage as a potential mechanism for resolving ambiguity, there is no direct evidence to support this hypothesis. Even Sher and McKenzie (2006, 2008), who have conducted empirical tests of information leakage in attribute framing and risky choice framing, find it questionable whether information leakage would apply to risky choice framing effects, and all acknowledge the lack of evidence for this speculation. However, hypotheses about how information leakage could explain risky choice framing effects have converged on the idea that subjects mentally add "or more" to the sure option based on the reference point and valence used to describe the sure option (Kuhberger & Gradl, 2013; Kuhberger & Tanner, 2010; Sher & McKenzie, 2006, 2008).

Schema theory. A *schema* is a set of interrelated knowledge on the basis of which new knowledge is interpreted, and different schemata held by the same individual may be activated in order to provide different ways of understanding new information. Jou, Shanteau and Harris (1996) liken schema theory to pragmatic norms: "The mental access to the other side of the outcome in processing a frame is analogous to [a pragmatic] inference process, whereby information not explicitly stated is inferred on the basis of some general knowledge (schemas) that comprehenders possess about the events in question" (p. 9). The distinction is that a schema might provide the background knowledge for making an inference about a statement, but the process of conversational implicature is not synonymous with the schema that is applied.

Jou et al. (1996) invoke schema theory in order to make predictions about how people understand framing options. They reference Cheng and Holyoak's (1985) report that people perform better on if-then problems when the problems are embedded in a familiar schema. Similarly, "People have prototypical knowledge about certain types of events and comprehend the relationship between events by referring to such general knowledge structures—known as *schemata*. When encountered events cannot be fit into a schema, the relationship between the events will not be understood…." (p. 2).

This point is clarified by Kuhberger (1995), who discusses Gigerenzer, Hoffrage and Kleinbolting's (1991) probabilistic mental model (PMM) theory. According to PMM theory, people understand problems by relating them to a "reference class" about which they have additional background knowledge. They apply this background knowledge in order to solve the new problem. Kuhberger (1995) applies this logic to the Asian disease problem as follows:

> Experience tells us that fighting disasters takes time. As time goes by things may change. After an initial number of people being saved (killed), as described in the programs, in the following days some additional people may be saved (killed). The crucial difference between Programs A and B…lies in the possibility that such an additional gain (loss) can happen. (p. 232)

Thus, Kuhberger (1995) provides a directional hypothesis consistent with that of Macdonald (1986), namely, that people assume the sure option to mean "at least" the number specified will be saved (or killed). Mandel (2001) echoes this logic, also citing Gigerenzer et al. (1991): "Given the uncertain and prolonged nature of the described situation (viz., an anticipated epidemic), this interpretation is both plausible and compatible with the type of probabilistic mental models (Gigerenzer, Hoffrage, & Kleinbolting, 1991) that people would likely generate in reasoning about this case" (pp. 59-60).

Based on schema theory, both Jou et al. (1998) and Okder (2012) believe that subjects find the options to be ambiguous because they do not apply a complementary schema when interpreting the stated and implicit parts of the sure option. Okder (2012) puts it this way: "Usually, the participants may not consider the relationship between the lives saved and those lost, nor are they motivated to do so. As a result, their schemata are unstable…." (p. 70). Both studies test this prediction, and the results are described in the next section. Schema theory itself does not make predictions about the direction of inference; rather, the content of the schema determines the direction of the effect, and different schemas might lead to opposite effects. The most coherent prediction based on schema theory is the one articulated by Kuhberger (1995) and Mandel (2001), that subjects mentally add "at least" to the description of the sure option.

Atheoretical hypotheses about the risky option. Each of the three theories discussed above offers an ambiguity hypothesis only about the sure option. This is because, in the traditional version of the framing options, the risky option is completely specified—that is, both logical complements are stated, leaving no implicit information. However, truncations of the risky option, in which one but not both complements are presented, have allowed for critical tests of theoretical explanations of framing effects (Chick & Reyna, 2012; Kuhberger & Tanner, 2010; Reyna, 2012; Reyna et al., 2013; Reyna & Brainerd, 2011). Kuhberger and Tanner (2010) describe a possible ambiguity in unstated information about the risky option. They note, "One could argue post hoc that removing the zero complement leads to inferences on the missing complement….Put more formally, v(0) is substituted by some unknown value, v(*)…." (p. 326).

Kuhberger and Tanner do not speculate on the direction of the effects of this possible ambiguity on framing behavior, since they describe the expected utility of this missing information as "indeterminate," that is, determined by what participants assume about the missing complement. Depending on whether subjects assumed the missing number to be positive or negative, this could render the expected utility of the options unequal in either of two directions: A>B or A<B (where A represents the sure option and B represents the risky option).

Although Kuhberger and Tanner do not posit a directional hypothesis about the effects of this ambiguity on framing effects when the zero risky complement is unstated, there are only two logical possibilities. If subjects were to substitute a positive number for the missing zero complement, in the gain frame, option B would be a 1/3 chance of saving 600, and a 2/3 chance of saving some positive number of people. This would make the expected utility of B greater than that of A, and subjects would choose B. In the gain frame, this hypothesis is the opposite of the standard framing effect, so it does not account for the observed data.

If subjects were to substitute a negative number for the unstated zero complement, the risky option would be a 1/3 chance of saving 600 people and a 2/3 chance of saving fewer than zero. It is unclear what saving fewer than zero people would mean. It could be interpreted as detracting from the 600 people who might be saved in the non-zero complement. It could also prompt subjects to flip the frame of the unstated complement, such that there is a 1/3 chance of saving 600 people and a 2/3 chance of more than zero people dying. Either of these interpretations would make the expected utility of the risky option lower than that of the sure option, so subjects would choose option A in the gain frame. Thus, the effects predicted by substituting a negative number for the unstated zero complement are consistent with the standard framing effect. However, substituting a negative number is complicated to implement and does not yield a consistent prediction, so it is more parsimonious to assume that, if subjects substitute a nonzero number for the zero complement, they choose a positive one. This would yield effects opposite of the standard framing effect, so it does not explain framing behavior. These hypotheses about missing information in the risky option violate either logic or linguistic convention.

Previous Research on Ambiguity: Base Rate and Relationship to Framing Effects

Frisch (1993): Subjects do not cite objective differences between gain and loss versions. To my knowledge, Frisch (1993) was the first to put gain and loss versions of the problem side-by-side and ask subjects whether they perceived them to be equal. In the first of two experiments, each subject answered both the loss and the gain version of one risky choice framing problem (though not consecutively; the risky choice was mixed in with other cognitive bias problems, such as reference point, sunk cost, and buy/sell). After making choices, the 29 out of 44 participants who answered differently for the gain and loss versions were shown both problems side by side and asked whether the two versions should be treated the same or differently. Of the 29 participants, nine said that, upon reflection, the two versions should be treated differently. Of these nine, six gave no reason, and three cited subjective differences between the options (e.g., the risky option gave everyone an equal chance at survival). No one said that the options seemed objectively different (i.e., that different numbers of people would be saved in the gain versus the loss versions).

The second experiment was an extended replication of the first. Each participant answered three risky-choice framing problems: one about human lives, one about animal lives, and one about money. Across all three problems, participants showed framing effects in 74% of responses. When subjects who showed framing effects were asked afterward whether they thought gain and loss versions of the problem should be treated the same, 53% said no.

Kuhberger (1995): Perceived ambiguity is unrelated to framing behavior. Kuhberger (1995) assessed ambiguity by asking participants whether they had perceived the numbers as exact or as estimates. In experiment 1, he presented each subject with both the gain and loss version of four problems (one of which was a filler). Degree of completeness of the sure option was varied between subjects. The sure option presented with either both complements, the affirmative complement only (saved or die, i.e., the traditional version), or the negational complement only (not saved or not die, i.e., the implicit complement in the traditional version). In the complete version (both complements of the sure option), there were no framing effects. In the traditional version (affirmative complement of sure option), standard framing effects occurred, and in the negational-complement-only version, reverse framing effects occurred.

After making all eight decisions, each subject answered a single binary-response question about how they had interpreted the numerical information in each option. Most subjects (62%) indicated that they understood the numbers as “estimated figures,” with only 38% of participants interpreting the numbers as “exact numerical data.” None of the independent variables, including frame and truncation, predicted perceived ambiguity (i.e., perception of numbers as estimates). In addition, correlations between perceived ambiguity and choices were weak and inconsistent, indicating that ambiguity was unrelated to framing behavior.

In experiment 2, participants made choices about the same four framing problems as in experiment 1 (each in both gain and loss frames, for a total of eight decisions). Framing effects were attenuated as compared to experiment 1. This time, instead of answering a single ambiguity question after making all eight decisions, they indicated after answering each problem whether they had interpreted the numbers as estimates or as exact figures. Ambiguity decreased relative to Experiment 1; participants indicated having interpreted the numbers as estimates only 43% of the time. As in experiment 1, ambiguity was unrelated to framing decisions. Ambiguity did differ by problem; it was higher in the Asian disease and cancer problems, which were about human lives, than in the car manufacturing plant problem, which was about jobs. (The fourth problem was a filler). In addition, there was a nonsignificant trend toward higher ambiguity in the loss frame than in the gain frame; Kuhberger cites Cohen et al. (1987) as having reported a similar finding.

Mandel (2001): For one-third of participants, one complement does not imply the other. Mandel (2001) argues that the traditional version of the framing problem confounds *descriptor formulation* (i.e., whether positive or negative words are used to describe the outcome) with *outcome formulation* (i.e., whether the resulting state of the world is good or bad, regardless of the words used to describe it). In the first of two experiments, Mandel factorially crossed descriptor with outcome formulation, such that each option was incompletely specified (containing only one of the logical complements). The traditional version of the problem yielded uni-directional framing effects driven by the loss frame (i.e., 54% risky choices in gain frame, and 85% risky choices in loss frame). In the incongruent condition (i.e., positive outcome frame with “died” descriptor frame and negative outcome frame with “saved” descriptor frame), there were no framing effects. In the congruent conditions (i.e., positive outcome frame with “saved” descriptor frame and negative outcome frame with “die” descriptor frame), there was a marginal framing effect only in the negative condition.

In experiment 2, Mandel replicated experiment 1 with a larger sample and found no framing effects, even in congruent conditions. Recall that Mandel's factorial manipulation required stating only one of the logical complements in the sure option and one in the risky option. Thus, after participants indicated their choices, Mandel explicitly asked participants how they interpreted each incompletely specified option. For example, in the congruent saved-positive condition, he asked about the sure option, "Did you interpret Plan A to mean that, as well as 200 people certainly being saved, the remaining 400 people stranded in the war-torn region will certainly not be saved?" and about the risky option, "Did you interpret Plan B to mean that, in addition to there being a 1/3 probability of all 600 people being saved, there is also a 2/3 probability that nobody will be saved?" Collapsing across congruent and incongruent descriptor conditions, the answer was "no" about 1/3 of the time. For the sure option, 36% of participants indicated they did not interpret the stated complement as implying the implicit complement. For the risky option, 32% of participants indicated they did not interpret the 1/3 "all" complement as implying the 2/3 "none" complement. Responses about the interpretation of sure and risky options were nonindependent, and the percentage of "no" answers did not differ significantly between sure and risky.

Mandel (2013): Specifying that options are lower bounded increases framing effects. Mandel (2013) reports three studies that, together, he argued suggested that framing effects are driven by the assumption that options are lower-bounded (i.e., people mentally add "at least"). In experiment 1, Mandel presented each subject with one gain and one loss problem, separated by an unrelated task. For each subject, the sure option in both problems was either lower-bounded ("at least") or specified as exact ("exactly"). Of the subjects who received lower-bounded problems, 67.7% showed the standard framing effect, 31.7% chose consistently, and

1.7% showed a reverse framing effect. However, only 21.7% of subjects in the exact condition showed a standard framing effect; 73.3% chose consistently across frames, and 5% showed a reversed framing effect. Mandel argues that these results are consistent with the interpretation that framing effects occur because people assume that the sure option means “at least,” and they do not really reverse preferences when this assumption is precluded.

In Experiment 2, Mandel replicated this effect in a between-subjects design. He factorially crossed frame with three modifiers to the sure option: “exactly,” “at least,” or no modifier. Participants also rated the strength of their preference for the option they chose on a scale from 0 to 10; these ratings were combined with choice to yield weighted preference scores ranging from -10 (high confidence in sure choice) to 10 (high confidence in risky choice). Across subjects, framing effects were highest when the “at least” modifier was used (with 79% of participants choosing the sure option in the gain frame or the risky option in the loss frame; mean difference between frames=7.20). Framing effects were intermediate when no modifier was used (mean difference=3.68), but were insignificant when the “exactly” modifier was used (mean difference=1.37). Mandel takes these results as further evidence that the “at least” assumption drives framing effects, since adding this wording enhanced framing effects, but making it clear that the number in the sure option was exact eliminated framing effects.

In experiment 3, Mandel truncated the sure and risky options , collected choice and preference data, and then asked subjects how they interpreted each option. In each problem, both options were framed either as gains or as losses, and the completeness of each option description was varied. Specifically, subjects saw either an incomplete description of both options (e.g., A: 200 saved; B: 1/3 probability 600 saved), an incomplete description of the sure option and a complete description of the risky option (e.g., in the gain frame, A: 200 saved; B:

1/3 probability 600 saved and 2/3 probability nobody saved), a complete description of the sure option and an incomplete description of the risky option (e.g., A: 200 saved and 400 not saved; B: 1/3 probability 600 saved), or a complete description of both options (e.g., A: 200 saved and 400 not saved; B: 1/3 probability 600 saved and 2/3 probability nobody saved). Framing effects occurred at typical levels in the standard condition, with A partially specified and B fully specified. When both A and B were fully specified, the framing effect was eliminated. However, when A was fully specified and B was partially specified, the framing effect was reversed; more subjects chose the risky option in the gain frame than in the loss frame. Mandel takes this reversal of preferences as further evidence that it is the incompleteness of information, rather than the risk level of each option, that drives framing choices.

After indicating their choice and rating their level of preference, subjects also answered a multiple choice question about their interpretation of each option. More participants considered the magnitude of the sure option as lower-bounded (implying "at least") when it was partially specified (64% of subjects) than when it was fully specified (24% of subjects). On the other hand, most participants (62%) considered the magnitude of the sure option to be exact when both complements were specified.

For the risky option, Mandel asked subjects how they interpreted the probability, rather than the magnitude. Most subjects understood the probability of the unstated complements to be complementary even when the option was truncated, but this effect increased when the option was partially specified (37%) compared to when both complements were presented (22%). Participants' interpretations of missing information did not differ by frame. Based on the ability to increase, eliminate, or even reverse framing effects by explicitly specifying that the options are lower-bounded or exact, or by adding or deleting information, Mandel argues that framing effects are driven by the implicit assumption of "at least" in the sure option, which renders the expected utilities unequal in a direction consistent with framing effects.

Sher and McKenzie (2008): Suggestive evidence about information leakage. In two experiments, Sher and McKenzie (2008) demonstrated that choice of frame descriptor was predicted by risk preference. In the first experiment, subjects were given fully specified framing options (in mixed frames—e.g., A: 200 people are saved and 400 people die; B: 1/3 chance 600 saved and 2/3 chance 600 die) and were asked to choose the frame that was most likely to convince a listener to choose either A or B. Participants tended to choose the gain frame when persuading listeners to choose A and the loss frame when persuading listeners to choose B, consistent with standard framing effects.

In a second experiment, participants indicated their preference based on the fully specified framing options (as described in parentheses above). Then, they selected which frame was best to describe each option. Although the risky option was presented in mixed frame and is therefore difficult to interpret, participants' choice of frame for describing the sure option was strongly predicted by their prior preference. Those who preferred option A (the sure option) tended to choose the gain frame to describe the sure option (e.g., 200 people will be saved), and those who preferred option B (the risky option) tended to choose the loss frame to describe the sure option (e.g., 400 people will die).

Jou, Shanteau & Harris (1996): Causal schemata increase perception of complementarity in the sure option and eliminate framing effects. Jou, Shanteau and Harris (1996) conducted two experiments based on schema theory. Jou et al. posit that subjects and experimenters may understand the sure option, which is incompletely specified, to mean different things. That is, experimenters presume that the unstated part of the sure option (e.g., 400 not saved) is *complementary* to the explicit part of the sure option (e.g., 200 saved). In order for this to be the case, subjects must understand that, out of the total number at stake, those who are not saved die (in the gain frame), and those who do not die are saved (loss frame). By providing subjects with a causal rationale for why 200 people living implied 400 must die (and vice-versa), such as a limitation in resources, subjects would be more likely to understand the implicit sure complement as intended by the experimenters, and to keep this representation mentally available when making a decision.

In the first of two experiments, half of subjects read problem descriptions that included such a rationale; the other half received the standard version of the problems, with no rationale. This rationale explained why, due to a limitation in resources, "it was impossible to save all life or property and why some could be saved only at the expense of others." In the Asian disease problem, for example, the rationale was that there was a limited supply of medicine (enough to save only 200 people). Each subject answered 8 problems in either loss or gain frame. Framing effects were significant among participants who received the standard version of the problem (i.e., with no rationale), but not among those in the rationale condition. In addition, when asked why they made the choices they did, people in the rationale condition cited the implicit sure complement more often (38% of answers) than did people in the no-rationale condition (19% of answers). An example of a reference to the implicit complement was "I would rather take a chance to save all of them than sending 400 of them to death" (gain frame) or "Better to assure the lives of 200 people than risk the death of so many" (loss frame; p. 5). Interestingly, subjects cited the implicit complement slightly more often in the loss frame (31% of answers) than in the gain frame (27% of answers).

The rationale behind the second experiment was that, if people invoked the unstated complement while making the decision, they would be more likely to recall it after an unrelated delay task. Each participant completed one problem; frame, rationale, and lives vs. money were between-subjects factors. As in experiment 1, framing effects were significant in the no-rationale condition, but not in the rationale condition. After indicating their choice and completing the delay task, participants were asked to recall three numbers: the total number (e.g., of lives) at stake; the total number in the sure option who were saved (in gain frame) or lost (in loss frame); and the total number lost or saved in the gain and loss versions, respectively, in the sure option (i.e., the implicit sure complement).

Almost all subjects correctly recalled the explicitly stated information, including the total amount at stake (98% correct in no-rationale condition; 95% correct in rationale condition) and the total amount in sure option who were saved (gain frame) or lost (loss frame; 96% correct in no-rationale condition, 98% correct in no rationale condition). However, over twice as many participants correctly remembered the implicit sure complement in the rationale condition (89% correct) than in the no rationale condition (41% correct). Thus, when the problem included a causal schema providing a reason for the complementarity of the stated and implicit aspects of the sure option, framing effects disappeared and memory for the unstated complement more than doubled. The latter result suggests that the unstated complement was more cognitively available (i.e., better integrated into the subjects' gist representation of the problem) when there was a schema provided.

Okder (2012): Complementary schemata reduce framing effects. Like Jou et al. (1996), Okder (2012) argues that participants and experimenters interpret the sure option differently. Okder argues that experimenters understand the relationship among the number at stake, the number saved, and the number lost to be complementary, such that knowing two of these numbers is sufficient to infer the third. However, Okder argues, subjects interpret these numbers to be independent of one another, such that there is no mutual constraint. In other words, according to the independent schema, knowing two of the numbers reveals nothing about the third. In order for the complementary schema to hold, Okder emphasizes, the total number of lives or property at stake must be known. In three experiments, he extends the findings of Jou et al. (1996).

Experiment 1 was a between-subject design crossing frame (gain or loss) with endowment (number of lives at stake: specified or unspecified). In both the endowment-specified and endowment-unspecified versions of the problem, framing effects were observed (although it is not indicated whether these were standard or reverse framing effects). However, framing effects increased when the endowment was unspecified relative to when it was specified. Based on the premise that a complementary schema depends on knowing the number of lives (or property) at stake, Okder takes this as evidence that framing effects arise from an independent schema.

Experiment 2 was a replication of experiment 1 with the modification that each subject saw both the gain and the loss options for each problem on the same page. The gain version was presented as the recommendation of one committee, and the loss version as the recommendation of a second committee. In contrast to experiment 1, in which frame was a between-subjects factor, framing depended on whether the endowment was specified. When the number of expected losses (e.g., 600 deaths) was known, fewer participants showed framing in each problem than showed a consistent preference for either the sure or the risky option in both frames. When the number of expected losses was unknown, the pattern reversed: more participants showed framing than showed consistent preferences for either the sure or the risky option in both frames. Okder did not specify whether the framing was standard or reverse, only that preferences changed depending on frame.

In experiment 2, after indicating a choice for each frame (i.e., for each committee's recommendation), subjects made a judgment about the equivalence of the sure and the risky options across frames. For the sure option, they were asked, "Do you think that Program A in committee 1 and Program C in committee 2 are equivalent?" For the risky option, they were asked, "Do you think that Program B in committee 1 and Program D in committee 2 are equivalent?" Most people who showed framing effects rated the options as unequal across frames (i.e., A was not equal to C, and B was not equal to D). Conversely, most people whose choices were consistent across frames rated the options as equivalent in both frames (i.e., A=C and B=D). Although the ratings of equivalence between frames differed significantly by endowment condition (i.e., endowment specified vs. unspecified), this difference disappeared when framing decisions were included as a covariate. Thus, whether a participant considers the options to be equivalent across frames accounts for the same variance as does whether a participant's choices differ across frames. In other words, people who showed the framing effect tended to consider the options as non-equivalent across frames, and both tendencies were associated with the unspecified endowment condition.

Experiment 3 used the same framing problem as in experiments 1 and 2, but this experiment was entirely between subjects, crossing frame (gain or loss) with endowment (specified or unspecified). Thus, each participant saw either the gain or the loss version of the options. Before indicating their choice, subjects answered six questions about their interpretation of the options. Three of the questions asked subjects to estimate the number of people saved when no program is adopted (i.e., the endowment), when the sure program is adopted, and when the risky program is adopted. The other three questions asked for estimates of the number of people lost in each of these three scenarios.

As in experiment 2, framing effects were significant when the endowment was unspecified, but not when it was specified. Most participants in both the specified and unspecified condition accurately estimated the stated sure complement (i.e., number of lives saved in the gain frame or lost in the loss frame). However, correct estimation of the implicit sure complement differed by endowment condition (i.e., specified vs. unspecified). When the endowment was specified (i.e., 600 lives at stake), correct estimates of the implicit sure complement were about as frequent as correct estimates of the stated sure complement. However, when the endowment was unspecified (i.e., it is unknown how many lives are at stake), almost no one (fewer than 10% of subjects) correctly estimated the implicit sure complement.

Summary: Base Rate of Ambiguity, and Relationship to Framing Effects

What is the base rate of ambiguity? Multiple experimenters have provided an estimate of the base rate of ambiguity, that is, how common it is for subjects to interpret the options as having unequal expected utility. Frisch (1993) put the gain and the loss frame of the same problem side-by-side and asked subjects, should the loss and the gain frame be treated differently? In two experiments, about one-third and one-half of subjects, respectively, answered that the options should be treated differently in different frames. Subjects also provided a rationale for their answer, and no one cited an objective difference (e.g., different expected utilities) as a reason for risky choice framing, even though objective differences were cited for other types of framing. Instead, subjects gave reasons like wanting to give everyone an equal chance to live (in the risky option).

Kuhberger (1995) asked subjects whether they interpreted the numbers as "estimated figures" or as "exact numerical values." In two experiments, 60% and 40% of the sample, respectively, answered that they took the numbers as estimates. Combined with the findings of Frisch's (1993) study 2, this suggests that the base rate of ambiguity is about 50%.

Mandel (2001) asked a more specific question about each option. For the sure option ("saved" descriptor formulation; "positive" outcome formulation), the question was, "Did you interpret Plan A to mean that, as well as 200 people certainly being saved, the remaining 400 people stranded in the war-torn region will certainly not be saved?" For the risky option in the same condition, the question was, "Did you interpret Plan B to mean that, in addition to there being a 1/3 probability of all 600 people being saved, there is also a 2/3 probability that nobody will be saved?" For both the sure and the risky option, about one-third of subjects said they did not take the stated complement to imply the unstated one. This is consistent with Frisch's (1993) study 1, in which about one-third of subjects also indicated an interpretation different from that assumed by the original framing researchers.

Taken together, these three studies used different approaches to assess ambiguity and still converged on an estimated base rate of one-third to one-half. Nonetheless, these studies do not provide evidence that the perception of ambiguity is necessary to framing bias.

Does ambiguity predict framing bias? Inferences about the necessity of ambiguity to framing bias have been based on indirect evidence; hence, researchers have come to opposite conclusions. Kuhberger (1995) sums up his own results as follows: "Although there is considerable ambiguity in the problems, it seems that framing effects and ambiguity judgments were totally unrelated" (p. 238). However, three other studies seem to contradict this finding. Mandel (2001) reports that when descriptor and outcome formulation are factorially crossed, framing effects disappear (although he reports weak framing effects when descriptor and outcome are congruent). Since the deep structure of the problem was the same for every combination of descriptor and outcome, Mandel takes this to mean that framing effects in the traditional version of the problem arise from a combination of congruent formulations and asymmetry between the incompletely specified sure option and the completely specified risky option.

Jou et al. (1996) invoke schema theory to argue that framing effects depend on ambiguity in the sure complement. When the problem information included a causal schema providing a reason for the complementarity of the stated and implicit aspects of the sure option, framing effects disappeared, subjects more frequently cited the implicit complement in justifying their choice, and memory for the unstated complement more than doubled. The latter two results suggest that the unstated complement was more cognitively available (i.e., better integrated into the subjects' gist representation of the problem) when a schema was provided. The experimenters take this as evidence that framing effects result from failure to understand that the implicit part of the sure option is the numerical complement to the stated part.

Okder (2012) supports and extends this argument. First, he reports that specifying the number of lives at stake (the endowment) makes subjects more likely to interpret the implicit and explicit parts of the sure option as complementary. This suggests that knowing the endowment encourages a complementary schema. Second, in addition to increasing the likelihood of a complementary schema, specifying the endowment decreased framing effects. Third, subjects who interpreted the sure and risky options, respectively, as unequal across frames were more likely to show framing effects. Okder (2012) takes these results to suggest that subjects do not interpret the options as experimenters have assumed (i.e., there is ambiguity in the sure option), and that this ambiguity is responsible for framing effects.

By extending the logic that missing information creates ambiguity, and that ambiguity increases framing, we would predict framing effects in any truncation. Instead, Reyna and Brainerd (1991) found that framing is enhanced when the risky "all" complement is removed but eliminated when the risky "none" complement is removed: "[R]emoving what ought to be redundant information from the gambles did not necessarily alter choices (compared to complete information), but choices differed depending on which complement was left implicit" (p. 257). This result is predicted by fuzzy-trace theory (Kuhberger & Tanner, 2010; Reyna, 2012; Reyna & Brainerd, 1991, 2011; Reyna, Estrada, DeMarinis, Myers, Stanisz & Mills, 2011). The explanation is not that subjects lack or misunderstand information; it is, rather, that they focus on the lowest level of distinction that suffices to produce a preference. For instance, in experiment 2, Reyna and Brainerd (1991) found that, when presented with the standard version of the problem (which includes both risky complements), participants behave as they do when the negative ("none") risky complement is removed, but not as they do when the positive ("all") risky complement is removed.[1]

This suggests that subjects mentally truncate the fully specified risky option so as to rely on the positive complement, which, in turn, suggests that subjects consider the negative risky complement to be redundant. In experiment 3, Reyna and Brainerd (1991) found that, when

[1] In this paragraph, I use "negative" in the sense intended by Reyna and Brainerd (1991), referring to a negation (e.g., "not saved"). This corresponds to the *descriptor formulation* conceptualized by Mandel (2001), as distinguished from *outcome formulation*. Kuhberger and Tanner (2010) also make this distinction (see pp. 318-319, especially Table 2). Correspondingly, in this paragraph, the word *positive* refers to an affirmation, or the opposite of a negation (e.g., "saved"). In order to distinguish between valences, I will use *gain* and *loss* instead of *positive* and *negative*.

presented with only the negative (non-gain or non-loss) complement of an option, subjects appear to mentally convert this to the positive (affirmative) complement, since their response patterns match those for problems presenting only the affirmative complement of the opposite frame. This spontaneous conversion implies that, even when presented with an incompletely specified option, subjects understand the complementary nature of the presented and unpresented consequences. If the missing information created ambiguity, conversion to the complementary representation of the same option would be impossible.

Reyna and Brainerd (1991) acknowledge that during such a conversion, subjects do not focus equally on all aspects of the problem information: "Because results differed depending on what was omitted, it is apparent that subjects did not reinstate the missing elements that would have made all three problem types equivalent. To a significant degree, what was out of sight was indeed out of mind" (p. 255). However, mental truncation and conversion to the unstated complement would be impossible if subjects misinterpreted the unstated complement. Thus, Reyna and Brainerd (1991) showed that unspecified information can change framing behavior, not because the missing information is ambiguous, but because truncations selectively focus attention on certain aspects of the problem information, which cues different cognitive processes and, hence, different decisions (see also Reyna, 2012; Reyna & Brainerd, 2011; Reyna, Estrada, DeMarinis et al., 2011).

This raises the question whether the results that have been interpreted in terms of schema theory are more consistent with cognitive availability (determined in part by selective attention) or with changes in knowledge structure. Jou et al. (1996) make statements consistent with both perspectives. On the one hand, they describe their manipulation in terms of Tversky and Kahneman's (1973) concept of availability:

> [W]e suggest that the way in which the original problem was presented created low availability of the reciprocal consequence in the subjects' mental representations of the problem, owing to its failure to activate a relevant schema. By raising the availability level of the other consequences through invoking a familiar schema, the framing effects may be largely reduced or even eliminated. (p. 3)

On the other hand, they suggest that their manipulation changes the inferences that people make, resulting in different knowledge structures: "The no-rationale version of the problems may be formulated so that inferring the other side of the consequence is less likely to occur, perhaps because of a failure to connect to the general knowledge base" (p. 9).

Empirically, there is also support for both perspectives. All three results reported by Jou et al. (1996) are consistent with both interpretations, since outcomes measured by memory or choice can be attributed to the cognitive availability of a mental representation and do not necessarily evidence a change in the representation itself. Although two of Okder's (2012) results are consistent with both interpretations, Okder is committed to the hypothesis that independent versus complementary schemata, which he induces via unspecified and specified endowments, respectively, confer different interpretations of implicit information. The best evidence for this is that subjects are more likely to estimate implicit numbers in a way that is complementary to stated information when the endowment is specified than when it is not. In short, Okder (2012) and Jou et al. (1996) have demonstrated that inducing a complementary schema can eliminate framing effects. However, it is not certain whether a complementary schema affects framing by changing knowledge or by changing cognitive availability (perhaps by refocusing selective attention). Moreover, although independent schemata are sufficient to create framing effects, it is unclear whether they are necessary (although the results reported by Reyna and Brainerd, 1991, suggest that they are not).

What is missing from the literature, therefore, is evidence that subjects can simultaneously understand the exact numerical value of all information, stated or implicit, and show framing effects that increase or decrease in response to manipulations of selective attention. The objective of distinguishing knowledge from attentional focus serves the broader goal of this study, which is to ascertain whether ambiguity is necessary to framing effects. The question whether framing effects depend on ambiguity of the options is easily tested. If it can be demonstrated that subjects perceive the options unambiguously (such that stated and unstated information about each option are treated as complementary), yet framing effects occur at normal levels, then framing can no longer be argued to depend on ambiguity.

Methods

Participants

Participants, including students, parents, and alumni, were recruited from Cornell University. Additional participants were recruited the New York City area and online via Mechanical Turk. Mechanical Turk participants completed all stimuli via computer; the other participants completed the 60 framing problems and the individual difference scales via computer and the ambiguity surveys via paper and pencil. Subjects ranged in age from 18 to 56 years; in order to account for the potential effects of cognitive aging on memory and information processing, subjects were categorized as either college students (age <22) or post-college (age >=22). Age distributions are presented in Table 1 and Figure 2.

Materials and Procedure

Design. The study proceeded in two experiments, one free response and one multiple choice. The free response experiment was a nested design in which subjects answered open-ended questions about their interpretations of truncated options. In a sample of college students (sample A, experiment 1-a), each subject answered one open-ended question about their interpretation of the sure option, and one open-ended question about their interpretation of a truncated risky option (non-zero complement presented), in the gain frame only. Twenty-three subjects completed the pretest (8 female, mean age=20.57, *SD*=1.83), of which 10 also completed posttest (4 female, mean age=20.00, *SD*=1.15). One subject (age=23, male) completed posttest only.

An additional sample (sample B, experiment 1-b) contained both college students and post-college adults (34 female, mean age=26.05, *SD*=9.96). Of these, 39 received the gain frame version of the question (16 female, mean age=21.95, *SD*=4.99), and 42 received the loss frame version of the question (18 female, mean age=29.86, *SD*=11.81). In experiment 1-b, each subject answered one open-ended question about a truncated risky option (non-zero complement presented) at both pretest and posttest. Therefore, combining samples A and B, 91 participants answered the free response question about the risky option at both pretest and posttest (38 female, mean age=25.38, *SD*=9.59). Of these, 49 answered the question in the gain frame (20 female, mean age=21.55, *SD*=4.54), and 42 answered it in the loss frame (18 female, mean age=29.86, *SD*=11.81).

The multiple choice experiment was a 2 x 2 x 2 x 2 factorial design with option referent (sure vs. risky) and test (initial vs. post-task) as within-subjects factors and frame (gain vs. loss) and age group (college vs. post-college) as between-subjects factors. The sample included 81 participants (34 female), mean age=26.05 years (*SD*=9.96). Of these, 39 received the gain frame version of the question (16 female, mean age=21.95, *SD*=4.99), and 42 received the loss frame version of the question (18 female, mean age=29.86, *SD*=11.81).

Procedure. Each experiment included the following phases: Instruction, initial ambiguity survey, framing problems, post-task manipulation check, behavioral scales, and post-scan debriefing. In the instruction phase, subjects were familiarized with the decision-making task, including the time limit for entering a response. They received an instruction sheet (Appendix A) explaining how to interpret the numerical information in the sure and risky options. These instructions were verbally reinforced by the experimenter. An initial ambiguity survey was administered so as to ensure that subjects understood how to interpret the magnitudes and probabilities described in each option. Additional written instructions were administered in order to explain the correct answer to each question on the initial ambiguity survey. Next, participants completed the 60 risky choice framing problems. After completing the framing stimuli, participants filled in an additional ambiguity survey as a post-task manipulation check. Lastly, participants completed a survey consisting of individual difference scales. At the end of each session, subjects were debriefed.

Instruction sheet. Before viewing stimuli, subjects read an instruction sheet explaining what they should assume about the stated and unstated information in the sure and risky options (Appendix A). The instruction sheet provided two example scenarios with a detailed explanation of each option.

Initial ambiguity survey. After reading the instruction sheet, each participant completed an initial ambiguity survey (called an “entry questionnaire”) designed, as described below, to address the forms of ambiguity that have been suggested in the literature.

Experiment 1: Free response. In experiment 1(a) (college students, gain frame, pretest only), a sample framing problem was presented, followed by two questions. All ambiguity surveys in experiment 1(a) were in the gain frame and were administered via paper and pencil; gain frame ambiguity surveys in experiment 1(b) were administered via paper and pencil, and loss frame ambiguity surveys were administered online via Qualtrics.

Two versions of the ambiguity survey were used in experiment 1 (see Appendix). In one version, the scenario was a boat sinking; in the other version, the scenario was an explosion in a manufacturing plant. Participants were randomly assigned to one of these versions at pre-test and completed the other version at post-test. Further, participants who received the boat scenario received either of two truncations of the risky option in the example problem: zero complement presented or non-zero complement presented.

The free response question about the sure option addressed the hypothesis that subjects add “or more” to the sure option (Kuhberger & Gradl, 2013; Mandel, 2001; Sher & McKenzie, 2008). This question was phrased, “For option A, what did you think happened to the other 200 people?” The free response question about the risky option addressed the hypothesis that subjects assume an indeterminate number of people to be saved or to die in the unstated complement (Kuhberger & Tanner, 2010). In experiment 1-a, this question was phrased, “For option B, what happens if everyone is not saved (what does the 3/5 probability indicate)?” In experiment 1-b, this question was phrased, “When you made the decision, what did you assume about the other 3/5 probability in option B?”

Experiment 2: Multiple choice. In Experiment 2, the free response question about the risky option was followed by three multiple choice questions about how subjects interpreted missing information in the options. We asked two questions about the sure option, since this has received the most attention in the ambiguity literature, and one question about the risky option. Two multiple choice questions about the sure option addressed the hypothesis that subjects add “or more" to the sure option (Kuhberger & Gradl, 2013; Mandel, 2001; Sher & McKenzie, 2008). In the first question, we asked subjects directly, "When you made the decision, did you assume that more than 300 people would be saved in option A?" Subjects circled either "yes" or "no." The correct answer was "no." In the second question, we asked a broader question, in order to capture potential nuances in interpretation: "When you made the decision, which of the following did you assume about option A?" Subjects were instructed to circle as many of the three options as applied, and the options were (a) "Exactly 300 will be saved," (b) "At least 300 people would be saved," and (c) Some of the other 200 people might be saved, as well." The correct answer was (a).

The multiple choice question about the risky option addressed the hypothesis that subjects assume an indeterminate number of people to be saved or to die in the unstated complement (Kuhberger & Tanner, 2010). This question was phrased, "When you made the decision, which of the following did you assume about option B?" Subjects were instructed to circle as many options as applied. The options were, (a) "There is a 2/5 probability that some people will be saved," (b) There is a 2/5 probability that everyone will be saved," and (c) "There is a 2/5 probability that no one will be saved." The correct answer was (c). We tested subjects' interpretation of only the non-zero complement presented condition, since this is the one discussed by Kuhberger and Tanner (2010): "One could argue post hoc that removing the zero complement leads to inferences on the missing complement….Put more formally, v(0) is substituted by some unknown value, v(*)…." (p. 326). However, the full set of 60 framing problems (completed after the initial ambiguity questionnaire, and before the post-task manipulation check) included an equal number of risky options with both complements presented, only the zero complement presented, and only the non-zero complement presented (20 each).

Additional instructions with worked example. After completing the initial ambiguity questionnaire, participants read a detailed explanation of the correct answer to each of the three questions (Appendix). After the participant read the detailed explanation, the experimenter verbally explained the correct answer to each question and gave the participant an opportunity to ask questions. After verifying that the participant understood how to interpret each option, the experimenter administered the framing problems.

Framing problems. The framing paradigm was a 2x2x3x5 factorial design with frame (gain, loss), modality (lives, money), truncation (zero, mixed, non-zero), and replication (1-5) as factors. Accordingly, in each problem, either lives or money were at stake, the sure and risky options were described as either gains or losses, and the risky option was truncated in one of three ways (described below). Using different problem stems, each type of problem from this factorial design was presented five times across the two runs, for a total of 60 problems per subject (Figure 1).

Truncation. The truncation was designed as follows. Keeping the sure option constant, the gamble option was manipulated to include the zero-complement, the non-zero complement, or both (Reyna, 2012; Reyna & Brainerd, 1991, 2011). See Table 2 for an example of each truncation. In the instructions, all participants in all conditions received the entire set of decision information, and their understanding of this information was verified in the ambiguity surveys. However, the zero, non-zero, and both complement conditions selectively focused participants' attention on certain aspects of the information.

Problem sets. Twenty problem stems, modeled after the Asian Disease Problem (Reyna, 2012; Tversky & Kahneman, 1981), were piloted. In half of the problem stems, lives were at stake, and in the other half, money was at stake. For each problem stem, six versions of the options were created, reflecting a factorial crossing of frame (lives, money) with truncation (zero complement presented, both complements presented, non-zero complement presented). The resulting 120 framing problems were divided into two sets of 60 problems each, so that the gain and loss versions of the options for each problem stem appeared in different stimulus sets. Each subject received problems from only one stimulus set, so that none received both the gain and loss versions of the same problem. Thus, each subject completed a total of 60 problems divided into two pseudorandomized and counterbalanced runs of 11 minutes and 20 seconds each. For a given problem, the expected outcomes of sure and gamble options were mathematically equivalent within each trial and between frames. No catch trials were included, as this was expected to bias processing. Stimuli from each set were presented in a fixed pseudorandom order, such that the same problem stem could not appear twice in a row.

Trial sequence. Each trial included presentation of a fixation cross (4.5 s), followed by the problem stem (7 s), the presentation of the sure and the gamble option (up to 8 s, during which participants entered their selection via button press), and a confidence rating for their choice ("How confident are you in your decision?" with response from 1 [not at all] to 5 [completely], up to 3 s). The decision phase (sure vs. gamble option) lasted only until a response was entered, at which point the next screen (confidence rating) appeared. This usually took less than the allotted 8 s. Similarly, the confidence phase lasted only until the participant entered a rating, at which point the next screen appeared. The other phases (fixation cross and problem stem) did not vary in duration.

Post-framing ambiguity survey. Following completion of the framing stimuli, participants completed a second ambiguity survey, labeled an "exit questionnaire" (Appendix).

The post-test ambiguity survey was identical to the pre-test ambiguity survey, except that a different example problem (within the same frame) was used. The purpose of the post-test was to ensure that subjects had retained the instructions about how to interpret each option while making decisions during the framing task.

Individual difference measures. Following the framing stimuli, participants completed an online survey consisting of multiple scales via Checkbox software (Checkbox Survey Solutions, Watertown, MA) and Qualtrics software (Qualtrics, Provo, UT). These scales included the objective numeracy scale (ONS; Lipkus et al., 2001); subjective numeracy scale (SNS; Fagerlin et al., 2008), and cognitive reflection test (CRT; Frederick, 2005). These scales were included in order to determine whether differences in cognitive ability or numeracy influence subjects' interpretations of framing problems (Jasper, Bhattacharya, Levin, Jones & Bossard, 2013; Peters, 2012).

Data analysis

Coding answers to free response questions. Answers to the question about the sure option were coded as correct or incorrect based on whether they indicated that more people might be saved later (in the gain frame) or die later (in the loss frame), that is, whether subjects implicitly added "or more" to the stated complement (Mandel, 2001). Some answers explicitly embraced or rejected the "at least" hypothesis, whereas others were ambiguous. Therefore, we used two coding systems: A strict and a liberal version. Under both systems, answers that indicated that it is impossible for anyone additional to survive were coded as 1 (correct; e.g., "They all die."). Answers that indicated a belief that it was possible for more people to be saved were coded as 0 (incorrect; e.g., "They weren't saved, they swam to shore?"). Answers that neither explicitly rejected nor embraced the "at least" assumption (e.g., "They would not be saved" or "They are caught in the manufacturing plant"), or that were irrelevant to the scoring criteria (e.g., "I didn't assume anything"), were coded as incorrect under the strict code and correct under the liberal code.

In addition to correct/incorrect scoring, we also coded answers based on whether they flipped the frame of the response, that is, whether they described the unstated outcome using the opposite frame as the option presented. For example, in the gain frame, subjects answered, "They drowned" or "forced to die." Since the presented information was stated in the gain frame ("200 people saved for sure"), these responses "flipped the frame" by describing the complementary outcome in terms of losses (i.e., deaths). Answers were therefore coded as 1 (flipped the frame) or 0 (did not flip the frame). Answers that used language corresponding neither to the gain nor to the loss frame (e.g., "I didn't assume anything") were not included in analyses on flipping the frame. Note that, in the gain frame, answers that did not flip the frame were almost always incorrect under strict scoring, because "not saved" could mean not saved now, but saved later. (These "not saved" answers were scored as correct under liberal scoring). The exception is responses that clarified that the remaining people would not be saved later (e.g., "never saved").

Scoring criteria for the risky option were based on the hypothesis, articulated by Kuhberger and Tanner (2010), that subjects interpret the unstated complement as something other than zero (i.e., "indeterminate"). We therefore coded answers based on whether subjects violated the assumption of an "all-or-nothing" outcome (i.e., either everyone is saved or no one is saved) in the risky option. Answers were coded as 1 (correct) if they indicated that either everyone is saved/dies, or no one is saved/dies (e.g., "500 people will be saved but only with a 3/5 chance.") Answers indicating that a subset of those at risk could be saved/die were scored as

0 (incorrect; e.g., “3/5 probability that some of the people will be saved,” or “Everyone will most likely die unless they are extremely lucky, which some might be”). Answers that were unclear as to whether the risky outcome was all-or-none (e.g., “They died,” or “There is 3/5 probability that people are saved”), or that were irrelevant to the scoring criteria (e.g., “I didn’t assume anything”), were coded as correct under liberal scoring and incorrect under strict scoring.

In addition to correct/incorrect, answers were scored based on whether they flipped the frame (see scoring criteria for strict option) and whether they explicitly stated that “everyone” or “no one” would be saved (or die). A score of 1 on either of these measures meant that the answer flipped the frame or made an all-or-none statement, respectively. A score of 0 for flipping the frame meant that the answer used language consistent with the frame in which the option was presented (e.g., “saved” in the gain frame and “died” in the loss frame). A score of 0 for all-or-none reference meant that the answer said “some” people would be saved/die, or stated a number corresponding to fewer than the entire group at risk, or otherwise indicated that a subset of those at risk might be saved (e.g., “Everyone will most likely die, unless they are extremely lucky, which some might be.”). Answers were excluded from analyses using these measures if they were irrelevant to the scoring criteria (e.g., “I didn’t assume anything.”).

Framing index. A measure of each individual’s propensity to show standard framing, termed framing index (FI), was calculated as the average number of risky choices in the loss frame minus the average number of risky choices in the gain frame. The higher the framing index, the larger the proportion of choices that were consistent with the standard framing effect, which is to prefer risk (choose the gamble option) in the loss frame but to avoid risk (choose the sure option) in the gain frame. Participants with negative framing indexes were labeled reverse framers (Reyna & Ellis, 1994; Reyna, Estrada, et al., 2011). Framing indexes were calculated separately within each factorial condition. For example, each subject answered 20 questions in the zero complement truncation: ten in the gain frame and ten in the loss frame. The number of risky choices in the loss frame was summed and then divided by 10. Then, the number of risky choices in the gain frame was summed and divided by 10. The average number from the gain frame was subtracted from the average in the loss frame. This yielded a possible range of -1 (reverse framing for all 20 questions: 0 risky choices in loss frame and 10 risky choices in gain frame) to +1 (standard framing for all 20 questions: 10 risky choices in loss frame and 0 risky choices in gain frame). The average was calculated in the same way within each of the three truncation conditions. In addition, a total framing index was calculated as the average of the three truncation-specific framing indexes. The possible range for total framing index was -1 (reverse framing for all 60 questions) to +1 (standard framing for all 60 questions).

Signed confidence framing index. A more sensitive measure of framing preferences was calculated by multiplying the confidence rating (1-5) for each problem by -1 if the risky option was selected and +1 if the sure option was selected. The resulting scores were averaged within each frame, and the average in the loss frame was subtracted from the average in the gain frame. Within each truncation, this yielded a score ranging from -5 (maximum confidence in reverse framing for all 20 problems, i.e., 0 risky choices in loss frame, 10 risky choices in gain frame, and confidence=5 for all problems) to +5 (maximum confidence in standard framing for all 20 problems, i.e., 10 risky choices in loss frame, 0 risky choices in gain frame, and confidence=5 for all problems). In addition, a total signed confidence framing index was calculated as the average of the three truncation-specific signed confidence framing indexes. The possible range for total signed confidence framing index was -5 (maximum confidence in reverse framing for all 60 questions) to +5 (maximum confidence in standard framing for all 60 questions). The signed confidence framing index is a more sensitive measure of framing preferences because it allows subjects to indicate how strongly the feel about their choice, given that each problem requires a forced binary choice (Mandel, 2013).

Statistical analyses. Individual difference scales were scored according to the instructions from the article in which they were first published. Statistical analyses, including *t*-tests, ANOVAs, and correlations, were calculated in SPSS 19 (IBM, Armonk, NY, 2010).

Results

Free Responses

Free responses are displayed in the Appendix. The most common incorrect assumption about unstated information in the sure option was that the stated information was lower-bounded (i.e., subjects inserted "at least" into the problem). The most common incorrect assumption about unstated information in the risky option was that the outcome associated with each probability could apply to some fraction of the sample, instead of an all-or-none outcome. Means for correct/incorrect, all-or-none, and flipping the frame are displayed in Tables 3 and 4. Demographic analyses for these scores are presented below.

Sure option: Age and gender. At pretest, all responses were correct under liberal scoring, so the lack of variation precluded significant correlations. However, even under strict scoring, at pretest, gender did not correlate with answers to the free response to the question about the sure option. Age was also unrelated to ambiguity for the free response question about the sure option.

Sure option: Relationship to framing bias. Those who flipped the frame when responding to the question about the sure option (i.e., those who referred to the number who died in the gain frame) showed marginally lower signed confidence framing index when only the zero complement was presented, $r(N=23)=-.40$, $p=.058$.

Risky option: Age and gender. Neither gender nor age correlated with correct answers to the free response question about the risky option. However, there were two instances when age was related to flipping the frame or referring to all-or-none. First, in the gain frame, on the initial questionnaire, younger participants were marginally more likely than older participants to refer to the unstated risky complement as all-or-none, $r(N=49)=-.28$, $p=.049$. This relationship was not present in the loss frame group, or in the combined sample. It was not present in any sample at the post-task manipulation check. Second, in the combined gain and loss samples, on the initial questionnaire, older participants were more likely than younger participants to flip the frame, $r(N=79)=.25$, $p=.024$. This relationship was not significant when the gain and loss samples were separated, and it was not present in any sample at the post-task manipulation check. Age and gender did not significantly correlate with any numeracy measure in either sample separately, or in the combined sample.

Multiple Choice: Decreased Ambiguity Following Worked Examples

Mean scores for each question on the ambiguity survey are displayed in Table 5. Means are calculated separately for the initial questionnaire and the post-task manipulation check. Out of three questions, the mean score on the post-task manipulation check was 2.95 ($SD=.22$) in the group receiving the gain frame manipulation check and 2.60 ($SD=.80$) in the group receiving the loss frame manipulation check. Although this high rate of correct responses to the manipulation check demonstrates that subjects retained our instructions for interpreting missing information, we further examined whether subjects improved on the post-task manipulation check compared to the initial questionnaire, and whether age, frame, or question type (sure vs. risky option) made a difference in the rate of correct responses.

Separate analyses were run on the yes/no question about the sure option and on the three-option questions about the sure and risky options. These analyses were not combined because of the different number of response options (hence, different odds of answering correctly by chance alone). For all analyses, the dependent variable was response to each ambiguity survey question, coded as 0 (incorrect, indicating ambiguity) or 1 (correct, indicating no ambiguity).

Yes/no question. For the yes/no question about the sure option, a 2 x 2 x 2 repeated measures ANOVA was run, with initial versus post-task ambiguity survey as a within-subject variable and frame (gain or loss) and age group (college or post-college) as between-subjects factors. Significant main effects were found for initial vs. post-task $F(1, 77)=8.08$, $p=.006$, $\eta_p^2=.095$, and for frame, $F(1, 77)=6.91$, $p=.01$, $\eta_p^2=.082$. More subjects answered correctly in the gain frame ($M=.90$) than in the loss frame ($M=.73$), and subjects improved on the post-task manipulation check ($M=.90$) compared to the initial ambiguity survey ($M=.73$).

Since subjects receiving the gain frame version of the manipulation check were higher in objective numeracy than those receiving the loss frame version (Table 1), we ran an additional ANOVA including all of the above factors, as well as objective numeracy as a covariate. No main effects or interactions were significant in this analysis (all $p>.1$), suggesting that the main effects of frame and initial versus post-task were accounted for by differences in objective numeracy.

Three-option questions. A repeated measures ANOVA was run on the three-option questions about the sure and risky options. The 2 x 2 x 2 x 2 factorial design included initial versus post-task and sure vs. risky as within-subjects factors, and frame (gain or loss) and age group (college or post-college) as between-subjects factors. As with the yes/no question about the sure option, there were main effects of initial versus post-task, $F(1, 77)=30.42$, $p<.001$, $\eta_p^2=.280$, and frame, $F(1, 77)=9.74$, $p=.003$, $\eta_p^2=.044$. The direction of these main effects was the same as for the yes/no question about the sure option: More subjects answered correctly in the gain frame ($M=.90$) than in the loss frame ($M=.73$), and more subjects answered correctly on the post-task manipulation check ($M=.94$) than on the initial ambiguity survey ($M=.69$).

Since subjects receiving the gain frame version of the manipulation check were higher in objective numeracy than those who received the loss frame version (Table 1), we ran an additional ANOVA including all of the above factors, with the addition of objective numeracy as a covariate. The only significant effect was objective numeracy, $F(1, 71)=6.36$, $p=.014$, $\eta_p^2=.082$. As objective numeracy increased, correct answers on the post-task manipulation check increased for the questions about the sure option, $r(N=79)=.55$, $p<.001$, and for questions about the risky option, $r(N=79)=.48$, $p<.001$.

Ambiguity as a Predictor of Framing

Repeated-measures ANOVA for frame and truncation. The critical test of the ambiguity hypothesis is whether subjects still show the framing effect even after receiving instructions to interpret missing information as complementary to stated information in each option. In a repeated-measures ANOVA, the entire sample ($N=81$) showed a main effect of frame, $F(1, 80)=124.15$, $p<.001$, $\eta_p^2=.61$. Consistent with the standard framing effect, participants made more risky choices in the loss frame ($M=60.1\%$ of choices) than in the gain frame ($M=34.2\%$ of choices). Moreover, as predicted, the truncation manipulation either enhanced or eliminated framing effects, based on an interaction between frame and truncation, $F(2, 160)=63.79$, $p>.001$, $\eta_p^2=.44$. Within each truncation condition, risk taking was higher in the loss frame than in the gain frame, but this difference was largest when only the zero complement was presented (Δ=.48), intermediate when both complements were presented (Δ=.24), and smallest when only the non-zero complement was presented (Δ=.06). The pairwise difference between gain and loss was significant in both the zero-complement and mixed conditions (p<.001) but was not significant in the non-zero-complement condition (p=.077).

Incidental to our hypotheses, we also found a main effect of whether lives or money were at stake, $F(1, 80)=5.08$, $p=.027$, $\eta_p^2=.06$. Participants took more risks with money (M=50.0% of choices) than with lives (M=44.4% of choices), but this effect did not interact with frame. Finally, we also found a main effect of replication, $F(4, 320)=3.47$, $p=.009$, $\eta_p^2=.04$. Participants took more risks in the first and second replications of each problem type than in the fifth replication, and they took more risks in the second than in the third replication.

In order to ensure that the framing and truncation effects were not driven by participants who violated our instructions about inferring missing complements (thus, who interpreted truncated options as ambiguous), we reran this analysis with only subjects who answered all questions correctly both initially and at the pre-task manipulation check. This entailed an additional analysis on each of three samples: those who answered all questions correctly on the initial questionnaire and the manipulation check (possible scores of 0-6, N=37), those who answered both questions about the sure option correctly on both the initial questionnaire and the manipulation check (possible scores of 0-4, N=44), and those who answered all questions correctly on the post-task manipulation check (possible scores of 0-3, N=68). The main effect of frame, and interaction of frame with truncation, were replicated in all of these samples at p<.001. In addition, the pairwise comparisons of gain vs. loss within each truncation replicated the qualitative pattern, with gain-loss differences in risk taking largest when the zero complement was presented, intermediate when both complements were presented, and nonsignificant when the non-zero complement was presented. The effects of lives vs. money and of replication were only sometimes significant in these analyses, perhaps due to the smaller sample sizes.

Although the previous ANOVAs demonstrated that the framing effect does not depend on linguistic ambiguity, we wanted to identify any modifying effect ambiguity might have on framing behavior. Therefore, we reran the ANOVAs with aggregate score on the ambiguity questionnaire as a covariate (N=81). The results would support the ambiguity hypothesis if any of these covariates interacted with frame. We ran separate analyses for the following covariates: number of correct answers to questions about the sure option (possible score 0-4), number correct at pretest (possible score 0-3), number correct at posttest (possible score 0-3), and number correct at pretest plus posttest (possible score 0-8). In each of these covariate analyses, the main effect of frame and the interaction of frame with truncation were both significant (all but one at p<.001). The qualitative patterns for these effects, including pairwise differences, were identical to the analyses described in more detail above. There were inconsistent effects of replication and of lives versus money, with the qualitative patterns consistent with those described above when these factors were significant. In none of these covariate analyses was the ambiguity covariate significant as a main effect or in a two-way interaction with frame.

Framing index by ambiguity for each question. Mean framing index and mean signed confidence framing index in each truncation condition, for correct versus incorrect responses to each ambiguity question, are displayed in Tables 6-9. None of the questions from the initial ambiguity survey were related to framing in any truncation condition. Only one of the questions from the post-task manipulation check was related to framing. These results do not carry statistical weight, since the cell containing incorrect answers to the ambiguity question is very small, but we report the trend for the sake of completeness.

The two significant *t*-tests compare framing bias for 9 people who incorrectly answered, versus 72 people who correctly answered, the yes/no question about the sure option on the post-task manipulation check. When the zero complement or both complements of the risky option were presented, the trend suggested that subjects who added “or more” to the sure option showed less standard framing bias than did those who did not add “or more.” This pattern was also significant when framing index was averaged over all three truncations, but it was not significant when only the non-zero complement was presented (i.e., in the truncation of the risky option that was presented in our ambiguity surveys). Again, due to the small cell size of people who answered incorrectly (N=9), this result, though statistically significant should be interpreted with caution. However, the trend was that less ambiguity was associated with more framing, the opposite result predicted by the ambiguity hypothesis.

Numeracy: Relationship to Ambiguity and Framing

Numeracy as a predictor of ambiguity. Higher numeracy was associated with less ambiguity as measured by multiple aggregate scales (Tables 10 and 11). Numeracy did not correlate significantly with any measure of ambiguity at the initial test (i.e., prior to receiving the worked example and completing framing problems). However, as indicated by post-task manipulation check scores, more numerate subjects were more likely to correctly infer unstated complements while completing framing problems. This effect was observed for both the sure and the risky option. Higher objective numeracy was associated with less ambiguity post-task, for questions about both the risky and the sure option. Higher subjective numeracy was also associated with less ambiguity post-task.

Regressions demonstrated that higher numeracy predicted correct inferences about unstated complements at the post-test manipulation check. In separate regressions, higher objective and subjective numeracy predicted a higher number of correct responses (0-4) to the post-task manipulation check (i.e., less ambiguity while completing framing problems; ONS: β=.66, $t(1, 77)$=7.61, p<.001; SNS: β=.41, $t(1, 77)$=3.92, p<.001). Objective and subjective numeracy also remained significant predictors of ambiguity when age and gender were included in each regression. Parameter estimates for age and gender were not significant. Cognitive reflection test was not a significant predictor of ambiguity on the post-task manipulation check, no matter whether age and gender were included. In all significant effects, higher numeracy predicted higher compliance with our instructions about how to interpret missing information.

Numeracy as a predictor of framing. In the combined sample (N=81), higher SNS was associated with more framing when both complements were presented (i.e., in the standard condition); and when only the non-zero complement was presented (Table 12).

Using a more sensitive measure of framing behavior, higher SNS was associated with higher signed confidence framing index (i.e. more framing, and higher confidence for framing-consistent decisions) collapsing across all truncations, and when only the non-zero complement was presented. Higher SNS was marginally associated with higher signed confidence framing index when both complements were presented (p=.052). In addition, higher scores on the CRT were associated with more framing, and higher confidence for framing-consistent decisions, when only the non-zero complement was presented.

This pattern of correlations was not consistent within each group separately, possibly due to reduced sample size. Among those who received the gain frame version of the manipulation check, higher subjective numeracy was marginally associated with more framing, and higher confidence for framing-consistent choices, when only the non-zero complement was presented, $r(N=38)=.32$, $p=.052$. Among those who received the loss frame version of the manipulation check, higher objective numeracy was associated with more framing, $r(N=41)=.32$, $p=.042$), as well as higher confidence for framing-consistent choices, $r(N=41)=.37$, $p=.018$, when only the non-zero complement was presented.

In a regression, higher SNS predicted higher signed confidence framing index for problems in which only the non-zero risky complement was presented, $B_{standardized}=.25$, $t(1, 76)=2.29$, $p=.025$. Subjective numeracy remained a significant predictor of signed confidence framing index even when age and gender were included in the regression, $B_{standardized}=.27$, $t(3, 74)=2.39$, $p=.019$. In regression analyses using the combined sample, neither objective numeracy nor CRT scores significantly predicted framing bias in any truncation condition.

Finally, as an additional way to test for an influence of numeracy on framing bias, we included objective numeracy as a covariate in the repeated-measures ANOVA on all 60 framing problems. The main effect of frame and the interaction between frame and truncation remained significant at $p<.001$, replicating the patterns described for the standard framing ANOVA. Numeracy was not significant as a covariate ($p=.454$).

Discussion

Scholars have argued, based on Gricean pragmatics, information leakage, and schema theory, that framing effects are caused by ambiguity about the unstated complement in the sure option (e.g., Jou et al., 1996; Kuhberger & Gradle, 2013; Mandel, 2013; Sher & McKenzie, 2008). In particular, these theories predict that subjects add “or more” to the sure option, resulting in a higher expected utility for the sure gain (leading subjects to select option A in the gain frame) or for the sure loss (leading subjects to select option B in the loss frame). We provided instructions and worked examples in order to disambiguate unstated information in the sure option and in truncations of the risky option. We then administered 60 framing problems. Before the worked example, and after the framing problems, subjects answered a multiple-choice questionnaire testing their comprehension of our instructions about unstated information. Although initial comprehension was high, comprehension increased after the worked example, and it remained while subjects completed all 60 framing problems, as indicated by the post-task manipulation check. Despite this thorough disambiguation, subjects showed robust framing and truncation effects. Limiting the analysis to subjects with perfect scores on the ambiguity questionnaire, or controlling for these scores in the larger sample, did not attenuate framing effects. This is strong evidence against the hypothesis that framing effects are caused by inferences that render the expected utility of the two options unequal.

Relationship of Ambiguity to Framing Effects

We obtained robust framing effects even after thoroughly disambiguating unstated information in both the sure and the risky options, and we observed no relationship between performance on any ambiguity survey question and framing index (Tables 6-9; in fact, the only exception, which was uninterpretable due to uneven cell size, trended in the opposite direction of the ambiguity hypothesis). It is difficult to interpret null results, but it is safe to say that these results provide little support for the claim that interpretations of unstated option information cause the framing bias observed under typical conditions. These results demonstrate that adding “at least” to the sure option is unnecessary in creating framing effects. Across truncation conditions, those who rejected the lower-bounded interpretation showed a robust framing bias (.28 on a scale from -1 to 1; Table 6).

It might be objected that we reduced ambiguity so much that we limited our own ability to detect a relationship between ambiguity and framing, even if one existed. This reduction in ambiguity was necessary in order to test whether ambiguity was necessary to framing effects. However, there was sufficient variation in ambiguity scores (Tables 10 and 11) and in framing scores (Table 12), respectively, to produce significant correlations with numeracy. Although effect sizes were generally small in the framing-numeracy correlations (with *r*s ranging from .19 to .25), effect sizes for the ambiguity-numeracy correlations were medium. For example, higher scores on the post-task manipulation check correlated with higher objective numeracy, $r(N=81)=.66$ ($p<.001$).

What People Assume about Missing Information

Sure option. The consistent prediction, articulated by proponents of Gricean pragmatics, information leakage, and schema theory, is that subjects add "or more" to the description of the sure option. By instructing subjects not to make this assumption, we minimized these inferences at pretest, and all but eliminated them by posttest. For the yes/no question about the sure option, subjects improved on the post-task manipulation check (90% correct) compared to the initial questionnaire (73% correct). The higher post-task comprehension rate reflects the additional instructions (with a worked example) provided following the initial instructions and questionnaire, and it strongly suggests that subjects retained their understanding that the sure option did not mean "or more" or "at least" while making framing decisions.

Performance on the yes/no question about the sure option was better in the gain frame (90% correct) than in the loss frame (73% correct), collapsing across pretest and posttest. This is unsurprising given the added complexity of choosing between risk aversion and loss aversion when processing the risky option in the loss frame (Clark & Chase, 1977; Gonzalez, Dana, Koshino, & Just, 2005).

Risky option. The question about the risky option allowed us to test whether subjects understood the all-or-none nature of the outcome. Although comprehension rate was high following our initial instructions (75% correct), it was significantly higher following the presentation of worked examples (93% correct, collapsing across gain and loss groups). As it was in the sure option, the higher comprehension rate on the post-task manipulation check reflects the additional instructions (with a worked example) provided following the initial test, and it strongly suggests that subjects retained their understanding of the all-or-none property of the risky option while making choices during the framing task. This is strong evidence against the speculation, noted by Kuhberger and Tanner (2010), that subjects interpret unstated information in the risky option as having an indeterminate value.

Performance on the multiple choice question about the risky option was better in the gain frame (100% correct) than in the loss frame (86% correct) on the post-task manipulation check. As with the analogous finding for the sure option, this is likely due to the added complexity of choosing between risk aversion and loss aversion (Gonzalez et al., 2005).

This is the fourth study (after Kuhberger, 1995 and Mandel, 2001, 2013) to test for ambiguity about a truncated risky option. Most of the literature has focused on ambiguity in the sure option, since this is the only option not fully specified in the traditional version of the problem. However, truncations of both the sure and the risky option have proved vital to testing theoretical accounts of framing effects (Kuhberger, 1995; Kuhberger & Tanner, 2010; Mandel, 2001; Reyna & Brainerd, 1991, 2011).

Free Response Format

This study is among the first to directly ask subjects, in free response format, how they interpreted each option. Although other free response questions in the literature have been interpreted as evidence about subjects' interpretations of unstated information, the questions themselves were not directly about the ambiguity hypothesis. For instance, Jou et al. (1996) asked subjects why they made the framing choices they did and used these answers to infer ambiguous interpretations of the options, but these researchers did not ask directly about interpretations of the options. Kuhberger (1995) asked subjects whether they interpreted the options as exact or approximate, but he only asked one question per problem, so that the answer applied to both the sure and the risky option. This potentially obscured differences in perceptions of each option. Moreover, Kuhberger (1995) did not allow for free responses (which would have indicated the nature of the ambiguity) or test for the direction of any perceived differences.

Additionally, Mandel (2001) and Frisch (1993) asked subjects whether each option should be treated equally across frames. These authors inferred from subjects' responses that the options were perceived ambiguously. However, neither of these authors obtained information about the interpretation of each option within frame. Presenting both gain and loss versions of the same problem side-by-side and asking subjects whether the options are equivalent is more relevant to the question about rationality (i.e., coherence) than to the question about ambiguity. Since most studies present framing problems sequentially, and some even present frame as a between-subjects factor, subjects' evaluations of equivalence when both frames are presented simultaneously provides little information about their perceptions of the options in normal decision contexts.

We found that the free response format provided the most variance in correct responses, particularly for questions about the risky option. These free responses suggested that, although most subjects correctly applied our instructions for interpreting missing information, in the few instances when people did make other inferences, they tended to assume that the stated information in the sure option was lower-bounded. This is consistent with the results reported by Mandel (2013). However, because not all free responses addressed the elements of ambiguity that were the focus of our analysis (i.e., some responses to the question about the sure option were neutral about the “at least” implicature, and some responses to the question about the risky option were neutral about the “all-or-none” principle), it was also crucial to ask multiple-choice questions in order to obtain more direct information about these elements of ambiguity.

Numeracy, Ambiguity, and Framing

We found that higher objective and subjective numeracy were associated with correct interpretations of unstated information in the sure and the risky options at the post-task manipulation check (Tables 10 and 11). Higher ONS and SNS predicted more correct responses on the post-task manipulation check, even controlling for age and gender. In addition, higher scores on the CRT were associated with correct interpretations of unstated information about the sure option on the manipulation check. These results suggest that more numerate people infer gains from losses and losses from gains, even when only one of two logical complements is presented in a framing option.

Numeracy also covaried with framing bias. Higher subjective numeracy predicted more framing in the condition that, on average, eliminated framing (i.e., when only the non-zero complement was presented). This is interesting given that higher SNS also predicted correct interpretations of missing information about the sure option (and about the risky zero complement). Taken together, these results suggest that more numerate people correctly inferred gains from losses and losses from gains, but that these correct inferences did not reduce framing bias in our sample. Further, it is possible that by mentally reinstating the missing zero-complement, those higher in numeracy were more likely to rely on a comparison of some people living versus no people living, or some people dying versus no people dying (leading to preferences in the direction of standard framing). We did not find any significant relationships between ambiguity and framing bias, so we do not mean to suggest that numeracy mediates such a relationship. However, these results are inconsistent with the assumption that framing bias depends on inferences that unstated information renders the expected utilities of the options unequal.

Necessity of Ambiguity to Framing Bias

Our results speak directly to recent work by Mandel (2013). Mandel presents three experiments in which he examines the relationship between ambiguity and framing effects both within and between subjects. Although Mandel increases framing effects by manipulating interpretations of unstated information that are consistent with the ambiguity hypothesis, we argue that he does not demonstrate that such interpretations are necessary in order to achieve framing effects under normal circumstances.

In Mandel's Experiment 1, only 21.7% of participants showed framing effects when Mandel added "exactly" to the incompletely specified sure option. Based on this result, he argues that framing effects are driven by subjects' assumption that the sure option is lower bounded (e.g., that "at least" 200 subjects will be saved), an assumption that is eliminated by adding "exactly." However, if ambiguity is the necessary ingredient for producing framing effects, this does not explain why over 1/5 of the sample showed framing effects when the "at least" assumption was ruled out. (Mandel argues on pages 3 and 11 that information leakage might still cause some framing even when options are disambiguated, but the information leakage account of risky choice framing effects has not been strongly established; see Sher & McKenzie, 2006, 2008.) We observed much higher rates of framing following a more thorough disambiguation of missing information, including worked examples and a manipulation check. Although Mandel's manipulation did reduce framing effects, one would expect disambiguation to eliminate framing effects if misinterpretation of the unstated information were necessary to produce framing.

In addition, Mandel increased framing effects to 73.3% of subjects by adding "at least" to the description of the incompletely specified sure option. However, that the "at least" assumption can increase framing does not mean that it is necessary in order to create the bias under ordinary circumstances. Adding "at least" to the sure option makes the expected utility of the sure option higher than that of the risky option in the gain frame, and lower than that of the risky option in the loss frame. Naturally, subjects choose the option with the higher expected utility, resulting in most subjects choosing the sure option in the gain frame and the risky option in the loss frame. Any number of manipulations could change behavior to achieve this pattern of results; the question is what mechanism drives framing bias in the standard version of the problems.

In Experiment 2, Mandel reported that adding "exactly" to the sure option eliminated framing effects between subjects, whereas adding "at least" increased framing bias compared to the unmodified version of the sure option. This interaction between frame and modifier (i.e., "exactly" or "at least") was reported for choices weighted by an 11-point preference scale, indicating how much subjects preferred the option they selected compared to the one they did not select (0=equally preferable; 10=much more preferable). It is possible that adding "exactly" versus "at least" modified subjects' degree of preference, but not the binary choices themselves (although an analysis of the latter is not reported).

In all three modifier conditions (no modifier, "exactly," and "at least), the direction of the effect was consistent with framing bias, even though the effect was not significant in all conditions. As we have argued, adding the "at least" modifier changes the problem information by rendering the expected utilities of the options unequal. Therefore, increased framing in this condition is not direct evidence that mentally adding "at least" is the reason that subjects show framing bias for the typical version of the problem. However, the difference between the no-modifier condition and the "exactly" modifier condition more clearly tests the hypothesis that people show framing bias because they make additional inferences about the options. Although preference-weighted choices differed between the no-modifier and "exactly" conditions in the loss frame (26.3% vs. 43.2% sure option chosen, respectively), weighted choices did not differ between these conditions in the gain frame (57.9% vs. 59.0% sure option chosen, respectively). Thus, even using preference-weighted choices (a more sensitive indication of framing bias), specifying that the numbers were exact did not reduce framing bias in the gain frame.

Mandel's Experiment 3 was also between-subjects; each participant answered one framing problem with one of several truncations, gave a preference rating, and indicated whether they thought the sure and the risky option meant "at most," "at least," or "exactly" the number specified would be saved or would die. Mandel reports three effects in this experiment. First, specifying typically unstated information changed the magnitude and direction of framing effects. When both options were fully specified, framing effects disappeared, and when the sure option was fully presented but the risky option was partially presented (non-zero complement presented), the typical framing effect was reversed. We have argued (Reyna et al., 2013) that by presenting only portion of each option, the experimenters selectively focus attention on one of two complementary outcomes, cuing different cognitive processes for comparing the options. These processes result in different decisions, but, as we explain in more detail in the next section, this need not be attributed to lack of complementarity between stated and unstated information.

Second, participants tended to interpret the sure option as “at least” when only one complement was presented, but not when both complements were presented. We report that some subjects interpreted missing information this way in the current study, lending support to Mandel’s hypothesis that, when people do interpret missing information ambiguously, their interpretations tend to be lower-bounded.

Third, Mandel reports that participants’ interpretations of the unstated information predicted their framing bias (for choices weighted by preference score). Participants who interpreted the options as “at least” showed standard framing bias, those who interpreted them as “at most” showed reverse framing effects, and those who interpreted the options as “exactly” showed no framing effects. Again, we agree that interpreting the sure option as lower-bounded, which changes the expected utility of the options, can cause framing effects; by the same logic, interpreting the sure option as upper-bounded would change the expected utility so as to decrease framing effects. However, that subjects’ choices maximize expected utility does not speak to the necessity of the lower-bounded assumption in producing framing effects under normal conditions. In addition, Mandel restricted participants’ answers to lower-bounded interpretations, upper bounded interpretations, or exact interpretations – leaving out an option for participants who did not at all consider the missing information during decision-making. A selective attention explanation would suggest that participants tend to ignore missing information while making decisions, even when they do have opinions about what the missing information means. We limited analyses to subjects who rejected lower-bounded options, and we also controlled for perceived ambiguity in the full sample. Neither of these analyses reduced, let alone eliminated, the framing effect.

Selective attention. In other published work, we have predicted, and reported, that drawing participants' attention to the equivalence of expected utility between the sure and risky options should eliminate within-subjects framing effects (Reyna et al., 2013). This manipulation of selective attention is the rationale for our truncation effects. Holding the traditional version of the sure option constant, presenting only the zero-outcome risky complement (e.g., 2/3 chance no one saved) enhances the categorical some-none contrast between the sure and risky options; since this simple, some-none difference is sufficient to distinguish between the options, subjects make their choice on this basis. On the other hand, presenting only the non-zero-outcome complement (e.g., 1/3 chance all 600 saved) does not allow for discrimination based on simplified categorical comparisons; instead, subjects must process the options in greater numerical detail by computing expected utility, which is the same for both options (leading to indifference). These predictions are supported by the data presented here as well as in other reports (Reyna et al., 2013; Reyna & Brainerd, 2012).

Crucially, our argument is not that subjects make different assumptions about the unstated complement when one or the other risky complement is presented. Rather, it is that each risky complement, presented in isolation, prompts a different cognitive process for comparing the sure versus risky options, resulting in either increased or decreased framing effects. When the zero complement is presented, subjects can distinguish between the sure and risky options on a categorical basis; since this is sufficient for producing a choice, they are not prompted to consider the unstated risky complement. This does not imply that they do not understand that the unstated information is complementary to the stated information. As we have shown here, subjects show robust frame and truncation effects even when they explicitly indicate in manipulation checks that they understand stated and unstated portions of each option to be complementary. That subjects indicated this on the manipulation checks after completing all framing problems demonstrates that they retained our instructions for interpreting missing information the entire time that they were making framing decisions.

Based on these manipulation checks, misinterpretations of unstated information cannot account for the diminished framing effects we observed when only the non-zero complement is presented. Rather, we predicted this diminution of framing because the non-zero complement requires subjects to compare the options with greater numerical precision, prompting them to recognize that the expected utilities are equal. The different effects of presenting one or the other risky truncation do not reflect misunderstanding of unstated information, as we have shown in our manipulation checks. Rather, our truncation manipulation is one of selective attention, and, as we have described, focusing on different parts of the problem information cues different types of cognitive comparison processes, resulting in different choice patterns. Our results therefore suggest that selectively focusing on different aspects of the problem information, rather than misinterpreting incompletely specified information, accounts for the causal mechanism of framing bias.

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Table 1

Age, Gender, Numeracy, and Framing Index by Experiment

		Experiment 1 (Free response)				Experiment 2 (Multiple choice)		
	Min/Max Possible	Sure Option (Pretest Only)	Risky Option (Pretest and Posttest)		Omnibus			Omnibus
		Gain	Gain	Loss		Gain	Loss	
N		23	49	42		39	42	
Age		20.57 (1.83)	21.55 (4.54)	29.86 (11.81)	$F(1, 89)=20.69^*$, $p<.001$, $\eta_p^2=.189$	21.95 (4.99)	29.86 (11.81)	$F(1, 79)=14.98^*$, $p<.001$, $\eta_p^2=.159$
Gender		34.78% female	40.82% female	42.86% female	$\chi^2(2)=0.042$, $p=.98$	41.03% female	42.86% female	$\chi^2(1)=0.028$, $p=.87$
ONS	0 to 16	14.27 (1.42)	14.72	13.31 (3.06)	$F(1, 87)=8.03^*$, $p=.006$, $\eta_p^2=.085$	14.74 (1.54)	13.31 (3.06)	$F(1, 79)=6.69^*$, $p=.012$, $\eta_p^2=0.08$
SNS	0 to 8	4.20 (.72)	4.41 (.88)	4.21 (1.04)	$F(1, 86)=.95$, $p=.33$. $\eta_p^2=.011$	4.38 (0.93)	4.21 (1.04)	$F(1, 78)=.62$, $p=.435$, $\eta_p^2=0.008$
CRT	0 to 3	1.05 (1.00)	1.33 (1.15)	1.62 (1.19)	$F(1, 88)=1.34$, $p=.25$, $\eta_p^2=.015$	1.31 (1.16)	1.62 (1.19)	$F(1, 79)=1.32$, $p=.253$, $\eta_p^2=0.02$
Framing Index	-1 to 1	.11 (.18)	.23 (.23)	.25 (.032)	$F(1, 89)=.13$,	.27 (.034)	.25 (.032)	$F(1, 79)=.28$,

(all conditions)					p=.72, η_p^2=.001			p=.599, η_p^2=0.004
Framing Index (Zero complement presented)	-1 to 1	.27 (.29)	.45 (.30)	.46 (.30)	F(1, 89)=.016, p=.90, η_p^2=0	.50 (.30)	.46 (.30)	F(1, 79)=.41, p=.525, η_p^2=.005
Framing Index (Non-zero complement presented)	-1 to 1	-.06 (.28)	.02 (.32)	.058 (.26)	F(1, 89)=.36, p=.55, η_p^2=.004	.06 (.34)	.058 (.26)	F(1, 79)=.003, p=.955, η_p^2<.001
Framing Index (Mixed: Both complements presented)	-1 to 1	.12 (.22)	.22 (.28)	.22 (.25)	F(1, 89)=.006, p=.94, *Eta*=0	.25 (.28)	.22 (.25)	F(1, 79)=.23, p=.63, η_p^2=.003

Note. Values are presented as mean (standard deviation) for each of the three samples (Experiment 1, gain frame; Experiment 2, gain frame; Experiment 2, loss frame). Only subjects who received both pretest and posttest are included. For statistical analyses, only subjects who received the 4-question version of the ambiguity survey are included. *Omnibus* refers to a univariate ANOVA with age, ONS, SNS, CRT, or Framing Index as dependent variable and frame of ambiguity survey as independent variable. For gender, *omnibus* refers to a chi square test with gender as dependent variable and frame of ambiguity survey as independent variable. Pairwise comparisons are reported at LSD significance levels.

Figure 1. Repeated measures factorial design of framing problems**.** Each risky option was created according to the following factorial design: 3 (truncation: zero complement presented, both complements presented, non-zero complement presented) x 2 (frame: gain, loss) x 2 (modality: lives, money). Each of these 12 conditions was replicated 5 times for a total of 60 problems per participant.

Table 2

Example of Risky Options for the Asian Disease Problem in Each Truncation

Condition	Safe option	Risky option	Prediction (FTT)
Zero complement presented			
Text	200 people saved for sure	2/3 probability no one saved	Increased framing
Categorical gist	SOME	NONE	
Mixed (Both complements presented)			
Text	200 people saved for sure	1/3 probability 600 saved, or 2/3 probability no one saved	Standard framing
Categorical gist	SOME	SOME or NONE	
Non-zero complement presented			
Text	200 people saved for sure	1/3 probability 600 saved	No framing
Categorical gist	SOME	SOME	

Note. The sure option was held constant. The traditional presentation is mixed (i.e., presenting both risky complements). For each problem stem, only one sure and one risky option were presented (i.e., only one truncation condition per problem). These options are framed as gains; analogous manipulations were created for the loss frame.

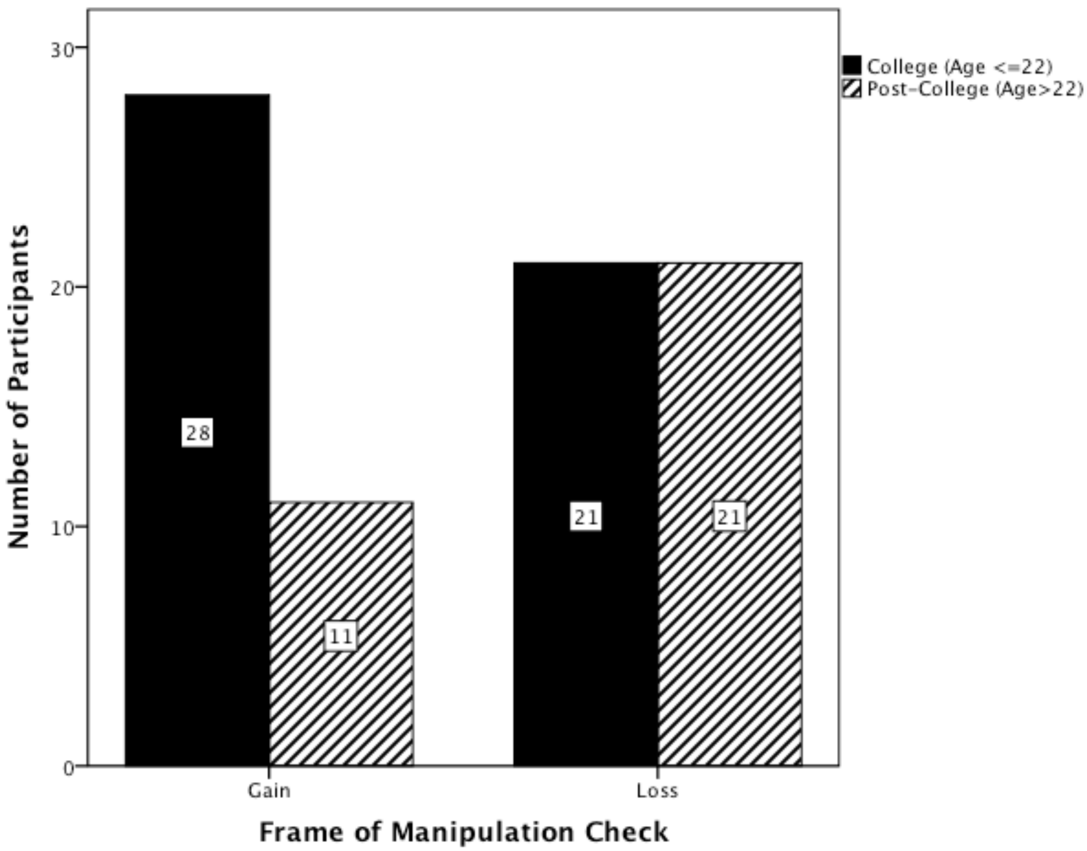

Figure 2. Age groups by frame of ambiguity survey, *N*=81 participants who completed the four-question version of the ambiguity questionnaire.

Table 3

Sure Option Referent: Coding for the "At Least" Implicature in Experiment 1

	Correct	Correct in Liberal, Incorrect in Strict	Incorrect
Criterion	Indicated that it is impossible for anyone additional to survive	Neither endorsed nor rejected possibility of more saved later	Indicated that it is possible for more people to be saved
Example	"They died." "Do not live."	"They would not be saved." "They are caught in the manufacturing plant."	"They probably died." "They weren't saved, they swam to shore?"
N Pre-test	18	5	0
Coding	1	0 (Strict) or 1 (Liberal)	0

Note. Table indicates scoring criteria as well as examples and distribution of responses to the question, "For option A, what did you think happened to the other 200 people?" in Experiment 1 (gain frame questionnaire). Option format was free response.

Table 4

Risky Option Referent: Coding Criteria

	Liberal/Strict				All-or-None			Flipping Frame			
	Correct	Correct in Liberal, Incorrect in Strict	Incorrect		Yes	No		Flipped frame	Did not flip frame	Unscored	
Criterion	Explicitly stated no one would be saved later (in gain frame)	Neither endorsed nor rejected all-or-none; did not flip frame (in gain frame)	Indicated that that a subset could be saved/die		Indicated that either everyone is saved [dies], or no one is saved [dies]	Indicated that a subset of those at risk could be saved		Indicated number who died (gain frame) or were saved (loss frame)	Gain: Indicated number saved (or not saved). Loss: Indicated number who died (or did not die)	Did not use valenced language in answer (i.e., no mention of number who died or were saved).	
Example	"That there is a 3/5 chance that you will save all 500 people in the boat."	"3/4 probability NOT SAVED." "Max 400 people would die instead of max 300."	"3/5 probability that some of the people will be saved." "Everyone will most likely die unless they are extremely lucky which some might be."		"2/5 probability that everyone will NOT be saved." "No one saved."	"The other 2/5 won't be saved." "I hoped that there was a possibility that the 2/5 could be saved, as well."		"They drowned." "Forced to die."	"2/5 chance no one will be saved." "2/5 probability everyone will NOT be saved."	"I didn't assume anything." "That it was too great a percentage to take a chance on."	
Coding	1	1 (Liberal); 0 (Strict)	0		1	0		1	0	No score	
				<u>Total</u>			<u>Total</u>				<u>Total</u>
<u>Gain</u>											
N Pre	10	34	5	49	33	16	49	9	33	7	49
N Post	22	24	3	49	36	13		24	25	0	49
<u>Loss</u>											
N Pre	17	19	6	42	18	24	42	32	5	5	42
N Post	23	15	4	42	24	18	42	26	14	2	42

Note. Table indicates scoring criteria for the question, "For option B, what happens if everyone is not saved (what does the 3/5 probability indicate)?" from Experiment 1. Option format was free response. Examples are from gain frame questionnaire.

Table 5

Mean Correct Responses to Ambiguity Survey

	Response Format	Possible Scores	*N*	Gain Frame: Initial *M* (*SD*)	Gain Frame: Manipulation Check *M* (*SD*)	*N*	Loss Frame: Initial *M* (*SD*)	Loss Frame: Manipulation Check *M* (*SD*)
Sure Option								
What did you assume happened to the other 200 people in Option A?	Free Response	0-1	23	Strict: .78 (.42) Liberal: 1 (0)	Strict: .82 (.40) Liberal: 1 (0)			
Did you assume that more than 300 people would be saved in option A?	Yes/**No**	0-1	39	.85 (.37)	.95 (.22)	42	.62 (.49)	.83 (.38)
Which of the following did you assume about option A? **(a) Exactly 300 saved** (b) At least 300 saved (c) Some of the other 200 saved	Multiple choice	0-1	39	.79 (.41)	1 (0)	42	.57 (.50)	.90 (.30)
Total correct sure option (Initial + Post)	Sum	0-4	39	3.59 (.68)		42	2.93 (1.05)	
Risky Option								
What did you assume about the other 2/5 probability in Option B?	Free Response	0-1	49	Strict: .20 (.41) Liberal: .90 (.31)	Strict: .45 (.50) Liberal: .94 (.24)	42	Strict: .41 (.50) Liberal: .86 (.35)	Strict: .55 (.50) Liberal: .91 (.30)
Which of the following did you assume about option B? (a) 2/5 probability some saved (b) 2/5 probability all saved **(c) 2/5 probability none saved**	Multiple Choice	0-1	39	.85 (.37)	1 (0)	42	.60 (.50)	.86 (.35)
Total correct risky option (Initial + Post)	Sum	0-4	39	Strict: 2.26 (.75) Liberal: 3.69 (.57)		42	Strict: 2.40 (1.27) Liberal: 3.21 (.95)	
Sure + Risky								
Total correct (initial **or** post-task), including free response	Sum	0-4	39	Strict: 2.59 (.91) Liberal: 3.41 (.91)	Strict: 3.26 (.55) Liberal: 3.87 (.41)	42	Strict: 2.19 (1.29) Liberal: 2.64 (1.21)	Strict: 3.14 (1.09) Liberal: 3.50 (.92)
Total correct (initial **or** post-task), multiple choice only	Sum	0-3	39	2.49 (.82)	2.95 (.22)	42	1.79 (1.14)	2.60 (.80)
Total correct (initial + Post-task), including free response	Sum	0-8	39	Strict: 5.85 (1.04) Liberal: 7.28 (.97)		42	Strict: 5.33 (1.98) Liberal: 6.14 (1.70)	
Total correct (initial + Post-task), multiple choice only	Sum	0-6	39	5.44 (.82)		42	4.38 (1.48)	

Note. "Initial" refers to ambiguity surveys completed prior to framing problems; "post-task" refers to ambiguity surveys (manipulation checks) completed after the presentation of worked examples and the completion of framing problems. There was no loss frame version of the free response question about the sure option. Only *N*=11 participants completed the free response question about the sure option at the post-task manipulation check.

Table 6

Framing Index by Truncation for Incorrect versus Correct Responses to Multiple Choice Ambiguity Survey

	Total (All truncations)					Both complements presented				Zero complement presented				Non-zero complement presented			
	N	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*
<u>Sure yes/no, initial</u>																	
Incorrect	22	.20	.17	1.63	.108	.15	.22	1.69	.095	.40	.30	1.56	.124	.04	.27	.38	.706
Correct	59	.28	.22			.27	.28			.51	.29			.07	.31		
<u>Sure yes/no, post-task</u>																	
Incorrect	9	.11	.18	2.29*	.025	.04	.21	2.46*	.016	.17	.25	3.64**	<.001	.13	.26	.79	.434
Correct	72	.28	.21			.26	.26			.52	.28			.05	.30		
<u>Sure multiple choice, initial</u>																	
Incorrect	26	.29	.20	.99	.325	.26	.29	.57	.573	.52	.31	.86	.394	.09	.28	.73	.469
Correct	55	.24	.21			.22	.26			.46	.29			.04	.31		
<u>Sure multiple choice, post-task</u>																	
Incorrect	4	.18	.27	.82	.416	.22	.42	.13	.898	.43	.49	.40	.689	-.12	.22	1.21	.229
Correct	77	.26	.21			.24	.26			.49	.29			.07	.30		
<u>Risky multiple choice, initial</u>																	
Incorrect	23	.22	.20	1.17	.247	.17	.31	1.35	.182	.47	.37	.34	.738	.01	.30	.93	.357
Correct	58	.28	.21			.26	.24			.49	.27			.08	.30		
<u>Risky multiple choice, post-task</u>																	
Incorrect	6	.24	.24	.19	.849	.27	.41	.30	.767	.43	.39	.43	.670	.03	.36	.24	.808
Correct	75	.26	.21			.23	.25			.49	.29			.06	.30		

Note. These analyses include subjects (N=81) who received either the gain or the loss frame version of the four-question ambiguity questionnaire. *p<.05. **p<.01.

Table 7

Signed Confidence Framing Index by Truncation for Incorrect versus Correct Responses to Multiple Choice Ambiguity Survey

		Total (All truncations)				Both complements presented				Zero complement presented				Non-zero complement presented			
	N	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*
Sure yes/no, initial																	
Incorrect	22	1.41	1.20	1.42	.161	1.21	1.83	1.28	.205	3.05	2.51	1.24	.220	-.04	2.04	.59	.556
Correct	59	1.99	1.79			1.89	2.24			3.79	2.32			.30	2.37		
Sure yes/no, post-task																	
Incorrect	9	.62	1.42	2.39*	.019	.22	1.50	2.25*	.027	1.10	2.13	3.56**	.001	.53	1.67	.45	.655
Correct	72	1.98	1.64			1.89	2.15			3.90	2.23			.16	2.35		
Sure multiple choice, initial																	
Incorrect	26	2.17	1.74	1.27	.208	1.96	2.35	.72	.471	4.09	2.78	1.31	.193	.47	2.19	.72	.475
Correct	55	1.67	1.61			1.59	2.06			3.35	2.16			.08	2.33		
Sure multiple choice, post-task																	
Incorrect	6	1.21	2.32	.76	.449	1.51	4.11	.19	.851	3.45	4.57	.12	.904	-1.31	2.30	1.37	.174
Correct	75	1.86	1.64			1.72	2.05			3.59	2.27			.28	2.26		
Risky multiple choice, initial																	
Incorrect	23	1.59	1.69	-.81	.420	1.30	2.56	1.08	.286	3.57	3.11	-.04	.971	-.09	2.33	.73	.470
Correct	58	1.93	1.66			1.87	1.97			3.59	2.06			.32	2.27		
Risky multiple choice, post-task																	
Incorrect	6	1.91	2.32	.12	.670	2.00	3.83	.34	.733	3.63	3.93	.04	.968	.10	2.83	.11	.909
Correct	75	1.83	1.62			1.68	2.00			3.58	2.25			.21	2.25		

Note. These analyses include subjects (*N*=81) who received either the gain or the loss frame version of the four-question ambiguity questionnaire. *p<.05. **p<.01.

Table 8

Framing Index by Truncation for Incorrect versus Correct Free Responses to Question about Risky Option

		Total (All truncations)				Both complements presented				Zero complement presented				Non-zero complement presented			
	N	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*
Initial (Liberal)																	
Inorrect	11	.25	.29	.20	.845	.21	.38	.29	.771	.34	.33	1.80	.076	.19	.31	1.61	.110
Correct	70	.26	.20			.24	.25			.51	.28			.04	.29		
Initial (Strict)																	
Incorrect	21	.27	.22	.86	.392	.24	.27	.02	.985	.50	.30	1.09	.281	.07	.31	.72	.471
Correct	60	.23	.18			.23	.25			.42	.29			.02	.27		
Post-Task (Liberal)																	
Incorrect	7	.29	.17	.35	.730	.27	.29	.37	.711	.60	.35	1.10	.276	-.01	.42	-.68	.498
Correct	74	.26	.21			.23	.26			.47	.29			.07	.29		
Post-Task (Strict)																	
Incorrect	46	.27	.22	.54	.593	.26	.30	.82	.414	.50	.32	.56	.575	.05	.31	.15	.879
Correct	35	.24	.20			.21	.21			.46	.26			.07	.28		

Note. These analyses include subjects (*N*=81) who received either the gain or the loss frame version of the four-question ambiguity questionnaire. *$p<.05$.

Table 9

Signed Confidence Framing Index by Truncation for Incorrect versus Correct Free Responses to Question about Risky Option

		Total (All truncations)				Both complements presented				Zero complement presented				Non-zero complement presented			
	N	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*	*M*	*SD*	*t(79)*	*p*
Initial (liberal)																	
Inorrect	11	2.09	2.57	.55	.584	1.87	3.37	.27	.785	2.89	3.00	1.04	.302	1.50	2.58	2.08*	.041
Correct	70	1.79	1.50			1.68	1.93			3.70	2.28			0.00	2.18		
Initial (Strict)																	
Incorrect	21	1.91	1.78	.67	.505	1.70	2.24	.06	.954	3.73	2.43	.92	.361	.29	.235	.56	.471
Correct	60	1.62	1.28			1.73	1.93			3.18	2.24			-.04	2.08		
Post-Task (Liberal)																	
Incorrect	7	2.11	1.62	.46	.647	2.05	2.95	.44	.663	5.00	3.24	1.67	.100	-.72	3.26	1.13	.263
Correct	74	1.81	1.67			1.67	2.08			3.45	2.27			.29	2.17		
Post-Task (Strict)																	
Incorrect	46	1.98	1.85	.89	.376	1.88	2.53	.86	.39	3.85	2.67	1.15	.251	.19	2.55	.06	.95
Correct	35	1.64	1.38			1.47	1.51			3.24	1.92			.22	1.89		

Note. These analyses include subjects (*N*=81) who received either the gain or the loss frame version of the four-question ambiguity questionnaire. *$p<.05$.

Table 10

Correlations between Numeracy and Composite Ambiguity Scores

	Possible Scores	*M*	*SD*	Objective Numeracy		Subjective Numeracy		Cognitive Reflection	
				r	*p*	*r*	*p*	*r*	*p*
Including risky free response (liberally scored)									
Pretest + posttest	0-8	6.69	1.51	.47**	<.001	.23*	.046	.19	.100
Pretest	0-4	3.01	1.13	.21	.062	.02	.885	.15	.197
Posttest	0-4	3.68	.74	.65**	<.001	.45**	<.001	.16	.169
Risky option	0-4	3.44	.82	.43**	<.001	.27*	.015	.14	.222
Including risky free response (strictly scored)									
Pretest + posttest	0-8	5.58	1.61	.43**	<.001	.18	.12	.24*	.035
Pretest	0-4	2.38	1.14	.18	.107	.02	.84	.20	.08
Posttest	0-4	3.20	.87	.56**	<.001	.30**	<.001	.19	.101
Risky option	0-4	2.33	1.05	.32**	.004	.16	.162	.21	.068
Excluding risky free response									
Initial (Risky + Sure)	0-3	2.12	1.05	.13	.239	-.01	.963	.10	.383
Initial (Sure option)	0-2	1.41	.82	.10	.386	-.07	.545	.08	.504
Initial (Risky option)	0-1	.72	.45	.13	.246	.11	.319	.09	.415
Post-task (Risky + Sure)	0-3	2.77	.62	.66**	<.001	.41**	<.001	.15	.187
Post-task (Sure option)	0-2	1.84	.43	.65**	<.001	.41**	<.001	.25*	.028
Post-task (Risky option)	0-1	.93	.26	.48**	<.001	.30**	.008	-.047	.682

Note. *N*=81 participants who received the four-question version of the ambiguity questionnaire. No correlations between numeracy and ambiguity at pretest were significant. ***p*<.01. **p*<.05.

Table 11

Correlations between Numeracy and Free Response Questions about the Risky Option

	M	*SD*	Objective Numeracy		Subjective Numeracy		Cognitive Reflection	
			r	*p*	*r*	*p*	*r*	*p*
<u>Initial</u>								
Correct (strict)	.30	.46	.15	.154	.12	.271	.28**	.008
Correct (liberal)	.88	.33	.24*	.023	.03	.805	.20	.056
All-or-none	.56	.59	.31**	.003	.22*	.038	.27**	.009
Flipped frame	.52	.50	-.28*	.013	-.10	.407	.09	.447
<u>Post-Task Manipulation check</u>								
Correct (strict)	.49	.50	.18	.087	.03	.782	.11	.283
Correct (liberal)	.92	.27	.24*	.024	.25*	.018	.07	.520
All-or-none	.66	.48	.11	.298	.11	.309	.10	.343
Flipped frame	.56	.50	.09	.433	.02	.884	.07	.516

Note. N=91. No correlations were significant between numeracy and free responses to the question about the sure option (correct/incorrect, at least, or flipped frame, N=23). **p<.01. *p<.05.

Table 12

Correlations between Numeracy and Framing Measures

	Possible Scores	*M*	*SD*	Objective Numeracy		Subjective Numeracy		Cognitive Reflection	
				r	*p*	*r*	*p*	*r*	*p*
Framing Index									
Total	-1 to 1	.26	.21	.13	.120	.13	.136	.06	.290
Non-zero complement presented	-1 to 1	.06	.30	.14	.114	.19*	.045	.14	.105
Both complements presented	-1 to 1	.24	.27	.11	.175	.19*	.048	.07	.279
Zero complement presented	-1 to 1	.48	.30	.05	.329	-.09	.210	-.07	.279
Signed Confidence Framing Index									
Total	-5 to 5	1.83	1.66	.16	.079	.19*	.046	.06	.297
Non-zero complement presented	-5 to 5	.20	2.28	.17	.063	.25*	.012	.19*	.047
Both complements presented	-5 to 5	1.70	2.15	.09	.222	.19	.052	.002	.494
Zero complement presented	-5 to 5	3.59	2.38	.09	.207	0.00	.494	-.05	.321

Note. *N*=81 participants who received the four-question version of the manipulation check. Framing index scores ranged from -1 (all choices reverse of standard framing) to +1 (all choices consistent with standard framing). Signed confidence framing index scores ranged from -5 (all choices reverse of standard framing, and highest confidence for these choices) to +5 (all choices consistent with standard framing, and highest confidence for these choices). *$p<.05$.

Appendix A

Instructions.

Hello, welcome to our study. We are interested in how people make decisions. You will be asked questions about disease prevention programs, disease treatment programs, environmental conservation programs, gambling, etc. You will be given two options for each question: Choice A or B. You can select only one choice. Here are some example problems.

Sample Problem #1

A boat with 1,000 people is stranded in the middle of the ocean. There is not enough food left on the boat. A captain suggests two rescue programs. Please indicate which program you prefer.
A: 500 people saved for sure.
B: ½ probability no one saved.

For Option A, the number given is the EXACT number of people that will be saved. In other words, there is NO probability that fewer than 500 people will be saved and NO probability that more than 500 people will be saved. If you select option A, EXACTLY 500 people will be saved; no fewer, no more.

Option B means that there is 1/2 probability (50% chance) that ALL 1,000 people will be saved and 1/2 probability (50% chance) that NO people will be saved. All probabilities in Option B are complementary and add up to 100%.

Sample Problem #2

A massive oil spill in the ocean is expected to kill 500 turtles. Please indicate which of the following conservation program you prefer.
A: 200 turtles saved for sure.
B: 2/5 probability 500 turtles saved and 3/5 probability no turtles saved.

For Option A, the number given is the EXACT number of turtles that will be saved. In other words, there is NO probability that fewer than 200 turtles will be saved and NO probability that more than 200 turtles will be saved. If you select option A, EXACTLY 200 turtles will be saved; no fewer, no more.

Option B means that there is 2/5 probability (40% chance) that ALL 500 turtles will be saved and 3/5 probability (60% chance) that NO turtles will be saved. All probabilities in Option B are complementary and add up to 100%.

To select option A, use your right *index* finger to press the “2” key.
To select option B, use your right *middle* finger to press the “3” key.

Please answer every single question. Note that you will have a LIMITED amount of time to select your option. Please do your best to make a decision in the allotted time frame. There are no “right” answers. Please make the decisions that you feel are best.

Appendix B

Experiment 1 ambiguity survey: Boat problem (non-zero complement presented).

Entry Questionnaire: Please answer the following questions in order.

A boat with 500 people has a hole in it and will inevitably sink. You have a choice between two options.

A: 300 people saved for sure.

B: 3/5 probability that everyone will be saved.

For option A, what did you think happened to the other 200 people?

For option B, what happens if everyone is not saved (the 2/5 probability)?

Note. At pretest, participants were randomly assigned to receive either the boat problem or the plant problem. Those who completed a posttest ambiguity survey received whichever problem they did not complete at pretest.

Appendix C

Experiment 1 ambiguity survey: Boat problem (zero complement presented).

Entry Questionnaire: Please answer the following questions in order.

A boat with 500 people has a hole in it and will inevitably sink. You have a choice between two options.

A: 300 people saved for sure.

B: 2/5 probability that no one will be saved.

For option A, what did you think happened to the other 200 people?

For option B, what scenario does the 3/5 probability indicate?

Note. At pretest, participants were randomly assigned to receive either the boat problem or the plant problem. Those who completed a posttest ambiguity survey received whichever problem they did not complete at pretest.

Appendix D

Experiment 1 ambiguity survey: Plant problem.

Entry questionnaire: Please answer the following questions in order.

A 400 person manufacturing plant is about to explode. You have a choice between two options.

A. 100 people saved for sure.

B. ¼ probability that everyone will be saved.

For option A, what happened to the other 300 people?

For option B, what happens if everyone is not saved (the ¾ probability)?

Note. At pretest, participants were randomly assigned to receive either the boat problem or the plant problem. Those who completed a posttest ambiguity survey received whichever problem they did not complete at pretest.

Appendix E

Pretest ambiguity survey in experiment 2: Gain frame.

Entry Questionnaire: Please answer the following questions in order.

A boat with 500 people has a hole in it and will inevitably sink. You have a choice between two options.

A: 300 people saved for sure.
B: 3/5 probability that everyone will be saved.

When you made the decision, what did you assume about the other 2/5 probability in option B?

When you made the decision, did you assume that more than 300 people would be saved in option A? (Yes/No)

When you made the decision, which of the following did you assume about option A? (Circle as many as apply).

(a) Exactly 300 people would be saved.
(b) At least 300 people would be saved.
(c) Some of the other 200 might be saved, as well.

When you made the decision, which of the following did you assume about option B? (Circle as many as apply).

(a) There is a 2/5 probability that some people will be saved.
(b) There is a 2/5 probability that everyone will be saved.
(c) There is a 2/5 probability that no one will be saved.

Appendix F

Pretest ambiguity survey in experiment 2: Loss frame.

Entry Questionnaire: Please answer the following questions in order.

A boat with 500 people has a hole in it and will inevitably sink. You have a choice between two options.

A: 200 people die for sure.
B: 2/5 probability that 500 people will die.

When you made the decision, what did you assume about the other 3/5 probability in option B?

When you made the decision, did you assume that more than 200 people would die in option A? (Yes/No)

When you made the decision, which of the following did you assume about option A? (Circle as many as apply).

(a) Exactly 200 people would die.
(b) At least 200 people would die.
(c) Some of the other 300 might die, as well.

When you made the decision, which of the following did you assume about option B? (Circle as many as apply).

(a) There is a 3/5 probability that some people will die.
(b) There is a 3/5 probability that everyone will die.
(c) There is a 3/5 probability that no one will die.

Appendix G

Additional instructions for participants who failed the pre-framing ambiguity survey in experiment 2.

Entry Questionnaire Contingency

As stated in the instructions that you read, all of the information that we give you in the preamble is exactly what happens. Therefore, when we say:

A boat with 500 people has a hole in it and will inevitably sink. You have a choice between two options.

We mean that there are exactly 500 people on the boat who are in jeopardy.

Additionally, when we give you the option of:

A: 300 people saved for sure

We mean that option A saves exactly 300 people. If you select option A, 300 people will be saved. No fewer, and no more. These 300 people will be the only ones saved. No others may be saved, might be saved, or could be saved.

For the other option:

B: 3/5 probability that everyone will be saved

We mean that option B has a 3/5 probability that everyone (all 500 people at risk) will be saved. If you select option B, that also means that there is a probability that no one would be saved.

The correct response to our first question, "what did you assume about the other 2/5 probability in option B," is:

The 2/5 probability indicates that NO ONE will be saved.

Common mistakes include "some might be saved," "some could be saved," and "they will swim to shore." These are all incorrect. We don't want you to assume anything outside of the information that is given to you. Therefore, if we specify that there is a probability that everyone will be saved, if that does not happen, then no one will be saved. Similarly, if we specify that there is a probability that no one will be saved, if that does not happen, then everyone will be saved.

The correct response to our second question, "did you assume that more than 300 people would be saved in option A," is:

NO.

As stated before, when we say "for sure," we mean exactly. This means that there is no way that more than 300 people, or less for that matter, could be saved in option A. We are not trying to trick you, so we don't want you to make assumptions.

The correct response to our third question, "which of the following did you assume about option A," is:

A: Exactly 300 people would be saved.

See explanation for question above.

The correct response to our final question, "which of the following did you assume about option B," is:

C: There is a 2/5 probability that no one will be saved.

As stated before, if the 3/5 probability that everyone will be saved does not happen, then there is a 2/5 probability that NO ONE will be saved. Given the 2/5 probability, it is not possible that 1 person will be saved, or 2 people will be saved. No one will be saved.

Does this make sense? If not, feel free to ask questions of the experimenter.

Appendix H

Posttest ambiguity survey for experiment 2: Gain frame.

Exit Questionnaire: Please answer the following questions in order.

There has been an explosion in a 400 person manufacturing plant and the plant is about to explode. You have a choice between two options.

A: 100 people saved for sure.
B: 1/4 probability that everyone will be saved.

When you made the decision, what did you assume about the other 3/4 probability in option B?

Did you assume when you made the decision that more than 100 people would be saved in option A? (Yes/No)

When you made the decision, which of the following did you assume about option A? (Circle as many as apply).

(a) Exactly 100 people would be saved.
(b) At least 100 people would be saved.
(c) Some of the other 300 might be saved, as well.

When you made the decision, which of the following did you assume about option B? (Circle as many as apply).

(d) There is ¾ probability that some people will be saved.
(e) There is ¾ probability that everyone will be saved.
(f) There is ¾ probability that no one will be saved.

Appendix I

Posttest ambiguity survey for experiment 2: Loss frame.

Exit Questionnaire: Please answer the following questions in order.

A 400 person manufacturing plant and is about to explode. You have a choice between two options.

A. 300 people die for sure.
B. 3/4 probability that everyone will die.

When you made the decision, what did you assume about the other ¼ probability in option B?

Did you assume when you made the decision that more than 300 people would die in option A? (Yes/No)

When you made the decision, which of the following did you assume about option A? (Select as many as apply).

(a) Exactly 300 people would die.
(b) At least 300 people would die.
(c) Some of the other 100 people might die, as well.

When you made the decision, which of the following did you assume about option B? (Select as many as apply).

(a) There is ¼ probability that some people will die.
(b) There is ¼ probability that everyone will die.
(c) There is ¼ probability that no one will die.

Appendix J

Free responses to open-ended question about sure option: Gain frame, initial ambiguity survey.

	Frequency	Flipped Frame?	Liberal Scoring	Strict Scoring
Die, drown, perish				
They die	2	Yes	Correct	Correct
They died	7	Yes	Correct	Correct
They all die	2	Yes	Correct	Correct
They die in explosion	1	Yes	Correct	Correct
Forced to die	1	Yes	Correct	Correct
I thought they would die	1	Yes	Correct	Correct
The other 200 people died	1	Yes	Correct	Correct
They drowned inside the boat & couldn't get out	1	Yes	Correct	Correct
They drowned	1	Yes	Correct	Correct
They all perished into the dark depths of infinitely vast and impersonal ocean. They are all dead. All of them!!!	1	Yes	Correct	Correct
SUBTOTAL	18	18 Yes	18 Correct	18 Correct
Not saved				
"Not saved"	1	No	Correct	Incorrect
"They are not saved"	1	No	Correct	Incorrect
"They are not saved FOR SURE."	1	No	Correct	Incorrect
"They would not be saved"	1	No	Correct	Incorrect
SUBTOTAL	4	4 No	4 Correct	4 Incorrect
Other				
"Their [sic] caught in the manufacturing plant"	1	No	Correct	Incorrect
SUBTOTAL	1	1 No	1 Correct	1 Incorrect
TOTAL	23	18 Yes, 5 No	23 Correct	18 Correct, 5 Incorrect

Appendix K

Free responses to open-ended question about sure option: Gain frame, post-task manipulation check.

	Frequency	Flipped frame?	Liberal scoring	Strict scoring
Die, sink				
Die	1	Yes	Correct	Correct
All die	1	Yes	Correct	Correct
They die	2	Yes	Correct	Correct
They died	5	Yes	Correct	Correct
Sink? [draws skull and crossbones]	1	No	Correct	Incorrect
SUBTOTAL	10	9 Yes, 1 No	10 Correct	9 Correct, 1 Incorrect
Not saved				
They are not saved	1	No	Correct	Incorrect
SUBTOTAL	1	1 No	1 Correct	1 Incorrect
TOTAL	11	9 Yes, 2 No	11 Correct	9 Correct, 2 Incorrect

Appendix L

Free responses to open-ended question about risky option: Gain frame, initial ambiguity survey.

Response	Freq.	Flipped frame?	All/None?	Liberal Scoring	Strict Scoring
<u>Die, drown, not survive</u>					
Everyone would die.	1	Yes	Yes	Correct	Correct
I assumed that the remaining 2/5 would not be saved. The 2/5 probability was less likely than the 3/5 option (A), but still significant enough to consider the potential undesired outcome of everyone onboard dying.	1	Yes	Yes	Correct	Correct
I assumed the worst would happen and no one would survive.*	1	No	Yes	Correct	Correct
It's better to give everyone a fair chance and 3/5 is greater than 2/5. 2/5=probability that everyone will die but it's fair.	1	Yes	Yes	Correct	Correct
That there is a 75% chance that all the people were going to die, while if you choose A it was a guarantee that 25% of the people were saved.**	1	Yes	Yes	Correct	Correct
They will not be saved (i.e., drown in the sunken boat).	1	Yes	Unclear	Correct	Incorrect (All/none unclear)
The other % probability is that everyone (400 people) will die.**	1	Yes	Yes	Correct	Correct
SUBTOTAL	7			7 correct	6 correct, 1 incorrect
<u>No one saved</u>					
2/5 chance [that] no one will be saved.	1	No	Yes	Correct	Incorrect (No one saved)
2/5 prob that no one will be saved.	2	No	Yes	Correct	Incorrect (No one saved)
2/5=40% probability that no one will be saved.	1	No	Yes	Correct	Incorrect (No one saved)
Assuming that there is a 2/5 probability that no one will be saved.	1	No	Yes	Correct	Incorrect
I assumed that there is a 2 out of 5 (40%) chance that no one will get saved.	1	No	Yes	Correct	Incorrect
No one saved.	1	No	Yes	Correct	Incorrect
No one will be saved.	1	No	Yes	Correct	Incorrect
No one would be saved.	1	No	Yes	Correct	Incorrect
Nobody would be saved.	1	No	Yes	Correct	Incorrect
That no one will be saved.	1	No	Yes	Correct	Incorrect (No one saved)
That no one would be saved.	1	No	Yes	Correct	Incorrect (No one saved)
That no one would be saved. [Crossed out "That they would not be saved."]	1	No	Yes	Correct	Incorrect (No one saved)
That there is a 2/5 probability that no one will be saved.	1	No	Yes	Correct	Incorrect
That there was a 40% chance that no one would be saved.	1	No	Yes	Correct	Incorrect
That there was a possibility for no one to be saved.	1	No	Yes	Correct	Incorrect
There is a chance that nobody may be saved, but the odds were in favor of having everyone saved.	1	No	Yes	Correct	Incorrect
SUBTOTAL	17			17 correct	17 incorrect
<u>Not Saved</u>					
2/5 probability that everyone will NOT be saved.	1	No	Yes	Correct	Incorrect (Not saved)
2/5 probability that the whole group will not be saved.	1	No	Yes	Correct	Incorrect (Not saved)
That everyone would not be saved in 40% of the scenarios.	1	No	Yes	Correct	Incorrect (Not saved)
That everyone would not be saved.	1	No	Yes	Correct	Incorrect (Not saved)
The other 2/5 prob is all 1000 people will not be saved.	1	No	Yes	Incorrect (wrong number of people)	Incorrect (Wrong number of people)
That they will not be saved.	1	No	Unclear	Correct	Incorrect (All/none unclear; not saved)
They would not be saved.	1	No	Unclear	Correct	Incorrect (All/none unclear; not saved)
I assumed that the other 2/5 will not be saved.	1	No	No	Incorrect	Incorrect (Partial; not saved)
The other 2/5 will NOT be saved.	1	No	No	Incorrect (Partial)	Incorrect (Partial; not saved)
The other 2/5 won't be saved, but the possibility of 3/5 being saved is higher than 2/5 not being saved.	1	No	No	Incorrect (Partial)	Incorrect (Partial; not saved)
SUBTOTAL	10			6 correct, 4 incorrect	10 incorrect
<u>Other</u>					
I hoped that there was a possibility that the 2/5 could be saved as well.	1	No	No	Incorrect (Partial)	Incorrect (Partial)
I assumed that the chance people will be saved is greater than the chance they will not.	1	No	Unclear	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation)
That the 2/5 probability is more likely to come true (fatalistic point of view).	1	N/A	N/A	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation)
That it was too great a percentage to take a chance on.	1	N/A	N/A	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation)
There is only a 3/5 chance that everyone will be saved.	1	No	Unclear	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation)
The other 2/5 probability will be not everyone saved but definitely not sacrificing all.	1	No	Yes	Incorrect (all/none)	Incorrect (all/none)
SUBTOTAL	6			4 correct, 2 incorrect	6 incorrect
<u>Nothing</u>					
I didn't assume anything.	1	N/A	N/A	Correct (No indication of mistake)	Incorrect (No indication of correct interpretation)
No assumption—just didn't want to assume personal responsibility for the sure deaths of 200 people.	1	Yes	N/A	Correct (No indication of mistake)	Incorrect (No indication of correct interpretation)
Nothing.	1	N/A	N/A	Correct (No indication of mistake)	Incorrect (No indication of correct interpretation)
SUBTOTAL	3			3 Correct	3 incorrect
TOTAL	43			39 correct, 4 incorrect	6 correct, 37 incorrect

Appendix M

Free responses to open-ended question about risky option: Gain frame, post-task manipulation check.

Response	Flipped frame?	All/None?	Liberal Scoring	Strict Scoring
Die, perish, not survive				
% probability that everyone will die.	Yes	Yes	Correct	Correct
Death.	Yes	No	Correct (no indication of misinterpretation)	Incorrect (no indication of all/none interpretation)
Everyone dies.	Yes	Yes	Correct	Correct
Everyone will die.	Yes	Yes	Correct	Correct
I assumed that % probability that all 400 people would die.	Yes	Yes	Correct	Correct
That % probability meant that % chance everyone will perish/not be saved.	Yes	Yes	Correct	Correct
That it was more likely that everyone would die.	Yes	Yes	Correct	Correct
That there is a % probability that everyone will be killed.	Yes	Yes	Correct	Correct
That there is a 75% chance all 400 people will perish.	Yes	Yes	Correct	Correct
That they die.	Yes	No	Correct (no indication of misinterpretation)	Incorrect (no indication of all/none interpretation)
They *all die.	Yes	Yes	Correct	Correct
They die.	Yes	No	Correct (no indication of misinterpretation)	Incorrect (no indication of all/none interpretation)
They would *all die.	Yes	Yes	Correct	Correct
They would die.	Yes	No	Correct (no indication of misinterpretation)	Incorrect (no indication of all/none interpretation)
SUBTOTAL	16 yes	12 yes; 4 no	16 correct	12 correct; 4 incorrect
No one saved	Flipped frame?	All/None?	Liberal Scoring	Strict Scoring
% prob. no one saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
% probability no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
% probability that no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
% probability that NO ONE will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
%=no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
No one is saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
No one would be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
Nobody would be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
That no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
That no one would be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
That there was % probability that no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
There is % probability that no one will be saved.	No	Yes	Correct (no indication of misinterpretation)	Incorrect (not saved)
SUBTOTAL	14 no	14 yes	14 correct	14 incorrect
Not saved				
% probability everyone will not be saved.	No	Yes	Correct (No indication of misinterpretation)	Incorrect (not saved)
I assumed that the % will not be saved.	No	No (partial)	Incorrect (partial)	Incorrect (partial; not saved)
That % will not be saved. There is a % probability no one will be saved.	No	No (partial)	Incorrect (partial)	Incorrect (partial; not saved)
They are not saved.	No	No	Correct (No indication of misinterpretation)	Incorrect (not saved; no indication of all/none interpretation)
They will not be saved.	No	No	Correct (No indication of misinterpretation)	Incorrect (not saved; no indication of all/none interpretation)
They won't be saved.	No	No	Correct (No indication of misinterpretation)	Incorrect (not saved; no indication of all/none interpretation)
They would not be saved.	No	No	Correct (No indication of misinterpretation)	Incorrect (not saved; no indication of all/none interpretation)
Would not be saved.	No	No	Correct (No indication of misinterpretation)	Incorrect (not saved; no indication of all/none interpretation)
SUBTOTAL	9 no	1 yes; 8 no	7 correct; 2 incorrect	9 incorrect
Other				
% prob that < everyone will be saved.	No	No (partial)	Incorrect (partial)	Incorrect (partial)
SUBTOTAL	1 no	1 no	1 incorrect	1 incorrect
TOTAL	16 yes; 24 no	27 yes; 13 no	37 correct; 3 incorrect	26 correct; 14 incorrect

Appendix N

Free responses to open-ended question about risky option: Loss frame, initial ambiguity survey.

Response	Flipped Frame?	All/None	Liberal scoring	Strict scoring
All Saved/Survive/Live				
That there's a chance that all 500 people may live	Yes	Yes	Correct	Correct
That all 500 people would be saved.	Yes	Yes	Correct	Correct
500 people will survive	Yes	Yes	Correct	Correct
that they will all live	Yes	Yes	Correct	Correct
Good odds to save all	Yes	Yes	Correct	Correct
There is 3/5 probability that 500 people will be saved.	Yes	Yes	Correct	Correct
I assumed that there was a 3/5 probablily that all 500 people would live.	Yes	Yes	Correct	Correct
500 people would live	Yes	Yes	Correct	Correct
That all 500 survive	Yes	Yes	Correct	Correct
3/5 probability that all 500 would live.	Yes	Yes	Correct	Correct
That 3/5 probability that 500 people will survive	Yes	Yes	Correct	Correct
there's a greater probability that everyone will survive	Yes	Yes	Correct	Correct
That I could save all the people.	Yes	Yes	Correct	Correct
That there is a 3/5 probability that 500 people will live.	Yes	Yes	Correct	Correct
500 people will live.	Yes	Yes	Correct	Correct
That 500 people will be saved	Yes	Yes	Correct	Correct
There was a 3/5 probability that all 500 would live.	Yes	Yes	Correct	Correct
SUBTOTAL	17 Yes	17 Yes	17 Correct	17 Correct
Survive/Saved/Live				
Survive	Yes	No	Correct	Incorrect (all/none)
They were saved!!!!	Yes	No	Correct	Incorrect (all/none)
That there is a 3/5 probability that they may live.	Yes	No	Correct	Incorrect (all/none)
That they would live for sure	Yes	No	Correct	Incorrect (all/none)
they would live	Yes	No	Correct	Incorrect (all/none)
That the probability was higher to have more survivors.	Yes	No	Correct	Incorrect (all/none)
they would survive.	Yes	No	Correct	Incorrect (all/none)
That they lived	Yes	No	Correct	Incorrect (all/none)
Live	Yes	No	Correct	Incorrect (all/none)
will live	Yes	No	Correct	Incorrect (all/none)
they will live	Yes	No	Correct	Incorrect (all/none)
That they would live.	Yes	No	Correct	Incorrect (all/none)
They will live	Yes	No	Correct	Incorrect (all/none)
The people would live.	Yes	No	Correct	Incorrect (all/none)
Will live	Yes	No	Correct	Incorrect (all/none)
They will live.	Yes	No	Correct	Incorrect (all/none)

They have a small chance to survive	Yes	No	Correct	Incorrect (all/none)
That they would live	Yes	No	Correct	Incorrect (all/none)
That they might be saved	Yes	No	Correct	Incorrect (all/none)
They lived	Yes	No	Correct	Incorrect (all/none)
That they will be saved	Yes	No	Correct	Incorrect (all/none)
This is the chance of survival.	Yes	No	Correct	Incorrect (all/none)
the other 3/5 will live	Yes	No	Incorrect (all/none)	Incorrect (all/none)
SUBTOTAL	23 Yes	23 No	22 Correct, 1 Incorrect	23 Incorrect
<u>No one die</u>				
no one will die	No	Yes	Correct	Correct
no one will die	No	Yes	Correct	Correct
that there was a 3/5 probability that no one would die	No	Yes	Correct	Correct
That no people would die.	No	Yes	Correct	Correct
3/5 probability that everyone will die.	No	Yes	Incorrect	Incorrect
SUBTOTAL	5 No	5 Yes	4 Correct, 1 Incorrect	4 Correct, 1 Incorrect
<u>Not die</u>				
They will not die			Correct	Incorrect (all/none)
SUBTOTAL	1 No	1 No	1 Correct	I Incorrect
<u>Other</u>				
yes			Incorrect	Incorrect
Yes			Incorrect	Incorrect
Yes and that seems to be the better choice			Incorrect	Incorrect
yes			Incorrect	Incorrect
They would die.			Incorrect	Incorrect
Some will die.			Incorrect (all/none)	Incorrect (all/none)
Less probability			Incorrect	Incorrect
from the information from the last pages			Incorrect	Incorrect
that it would not occur			Correct	Incorrect (no indication of understanding)
SUBTOTAL			1 Correct, 8 Incorrect	9 Incorrect

Appendix O

Free responses to open-ended question about risky option: Loss frame, post-task manipulation check.

Response	Flipped Frame?	All/None	Liberal Scoring	Strict Scoring
All Live				
1/4 probability everyone lives	Yes	Yes	Correct	Correct
1/4 probability that everyone will live.	Yes	Yes	Correct	Correct
400 would live	Yes	Yes	Correct	Correct
all live	Yes	Yes	Correct	Correct
All would die	No	Yes	Incorrect	Incorrect
everyone will live	Yes	Yes	Correct	Correct
everyone will live	Yes	No	Correct	Correct
everyone will live	Yes	Yes	Correct	Correct
everyone would live	Yes	Yes	Correct	Correct
I assume that there was 1/4 of a chance that everyone would survive.	Yes	Yes	Correct	Correct
That everyone will live	Yes	Yes	Correct	Correct
That everyone would live	Yes	Yes	Correct	Correct
the 1/4 will all survive	Yes	No	Incorrect (partial)	Incorrect (partial)
There was a quarter chance everyone would live.	Yes	Yes	Correct	Correct
they will all live	Yes	Yes	Correct	Correct
They will all live.	Yes	Yes	Correct	Correct
SUBTOTAL	15 yes, 1 no	14 yes, 2 no	14 correct, 2 incorrect	14 correct, 2 incorrect
Live/Survive				
Survive	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
They live!!!!!	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
That more than 300 may live.	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
they will live	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
they survive	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
they live	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
they will live	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
they would live	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
Yes I chose option b because there is still a chance that more will survive and I would rather leave it up to chance than decide on a specific amount to die	No	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none)
That the other 1/4 will live.	Yes	No	Incorrect (partial)	Incorrect (Partial)

That they would live	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none)
That most will survive	Yes	No	Incorrect (partial)	Incorrect (Partial)
SUBTOTAL	11 yes, 1 no	12 no	10 correct, 2 incorrect	12 incorrect
No one die				
1/4 probability no one will die	No	Yes	Correct	Correct
1/4 probability that no one dies	No	Yes	Correct	Correct
No one dies	No	Yes	Correct	Correct
no one will die	No	Yes	Correct	Correct
no one will die	No	Yes	Correct	Correct
no one will die	No	Yes	Correct	Correct
Nobody dies	No	Yes	Correct	Correct
that no one will die	No	Yes	Correct	Correct
That nobody will die.	No	Yes	Correct	Correct
That there is a 1/4 chance that NO ONE will die.	No	Yes	Correct	Correct
There is 1/4 probability that no one will die.	No	Yes	Correct	Correct
There was 1/4 probability that no one would die.	No	Yes	Correct	Correct
There was a 1/4 possibility that no one would die.	No	Yes	Correct	Correct
SUBTOTAL	12 No	13 Yes	13 Correct	13 Correct
Not die				
They would not die	No	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
They would not die	No	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
SUBTOTAL	2 No	2 No	2 Correct	2 Incorrect
Other				
I assumed I was right	N/A	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
saving 100 people is important	Yes	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
that they may or may not die	No	No	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
yes	N/A	N/A	Correct (No indication of misinterpretation)	Incorrect (No indication of correct interpretation of all/none principle)
SUBTOTAL	1 Yes, 1 No, 2 N/A	3 No, 1 N/A	4 Correct	4 Incorrect

Appendix P

Framing stimuli, set A.

V1 Loss: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 400 people die for sure.
B: 2/3 probability 600 people die.

M1 Loss: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 400 people die for sure.
B: 2/3 probability 600 people die and 1/3 probability no one dies.

G1 Loss: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 400 people die for sure.
B: 1/3 probability no one dies.

V2 Gain: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Win 250 dollars for sure.
B: 25% chance you win 1,000 dollars.

M2 Gain: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Win 250 dollars for sure.
B: A 25% chance you win 1,000 dollars and a 75% chance you win nothing.

G2 Gain: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Win 250 dollars for sure.
B: 75% chance you win nothing.

V3 Loss: You agree to test a new casino game in which 45 is at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.
B: 1/3 probability you lose 45 dollars.

M3 Loss: You agree to test a new casino game in which 45 dollars is at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.
B: 1/3 probability you lose 45 dollars and 2/3 probability you lose nothing.

G3 Loss: You agree to test a new casino game in which 45 dollars is at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.
B: 2/3 probability you lose nothing.

V4 Gain: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 30% chance 1,000 people saved.

M4 Gain: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 30% chance 1,000 people saved and 70% chance no one saved.

G4 Gain: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 70% chance no one saved.

V5 Loss: You are playing a game where you have a chance to win or lose money, with 20 dollars at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.
B: 3/4 probability you lose 20 dollars.

M5 Loss: You are playing a game where you have a chance to win or lose money, with 20 dollars at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.
B: 3/4 probability you lose 20 dollars and 1/4 probability you lose nothing.

G5 Loss: You are playing a game where you have a chance to win or lose money, with 20 dollars at stake. Indicate the option you prefer.

A: Lose 15 dollars for sure.

B: 1/4 probability you lose nothing.

V6 Gain: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 600 people saved for sure.
B: 40% chance 1,500 people saved.

M6 Gain: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 600 people saved for sure.
B: 40% chance 1,500 people saved and 60% chance no one saved.

G6 Gain: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 600 people saved for sure.
B: 60% chance no one saved.

V7 Gain: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 4,200 jobs saved for sure.
B: 35% chance 12,000 jobs saved.

M7 Gain: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 4,200 jobs saved for sure.
B: 35% chance 12,000 jobs saved and 65% chance no jobs saved.

G7 Gain: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 4,200 jobs saved for sure.
B: 65% chance no jobs saved.

V8 Gain: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 4,000 acres saved for sure.
B: 2/5 probability 10,000 acres saved.

M8 Gain: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 4,000 acres saved for sure.
B: 2/5 probability 10,000 acres saved and 3/5 probability no acres saved.

G8 Gain: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 4,000 acres saved for sure.
B: 3/5 probability no acres saved.

V9 Loss: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A; 1,500 people die for sure.
B: 3/4 probability 2,000 people die.

M9 Loss: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A; 1,500 people die for sure.
B: 3/4 probability 2,000 people die and 1/4 probability no one dies.

G9 Loss: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A; 1,500 people die for sure.
B: 1/4 probability no one dies.

V10 Gain: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 1/3 probability 900 people saved.

M10 Gain: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 1/3 probability 900 people saved and 2/3 probability no one saved.

G10 Gain: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 300 people saved for sure.
B: 2/3 probability no one saved.

V11 Loss: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people die for sure.
B: 1/2 probability 1,200 people die.

M11 Loss: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people die for sure.
B: 1/2 probability 1,200 people die and 1/2 probability no one dies.

G11 Loss: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people die for sure.
B: 1/2 probability no one dies.

V12 Loss: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 2,000 people die for sure.
B: 2/3 probability 3,000 people die.

M12 Loss: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 2,000 people die for sure.
B: 2/3 probability 3,000 people die and 1/3 probability no one dies.

G12 Loss: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 2,000 people die for sure.
B: 1/3 probability no one dies.

V13 Loss: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs you prefer.

A: 175 species die out for sure.
B: 7/12 probability 300 species die out.

M13 Loss: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs you prefer.

A: 175 species die out for sure.

B: 7/12 probability 300 species die out and 5/12 probability no species die out.

G13 Loss: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs you prefer.

A: 175 species die out for sure.
B: 5/12 probability no species die out.

V14 Gain: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and win 200 dollars for sure.
B: Answer, with 2/5 probability of winning 500 dollars.

M14 Gain: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and win 200 dollars for sure.
B: Answer, with 2/5 probability of winning 500 dollars and 3/5 probability of winning nothing.

G14 Gain: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and win 200 dollars for sure.
B: Answer, with 3/5 probability of winning nothing.

V15 Loss: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Lose 120 dollars for sure.
B: 3/4 probability you lose 160 dollars.

M15 Loss: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Lose 120 dollars for sure.
B: 3/4 probability you lose 160 dollars and 1/4 probability you lose nothing.

G15 Loss: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Lose 120 dollars for sure.
B: 1/4 probability you lose nothing.

V16 Loss: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Lose 45 dollars for sure.
B: 3/5 probability you lose 75 dollars.

M16 Loss: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Lose 45 dollars for sure.
B: 3/5 probability you lose 75 dollars and 2/5 probability you lose nothing.

G16 Loss: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Lose 45 dollars for sure.
B: 2/5 probability you lose nothing.

V17 Loss: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Lose 50 dollars for sure.
B: 5/8 probability you lose 80 dollars.

M17 Loss: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Lose 50 dollars for sure.
B: 5/8 probability you lose 80 dollars and 3/8 probability you lose nothing.

G17 Loss: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Lose 50 dollars for sure.
B: 3/8 probability you lose nothing.

V18 Gain: You are playing a slot machine with two levers. 40 dollars is at stake. Please indicate which lever you will pull.

A: Win 10 dollars for sure.
B: 25% chance you win 40 dollars.

M18 Gain: You are playing a slot machine with two levers. 40 dollars is at stake. Please indicate which lever you will pull.

A: Win 10 dollars for sure.
B: 25% chance you win 40 dollars and 75% chance you win nothing.

G18 Gain: You are playing a slot machine with two levers. 40 dollars is at stake. Please indicate which lever you will pull.

A: Win 10 dollars for sure.
B: 75% chance you win nothing.

V19 Gain: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Win 200 dollars for sure.
B: 50% chance you win 400 dollars.

M19 Gain: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Win 200 dollars for sure.
B: 50% chance you win 400 dollars and 50% chance you win nothing.

G19 Gain: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Win 200 dollars for sure.
B: 50% chance you win nothing.

V20 Gain: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Win 60 dollars for sure.
B: 1/5 probability you win 300 dollars.

M20 Gain: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Win 60 dollars for sure.
B: 1/5 probability you win 300 dollars and 4/5 probability you win nothing.

G20 Gain: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Win 60 dollars for sure.
B: 4/5 probability you win nothing.

Appendix Q

Framing stimuli, set B.

V1 Gain: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 200 people saved for sure.
B: 1/3 probability 600 people saved.

M1 Gain: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 200 people saved for sure.
B: 1/3 probability 600 people saved and 2/3 probability no one saved.

G1 Gain: Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Please indicate which option you prefer.

A: 200 people saved for sure.
B: 2/3 probability no one saved.

V2 Loss: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Lose 750 dollars for sure.
B: 75% chance you lose 1,000 dollars.

M2 Loss: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Lose 750 dollars for sure.
B: 75% chance you lose 1,000 dollars and 25% chance you lose nothing.

G2 Loss: Imagine you are on a game show and have accumulated 1,000 dollars that is now at stake. You have two choices.

A: Lose 750 dollars for sure.
B: 25% chance you lose nothing.

V3 Gain: You agree to test a new casino game in which 45 dollars are at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 2/3 probability you win 45 dollars.

M3 Gain: You agree to test a new casino game in which 45 dollars are at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 2/3 probability you win 45 dollars and 1/3 probability you win nothing.

G3 Gain: You agree to test a new casino game in which 45 dollars are at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 1/3 probability you win nothing.

V4 Loss: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 700 people die for sure.
B: 70% chance 1,000 people die.

M4 Loss: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 700 people die for sure.
B: 70% chance 1,000 people die and 30% chance nobody dies.

G4 Loss: 1,000 people are expected to die from a disease. You have a choice between two programs to combat the disease.

A: 700 people die for sure.
B: 30% chance nobody dies.

V5 Gain: You are playing a game where you have a chance to win or lose money, with 20 dollars at stake. Indicate the option you prefer.

A: Win 5 dollars for sure.
B: 1/4 probability you win 20 dollars.

M5 Gain: You are playing a game where you have a chance to win or lose money with 20 dollars at stake. Indicate the option you prefer.

A: Win 5 dollars for sure.
B: 1/4 probability you win 20 dollars and 3/4 probability you win nothing.

G5 Gain: You are playing a game where you have a chance to win or lose money, with 20 dollars at stake. Indicate the option you prefer.

A: Win 5 dollars for sure.
B: 3/4 probability you win nothing.

V6 Loss: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 900 people die for sure.
B: 60% chance 1,500 people die.

M6 Loss: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 900 people die for sure.
B: 60% chance 1,500 people die and 40% chance no one dies.

G6 Loss: Imagine that a new strain of AIDS is expected to kill 1,500 people this year. You have a choice between two drug trials.

A: 900 people die for sure.
B: 40% chance no one dies.

V7 Loss: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 7,800 jobs lost for sure.
B: 65% chance 12,000 jobs lost.

M7 Loss: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 7,800 jobs lost for sure.
B: 65% chance 12,000 jobs lost and 35% chance no jobs lost.

G7 Loss: A large car manufacturer is in serious economic difficulty, and 12,000 jobs are at stake. You must choose between two programs to help save the jobs.

A: 7,800 jobs lost for sure.
B: 35% chance no jobs lost.

V8 Loss: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 6,000 acres destroyed for sure.
B: 3/5 probability 10,000 acres destroyed.

M8 Loss: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 6,000 acres destroyed for sure.
B: 3/5 probability 10,000 acres destroyed and 2/5 probability no acres destroyed.

G8 Loss: Pollution is destroying a 10,000-acre rainforest. You have a choice between two conservation programs.

A: 6,000 acres destroyed for sure.
B: 2/5 probability no acres destroyed.

V9 Gain: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A: 500 people saved for sure.
B: 1/4 probability 2,000 people saved.

M9 Gain: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A: 500 people saved for sure.
B: 1/4 probability 2,000 people saved and 3/4 probability no one saved.

G9 Gain: A hurricane is expected to hit a major city and kill 2,000 people. City planners have proposed two evacuation procedures; you must choose one.

A: 500 people saved for sure.
B: 3/4 probability no one saved.

V10 Loss: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 600 people die for sure.
B: 2/3 probability 900 people die.

M10 Loss: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 600 people die for sure.
B: 2/3 probability 900 people die and 1/3 probability no one dies.

G10 Loss: Spinach products contaminated with a deadly strain of *E. coli* are expected to kill 900 people. You have a choice between two programs to combat the disease.

A: 600 people die for sure.

B: 1/3 probability no one dies.

V11 Gain: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people saved for sure.
B: 1/2 probability 1,200 people saved.

M11 Gain: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people saved for sure.
B: 1/2 probability 1,200 people saved and 1/2 probability no one saved.

G11 Gain: Imagine a tsunami is expected to hit a major city and kill 1,200 people. Government officials have asked you to decide between two evacuation programs.

A: 600 people saved for sure.
B: 1/2 probability no one saved.

V12 Gain: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 1,000 people saved for sure.
B: 1/3 probability 3,000 people saved.

M12 Gain: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 1,000 people saved for sure.
B: 1/3 probability 3,000 people saved and 2/3 probability no one saved.

G12 Gain: A lake that supplies water to a large city is expected to dry up, resulting in 3,000 human deaths. You must choose between two resource management programs.

A: 1,000 people saved for sure.
B: 2/3 probability no one saved.

V13 Gain: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs you prefer.

A: 125 species saved for sure.
B: 5/12 probability 300 species will be saved.

M13 Gain: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs you prefer.

A: 125 species saved for sure.
B: 5/12 probability 300 species saved and 7/12 probability no species saved.

G13 Gain: Poor waste management is expected to kill 300 species of fish in a large lake. Please indicate which of the following conservation programs do you prefer.

A: 125 species saved for sure.
B: 7/12 probability no species will be saved.

V14 Loss: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and lose 300 dollars for sure.
B: Answer, with 3/5 probability of losing 500 dollars.

M14 Loss: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and lose 300 dollars for sure.
B: Answer, with 3/5 probability of losing 500 dollars and 2/5 probability of losing nothing.

G14 Loss: Imagine you are on a game show where you earn money by correctly answering questions. You have 500 dollars at stake and have one question remaining.

A: Do not answer and lose 300 dollars for sure.
B: Answer, with 2/5 probability of losing nothing.

V15 Gain: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Win 40 for sure.
B: 1/4 probability you win 160 dollars.

M15 Gain: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Win 40 dollars for sure.
B: 1/4 probability you win 160 dollars and 3/4 probability you win nothing.

G15 Gain: Imagine you are on a trip to Las Vegas. As part of the casino's welcome program, the concierge offers you two options with 160 dollars at stake.

A: Win 40 dollars for sure.
B: 3/4 probability you win nothing.

V16 Gain: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 2/5 probability you win 75 dollars.

M16 Gain: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 2/5 probability you win 75 dollars and 3/5 probability you win nothing.

G16 Gain: As part of a consumer behavior study, you are given a chance to play a game with two options and 75 dollars at stake. Indicate the option you prefer.

A: Win 30 dollars for sure.
B: 3/5 probability you win nothing.

V17 Gain: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Win 30 dollars for sure.
B: 3/8 probability you win 80 dollars.

M17 Gain: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Win 30 dollars for sure.
B: 3/8 probability you win 80 dollars and 5/8 probability you win nothing.

G17 Gain: While walking down the street, you run into a friend who gets you to play a game for money, with 80 dollars at stake. Please indicate the option you prefer.

A: Win 30 dollars for sure.
B: 5/8 probability you win nothing.

V18 Loss: You are playing a slot machine with two levers. With 40 dollars at stake, please indicate which lever you will pull.

A: Lose 30 dollars for sure.
B: 75% chance you lose 40 dollars.

M18 Loss: You are playing a slot machine with two levers. With 40 dollars at stake, please indicate which lever you will pull.

A: Lose 30 dollars for sure.

B: 75% chance you lose 40 dollars and 25% chance you lose nothing.

G18 Loss: You are playing a slot machine with two levers. With 40 dollars at stake, please indicate which lever you will pull.

A: Lose 30 dollars for sure.
B: 25% chance you lose nothing.

V19 Loss: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Lose 200 dollars for sure.
B: 50% chance you lose 400 dollars.

M19 Loss: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Lose 200 dollars for sure.
B: 50% chance you lose 400 dollars and 50% chance you lose nothing.

G19 Loss: While walking the boardwalk of Atlantic City, you decide to play a casino game where 400 dollars are at stake. The dealer gives you two options.

A: Lose 200 dollars for sure.
B: 50% chance you lose nothing.

V20 Loss: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Lose 240 dollars for sure.
B: 4/5 probability you lose 300 dollars.

M20 Loss: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Lose 240 dollars for sure.
B: 4/5 probability you lose 300 dollars and 1/5 probability you lose nothing.

G20 Loss: You are playing a computer game that lets you gamble for money. 300 dollars are on the line. Please indicate the option you prefer.

A: Lose 240 dollars for sure.
B: 1/5 probability you lose nothing.