Similarity Judgments in Choice Under Uncertainty: A Reinterpretation of the Predictions of Regret Theory

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The Regret theory of Loomes and Sugden (1982) predicts choice anomalies implied by other alternatives to expected utility (e.g., violations of the independence axiom). It also makes unique and controversial predictions regarding the *rational* violation of stochastic dominance and invariance. All these predictions depend critically on assumptions regarding the statistical independence or dependence of the available alternatives. None of the predictions depend on the framing or representation of the alternatives. Leland (1994) shows that a model of choice based on similarity judgments predicts choices implied by Regret theory. In contrast to Regret theory, however, these predictions depend critically on the way the choices are framed and not on the dependence or independence of the alternatives. This paper presents experimental results indicating that the frequencies with which violations of independence, dominance, and invariance occur are, in most cases, insensitive to the statistical dependence or independence of the alternatives but sensitive to the way the choices are presented. These findings support the hypothesis that such behaviors arise as a consequence of reliance upon similarity judgments.
(*Decision Making; Similarity Judgments; Regret Theory; Choice Theory*)

Introduction

Evidence accumulated over the past several decades shows that individuals systematically violate axioms of the expected utility hypothesis, even an axiom such as transitivity, which many view as central to the notion of coherent, rational choice. Individual choices also vary systematically as a result of seemingly inconsequential changes in the way the alternatives are presented. These findings pose difficult questions for decision analysts. If preferences do not obey the axioms of expected utility, then what axioms do they obey? If choices vary depending upon specifics of the elicitation procedure, then what procedure elicits "true" preferences? Finally, if individuals' preferences are truly incoherent, then what is the benefit of prescriptive efforts—what is being gained?

Loomes and Sugden's (1982) Regret theory provides a possible resolution to these problems.[1] Regret theory is unique among alternatives to expected utility in that preferences in the theory are defined over actions rather than over prospects. Agents' choices between alternatives are assumed to depend not only on the payoffs offered in each action but also on the feelings of regret or elation the agents anticipate experiencing once the choice is made, the uncertainty resolved, and the outcome had they chosen otherwise is revealed. As a consequence of these differences relative to other alternatives to expected utility, Regret theory not only predicts the types of anomalies implied by such alternatives (e.g., violations of the independence axiom) but makes unique predictions regarding violations of stochastic dominance and invariance[2]—predictions confirmed experimentally.[3] Moreover, in the context of the theory

[1] Also see Bell (1982) and Fishburn (1981, 1982).

[2] That is, preference reversals between different representations of a choice between the same pair of probability distributions.

[3] See, for example, Loomes (1988), Loomes and Sugden (1987b), and Loomes et al. (1992).

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such behaviors are *rational*: Agents violate dominance and invariance because they are better off doing so once anticipation regarding post-decision regret and elation is accounted for.

Predictions of Regret theory, as well as their interpretation as rational forms of behavior, depend critically on assumptions regarding the statistical dependence or independence of the available alternatives. How alternatives are framed, on the other hand, is irrelevant according to the theory.

Leland (1994) examines the implications of individuals' basing choices between risky prospects on similarity judgments along the lines suggested by Rubinstein (1988).[4] There I show that for representations of choices as probability distributions, similarity judgments imply much of the behavior upon which Kahneman and Tversky's (1979) Prospect theory was based.[5] On the other hand, for alternatives represented in the state-matrix form employed in experiments testing the predictions of Regret theory, similarity judgments imply violations of dominance and invariance predicted by Regret theory. However, these predictions do not depend on assumptions regarding the statistical dependence or independence of the alternatives involved. Instead, violations of stochastic dominance and invariance occur simply because different matrix representations of a choice between the same pair of probability distributions foster different sets of comparisons of prizes and probabilities across alternatives. Violations of the independence axiom, on the other hand, arise because the arithmetic manipulations of lottery components used to produce such violations (e.g., reducing the values of probabilities across alternatives holding their ratio constant) alter the perceived similarity or dissimilarity of probabilities across alternatives.

In this paper we report the results from two experiments designed to determine whether the frequencies with which violations of stochastic dominance, invariance, and the independence axiom occur are sensitive to whether the alternatives involved are statistically dependent or independent (as implied by Regret theory) or not (as implied by the Similarity model). With one exception, these results suggest not, thus providing additional support for the Similarity model proposed.

The paper is organized as follows. First, we review the structure of Regret theory and its implications regarding violations of stochastic dominance, invariance, and the independence axiom. Next, we propose a model of choice based on similarity judgments and show that it also implies systematic violations of these axioms. We then present the results of experiments that enable us to distinguish between these two explanations for violations of expected utility. Finally, we discuss how these findings may affect decision analysis.

Regret Theory: Structure and Implications

Let $S \equiv \{S_1, S_2, \cdots S_n\}$ be the set of possible states of the world where each state S_j occurs with probability p_j ($\Sigma_j p_j = 1$).[6] Let A_1 and A_2 be two actions where agents choosing A_1 (A_2) receive outcome x_{1j} (x_{2j}) $\in$ the prize set X if state S_j occurs ($j = 1$ to n). Let $\sim$ and $>$ denote indifference and strict preference, respectively. In Regret theory, agents choose between actions according to the following decision rule where $\psi(\cdot,\cdot)$ is a real-valued regret / rejoice function:

$$A_1 \gtrless A_2 \Leftrightarrow \Sigma_j p_j \psi(x_{1j}, x_{2j}) \gtrless 0. \quad (1)$$

The function $\psi(\cdot,\cdot)$ is assumed to exhibit three properties:

(2a) Skew-symmetry—for all $x_g, x_h \in X$: $\psi(x_g, x_h) = -\psi(x_h, x_g)$,

(2b) Increasingness—for all $x_f, x_g, x_h \in X$: $\psi(x_f, x_g) \gtreqless 0 \Leftrightarrow \psi(x_f, x_h) \gtreqless \psi(x_g, x_h)$,

(2c) "Regret aversion" or "convexity"—for all $x_f, x_g, x_h \in X$: $\psi(x_f, x_g) > 0$, and $\psi(x_g, x_h) > 0$, and $\psi(x_f, x_h) > 0 \Rightarrow \psi(x_f, x_h) > \psi(x_f, x_g) + \psi(x_g, x_h)$.

Now consider being given a choice between two actions, A_1 and A_2. Each offers a one-third chance of receiving outcomes $x_1 > x_2 > x_3$ depending on the number

[4] Earlier work by Luce (1956) and by Tversky (1969) is also closely related.

[5] Specifically, in a section entitled "A reinterpretation of the evidence motivating Prospect theory," I show how reliance on similarity judgments results in common consequence and common ratio violations of the independence axiom, reflection effects, and violations of the reduction of compound lotteries axiom.

[6] This discussion of the structure of Regret theory follows Loomes and Sugden (1987a).

drawn from an urn containing 99 tickets numbered 1 to 99. For A_1 (A_2), the numbers 1 through 33 pay x_1 (x_3), 34 through 66 pay x_2 (x_1), and 67 through 99 pay x_3 (x_2). Note that the acts are *statistically dependent*.

According to Regret theory, agents would interpret this choice as shown below where the occurrence of state S_1, S_2, or S_3 results from drawing 1 through 33, 34 through 66, or 67 through 99, respectively.

	S_1 $\frac{1}{3}$	S_2 $\frac{1}{3}$	S_3 $\frac{1}{3}$
A_1	x_1	x_2	x_3
A_2	x_3	x_1	x_2

The choice between these two acts is determined as follows:

$$A_1 \gtreqless A_2 \Leftrightarrow \tfrac{1}{3}\psi(x_1, x_3) + \tfrac{1}{3}\psi(x_2, x_1) + \tfrac{1}{3}\psi(x_3, x_2) \gtreqless 0. \tag{3a}$$

Exploiting the skew symmetry property of $\psi(\cdot, \cdot)$ and simplifying, (3a) reduces to:

$$A_1 \gtreqless A_2 \Leftrightarrow \tfrac{1}{3}[\psi(x_1, x_3) - \psi(x_1, x_2) - \psi(x_2, x_3)] \gtreqless 0. \tag{3b}$$

Regret aversion implies that this expression will be positive, thus requiring the choice of action A_1. Further, the addition of a sufficiently small amount ε to prize x_2 in lottery A_2 will leave the inequality in expression (3b) unaffected, in which case agents will exhibit violations of stochastic dominance.

These behaviors are interpreted as rational within the context of Regret theory. The reason is straightforward. Agents recognize that if they choose A_1 and draw a ball numbered 34 through 66, they will feel bad for having received x_2 instead of x_1, the prize they would have received if they had chosen otherwise. Likewise, if they draw 67 through 99, they will feel bad for having received x_3 instead of x_2. However, they also recognize that if they draw a ball numbered 1 through 33, they will feel terrible for having received x_3 instead of x_1. In this context, regret aversion simply means that feeling "terrible" is more than twice as bad as feeling "bad."

Now suppose that prizes in A_1 and A_2 were awarded by draws from different urns. In this *statistically independent* situation, what one draws given the choice of one alternative is uninformative as to what would have happened if one had chosen otherwise. As a result, Regret theory predicts adherance to equivalence and stochastic dominance when A_1 and A_2 are statistically independent alternatives.[7]

In addition to implying violations of stochastic dominance, Regret theory also implies that agents' choices may exhibit "juxtaposition" effects (preference reversals between different choice pairs where the actions in one pair correspond to the same probability distributions as those in the other pair) and systematic violations of the independence axiom. To demonstrate, consider a choice between lotteries of the general form A: $[x_1, \lambda p; 0, 1 - \lambda p]$ and B: $[x_2, p; 0, 1 - p]$ for $x_1 > x_2 > 0$, $1 \geq p > 0$, and $1 > \lambda > 0$. Regret theory assumes that agents confronted with such alternatives perceive the decision as between the following actions where the parameter $1 \geq \omega \geq \max[0, (\lambda p + p - 1)/\lambda p]$ equals the probability that action B yields consequence x_2 conditional upon action A yielding consequence x_1.[8]

	S_1 $\omega\lambda p$	S_2 $(1-\omega)\lambda p$	S_3 $p(1-\omega\lambda)$	S_4 $1 - p(1 + (1-\omega)\lambda)$
A	x_1	x_1	0	0
B	x_2	0	x_2	0

Choice between actions is determined as follows:

$$A \gtreqless B \Leftrightarrow p\{\omega\lambda\psi(x_1, x_2) + (1-\omega)\lambda\psi(x_1, 0) + (1-\omega\lambda)\psi(0, x_2)\} \gtreqless 0. \tag{4a}$$

Factoring out p and exploiting the skew symmetry property of $\psi(\cdot, \cdot)$, expression (4a) reduces to:

$$A \gtreqless B \Leftrightarrow \{\lambda\psi(x_1, 0) - \psi(x_2, 0)\} + \omega\lambda\{\psi(x_1, x_2) + \psi(x_2, 0) - \psi(x_1, 0)\} \gtreqless . \tag{4b}$$

[7] According to Regret theory, individuals faced with a choice between A_1 and A_2 with two urns would interpret the decision as involving a matrix with 9 states where each state occurs with probability $\frac{1}{9}$th and where each prize in A_1 is juxtaposed with each prize in A_2 three times.

[8] I.e., ω measures the degree of overlap between those states where A gives x_1 and B gives x_2.

The sign of the first bracketed component in expression (4b) is indeterminate and independent of the level of ω. The second component, on the other hand, is negative as a consequence of regret aversion and becomes more negative the greater the value of ω.

The sign dependence of (4b) on ω makes "juxtaposition" effects possible. To demonstrate, consider choices AB and $A'B'$ below.

	S_1	S_3	S_4
	λp	$p(1-\lambda)$	$1-p$
A	x_1	0	0
B	x_2	x_2	0

	S_2	S_3	S_4
	λp	p	$1-p(1+\lambda)$
A'	x_1	0	0
B'	0	x_2	0

A and A' correspond to the probability distribution [\$$x_1$, λp; \$0, $1-\lambda p$] and B and B' to the probability distribution [\$$x_2$, p; \$0, $1-p$]. The choice pairs differ, however, in that in AB ω equals 1, whereas in $A'B'$ it equals 0 (in which case one and/or both choices must involve statistically dependent alternatives). The sign dependence of (4b) on ω implies that individuals preferring the safer option B when ω is high may, nonetheless, prefer the riskier option A' when ω is small.

The sign dependence of (4b) on ω also allows common ratio violations of the independence axiom. Given choices between the lotteries C: {\$30, 0.45; \$0, 0.55} and D: {\$15, 0.90; \$0, 0.10} and between C': {\$30, 0.01; \$0, 0.99} and D': {\$15, 0.02; \$0, 0.98}, the independence axiom requires that agents choose either C and C' or D and D'. Experimental evidence (e.g., Kahneman and Tversky (1979)) suggests instead that individuals tend to prefer the safer alternative when p is high (e.g., D) but the riskier alternative when p is sufficiently small in value (e.g., C').

If the actions in CD and $C'D'$ are statistically independent then $\omega = p$. In this case the sign dependence of (4b) on ω implies that an agent who prefers the safer option D when ω $(=p)$ is high may prefer the riskier option C' for ω $(=p)$ sufficiently small. As such, Regret theory predicts common ratio type violations of the independence axiom among statistically independent prospects. For statistically dependent choices, on the other hand, ω is constant, in which case the change from CD to $C'D'$ occurs solely as a consequence of a change in the value of p. To the extent that p does not appear in (4b), changes in its value will have no effect on choice. In most experiments revealing common ratio violations of the independence axiom including Kahneman and Tversky (1979), the dependence or independence of the alternatives is ambiguous. Loomes and Sudgen (1982) suggest that in situations where "subjects were simply asked to choose between pairs of prospects. . . . The most natural assumption for subjects to make is that the prospects are statistically independent." If so, then common ratio violations are consistent with Regret theory.

To summarize, Regret theory implies systematic violations of stochastic dominance and juxtaposition effects in choices between statistically dependent alternatives and also implies common ratio violations of the independence axiom in choices between statistically independent alternatives. These behaviors, and their interpretation as rational forms of behavior, occur irrespective of the way the alternatives are presented—according to Regret theory they are not framing effects. Moreover, violations of stochastic dominance are predicted even when the dominance relationship between alternatives is transparent—choice of dominated alternatives is intentional. Violations of stochastic dominance and juxtaposition effects in choices involving statistically independent alternatives and violations of the independence axiom between statistically dependent alternatives are, on the other hand, inconsistent with Regret theory.

Similarity Judgments

Rubinstein (1988) suggested that for the purposes of choosing between simple lotteries [x_1, p_1; 0, $1-p_1$] and [x_2, p_2; 0, $1-p_2$] agents employ a three-step process. In the first step, they check to see whether one lottery stochastically dominates the other. If so, that option is selected. If not, agents then compare the non-zero prizes (x_1 and x_2) and their corresponding probabilities (p_1 and p_2) in terms of their similarity or dissimilarity. If the lotteries are perceived as similar on one dimension but dissimilar on the other, the dissimilar dimension becomes decisive in determining the choice. Otherwise, the choice is resolved in a third step by an unspecified procedure.

Rubinstein suggested that reliance on this decision procedure could lead to CD' type violations of the independence axiom discussed earlier. In the choice between lotteries C' and D', the former would be selected because it offers a dissimilar and better prize ($30 versus $15) at similar probability (.01 versus .02). The choice between C and D, on the other hand, cannot be resolved by appeal to similarity since probabilities (.45 and .90) as well as prizes may appear dissimilar. In concluding, Rubinstein noted that, to the extent this explanation for common ratio violations is correct, it raises questions regarding the transitivity of preferences.

From a descriptive standpoint, the fact that individuals choosing according to Rubinstein's procedure may have intransitive preferences is probably of lesser concern than the fact that their choices will, in some circumstances, be completely and implausibly insensitive to differences in the expected values of the alternatives. For example, individuals trying to decide between C and D based on similarity judgments would be no more successful at identifying a preferred alternative if the $30 in C were replaced with $30,000 or $3,000,000—in each case one alternative offers a noticeably better prize but the other offers a good prize at dissimilar and better odds.

Leland (1994) modifies the decision procedure proposed by Rubinstein and applies it to the larger class of lotteries L_1 and L_2 represented or perceived by agents as shown below where for $i = 1, 2$ and $j = 1, 2, \ldots, n$, $x_{ij} \in X$, $p_{ij} \in [0, 1]$ and $\Sigma_j p_{ij} = 1$.[9]

$$L_1 = \{x_{11}, p_{11}; x_{12}, p_{12}; \cdots; x_{1n}, p_{1n}\}$$

$$L_2 = \{x_{21}, p_{21}; x_{22}, p_{22}; \cdots; x_{2n}, p_{2n}\}$$

[9] Generally speaking, the model applies only to decisions between alternatives having the same number of outcomes. In certain circumstances, predictions can be obtained for alternatives involving unequal outcomes. Leland (1994), for example, provides an explanation for common consequence violations of independence where one choice pair involves deciding between a certain outcome and a lottery. However, the model cannot explain other evidence revealing systematic departures from expected utility where lotteries contain unequal numbers of outcomes (e.g., Wu and Gonzalez (forthcoming)) since we cannot infer what subjects are comparing across lotteries nor even whether the decision process used involves comparative, as opposed to absolute, evaluations.

To choose between such alternatives, assume agents first attempt to resolve the choice either through appeal to preference or based solely on the difference in the expected values of the alternatives. If, in this process, one alternative is perceived to be distinctly better than the other (which we will assume occurs for alternatives that are sufficiently far apart in expected value) it is selected.[10]

If a clear choice cannot be identified in this stage, agents next proceed to make comparisons of prizes and probabilities across lotteries in an attempt to identify a dominant alternative. Specifically, assume that agents compare prize x_{11} with x_{21} and their corresponding probabilities p_{11} with p_{21} in terms of their equality or inequality, then x_{12} with x_{22} and p_{12} with p_{22} and so forth for a total of j pairs of comparisons. For each of these j pairs of comparisons, agents note whether the comparisons "favor L_1" (e.g., if $x_{11} > x_{21}$ and $p_{11} > p_{21}$ or $x_{11} > x_{21}$ and $p_{11} = p_{21}$), "favor L_2," are "inconclusive" (e.g., if $x_{11} > x_{21}$ but $p_{21} > p_{11}$ in cases where x_{21} is a desirable outcome), or are "inconsequential" (e.g., if $x_{11} = x_{21}$ and $p_{11} = p_{21}$). Once each of the j pairs of comparisons is made, agents choose L_1 (L_2) if it is favored in any comparisons and inconsequential in the remainder. Otherwise, agents proceed to a third step in the decision procedure.

For the purpose of describing step 3, assume the binary relations $>^x$ and $>^p$ (reading "greater than and dissimilar") are strict partial orders[11] on consequences and probabilities, respectively. In this case, the similarity relations, $\sim^x$ and $\sim^p$, defined by the symmetric complements of $>^x$ and $>^p$, are not necessarily transitive because for some prizes $x_f > x_g > x_h$, $x_f \sim^x x_g$, $x_g \sim^x x_h$ but $x_f >^x x_h$, with a like result holding for probabilities. To resolve choice in this step, agents again compare prize x_{11} with x_{21} and their corresponding probabilities p_{11} with p_{21}, but now in terms of their similarity or

[10] This step rules out the possibility that certain prizes in a lottery can be made arbitrarily large without eventually eliciting a strict preference for that lottery over another. While this step restricts the applicability of the model, the class of decisions for which similarity judgments apply may, nonetheless, be quite large. As was pointed out by a reviewer on an earlier draft of this manuscript, expected utility violations like those original proposed by Allais (1953) involve lotteries with very different expected values.

[11] That is, asymmetric and transitive.

dissimilarity, then x_{12} with x_{22} and p_{12} with p_{22} and so forth for a total of j pairs of comparisons. For each of these j pairs of comparisons, agents note whether the comparisons "favor L_1" (e.g., if $x_{11} >^x x_{21}$ and $p_{11} >^p p_{21}$ or $x_{11} >^x x_{21}$ and $p_{11} \sim^p p_{21}$), "favor L_2," are "inconclusive" (e.g., if $x_{11} >^x x_{21}$ but $p_{21} >^p p_{11}$ in cases where x_{21} is a desirable outcome), or are "inconsequential" (e.g., if $x_{11} \sim^x x_{21}$ and $p_{11} \sim^p p_{21}$).[12] Once each of the j pairs of comparisons is made, similarity recommends the choice of L_1 (L_2) if L_1 (L_2) is "favored" for any j and L_2 (L_1) is not favored for any j.[13] Otherwise, the choice is resolved at random.

While this model of choice is exceedingly simply, it, nevertheless, yields a very rich set of behavioral implications. To demonstrate, consider lotteries A_1 and A_2 presented in the prior section (shown in the L_1L_2 format below).

$$A_1: \{x_1, \tfrac{1}{3}; x_2, \tfrac{1}{3}; x_3, \tfrac{1}{3}\}$$

$$A_2: \{x_3, \tfrac{1}{3}; x_1, \tfrac{1}{3}; x_2, \tfrac{1}{3}\}$$

Assuming the choice is not resolved by appeal to preference—which we assume henceforth—agents given these options will next compare the prizes and their corresponding probabilities according to their equality or inequality. The first paired comparison (x_1 and x_3 and $\frac{1}{3}$ and $\frac{1}{3}$) will favor A_1. However, the remaining paired comparisons (x_2 with x_1 and $\frac{1}{3}$ with $\frac{1}{3}$, and x_3 with x_2 and $\frac{1}{3}$ with $\frac{1}{3}$) will favor A_2. Taken together, these results are uninformative, in which case agents proceed to step 3.

In step 3, agents again compare prizes and probabilities across lotteries but now in terms of their similarity or dissimilarity. In each pair of comparisons, the probabilities are identical and hence similar. Thus, the choice predictions of the Similarity model depend upon the similarity/dissimilarity results between the prizes x_1 and x_3, x_2 and x_1, and x_3 and x_2. There are five possible patterns of similarity/dissimilarity perceptions between outcomes for each of these three comparisons:

1. $x_1 >^x x_3, x_1 >^x x_2, x_2 >^x x_3,$
2. $x_1 >^x x_3, x_1 >^x x_2, x_2 \sim^x x_3,$
3. $x_1 >^x x_3, x_1 \sim^x x_2, x_2 >^x x_3,$
4. $x_1 >^x x_3, x_1 \sim^x x_2, x_2 \sim^x x_3,$
5. $x_1 \sim^x x_3, x_1 \sim^x x_2, x_2 \sim^x x_3.$

For the first three of these patterns, certain comparisons of prizes across alternatives will favor A_1 but others will favor A_2. These will be resolved at random. Likewise, for the fifth pattern of perceptions, the choice will be random because all comparisons are inconsequential. For the fourth pattern, however, similarity recommends the choice of A_1 over A_2 since the comparison $x_1 >^x x_3$ "favors" A_1 with the latter two comparisons, $x_1 \sim^x x_2$ and $x_2 \sim^x x_3$ being "inconsequential." The choice of A_1 is the one required by Regret theory. Also like Regret theory, agents may systematically persist in choosing A_1 even if a sufficiently small amount, ε, is added to one of the outcomes in A_2. However, unlike Regret theory, these predictions of the Similarity model apply to the statistically independent as well as dependent alternatives.[14]

The explanation for juxtaposition effects provided by similarity is closely related to the explanation for violations of equivalence and systematic violations of stochastic dominance. To demonstrate, consider choices AB and $A'B'$ from the previous section again rewritten in L_1L_2 format.

[12] For the types of lotteries considered in this paper, the conclusions regarding when one lottery will be favored over another and when comparisons will be judged either "inconclusive" or "inconsequential" are obvious. Leland (1994) contains a general discussion as to when similarity comparisons will "favor" one lottery over another, be "inconclusive," or be "inconsequential."

[13] Starmer and Sudgen (1993) present evidence suggesting that types of behaviors predicted by Regret, as well as ones inconsistent with Regret theory, result because the subjective probability of an event (e.g., a 50% chance of winning \$100) can be enhanced by describing it as two events (e.g., a 25% chance of winning \$100 and another 25% chance of winning \$100). This result, termed "event splitting," suggests that the pareto rule for choosing between alternatives based on similarity should be replaced by a majority rule (i.e., choose A (B) if it is favored in more pairs of comparisons). This possibility will be explored in detail in a companion paper. For all the experimental results reported in this paper, the behaviors implied by the two rules are identical.

[14] Also unlike Regret, violations of stochastic dominance will occur at chance levels even for agents whose perceptions do not correspond to pattern 4. One might object that this implies an implausible number of violations of dominance. Bear in mind, however, that agents choosing according to the Similarity model proposed take the representation of the choices as given. If they were allowed to reorder prizes so as to match x_1 in A_1 with x_1 or $x_1 + \varepsilon$ in A_2, x_2 in A_1 with x_2 in A_2, and so forth, they would detect the dominated alternative in step 2. This matching of prizes produces what Tversky and Kahneman (1986) refer to as "transparent" dominance and what Loomes and Sugden (1987a) term "statewise dominance."

$$A: \{x_1, \lambda p; 0, p(1-\lambda); 0, 1-p\}$$

$$B: \{x_2, \lambda p; x_2, p(1-\lambda); 0, 1-p\}$$

$$A': \{x_1, \lambda p; 0, p; 0, 1-p(1+\lambda)\}$$

$$B': \{0, \lambda p; x_2, p; 0, 1-p(1+\lambda)\}$$

In each pair of comparisons, the probabilities are again identical and therefore similar, in which case the choice predictions of the Similarity model depend on the similarity / dissimilarity results between the prizes. In the choice between A and B, the Similarity model may recommend either the choice of A (if $x_1 >^x x_2$ but $x_2 \sim^x 0$) or B (if $x_1 \sim^x x_2$ but $x_2 >^x 0$). In the choice between A' and B', on the other hand, only A' can be recommended (if $x_1 >^x 0$ but $x_2 \sim^x 0$) since for B' to be recommended it would have to be that $x_1 \sim^x 0$ in which case all comparisons are deemed inconsequential. As with violations of stochastic dominance, however, these predictions depend only upon the representation of the choices fostering an appropriate set of comparisons between prizes and probabilities—the statistical dependence or independence of the alternatives is irrelevant.

The reason for the close correspondence between the predictions of the Regret and the Similarity models regarding violations of stochastic dominance and juxtaposition effects is obvious: The assumption that the similarity relation on prizes, $\sim^x$, may be intransitive (i.e., that $x_f > x_g > x_h$, $x_f \sim^x x_g$, $x_g \sim^x x_h$ but $x_f >^x x_h$) implies behaviors analogous to those implied by the assumption of regret aversion (i.e., that $\psi(x_f, x_h) > \psi(x_f, x_g) + \psi(x_g, x_h)$). In contrast, common ratio violations of the independence axiom follow in the Similarity model as a consequence of similarities and dissimilarities between probabilities across alternatives. In the choice between C: [\$30, 0.45; \$0, 0.55] and D: [\$15, 0.90; \$0, 0.10] discussed earlier, for example, individuals will first compare \$30 with \$15 and 0.9 with 0.45 and then compare \$0 with itself and 0.1 with 0.55. Assuming that \$30 $>^x$ \$15 and 0.9 $>^p$ 0.45, the first paired comparison will be deemed "inconclusive." The second comparison, on the other hand, will favor the safer option D, since C offers a noticeably larger probability (0.55 $>^p$ 0.1) of the worst possible outcome. In the choice between C': [\$30, 0.01; \$0, 0.99] and D': [\$15, 0.02; \$0, 0.98], on the other hand, agents may perceive the probabilities 0.02 and 0.01 and 0.98 and 0.99 as similar. If so, then the riskier alternative C' is recommended as the first pair of comparisons (\$30 $>^x$ \$15 and 0.02 $\sim^p$ 0.01) now favor C', whereas the second pair (\$0 $\sim^x$ \$0 but 0.99 $\sim^p$ 0.98) is deemed "inconsequential."[15]

Experimental Results

Predictions following from Regret theory and those following from the hypothesis that choices are based upon similarity judgments correspond closely. Nevertheless, these two alternative explanations for violations of expected utility are quite different and empirically distinguishable. Specifically, if the explanation for violations of stochastic dominance, invariance, and independence provided by Regret theory is correct, then the frequency with which such violations occur should be sensitive to the statistical dependence or independence of the alternatives, insensitive to the way the alternatives are framed, and, in the case of stochastic dominance violations, insensitive to whether the dominance relation between alternatives is transparent or obscured. If violations are a consequence of similarity judgments, exactly the opposite implications follow.

To test between these two models of behavior, four groups of Carnegie Mellon undergraduates filled out a questionnaire consisting of seven choice problems. Two groups were given choices between alternatives referred to as "Lottery A" and "Lottery B." In this treatment, the prize to be awarded in each choice pair was determined by drawing a number between 1 and 100 from a single envelope; the alternatives are statistically dependent.

The other two groups' choices involved alternatives referred to as "Envelope A" and "Envelope B." In this treatment, for each choice pair, the prize if one chose Envelope A was determined by drawing a number from 1 to 100 from an envelope labeled "A," whereas the prize awarded if one chose Envelope B was awarded by

[15] Rubinstein (1988) shows that to be consistent with expected utility, $\sim^p$ must be a λ-ratio similarity such that $p \sim^p q$ if $1/\lambda \leq p/q \leq \lambda$. Consistent with the type of behavior described above, Leland (1994) presents experimental results suggesting that in hypothetical choices like CD and $C'D'$ above, $\sim^p$ is an ε-difference similarity such that $p \sim^p q$ if $|p-q| \leq \varepsilon$ with a value of ε for the "representative agent" of between .05 and .15.

drawing a number from the envelope labeled "B." Here the alternatives are independent.[16]

Aside from differences in the way prizes were awarded, the two treatments were identical. Ordering of choices within each question and ordering of questions within questionnaires were varied in both treatments to compensate for systematically capricious responding.

Two of the seven questions presented to subjects pertain to common ratio violations of the independence axiom. These are shown below where the only difference between questions across treatments is that the choices in the dependent treatment were described as *lotteries*, whereas the choices in the independent treatment were referred to as *envelopes*.

A_1B_1

You are to choose between Lotteries (Envelopes) A_1 and B_1. For Lottery (Envelope) A_1, if you draw a 1–45 you receive \$30 and \$0 otherwise. For Lottery (Envelope) B_1, if you draw a 1–90 you receive \$15 and \$0 otherwise.

As such, your choice is between

A_1: Win \$30 if draw 1–45 (45% chance), \$0 otherwise (55% chance).——

B_1: Win \$15 if draw 1–90 (90% chance), \$0 otherwise (10% chance).——

A_2B_2

You are to choose between Lotteries (Envelopes) A_2 and B_2. For Lottery (Envelope) A_2, if you draw a 1 you receive \$30 and \$0 otherwise. For Lottery (Envelope) B_2, if you draw a 1–2 you receive \$15 and \$0 otherwise.

As such, your choice is between

A_2: Win \$30 if draw 1 (1% chance), \$0 otherwise (99% chance).——

B_2: Win \$15 if draw 1–2 (2% chance), \$0 otherwise (98% chance).——

For choices between independent Envelope alternatives, Loomes and Sudgen (1982) propose that agents transform or choose "as if" they transform the alternatives into the following state-contingent representations:

	0.405	0.045	0.495	0.055
A_1	\$30	\$30	\$0	\$0
B_1	\$15	\$0	\$15	\$0

	0.0002	0.0098	0.0198	0.9702
A_2	\$30	\$30	\$0	\$0
B_2	\$15	\$0	\$15	\$0

For reasons discussed in the previous section, individuals who choose B_1 over A_1 may, nonetheless, choose A_2 over B_2 in violation of the independence axiom.

For statistically dependent Lottery alternatives, on the other hand, the corresponding state-contingent choice matrices are:

	0.45	0.45	0.10
A_1	\$30	\$0	\$0
B_1	\$15	\$15	\$0

	0.01	0.01	0.98
A_2	\$30	\$0	\$0
B_2	\$15	\$15	\$0

Here, agents choosing according to Regret theory must adhere to the independence axiom.

The Similarity model, in contrast, assumes no such transformation of the alternatives.[17] Instead, individuals

[16] Several steps were taken in each treatment to emphasize to subjects how prizes would be awarded. Before the start of the experiment, the instructions (complete questionnaires from both experiments reported here are available upon request) were read aloud by the group instructors. The instructions stated that one person from each of the four groups in the experiment would be selected to play one of the alternatives he or she chose on one of the seven questions and would be paid off accordingly. Group instructors in the dependent treatments emphasized that the prize to be awarded in each choice would be determined by drawing a number from the single envelope in the front of the room. Likewise, instructors in the independent treatment emphasized that prizes for lotteries denoted by *As* would be determined by drawing out of the envelope marked A, whereas those awarded for lotteries denoted by *Bs* would be determined by drawing from the envelope marked B. Envelopes were large (8.5" × 11") and were displayed prominently in the front of each classroom.

[17] If subjects mentally converted choices A_1B_1 and A_2B_2 into the matrices above, similarity would imply the same behaviors as Regret

who choose B_1 over A_1 in either treatment may switch and choose A_2 over B_2 because, in the latter, probabilities across alternatives appear more similar.

Results obtained are as follows:

	Dependent A_2	Dependent B_2			Independent A_2	Independent B_2	
A_1	16 (28%)	9 (15%)	25 (43%)	A_1	11 (23%)	1 (2%)	12 (25%)
B_1	25 (43%)	8 (14%)	33 (57%)	B_1	30 (63%)	6 (12%)	36 (75%)
	41 (71%)	17 (29%)	58		41 (86%)	7 (14%)	48

Consistent with the hypothesis that common ratio violations can be attributed, at least in part, to anticipated regret, the difference in the frequency of predicted to nonpredicted violations between treatments (25 to 9 in the dependent treatments versus 30 to 1 in the independent treatments) cannot be attributed solely to chance. The Fisher exact test probability for such a discrepancy occurring by chance equals .009. Consistent with the Similarity model, on the other hand, significant systematic departures from the requirements of the independence axiom occur in the statistically dependent (Conlisk's $z = 2.99$)[18] as well as independent (Conlisk's $z = 8.02$) treatments.

In contrast to these findings, results on the determinants of juxtaposition effects and stochastic dominance violations are unequivocal. Beginning with the former, consider question pairs A_3B_3 and A_4B_4 shown below (along with the instructions to subjects) where both involve a choice between the probability distribution [\$13, .3; \$0, .7] and the probability distribution [\$7, .5; \$0, .5].

Given a choice between Lottery (Envelope) A and Lottery (Envelope) B shown below, which would you prefer to play (make a check mark to the right of the preferred lottery (envelope)?

	1–50 (50%)	51–70 (20%)	71–100 (30%)
Lottery (Envelope) A_3	\$0	\$0	\$13
Lottery (Envelope) B_3	\$0	\$7	\$7

	1–20 (20%)	21–70 (50%)	71–100 (30%)
Lottery (Envelope) A_4	\$0	\$0	\$13
Lottery (Envelope) B_4	\$0	\$7	\$0

In the statistically dependent Lottery treatment, individuals who choose according to Regret theory and select B_3 over A_3 might, nevertheless, choose A_4 over B_4 as a consequence of the extreme regret anticipated should one choose B_4 and then draw one of the numbers 71 through 100. In the independent Envelopes treatment, on the other hand, no systematic juxtaposition effects are predicted by Regret.

The Similarity model also implies that preference reversals, to the extent they occur, will be of the form B_3A_4 because either A_3 or B_3 can be recommended by similarity in the first choice, but B_4 can never be recommended by similarity in the second. According to the Similarity model, however, the pattern B_3A_4 should occur both in the statistically independent and the dependent treatments. Results for these questions are shown below.

	Dependent A_4	Dependent B_4			Independent A_4	Independent B_4	
A_3	9 (15%)	6 (10%)	15 (25%)	A_3	6 (12%)	1 (2%)	7 (14%)
B_3	10 (17%)	35 (58%)	45 (75%)	B_3	12 (25%)	30 (61%)	42 (86%)
	19 (32%)	41 (68%)	60		18 (37%)	31 (63%)	49

Contrary to Regret theory and consistent with the hypothesis that juxtaposition effects arise as a consequence of similarity judgments, the choice pattern B_3A_4 occurs more often than the pattern A_3B_4 in the independent treatment, 12 versus 1 (Conlisk's $z = 3.21$) as well as in the dependent treatment, 10 versus 6 (Conlisk's $z = 1.047$).[19]

theory, although the statistical dependence or independence of the alternatives would be irrelevant in producing these behaviors.

[18] This z statistic, proposed by Conlisk (1989) tests whether violations of expected utility across pairs of questions like A_1B_1 and A_2B_2 are systematic in the sense that the pattern A_1B_2 occurs more often than the pattern B_1A_2 or vice versa.

[19] This difference in the relative frequency of predicted to nonpredicted response patterns between treatments, while large, is not, arguably,

The remaining choice problems in the questionnaire pertained to violations of stochastic dominance. Two of these are shown below.

	1–20 (20%)	21–40 (20%)	41–80 (40%)	81–100 (20%)
Lottery (Envelope) A_5	\$5	\$5	\$0	\$13
Lottery (Envelope) B_5	\$0	\$12	\$5	\$0

	1–20 (20%)	21–40 (20%)	41–80 (40%)	81–100 (20%)
Lottery (Envelope) A_6	\$0	\$13	\$5	\$0
Lottery (Envelope) B_6	\$5	\$5	\$0	\$12

Note that here the A alternatives (both corresponding to the prospect [\$13, 0.2; \$5, 0.4; \$0, 0.4]) stochastically dominate the B alternatives (both corresponding to the prospect [\$12, 0.2; \$5, 0.4; \$0, 0.4]).

Among statistically dependent lotteries, Regret theory predicts that individuals will choose the dominant alternative A_5 over B_5 because the regret associated with receiving \$0 and missing out on \$13 if one chooses B_5 must be greater than the sum of the regrets associated with receiving \$5 instead of \$12 or \$0 instead of \$5. In the second choice, however, individuals might rationally choose the dominated alternative B_6 if the anticipated regret associated with receiving \$0 and missing out on \$12 if they choose A_6 is greater than the regret associated with receiving \$0 instead of \$5 and \$5 instead of \$13. As such, stochastic dominance violations of the form A_5B_6 should occur more frequently than those of the form B_5A_6 but only among statistically dependent lotteries.

According to the Similarity model, individuals cannot systematically choose the dominated alternative B_5 over A_5 because for this to occur \$13 would have to appear similar to \$0, in which case all comparisons are inconsequential. The dominated alternative B_6 can, on the other hand, be recommended by similarity if \$12 $>^x$ \$0 but \$13 $\sim^x$ \$5 and \$5 $\sim^x$ \$0. As such, the Similarity model, like Regret theory, predicts systematic dominance violations of the form A_5B_6 but, unlike Regret, predicts that this will be the case irrespective of the statistical dependence or independence of the alternatives.

Results for these questions for both treatments are shown below along with Loomes et al.'s (1992) results for choices between statistically dependent acts A_5 and B_5 and between A_6 and B_6 in which the prizes were denominated in British pounds.

Dependent

	A_6	B_6	
A_5	31 (53%)	18 (31%)	49 (83%)
B_5	5 (8%)	5 (8%)	10 (17%)
	36 (61%)	23 (39%)	59

Independent

	A_6	B_6	
A_5	25 (51%)	17 (35%)	42 (86%)
B_5	5 (10%)	2 (4%)	7 (14%)
	30 (61%)	19 (39%)	49

Loomes et al.
Dependent

	A_6	B_6	
A_5	45	37	82
B_5	12	6	18
	57	43	100

Consistent with the predictions of the similarity model and contrary to Regret theory, violations of dominance of the form A_5B_6 occur systematically in both the independent treatment (McNemar's $\chi^2 = 7.35$, $p < 0.01$)[20] and the dependent treatment (McNemar's $\chi^2 = 6.55$, $p < 0.02$). Moreover, the overall pattern of responses observed is similar in the two treatments and corresponds closely to the pattern found by Loomes et al. (1992).

inconsistent with the hypothesis that the statistical dependence or independence of alternatives is irrelevant as implied by the Similarity model. The probability of such a discrepancy occurring by chance equals 0.07 (Fisher exact test).

[20] Conlisk's z is not appropriate to test for violations of dominance since there is only one rational response pattern across choice pairs: Select the dominant alternative consistently.

In addition to choices between A_5B_5 and between A_6B_6, subjects in both treatments were asked to choose between the following alternatives where this choice was always the last one presented:

> You are to choose between Lotteries (Envelopes) A and B. For Lottery (Envelope) A, if you draw 1–25 you receive \$5, 26–50 you receive \$12.50, 51–75 you receive \$0, and 76–100 you receive \$0. For Lottery (Envelope) B, if you draw a 1–25 you receive \$0, 26–50 you receive \$5, 51–75 you receive \$12, and 76–100 you receive \$0.
> As such, your choice is between:
> A_7: Win \$12.50 (25% chance), win \$5 (25% chance), win \$0 (50%) chance.——
> B_7: Win \$12.00 (25% chance), win \$5 (25% chance), win \$0 (50%) chance.——
> Place a check next to the Lottery (Envelope) you prefer to play.

In this question the dominance relation between alternatives is made transparent, in which case individuals choosing according to Similarity will select A_7. Regret theory, on the other hand, requires individuals who chose the dominated alternative B_6 also choose the dominated alternative B_7 since $\psi(12, 0) > \psi(5, 0) + \psi(13, 5) \Rightarrow \psi(12, 0) > \psi(5, 0) + \psi(12.50, 5)$. Contrary to this prediction and consistent with the hypothesis that individuals wish to obey stochastic dominance, of the 17 subjects exhibiting the predicted pattern A_5B_6 between statistically dependent alternatives, only 2 (12%) chose the dominated alternative when the dominance relationship was made transparent. As points of reference, of the 18 subjects who chose A_5B_6 in the statistically independent treatment, 4 (22%) continued to violate dominance in the choice A_7B_7, whereas overall rates of violation on A_7B_7 were 8 of 59 (16%) for the dependent treatment and 6 of 49 (12%) for the independent treatment.

To summarize, violations of the independence axiom occur significantly more often in the independent treatment than in the dependent treatment. However, the frequency of systematic violations of independence in the dependent treatment is also significant. Juxtaposition effects occur at a statistically significant level in choices between independent alternatives and occur in the same direction but at a statistically insignificant level between dependent alternatives. The difference between the frequency of predicted to nonpredicted violations in the two treatments is, however, insignificant. Finally, systematic violations of stochastic dominance occur with significant frequency between both statistically independent and dependent alternatives, but they vanish when the dominance relationship is made transparent—even among subjects from which Regret theory would require violations.

All the findings summarized above, save the first, appear to support the hypothesis that choices are being based on similarity judgments and not as assumed in Regret theory. However, these results would also follow if subjects in the experiment interpreted matrix representations of alternatives as implying statistical dependence and prospect representations as indicating independence.[21] In light of this possibility, an additional 83 Carnegie Mellon undergraduates completed a questionnaire (available on request) consisting of four decision problems.[22,23]

In this experiment, eight average sized lunch bags labeled F, T, Q, L, W, R, K, and N were placed in the front of the classroom. Each bag contained 100 colored balls (O_{range}, R_{ed}, G_{reen}, Y_{ellow}) in different proportions. On each of the four questions, subjects were asked to choose one of two bags.

The first two choice pairs, testing for violations of stochastic dominance, are shown below.[24]

Problem 1

Bag F	19% O win \$5	20% R win \$5	40% G win \$0	21% Y win \$13——
Bag T	20% O win \$0	20% R win \$12	40% G win \$5	20% Y win \$0——

Problem 2

Bag Q	20% O win \$0	21% R win \$13	39% G win \$5	20% Y win \$0——
Bag L	20% O win \$5	20% R win \$5	40% G win \$0	20% Y win \$12——

Lotteries T and L are identical to lotteries B_5 and B_6 in the prior experiment. F and Q have been made slightly

[21] I am indebted to the two referees on an earlier version of this paper for pointing out this possibility.

[22] I would like to thank Professor John Miller and his Fall 1995 Policy Analysis class at Carnegie Mellon University for their participation in this experiment.

[23] As in the previous experiment, subjects were informed that one member of the class would be selected to play one of the alternatives he or she chose and be paid off accordingly. Ordering of choices within each question and ordering of questions within questionnaires were systematically varied.

[24] These choices were constructed like ones used to demonstrate violations of stochastic dominance in Tversky and Kahneman (1986).

better than A_5 and A_6 in the prior experiment to make the probabilities across bags different (further ensuring that people don't treat the choice as dependent). For these choice pairs, Regret theory predicts that there will be no violations of dominance.

If subjects choose according to similarity, systematic violations of dominance are ruled out in the first choice because the only way T can be recommended over F is if $\$13 \sim^x \$0$ but, if so, all comparisons will be deemed inconsequential. In QL, on the other hand, L can be recommended by similarity if $\$12 >^x \$0$, but $\$5 \sim^x \$0$ and $\$13 \sim^x \$5$. As a result, the Similarity model predicts that responses of the form FL will outnumber those of the form TQ. Results for these two choice problems are shown below along with the results we obtained for the independent matrix representations in the first experiment.[25]

Independent Bags

	Q	L	
F	43 (52%)	31 (37%)	74 (89%)
T	6 (7%)	3 (4%)	9 (11%)
	49 (59%)	34 (41%)	83

Independent Matrix

	A_6	B_6	
A_5	25 (51%)	17 (35%)	42 (86%)
B_5	5 (10%)	2 (4%)	7 (14%)
	30 (61%)	19 (39%)	49

Results from the "bags" representation of the choices closely mirror those found in the "matrix" representation, and the discrepancy between predicted and nonpredicted violations of stochastic dominance is even more significant (McNemar's $\chi^2 = 16.9$, $p < 0.0005$ here versus 7.35 in the independent matrix case). Moreover, this is true even though the dominant alternative has been, albeit slightly, improved.

[25] Recall that results regarding stochastic dominance violations were very similar for the dependent and independent manipulations and also very similar to those reported for dependent alternatives by Loomes et al. (1992).

The second two choice pairs presented to subjects in this experiment involved juxtaposition effects. They were as shown below.

Problem 3

Bag W 50% O win \$0 20% R win \$0 30% G win \$13——

Bag R 51% O win \$0 19% R win \$7 30% G win \$7——

Problem 4

Bag K 20% orange win \$0 50% red win \$0 30% green win \$13——

Bag N 20% orange win \$0 49% red win \$7 31% green win \$0——

Lotteries W and K are the same as Lotteries A_3 and A_4 in the previous experiment. Alternatives R and N are slightly degraded relative to B_3 and B_4 in the first experiment, again to allow for different probabilities between bags. Regret theory predicts no juxtaposition effects between these choice pairs because the options are independent.

In contrast, although similarity judgments can recommend either the choice of W or R in Problem 3, N cannot be recommended over K in Problem 4 because for this to occur, 13 must appear similar to 0, but then everything will appear similar across lotteries. As a result, the prediction is that juxtapositions $RK > WN$. Results for these two choice problems are shown below along with those obtained for the independent matrix representation in the first experiment.

Independent Bags

	K	N	
W	16 (19%)	1 (1%)	17 (20%)
R	20 (24%)	46 (55%)	66 (80%)
	36 (43%)	47 (57%)	83

Independent Matrix

	A_4	B_4	
A_3	6 (12%)	1 (2%)	7 (14%)
B_3	12 (25%)	30 (61%)	42 (86%)
	18 (37%)	31 (63%)	49

As in the earlier experiment, juxtaposition effects occur as predicted by similarity although the effect here is much stronger—20:1 here versus 12:1 in the first experiment.

In summary, the results obtained in the first experiment replicate here. These findings cannot, however, be attributed to subjects interpreting matrix representations as signaling statistical dependence as the choices weren't represented as matrices. Moreover, even though the representations used are matrix-like, to treat the choices as involving draws from a single urn (i.e., as statistically dependent choices) would require that subjects believe that the urn simultaneously contains different proportions of white, red, green, and yellow balls. If people commonly suffer from this misconception, then the types of violations of rationality described in this paper would seem to be the least of our problems.

Discussion

Both Regret theory and the Similarity model presented here predict systematic violations of independence, monotonicity, and invariance. If these violations result from consideration of post-decision regret or elation, their occurrence will be sensitive to the statistical dependence or independence of the alternatives, insensitive to the framing of the choices and, in the case of violations of dominance, insensitive to whether the dominance relationship is transparent or obscured. If violations result from choices being based on similarity judgments, the statistical dependence or independence of the alternatives is irrelevant in producing such behaviors. Instead, what is important is that the representation of the options fosters the appropriate set of comparisons of prizes and probabilities across alternatives. The vast majority of data presented in this paper suggests that similarity judgments and not concerns over post-decision regret are responsible for violations of expected utility.

The conclusion that individuals rely on similarity judgments to make choices has decidedly mixed implications for decision analysis. On one hand, we have seen that individuals who choose based on such judgments can make unambiguously bad decisions—assisting them to make better decisions is certainly a laudable goal. Just how to do this is, however, unclear. Traditionally, decision analysts have derived clients' utility functions by presenting them with a series of simple lotteries of the form [$\$x, p; \$0, 1 - p$] for varying values of x and asking them to state certainty equivalents for each gamble. In theory, clients respond to each of these queries by evaluating the expected utility of the lottery presented and then taking the inverse of this value to obtain a certainty equivalent. However, McCord and de Neufville (1984), among others, have shown that the shape of the utility function obtained using this procedure varies systematically with the value of p. To avoid this systematic bias, McCord and de Neufville (1986) recommend using a *lottery equivalent* elicitation method where subjects are presented with two lotteries; a reference lottery [$\$x, p; \$0, 1 - p$] where both the prize and probability are specified, and other lotteries of the form [$\$x^*, q; \$0, 1 - q$] where the value of $\$x^*$ is varied and q is left unspecified. For each pair of lotteries, clients are asked to specify the value of q that makes them indifferent between the options. These responses are then used to obtain the client's utility function. McCord and de Neufville (1986) present evidence suggesting that this procedure eliminates "much of the dependence of the utility function on the assessment probability p."

Lottery equivalent elicitation involves alternatives with an equal number of outcomes. Results reported in this paper suggest that in such cases individuals base their decisions on similarity judgments. If so, then replacing the *certainty equivalent* elicitation procedure with a *lottery equivalent* one will not provide a better estimate of a client's true utility function. On the contrary, the analysis presented here suggests that it will reveal information not about preferences but instead about the, at times, incoherent process used to make decisions.[26]

[26] Robyn Dawes, George Loewenstein, and Patrick Sileo provided valuable comments on earlier versions of this paper. Remaining errors are the responsibility of the author.

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