Research Report

FUZZY-TRACE THEORY AND FRAMING EFFECTS IN CHILDREN'S RISKY DECISION MAKING

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Abstract—*Traditional theories of cognitive development predict that children progress from intuitive to computational thinking, whereas fuzzy-trace theory makes the opposite prediction. To evaluate these alternatives, framing problems were administered to preschoolers, second graders, and fifth graders. Consistent with fuzzy-trace theory, results indicated (a) that younger children focused on quantitative differences between outcomes and did not exhibit framing effects (risk avoidance for gains, risk seeking for losses) and (b) that older children assimilated these quantitative differences and displayed framing effects.*

Because the study of decision making has important applications in a variety of fields—such as business, health, and social policy—there has been an emphasis on identifying biases that compromise the quality of decisions (e.g., Arkes, 1991). Textbooks document a growing list of such biases (Hastie, 1991), but among these, framing effects have achieved a special status. A framing effect occurs when, for example, a decision described in terms of gains elicits different preferences for risk than an objectively identical decision described in terms of losses (Table 1). Framing effects challenge a fundamental assumption of rationality—that preferences remain constant across superficial variations in the description of the same options (Tversky & Kahneman, 1986).

Despite the importance of framing, little is known of its developmental origins. The current study concerns developmental differences in (a) the effect of framing identical outcomes as gains versus losses and (b) the degree to which framing effects—changes in preferences for sure versus risky options—are modulated by magnitude of outcome and level of risk.

There are three distinct ways in which children might process outcome and risk information in framing problems. First, children might process these dimensions in a manner analogous to computing expected value or expected utility (von Neumann & Morgenstern, 1947)—by multiplying the magnitude of outcomes by their probabilities. In this case, choices would be consistent across differences in framing. Decision making, then, would resemble correct reasoning in Piagetian balance-beam or area judgment tasks: Outcomes and probabilities would be treated as compensating quantitative variables. Traditional theories of cognitive development (both Piagetian and information processing) characterize this kind of processing as the most advanced (Reyna & Brainerd, in press).

Second, a somewhat less advanced approach would involve focusing on one of the two quantitative dimensions. On the one hand, children might focus on the risk dimension, in which case preferences for the sure option would increase as the gamble became riskier. (This trend would not differ across frames, however, because the "bad" outcome in the gamble becomes more probable for both gains and losses as risk increases.) On the other hand, children might focus on the outcome dimension. This would result in a pattern we will call "reverse" framing to distinguish it from the standard pattern of greater risk seeking for losses than for gains. Reverse framing—greater risk seeking for gains than for losses—is consistent with the direction of differences between relevant outcomes. Thus, if children based their choices on outcome differences, they would prefer the gamble in the gain frame because it offers the prospect of winning more, compared with the sure outcome (and they would prefer the sure outcome in the loss frame because it offers the prospect of losing less, compared with the gamble).

Whether children focus on both dimensions, or just one, the strategies we have discussed thus far share the feature that children process the quantitatively relevant portion of the gamble. The other portion, the zero-outcome complement, literally contributes nothing that affects the quantitative value of the gamble. (The zero-outcome complement is the part of the gamble that contains the zero outcome and its probability, e.g., a 2/3 probability that no people will be saved; see Table 1.) Traditional developmental theories, as well as the expected-value model and its descendants (e.g., expected utility theory and prospect theory), predict that choices should be a function of the nonzero portion of the gamble because the zero portion drops out of the calculations.

A strategy that is at variance with all of these theories would be to base choices on the zero portion of the gamble—that is, to choose the sure option in the gain frame to avoid gaining nothing, and to choose the gamble in the loss frame to avoid losing something (as opposed to nothing). Fuzzy-trace theory's analysis of framing effects in adults suggests that such effects are due to precisely these kinds of qualitative comparisons (Reyna & Brainerd, 1991b, 1993, in press; Reyna & Fulginiti, 1992). According to fuzzy-trace theory, adults tend to base their decisions on the gist of information (within the constraints of the task). The gist of framing problems is that they offer a choice between a sure something and the possibility of nothing. When that something is gains, most people prefer something rather than nothing, and so they choose the sure option. For losses, however, nothing is better than something, so people choose the risky option. The result is the standard framing pattern (for details, see Reyna & Brainerd, 1991a).

We have so far identified three possible patterns of choices: consistency

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Table 1. *The same problem framed as gains versus losses*

Preamble	Frame: Gain	Frame: Loss
Imagine that the United States is preparing for the outbreak of an unusual disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:	If program A is adopted, 200 people will be saved. If program B is adopted, there is ⅓ probability that 600 people will be saved, and ⅔ probability that no people will be saved.	If program C is adopted, 400 people will die. If program D is adopted, there is ⅓ probability that nobody will die, and ⅔ probability that 600 people will die.

Note. Subjects are typically presented with the preamble and either the gain or the loss frame (e.g., Tversky & Kahneman, 1986).

across frames, reverse framing, and standard framing. We have also described three kinds of processing that, respectively, would produce these patterns: computing expected values (or utilities), comparing differences between nonzero outcomes, and comparing gaining something with gaining nothing or losing something with losing nothing (i.e., assimilating differences between nonzero outcomes). These three kinds of processing deviate increasingly from quantitative compensation. Hence, for traditional developmental theories, predictions are straightforward: If there are developmental differences, they should lie in the direction of increasing adherence to quantitative compensation (Siegler, 1991; Surber & Haines, 1987).

The assumption that underlies such predictions is the familiar notion that intuition gives way to quantitative reasoning during cognitive development (Piaget, 1967). However, research related to fuzzy-trace theory contradicts this assumption (Reyna & Brainerd, 1991a, 1993, in press; Swanson, Cooney, & Brock, 1993; Wedell & Bockenholt, in press; Winer & McGlone, 1993; Wolfe, 1994). According to fuzzy-trace theory, children are more likely than adults to reason quantitatively—within the limits of their computational knowledge (Brainerd & Reyna, 1992; Reyna, 1991; Reyna & Brainerd, 1993). This is because reasoning generally relies less on exact memory for informational inputs, and more on memory for qualitative gist, as development proceeds (Brainerd & Reyna, 1993; Reyna, 1992). This account raises the possibility we now explore: that decision making, rather than becoming more consistent and less biased with age, might become less consistent and more biased.

METHOD

A total of 111 children, 28 preschoolers (mean age = 4 years, 8 months), 40 second graders (mean age = 8 years, 0 months), and 43 fifth graders (mean age = 11 years, 1 month), participated in the study. Children were given two blocks of nine problems each, one block of gain-frame problems and the other of loss-frame problems. The order of presentation of blocks was counterbalanced across subjects. Within a block, problems were presented in a different random order for each subject. The nine problems in each block, shown in Table 2, were constructed by factorially combining three levels of risk (a 1/2, 2/3, or 3/4 chance to win nothing or, in the loss frame, to lose something) with three levels of outcomes (corresponding to expected values of 1 prize, 4 prizes, or 30 prizes). Expected values were the same for gain and loss problems.

The main apparatus was a large wooden spinner (radius = 9 in.), similar to those found in children's board games. Sections of red cardboard corresponding to probabilities of 1/2, 2/3, and 3/4 were placed on the spinner's blue background to convey levels of risk. Prizes (i.e., brightly colored superballs) were placed in transparent bags so that the exact number of prizes attaching to each of the possible outcomes was clearly visible (an outcome of zero was represented by an empty bag). Bags representing the outcomes of the gamble were placed directly on the appropriate sections of the spinner. After indicating their choice on each trial, children also pointed to one of seven increasingly happy "smiley faces" to indicate how much they liked their choice.

Children were interviewed individually in a quiet room in their school. They were seated opposite the experimenter at a table divided by a low barrier, with the sure option on one side of the barrier and the spinner on the other. Children were positioned centrally, at the barrier, and could survey both sides of the table easily. The task was presented as a game called "Pick the One You Want." Children were told that, at the end of the game, they would win a real prize based on their choices in the game (all children received a prize).

At the beginning of each block, children were given a sample problem in the appropriate frame to familiarize them with the procedure, especially the correct use of the rating scale. For each of the actual problems, the experimenter

Table 2. *Outcomes for presented problems with varying levels of risk*

	Risk		
Option	½	⅔	¾
	Small outcomes		
Sure	1	1	1
Gamble	2, 0	3, 0	4, 0
	Intermediate outcomes		
Sure	4	4	4
Gamble	8, 0	12, 0	16, 0
	Large outcomes		
Sure	30	30	30
Gamble	60, 0	90, 0	120, 0

reviewed the options, including the number of prizes associated with each outcome and the fact that the spinner "sometimes lands on red and sometimes lands on blue." The use of the spinner was predicated on research indicating that children can estimate relative probabilities based on the magnitudes of colored areas (Hoemann & Ross, 1982; Reyna & Brainerd, in press).

The procedure for gain- and loss-frame problems was identical except that, for losses, children were initially given an "endowment" of prizes from which the experimenter proposed to take back either a sure amount or an amount based on the outcome of the gamble. The amounts to be taken back were contained in smaller transparent bags that were inside larger transparent bags. The experimenter acted out the operation of taking back prizes by removing the smaller bags from the larger ones such that the amounts children kept were plainly displayed in front of them. The amounts to be taken back remained on the table near the experimenter's side.

RESULTS

The main questions of this study concern developmental differences in framing effects and in processing quantitative dimensions such as outcome and risk. As we have noted, children might display any one of three patterns of choices (consistency across frames, reverse framing, and standard framing), and different orders of emergence are predicted by different developmental theories.

Each grade level exhibited a distinctive pattern of preferences. First, preschoolers' choices were consistent across frames: They chose the sure option 28% of the time in the gain frame and 26% of the time in the loss frame, a nonsignificant difference. Second, for second graders, frame interacted with level of risk. They chose the gamble less often in both frames as risk increased from 1/2 to 2/3. At the highest level of risk, however, responses to gains and losses diverged in a reverse-framing pattern. Because expected values were kept constant across levels of risk, differences between nonzero outcomes increased as risk increased (see Table 2). In short, second graders were more likely to prefer the smaller losses in the sure option, but larger gains in the gamble, as disparities between outcomes increased (Fig. 1).

Finally, fifth graders showed a monotonic increase in risk aversion as the level of risk increased (Fig. 2). They were also the only age group whose choices resembled the standard framing pattern (Fig. 3). However, the pattern depended on the size of differences between outcomes. For small differences between outcomes, risk seeking was greater in the loss frame, as in standard framing; at intermediate levels, there were no differences between frames; and for large differences, the framing pattern reversed. Thus, when differences were large, fifth graders preferred larger potential gains over smaller sure gains (and smaller sure losses over potentially larger losses). When differences were small, preferences violated the direction of those differences; fifth graders were more likely to prefer smaller sure gains and potentially larger losses.

These differences were confirmed by a 3 (Grade) × 2 (Order of Blocks) × 2 (Frame) × 3 (Outcome Magnitude) × 3 (Level of Risk) analysis of variance conducted on the choices children made, as well as on their signed preference ratings. Signed preference ratings were obtained by multiplying each rating by +1 for sure choices and by −1 for gamble choices, yielding a measure of preference that ranged from +7 (strongest preference for the sure option) to −7 (strongest preference for the gamble). According to the choice analysis, frame and outcome interacted, $F(2, 210) = 7.07$, $p < .002$, as did frame, outcome, and grade, $F(4, 210) = 2.95$, $p < .03$. These interactions were also obtained in the signed preference analysis: $F(2, 210) = 7.06$, $p < .002$, and $F(4, 210) = 2.35$, $p < .05$, respectively. In addition, the signed preference analysis yielded interactions between risk and grade, $F(4, 210) = 2.62$, $p < .04$, and among frame, risk, and grade, $F(4, 210) = 2.49$, $p < .05$. Thus, each of the two-way interactions was qualified by a three-way interaction that contained grade.

Planned comparisons were then conducted for each grade to isolate developmental trends. The choice and signed preference analyses revealed identical patterns of significance: For preschoolers, none of the factors was significant. For second graders, frame interacted with risk in the choice analysis, $F(2, 76) = 3.81$, $p < .03$, and in the signed preference analysis, $F(2, 76) = 4.68$, $p < .02$. For fifth graders, there was a significant main effect of risk in the choice analysis, $F(2, 82) = 4.16$, $p < .02$, and in the signed preference analysis, $F(2, 82) = 4.39$, $p < .02$. There was also a significant frame-by-outcome interaction in the choice analysis, $F(2, 82) = 10.20$, $p < .02$, and in the signed preference analysis, $F(2, 82) = 10.05$, $p < .0002$.

DISCUSSION

Age changes in framing patterns were exactly the opposite of what traditional theories of cognitive development would predict: Consistency across frames was observed in the youngest children; re-

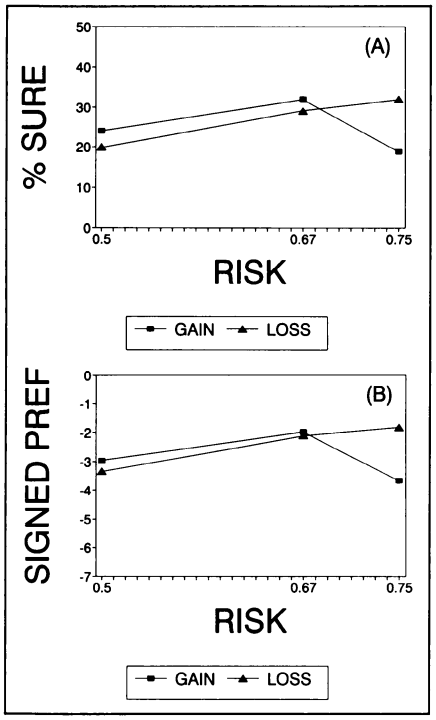

Fig. 1. Second graders' choices of the sure option (a) and signed preference ratings (b) for gain versus loss problems at different levels of risk.

verse framing (greater risk seeking for gains than for losses) first appeared in the intermediate age group; and the standard framing pattern (greater risk seeking for losses than for gains) was observed in the oldest group.

Ideally, the frame of a problem should be irrelevant because actual outcomes are identical across frames. Preschoolers' choices conformed to this ideal. Although a risk-only processing strategy would also have supported consistent choices, there was no evidence that preschoolers used such a strategy. Risk failed to produce a main effect, and failed to interact with other factors. In fact, preschoolers tended to prefer the risky option (presumably because it offered higher potential gains). Preschoolers seemed to base their choices solely on their "final asset position," rather than on the description of options as gains versus losses. This was doubtlessly facilitated by the separation of losses from final assets. (The amount to be taken back was separated from the amount to be kept.) However, this does not explain why older children were affected by a problem's frame because they were aided in the same way.

Unlike the preschoolers, second graders distinguished between gains and losses at the highest level of risk (when differences between outcomes were largest). Second graders' nonmonotonic pattern of preferences suggests that they were in conflict between fear of risk and attraction to larger potential gains (or smaller potential losses; see Lopes, 1987). The oldest children exhibited the pattern of choices at greatest variance from quantitative compensation: greater risk seeking for losses than for gains. Such a pattern is inconsistent with choosing on the basis of quantitative differences between relevant outcomes; the options that children preferred differed in the wrong direction (i.e., in the direction of smaller gains and larger losses). They displayed this pattern when quantitative differences between outcomes were small, which suggests that they were assimilating similar amounts. Thus, our results indicate that younger children focused on differences between quantitatively relevant outcomes, whereas older children assimilated those differences, consistent with the predictions of fuzzy-trace theory.

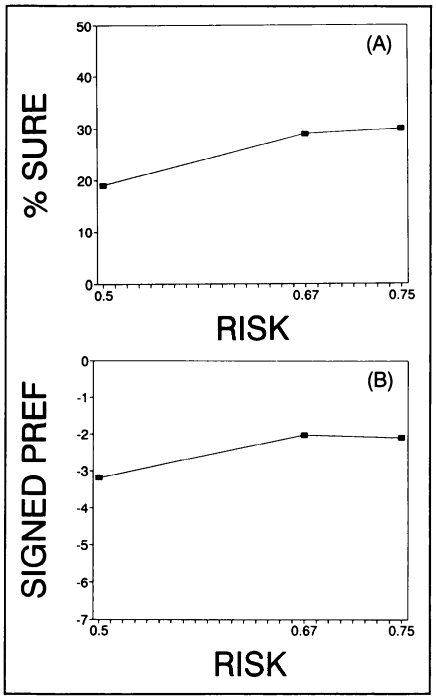

Fig. 2. Fifth graders' choices of the sure option (a) and signed preference ratings (b) at different levels of risk.

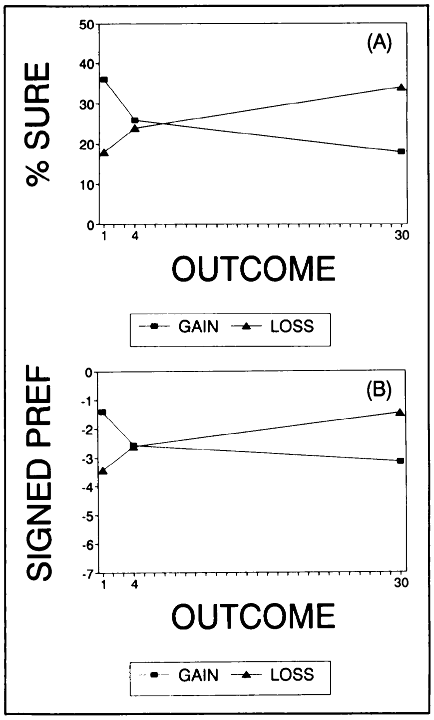

Fig. 3. Fifth graders' choices of the sure option (a) and signed preference ratings (b) for gain versus loss problems at different levels of outcomes.

Although normative models of decision making (e.g., expected utility theory) do not necessarily imply that risk aversion is superior to risk seeking, the clinical and applied literatures on decision making suggest that young people are not as risk averse as they ought to be (Furby & Beyth-Marom, 1992). There is no evidence in this study that the overall rate of risk aversion (choosing the sure option over the gamble) increases with age. However, there is evidence that older children differentiated levels of risk more consistently than younger ones. The youngest group showed no effect of levels of risk, the second graders showed a nonmonotonic trend, and the oldest group showed a clear monotonic trend in a sensible direction (i.e., they avoided the gamble more as its riskiness increased). In the sense that older children are more likely to differentiate levels of risk, our results could be construed as evidence for developmental progress. Indeed, the presumption that overall risk aversion increases with age may not be well founded (see also Quadrel, Fischhoff, & Davis, 1993). Framing effects in adults demonstrate that development does not move toward consistent risk aversion. Adults find risk highly attractive under certain circumstances. They are willing to "take chances," for instance, when options involve losses.

There were, however, developmental differences in responses to framing. Older children were sensitive to perceived losses. Whether something was taken away, not just the amount received, was important. This is not a rational distinction in the usual sense of that term. Although it seems unfathomable that younger children could be "more rational" than older children (and even adults), such findings have multiplied in recent years. In a related context, for example, Jacobs and Potenza (1991) found that young children's probability judgments were not biased by the representativeness heuristic, but use of the heuristic increased with age, and adults' judgments were inferior to those of children. Similarly, Davidson (1991a, 1991b) showed that older children were more likely to use noncompensatory reasoning strategies in decision making under certainty (i.e., that did not involve risk), compared with younger children (see also Klayman, 1985). In the present study, the framing bias, too, increased with age, and like probability judgment and decision making under certainty, risky decision making departed increasingly from the ideal quantitative model.

The classical view that cognitive development involves progress away from intuition and toward quantitative thinking has been challenged further by demonstrations that adults often engage in intuitive and qualitative reasoning (Arkes, 1991; Fischer & Hawkins, 1993). Although such findings are widely acknowledged, they are treated as anomalies of what is essentially numerical processing. According to fuzzy-trace theory, however, these findings are not anomalous. The verbatim, bottom-line orientation typical of preschoolers is gradually relinquished in favor of gist-based processing (Reyna, in press). This shift causes certain local biases to emerge, by virtue of experience, but these biases confer global increases in reasoning accuracy (see Reyna & Brainerd, 1992, in press). Thus, cognitive development can be seen as progress toward intuition, rather than away from it.

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