Judgment and Decision Making, Vol. 2, No. 4, August 2007, pp. 225-233.

Age-related differences in adaptive decision making: Sensitivity to expected value in risky choice

Irwin P. Levin*, Joshua A. Weller, Ashley A. Pederson, and Lyndsay A. Harshman
Department of Psychology
University of Iowa

Abstract

While previous research has found that children make more risky decisions than their parents, little is known about the developmental trajectory for the ability to make advantageous decisions. In a sample of children, 5–11 years old, we administered a new risky decision making task in which the relative expected value (EV) of the risky and riskless choice options was varied over trials. Younger children (age 5–7) showed significantly less responsiveness to EV differences than their parents on both trials involving risky gains and trials involving risky losses. For older children (age 8–11) this deficit was smaller overall but was greater on loss trials than on gain trials. Children of both ages made more risky choices than adults when risky choices were disadvantageous. We further analyzed these results in terms of children's ability to utilize probability and outcome information, and discussed them in terms of developing brain structures vital for decision making under uncertainty.

Keywords: risky decision making, child-adult differences, reward sensitivity

1 Introduction

A traditional goal of risky decision making studies has been to compare the incidence of risky choices between groups or experimental conditions. One particular group difference of interest is the decision making ability of children versus adults. In fact, a number of studies have found that children make more risky choices than adults (e.g., Harbaugh, Krause, & Vesterlund, 2002; Levin & Hart, 2003; Levin, Hart, Weller, & Harshman, 2007; Reyna & Ellis, 1994; Schlottmann, 2000). In the typical risky decision making study, however, the expected value of risky and riskless choice options is the same (e.g., Tversky & Kahneman, 1981), so there is nothing inappropriate per se in making risky choices. Yet, excessive risk-taking has been implicated in real-world problems encountered in childhood and adolescence (Parker & Fischhoff, 2005). In an attempt to deal with this important issue, the present study focuses on age-related differences in the ability to make advantageous decisions and avoid disadvantageous decisions.

*This research was supported by NSF Grant Nos. SES 02–17620 and SES 03–50984 awarded to the first author. The authors would like to thank Antoine Bechara for his insights on neural development related to decision-making competence. Correspondence regarding this manuscript should be directed to Irwin P. Levin, Department of Psychology, University of Iowa, E11 Seashore Hall, Iowa City, IA 52242–1407, irwin-levin@uiowa.edu, (319) 335–2451 or Joshua Weller, Decision Research, 1201 Oak Street, Eugene, OR 97401, jweller@decisionresearch.org, (541) 485–2400.

Although the study of risky decision making in children has been relatively rare, several investigators have developed "child-friendly" tasks that appear to capture developmental trends in risky decision making processes (e.g., Harbaugh et al., 2002; Reyna & Ellis, 1994; Schlottmann, 2000). Thus, they are able to address questions such as the following: At what age does the assessment of riskiness develop? At what age do children develop the capacity to utilize information about risk (probability) and outcome magnitude in evaluating choice options? Recent studies by Levin and Hart (2003; Levin, et al., 2007) illustrate these points. Using the "cups" task in which probability is conveyed simply by the number of cups from which to choose, these researchers showed that children as young as age 6 adjusted their choices on the basis of both probability and outcome information, but they made more risky choices than adults (their parents).

Levin and Hart's results, like those of earlier related studies, were confined to the case of equal expected value of choice options. Thus, for example, a sure gain of one coin was pitted against choosing from five cups, one of which contained five coins and the others zero. Although Schlottmann (2000) found that children as young as 5 years of age have a basic understanding of expected value when evaluating the riskiness of a particular decision, it is still unclear whether children actually utilize this information in order to make adaptive decisions. We test this in the present study by extending the cups task to include trials where the risky option has higher or lower expected value than the riskless or "sure thing" option (See Weller, Levin, Shiv & Bechara, in press, for parallel application of this methodology to brain-lesion patients). An auxiliary finding of the Levin and Hart studies was that children's risky choices were less affected by changes in probability level (number of cups from which to choose) than were adults'. With equal expected value between choice options, this result cannot be used to infer decision-making deficits in children. However, if children can be shown to be less responsive than adults to expected value differences between choice options, then a value judgment can be made that children of a certain age have less developed decision making skills than adults, at least in the area of risky decision making.

In order to capture this element of disadvantageous or "non-adaptive" risk taking in a controlled study, we administered a risky choice task where the relative expected value of risky and riskless choice options was varied over trials. Some trials had equal expected value for the two options; some trials had more favorable expected value for the risky option; and some trials had more favorable expected value for the riskless option. This allowed us to gauge performance not only in terms of overall risk taking but also in terms of sensitivity to differences in expected value between choice options. We use these measures of performance in a risky decision making task to differentiate between (a) choices of children of two different age groups and choices of adults and (b) choices involving potential gains and choices involving potential losses.

There is some precedence for predicting age-related developments in decision making competence. In an earlier study related to the present one in terms of children's reliance on numerical contextual cues, Jacobs and Potenza (1991) studied base rate neglect in children of different ages. Children in the first, third, and sixth grades, as well as college students, were asked questions such as "Which bike should Jim buy?" When base rate information said that most people prefer Bike A but individuating information said that Jim's neighbor prefers Bike B, the researchers report that the use of base rates to make such choices increased with age and that younger children were more apt to use idiosyncratic strategies. More examples of children's decision making competence can be found in the recent book edited by Jacobs and Klaczynski (2005). In the present study EV is akin to base rates in that it provides information regarding the relative likelihood of different events. Thus, the major new contribution of the present study is to show how children's risky decision making at two different age levels compares to adults, not only in terms of overall riskiness, but also in terms of sensitivity to expected value differences that lead risky choices to be either advantageous or disadvantageous.

1.1 Hypotheses

Hypothesis 1. Based on the assumption that risk-taking skills develop during childhood and adolescence (e.g., Jacobs and Potenza, 1991) and the specific results of Levin and Hart (2003) that children are less responsive to probability differences in the cups task than adults, we predict that children, the younger group in particular, will be less responsive than adults to expected value differences that render the risky choice more or less advantageous in the long run.

Hypothesis 2. Related to Hypothesis 1 but based on a separation of factors that contribute to expected value, we predict that the extent to which risky choices vary as a function of variations in probability and outcome magnitude will be less for children than for adults.

2 Method

2.1 Participants

Participants were 37 children of age 5–7 (range 62–86 months, mean 72.92, SD 6.44, 17 girls, 20 boys), 43 children of age 8–11 (range 97–134 months, mean 111.61, SD 15.94, 21 girls, 22 boys), and each child's accompanying parent (53 mothers, 12 fathers; 11 were parents of two children in the study and 2 were parents of three children in the study). Participants were recruited from the child research participant pool at the University of Iowa Department of Psychology. Each child-parent pair was paid $15 plus what they earned in the decision making task.

2.2 Procedure

To assess individuals' decision propensities under risk, we used a computerized version of Levin and Hart's (2003) cups task (Weller et al., in press). The cups task was originally designed to provide a simple and direct way of depicting probability by merely counting the number of cups from which to choose in risky decision making (Levin & Hart, 2003). For example, the risky option might require a choice between three cups, one of which contains coins and the other two not. The current extension included manipulation within-participants of the relative EV of the risky and riskless options, which allows the examination of a decision maker's sensitivity to contingencies that make the risky choice advantageous or disadvantageous in the long run. We are particularly interested in how children of different ages compare to adults (parents) on this measure, examined separately for risky choices involving potential gains and potential losses.

The cups task consisted of 54 trials representing 3 trials each of all combinations of 2 levels of domain (gain, loss), 3 levels of probability (.20, .33, or .50) and 3 levels of outcome magnitude for the risky option (2, 3, or 5 quarters) compared to 1 quarter for the riskless option. Some combinations of probability and magnitude created equal EV for the risky and riskless options: .20 x 5, .33 x 3, and .50 x 2 on both gain and loss trials. Some combinations were risk-advantageous in the sense that the EV for the risky option was more positive (on gain trials) or less negative (on loss trials) than the sure gain or loss of one coin: .33 x 5, .50 x 3, .50 x 5 on gain trials; .20 x 2, .20 x 3, .33 x 2 on loss trials. Some combinations were risk-disadvantageous in the sense that the EV for the risky option was less positive or more negative than the sure gain or loss: .20 x 2, .20 x 3, .33 x 2 on gain trials; .33 x 5, .50 x 3, .50 x 5 on loss trials. Gain and loss trials were presented as blocks, counterbalanced in order across participants in each group. Within a block of gain or loss trials, probability and outcome combinations were presented in random order and the left-right position of riskless and risky options was also randomized.

All participants were individually tested during a 20 minute session. Parents independently completed the exact same task as the children and were given the same instructions verbatim. The task performed by both parent and child was administered using a computer game specifically designed for this experiment. The computer task was presented as a game of chance in which participants could win or lose quarters which were displayed on the computer screen. To help simulate the effects of using real money, participants were informed that based on the final score on the computer game, they would receive actual monetary compensation determined by a points-based pay scale.

Gain trials involved the choice between an option that offered a sure gain of one quarter and another option that offered a designated probability of winning multiple quarters or no quarters. Loss trials involved the choice between a sure loss of one quarter and a designated probability of losing multiple quarters or no quarters. Participants started the block of loss trials with enough quarters in the bank to ensure that they would not end up with a losing total. On each trial, an array of 2, 3, or 5 cups was shown on each side of the screen. One array was identified as the certain side where one quarter would be gained (lost) for whichever cup was selected. The other array was identified as the risky side where the selection of one cup would lead to a designated number of quarters gained (lost) and the other cups would lead to no gain (loss). At the bottom of the screen was a depiction of a bank where coins were shown being added to (subtracted from) the decision maker's account. The outcome on each trial depended on which side was selected and, if it was the risky side, the choice of one cup determined whether quarters were added (taken away). A random process with $p = 1/(\text{number of cups})$ determined whether the risky choice led to a gain (loss). When the participant completed all 54 trials, their total amount won appeared on the screen. Participants were compensated based on the money that they won on the task.

2.3 Statistical plan

Our research design allowed two levels of analysis of decision making under risk. First, to measure how participants adapted to differences in EV between riskless and risky options, we calculated the percentage of risky choices at each of the three EV levels: risk advantageous trials (RA; the EV of the risky choice was more favorable than that of the riskless choice), equal EV trials (EQEV; the EVs for the riskless and risky option were equal), and risk disadvantageous trials (RD; the EV was more favorable for the riskless option than the risky option). These measures were computed separately for the gain and loss domain and are particularly important for identifying when children's decisions are less advantageous/more disadvantageous than adults.

Second, because we factorially manipulated probability level and outcome magnitude level for the risky option in each domain, we were able to assess how each of these components of EV independently affected risky choice. This is particularly important for understanding children's ability to utilize these two sources of information.

3 Results

3.1 Adaptive risky decision making

Figure 1 displays the proportion of risky choices for each child age group and adults as a function of EV level, plotted in separate panels for gain trials and loss trials. The elevation of lines in each panel represents level of risk-taking, the slopes of the lines represent responsiveness to expected value differences, and the differences between the two panels represent domain (gain vs. loss) effects. The major trends observed in Figure 1 are: (1) Consistent with Hypothesis 1, younger children were substantially less responsive than their parents to expected value differences on both gain and loss trials, with the net result being a much smaller difference in the proportion of risks taken on risk advantageous versus risk disadvantageous trials by the children; (2) also consistent with Hypothesis 1 but with domain-specific effects, the older children displayed results intermediate between those of younger children and adults. While they showed approximately

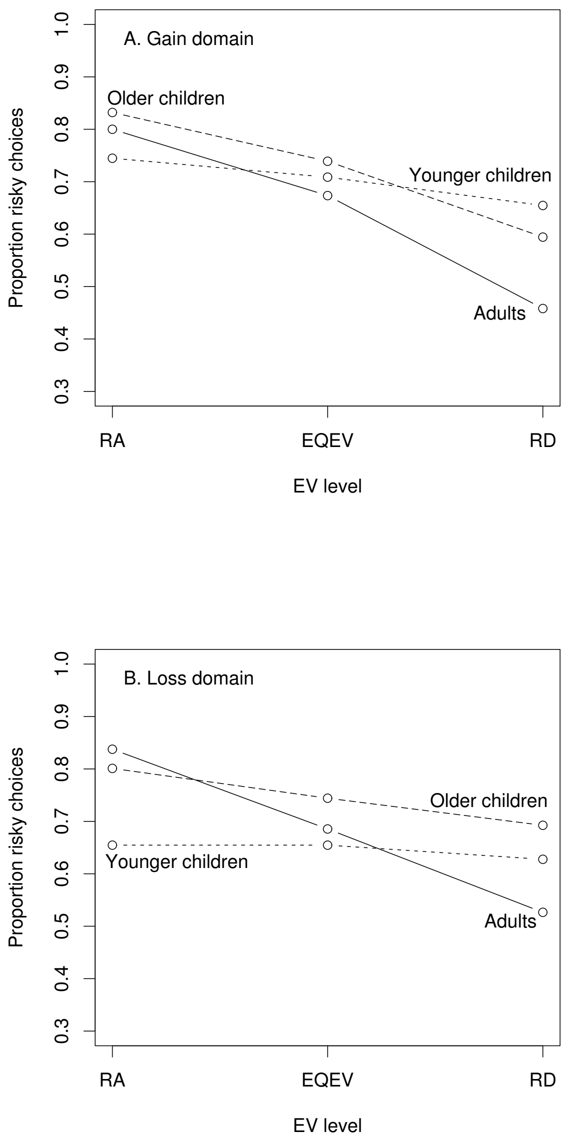

Figure 1: Adaptive decision making as a function of age, domain, and EV level. RA = Risk Advantageous trials. EQEV = Equal Expected Value trials. RD = Risk Disadvantageous trials.

the same sensitivity to EV differences as their parents on gain trials, they showed much less responsiveness to EV differences on loss trials. (3) In terms of overall risk-taking, we observed that older children made more risky choices than their parents. In contrast, we did not find that younger children's overall risk taking was greater than either their parents or older children. However, children of both age groups were especially apt to make more risky choices than their parents on trials in which it was disadvantageous in the long run to take a risk. (4) Only adults displayed the classic preference shift (Tversky & Kahneman, 1981) of more risky choices to avoid a loss than to achieve a gain across all EV levels.

Table 1: Summary of analysis of variance tests for responsiveness to EV differences

Source	df	SS	F	Significance
Age group	2, 142	0.66	1.64	.197
EV level	2, 284	4.77	57.01	$< .001$
Domain	1, 142	0.00	0.13	.910
Group x EV	4, 284	1.85	11.03	$< .001$
Group x Domain	2, 142	0.41	2.54	.083
EV x Domain	2, 284	0.21	3.57	.030
Group x EV x Domain	4, 284	0.09	0.73	.575

An ANOVA was conducted to support these observations where the factors were age group (younger children, older children, adults), EV level (RA vs. EQEV vs. RD trials), and gain/loss domain. Results are summarized in Table 1. The most important age-related results were a significant interaction ($p < .001$) between age group and EV level, and an interaction between age group and domain that approached significance ($p < .10$). Several specific contrasts were conducted to follow up these results. The age group by EV level interaction was broken down into the following four independent contrasts: younger children vs. adults on gain trials, younger children vs. adults on loss trials, older children vs. adults on gain trials, older children vs. adults on loss trials. A Bonferroni correction was applied and thus significance level was adjusted to $p < .01$. Younger children were significantly less responsive to differences in relative EV between options than adults on both gain and loss trials, $F(2, 202) = 10.60$ and 10.41, $p < .001$ for the gain and loss domain, respectively. Older children were significantly less responsive to EV level than adults on loss trials, $F(2, 212) = 6.68$, $p < .01$, but not on gain trials, $F(2, 212) = 1.99$, $p = .14$.

Furthermore, irrespective of domain, younger children were not only more likely to take risks than their parents when it was disadvantageous to do so (RD trials), $t(100) = 2.94$, $p < .01$, but they were also less likely to take risks when it was advantageous to do so (RA trials), $t(100) = -2.62$, $p < .01$. Older children took significantly more risks on RD trials than their parents $t(106)=2.85$, $p < .01$ but there was no significant difference on RA trials, $t(106)=-.30$, p=.76.

3.2 Preference shifts

With respect to domain-specific differences in risk-preference, we conducted three parallel paired-samples t-tests to examine the preference shift in children and adults. Indeed, we found that adults exhibited the traditional pattern of more risk-taking in losses ($M = 17.32$, $SD = 6.31$) than in gains ($M = 18.5$, $SD = 6.44$,$t(64) = 1.73$, $p < .05$, one-tailed). In contrast, neither child group showed such an effect, $t(36) = 1.36$ and $t(42) = .73$, ns, for younger and older children, respectively.

3.3 Responsiveness to probability and outcome information

Age-related differences in response to EV variations were further broken down into the independent effects of probability and outcome information. The factorial manipulation of probability level and outcome magnitude within each domain for each age group allowed us to examine risk taking as a function of probability level (.50, .33, .20), outcome magnitude (2, 3, or 5 quarters at stake with a risky choice), and gain/loss domain. These results, summarized in Figure 2, are supportive of H2. As plotted in Figure 2, risk taking on gain trials should increase with increasing probability and increasing outcome magnitude. Conversely, risk taking on loss trials should decrease with increasing probability and increasing outcome magnitude which in this case is negative. The slopes and separation of lines in each panel display the size of these effects for each age group-domain combination.

We start with the adults because they represent the "baseline" comparison for the children. As expected, adults show large effects of probability and outcome magnitude on both gain and loss trials. However, their responses do not conform exactly to the patterns predicted by the normative multiplicative model of probability-by-outcome (assuming that proportion of risky choices depends linearly on the EV of that choice). This model predicts a fan of lines that diverge upward to the right in the case of gains and diverge downward to the right in the case of losses (Anderson, 1991). Only the loss pattern conforms.

The panels for the younger children show an irregular pattern. On gain trials the children made the most risky choices when the amount to be won was greatest and on loss trials they made the least risky choices when the amount to be lost was greatest. As a group, however, they were clearly not responsive to differences in probability level. Consistent with our earlier analyses, the older children were like adults on gain trials, displaying differences in risk taking as a function of both probability and outcome magnitude. On loss trials they were like adults in responding to extreme outcomes, but showed irregular responding to the intermediate outcome level.

For each participant, we regressed risky choice (1 or 0) against outcome and probability of winning, separately for gains and losses. (Actually, instead of probability, we used its reciprocal, the number of cups, which provided a slightly better fit.) Note that we are not carrying out significance tests on individual participants. Rather, we

Table 2: Mean regression weights predicting risky choices as a function of age group, probability level, and outcome magnitude.

Source	Mean coefficient[1]	Standard error
Gain Domain		
Younger children		
Probability	.023	.011
Outcome	.030	.014
Older children		
Probability	.049	.011
Outcome	.056	.010
Adults		
Probability	.095	.015
Outcome	.066	.010
Loss Domain		
Younger children		
Probability	−.002	.011
Outcome	.017	.013
Older children		
Probability	.027	.011
Outcome	.031	.011
Adults		
Probability	.060	.015
Outcome	.089	.012

1. Signs are positive when participants responded according to EV.

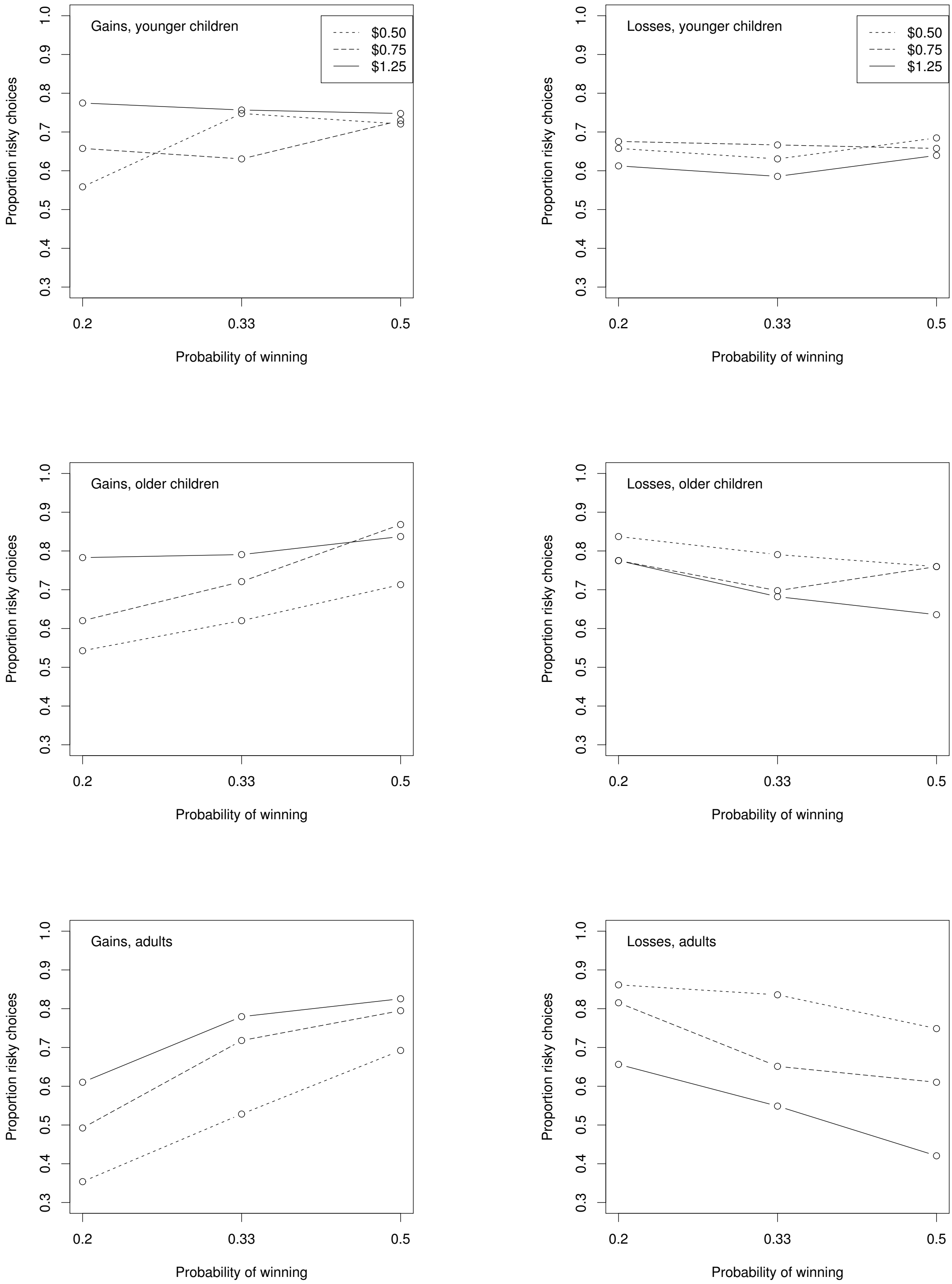

Figure 2: Risk taking as a function of outcome, probability level, and age group.

are examining these regression coefficients, which simply represent the effect of each variable on the proportion of risky choices for each participant. The independent variables were orthogonal.

Table 2 provides results, means and standard deviations, for the analyses. Upon inspection of this table, one can see several interesting trends. In the gain domain, adults, as expected, were able to adjust their choices based on variations of both probability and outcome magnitude. Older children also displayed sensitivity to these contextual cues, albeit to a lesser degree than adults, and younger children used the cues even less. Younger children did not systematically use probability or outcome magnitude when trying to avoid a loss.

In the light of these findings, we tested the degree of consistency in responses for children and adults. Children, especially the younger children, were less consistent overall. In particular, children were more likely to violate dominance. For example, if a participant chooses the gamble (in gains) for 2 cups and 2 quarters, but does not choose it for 2 cups and 3 quarters, that is a violation. The percent of violations (out of the possible violations that could occur) in the gains domain were 16%, 11% and 8% for younger children, older children, and adults, respectively. The respective percents for losses were 16%, 12% and 8%. All age differences were highly significant.

Moreover, the lack of consistency did not result at all from across-participant variability in the relative weights of probability and outcome. If anything, adults were more variable than children in the within-participant difference between the weight of probability and that of outcome, but the differences in variability were small.

Taking all the analyses together, these results demonstrate that the younger children were the most impaired in their risky decision making. They were the group least responsive to EV differences between risky and riskless choice options. At a more microscopic level, the younger children were the least responsive to changes in the components of EV, especially in probability level. This occurred both on those trials in which a risky choice could lead to a substantial loss and those trials where a risky choice had a high probability of zero gain. For older children, results were mixed. They were clearly responsive to EV differences and probability and outcome magnitude differences on gain trials. Nevertheless, when coupled with overall greater risk-taking, the result was that these children still made more risky choices than adults on risk-disadvantageous gain trials. It was in the domain of losses, however, where the responses of this group particularly deviated from those of their parents. The extent to which older children adjusted their risky choices based on EV differences was much less than their parents' adjustments. While older children showed evidence of a more refined decision strategy compared to their younger counterparts, both groups of children made substantially more than 50% risky choices even when it was disadvantageous to do so.

4 Discussion

The major contribution of this study is to directly test for age-related differences in the ability to make choices which take into account differences in expected value between choice options. Through our methodology, we uncovered differences between the way children of different ages and adults react to risky decision making. While the task was presented as a game of chance using "house money" and consequently there may have been a premium on making risky choices (see Levin et al., 2007), we nevertheless found that adults and older children made more risky choices when it was advantageous to do so than when it was disadvantageous.

As expected, adults were the most able to adjust their risk-taking based on EV differences between choice options in both gain and loss domains while the youngest age group was the least able to do this. Older children demonstrated an intermediate level of adaptive decision making. Specifically, older children displayed a sensitivity to EV differences in the gain domain, but much less so in the loss domain.

On the basis of earlier studies, the current authors (Levin, et al., 2007) and others (e.g., Harbaugh, et al., 2002; Reyna & Ellis, 1994; Rice, 1995; Schlottmann & Tring, 2005) concluded that young children possess the basic understanding and ability to consider both probability and outcome information in making risky choices. However, earlier studies did not require decision makers to discriminate between situations in which in the long run it was advantageous or disadvantageous to make risky choices. Present results, related to the earlier finding that children were less responsive than adults to changes in probability (Levin & Hart, 2003), clearly show that younger children are less able than adults to use probability information to discriminate between advantageous and disadvantageous risky choices.

These results seem to suggest a continuum from nonsystematic to systematic responding to the components of risky choice across age groups. The risk taking of adults, who were benchmarks for assessing children's decision making, clearly depended on the relative expected value of choice options and the components of EV, probability and outcome magnitude. At the other extreme, younger children showed signs of responding on the basis of an overall preference for risk, with only slight adjustment to the particular circumstances of any single risky choice even when the probability of an unfavorable outcome was great. What appears to be the case is that children and adults respond to a risky choice on the basis of an underlying attitude to seek or avoid risks which is probably primarily emotional in nature, and then adjust employing a computational process operating on probabilities and outcomes. Age-related maturation clearly affects the computational component. Results with the older children reveal the possibility that this maturation may occur at different rates for dealing with risky gains and risky losses.

Such findings concerning age-related differences in adaptive decision making can add to research in developmental neuropsychology which suggests that during childhood and adolescence there are pronounced changes in patterns of decision making which may be heavily influenced by affective processes, especially the ability to anticipate the future consequences of one's actions (Crone, Vendel, & Van der Molen, 2003). Researchers have associated these changes with functional maturation of the prefrontal cortex, which is presumed to be the latest to functionally mature (Luna & Sweeney, 2001). With such immaturity comes less ability for affective control (mediated by the ventromedial prefrontal cortex or VMPC), which may lead to impaired decision making (Bechara, Damasio, Damasio, & Lee, 1999). In fact, Weller et al. (in press) found that individuals with bilateral VMPC lesions, much like the younger children in the present study, demonstrated a pattern of non-adaptive decision making, taking risks without regards to EV differences in both the gain and loss domain of the cups task. Future research may be able to track how different stages of neural development separately impact the emotional and cognitive components of adaptive decision making.

Additionally, our results reinforce research from a variety of areas which strongly suggests that negative information and positive information involve different processing resources (for a review, see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). Our finding that both child groups performed sub-optimally in the loss domain even when older children showed signs of adult-like sensitivities in the gain domain may indicate that risk seeking in the loss domain is an early learned decision strategy (see Reyna, 1996). There are, however, situations in everyday life in which the sacrifice incurred by a sure but small loss benefits the decision maker in the long run by avoiding even larger losses. We propose that these types of decisions, like those on RD loss trials in the current study, especially rely on the ability of the individual to control an emotional reaction towards a decision involving a possible loss. For this to occur, the ventromedial prefrontal cortex must be mature and intact.

So, are children of the ages studied here poor decision makers when it comes to choices involving risk? It depends. In activities in which parents and teachers are likely to provide positive reinforcements such as trying out for sports teams or musical performances, the child's natural tendency to take risks will likely be welcome. By contrast, insensitivity to risk levels for activities with potential dire consequences such as excessive thrill-seeking or experimenting with dangerous substances may be especially worrisome with children.

References

Anderson, N.H. (1991). *Contributions to information integration theory: Vol. 1. Cognition.* Hillsdale, NJ: Erlbaum.

Baumeister, R.F., Bratslavsky, E., Finkenauer, C. & Vohs, K.D. (2001). Bad is stronger than good. *Review of General Psychology, 5,* 323–370.

Bechara, A., Damasio, H., Damasio, A. R., Lee, G. P. (1999). Different contributions of the human amygdala and ventromedial prefrontal cortex to decision-making. *Journal of Neuroscience. 19,* 5473–5481.

Crone, E. A., Vendel, I., & Van der Molen, M. W. (2003). Decision-making in disinhibited adolescents and adults: insensitivity to future consequences or driven by immediate reward? *Personality and Individual Differences, 35*(7), 1625–1641.

Harbaugh, W. T., Krause, K., & Vesterlund, L. (2002). Risk attitudes of children and adults: Choices over small and large probability gains and losses. *Experimental Economics, 5*, 53–84.

Jacobs, J. E.,& Klaczynski, P. A. (Eds). (2005). *The development of judgment and decision making in children and adolescents.* Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Jacobs, J. E., & Potenza, M. (1991). The use of judgment heuristics to make social and object decisions: A developmental perspective. *Child Development, 62,* 166–178.

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: Early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making, 16*, 397–413.

Levin, I. P., Hart, S. S., Weller, J. A., & Harshman, L. A. (2007). Stability of choices in a risky decision making ask: A 3-year longitudinal study with children and adults. *Journal of Behavioral Decision Making, 20, 241–252*.

Luna, B., & Sweeney, J. A. (2001). Studies of brain and cognitive maturation through childhood and adolescence: A strategy for testing neurodevelopmental hypotheses. *Schizophrenia Bulletin, 27*, 443–455.

Parker, A. M., & Fischhoff, B. (2005). Decision-making competence: External validation through an individual-differences approach. *Journal of Behavioral Decision Making, 18*, 1–27.

Reyna, V. F. (1996). Conceptions of memory development with implications for reasoning and decision making. *Annals of Child Development, 12*, 87–118.

Reyna, V. F., & Ellis, S. C. (1994). Fuzzy-Trace Theory and framing effects in children's risky decision making. *Psychological Science, 5*, 275–279.

Rice, C. (1995). *The Effects of Outcome Attractiveness and Framing on Children's Risky Decision Making.* Unpublished masters thesis, University of Arizona, Tucson.

Schlottmann, A. (2000). Children's judgments of gambles. *Journal of Behavioral Decision Making, 13*, 77–89.

Schlottmann, A., & Tring, J. (2005). How children reason about gains and losses: Framing effects in judgment and choice. *Swiss Journal of Psychology, 64,* 153–171.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211*, 453–458.

Weller, J. A., Levin, I. P., Shiv, B., & Bechara, A. (in press); Neural correlates of adaptive decision making in risky gains and losses. *Psychological Science*, forthcoming.