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ABSTRACT
Age differences involving decision by description versus decision by experience were examined using the same general task structure to facilitate comparisons across decision types. Experiment 1 compared younger (19–43 years) and older (65–85 years) adults in four different experimental conditions involving a choice between a low-risk, low-return bet versus a high-risk, high-return bet. Experiment 2 compared young (18–27 years) to older (60–87 years) adults using similar experimental conditions, but with decisions involving a risky versus a certain option. Contrary to expectations, minimal differences were observed between ages in either study. Higher levels of ability and numeracy were associated with better performance and greater ability to benefit from experience, but the impact of these factors was not moderated by age. The results suggest that factors other than the simple distinction between decisions by description versus experience are necessary to characterize the nature of age effects in decision-making.

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Increasing attention is being paid to understanding the impact of aging on the ability to make effective decisions for a number of reasons relating to both practical and public health concerns. Effective decision-making about finances, housing, and health are likely to have significant consequences in later life in terms of maintaining independence and decreasing the need for assistance from family, government, and other external supports. Decisions in the areas of finance and health may be particularly consequential given that, relative to younger adults, older adults may have fewer opportunities and resources to counter poor decisions. Thus, it is important to understand how aging might impinge on decision-making and to identify the contexts associated with optimal and nonoptimal decision processes in later life.

Two contexts of interest in the present study involve the distinction between decisions by description versus decisions by experience (e.g., Brand, Labudda, & Markowitsch, 2007; Hertwig, Barron, Weber, & Erev, 2004). Decision by description refers to those cases where individuals are given prior information about potential outcomes (e.g., the odds associated with winning two competing lotteries) and then asked to make a decision based on this information. In some cases, repeated decisions are made,

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all without the benefit—or perhaps hindrance—of feedback. This type of task is analogous to many real-life scenarios involving financial investments. For example, individuals may make decisions about automatic monthly contributions to a retirement fund chosen based on comparative information involving past performance (e.g., rates of return) of different mutual funds. Certainly, subsequent decisions to invest in the same funds may be based on specific experience with outcomes of their choice, but the initial decision is made without such information and based solely on descriptive information —not an uncommon event in everyday life. Alternatively, decisions by experience involve situations where no prior descriptive information is provided (e.g., investing in initial-offering stocks), with individuals relying solely on feedback from their choices to make subsequent decisions (e.g., buy more or sell the stock based upon returns on initial investment).

These two types of tasks are associated with very different outcomes, particularly as they relate to making risky decisions (for review, see Hertwig & Erev, 2009). Specifically, decisions by description are typically characterized by overweighting of small probabilities. In a situation involving choosing between two potentially positive outcomes (i.e., gains), this may result in risk aversion whereby an individual avoids selecting an option with the higher expected value (EV) by focusing on the small probability of not winning associated with that option. Alternatively, this same overweighting may result in risk-seeking in situations where the individual unduly focuses on a nonoptimal option because it contains a small probability of winning a large amount. This pattern of responding is consistent with the dominant descriptive theory of risky decision-making—Prospect Theory (Kahneman & Tversky, 1979)—which focuses on expected utility.

In contrast, decisions by experience are associated with underweighting of low probabilities, leading to the opposite responses to those just described. Thus, within a gain context, risk-seeking occurs when individuals de-value the small probability of not winning associated with a nonoptimal option, whereas risk aversion associated with an optimal choice occurs when the small probability associated with winning a large amount for that option is undervalued. The underweighting observed in decisions by experience most likely reflects the effects of limited sampling of, or rare experience with, low-probability (LP) events (e.g., Hadar & Fox, 2009; Hertwig et al., 2004), along with the emotional responses to feedback associated with experienced outcomes (e.g., Jessup, Bishara, & Busemeyer, 2008).

With respect to aging, a recent meta-analysis (Mata, Josef, Samanez-Larkin, & Hertwig, 2011) found that age differences in performance were generally greater for decisions by experience than for those by description, with older adults being somewhat more likely to take risks in the former. An implication derived from this analysis was that declines in cognitive skills and the associated ability to learn from experience may have impaired older adults' ability to assess risk and effectively use this information in guiding optimal patterns of responding in experiential decision-making tasks. Indeed, some research (e.g., Wood, Busemeyer, Koling, Cox, & Davis, 2005; Worthy, Otto, Doll, Byrne, & Maddox, 2015) suggests that, relative to young adults, older adults pay greater attention to recent choice outcomes (e.g., loss on last trial) as opposed to consideration of cumulative information regarding outcomes. In contrast, other research (e.g., Huang, Wood, Berger, & Hanoch, 2015) has found that age differences in performance were greater on a task assessing decision by description than on one assessing decision by experience, with older adults exhibiting higher levels of risk-taking than younger adults in the former. One problem in comparing age effects in all these situations, however, is the fact that different types of tasks have been used to assess performance associated with these two types of decisions.[1]

Thus, our first study was designed to obtain some initial data relating to age differences associated with these two types of decisions using variants of the same basic task. Specifically, individuals were presented with a series of choices between two risky bets, one involving a higher probability (.8) of winning than the other (.4), but also having a lower payout. Prior to the task, some participants were given relatively specific descriptive information about payoff probabilities and consideration of EV, and then proceeded to make choices across trials without receiving feedback about outcomes associated with their choices. Others were presented with the same series of choices, but without descriptive information. They did, however, receive feedback about the outcomes associated with each choice. By examining differences in success rates and types of bets (i.e., low- vs. high-risk), we were able to make a more direct comparison of young and older adults within and across decision contexts.

We were also interested in whether there were age differences in the degree to which experience moderated the impact of descriptive information on performance. Previous research (e.g., Jessup et al., 2008) found that combining trial-by-trial feedback along with initial descriptive information resulted in young adults underweighting small probabilities, similar to what occurs with decision by experience. These researchers concluded that the shift resulted from individuals developing more accurate depictions of objective probability information, which in turn appeared to influence their willingness to engage in risk-taking. If aging negatively affects the ability to benefit from experience, we would expect to see older adults exhibit less evidence of such a shift. To test this hypothesis, we included a condition in which participants received both descriptive information regarding payoff structures along with trial-by-trial feedback.

We included one additional condition to determine whether the nature of feedback would influence performance. This condition was similar to that just described, but the outcomes experienced over trials were not in line with expectations based on stated probabilities. Note that such apparent inconsistencies might occur under normal circumstances, reflecting normal variability in probability-based events. For example, investments may fluctuate in unforeseen ways over the short-term based on market conditions and thus appear to contradict expected performance data. Within the limited sampling frame of the current task, the salience of inconsistencies is likely to be heightened, and the impact on performance consequential. Thus, we anticipated that the shift toward risk-averse choices would be less than in the previously described condition combining description and experience, reflecting the experienced probabilities.

Based on previous research focused on positive outcomes (i.e., situations only involving gains and non-gains as opposed to losses), we expected that participants receiving only descriptive information would overweight the smaller probability of winning associated with the riskier bet and thus would exhibit higher risk-taking when compared to the other conditions. We also expected that feedback-based experience would result in underweighting of low probabilities, thus resulting in greater risk aversion over time. In addition, we tested the general hypothesis that age differences in performance would be greater in the situations involving experience than in the condition containing descriptive information only, with less systematic shifts in responses following feedback in the older adults.

Finally, we also assessed measures of ability and numeracy to determine whether any observed age effects might be associated with these factors. For example, normative declines in working memory and executive functions might impede older adults' abilities to benefit from experience or engage deliberative processes to calculate EVs from descriptive information. Past research has suggested that both might be associated with decision-making performance and age differences therein (e.g., Frey, Mata, & Hertwig, 2015; Sinayev, Peters, Tusler, & Fraenkel, 2015; Wood et al., 2011). Thus, we examined the extent to which performance across conditions might be differentially related to ability, and the extent to which age might moderate such effects.

Experiment 1

Method

Participants

A total of 193 community-residing adults were recruited through newspaper and Internet-based ads. All received an honorarium of $25, with an opportunity to earn an additional $5 or $10 depending upon their performance on the decision task. The young adult group (*M* age = 32.2 years; range = 19–43) included 51 women and 45 men, whereas the older adult group (*M* age = 74.4 years; range = 65–85) included 52 women and 45 men (see Table 1 for participant descriptives). Participants were randomly assigned to one of the four conditions (see below), stratified by age and sex.

Materials

Decision-making task

The primary decision task was created in our lab and consisted of four different versions corresponding to the four experimental conditions. In all conditions, participants received 60 trials consisting of two choices presented on a computer screen, a low-

Table 1. Participant characteristics.

	Experiment 1				Experiment 2			
	Young adults		Older adults		Young adults		Older adults	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age*	32.2	6.4	74.4	5.7	19.2	1.52	73.8	6.0
Education	16.2	2.2	16.0	2.3	13.1	1.3	16.8	2.4
Physical health*	49.1	6.6	45.0	8.1	42.1	4.0	42.1	3.9
Mental health*	50.4	9.7	55.4	7.1	38.9	10.4	46.7	3.7
Letter-Number Sequencing*	12.1	3.3	9.9	2.2	11.3	2.5	10.4	2.6
Digit-Symbol Substitution*	84.6	16.2	61.2	16.1	81.51	14.2	63.0	12.2
Plus–Minus Task*	27.2	18.4	35.2	21.3	-	-	-	-
Stroop Task*	14.0	7.3	24.4	10.1	–	–	–	–
Vocabulary*	50.7	8.5	53.1	8.3	18.1	4.6	26.9	6.2
Numeracy*	3.2	1.7	2.5	1.5	3.8	1.8	3.5	2.1

Different vocabulary tests were used in the two experiments, so scores reflect different scales.
*Significant difference between age groups ($p < .05$).

risk bet (A) or high-risk bet (B). Each bet varied in terms of the range of possible payout (A: \$60–\$200; B: \$100–\$450) and the probability of payoff (A = .80; B = .40). In addition, the amount associated with B was always equal to or greater than that associated with A. Thus, A was a low-risk, low-return choice, whereas B was relatively high-risk, high-return option. On each trial, participants selected one of the two bets. If the choice paid off, they would gain the amount of money associated with their choice. If the choice did not pay off, they would not gain any money. To increase motivation, players received an additional \$5 at the end of the study if they accumulated \$6,200 and \$10 if they accumulated \$6,700 in winnings.

In the experience-only (EO) condition, instructions provided only very general information, including that the two bets had different chances of winning, and that this probability would remain constant over trials. Participants also were informed that success would be predicated on them not consistently choosing bet A or B, but in learning when each bet was most advantageous. Following their choice, participants were given feedback as to whether their bet paid off, and the screen displayed the amount of accumulated winnings as well as a running tally of how many more chances out of 60 they had to achieve their goal.

In the description-only (DO) condition, participants were given two additional pieces of information about payoff structures to use in guiding their choices. First, they were informed about the payoff probabilities. Second, consistent with a rule based on EVs—(p[win] $\times$ gain) + (p[losing] $\times$ loss)—they were told that a general rule of thumb was to select B if the associated payoff was more than double of that associated with A; otherwise they should stick with A, the safer choice. (Note that since participants could not incur losses in the present case, EV would simply reduce to p(win) $\times$ gain.) Although this strategy would not always lead to a payoff, it would increase their probability of success. Participants also received no trial-by-trial feedback about the success of their individual choices but rather were simply informed of their total winnings at the end of the task.

The two other conditions—consistent experience (CE) and inconsistent experience (IE)—were essentially a combination of the two just-described conditions. Participants in each condition received the same descriptive information as those in the DO condition and also received the trial-by-trial feedback as received by those in the EO condition.

Although the frequency of payoffs for the two bets was consistent with the stated probabilities, we structured the task by predetermining (a) the pairing of bets (i.e., amounts associated with each) and (b) which bets in a pair would pay off (i.e., neither, low risk, high risk, nor both). Thus, picking bet A when it had the higher EV resulted in a win 80% of the time, whereas picking bet B when it had the higher EV resulted in a win 40% of the time. For the EO, DO, and CE conditions, success was ensured if participants adopted a strategy based on optimizing EV; by sticking to this strategy, they could win a maximum of \$7,650. In addition, adopting either a consistent low- or high-risk choice strategy would result in their winning at the most \$5,850, and thus not being able to receive the additional cash payment. In contrast, the bet pairings in the IE condition were arranged so that consistent adherence to either an EV-based, high-risk, or low-risk strategy would not result in success. Note that the probabilities associated with each type of bet were maintained across trials; however, the timing of when each type of bet would win was predetermined to ensure cumulative feedback inconsistent with the descriptive information provided. Specifically, bet A in the IE condition paid off only 67% of the time when it was appropriately selected (i.e., its EV was greater than that of the paired high-risk bet), and bet B paid off only 27% of the time when appropriately selected.

Numeracy

We included an assessment of numeracy as a potential influence on performance given that it has been shown to both be related to decision-making effectiveness (e.g., Låg, Bauger, Lindberg, & Friborg, 2014; Peters et al., 2006) and vary with age, although not consistently (e.g., Delazer, .Kemmler, & Benke, 2013; Kutner et al., 2007; Taha, Czaja, Sharit, & Morrow, 2013). Numeracy was assessed using the 7-item version of the Berlin Numeracy Test (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012), which was constructed to produce discriminability across a range of age groups and education levels. A sample question is: "Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?"

Ability

The Digit-Symbol Substitution, Letter-Number Sequencing, and Vocabulary Subtests of the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997) were used to assess processing speed, working memory, and verbal ability, respectively. Task-switching costs were assessed using a paper-and-pencil version of the Plus–Minus Task (adapted from Jersild, 1927). Participants viewed three consecutive lists consisting of 30 two-digit numbers and were instructed to add 3 to each number on the first list, subtract 3 from each number of the second list, and sequentially alternate between adding 3 and subtracting 3 from the numbers on the third list. Task-switching cost was calculated by subtracting the mean total time on addition-only and subtraction-only lists from the total time on the alternating list, with higher scores indicating less efficient performance. Finally, participants completed a paper–pencil version of the Stroop task (Stroop, 1935), in which inhibitory control is measured by subtracting mean response time of congruent trials from incongruent trials.

Procedure

Volunteers who agreed to take part in the study received background questionnaire packets in the mail, which they were asked to complete prior to testing. The questionnaire assessed basic demographic information and also included the SF-36 Health Survey (Ware, 1993) as well as several other questionnaires unrelated to the present study. Upon arrival, participants handed in their questionnaire packet and, after having given their informed consent to participate in the study, were told that the goal of the study was to understand how people use information to make decisions. They were then asked to sit in front of a computer screen to complete the decision task. Prior to coming to the lab, participants were assigned to one of the four experimental conditions. Participants were allowed to read the instructions on the screen on their own, using a response button to advance from screen to screen. They then proceeded through five practice trials and then, if they had no questions, proceeded through the 60 trials associated with the main task.

After completing the task and receiving their score, participants were asked to describe the strategy they had adopted during the task. (Due to a procedural error, only 84 younger adults and 73 older adults received this questionnaire.) They were asked what they remembered being told about choices A and B, and how they should go about adopting a strategy. Answers were recorded, and participants were then debriefed about the nature of the study. Participants then completed the ability and numeracy assessments.

Results

Sample characteristics

Age Group × Condition analyses of variance (ANOVA) were conducted on all of the background measures listed in Table 1. Age differences on these measures were consistent with trends observed in the literature. Notably, we found that numeracy scores were significantly higher in the young than in the old group. In addition, we only observed one effect involving condition: a significant Age × Condition interaction for Letter-Number Sequencing scores, $F(3, 185) = 3.16$, $p = .003$, $\eta^2_{partial} = .05$. Follow-up comparisons revealed that there were no significant differences between conditions within age groups (*ps* >.056), but that the differences between age groups were significant (*ps* <.04) for every condition except for EO ($p = .63$). We examine the potential impact of this ability later.

Performance

Winnings

Our analysis of performance focused first on total amount won using a 2 × 4 × 3 (Age Group × Condition × Trial Block [first vs. second vs. third set of 20 trials]) ANOVA (see Table 2). Note that winnings would in part reflect successful identification of the option with the highest EV. A significant condition effect was observed, $F(3, 185) = 29.58$, $p < .001$, $\eta^2_{partial} = .33$. Contrasts revealed that performance was significantly better in the DO condition than in the other three conditions, and in the CE condition than in the IE and EO conditions (which did not differ from each other). There were no significant effects due to age (*ps* >.08).

Optimal choice

Our second performance assessment examined the proportion of trials on which participants chose the option with the higher EV using a 2 × 4 × 2 × 3 (Age Group × Condition × Bet Type [low- vs. high-risk] × Trial Block ANOVA (Table 3). (Data from three young and one older adults were removed after being identified as outliers based on

Table 2. Experiment 1: mean winnings per trial block.

	Young adults			Older adults		
Condition	*N*	*M*	*SD*	*N*	*M*	*SD*
Description only	23	2,319	120	24	2,164	227
Consistent experience	24	2,130	250	24	2,157	241
Inconsistent experience	25	1,899	173	25	1,897	191
Experience only	24	2,003	209	24	1,931	173

Table 3. Experiment 1: proportion of correct bets (i.e., highest expected value).

		Young adults				Older adults			
		Low-risk bets		High-risk bets		Low-risk bets		High-risk bets	
Condition	Trial block	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Description only	1	0.91	0.10	0.85	0.16	0.69	0.34	0.73	0.29
	2	0.94	0.08	0.85	0.14	0.72	0.35	0.80	0.31
	3	0.93	0.08	0.86	0.17	0.69	0.38	0.76	0.33
Consistent experience	1	0.77	0.25	0.67	0.24	0.83	0.21	0.71	0.23
	2	0.75	0.30	0.56	0.30	0.82	0.21	0.66	0.24
	3	0.78	0.24	0.54	0.28	0.85	0.17	0.61	0.29
Inconsistent experience	1	0.78	0.25	0.72	0.27	0.68	0.25	0.66	0.28
	2	0.82	0.13	0.66	0.30	0.63	0.29	0.59	0.31
	3	0.76	0.20	0.58	0.34	0.74	0.21	0.55	0.30
Experience only	1	0.51	0.20	0.50	0.19	0.42	0.21	0.54	0.24
	2	0.59	0.18	0.37	0.19	0.51	0.26	0.50	0.29
	3	0.67	0.25	0.37	0.22	0.53	0.27	0.47	0.31

Table 4. Experiment 2: proportion of certain bets chosen.

		Young adults					Older adults				
			Low probability		High probability			Low probability		High probability	
Condition	Trial block	*N*	*M*	*SD*	*M*	*SD*	*N*	*M*	*SD*	*M*	*SD*
Description only	1	20	0.66	0.25	0.51	0.19	18	0.61	0.36	0.56	0.28
	2		0.71	0.22	0.53	0.18		0.61	0.39	0.52	0.30
	3		0.70	0.21	0.52	0.20		0.61	0.37	0.49	0.30
Description and experience	1	22	0.73	0.23	0.57	0.25	22	0.66	0.30	0.64	0.24
	2		0.83	0.23	0.46	0.28		0.79	0.27	0.52	0.34
	3		0.80	0.21	0.43	0.28		0.77	0.32	0.55	0.33
Experience only	1	21	0.69	0.11	0.42	0.18	20	0.68	0.16	0.43	0.15
	2		0.84	0.17	0.33	0.17		0.81	0.21	0.38	0.20
	3		0.84	0.22	0.32	0.19		0.84	0.19	0.37	0.26

The risky bet always had the higher expected value, so certainty responses reflect both avoidance of risk and incorrect choice.

extreme scores identified from boxplots within each Age × Condition group.) A significant effect due to condition was obtained, $F(3,181) = 31.87$, $p < .001$, $\eta^2_{partial} = .35$. This was due to the proportion of correct choices being (a) significantly greater in the DO condition than in the other three conditions and (b) significantly lower in the EO condition than in the other three conditions (*p*s <.05). Age moderated this effect, $F(3,181) = 4.38$, $p = .005$, $\eta^2_{partial} = .07$, due to younger adults making significantly ($p = .004$) more correct choices than older adults in the DO condition. No age differences were observed in the other three conditions.

One possible reason for the observed age effects may have to do with older adults having poorer memory for the decision rules as opposed to their ability to reason based on the probability information. To examine this possibility, we scored information from the follow-up questionnaire to determine whether each participant recalled the critical strategy. Excluding participants in the EO group, who were not given prior information, we found that 74% of younger adults recalled the rule compared to only 49% of older adults, $\chi^2(1) = 8.15$, $p = .004$. When controlling for this, the significant age effect in the DO condition was eliminated ($p = .08$).[2]

Participants were also more likely to choose the correct low-risk bet than the correct high-risk bet (*M*s = .72 vs. .63), $F(1,181) = 15.92$, $p < .001$, $\eta^2_{\text{partial}} = .08$. This suggests that, on average, participants were somewhat risk averse given that failure to choose a high-risk bet when appropriate implied that they incorrectly selected the low-risk alternative. This effect was moderated by age, $F(1,181) = 4.39$, $p = .04$, $\eta^2_{\text{partial}} = .02$, however, with the difference in proportion correct for low- versus high-risk bets being greater for the young (.77 vs. .63) than for the old (.68 vs. .63). This implies that older adults were making more high-risk bets than were younger adults. One potential reason for this is that, due to their poorer performance in accumulating winnings, older adults may have been more likely to either increase or maintain the choice of high-risk bets in order to make up ground. Age did not interact with bet types over trial blocks, however, providing little support for this hypothesis.

Significant Bet Type × Trial Block, $F(2,362) = 16.92$ $p < .001$, $\eta^2_{\text{partial}} = .09$, Condition × Trial Block, $F(6,362) = 2.42$ $p = .03$, $\eta^2_{\text{partial}} = .04$, and Condition × Bet Type × Trial Block, $F(6,362) = 2.91$, $p = .009$, $\eta^2_{\text{partial}} = .05$, interactions were also obtained. Examination within conditions revealed no variation across bet types or trials in the DO condition. In contrast, significant Bet Type × Trial Block interactions were observed in the other three conditions. In all the three conditions, identification of the correct high-risk bet declined over trials. In contrast, identification of the correct low-risk bet remained stable in the CE and IE conditions, but increased in the EO condition. These trends suggest that participants in these three conditions became more risk averse over time, a trend consistent with expectations from the literature whereby experience leads to undervaluing LP outcomes.

Risk-taking

To more specifically focus on the differences in risk-taking suggested by the foregoing analyses, we examined proportion of times the risky bet was chosen—irrespective of correctness—using a 2 × 4 × 3 (Age × Condition × Trial Block) ANOVA, excluding the outlier data of two older adults. Significant effects were observed due to trial block, $F(2,366) = 16.06$, $p < .001$, $\eta^2_{\text{partial}} = .08$, and its interaction with condition, $F(6,366) = 3.30$, $p = .004$, $\eta^2_{\text{partial}} = .05$. These effects reflected the fact that risk-taking declined over trials in all conditions involving feedback—especially in the EO condition—but remained stable in the DO condition. In addition, risk-taking in the DO condition was generally higher than in the other three conditions, with this difference increasing over trial blocks. Although the older adults numerically made more risky bets than did younger adults (.47 vs. .43), this difference was not significant.

Numeracy

We next examined the impact of numeracy on performance, focusing on the optimal choice data given that this is assumed to be reflective of risk assessment, which is likely to be related to numerical abilities. To do this, we entered numeracy scores as an additional continuous variable in a general linear model (GLM)-based ANOVA, which allowed us to examine both main effects and interactions involving this variable. The only significant numeracy effect obtained was a main effect, $F(1,177) = 5.41$, $p = .02$, $\eta^2_{\text{partial}} = .03$, with numeracy positively associated with better decisions ($r = .22$).

Additionally, all previously observed effects remained significant with inclusion of this variable in the analysis.

Ability

We also examined general ability-related influences on performance. To do so, we obtained a composite ability score by performing a principal component analysis on Letter-Number Sequencing, Digit-Symbol Substitution, Plus–Minus, and Stroop Interference scores. This analysis identified a single component that accounted for 53.7% of the variance, which was used to construct factor scores. Once again using a GLM-based ANOVA, we examined the proportion of optimal choices selected while including ability scores as an additional, continuous factor.[3] This resulted in significant effects due to ability, $F(1,172) = 5.34$, $p = .02$, $\eta^2_{partial} = .03$, and its interaction with condition, $F(3,172) = 2.91$, $p = .04$, $\eta^2_{partial} = .05$. This reflected the positive association between the overall accuracy and ability ($r = .14$), but this relationship was only significant within the IE condition ($r = .42$, $p = .001$); correlations within the other conditions ranged from −.06 to .24. Also, inclusion of ability as a factor did not diminish the strength of the Age × Condition interaction, $F(3,172) = 5.20$, $p = .002$, $\eta^2_{partial} = .08$.

Discussion

This experiment was designed to provide an initial examination of age differences in decision by description and decision by experience within a common task structure. Consistent with expectations, we found that decision-making behavior varied as a function of the presence or absence of both descriptive information and feedback. Specifically, those participants receiving only descriptive information without feedback tended to overweight small probabilities relative to those who did receive feedback—with or without descriptive information—resulting in higher levels of risk-taking. Feedback resulted in underweighting of small probabilities and an associated increase in risk-averse behavior in the present task, with this aversion increasing over trials. (Note that this effect is specific to the probabilities used in the present task. As we demonstrate in Experiment 2, feedback may result in increased risk-taking in other situations involving different probabilities.)

With respect to age, we had predicted that age differences would be greater in the EO condition than in the DO condition. In fact, we observed the opposite. These findings appear inconsistent with the recent meta-analysis (Mata et al., 2011) and with the expectation that normative reductions in cognitive functioning would negatively impact older adults' ability to benefit from experience (e.g., feedback about outcomes). Instead, it appeared that older adults' worse performance in the DO condition was related to ability, reflected in poorer memory for descriptive information regarding rules for use of EV provided at the beginning of the task. The obtained age effect is also consistent with perspectives that argue that aging is associated with a decline in the ability to maintain contextual goal-related information in mind during task performance (e.g., Braver & Barch, 2002).

A potential issue regarding the ability to draw conclusions about aging and decision by description versus experience has to do with the nature of the descriptive information provided in our study. Although not always the case, many studies that might be classified as examining decision by description simply provide statistical probabilities without the somewhat more extensive guidance given in our study regarding use of EV information. Thus, the observed age difference may not reflect differences in ability to effectively use probability information, but rather variation in memory for and application of the provided decision rule. Whereas this additional information may have influenced performance, it is important to note that the differences observed between the DO and EO conditions were similar to those observed elsewhere in the literature (e.g., overweighting LP outcomes in the former). The addition of feedback to descriptive information also resulted in a change toward underweighting LP outcomes similar to that observed elsewhere (Jessup et al., 2008). These findings suggest that the influence of these two types of information is similar to that observed previously, thus increasing the validity of our results regarding age differences in decision by description versus experience.

Higher levels of numeracy and ability were both associated with better risk assessment, although the latter factor only reliably predicted performance when descriptive information and feedback were inconsistent. In addition, age did not moderate the impact of ability. The absence of ability and associated age effects when participants received only feedback was somewhat surprising. It is reasonable to think that those with greater ability would be able to benefit more from the feedback provided in an ill-structured learning environment. It is possible that age-related ability effects were masked by the relatively advantaged nature of our sample. We did obtain some evidence regarding the benefits of experience with respect to feedback in that ability was positively associated with success when feedback was inconsistent with descriptive information. Given that our ability assessments tapped into processes associated with executive functions, one potential explanation of this effect is that participants were better able to control the influences of affective feedback on subsequent choices. Note that continued focus on EV when making decisions in this condition would actually lead to worse outcomes in terms of earnings. Indeed, when the association between ability and winnings was examined, a small negative association was associated with performance in the IE condition (r = –.02) compared with positive associations in the other three conditions (rs = .04–.31).

Experiment 2

Given the somewhat unexpected findings and potential complications associated with the descriptive information provided in the first study, we decided to conduct a second study using a more straightforward approach in which descriptive information simply consisted of information about two lotteries. No information was given regarding use of this information (e.g., decision rules). We also modified the nature of these probabilities to examine potential differences in responses to bets that vary in terms of degree of risk. Specifically, we used lotteries contrasting a certain gain with an uncertain one, with the risky lottery varying in degree of risk. In both cases, the risky bet was associated with a somewhat greater EV. Following the lead of Jessup et al. (2008), however, we also used two different risky bets, one in which overweighting of small probabilities would lead to the certain option being preferred versus one leading to preference for the risky option. Importantly, this eliminated the possibility that covariation between risk and EV might have contributed to the results obtained in Experiment 1, which also eliminated a potential alternative explanation for the obtained pattern of age effects. Finally, we kept the actual lotteries (i.e., probabilities and outcomes) relatively constant across trials. This reduced variation across trials in factors such as the potential winnings or differences in potential rewards between lotteries, which further eliminated possible confounds in examining the impact of description and experience on performance.

Method

Participants

The old group comprised 30 men and 30 women aged 60–87 years, who were recruited as in the first experiment and received a $20 honorarium for their participation. The young adult group comprised 28 men and 35 women aged 18–27 years who were undergraduates at North Carolina State University and fulfilled a course option through participation. All participants earned an additional $4 after completing the decision task. Participants were randomly assigned to one of the three conditions (see below), stratified by age and sex.

Materials

Gambling task

We created a computer-based betting task similar to that used in Jessup et al. (2008). Specifically, there were two 60-trial blocks, with each trial pitting a risky bet against a certain option. In the high-probability (HP) condition, a certain option—100% chance to win $0.03—was paired with a HP risky option with a higher EV—80% chance to win $0.0375–$0.0425 vs. 20% chance to win nothing. In the LP condition, we paired the same certain bet with a LP risky option with a higher EV—5% chance to win $0.60–$0.66. Within each condition, participants made repeated choices between the certain option and the five variants of the risky option, each of which was presented 12 times within the block of 60 trials. We varied the amount of the risky bet slightly across trials to help maintain interest.

Ability and numeracy

We once again administered the WAIS-III Digit-Symbol Substitution and the Letter-Number Sequencing tasks in order to assess processing speed and working memory. We also used the vocabulary test V-2 from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1976) to assess verbal ability. The Berlin Numeracy Test (Cokely et al., 2012) was used again to assess numerical ability.

Procedure

Participants gave their informed consent to participate in the study upon entering the lab. Experimenters provided information about the goals of the study before allowing participants to complete background questionnaire packets which assessed basic demographic information, and included the SF-36 Health Survey (Ware, 1993) as well as other questionnaires unrelated to the current study. Following completion of the background questionnaire packets, participants sat in front of a computer screen in order to complete the gambling task.

We assigned participants to one of the three experimental conditions prior to each session. We instructed participants across conditions that they would make a series of decisions that involved two choices involving different chances to win different amounts of money, and that they should choose one of the two options with the highest potential payoff on each trial. In the DO condition, instructions informed participants that they would see information about the possible outcomes and the probabilities associated with actually winning these outcomes on each trial. Whereas participants in the DO condition received feedback about which choice (e.g., "A" or "B") they made on each trial, they did not have the opportunity to learn whether their choices paid off. Participants in the EO condition did not receive the descriptive information that those in the DO condition received but instead were instructed to simply make a choice between "A" and "B." Individuals in this condition, however, did receive feedback not only about which choice they made on a particular trial, but also about the outcome (e.g., "You won \$0.03") of their choice. Finally, participants in the description with experience (DE) condition saw the same descriptive information viewed by those in the DO condition prior to making a choice and then received the same type of feedback after each trial as did those in the EO condition. To increase engagement, participants were informed that they would get to keep all of the money that they won. (The maximum amount that could be earned was \$4, and all participants were given this extra \$4 at the end of the study regardless of performance.) All participants learned about their total winnings at the end of the task. Note payoffs were randomly distributed across trials, with the payoff schedule conforming to the actual probabilities (e.g., the risky bets in the LP condition paid off 5% of the time).

Participants initially completed five practice trials before proceeding to the first 60-trial block. Upon completion of this block, participants were administered the vocabulary test. They then proceeded through the second block of 60 trials in the main task. We counterbalanced the order of the LP and HP trial blocks across participants so that approximately equal numbers of participants across age groups and experimental conditions saw either LP or HP bets first. In addition, the certain bet appeared on the left side of the screen for half of the participants and the right for the other half. Following the second trial block, participants completed the numeracy, Letter-Number Sequencing, and Digit-Symbol Substitution tests. Finally, experimenters debriefed participants about the nature of the study at the conclusion of the session.

Results

Sample characteristics

Age × Condition ANOVAs were performed on each of the background variables listed in Table 1 to determine if there were any inadvertent differences across conditions that might complicate interpretation of condition effects. The only significant effect involving condition that was observed was a significant interaction for numeracy, $F(2,117) = 3.13$, $p = .047$, $\eta^2_{partial} = .05$. This was due to scores in the young group being somewhat higher in the EO condition ($M = 4.2$) than in the DO and DE conditions (Ms = 3.7 and 3.6, respectively), whereas scores in the old group were higher in the DO condition ($M = 4.4$) than in the DE and EO conditions ($Ms = 3.2$ and 2.9, respectively). Inclusion of this variable as a covariate in the analyses below, however, did not affect the results.

Performance

The dependent variable employed in our analysis was the proportion of times the certain option was chosen within each block of 20 trials (see Table 4), which we examined using a 2 × 3 × 2 × 3 (Age Group × Condition × Probability [high vs. low] × Trial Block) ANOVA. (No effects associated with order of presentation of the probability conditions were obtained when included as a factor in the analysis.) Note that underweighting of small probabilities with feedback would be associated with increases in selection of the certain option in the LP condition and a decrease in the HP condition. A significant main effect of probability was obtained, $F(1,117) = 118.58$, $p < .001$, $\eta^2_{\text{partial}} = .50$, along with the following interactions: Condition × Probability, $F(2,117) = 11.73$, $p < .001$, $\eta^2_{\text{partial}} = .17$; Probability × Trial Block, $F(2,117) = 32.48$, $p < .001$, $\eta^2_{\text{partial}} = .22$; and Condition × Probability × Trial Block, $F(4,234) = 4.50$, $p = .002$, $\eta^2_{\text{partial}} = .07$. To better understand the obtained interactions, we focused on analyses within each information condition. For the DO condition, the only significant effect was due to probability, $F(1,36) = 21.90$, $p = .008$, $\eta^2_{\text{partial}} = .18$, with the certain option being chosen less in the HP than in the LP condition ($Ms = .52$ vs. .65, respectively). As would be expected in the absence of feedback, there was no reliable change over trials. In the EO condition, a significant Probability × Trial Block interaction was obtained, $F(2,78) = 21.90$, $p < .001$, $\eta^2_{\text{partial}} = .36$. This was due to the expected diverging trends over trials across probability levels, with focus on certainty increasing in the LP condition, but decreasing in the HP condition. A Probability × Trial block interaction was also obtained in the DE condition, $F(2,84) = 18.37$, $p < .001$, $\eta^2_{\text{partial}} = .30$, reflective of a similar pattern of change.

Of main interest was the fact that there were no significant effects involving age. The only effect approaching significance was an Age × Probability interaction, $F(1,117) = 3.51$ $p = .06$, $\eta^2_{\text{partial}} = .03$, due to the difference between LP and HP conditions being greater for the young (.75 vs. 46) than for the old (.71 vs. .50): $F(1,120) = 125.36$, $p < .001$, $\eta^2_{\text{partial}} = .68$, vs. $F(1,114) = 29.32$, $p < .001$, $\eta^2_{\text{partial}} = .34$.

Although the pattern of change observed following feedback was as expected, the higher rates of choosing the certain option when paired with the LP risky bet—regardless of condition—was inconsistent with expectations and past research. The reasons for this are unclear but may reflect the fact that participants experienced only high- or low-risk bets within each trial block. If these bets had been intermixed within trials, greater conformity to expectations might have been achieved.

Numeracy

As before, we added numeracy score as a continuous variable to our GLM-based ANOVA. The only effect to emerge was a main effect of numeracy, $F(1,111) = 6.45$, $p = .01$, $\eta^2_{\text{partial}} = .06$, with individuals who were low in numeracy being more likely to select the certain option regardless of condition ($r = -.26$).

Ability

Using the same procedure as in the first experiment, we once again obtained a composite ability score based on a principal component analysis of Digit-Symbol Substitution and Letter-Number Sequencing scores—which were positively correlated (r = .33, p < .001) —and then entered this into the GLM-based ANOVA as a continuous variable. A significant Ability × Condition × Trial Block interaction was obtained, $F(4,222) = 3.21$, $p = .02$, $\eta^2_{partial} = .06$, along with a marginal Ability × Condition × Probability × Trial Block interaction, $F(4,222) = 2.19$, $p = .07$, $\eta^2_{partial} = .04$. Teasing apart this interaction by examining ability effects within conditions revealed that the effect of ability was specific to the DE condition in response to LP bets. Specifically, low-ability individuals exhibited a pattern that was similar to that observed for the sample as a whole (i.e., increases in selection of certainty across trials). In contrast, there was little change in the probability of choosing the certain option in the high-ability participants in the DE condition. In other words, their performance was very similar to those in the DO conditions, with feedback having minimal effect on choices over trials.

Discussion

Using a more traditional approach, the results of this study essentially replicated those of the previous one in showing that age differences in decision by experience and description were minimal. We did find some influences associated with ability. Specifically, those individuals with poor numerical skills were more likely to select the certain option—regardless of condition—than were those of higher ability. This suggests that numeracy is associated with the ability to assess risk, with those individuals lower in this ability being less sensitive to EV. In addition, general ability factors were also associated with performance, but only when descriptive information was paired with feedback. Notably, age did not moderate any effects associated with ability.

General discussion

Extant research has presented conflicting evidence regarding the impact of aging on decisions by description versus decisions by experience. Some have suggested that age-related declines in executive skills and other cognitive abilities would have a disproportionate negative impact on older adults' ability to benefit from experience (e.g., Mata et al., 2011). Alternatively, others have suggested that relative preservation of mechanisms associated with processing affective information and declines in deliberative processes would lead to just the opposite trend, with older adults maintaining relatively high performance on experience-based tasks, as opposed to description-based tasks (e.g., Huang et al., 2015). A concern with previous investigations has to do with the fact that aging research examining decisions by description versus experience has used different tasks to examine each. As pointed out by Mata et al. (2011), this introduces task-specific confounds which complicate simple comparisons. In the present research, we attempted to deal with the concern by examining the effects of descriptive information and feedback within the same task structure.

We found little evidence that older adults were different from young adults in their use of descriptive information and feedback in making decisions. There was some suggestion in Experiment 1 that older adults performed worse when making decisions by description, but the effect appeared to be related to age differences in the consistency of applying a decision rule as opposed to assessing risk. When the task was restructured to eliminate specific guidance regarding decision criteria, this age difference was eliminated.

We did observe some effects relating to ability. Based on previous research suggesting that numeracy is an important factor in risk-taking and the ability to assess risk (e.g., Jasper, Bhattacharaya, Levin, Jones, & Bossard, 2013), but that this ability declines with age in later adulthood (e.g., Bruine De Bruin, McNair, Taylor, Summers, & Strough, 2015; Wood et al., 2011), we explored the impact of this factor on performance as well as its possible association with age effects. In both studies, we found that numeracy was positively associated with risk assessment. In Experiment 1, those high in numeracy were more likely than those low on this ability to choose the option with the higher EV. A similar trend was observed in Experiment 2, where numeracy was negatively associated with the probability of choosing the certain option. Given that the certain option always had a lower EV than the risky option, this again indicates that numeracy is positively associated with risk assessment. Older adults in both experiments had significantly lower numeracy scores—although the differences between groups were not numerically great—which, given the just-described effects associated with numeracy, might have been expected to lead to age differences in performance. The absence of age effects, however, suggests that other factors may counteract poorer numeracy in maintaining levels of performance in the older groups.

Ability measures reflective of executive skills and working memory were also associated with performance, although the effects were specific to conditions involving both description and feedback. In general, those high in ability were less likely than lower-ability individuals to be influenced by feedback. Specifically, whereas lower-ability individuals shifted their choices to less advantageous options (i.e., lower EV) with feedback, high-ability individuals were more likely to continue to use the descriptive information effectively in making choices. As with numeracy, it is interesting that age effects were not observed in performance even though young and older adults differed in ability, which did influence performance.

There are at least two possible explanations for the lack of age effects in our EO conditions. First, older adults showed a greater tendency toward risk-taking. Regardless of age differences in the ability to benefit from feedback, the greater willingness of older adults to make high-risk bets increases the probability of their making such bets when appropriate. This would counteract potential learning deficits, and, taken along with younger adults becoming more risk averse over trials, potentially account for the absence of age effects in this condition. Second, to a similar extent, both young and older adults may have achieved the same level of performance in our task by using qualitatively different strategies that placed differential importance on deliberative and experiential processes. Although we did not assess the use of these two processes explicitly, young adults tended to use descriptive information in order to assess risk more effectively in description conditions in the absence of feedback, whereas older adults tended to fare better in situations where they could rely on experience. These trends may suggest that young adults could have more easily and efficiently marshaled their cognitive resources in the absence of feedback, but that older adults may have employed compensatory strategies which allowed them to capitalize on affect-based and experiential knowledge or biases when feedback was available, leading to generally similar levels of performance. Moreover, if the extent to which older adults exhibit more risk-seeking or risk aversion depends upon the criterion for success in a given task (Mata et al., 2011), compensatory strategy use may well have a meaningful impact, over and above learning, on decision outcomes in experience-based situations by serving to mitigate differences between young and older adults.

Our findings should be viewed with a few caveats in mind. The task we used focused solely on gains versus non-gains, whereas many other tasks involve losses. Observed age differences in risk assessment may reflect, at least in part, the domain in which risk-taking is assessed (e.g., Frey et al., 2015; Mather et al., 2012; Yechiam & Telpaz, 2013). Additionally, our task involved a choice between two options and did not allow participants in the experience conditions to freely sample the payoff distributions of the two options for each bet pair before they made their final choice. Concerning sampling, we saw some evidence that individuals underweighted LP options in experience conditions (e.g., Hertwig et al., 2004; Jessup et al., 2008), but age differences in performance may have been reduced to the degree that the sampling frame influenced the impact of learning and risk assessment on choices. Differences between our task and those used in other studies in terms of demands placed on cognitive ability may have attenuated possible age differences. Frey et al. (2015) showed that impairments in fluid ability negatively influenced search effort, particularly among older adults, when multiple (i.e., greater than two) options were available in a decision problem. In effect, when compared to tasks that involve choices with many alternatives, our task may have placed fewer demands on cognitive resources by eliminating the opportunity—and the need—for search effort. Lastly, we cannot make conclusions about decision-making processes involved in decisions by description versus experience among middle-aged individuals based on our extreme age groups design. Thus, some avenues for future research include examining deliberative and experiential decision-making in the context of losses, employing tasks with a larger number of alternatives, considering a broader range of cognitive functions as predictors of performance, and investigating these ideas in a lifespan adult sample.

In conclusion, the present results suggest that the distinction between tasks involving decision by description versus experience may not be very useful in predicting age effects. Instead, such effects may depend more on other aspects of the task structure, such as the extent to which the reward structure is congruent with age-related biases. Additional factors may complicate the issue even further, such as whether the task involves choices that include a no-risk or certain alternative (e.g., 50% chance of winning $100 vs. $0, or a 100% chance of getting $40). In such cases, the greater risk-seeking by older adults observed in other cases involving large rewards may be counteracted by the opportunity to engage in no risk. Indeed, there is some research showing that older adults become more risk averse in gain settings when certain outcomes are available (e.g., Boyle, Yu, Buchman, & Bennett, 2012; Mather et al., 2012; Weller, Levin, & Denburg, 2011), although these effects are not consistent across tasks or gain versus loss domains (see Hess, 2015). This reinforces advocacy for a more contextual perspective on aging and decision-making, in which an understanding of task factors in relation to age differences in affective, cognitive, reward-sensitivity, and other factors must be considered.

Notes

1. Mata et al. (2011) also note variations in age effects across tasks within decision types, complicating our ability to make strong conclusions regarding aging-related influences.
2. Reducing the sample to the 157 participants who completed the posttest questionnaire did not affect the results of our previous analyses, suggesting that the effects associated with rule memory could not be directly attributed to changes in the underlying sample.
3. One younger adult outlier on ability was excluded.

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