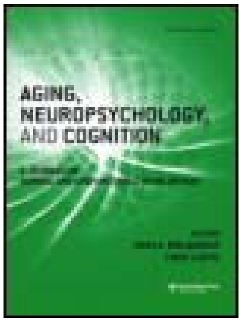

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Age differences in risk taking: now you see them, now you don't

Jenna M. Wilson [a], Barış Sevi [b], JoNell Strough [a] and Natalie J. Shook [a,b]

[a]Department of Psychology, West Virginia University, Morgantown, United States; [b]Department of Psychological Science, University of Connecticut, Storrs, United States

ABSTRACT

Older age has often, but not always, been associated with less risk taking. Inconsistencies may be due to diversity in the risk-taking measures used and/or individual differences in cognitive abilities. We investigated the robustness of age differences in risk taking across three measures, and tested whether age differences in risk taking remained after accounting for cognitive abilities. Younger (aged 25–36) and older (aged 60+) adults completed behavioral (i.e., Balloon Analogue Risk Task, BART) and self-report (i.e., framing tasks and Choice Dilemmas Questionnaire) measures of risk, as well as several measures of cognitive ability (i.e., analytic thinking, numeracy, processing speed, memory, and attention). Older adults showed significantly less risk taking than younger adults on the behavioral measure of risk, but not on the two self-report measures. Older adults also had significantly lower analytic thinking, slower processing speed, and worse executive control compared to younger adults. Less risk taking on the BART was associated with lower analytic thinking and numeracy, slower processing speed, and worse shifting of attention. Age differences in risk taking on the BART remained after accounting for older adults' lower scores on tests of cognitive abilities. Implications for measuring age differences in risk taking are discussed.

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Risk taking; cognitive ability; aging; decision making

As people age, they are increasingly faced with health and financial decisions that entail risky, or uncertain outcomes (Hershey et al., 2015; Morrow & Chin, 2015). Generally, older age has been associated with less risk taking (Josef et al., 2016; Mamerow et al., 2016; Mata et al., 2016). However, this is not always the case. Some studies have shown that older adults are more or equally willing to take risks relative to younger adults (Chou et al., 2007; Mather et al., 2012; Wang et al., 2001; Weller et al., 2011). This inconsistency may reflect measurement differences in risk taking (see Mata et al., 2018, for a review). Alternatively, or in addition, inconsistencies may stem from variability due to sampling. When age differences in risk taking are found, some have suggested they reflect age-related declines in cognition (Mata et al., 2011). Potentially, then, inconsistencies may stem from variability in cognitive abilities across samples. Most studies have not included both multiple measures of risk taking and cognitive

CONTACT Jenna M. Wilson jw0097@mix.wvu.edu
Supplemental data for this article can be accessed here.

abilities. To address these limitations, we used existing data from a sample of older (60 years or older) and younger (25–36 years) adults who completed multiple risk taking and cognitive ability measures. We tested the consistency of age differences across risk-taking measures and whether controlling for cognitive abilities eliminated age differences in risk taking.

Risk-taking measures and age

The Balloon Analogue Risk Task (BART; Lejuez et al., 2002) is a commonly used behavioral measure of risk. It predicts real-life risk-taking behaviors including average number of cigarettes smoked daily, harmful consumption of alcohol, gambling, sexual intercourse without a condom, infrequent seatbelt use, and delinquency (Lauriola et al., 2014; Lejuez et al., 2003). The BART requires participants to inflate a virtual balloon. With each pump, they receive a token, but the balloon may pop with each pump. If the balloon pops, participants lose the tokens accumulated for that balloon. Older adults have consistently been found to take less risks relative to younger adults on the BART (see Mata et al., 2011, for a review).

The framing task is a commonly-used self-report measure of risk that presents a choice between a "sure thing" and a "risky" option using either gain (e.g., 60% of lives saved) or loss (e.g., 40% of lives lost) wording to "frame" options that are objectively the same (Tversky & Kahneman, 1981). Choices about hypothetical monetary gambles framed as gains or losses match choices about real monetary earnings (Kuhberger et al., 2002). There is mixed evidence of age differences in risk taking on framing tasks (see Strough et al., 2011, for a review). One meta-analysis found no evidence of age differences in risk taking for gain or loss frames (Mata et al., 2011). However, another meta-analysis found that when options were framed as gains, younger adults were more likely to choose the risky option than older adults (Best & Charness, 2015). When options were framed as losses, younger adults were also more likely to choose the risky option, but only for scenarios about mortality, suggesting that age differences may depend on the scenario. Recent research showed that gain/loss framing about mortality elicited high-emotional arousal relative to money-gambling framing tasks, which further demonstrates how inconsistencies in the framing effect across studies may be attributed to the use of differing scenarios (Pu et al., 2017).

A few studies have considered age differences in the Choice Dilemmas Questionnaire (CDQ; Kogan & Wallach, 1964), with varied results. The CDQ is a widely used self-report measure that assesses risk taking (e.g., Chou et al., 2007; Forgas, 1982). Respondents are presented with a scenario about a character who is facing a life dilemma and must choose between two options varying in risk and reward. Respondents imagine themselves in the position of the character in each scenario, and indicate the probability of success of the riskier (but more rewarding) option they view as necessary to choose it. Two studies showed that older age was associated with less risk taking (Vroom & Pahl, 1971; Wallach & Kogan, 1961), but another found no age differences (Okun et al., 1980). It is important to note, however, that older age was not well-represented in two of the three studies. Although Wallach and Kogan (1961) specifically assessed risk taking in older adults (M_{age} = 70 years), in Okun et al. (1980), the average age was 46 years (SD = 18.50, range = 18–78 years), and in Vroom and Pahl (1971), the mean age was 39 years

(*SD* = 6.79, range = 22–58 years). Thus, there remains a need to further explore age differences in risks assessed by the CDQ in samples that include older adults 60 years and older.

Most studies of age differences are based on a single measure of risk, so it is difficult to discern the extent to which measures or sample characteristics may explain discrepancies across studies. To date, two studies have examined age differences using multiple measures of risk within the same sample (e.g., Henninger et al., 2010; Mamerow et al., 2016). Henninger et al. (2010) found inconsistent age differences on three behavioral measures of risk (i.e., BART, Cambridge Gambling Task (CGT), Iowa Gabling Task (IGT)) in a comparison of younger (18–25 years) and older adults (66–77 years). Specifically, older adults were more risk taking on the CGT, but less risk taking on the BART, compared to younger adults, and there were no significant age differences on the IGT. Mamerow et al. (2016) found that older age was associated with less risk taking on a single self-report item (i.e., "are you in general a risk-taking person or do you usually try to avoid taking risks?") and two behavioral measures (i.e., BART and a gambling task) among adults aged 18–90 years. There is growing evidence that self-report and behavioral measures of risk are not associated, or only weakly so (Frey et al., 2017). Using multiple risk measures and including both self-report and behavioral tasks within the same sample may provide insight as to whether age differences in risk taking are tied to specific measures.

Cognitive abilities, age, and risk taking

Fluid cognitive abilities support analytic decision-making processes and reasoning that involves effortful control (Peters et al., 2007a). Further, greater analytic thinking is associated with better comprehension of information about risks and benefits (Peters et al., 2007b). Thus, well-documented age-related declines in fluid cognitive abilities and working memory (e.g., Baltes et al., 2006; Hartshorne & Germine, 2015; Park et al., 2002) have been posited to explain age differences in risk taking (Mata et al., 2011).

Encouraging analytic processing by encouraging younger and older adults to justify their answers reduced the so-called "framing effect" that occurs when gain or loss wording is used to describe risky and certain outcomes (Kim et al., 2005). Older adults' lower scores on tests of fluid cognitive abilities accounted for their greater susceptibility to how options were framed (Bruine de Bruin et al., 2012). Yet, another study found that older adults were not influenced by gain versus loss framing of a mortality scenario, regardless of whether or not cognitive abilities (i.e., working memory, processing speed, deliberation) were controlled (Pu et al., 2017).

Slower processing speed, but not memory, accounted for older adults' less risk taking on the BART (Henninger et al., 2010; Koscielniak et al., 2016). Older adults tend to have difficulty sustaining attention relative to younger adults (Fernandez-Duque & Black, 2006). Attention is a key factor for performance on the BART because participants must focus on inflating the balloon without popping it (Koscielniak et al., 2016). Age differences in attention have not been investigated in prior studies of aging and risk taking that used the BART.

In summary, prior work points to cognitive abilities as potentially important for understanding age differences in risk taking. However, few studies simultaneously test associations among cognitive abilities, risk taking, and age. Of these, only processing speed has been shown to be related to age differences on the BART whereas research investigating associations among analytical reasoning, age, and performance on framing tasks yields mixed results. Investigating how an array of cognitive abilities relate to risk taking as assessed by multiple measures may foster a more complete understanding of age differences in risk taking.

Present study

In the current study, we conducted a secondary analysis of existing data that were originally collected to investigate age differences in information processing and decision making.[1] Building from the prior literature, the present study addressed two research questions:

(1) Are there consistent differences in risk taking between younger (aged 25–36) and older adults (aged 60+) when using multiple measures of risk (i.e., framing tasks, CDQ, BART)?
(2) Are age differences in risk taking eliminated when controlling for cognitive abilities (i.e., analytic thinking, numeracy, processing speed, memory, and attention)?

Method

Participants

Participants were community-dwelling younger (*n*= 75; 25–36 years, M_{age} = 29.01, *SD* = 3.05) and older (*n*= 74; 60–90 years, M_{age} = 69.11, *SD* = 7.60) adults recruited as part of a larger study on age differences in information processing and decision making. Participants were recruited using flyers, newspaper advertisements, and in-person appeals from a metropolitan area in the South Atlantic region of the U.S. To screen for cognitive impairments, older adults scoring less than 24 out of 30 on the Mini-Mental State Exam (MMSE; Folstein et al., 1975) were excluded from participating.[2] Additional exclusion criteria included having participated in a prior study, and significant visual impairments that could not be corrected. (Table 1) presents demographic variables and descriptive statistics for each age group.

Measures

Balloon analogue risk task

(BART; Lejuez et al., 2002). Across 30 trials, participants inflated a virtual balloon and received hypothetical tokens for each pump. The BART has moderate to high test-retest reliability, as well as predictive validity (Lauriola et al., 2014; Lejuez et al., 2007). Following the standard scoring procedure (Lejuez et al., 2002), higher numbers indicated greater risk taking (*M*= 27.44; *SD* = 14.24).

Framing task

Participants saw a pair of hypothetical scenarios about a fatal disease (Wang et al., 2001) and another pair of scenarios about a cancer treatment (McNeil et al., 1982).

Table 1. Group comparisons and descriptive statistics by age for all variables.

	Younger Adults				Older Adults				
Measure	*M* (*n*)	*SD* (%)	Min.	Max.	*M* (*n*)	*SD* (%)	Min.	Max.	Group Comparison
Demographics									
Age	29.01	3.05	25	36	69.11	7.6	60	90	$t(147) = -42.36$***
Gender									$x2(1) = 1.59$
Female	35	46.7%	–	–	42	56.8%	–	–	
Male	40	53.3%	–	–	32	43.2%	–	–	
Race									$\chi^2(3) = 0.01$*
White	55	73.3%	–	–	71	95.9%	–	–	
Black	8	10.7%	–	–	1	1.4%	–	–	
Asian	4	5.3%	–	–	1	1.4%	–	–	
Native Am.	2	2.7%	–	–	0	0.0%	–	–	
Not reported	6	8.0%	–	–	1	1.4%	–	–	
Ethnicity									$\chi^2(1) = 0.20$
Hispanic/Latino	7	9.3%	–	–	3	4.1%	–	–	
Not Hispanic/Latino	68	90.7%			71	95.9%			
Income									$\chi^2(5) = 0.12$
< $20,000	15	20.0%	–	–	18	24.3%	–	–	
$20,000-$39,000	26	34.7%	–	–	15	20.3%	–	–	
$40,000-$59,000	16	21.3%	–	–	10	13.5%	–	–	
$60,000-$79,000	7	9.3%	–	–	13	17.6%	–	–	
$80,000-$99,000	4	5.3%	–	–	4	5.4%	–	–	
>$100,000	7	9.3%	–	–	14	18.9%	–	–	
Education									$\chi^2(8) = .01$*
Elementary to 8th Grade	0	0.0%	–	–	3	4.1%	–	–	
Some High School	0	0.0%	–	–	3	4.1%	–	–	
High School Grad	5	6.7%	–	–	12	16.2%	–	–	
Some College	16	21.3%	–	–	4	5.4%	–	–	
Associate Degree	4	5.3%	–	–	5	6.8%	–	–	
Bachelor’s Degree	23	30.7%	–	–	19	25.7%	–	–	
Master’s Degree	21	28.0%	–	–	16	21.6%	–	–	
Professional Degree	1	1.3%	–	–	3	4.1%	–	–	
Doctorate	5	6.7%	–	–	9	12.2%	–	–	
Risk Taking									
BART	31.24	13.4	3.33	67.5	23.60	14.14	0.97	65.60	$t(147) = 3.39$**
CDQ	72.28	13.9	40	102	74.74	13.96	42	111	$t(147) = -1.08$
Gain Disease Frame	.24	.43	0	1	.29	.46	0	1	$t(147) = -.79$
Loss Disease Frame	.25	.44	0	1	.38	.49	0	1	$t(147) = -1.64$
Gain Cancer Frame	.55	.50	0	1	.70	.46	0	1	$t(147) = -1.98$
Loss Cancer Frame	.67	.47	0	1	.68	.47	0	1	$t(147) = -.12$
Cognitive Abilities									
Analytic Thinking	1.13	1.15	0	3	.70	.92	0	3	$t(147) = 2.52$*
Numeracy	3.81	1.30	0	6	3.36	1.49	0	6	$t(147) = 1.96$
Processing Speed	65.71	17.89	12	112	27.82	14.09	0.00	56	$t(147) = 14.34$***
Memory	51.92	12.95	25	87	53.92	11.81	27	82	$t(147) = -0.98$
Alerting	57.12	36.16	−11.89	185.29	58.74	43.6	−24.19	221.48	$t(147) = -0.25$
Orienting	31.53	25.89	−16.58	4127.65	22.99	33.46	−73.65	122.58	$t(147) = 1.74$
Executive Control	97.15	70.60	−72.56	387.62	131.66	128.06	−621.45	533.23	$t(147) = -2.04$*

Note. * $p < .05$, ** $p < .01$, *** $p < .001$. BART = Balloon Analogue Risk Task, CDQ = Choice Dilemmas Questionnaire, Disease Scenario = fatal disease scenario, Cancer Scenario = cancer treatment scenario.

Pairs of scenarios presented information that was objectively the same, but differed in gain versus loss framing. Frames were presented in random order. Each frame portrayed a choice between a certain and a risky option. Choosing the certain option was coded as “0” and choosing the risky option was coded as “1” (gain frame, fatal disease, $M = 0.26$, $SD = 0.44$; loss frame, fatal disease, $M = 0.32$, $SD = 0.47$; gain

Table 2. Bivariate correlations between study variables.

	1	2	3	4	5	6	7	8	9	10	11	12
Risk Taking												
1. BART	-											
2. CDQ	−.12	-										
3. Gain Disease Frame	−.06	−.19*	-									
4. Loss Disease Frame	−.13	−.17*	.53**	-								
5. Gain Cancer Frame	−.08	.12	.00	.05	-							
6. Loss Cancer Frame	.14	.06	.04	.11	.40**	-						
Cognitive Abilities												
7. Analytic Thinking	.22**	−.08	−.11	−.09	−.09	−.01	-					
8. Numeracy	.24**	−.06	−.24**	−.13	−.03	.06	.55***	-				
9. Processing Speed	.20*	−.04	−.09	−.03	−.16	−.03	.30***	.30**	-			
10. Memory	.08	.11	−.08	−.06	.05	.75	.27**	.35***	.09	-		
11. Alerting	.02	−.09	.02	−.12	.12	−.07	.12	.08	−.09	.06	-	
12. Orienting	.29*	−.05	−.09	−.11	.17*	.04	.12	.26**	.09	.13	−.03	-
13. Executive Control	−.06	−.01	−.09	.02	.13	−.03	−.10	-.05	.09	−.12	.07	.00

Note. *$p < .05$, ** $p < .01$. BART = Balloon Analogue Risk Task, CDQ = Choice Dilemmas Questionnaire. Lower scores on the BART and framing tasks indicated less risk taking, whereas higher scores on the CDQ indicated less risk taking.

frame, cancer treatment M = 0.62, SD = 0.49; and loss frame, cancer treatment, M = 0.67, SD = 0.47).

Choice dilemmas questionnaire

(CDQ; Kogan & Wallach, 1964). Participants were presented with 12 hypothetical life dilemma scenarios that presented a choice between a low-risk/low-reward option (e.g., staying in a secure, low-paying job) and a high-risk/high-reward alternative (e.g., taking a new, high-paying job in a company with an uncertain future). Participants were instructed to imagine themselves as the main character in the scenario and to select one of six options that indicated the minimum probability of success of the risky option necessary to justify its choice: *the chances are 1 in 10 that the risky option will be successful, the chances are 3 in 10 that the risky option will be successful, the chances are 5 in 10 that the risky option will be successful, the chances are 7 in 10 that the risky option will be successful, the chances are 9 in 10 that the risky option will be successful*, and *Mr. X should not choose the risky option no matter what the probabilities*. Following the standard scoring procedure (Kogan & Wallach, 1964), appropriate items were reverse coded and responses were summed such that lower scores indicated greater risk taking (M = 73.50, SD = 13.94, α = .61).

Analytic thinking

Participants completed the Cognitive Reflection Test (CRT; Frederick, 2005), which consisted of three open-ended questions that measure the ability to override quick, intuitive processing by using more effortful, analytic processing to arrive at the correct answer instead of the common, but incorrect answer. Responses were scored as correct (1) or incorrect (0) and summed. Higher scores indicated greater analytic thinking (M= .92; SD = 1.06).

Numeracy

Participants completed the Abbreviated Numeracy Scale (Weller et al., 2013), which consisted of six open-ended questions that required participants to convert percentages, decimals, or proportions, and compute probabilities. Responses were scored as correct (1) or incorrect/no response (0) and summed. Higher scores indicated greater numeracy (M= 3.59; SD = 1.06).

Digit symbol substitution test

(DSST; Wechsler, 1981). To assess processing speed, participants were presented with an 18 (columns) x 16 (rows) matrix of numbers and matching hieroglyphic-like symbols. Participants then had two-minutes to match symbols to numbers and record them in boxes, using keys on a laptop computer. Higher accuracy scores indicated greater processing speed (M= 46.89; SD = 24.88).

California verbal learning test – II short form

(CVLT-II; Delis et al., 2000). The CVLT-II was used to assess memory. Participants were read four lists of nine words. Immediately after each list, participants were asked to recall as many words as possible (i.e., free recall). Following the standard scoring procedures, raw scores were then converted to standard scores. Participants' total free recall was based on the sum of scores from the four trials (M = 51.91, SD = 12.40).[3]

Attention network test

(ANT; Fan et al., 2002). The ANT is a computer task that assesses attention (see Fan et al., 2002, for detailed description of the task). The ANT yields three attention indices: Executive control, Alerting, and Orienting. *Executive control* is the system that solves conflict among dissimilar stimuli. *Alerting* is the component that maintains an attentive state. *Orienting* is the shifting of attention among stimuli. Higher scores on Alerting and Orienting indicate better attention on each index, whereas higher scores on Executive control indicate less efficiency of executive attention.

Procedure

The authors' university Institutional Review Board approved all study procedures.

Participants provided informed consent and then completed all study measures on a laptop computer. Measures were presented in the following order: two randomized scenarios from the framing task, BART, CVLT-II, six randomized scenarios from the CDQ, CRT, numeracy, two randomized scenarios from the framing task, DSST, six randomized scenarios from the CDQ, and demographic characteristics. Other measures for the larger project were inter-mixed throughout the survey. Study sessions were held at a location chosen by the participant (e.g., senior center, research lab), which did not affect the results. Participants received a 50 USD honorarium.

Results

Consistency of age differences in risk taking

To investigate age differences in risk taking using the BART and CDQ, two independent samples *t*-tests were conducted (see Table 1). The BART yielded the expected age difference – older adults took significantly fewer risks than younger adults.[4] Scores on the CDQ did not significantly differ by age.

To investigate age differences in risk taking as assessed by the framing tasks, two repeated-measures ANOVAs were conducted – one for the fatal disease scenario and one for the cancer treatment scenario. In each, frame type (gain vs. loss) was the within-subjects variable, and age (younger vs. older) was the between-subjects variable. The main effects of age and frame type, as well as the interaction, were nonsignificant for both scenarios (all *p*s > .05; see Supplemental Table 3).

Age, risk taking, and cognitive abilities

To identify age differences in cognitive abilities, we computed *t*-tests (see Table 1). Older adults had significantly lower analytic thinking, slower processing speed, and worse Executive control attention compared to younger adults. There were no significant age differences in memory or the Alerting and Orienting attention scores.

To assess the association between measures of risk-taking and cognitive abilities, bivariate correlations were computed (see Table 2). Less risk taking on the BART was significantly associated with lower analytic thinking, lower numeracy, slower processing speed, and worse shifting of attention as measured by Orienting attention.[5] Less risk taking in the gain frame of the fatal disease scenario was significantly associated with lower numeracy, whereas less risk-taking in the gain frame of the cancer scenario was associated with worse shifting of attention as measured by Orienting attention. Risk taking as assessed by the CDQ was not significantly correlated with any cognitive ability measure.

Next, we conducted a hierarchical regression analysis to investigate whether age differences in risk taking on the BART remained after controlling for cognitive abilities (see Table 3). Age group (1 = younger adults, 2 = older adults) was entered in Model 1. Significant cognitive correlates of BART scores (i.e., analytic thinking, numeracy, processing speed, Orienting attention) were entered in Model 2. Model 1 was significant ($F(1, 147) = 11.49$, $p = .001$, $R^2 = 0.07$), such that older age was associated with less risk taking.

Table 3. Hierarchical regression predicting risk taking as measured by the BART.

Variables	β	*B(SE)*	*p*	95% *CI*	Adjusted R^2
Model 1			< .01		.07
Age	−.27	−7.64 (2.25)	< .01	−12.09, −3.19	
Model 2			< .01		.17
Age	−.26	−7.38 (3.38)	.03	−14.10, −0.63	
Analytic thinking	.11	1.48 (1.24)	.24	−0.98, 3.94	
Numeracy	.10	1.05 (0.97)	.28	−0.87, 2.97	
Processing speed	−.08	−0.05 (0.07)	.52	−0.19, 0.09	
Orienting attention	.23	0.11 (0.04)	< .01	0.03, 0.18	

Model 2 was also significant ($F(4, 143) = 5.85$, $p < .001$, $R^2 = 0.17$). Lower Orienting attention was significantly associated with less risk taking, but analytic thinking, numeracy, and processing speed were unrelated to risk taking. Adding the measures of cognitive abilities accounted for significantly more variance ($\Delta R^2 = .10$, $p = .001$) relative to only taking age into account, however, age differences in risk taking were still significant.[6]

Discussion

Our first research question addressed the consistency of age differences in risk taking across three measures. For the behavioral task, the BART, older adults were less risk taking than younger adults. Neither self-report measure of risk taking showed significant age differences. Our second research question addressed whether age differences in risk taking remained after controlling for cognitive abilities. After accounting for associations among risk taking, analytic thinking, numeracy, Orienting attention and processing speed, age differences in risk taking were still significant, indicating that both age and cognitive abilities are important.

Older adults' less risk taking on the BART relative to younger adults aligns with previous findings (Mamerow et al., 2016; see Mata et al., 2011 for a review). Some have argued that the BART is more reliable than self-report measures (Lejuez et al., 2002), which could contribute to the consistent findings of age differences on this measure across studies. Further, age differences in risk taking on the BART remained after accounting for cognitive abilities, suggesting that other age-related processes such as motivation and emotion may play a role. Completing the BART has been shown to be emotionally arousing (Schonberg et al., 2011). Older adults are more likely than younger adults to report that they find high arousal aversive (Grühn & Scheibe, 2008; Keil & Freund, 2009). Older adults' lesser risk taking may thus reflect their attempts to avoid arousal caused by popping the balloon. Real-world risky decisions older adults face, such as choosing a treatment to deal with a life-threatening illness, are emotionally arousing (Ferrer & Mendes, 2018), highlighting the need to isolate the role of arousal in age differences in risky decisions (Depping & Freund, 2011).

Our findings expand upon prior work (e.g., Henninger et al., 2010; Mamerow et al., 2016) first, by including multiple measures of cognitive ability, and second by adding different risk-taking measures (i.e., CDQ and framing task). Henninger et al. (2010) examined whether processing speed and memory accounted for age differences in risk taking, and found that slower processing speed accounted for older adults' less risk taking on the BART. Our findings showed that processing speed was no longer significantly associated with risk taking on the BART when accounting for analytic thinking, **numeracy** and shifting of attention. Yet, less shifting of attention (Orienting) was still significantly associated with less risk taking when all **four** cognitive ability measures were included in the regression equation. Thus, relative to processing speed, this aspect of cognitive ability appears to be relatively more important for understanding risk-taking behavior as assessed by the BART. This may reflect that the BART requires careful attention to the number of pumps across trials (Koscielniak et al., 2016). Future research that uses the BART should consider how cognitive demands may shape performance.

We did not find evidence of age differences in risk taking on either framing scenario or the CDQ. Meta-analyses have indicated either no age differences (Mata et al., 2011) or age differences in risk taking that are specific to mortality scenarios (Best & Charness, 2015). While our scenarios (fatal disease, cancer treatment) involved mortality and health, prior meta-analytic conclusions about age differences specific to mortality scenarios were based on only two effect sizes (Best & Charness, 2015). Including our results in future meta-analyses may help to elucidate the robustness of age differences in framing tasks. Unlike some prior work (e.g., Vroom & Pahl, 1971; Wallach & Kogan, 1961), but consistent with Okun et al. (1980), we found no age differences on the CDQ. Our sample included older adults 60 and older, whereas the average age of participants in Vroom and Pahl (1971) study was much younger, only 39 years, which could explain the discrepancy. Historical factors and cohort effects (Schaie, 1983) could also play a role. Some of the CDQ questions pertain to historical events such as World War II that would be arguably more salient to older cohorts in 1961 (the year that Wallach & Kogan's results were published) versus 2020.

Together, our results suggest that measurement issues should be considered when investigating age differences in risk taking. In our sample, the self-report measures were inconsistently correlated with each other. The largest correlations were between the pairs of a given framing task (e.g., gain disease frame and loss disease frame); however, the disease frames were not significantly correlated with the cancer frames. Further, the two versions of the framing task were differentially related to cognitive abilities. The CDQ was not correlated with any of the framing tasks. Other work has found weak evidence ($r = .20$) of associations between 29 self-report measures of risk (Mata et al., 2018); however, the framing tasks and CDQ were not included in their assessment. Thus, our findings provide further evidence of the lack of, or weak convergence between self-report measures. Additionally, our data showed that the self-report measures, framing tasks and the CDQ, were not significantly correlated with the behavioral measure, the BART. Other research reported a weak association ($r = .10$) between a single-item self-report measure of general risk taking propensity and the BART (Mamerow et al., 2016). Prior work has demonstrated a lack of convergence between self-report and behavioral risk assessments (see Hertwig et al., 2018; Mata et al., 2018 for reviews; Millroth et al., 2020), which raises concerns about the construct validity of these measures. Still, other self-report measures may show different correlations with the BART, as well as other behavioral measures.[7]

Taken together, our findings indicate that cognitive abilities are important for understanding risk taking as assessed by the BART. At the same time, our findings indicate that age differences in risk taking remain after accounting for cognitive abilities, suggesting that other factors such as emotion and motivation may be important pathways to explore in future research on age differences in risk taking.

Limitations and future directions

The present research has limitations. First, our cross-sectional, correlational data cannot address cohort effects or causality (Schaie, 1983). Second, our sample size was insufficient to detect the small effects that are often found in studies investigating age differences in risk taking (Mata et al., 2011). This may have contributed to the null findings regarding age differences for two of the three measures we investigated. Future work should recruit a larger sample size and utilize a multivariate approach to test whether the measures of risk load on a single risk-taking latent factor and whether the factor solution is invariant across age groups. Third, even though our use of multiple measures of risk taking improved upon prior research, other risk measures could be used to investigate the correspondence between self-report and behavioral measures (Mata et al., 2018). Fourth, the use of hypothetical scenarios to assess risk taking limits the ecological validity of the tasks. Although links between hypothetical monetary gambles framed as gains and losses and performance on the BART have been linked to real-world decisions (Kuhberger et al., 2002, Lejuez et al., 2003**),** it remains unknown how mortality scenarios framed as gains and losses and choices on the CDQ relate to real-world risk taking. Additionally, incorporating actual monetary earnings in studies that use the BART to investigate age differences would improve ecological validity. Research with younger adults has shown that they are more risk averse in response to losses during the BART with real monetary rewards compared to those with hypothetical rewards (e.g., Xu et al., 2016). The predictive validity of the BART for older adults' real-world health and financial risk taking should also be investigated since most validity studies are based on younger adults and addictive behaviors such as smoking and drinking (e.g., Lejuez et al., 2003). Fifth, although screening older adults for cognitive impairments increased our understanding of risk taking and non-pathological aging, it may have reduced variability in cognitive abilities shown to account for age differences in other samples (e.g., Henninger et al., 2010).

Conclusion

We assessed the consistency of age differences in risk taking using one behavioral and two self-report measures of risk and while controlling for cognitive abilities. Older adults were less risk taking than younger adults only on the BART and this difference remained after accounting for cognitive correlates of risk taking. Further research is needed to understand factors that dampen and heighten risk taking in people of diverse ages. Ultimately, such research can be used to help people make decisions about options with uncertain outcomes.

Notes

1. The larger project from which the current data were drawn also included the Domain Specific Risk-Taking scale (DOSPERT; Weber et al., 2002). DOSPERT data are not included in the current report because results based on two of the five domains have been published. Specifically, older adults reported less risk-taking in the health/safety (Shook et al., 2019) and social (Delaney et al., 2020) domains relative to younger adults. As shown in Supplemental Table 1, older adults also reported less risk-taking in the financial, ethical, and recreational domains. Supplemental Tables 1 and 2 show associations among all five DOSPERT domains, the other measures of risktaking included in the current report, age, and cognitive abilities.
2. One participant was excluded due to failing the MMSE.
3. Participants also completed a short-delay recall task after 30 seconds and a long-delay recall task after 10 minutes. The short-delay recall score was strongly correlated with total free recall scores ($r = .58$, $p < .001$). Due to similarities in the two indices, we only report on total free recall. The long-delay free recall task was supposed to take place after a 10-minute delay. Due to inconsistency in the time delay across participants, the long-delay recall score was not used.

4. To test for learning effects on the BART, a repeated measures ANOVA was conducted. Trial was entered as the within-subjects variable and age group as the between-subjects variable. There was a learning effect where people increased the pumps across trials, suggesting an increase in risktaking, $F(1,147) = 53.44$, $p < .001$. There was also a main effect of age, with younger adults showing greater risktaking than older adults, $F(1,147) = 12.78$, $p < .001$. There was no interaction between trial and age, suggesting no age differences in learning over time.
5. Correlations within age groups showed mainly consistent patterns (see Supplemental Table 4).
6. The regression analysis was also conducted with education as a covariate due to significant differences between the age groups. The primary results regarding age and attentional Orienting remained the same, and thus education was not included in the main analyses.
7. Scores on the BART and DOSPERT were significantly correlated (see Supplemental Table 1).

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ORCID

Jenna M. Wilson http://orcid.org/0000-0003-3154-0467

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