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Research Article

Age and Framing Effects in the Balloon Analogue Risk Task

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Abstract

Objectives: Prior research has documented age differences in risky decisions and indicates that they are susceptible to gain versus loss framing. However, previous studies focused on "decisions from description" that explicitly spell out the probabilities involved. The present study expands this literature by examining the effects of framing on age differences in the Balloon Analogue Risk Task (BART), a widely used and ecologically valid measure of experience-based risky decision making that involves pumping a virtual balloon.

Methods: In a preregistered study, younger (aged 18–30, n = 129) and older adults (aged 60 and older, n = 125) were randomly assigned to either a gain version of the BART, where pumping the balloon added monetary gains, or a loss version, where pumping the balloon avoided monetary losses.

Results: We found a significant age by frame interaction on risk-taking: in the loss frame, older adults pumped more frequently and experienced more popped balloons than younger adults, whereas in the gain frame no significant age differences were found. Total performance on the BART did not vary by age or frame. Supplementary analyses indicated that age differences in pumping rates were most pronounced at the beginning of the BART and leveled off in subsequent trials. Controlling for age differences in motivation, personality, and cognition did not account for age differences in risk-taking.

Discussion: In combination, findings suggest that age differences in risk-taking on the BART are more pronounced when the task context emphasizes avoiding losses rather than achieving gains.

Keywords: Decision making, Emotion, Risk perception, Time perception

Many momentous choices—from long-term investments to split-second reactions in traffic—involve managing risks and benefits. Stakes are particularly high in later life as older adults may have limited physical, cognitive, and material resources to recover from poor choices (Baltes, 1997; Depping & Freund, 2011). A growing body of literature has examined age differences in risky choices, broadly defined as decisions that entail uncertainty with respect to the valence and probability of their outcomes, but results are inconsistent across tasks and contexts (e.g., Mamerow et al., 2016; Mata et al., 2011). In response, recent meta-analyses have examined potential moderators (Best & Charness, 2015; Mata et al., 2011) and suggest that age effects depend on whether risks are taken in order to obtain a gain or avoid a loss (Best & Charness, 2015). So far, such framing effects have been primarily examined in scenarios where information about relative risks is provided upfront (also referred to as decisions from description; Best & Charness, 2015) and it is not clear whether or not they extend to scenarios that entail a learning component (i.e., decisions from experience; Mamerow et al., 2016; Mata et al., 2011). This question is of theoretical relevance, because framing may not only influence how we evaluate probabilities but also how we learn about them. It also has practical relevance because many risky decisions in real-life contexts do not provide explicit information about risk levels.

To address this gap in the literature, we examined the effects of framing on younger and older adults' responses on the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). We choose the BART because it is a well-established measure of risky decision making from experience that has been linked to real-life risk-taking behaviors in a variety of contexts (e.g., Hopko et al., 2006; Lejuez et al., 2003; Seaman et al., 2015).

In the BART (Lejuez et al., 2002) participants pump a virtual balloon that may pop. They are compensated according to the number of pumps. Within each trial, they can stop pumping and cash in at any time, but they lose all points accumulated for that trial if the balloon pops (Lejuez et al., 2002). Consistent with the risk–reward trade-offs inherent to real-life decisions, participants do best if they balance their risk-taking and pump enough to reap most of the available points but stop before they trigger a pop. Further, because participants are not told about average balloon capacity, the task captures both initial risk-taking propensity and adjustments in pumping rates as experience accumulates.

Several studies have documented age differences in BART performance. Findings generally suggest that older adults reap lower earnings because they are more risk-averse as reflected by fewer pumps and a greater propensity to cash in on a given trial (Henninger et al., 2010; Koscielniak et al., 2016; Li et al., 2017; Sproten et al., 2018; Wilson et al., 2021). This tendency appears to be especially pronounced early in the task and levels off in later trials (Rolison et al., 2012). Studies have also examined if age effects on the BART are susceptible to task characteristics. So far, these efforts have focused on the role of balloon capacity. Findings suggest that if balloon capacity only varies for the initial trials, it does not modulate age effects (Koscielniak et al., 2016), but, over the course of 20 trials, age effects in risk aversion are more pronounced for balloons with higher capacity (i.e., 32 vs 16 maximum pumps; Mamerow et al., 2016).

Importantly, prior research suggests that BART performance not only varies across age groups and by balloon capacity but also responds to framing. Specifically, previous studies have compared the standard gain-framed BART (G-BART), where pumps accrue points, to a loss-framed BART (L-BART), where pumps avoid losses (Benjamin & Robbins, 2007). Consistently, participants in the L-BART were shown to take greater risks than participants in the G-BART (Benjamin & Robbins, 2007; Wright & Rakow, 2017). This is consistent with prospect theory (Tversky & Kahneman, 1981), which argues that people subjectively overvalue losses relative to gains and are therefore more willing to take risks in order to avoid losses than to acquire gains. However, framing effects on the BART have only been examined in younger adults, and it is not clear whether they extend to older age groups.

Mata and Hertwig (2011) highlight two major theories of lifespan motivational development that differ in their predictions regarding age effects in gain- versus loss-framed risky choices. The first, Goal Orientation Theory (GOT; Ebner et al., 2006), focuses on age-related limitations in resources that are thought to trigger motivational shifts from growth-oriented goals toward maintenance and loss prevention. The second, Socioemotional Selectivity Theory (SST; Carstensen et al., 1999), focuses on age-related limitations in time horizons that are thought to prioritize present- over future-oriented goals.

Specifically, GOT argues that age-driven constraints on physical, cognitive, and social resources shift people's goal orientation from resource acquisition to maintenance and loss prevention (Depping & Freund, 2011; Ebner et al., 2006). In other words, younger adults would be expected to focus on maximizing gains, whereas older adults focus on maintaining existing resources or minimizing losses. With respect to prospect theory, GOT suggests that older adults are even more likely than younger adults to overvalue losses relative to gains (Best & Charness, 2015; Mata & Hertwig, 2011), making them relatively more risk-avoidant in gain frames (i.e., fewer pumps) and more risk-seeking in loss frames (i.e., more pumps). Thus, the tendency of older adults to take less risk than younger adults (e.g., Henninger et al., 2010; Koscielniak et al., 2016) should be weaker in loss frames than in gain frames.

Conversely, SST theorizes that, with less perceived time left in life, older adults find lower utility in gathering information to prepare for an uncertain future and instead prioritize their affective well-being in the present moment (Carstensen et al., 1999). This entails focusing toward positive and away from negative aspects of the environment, a phenomenon known as the positivity effect (Reed & Carstensen, 2012), which has been documented in contexts such as affectively framed health messages (Notthoff et al., 2016) and predecisional information-seeking (Löckenhoff & Carstensen, 2007). With respect to prospect theory, older adults' emphasis on the positive would be expected to reduce the relative overvaluing of losses relative to gains that is seen in younger adults (Best & Charness, 2015; Mata & Hertwig, 2011), resulting in a tendency to be relatively more risk-seeking in gain frames (i.e., more pumps) and more risk-avoidant in loss frames (i.e., fewer pumps). Thus, the tendency of older adults to seek less risk than younger adults (e.g., Henninger et al., 2010; Koscielniak et al., 2016) should be stronger in loss frames versus gain frames.

So far, the implications of gain versus loss framing for age differences in risky choices have been selectively examined in decisions from description. Consistent with GOT (Depping & Freund, 2011), a recent meta-analysis found that younger adults were more risk-seeking than older adults in positively framed scenarios, whereas no age differences were found in negatively framed scenarios (Best & Charness, 2015). However, these effects were sensitive to moderators such as outcome amount and decision domain (Best & Charness, 2015) and it is not clear whether they extend to decisions from experience. On one hand, the age-related prioritization of loss prevention proposed by GOT (Depping & Freund, 2011) may persist across decision scenarios and types. On the other hand, GOT with its emphasis on decision outcomes may be more applicable to decisions from description that explicitly spell out risk levels and payouts. SST, in contrast, has been linked to affective responses during the decision process itself (Löckenhoff, 2018) that are likely to be more salient during decisions from experience. Specifically, the BART was found to be sensitive to both ambient- and task-related affective and physiological responses (Heilman et al., 2010; Wright & Rakow, 2017). This would suggest a reversal of effects such that the age-related tendency toward risk aversion is more pronounced in loss frames.

Drawing on these considerations, the present study was designed to broaden our understanding of age differences in risky choices by comparing younger and older adults' risk-taking and performance on the G-BART versus the L-BART. Specifically, we preregistered the following hypotheses:

Hypothesis 1: Consistent with the prior literature on age effects in the BART (Henninger et al., 2010; Koscielniak et al., 2016; Li et al., 2017; Sproten et al., 2018; Wilson et al., 2021) we predicted that BART responses would show a main effect of age such that younger as compared to older adults would take more risks (1a) and perform better as a result (1b).

Hypothesis 2: Consistent with prior literature on framing effects in general (Tversky & Kahneman, 1981) and framing effects on the BART in particular (e.g., Benjamin & Robbins, 2007; Wright & Rakow, 2017) we predicted that BART responses would show a main effect of frame such that participants who were pumping to avoid losing points on the L-BART would take more risks than participants who were pumping to gain points on the G-BART.

Hypothesis 3: As noted previously, GOT and SST offer divergent predictions with respect to age by frame interactions. For the sake of parsimony, we based our hypotheses on the existing literature on age differences in risky choices which is heavily focused on decisions from description (Best & Charness, 2015). Following GOT, we therefore predicted that the age-related tendency toward risk avoidance would be stronger for the G-BART as compared to the L-BART and that this pattern would be observed for both risk-taking (3a) and performance (3b). Note that finding the opposite pattern (i.e., a stronger age-related tendency toward risk avoidance for the L-BART vs the G-BART) would be supportive of SST.

Preregistered secondary analyses explored variations in task-related learning. Prior research suggests that compared to younger adults, older adults not only take longer to learn new information (Schaie & Willis, 2021) but also show a positivity effect in their recall (Reed & Carstensen, 2012). We therefore examined changes in performance from earlier to later trials, retrospective recall of pumping and popping rates, and retrospective estimates of balloon capacity.

Preregistered analyses also examined the specific mechanisms implicated by the different theoretical frameworks. For GOT, we examined self-reported goal preferences for growth versus maintenance goals. For SST, we examined future time perspective and subjective processing preferences favoring feelings over facts.

Finally, we preregistered a set of general covariates including variables that were previously observed to be associated with age and/or decision making (Löckenhoff, 2018; Schaie & Willis, 2021) including subjective physical and mental health, five-factor personality traits, as well as cognitive strategies and abilities (i.e., self-rated cognition, need for cognition, working memory, and numeracy).

The primary hypotheses, plans for secondary analyses, and the list of covariates were preregistered at https://aspredicted.org/7qj5p.pdf.

Method

Participants

The sample consisted of 129 younger adults (aged 18–30) and 125 older adults (aged 60–87), yielding a power of 0.98 to detect medium-sized main and interaction effects (f = 0.25) at α = 0.05 for a 2 (age: young vs old) by 2 (frame: gain vs loss) between-subjects analysis of variance (ANOVA; analysis conducted with G*Power; Faul et al., 2009). Seventeen percent participated via group-based laboratory sessions; the remainder participated online. We exceeded the preregistered sample size of 200, but preliminary analyses examining the effects of age and framing on BART responses yielded the same pattern of significant effects across the preregistered and the full sample. Subsequent analyses therefore included the full sample. Supplement A provides the rationale for deviations from the preregistered recruitment plans as well as details on recruitment procedures, attention checks, excluded participants, and participant compensation.

Table 1 (top) reports demographic characteristics. Age groups were comparable in gender and education but older adults reported higher income and were more likely to be non-Hispanic White than their younger counterparts (ps < .05).

Balloon Analogue Risk Task

We used an automatic version of the BART (Pleskac et al., 2008) where participants preselected the desired number of pumps. To retain perceptual aspects of the standard task, each pump was shown to gradually inflate a preview of a virtual balloon (see Figure 1). After participants pressed a "collect" button, they were shown an animation in which the balloon was automatically inflated to the desired size, resulting either in a pop (visualized as the balloon blowing up) or a nonpop (visualized as the balloon bopping in place). This design allowed us to obtain data on the desired number of pumps from all trials, not

Table 1. Age Differences and Associations With the BART for Demographics and Covariates

		Age differences			Correlations with BART	
Variable	*n*	Young *M* (*SD*) [%]	Old *M* (*SD*) [%]	*t* [χ^2]	r_{pumps}	r_{total}
Demographics						
Age	254	25.39 (3.59)	68.72 (5.24)	76.69**	0.06	–0.06
% Female (vs male)[a]	251	[54%]	[54%]	[0.01]	–0.04	–0.07
% Non-Hispanic White	254	[80%]	[94%]	[10.26**]	–0.00	0.06
Income (1–7 scale)	253	3.80 (1.89)	4.54 (1.82)	3.12**	0.17**	0.10
Education (1–8 scale)	254	5.39 (1.37)	5.65 (1.44)	1.48	0.19**	0.12
Socioemotional/health						
Self-rated physical health	254	3.37 (1.00)	3.62 (0.80)	2.22*	0.21**	–0.05
Self-rated emotional health	254	3.03 (1.06)	3.87 (0.84)	6.99**	0.10	0.01
Current affect: valence	254	4.53 (1.36)	5.49 (1.22)	5.87**	0.13*	0.00
Current affect: activation	254	3.78 (1.39)	4.32 (1.42)	3.04**	0.17**	0.04
Future time perspective	254	4.83 (1.01)	4.02 (1.13)	6.07**	0.05	0.05
Growth (vs maintenance) goals	254	1.78 (2.16)	0.65 (2.16)	4.16**	0.10	0.07
Information (vs affect) goals	253	0.50 (2.34)	0.94 (2.16)	1.52	0.07	–0.07
Personality						
Neuroticism	254	6.30 (1.79)	5.09 (1.76)	5.46**	–0.07	–0.06
Extraversion	254	5.42 (2.05)	6.27 (1.81)	3.52**	0.09	0.06
Openness	254	6.98 (1.77)	7.02 (1.64)	0.18	0.08	0.06
Agreeableness	254	6.81 (1.73)	7.42 (1.51)	2.99**	0.02	–0.04
Conscientiousness	254	7.15 (1.66)	8.25 (1.39)	5.70**	0.12	0.01
Need for cognition	254	10.13 (2.57)	10.20 (2.57)	0.21	0.18**	0.07
Cognition						
Self-rated learning ability	254	3.91 (0.80)	3.69 (0.81)	2.17*	0.10	–0.06
Self-rated memory	254	3.52 (0.93)	3.26 (0.87)	2.26*	0.06	–0.02
Numeracy	249	2.09 (1.00)	1.71 (1.01)	2.97**	0.11	0.17**
N-back	85	34.36 (4.78)	32.23 (4.99)	2.00*	–0.10	–0.11

Notes: r_{pumps} = correlations with number of pumps; r_{total} = correlations with BART total score; BART = Balloon Analogue Risk Task; *SD* = standard deviation.
[a]One transgender participant identifying as "FTM" was coded as male; three participants identifying as "nonbinary" or "genderfluid" were excluded from analyses involving gender.
**p* < .05. ***p* < .01.

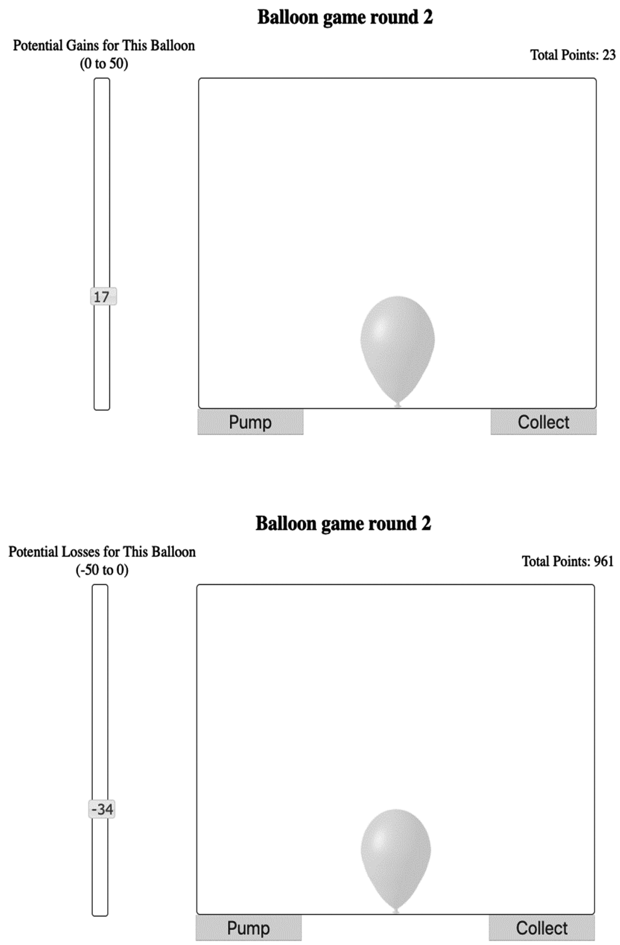

Figure 1. Sample screenshots for the pumping phase of the Balloon Analogue Risk Task (BART) showing the gain frame (top) and the loss frame (bottom). Participants pressed "pump" to indicate the desired number of pumps. Pumps were visualized by both the increasing size of the shaded balloon and by the scale on the left. Participants pressed "collect" to have the computer automatically implement the desired number of pumps resulting in either a pop or a nonpop. Trial number and cumulative points were shown at the top. Complete instructions are provided in Supplement B.

just the trials without pops. Framing was implemented following Benjamin and Robbins (2007) such that each pump either resulted in gaining points (G-BART, Figure 1, top) or avoiding lost points (L-BART, Figure 1, bottom). There were 20 trials and balloons had a maximum capacity of 50 pumps. For further details including practice trials, pilot testing, and performance incentives, see Supplement B.

For each trial, we logged the number of pumps and the outcome (pop vs nonpop). We computed the average number of pumps per trial, the total number of pops, and the total score (summing the number of pumps on nonpop trials). As preregistered, outliers were winsorized at 3 *SD* above/below the mean.

A *manipulation check* asked participants whether they were focused more on gaining points or on avoiding popped balloons, using a slider scale from −5 to 5 with higher scores indicating a focus on gains. To assess *task-specific memory*, participants were asked to recall how many times they pumped on average for each balloon and how many of the 20 balloons popped. We also assessed *estimated balloon capacity*, asking participants after how many pumps the balloons usually popped. Based on these responses, we computed bias scores. Specifically, we subtracted the actual number of pumps and pops from the recalled number and we subtracted the actual average capacity (i.e., 25 pumps) from the estimated capacity. Thus, higher scores indicate overestimation and lower scores indicate underestimation.

Measures

Subjective health and cognition were screened by asking participants to rate their physical health, emotional health, learning ability, and memory on 5-point Likert scales from 1 = poor to 5 = excellent.

Current affect at baseline was screened by asking participants to rate their current affective state with respect to valence (1 = very negative to 7 = very positive) and arousal (1 = very quiet or still to 7 = very activated and aroused; adapted from Nielsen et al., 2008).

Future time perspective was measured using the Future Time Perspective scale, a 10-item, 7-point Likert-style rating scale (α = 0.89) asking participants to rate perceived time and opportunities left in their lives (Carstensen & Lang, 1996). Higher scores indicate a more expansive time perspective.

Goal preferences were screened with respect to growth versus maintenance preferences ("In planning your life and pursuing your goals, are you more focused on maintaining something/preventing a loss OR more focused on improving something/achieving something new?"; derived from Ebner et al., 2006) and with respect to fact-based versus affective/intuitive preferences ("In planning your life and pursuing your goals, do you rely more on your feelings and intuition OR more on analyzing the specific facts and details?"; Nolte & Löckenhoff, 2021). Reponses ranged from −5 to 5 on a slider scale with higher scores indicating a preference for growth and fact-based preferences, respectively.

Personality was screened using a 10-item short version of the Big Five Inventory (Rammstedt & John, 2007). Two items each assessed neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness from 1 (strongly disagree) to 5 (strongly agree).

Need for cognition was assessed using a three-question short scale (α = 0.84; Bizer et al., 2000) assessing participants' preference for thinking and cognitive engagement from 1 = strongly disagree to 5 = strongly agree.

Numeracy was assessed with the three-item Lipkus numeracy scale (Lipkus et al., 2001, α = 0.56).

Working memory was assessed using a two-back task (Ragland et al., 2002). A sequence of letters was shown to the participant at the rate of one letter per second.

Participants were asked to indicate whether the letter on the current trial was the same or different as the one shown two trials ago. There were 40 trials and we computed the number of correct responses across all trials.

Procedure

After providing informed consent, participants completed the experimental tasks in a group-based laboratory setting or in a self-administered online format (for details, see Supplement A and B). They first completed demographic questions and rated their current affect, subjective health and cognition, personality traits, need for cognition, future time perspective, and goal preferences. Next, they were randomly assigned to complete either the G-BART or the L-BART. Afterwards, they completed the manipulation check and task-specific memory items. Finally, they completed the n-back (skipped in the survey sample) and the numeracy items.

Results

Balloon Analogue Risk Task

On average, participants pumped 20.42 times on each trial (SD = 7.31) and scored 195.48 total points (SD = 60.72). The manipulation check indicated that the self-reported focus on gaining points (vs avoiding popped balloons) was stronger in the gain condition (M = 0.24, SD = 3.01) than in the loss condition (M = −0.97, SD = 2.77, $t(252)$ = 3.33, $p < .001$) and this pattern did not differ significantly by age. Thus, the instructional framing intervention was successful in both age groups.

To examine the preregistered hypotheses about age and framing effects on the BART, we conducted age group (young vs old) by frame (loss vs gain) between-subject ANOVAs. Table 2 (top) shows the average pumps per trial and the total BART score by age group and frame. For *average pumps*, there were no main effects of age or frame. Thus, Hypotheses H1a and H2 were not supported. There was a significant age by frame interaction (see Figure 2, top), but it did not support H3a, which predicted larger age differences in the gain versus the loss frame. Instead, Bonferroni-corrected post hoc tests (see Table 2) revealed that there were significant age differences in the loss frame (with older adults pumping more frequently than younger adults), but there were no significant age differences in the gain frame. In addition, pump counts differed significantly across frames for older adults (with older adults showing higher pump counts in the loss vs the gain frame), but they did not differ for younger adults (all $ps < .05$). For the *total BART score*, there were no significant main effects or interactions (all $ps > .05$). Thus, we found no support for Hypotheses 1b and 3b. Bayesian analyses examining the preregistered hypotheses yielded convergent results and are reported in Supplementary Table S1.

Table 2. The Effects of Age Group and Frame on BART Performance

	Younger		Older		Age group × Frame ANOVA		
	Loss	Gain	Loss	Gain	Age	Frame	Age × Frame
	n = 64	n = 65	n = 62	n = 63			
	M (SD)	M (SD)	M (SD)	M (SD)	F (η^2_p)	F (η^2_p)	F (η^2_p)
Average pumps	19.19 (6.01)^{b}	20.98 (6.06)^{ab}	22.74 (8.24)^{a}	18.83 (8.16)^{b}	0.60 (0.00)	1.39 (0.01)	9.98 (0.04)**
Total score	200.45 (58.41)^{a}	199.92 (55.40)^{a}	196.73 (64.52)^{a}	184.63 (64.42)^{a}	1.56 (0.01)	0.69 (0.00)	0.58 (0.00)
Number of pops	7.48 (2.93)^{b}	8.25 (2.99)^{ab}	8.95 (3.47)^{a}	7.83 (3.19)^{ab}	1.75 (0.01)	0.21 (0.00)	5.70 (0.02)*

Notes: Within each row, means that do not share any superscript differ significantly at $p < .05$ based on Bonferroni-corrected post hoc tests conducted within each ANOVA, η^2_p = partial eta-squared. ANOVA = analysis of variance; BART = Balloon Analogue Risk Task; SD = standard deviation.

*$p < .05$. **$p < .01$.

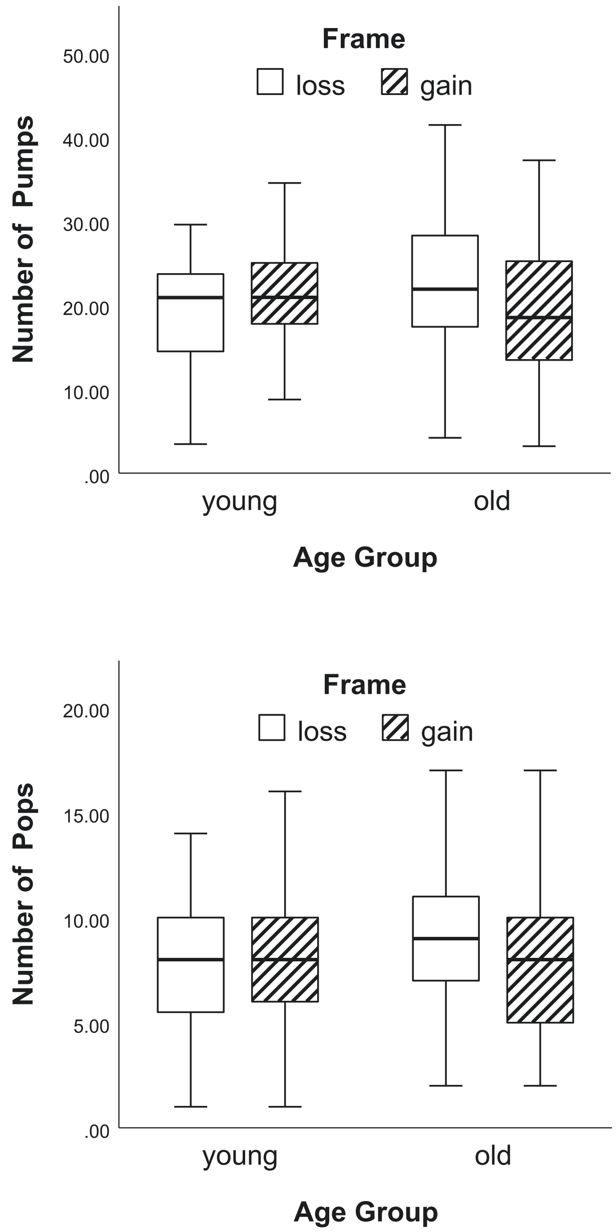

Figure 2. Effects of age and frame on Balloon Analogue Risk Task (BART) pumping rates (top) and balloon pops (bottom).

The finding that significant differences in pumping patterns did not yield significant differences in total scores was unexpected. We therefore conducted supplemental, not preregistered analyses examining the number of popped balloons. There were no significant main effects of age or frame, but there was a significant age by frame interaction (see Table 2, bottom and Figure 2, bottom). Bonferroni-corrected post hoc tests found that in the loss frame, older adults triggered significantly more pops than younger adults ($p < .01$), whereas the number of pops did not differ significantly by age in the gain condition. Thus, older adults' increased pumping in the loss condition did not yield higher total scores because they pumped too much, resulting in more frequent pops.

As preregistered, secondary analyses examined whether the effects of age and frame on pumping patterns varied over the course of the task. We conducted an age group (young vs old, between-subject) by frame (loss vs gain, between-subject) by trial block (trials 1–5, 6–10, 11–15, 16–20, within-subject) ANOVA with average pumps per trial as the dependent variable. Greenhouse–Geisser corrections addressed deviations from sphericity. The age group by frame interaction that had been found in the between-subjects analyses remained significant, $F(1, 250) = 9.98$, $p = .002$, $\eta^2_p = 0.04$. In addition, there was a significant age group by trial block interaction, $F(2.62, 656.00) = 5.82$, $p = .001$, $\eta^2_p = 0.02$, indicating that age differences in pumping rates were most pronounced within the first block of five trials and leveled off in the remaining blocks (see Supplementary Figure S1). There were no other significant main effects or interactions (all $ps > .10$).

As preregistered, we examined memory biases for the BART as possible contributors to the observed age by framing effects. One-sample *t* tests comparing average bias scores to zero indicated that participants significantly underrecalled their pump counts ($M = -1.48$, $SD = 6.21$, $t(251) = 3.78$, $p < .001$), significantly overrecalled the number of pops ($M = 1.27$, $SD = 6.27$, $t(241) = 3.16$, $p = .002$), and significantly underestimated balloon capacity ($M = -8.79$, $SD = 9.30$, $t(241) = 14.71$, $p < .001$). We conducted age group (young vs old) by frame (loss vs gain) between-subject ANOVAs with bias scores as the dependent variables. This revealed significant main effects of frame indicating that participants were more likely to underrecall their pump counts in the gain frame ($M = -2.64$, $SD = 4.36$) than in the loss frame ($M = -0.28$, $SD = 7.49$, $F(1, 252) = 9.21$, $p < .01$, $\eta^2_p = 0.04$), more likely to overrecall the number of pops in the loss frame ($M = 2.61$, $SD = 8.33$) than in the gain frame ($M = 0.00$, $SD = 2.78$, $F(1, 242) = 11.06$, $p < .01$, $\eta^2_p = 0.04$), and more likely to underestimate balloon capacity in the gain frame ($M = -11.15$, $SD = 7.76$) than in the loss frame ($M = -6.32$, $SD = 10.14$, $F(1, 242) = 17.94$, $p < .001$, $\eta^2_p = 0.07$). Main effects of age group and age by frame interactions were not significant (all $ps > .05$). When the bias scores were included as covariates in the ANOVAs reported in Table 2, the pattern of results remained unchanged: The age by frame interaction for average pumps and number of pops remained significant (all $ps < .05$), all other effects remained nonsignificant. In combination, this indicates that although memory biases were present and varied across frames, they did not differ by age and did not account for age by framing effects in BART performance.

Covariates

Table 1 (left columns) reports age differences in the preregistered demographics and socioemotional, health, personality, and cognitive covariates (for the full intercorrelation matrix of covariates and dependent variables, see

Supplementary Table S2). Age differences were largely consistent with the general aging literature (Schaie & Willis, 2021). Compared to younger adults, older adults reported significantly more limited future horizons and a reduced preference for growth versus maintenance goals, but age groups did not differ in preferences for information- versus affect-focused reasoning. In terms of emotional well-being, older adults reported significantly better emotional health than younger adults and their current affective state was more positive in valence and higher in arousal. Somewhat surprisingly, older adults also reported slightly better subjective physical health than their younger counterparts. With respect to personality, older adults reported higher levels of extraversion, agreeableness, and conscientiousness but lower levels of neuroticism than younger adults, whereas age groups did not differ in openness or need for cognition. Finally, following broad age trends toward decrements in fluid cognition (Schaie & Willis, 2021), older adults reported significantly lower self-rated learning ability and memory and scored lower on both numeracy and working memory (all ps < .05).

As seen in Table 1 (right columns) associations between covariates and BART performance were limited. Participants who pumped more frequently reported higher income, higher education, better self-rated physical health, higher affective valence/arousal, and scored higher in need for cognition. Total scores on the BART, in turn, were selectively associated with higher numeracy scores (ps < .05).

To examine whether any of the covariates could account for the observed pattern of age effects on the BART, we conducted analyse of covariance that tested our preregistered hypotheses about age and framing effects in average pumps and total scores while controlling for potential covariates. Variables in Table 1 that showed associations with both age and BART performance were added as covariates. For pumping rates, the age by frame interaction remained significant (p < .05) and the main effects of age and frame remained nonsignificant even when the potential covariates (income, self-rated physical health, affective valence, and affective arousal) were included simultaneously or one at a time. For total BART scores, in turn, no significant main or interaction effects emerged even after controlling for numeracy. Thus, results remained robust after controlling for covariates.

Discussion

To the best of our knowledge, this is the first study to examine the effects of gain versus loss framing on age differences in the BART. When simultaneously considering the effects of framing and age, we did not find the previously reported main effects of age (Hypothesis 1a, 1b) and framing (Hypothesis 2). Instead we found a significant age by frame interaction. Specifically, loss framing did not just *attenuate* the age-related tendency to take less risk that had been previously observed for the G-BART (e.g., Henninger et al., 2010; Sproten et al., 2018, see Hypothesis 3a, 3b); loss framing actually *reversed* the age pattern such that older adults took significantly greater risks than younger adults in the L-BART.

From a theoretical perspective, this finding is consistent with GOT, which proposes that age-related limitations in resources trigger a shift from growth-oriented goals toward maintenance and loss prevention (Ebner et al., 2006), making older adults more susceptible to the framing effect proposed by prospect theory (Mata & Hertwig, 2011). Conversely, our results do not show any evidence of an age-related positivity effect (Reed & Carstensen, 2012), which would manifest itself as reduced sensitivity to framing among older adults (Mata & Hertwig, 2011). However, as suggested by one astute reviewer, there is an alternative interpretation of our results that would be consistent with the prediction of SST that older adults are more focused on affective well-being in the present moment (Carstensen et al., 1999). Given that the initial affective state is likely to be more positive in the G-BART (which promises gains) than in the L-BART (which threatens losses), older adults may be less likely to pump in the G-BART because it jeopardizes their current positive mood and more likely to pump in the L-BART because it may avoid losses and thus function as a mood repair strategy. Future studies could explore this possibility by tracking affective dynamics over the course of the task.

Interestingly, even though older adults took more risk on the L-BART, as seen in their higher average pumping rates, they did not achieve higher total scores because they also popped more balloons. In other words, older adults may have placed so much emphasis on loss avoidance that they took too much risk and made suboptimal decisions. Interestingly, when examining patterns of age effects over the course of the 20 trials, age differences were most pronounced in the first block of trials, suggesting that older adults were able to flexibly adjust their strategies in response to feedback.

The present study also adds to the literature by examining age differences in memory accuracy for the BART. We found that participants underrecalled how often they had pumped and overrecalled how many balloons had popped. In addition, participants underestimated average balloon capacity. These biases varied by framing such that participants in the gain frame were more likely to underrecall pumping and balloon capacity and participants in the loss frame were more likely to overrecall pops. Thus, framing appears to influence participants' estimates of risk and benefit in decisions by experience. Regardless of framing, however, older adults were as accurate as younger adults in recalling their experiences during the task. This may have helped them to successfully downregulate their initial tendency to overpump in the L-BART.

We also examined a range of theoretically implicated covariates. Our sample showed fairly typical age differences in affective valence and well-being, personality, cognition, future time perspective, and goal orientation (Willis et al., 1999). This indicates that the sample adequately represents normal, healthy older and younger adults. However, none of the covariates mapping onto SST or GOT (i.e., future time perspective, processing preferences, and goal orientation) were significantly associated with BART outcomes. Furthermore, the central pattern of age by frame interactions on the BART remained the same when controlling for covariates. In part, this lack of covariate effects may be due to our reliance on single-item self-report screeners for many of the individual-difference measures. Although this had the benefit of being able to account for a wide range of potential correlates, future studies should assess key concepts such as goal priorities and affect via multi-item measures tapping into both explicit and implicit components.

There are several other limitations to the present study that also necessitate further research. First, the study excluded middle-aged participants. Thus, we were not able to observe potential curvilinear trajectories (Guttman et al., 2021; Rolison et al., 2014). Second, we utilized an automatic version of the BART. Future studies should replicate our findings across a wider range of BART versions. Further, pumping to gain points on the G-BART may have been more intuitive than pumping to avoid points on the L-BART. It is therefore reassuring that the manipulation check was equally successful in both age groups. More broadly, the BART is just one representative of experience-based risky choices. Given that previous research on risk preferences shows low convergence across behavioral measures (e.g., Frey et al., 2017; Mata et al., 2011), future research should examine how age differences in framing effects play out in other decisions from experience, such as the Iowa Gambling Task (Singh & Khan, 2012) and the Columbia Card Task (Figner et al., 2009). Future studies would also benefit from directly comparing decisions from experience to decisions from description. In terms of generalizability, the present findings are limited to a laboratory and online survey setting. Even though participants were given a monetary incentive toward better performance, and even though BART performance has been associated with real-world risk-taking (Lejuez et al., 2002, 2003), it does not approach the intensity and complexity of real-life choices. Thus, further studies should examine whether older adults' exacerbated loss aversion translates into more realistic settings.

If corroborated by future studies, our findings have potential implications for designing choice architecture for realistic settings. Those who advise others in making decisions—from family members to financial consultants and health care providers—should be aware that people of different ages may vary in their responses to such framing. Specifically, older adults may be more susceptible to loss-framed messages. While this can be helpful in "nudging" individuals toward somewhat risky but potentially beneficial choices (such as joint replacement surgery; Hudak et al., 2002), it could also be instrumentalized to lure older adults toward suboptimal decisions. For instance, the common strategy of conjuring up bogus financial threats to peddle shady investment schemes may work particularly well on older victims (Burnes et al., 2017). Thus, even though framing appears to retain or even expand its impact on risky decisions from experience across the adult life span, it should be employed judiciously to avoid overreactions.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Conflict of Interest

None declared.

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