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Abstract: Background: Older adults are stereotypically considered to be risk averse compared to younger age groups, although meta-analyses on age and the influence of gain/loss framing on risky choices have not found empirical evidence for age differences in risk-taking. Objective: The current study extends the investigation of age differences in risk preference by including analyses on the effect of the probability of a risky option on choices in gain versus loss situations. Methods: Participants (n = 130 adults aged 19–80 years) chose between a certain option and a risky option of varying probability in gain- and loss-framed gambles with actual monetary outcomes. Results: Only younger adults displayed an overall framing effect. Younger and older adults responded differently to probability fluctuations depending on the framing condition. Older adults were more likely to choose the risky option as the likelihood of avoiding a larger loss increased and as the likelihood of a larger gain decreased. Younger adults responded with the opposite pattern: they were more likely to choose the risky option as the likelihood of a larger gain increased and as the likelihood of avoiding a (slightly) larger loss decreased. Conclusion: Results suggest that older adults are more willing to select a risky option when it increases the likelihood that larger losses be avoided, whereas younger adults are more willing to select a risky option when it allows for slightly larger gains. This finding supports expectations based on theoretical accounts of goal orientation shifting away from securing gains in younger adulthood towards maintenance and avoiding losses in older adulthood. Findings are also discussed in respect to the affective enhancement perspective and socioemotional selectivity theory.

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Age, Loss Minimization, and the Role of Probability for Decision-Making

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Decision-making · Framing effects · Loss avoidance · Goal orientation · Adulthood

Abstract
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Introduction

Imagine you are on a quiz show. You have to choose between a game involving a small chance of winning a large amount of money or a game offering a large chance of winning a small amount. How do you go about this decision? Would you choose differently if the situation involved losing money rather than winning? The current study explores how people of different ages come to a decision between 2 options that differ both concerning the

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risk associated with them and the potential outcome (gain vs. loss). Such decisions are reached through balancing personal preferences related to risk-taking and to maximizing gains or minimizing losses [1]. Given the importance and prevalence of such kinds of decisions throughout adulthood, particularly in financial and health-related domains, the current study aims at contributing to the understanding of the relationship between age and decision-making.

Studies using both cross-sectional [2–6] and longitudinal data [7] show that aging is associated with a decrease in self-reported risk-taking propensity. One of the factors that might contribute to this age trend is the shift in goal orientation from striving for gains towards maintenance and the prevention of losses across adulthood [8, 9]. Alongside personal preferences towards risk, gain/loss framing manipulations have a robust effect in influencing risky choice selection [10]. Termed the framing effect [11], decision scenarios described as potential gains promote risk-averse choices, while equivalent scenarios described as potential losses promote risk-seeking choices. To illustrate this effect, let us present a scenario that was used by Kahneman and Tversky [12]: 600 persons have become mortally ill and you (i.e., the participant) must choose between 2 possible options. Treatment 1 provides a 100% chance that 200 individuals will survive (and 400 will die). Treatment 2 provides a 1/3 probability that 600 individuals will survive (and 0 individuals will die) and a 2/3 probability that 0 individuals will survive (and 600 will die). Treatment 1 is the certain option, treatment 2 the risky one. Phrasing the options using wording that only mentions the positive outcomes (100% chance that 200 will survive or 1/3 probability that 600 will survive and 2/3 probability that 0 will survive) promotes the selection of the certain option, while only describing the negative outcomes (100% chance that 400 will die or 1/3 probability that 0 will die and 2/3 probability that 600 will die) promotes the selection of the risky option.

Prospect theory [12] describes the framing effect as an s-shaped value function, concave in gains and convex in losses, that overvalues losses compared to equivalent gains. Contemporary theories on age differences in the framing effect focus on affective and motivational differences across the lifespan. According to Mata and Hertwig [13], 2 predominant viewpoints predict opposite effects of framing manipulations on risky choice. Socioemotional selectivity theory (SST) theorizes that decreasing future time perspective results in older adults showing preference for positive information [14], resulting in older adults overvaluing potential gains and undervaluing potential losses. Conversely, the goal orientation account, which describes a motivational shift from resource acquisition towards loss prevention with advancing age [8, 15, 16], predicts that older adults undervalue potential gains while overvaluing potential losses. When mapping these predictions onto the prospect theory value function [13], the goal orientation account predicts a greater framing effect (preferring the certain option in gain choices and the risky option in loss choices) in older compared to younger adults, whereas SST predicts a lesser framing effect.

There is currently no consistent evidence for either account. The two extant meta-analyses of age comparisons in framing studies have not found significant age differences in the framing effect [17, 18]. A small effect was found for gain-framed scenarios in the meta-analysis by Best and Charness [18] with younger adults showing a slight preference for the risky option compared to older adults. This result was driven by young adults' preference for the risky option in small-amount, gain-framed financial choices. Although this result is limited to a particular frame (i.e., gain), domain (i.e., financial), and outcome (i.e., small amount), the significant age effect supports the goal orientation perspective on age differences in decision-making.

Unfortunately, study designs or insufficient reporting of results limited the potential for further exploration of moderating factors in the aging and framing relationship in published studies. Few studies included manipulations of probabilities for risky choice options which are necessary to investigate the relation between risk tolerance and gain/loss framing. A prior meta-analysis on the general framing effect highlighted this issue, noting that common framing paradigms overrepresented low probabilities in gain-framed scenarios and high probabilities in loss-framed scenarios as a consequence of keeping expected values equal across conditions [10]. From the pool of 18 studies used in Best and Charness's meta-analysis [18], only 5 used designs that included a full range of probabilities for both gain and loss frames, only 1 study [19] reported data by age groups across all probability conditions, and none reported analyses on the influence of probability within a frame. The current study serves as a follow-up to Mather et al. [19], specifically focusing on age differences in the effect of framing and the influence of the outcome probability associated with the risky option. For the purposes of our study, which includes decisions between a certain option and a risky option of varying probability (but always of the same expected outcome, i.e., equal utility), risk is defined as the range of the poten-

tial outcome variance [20, 21]. When comparing risky options of varying probabilities, the risky option in a scenario with a larger range of outcomes (e.g., 100% chance for a gain of 1 USD as the certain option vs. 10% chance of a gain of 10 USD as the risky option) is defined as being *more risky* when compared to a second risky option with a smaller range of possible outcomes (e.g., 100% chance for a gain of 1 USD as the certain option vs. 90% chance of a gain of 1.11 USD as the risky option). In this example, a 10% chance of winning 10 USD is more risky than a 90% chance of winning 1.11 USD, although their expected utility is equivalent.

The goal orientation approach to aging predicts a greater framing effect in older adults and provides some assumptions on how different age groups respond to probability variations within a given frame. In gain-framed choices, younger adults should prefer the risky option due to their increased sensitivity to gains compared to older adults [13]. As an extension of this increased preference for a risky option over a certain option, this preference should increase along with the relative risk of the risky option (i.e., increasing outcome variance as the probability of "winning" decreases and the magnitude of the potential reward increases). Young adults' orientation towards the maximization of gains should result in them choosing the risky option more often as the relative risk increases.

The opposite is predicted for loss-framed choices. Unlike younger adults, older adults' orientation towards the prevention of losses should result in an increased preference for the risky option as the relative risk increases (as probability decreases and potential loss increases) in an effort to prevent certain losses. Using similar language from the gain-framed predictions to describe this preference, as the relative risk increases, the risky option allows older adults to "maximize" their opportunity to avoid possible losses.

Methods

A total of 130 young, middle-aged, and older adults participated in this online study. The link to the study was distributed by contacting clubs and companies based in the canton of Lucerne, Switzerland. Young adults were primarily contacted through club memberships, middle-aged adults were primarily contacted through their employers, and older adults were contacted through social clubs and their employers if still employed. Links were distributed to 245 potential participants and 131 participated in the study. Data for 1 person was removed because of incomplete data, resulting in a final sample comprised of 38 younger adults (M_{age} = 25.11 years, SD = 2.25, range = 19–29; 71.1% women), 52 middle-aged adults (M_{age} = 44.63 years, SD = 10.43, range = 30–59; 53.8% women), and 40 older adults (M_{age} = 64.90 years, SD = 4.87, range = 60–80; 42.5% women). All participants had completed secondary education, with 86.8% of younger adults (n = 15, vocational/apprenticeship; n = 18, college/university), 84.6% of middle-aged adults (n = 26, vocational/apprenticeship; n = 18, college/university), and 82.5% of older adults (n = 23, vocational/apprenticeship; n = 10, college/university) completing some form of post-secondary education. Employment status is reported by age group in Table 1. In keeping with the Swiss retirement regulations, some of the older adults <65 years reported working full time, but no older adults reported working more than 50% above the age of 65 years, the mandatory retirement age in Switzerland.

The study included 48 choices between 2 possible monetary outcomes differing in amount and probability. Participants were instructed that all of the decisions had actual outcomes based on their choices and the amount of money accumulated over the course of the experiment would be donated to charity (Doctors Without Borders). Participants gave informed consent prior to participation, including a short description of Doctors Without Borders. At the conclusion of the study, 1,108 CHF (approximately 1,080 USD) were accumulated across participants, and were donated to Doctors Without Borders in July of 2016.

Monetary donations, as opposed to monetary rewards paid out to the participants, were used as the outcome variable in an attempt to control for potential age-related differences in wealth that can affect participants' subjective valuation (i.e., the marginal utility) of small monetary rewards. In the description of the charity, information was provided describing the positive impact of even relatively small monetary donations (e.g., 1 CHF provides 20 days of drinking water for 5 people). Previous studies have found that donations function as desirable rewards across adulthood [22].

Procedure

After providing informed consent, participants completed demographic questions and 2 brief questionnaires measuring risk attitudes and numeracy. The 8-item finance subset of the Domain-Specific Risk-Taking (DOSPERT) Scale [23] assessed the willingness to take risks in both investment and gambling domains. Numeracy was assessed with the Subjective Numeracy Scale [24], including two 4-item subsets to measure self-perceptions of numerical ability and preferences for the presentation of numerical information. Measures of self-reported risk attitudes and numeracy were collected to control for potential age differences in risk preference and risk literacy in the regression analyses. Results for these measures, as well as other demographic information, are reported by age group in Table 1.

After completing these measures, participants made 48 decisions in a 2 (frame: gain, loss) ×2 (choice structure: certain-risky, risky-risky) ×2 (utility: equal, unequal) ×6 (probability: 10, 20, 40, 60, 80, 90%) design. Individual decision scenarios were presented one at a time within 3 blocks. Participants were first presented with a block of 12 gain items, then a block of 12 loss items, and lastly a single block of 24 items from both framing conditions (12 gain items and 12 loss items). The first two 12-item blocks were comprised of 3 items from each of the 4 cells of the 2 (choice structure: risky vs. certain option) ×2 (utility: equal vs. unequal) table. The last block contained the remaining 6 items from each of these 4 cells from both framing conditions (gain vs. loss). Items were randomly presented within each block. Participants were not in-

Table 1. Participant demographics

	Younger adults (n = 38)	Middle-aged adults (n = 52)	Older adults (n = 40)
Age, years	25.11±2.25	44.63±10.43	64.90±4.87
Life satisfaction[a]	5.13±0.66	5.10±1.00	5.33±0.89
Health[a]	5.08±0.71	4.83±0.73	5.23±0.66
DOSPERT (8 items)[b]	1.87±0.71	1.88±0.75	1.86±0.83
Gambling (4 items)[b]	1.51±0.89	1.43±0.83	1.29±0.63
Investment (4 items)[b]	2.23±1.05	2.32±1.09	2.42±1.28
Numeracy (8 items)[c]	4.41±0.79	4.26±0.81	4.53±0.70
Ability (4 items)[c]	4.47±1.08	4.56±1.01	5.16±0.71
Preference (4 items)[c]	4.36±0.95	3.96±0.95	3.89±0.88
Female gender	27 (71.05)	28 (53.85)	17 (42.50)
Education			
Compulsory	0 (0)	3 (5.77)	3 (7.50)
Apprenticeship	8 (21.05)	15 (28.85)	12 (30.00)
Higher professional/vocational training	6 (15.79)	11 (21.15)	10 (25.00)
High school	5 (13.16)	5 (9.62)	4 (10.00)
Higher technical school	1 (2.63)	6 (11.54)	1 (2.50)
University/college	17 (44.74)	12 (23.08)	9 (22.50)
Other	1 (2.63)	0 (0)	1 (2.50)
Employment			
Employed	30 (78.95)	51 (98.08)	28 (70.00)
Part time ≤50%	9 (30.00)	12 (23.53)	11 (39.29)
Part time >50%	4 (13.33)	11 (21.57)	4 (14.29)
Full time	17 (56.67)	28 (54.90)	13 (46.43)
College student	16 (42.11)	4 (7.69)	0 (0.00)
Apprentice	0 (0.00)	0 (0.00)	0 (0.00)
Unemployed	0 (0.00)	0 (0.00)	0 (0.00)
Retired	0 (0.00)	0 (0.00)	15 (37.50)

Values are shown as means ± SD or n (%). Employment designations allowed individuals to identify in multiple categories (e.g., both a college student and employed; both retired and working part-time).

[a] Items are answered on a 6-point Likert scale ranging from 1 to 6. [b] DOSPERT items are answered on a 5-point Likert scale ranging from 1 to 5 [16]. [c] Numeracy items are answered on a 6-point Likert scale ranging from 1 to 6 [17].

formed of the outcome of previous choices in an effort to isolate individual decisions and avoid decision-making based on prior gains or losses.

A subset of 12 items mirroring classic framing scenarios (2 options, 1 risky choice vs. 1 certain choice of equal expected value, presented either as potential gains or losses) was selected for the current analysis (see online suppl. Table S1 for results from the 36 unused items presented by framing condition, probability, and age group; see www.karger.com/doi/10.1159/000487636 for all online suppl. material). These items included 6 gain and 6 loss choices, each across all 6 probabilities. All 6 different probabilities and accompanying outcome amounts for the risky option were tested in each framing condition (see Table 2). Three gain items were presented in the first block (see previous paragraph), 3 loss items were presented in the second block, and the remaining items were presented in the final block.

Results

Bivariate correlations of the variables included in this study are displayed in Table 3. Age was not related to the self-reported willingness to take risks as assessed with the DROSPERT. Age was positively associated with subjective perceptions of numerical *ability* (r = 0.32, p < 0.001), but negatively with the *preference* for numerical information (r = –0.19, p = 0.03). Age was not significantly related to the number of risky choices in neither the gain-framed (r = 0.11, p = 0.22) nor loss-framed condition. However, there was a negative trend between age and risky choices (r = –0.16, p < 0.08) in loss-framed items.

Table 2. Probabilities and reward amounts for certain/risky choice framing items

Gain-framed choice options				Loss-framed choice options			
certain		risky		certain		risky	
probability, %	outcome, CHF	probability (PNI), %	outcome, CHF	probability, %	outcome, CHF	probability (PNI), %	outcome, CHF
100	+1	10 (10)	+10	100	–1	10 (90)	–10
100	+1	20 (20)	+5	100	–1	20 (80)	–5
100	+1	40 (40)	+2.5	100	–1	40 (60)	–2.5
100	+1	60 (60)	+1.67	100	–1	60 (40)	–1.67
100	+1	80 (80)	+1.25	100	–1	80 (20)	–1.25
100	+1	90 (90)	+1.11	100	–1	90 (10)	–1.11

Certain options were described as 100% probability. "Losing" in the risky choices results in gaining or losing 0 CHF in the gain- and loss-framed items, respectively. PNI is the probability of a net increase when choosing the risky option (used in logistic mixed-effects regression analyses; see Tables 5 and 6). At the time of writing, the Swiss Franc (CHF) was approximately equal to the US Dollar (USD).

Table 3. Bivariate correlations between age and psychometric measures

	Age	DOSPERT (total)	DOSPERT (gambling)	DOSPERT (investing)	Numeracy	Numeracy (ability)	Numeracy (preference)	Risky choice (gains)	Risky choice (losses)
Age	–								
DOSPERT (total)	–0.03	–							
DOSPERT (gambling)	–0.17	0.68**	–						
DOSPERT (investing)	0.08	0.86**	0.22*	–					
Numeracy	0.09	0.14	–0.02	0.21*	–				
Numeracy (ability)	0.32**	0.15	0.00	0.20*	0.81**	–			
Numeracy (preference)	–0.19*	0.08	–0.04	0.14	0.79**	0.29**	–		
Risky choice (gains)	0.11	0.13	0.08	0.12	0.02	0.04	0.00	–	
Risky choice (losses)	–0.16	0.10	0.04	0.10	–0.01	–0.05	0.03	–0.04	–

Increasing scores on the DOSPERT measures indicate a greater preference for risk in financial domains (gambling and investing). Increasing scores on the numeracy measures indicate greater self-reported numeracy (ability to work with numbers and preference for information to be displayed numerically).

* $p < 0.05$, ** $p \leq 0.001$.

To investigate the relationship between age and the framing effect, the data were fit to a linear mixed-effects regression model using the lme4 [25] and lmerTest [26] packages in R [27] using the R Studio interface [28]. The mean of risky choice selections in each framing condition was used as the dependent variable (see online suppl. Table S2 for results presented by framing condition, probability, and age group), including participant as a random factor, and age, framing condition, and the interaction term as fixed factors. A subsequent model was tested, adding gender as a fixed factor to control for the differing gender ratio across age groups. The models were compared using a likelihood ratio test, which indicated that the addition of gender improved model fit ($\chi^2(1) = 5.72$, $p = 0.02$). This model is displayed in Table 4. Along with a significant effect of gender, with females less prone to choosing the risky option ($p = 0.02$), the interaction between age and framing condition was also significant. This interaction is displayed in Figure 1 and shows an overall framing effect (choosing the risky option more often in loss-framed, rather than gain-framed, scenarios) in the lower age ranges and disappearing with increasing

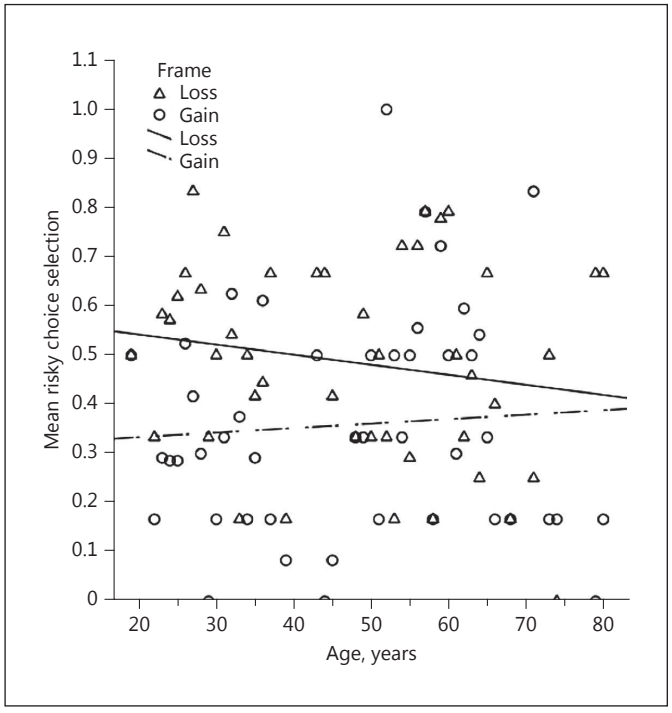


Fig. 1. Mean risky choice selection as a function of age for both gain and loss framing conditions.

age ($p = 0.03$). Further inclusion of the risk attitudes and numeracy variables to the model did not significantly improve model fit ($\chi^2(1) = 2.99$, $p = 0.22$).

To further investigate the potential influence of the outcome probability of the risky choice, the data were fit to a logistic mixed-effects regression model using the lme4 package in R [25]. Certain versus risky choice selection was used as the binary dependent variable, including participant as a random factor, and age, probability, frame, and the associated 2- and 3-way interactions, were included as fixed factors. In these analyses, probability of risky options was recoded to reflect the probability of a net increase (PNI). For example, both a loss-framed option that presents a 90% chance of losing money and a 10% chance of losing nothing and a gain-framed option that presents a 10% chance of winning money and a 90% chance of winning nothing were coded as a PNI of 10%, reflecting the 10% possibility of a net-positive outcome.

Along with the base logistic mixed-effects regression model, a second model was tested adding gender as a fixed factor to the base model to account for the difference in gender ratio across age groups. The models were compared using a likelihood ratio test, revealing that the addition of gender improved model fit ($\chi^2(1) = 5.96$, $p = 0.01$), the results of which are displayed in Table 5. There was a main effect of gender with females being generally less likely to select the risky option. The 3-way interaction between age, probability, and frame was significant. The probability of choosing the risky option was calculated as a function of the regression model (Table 5) and plotted as two 3-dimensional graphs with age and PNI for each framing condition (Fig. 2, 3). Again, the inclusion of the risk attitudes and numeracy variables did not significantly improve model fit ($\chi^2(1) = 3.21$, $p = 0.20$), and they were not included in the reported model.

To further explore the significant 3-way interaction, a separate logistic mixed-effects regression analysis was conducted for each frame (Table 6). The loss condition showed a significant interaction between age and PNI. The same interaction term did not reach the traditional level of sig-

Table 4. Linear mixed-effects regression analyses predicting risky option selection from gender, frame, and age

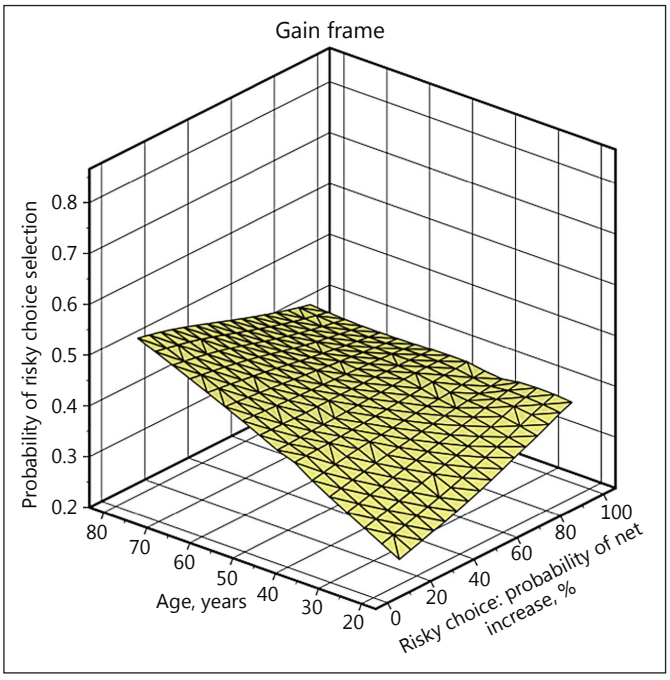
Predictor	*b*	SE	*t*	*p*
Intercept	0.57	0.03	16.72	<0.001
Gender	–0.09	0.04	–2.40	0.02
Frame	–0.12	0.04	–3.14	<0.01
Age	–0.06	0.03	–2.25	0.03
Frame × age	0.08	0.04	2.18	0.03

Binary predictors were coded as follows – gender: male = 0, female = 1; frame: loss = 0, gain = 1.

Table 5. Logistic mixed-effects regression analyses predicting risky option selection from gender, frame, probability, and age

Predictor	*b*	SE	*z*	*p*
Intercept	0.31	0.14	2.21	0.03
Gender	–0.44	0.18	–2.46	0.01
Frame	–0.53	0.11	–4.86	<0.001
Probability	0.08	0.08	1.00	0.32
Age	–0.28	0.10	–2.68	0.01
Frame × probability	–0.03	0.11	–0.26	0.79
Frame × age	0.37	0.11	3.39	<0.001
Probability × age	0.16	0.08	2.10	0.04
Frame × probability × age	–0.30	0.11	–2.71	0.01

Binary predictors were coded as follows – gender: male = 0, female = 1; frame: loss = 0, gain = 1. Probability was reverse coded in the loss condition, and in this analysis reflects the probability of a net increase (i.e., probability of not losing money).



Color version available online

Fig. 2. Probability of risky choice selection in gain-framed items as a function of age and probability of net increase from the risky option. The *x* and *z* axes are rotated 90° compared to Figure 3 to aid visualization. See online supplementary Figure S1a for an axis rotation matching Figure 3.

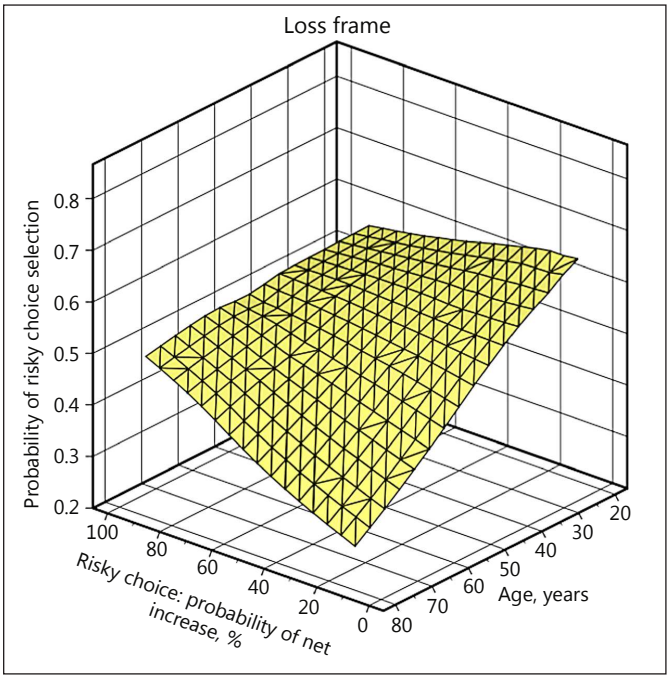


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Fig. 3. Probability of risky choice selection in loss-framed items as a function of age and probability of net increase from the risky option. The *x* and *z* axes are rotated 90° compared to Figure 2 to aid visualization. See online supplementary Figure S1b for an axis rotation matching Figure 2.

nificance ($p = 0.06$) in the gain condition. As seen in Figure 2, the trending interaction effect between age and PNI on the probability of risky choice in the gain condition is characterized by an increase in risky choice selection with age as PNI decreases (lower probabilities of larger rewards, see Table 2). Conversely, the significant interaction effect in the loss condition (Fig. 3) is characterized by a relative decrease in risky choice selection with age as PNI decreases, though age is generally associated with a lower probability of choosing the risky option across all PNIs.

Discussion

Overall, younger adults demonstrated the framing effect (preference for the risky option in loss-framed compared to gain-framed choices), but this effect diminished and ultimately disappeared with advancing age. Given that age was not associated with a preference for the risky choice in either frame, this framing effect cannot be attributed to age-differential preferences for risk in either the gain or loss frame.

Table 6. Logistic mixed-effects regression analyses predicting risky option selection from gender, probability, and age for both gain and loss frames

Predictor	*b*	SE	*z*	*p*
Gain frame				
Intercept	0.06	0.21	0.29	0.77
Gender	–1.07	0.29	–3.70	<0.001
Probability	0.05	0.09	0.61	0.54
Age	0.03	0.14	0.23	0.82
Probability × age	–0.16	0.09	–1.86	0.06
Loss frame				
Intercept	0.04	0.23	0.16	0.87
Gender	0.06	0.31	0.21	0.83
Probability	0.09	0.08	1.08	0.28
Age	–0.27	0.15	–1.75	0.08
Probability × age	0.19	0.08	2.27	0.02

Gender was coded as male = 0, female = 1. Probability was reverse coded in the loss condition, and in this analysis reflects the probability of a net increase (i.e., probability of not losing money).

What is the role of the probability of the risky option in gain- versus loss-framed decisions across adulthood? The results in the loss condition supported our expectation: older adults showed a stronger preference for the risky option as the relative risk increased (i.e., as the PNI increased and the magnitude of potential losses increased), thereby preventing certain losses. The younger the participants, the more likely they were to choose the risky option as the relative risk decreased. In other words, the older the person in our study, the more willing they appeared to incur a risk as the probability of losses decreased, even as the amount of losses at stake become more severe. We interpret this trend as an indicator of a motivational shift to attempt to prevent certain losses.

Contrary to our expectations, younger adults did not choose the risky option more often in gain-framed scenarios. An interaction between age and probability approached significance in the gain condition, but in the opposite direction from our expectations. Younger adults were more likely to choose the risky option as the relative risk decreased (i.e., as the probability increased and potential rewards decreased). This relation changed across adulthood: age was associated with a gradual shift towards a higher probability of risky choice selection as the relative risk increased. In other words, age was associated with an increased probability of choices that have the potential to maximize the amount of gain at the cost of an increased risk of gaining nothing.

A shifting preference for the consideration of probability versus the relative size of the potential outcome appears to occur across adulthood in both gain and loss frames. Young adults appear to focus on the *probability* for potential gains, showing an increasing preference for the risky option as "winning" becomes more likely although the resulting reward is relatively small. In losses, they appear to focus on the *amount* of losses at stake, choosing the risky option less often as the possible loss increases even though the probability of the loss decreases. Older adults show the opposite pattern. Supporting our hypothesis, older adults' probability of selecting the risky option increased as the likelihood of loss decreased, showing a focus on *probability* and an attempt to avoid a certain loss. This result supports the perspective of a motivational shift across adulthood towards a stronger motivation to avoid losses. However, contrary to the goal orientation perspective, older adults appeared to focus on the outcome *amount* in the gain frame; the probability of making a risky choice increased with the potential reward amount. This result is in line with SST as it appears to reflect a stronger focus on positive events in older adulthood. Taken together, then, the current study suggests that the age-related shift in goal orientation affects primarily the reactions to the likelihood with which losses may occur, whereas the positivity effect postulated by SST might be primarily related to reactions to the size of a gain. This pattern is consistent with the affective enhancement perspective [29, 30], which describes an age-related increase in the influence of affective responses in decision-making. Faced with potential losses, older adults may have a stronger affective response to an increasing probability that a loss may be avoided. Likewise, when faced with possible gains, older adults may show a stronger affective response to the potential reward amount.

These results pertaining to the role of probability on risky choice selection across adulthood warrant further investigation. A number of prior gain/loss framing studies that compared participants across age groups have also used designs that include varying probabilities [19, 31–34], but only one of them reported results sufficiently to estimate age differences in choice selection across differing probabilities. Mather et al. [19] did not directly investigate the role of probability in risky choice preference in their analyses, but it appears that their data would not support the significant age and probability interaction in the loss condition found in the current study. Although these results may appear to differ from the current study, it is important to note that older adults' preference for the risky option was uncharacteristically large across all probabilities in the Mather et al. study [19, Table 6]. This paper provided the largest effect size calculated in Best and Charness's [18] meta-analysis among loss-framed items in the direction of older adults preferring the risky option compared to younger adults. It also differed from the current study in reward amount (10 USD vs. ~1 USD) and young adult participant composition (student vs. community). Moreover, the current study used a contingent-dependent payment such that the gains and losses were actually added or subtracted from the amount donated to charity.

The current study has several limitations. First and foremost, the study is cross-sectional and does not allow disentangling effects of cohort and age. It might be the case that attitudes towards risks as well as gains versus losses have changed across cohorts. Additionally, older adult participants were either contacted through their employer or through social clubs. Although it is highly usual for older adults in Switzerland to be part of a social club, results may not be generalizable to less active older adults. Note, however, that experiences of health-related losses would probably lead to stronger loss aversions in

older adults. Thus, we maintain that our sample of relatively healthy and active older adults would, if anything, work against our hypotheses and weaken our findings.

Pertaining to the reward domain, although we attempted to increase the value of the won (or lost) money in this study by pointing out that even small amounts can make a difference for the humanitarian work of this charity, the absolute amount of money was small. Furthermore, age-related differences in altruistic tendencies [35] may cause younger and older adults to differentially value the benefits provided by monetary donations to the charity. Finally, winning (or losing) money, even if it is associated with charitable giving, might not be equally motivating to different age groups [22]. Note, that although the money won or lost in this paradigm will ultimately affect somebody else who is in need, the gains and losses are nevertheless incurred by the participant and count towards their donation account. Thus, participants are likely to experience the gains and losses as pertaining first and foremost to them, and only in a more distal consequence it affects the amount that will be donated to charity.

Despite these limitations, this study provides evidence of a motivational shift away from gain in younger adulthood towards the prevention of losses in older adulthood. Unlike younger adults, older adults are increasingly more likely to choose the risky option when the likelihood of avoiding a loss is large, even when the potential loss is relatively severe. This preference can impact older adults' susceptibility to fraud or decisions to not buy certain types of potentially profitable insurance policies (e.g., long-term care insurance) if losses are framed as unlikely. Conversely, in gain-framed choice scenarios, younger adults are more likely to choose the risky option when the likelihood of a gain is larger, even when the relative gain is small in magnitude. This preference for a more certain, although potentially less beneficial, outcome may influence younger adults' tendency to incur less risk in their monetary investments (e.g., own fewer stocks [36]) at an age where a greater, riskier portfolio would likely show greater returns [37]. Going beyond monetary decisions, risky decisions involving gains and losses play an important role in the domain of health [38]. Most medical procedures have intended and unintended outcomes that occur with varying degrees of uncertainty. Extending our results to decision-making in the health domain, older adults might choose riskier medical treatment options when the likelihood is high that a negative state can be alleviated even if there is a possibility that the treatment may cause severe losses (e.g., joint replacement). As of yet, the applications are highly speculative and further research is needed to further explore how to best communicate potential gains and losses involved in financial and health-related decisions to different age groups.

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