Individual Differences in Loss Aversion and Preferences for Skewed Risks Across Adulthood

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Author contributions: G. R. Samanez-Larkin, K.L. Seaman, and S. Shu developed the study concept and design. Data collection was performed by K.L. Seaman. K. L. Seaman and M. Green performed the data analysis and interpretation under the supervision of G.R. Samanez-Larkin. K. L. Seaman and M. Green drafted the manuscript and S. Shu and G.R. Samanez-Larkin provided critical revisions. All authors approved the final version of the manuscript for submission.

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Data: Data and code used in the manuscript can be viewed and downloaded at https://osf.io/rm2we/.

Abstract

In a previous study, we found adult age differences in the tendency to accept more positively-skewed gambles (with a small chance of a large win) than other equivalent risks, or an age-related positive-skew bias. In the present study, we examined whether loss aversion explained this bias. 508 healthy participants (ages 21-82) completed measures of loss aversion and skew preference. Age was not related to loss aversion. While loss aversion was a significant predictor of gamble acceptance, it did not influence the age-related positive-skew bias.

Keywords: aging; decision making; loss aversion; skew; risk taking

Introduction

Should I buy a raffle or lottery ticket? Should I invest in a risky stock or financial scheme that promises huge returns? Many financial decisions involve considering options that promise large, but unlikely, gains coupled with small, but likely, losses. These stakes are also known as positively-skewed risks. Recent work has shown that compared to younger adults, older adults have a tendency to accept more positively-skewed financial risks than other types of equivalent gambles (Seaman, Leong, Wu, Knutson, & Samanez-Larkin, 2017). We call this propensity an age-related positive-skew bias. This bias may be problematic as it could increase susceptibility to financial fraud (which is typically described as a rare chance of very large gain). However, it remains unclear why older adults show this bias. One possible explanation is that a bias towards positively-skewed gambles is due to increased loss aversion, or peoples' tendency to prefer avoiding a loss to acquiring an equivalent gain, and that loss aversion increases with age.

Studies have shown that both humans (Åstebro, Mata, & Santos-Pinto, 2015; Burke & Tobler, 2011; Wu, Bossaerts, & Knutson, 2011) and primates (Genest, Stauffer, & Schultz, 2016) prefer positively-skewed risk, suggesting that people may place greater *subjective value* on positively-skewed gambles than otherwise objectively equivalent gambles. This difference in subjective value may come about because people have been shown to overweigh unlikely events (Hertwig, Barron, Weber, & Erev, 2004). In a positively-skewed gamble, a potential *positive* outcome would be given a greater weight, leading to a larger subjective value for that gamble. Conversely, in a negatively-skewed gamble, the potential *negative* outcome would be given greater weight, leading to a smaller subjective value. In our prior study of skewed risky decision making (Seaman et al., 2017), we asked participants to accept or reject skewed gambles with an expected value of $0. However, if participants gave a greater *subjective value* to positively-skewed gambles (SV > $0) and a lower *subjective value* to negatively-skewed gambles (SV < $0), then positively-skewed gambles would be considered a gain and negatively-skewed gambles would be considered a loss. Thus, people who are more loss averse may be more likely to avoid negatively-skewed gambles than equivalent symmetric or positively-skewed gambles.

An increase in loss aversion with age is theoretically supported by the selection, optimization and compensation model (Baltes & Baltes, 1990) of adult development. This theory posits that as people age, they become less focused on acquiring new resources and more focused on maintaining and avoiding the loss of current resources (Baltes & Baltes, 1990; Freund & Ebner, 2005). Thus, this theory would predict that older adults are more loss averse than their younger counterparts. However, the empirical literature testing the effect of age on loss aversion in the context of risky decision making is mixed, with some studies suggesting an increase of loss aversion with age (Gächter, Johnson, & Herrmann, 2007; Kim, Goldstein, Hasher, & Zacks, 2005) while others find no relationship (Kovalchik, Camerer, Grether, Plott, & Allman, 2005; Li, Baldassi, Johnson, & Weber, 2013; Pachur, Mata, & Hertwig, 2017). While it is unclear if loss aversion increases with age, if it does, it may help explain the age-related positive-skew bias.

This study uses data from (Seaman et al., 2017) to examine the influence of loss aversion on the age-related positive-skew bias. Our first goal was to assess the relationship between age and loss aversion. Based on the SOC theory, we predicted that there would be a significant relationship between age and loss aversion. However, based on the mixed empirical literature, it is also possible that there is no relationship between age and loss aversion. Our second goal was to examine whether loss aversion influences skewed decision making, and if it explains the age-related positive-skew bias observed in previous research. Based on a subjective value model of skewed decision making, we predicted that loss aversion would influence skewed choice.

Finally, assuming an increase in loss aversion with age as suggested by SOC theory, we predicted that loss aversion would moderate the relationship between age and the acceptance of positively-skewed gambles.

Methods

Some of these data were included in Study 2 of another publication focused on the age-related positive-skew bias (Seaman et al., 2017). Five hundred and eight participants (Age: *Mean* = 48.62, *SD* = 17.02, Range = 20 – 81 years old) were recruited for an online study using Qualtrics Panels. Screening questions were used to exclude people with a history of psychiatric/neurological illness or prior head injury. Age and gender quotas were used to ensure the sample included equal numbers of men and women in each age decade. Participants completed a brief demographic questionnaire, a brief skewed gambling task, and a brief loss aversion gambling task. Total survey time was approximately 10 minutes. The Yale University Institutional Review Board (where K. Seaman and G. Samanez-Larkin collected these data) approved all experimental procedures.

Skewed Gambling Task. During the skewed gambling task participants chose between a safe, certain amount ($0; reject the gamble) and a risky, uncertain gamble (accept the gamble). In contrast to Study 1 of the previous neuroimaging study (Seaman et al., 2017), the gambles did not play out and the participants received no feedback after their choices. The task was not incentive-compatible in that subjects were not paid according to their choices; choices were made hypothetically. There were three gamble types: positively-skewed, negatively-skewed, and symmetric gambles. Symmetric gambles featured an equal probability (50%) of winning or losing a moderate amount of money ($3.05). Positively-skewed gambles featured a low probability (25%) of winning a large amount ($5.25) paired with a high probability (75%) of losing a small amount ($1.75). In negatively-skewed gambles, these contingencies were flipped. They featured a low probability (25%) of losing a large amount ($5.25) paired with a high probability (75%) of winning a small amount ($1.75). Critically, all these gambles were equated on expected value (EV = $0) and variance ($\sigma^2 = 9.19$), and only one level of skewness ($\gamma = \pm 32.16$) was tested. Participants saw each gamble type three times (for a total of 9 choices).

In addition to the mixed gambles described above, participants also saw three "Gain-only" gambles (where the only possible outcomes were monetary gains) and three "Loss-only" gambles (where the only possible outcomes were monetary losses) to examine whether age differences were due to potential differences in framing effects. These exploratory trials were excluded for all analyses in this manuscript. These data are included in the publicly available data files on OSF: https://osf.io/rm2we/

In the first wave of data collection (*N* = 110), participants made choices in the following order: 3 Mixed gambles, 3 Gain-only gambles, 3 Mixed gambles, 3 Loss-only gambles, 3 Mixed gambles (15 gambles total). Within each set of gambles the participants saw one positively-skewed gamble, one negatively-skewed gamble, and one symmetric gamble. Because of concerns about order effects, for the second wave of data collection (*N* = 398), participants made choices about all 3 sets of Mixed gambles first (9 gambles), and then made choices about a set of gain-only gambles and a set of loss-only gambles (15 gambles total). The presentation of gambles was randomized within each set of 3 gambles. There was no significant difference in gamble acceptance between waves, so the data from both waves is combined for analysis below. Analysis of the age effects on skewed risk taking in these data was already published in Study 2 of (Seaman et al., 2017).

Loss Aversion Gambling Task. During the loss aversion gambling task, participants chose between pairs of gambles each with three equally possible outcomes consisting of a gain, neutral, or loss payoff, hereafter denoted using the notation of (gain, neutral, loss). The task is publicly available at http://www.digitai.org as the Loss Aversion Calculator. We presented the gambles and calculated loss aversion scores within the same Qualtrics survey used to collect the measures described above.

Each of the ten trials offered the participant the option of choosing either a gamble of ($100, $0, -$100), referred to as the "Loss Averse gamble," or a gamble of ($X, $0, -$300), referred to as the "Gain Seeking gamble," where $X was randomly drawn without replacement from the set of gain amounts of {$200, $300, $350, $400, $500, $600, $700, $900, $1100, and $2100}, until all ten gain amounts had been used in a Gain Seeking gamble combination presented to the participant. Additionally, the ordering as to whether the Loss Seeking or Gain Seeking gamble was presented on the left or right was also randomized. This methodology of eliciting choices between risky gambles has been used previously (Payne, Shu, Webb, & Sagara, 2015) to assess an individual's degree of loss aversion. This methodology estimates the point at which a participant finds that the marginal gain-loss tradeoff between the Gain Seeking and Loss Averse gamble switches to where the Gain Seeking gamble becomes more attractive (i.e., because the prospective gain amount in the Gain Seeking gamble has been raised high enough to preferentially offset the increase in prospective loss). Additional details about the calculation of the Loss Aversion score appear in the Supplementary Materials.

Data Analysis. Multilevel binary logistic regressions were carried out using the lme4 package in R. The following models were used to model the effects of age (varied between-subjects; as a continuous variable), gamble type (varied within-subjects; deviation coding compared each skew condition to the symmetric condition: Contrast 1 = positive skew > symmetric, Contrast 2 = negative skew > symmetric), and loss aversion (varied between-subjects; as a continuous variable):

Baseline Model

$$ACCEPT = b_{0j} + b_{1j}(age_{ij}) + b_{2j}(gamble\ type) + b_{3j}(age\ x\ gamble\ type) + e_{ij}$$

$$b_{0j} = \beta_{00} + u_{0j}$$

$$b_{1j} = \beta_{10} + u_{1j}$$

Model 1

$$ACCEPT = b_{0j} + b_{1j}(age_{ij}) + b_{2j}(gamble\ type)$$

$$+ b_{3j}\ (loss\ aversion) + b_{4j}(age\ x\ gamble\ type)$$

$$+ b_{5j}(age\ x\ loss\ aversion) + b_{6j}\ (gamble\ type\ x\ loss\ aversion) + e_{ij}$$

$$b_{0j} = \beta_{00} + u_{0j}$$

$$b_{1j} = \beta_{10} + u_{1j}$$

Model 2

$$ACCEPT = b_{0j} + b_{1j}(age_{ij}) + b_{2j}(gamble\ type)$$

$$+ b_{3j}\ (loss\ aversion) + b_{4j}(age\ x\ gamble\ type)$$

$$+ b_{5j}(age\ x\ loss\ aversion) + b_{6j}\ (gamble\ type\ x\ loss\ aversion)$$

$$+ b_{7j}\ (age\ x\ gamble\ type\ x\ loss\ aversion) + e_{ij}$$

$$b_{0j} = \beta_{00} + u_{0j}$$

$$b_{1j} = \beta_{10} + u_{1j}$$

Results from the baseline model were published in the supplement of Seaman et al., 2017.

Results

Contrary to our predictions, we found no significant association between age and loss aversion (R = 0.020, 95%CI [–.07, 0.11]. However, it was still possible that loss aversion could be a significant moderator or predictor of behavior. Therefore, we added loss aversion, and its interactions with gamble type and age, to our baseline model of skewed gamble acceptance (Model 1, Table 1). Adding these predictors significantly improved model fit ($\chi^2(4, N = 508) = 50.20, p < .001$). We also tested a full factorial model that included the three-way interaction between age, loss aversion and gamble type (Model 2, Table 2), but adding the three-way interaction did not significantly improve model fit ($\chi^2(2, N = 508) = 0.92, p = .632$).

Our baseline model, originally included as a replication study in the supplementary material of Seaman et al, 2017, showed that participants were more likely to *accept* positively-skewed (compared to symmetric) gambles and more likely to *reject* negatively-skewed (compared to symmetric) gambles. Furthermore, an interaction of gamble type with age indicated that this trend was most pronounced in older adults, who were more willing to accept positively-skewed than symmetric gambles. We call this effect the age-related positive-skew bias.

Adding loss aversion to the model did not change the direction or significance of these effects (Table 1, Model 1). Controlling for loss aversion, the main effect of age was significant, with older adults accepting more gambles than their younger counterparts. As expected, loss aversion was a significant predictor of gamble acceptance, with higher values of loss aversion leading to lower gamble acceptance. However, this effect differed by age and gamble type. Although the direction of the effect of loss aversion on choice was the same across the adult life span, the influence of loss aversion on gamble acceptance was greater for older adults than for younger adults (Figure 1a). This pattern also varied across gamble type. As loss aversion increased, acceptance rates declined sharply for positively-skewed gambles, and declined more gradually for symmetric and negatively-skewed gambles (Figure 1b). Critically, because the three-way interaction between age, loss aversion, and gamble type (Model 3) was not significant, there was no evidence that loss aversion moderated the age-related positive-skew bias.

Discussion

This study investigated the influence of loss aversion on the age-related positive-skew bias. Contrary to our predictions, we did not find a relationship between age and loss aversion. Loss aversion was, however, a significant predictor of gambling behavior. Those who were more loss averse accepted fewer gambles, and this pattern varied across age and across gamble type. Critically, there was no three-way interaction between age, loss aversion, and gamble type on choice behavior, suggesting that loss aversion did not account for the age-related positive-skew bias.

The lack of a relationship between age and loss aversion was not predicted, but these results are consistent with other studies that did not find an effect of age on loss aversion (Li et al., 2013; Mayhorn, Fisk, & Whittle, 2002; RÖnnlund, Karlsson, Laggnäs, Larsson, & Lindström, 2005). It is possible that loss aversion increases with age in other, non-monetary domains. SOC, for example, does not make specific predictions about loss minimization in the financial domain. In fact, monetary outcomes may be less salient than other types of rewards, like social incentives and positive health outcomes, especially in older age (Seaman et al., 2016). Age differences in loss aversion have been reported when making health decisions (Kim et al., 2005), although see (Mayhorn et al., 2002). Future research should explore the possibility that loss aversion in older adults varies by decision domain.

Another somewhat unexpected finding was that acceptance of risky gambles (across skew conditions) increased with age after controlling for individual differences in loss aversion. Although it has been commonly assumed that risk aversion increases with age, meta-analyses reveal that age effects on risk taking vary across tasks and contexts (Best & Charness, 2015; Mata, Josef, Samanez-Larkin, & Hertwig, 2011). The main effect of age was not significant without loss aversion in the model. It is unclear why controlling for loss aversion increased the size of the age effect. However, the significant age effect was small, consistent with the overall lack of an age effect on risk taking in other similar tasks where decisions are made from description (Mata et al., 2011).

There are several limitations of this study. First, the measure of loss aversion contained mixed gambles, and within those gambles loss magnitude was confounded with skewness. Future studies could use measures of loss aversion that either involve only symmetric gambles (Tom, Fox, Trepel, & Poldrack, 2007) or calculate the difference between willingness to accept versus the willingness to pay in the endowment effect (Knutson et al., 2008) to avoid this confound. Second, the measure of skewed decision making only tested one level of skewness. Future studies could vary the degree of skewness, while controlling for expected value and variance, to examine how the degree of skewness influences gambling behavior. Third, by controlling for expected value and variance, we were not able to test the independent effects of these gamble characteristics on gambling behavior generally, or the age-related positive-skew bias specifically. Following work done in young adults (Burke & Tobler, 2011; Symmonds, Wright, Bach, & Dolan, 2011; Wright, Symmonds, Morris, & Dolan, 2013), future studies could vary multiple gamble characteristics to examine the independent influence of each of these characteristics on the age-related positive-skew bias.

If loss aversion is not driving the age-related positive-skew bias, what is? It is possible that this bias is at least partially due to the age-related positivity effect (Carstensen & Mikels, 2005; Mather & Carstensen, 2005), where older adults pay more attention to and have better memory for positive compared to negative information. It is possible that older adults focus more on the less likely but large potential gains, which increases the subjective value of and the tendency to accept positively-skewed gambles. However, this interpretation cannot be tested with the current data and will need to be tested in future research. For example, eye tracking could be used to more precisely assess the allocation of attention to specific gambles features.

Although loss aversion explains some variance in acceptance of skewed gambles, it remains unclear why some older adults display an age-related positive-skew bias. Understanding why some individuals are susceptible to this decision-making bias is important because it has the potential to facilitate the identification of individuals who are vulnerable to taking skewed risks in the real world, such as falling victim to financial fraud. Brief assessments of skew bias, such as the one used here, may enable rapid identification of susceptibility so that interventions can be implemented *before* individuals take drastic skewed risks in everyday life (Scheibe et al., 2014).

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Table 1
Logistic regression models predicting risky choice

Variables	Comparison	Baseline Model	Model 1	Model 2
Intercept		**0.4 [0.24, 0.57]**	**0.8 [0.56, 1.05]**	**0.8 [0.56, 1.05]**
Skewness	Positive > Symmetric	**0.56 [0.46, 0.67]**	**0.9 [0.75, 1.07]**	**0.91 [0.75, 1.08]**
	Negative > Symmetric	**-0.57 [-0.67, -0.47]**	**-0.73 [-0.89, -0.58]**	**-0.73 [-0.9, -0.58]**
Age		0.11 [-0.05, 0.28]	**0.38 [0.13, 0.65]**	**0.39 [0.14, 0.65]**
Loss Aversion			**-0.12 [-0.17, -0.06]**	**-0.12 [-0.17, -0.06]**
Skewness by Age	Positive > Symmetric x Age	**0.21 [0.1, 0.32]**	**0.22 [0.11, 0.33]**	**0.29 [0.11, 0.46]**
	Negative > Symmetric x Age	0.01 [-0.09, 0.12]	0.01 [-0.09, 0.11]	-0.01 [-0.18, 0.15]
Skewness by Loss Aversion	Positive > Symmetric x Loss Aversion		**-0.1 [-0.13, -0.06]**	**-0.1 [-0.14, -0.06]**
	Negative > Symmetric x Loss Aversion		**0.05 [0.01, 0.08]**	**0.05 [0.01, 0.09]**
Age by Loss Aversion			**-0.08 [-0.13, -0.02]**	**-0.08 [-0.13, -0.02]**
Skewness by Age by Loss Aversion	Positive > Symmetric x Age x Loss Aversion			-0.02 [-0.06, 0.02]
	Negative > Symmetric x Age x Loss Aversion			0.01 [-0.03, 0.04]
AIC		5362.9	5320.7	5323.7
BIC		5420.7	5404.2	5420.2
Pseudo R^2		0.47	.480	.480

Notes. Unstandardized betas (and 95% confidence interval) reported. Participants modeled as random effects. Significant fits highlighted in **bold**.

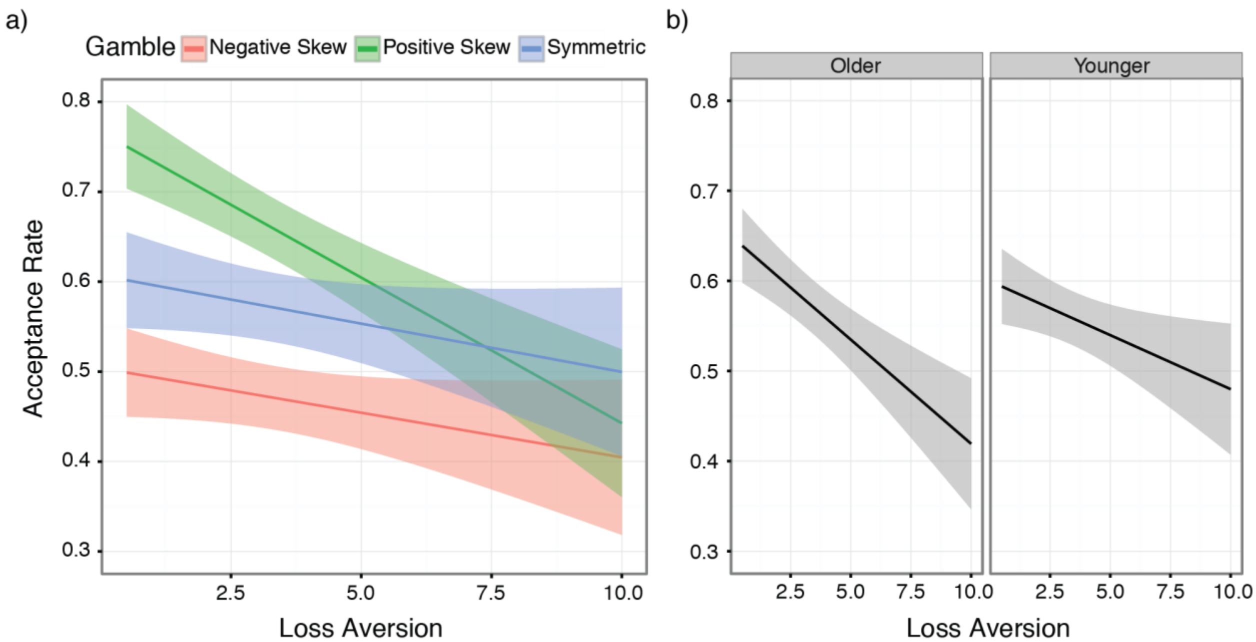

Figure 1. Associations between loss aversion and skewed gamble acceptance. (a) Effects of loss aversion on the proportion of trials where the gamble was accepted within each skew condition. (b) Effects of loss aversion on the proportion of trials where the gamble was accepted within younger adults (ages 21–50) and older adults (ages 51–82).

Supplementary Materials – Seaman, Green, Shu, Samanez-Larkin

Calculation of Loss Aversion

The loss aversion score computed for each participant is related to both the loss aversion scores associated with each trial and the participant's choices during those trials. For the loss aversion score associated with a trial, this is calculated as the difference in gain amounts between the Gain Seeking and Loss Averse gambles divided by the difference in loss amounts between the Gain Seeking and Loss Averse gambles and then adjusting the sign. By way of example, suppose for a trial the Loss Averse gamble is ($100, $0, -$100) and the Gain Seeking gamble is ($500, $0, -$300). This leads to an associated loss aversion score for the trial of ($500-$100)/(-$300-(-$100))*(-1) = 2.0. If a participant selected the Gain Seeking gamble in this case, then we have evidence that the participant's loss aversion score is less than or equal to 2.0. For other trials, a participant may reject the Gain Seeking gamble and choose the Loss Averse gamble. For example, suppose a participant chooses the Loss Averse gamble of ($100, $0, -$100) over a Gain Seeking gamble of ($400, $0, -$300). For this trial, the associated loss aversion score is ($400-$100)/(-$300-(-$100))*(-1)=1.5, and since the participant chose the Loss Averse gamble, we have evidence that the participant has a loss aversion score greater than 1.5. In essence, "$400 wasn't enough for them" to compensate for the increased, potential loss amount. The second step of the scoring procedure is to examine all of a participant's choices across trials, and recognizing that a participant may make inconsistent choices, such as choosing a Gain Seeking gamble of ($500, $0, -$300) while rejecting a Gain Seeking gamble ($700, $0, -$300), use an estimation procedure that accounts for potential inconsistencies. This procedure involves 1) identifying the trial associated with the lowest loss aversion score where a participant switches from taking Loss Averse gambles and starts to take Gain Seeking gambles, 2) identifying the trial associated with the highest loss aversion score where a participant switches from taking Gain Seeking gambles and starts to take Loss Averse gambles, and 3) taking the average of the associated loss aversion scores associated with those trials. In the case above where a participant switched over their choices at a point between the loss aversion scores of 1.5 and 2.0, we estimate their loss aversion score to be 1.75 (presuming that they made consistent choices and there is only one switchover point). By using the steps above, each participant receives a final loss aversion score which is greater than or equal to 0.5 and less than or equal to 10.0.