The positivity effect as a mediator for age-related positive-skew bias:

An unsuccessful study

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Abstract

People across the lifespan prefer positively skewed gambles—those with a small chance of winning a large amount coupled with a large chance of losing a small to moderate amount (e.g., a lottery ticket). However, older adults have been seen to show an even stronger bias for these positively-, compared to negatively-, skewed gambles. This age-related increase in positive skew bias may be related to the age-related positivity effect—i.e., an increase in attention to and memory for positive information seen in later life. In this study, we test whether the positivity effect, as assessed by memory for choice features, may explain the increased preference for positively skewed gambles seen in later life. We predicted that the positivity effect would mediate the relationship between age and positive skew preference. However, after collecting data from approximately half of the required participants (N = 117/220), we found that neither the age-related positivity effect nor the age-related positive-skew bias emerged, despite having enough statistical power to detect these relationships. Because age was unrelated to the positive-skew bias, there was no statistical relationship to mediate. Thus, to preserve time and resources, we stopped data collection. In this paper, we present explanations for these effects' absence.

The positivity bias as a mediator for positive-skew bias: An unsuccessful study

Individuals tend to prefer positively skewed gambles—those that have a small chance of large gain and a large chance of a small to moderate loss (e.g., a lottery ticket). Older adults have been seen to prefer these gambles even more so than younger adults. This is problematic because older adults are frequently targeted for financial scams and more than 20% of schemes are lottery-based (i.e., framed in a positively skewed manner) (AARP, 2011). Thus, if we can identify the mechanisms underlying this age-related increased preference, we may find ways to prevent this from happening. In this study, we test whether age-related increase in attention to and memory for positive information—often referred to as the positivity effect—may explain the increased preference for positively skewed gambles seen in later life.

Skewed gambles are those with unequal distribution of probabilities and outcomes. There can be negatively skewed gambles—such as car insurance for insurance providers—a small chance of losing a large amount (i.e., having to payout for customer if they get an in accident) and a large chance of gaining a small to moderate amount (i.e., receiving monthly payments from customers). On the other hand, positively skewed gambles refer to those where there is small chance of a large gain and a large chance of a small to moderate loss, such as the car insurance consumer (i.e., making monthly payments but “winning big” in the rare occasion you have an accident and receive a payout). Lottery tickets is another example of a positively skewed gamble. There is evidence that people tend to prefer positively skewed choices. Moreover, there is evidence that older individuals prefer these positively skewed gambles even more so than younger adults. However, it is unknown why this age-related increase in positive skew bias exists.

One possible explanation for positive skew preference increasing in later life is the age-related positivity effect. The positivity effect refers to older adults’ increased attention to, and memory for, positive information (Mather & Carstensen, 2005). This effect is hypothesized to be related to the shift in goals and motivation often seen in older adults. The positivity effect has been seen across several attention studies, including those that use a visual attention dot-probe paradigm (Mather & Carstensen, 2003) and eye-tracking methodology (Isaacowitz et al., 2006a; 2006b). Another way to test this effect is using memory, which can be easier to test because of the direct nature of assessing accuracy. Testing memory allows us to infer attentional processes from memory performance, as attention is necessary for encoding and subsequent retrieval (see Oberauer, 2019 for a review). Like findings from attention, there is robust evidence of an increase in memory for positive, relative to negative, information seen across adulthood (see Reed, Chan, and Mikels, 2014 for meta-analysis). This has even been seen in studies of memory during decision making where older adults remembered more positive compared to negative features of the options (Mather et al., 2005, Lockenhoff & Carstensen, 2007).

In the present study, we examined whether the relationship between age and positive-skew bias is mediated by the age-related positivity effect, as tested by memory for positive, relative to negative, information during decision making. Participants across the adult lifespan (ages 25-85) completed a skewed gambling task where participants had to choose between a certain and uncertain gamble. After some trials, participants were asked to recognize the amounts and probabilities presented just before. We predicted that if the age-related increase in positive memory bias mediates the age-related increase in positive skew bias, the memory bias would partially explain the variability in age-related preference for positively skewed gambles.

Method

Participants

An a priori power analysis indicated we would need at least 220 participants to test for the hypothesized mediation. Due to the absence of age-related associations (see results) that should have emerged with ≥80 participants, we halted data collection prematurely to save time and resources. Thus, 140 participants ages 25-85 were recruited. Twenty-one older adult participants did not complete the study due to failure to pass the MoCA, indicating insufficient cognitive health, leaving 119 participants who completed the study. Participants were excluded if they missed more than 10% of the choice or memory trials, had extreme reaction times, or had the same response for more than 95% of each type of trial. Two participants were excluded because they responded with the same key on more than 90% of memory trials. Thus, the present report includes 117 participants (mean age = 57.2 (SD = 16.8) years, 64% female, 76% white, 6% Black, 12% Asian, 8% multiracial or other).

Materials

Skewed Decision Making and Memory Task

In this task, participants saw pairs of gambles and indicated which one they would choose if given this gamble in the real world. One of the gambles was always certain—no gain or loss of any additional money—whereas the other was uncertain. These uncertain gambles were positively skewed, negatively skewed, or symmetric. Positive skew bias was calculated as the proportion of times positively, compared to negatively, skewed gambles were selected. Participants completed five blocks of 20 trials each. Within each block, participants saw nine positively skewed, nine negatively skewed and two symmetric gambles, for a total of 100 trials. The task was incentive compatible such that participants started the task with a $10 endowment and their final compensation was based on their choice on a selected trial.

After 32 of the 100 total trials, participants were asked yes/no questions about the previous trial regarding either the possible amount gained (8 trials) or lost (8 trials) or the probability of winning (8 trials) and losing (8 trials). The memory trials were pseudo-randomly distributed throughout the five blocks and the same trial order was used for all participants. Memory accuracy was calculated as d', standardized hit rate – false alarm rate. Positive memory bias was calculated as the difference between the memory accuracy scores for the positive, compared to negative information, collapsed across amount and probability.

Procedure

Participants completed surveys including a demographics questionnaire, the Emotion Regulation Questionnaire (Gross & John, 2003) and the Affect Valuation Index (Tsai et al., 2006). Participants then completed the cognition battery of the NIH Toolbox (Weintraub et al., 2013), which includes tests of executive function, episodic memory, language, processing speed, working memory, and attention. Participants then completed the skewed decision making and memory task, followed by another series of questionnaires including subjective graph literacy (Garcia-Retamero et al., 2016), objective graph literacy (Okan et al., 2019), subjective numeracy (Zikmund-Fisher et al., 2007), objective numeracy (Cokely et al., 2012), and a survey asking about their investments and financial portfolios.

Results

A mediation analysis requires two existing relationships with a shared construct. To test for these, we ran simple linear models with bias scores (skew and memory) as the outcome variables and standardized age as the predictor. Preliminary analysis of preregistered hypotheses found that in this sample, age was not related to either positive skew bias ($\beta = -.02$, $p = .59$) or positive memory bias ($\beta = -.01$, $p = .32$). Therefore, we were unable to test for mediation between these constructs. Further, based on the weakness of the relationships and the spread of the data collected, it seems unlikely that these relationships would emerge with an additional 100 participants. See Figures 1 and 2 for scatterplots of age and bias scores.

Discussion

This study tested whether the age-related positivity effect mediated the positive association between age and positive skew bias. However, due to unexpected findings, we halted data collection after 117 of the 220 necessary participants. Contrary to prior studies, age was not related to positive memory bias, nor positive skew bias. Because neither relationship with age emerged, despite having enough power to detect these relationships, it was highly unlikely that these relationships would emerge with additional data. Thus, we were unable to test the proposed mediation. Below, we document some of the hypothesized issues in the current study and potential remedies for future work.

We found no evidence of an age-related difference in memory for positive, relative to negative, information. Overall, memory performance in our sample was quite low. In fact, many participants had unstandardized d' scores of 0 or lower (see Figure 2), indicating they had just as many or even more false alarms than hits, suggesting these participants were not performing better than chance. This was the case regardless of the type of information (amounts and probabilities) and valence (gains or losses). Even after removing the extremely low performers—those with d' of 0 or lower—there was still no relationship between positive memory bias and age.

Although the absence of a positivity effect is in direct contrast with findings from many previous studies, in the Reed et al. (2014) meta-analysis, the authors identified specific contexts in which the positivity effect disappears. This includes when task demands are high and for highly arousing stimuli. Since memory performance in this study was on the lower side, it suggests that the task was difficult and task demands were quite high. Additionally, the large amounts of gain or loss in the gambles would likely be more arousing than smaller values. Therefore, the present task design may partially explain why the positivity effect was not observed. However, it is important to note that since the 2014 meta-analysis, multiple studies have not replicated this age-related increase in memory for positive information (Gallant & Yang, 2014; Eich & Castel, 2016). Thus, additional research is necessary to better understand the robustness of this effect and the conditions in which the positivity effect arises.

There was also no age-related positive skew bias. This is not what has been found in at least two studies of skewed decision making (Seaman et al., 2017; 2018). When examining the acceptance rates of positively and negatively skewed gambles, past research found that acceptance rates for negatively skewed gambles decrease with age, and acceptance rates for positively skewed gambles increase, leading to the positive-skew bias. However, as can be seen in Figure 1, there are no strong age-related changes in any type of gamble and acceptance of negatively skewed gambles may even be increasing with age.

To further explore the absence of the age-related positive skew bias, we considered whether it was the gambles themselves that were used in the current work, which differed slightly from previous studies. Therefore, we calculated positive skew bias only for the trials used in the prior work (i.e., negatively skewed: 25% loss /75% gain, positively skewed: 75% loss/25% gain), but no age effect emerged. Given recent evidence that the strength of the skewness may matter when selecting gambles (Frank et al., 2024), we also tested whether the degree of the skewness influenced positive skew bias. Yet we found no age-related increase in positive skew bias for weak, moderate or strongly skewed gambles. We also considered whether it was the time in which data was collected. However, this is unlikely because we ran a similar study using the same gambles but without the memory probes and found the age-related relationship with positive skew bias, albeit less strongly than the previous work (Frank et al., 2024). Lastly, we also looked at variables such as gender, socioeconomic status, subjective and objective graph literacy and numeracy and contrary to prior work (Frank et al., 2024), no relationship between skew bias and these variables was identified.

Despite our best efforts to find a cause for the absence of the expected relationship, one alternative explanation is that there is something about the memory probes that are influencing how the task is being performed. For example, perhaps participants are focusing so much on trying to remember the information that their decision-making processes are altered. This may be exacerbated if participants find the memory task particularly difficult, which is consistent with the relatively low memory performance we observed. However, in two recent studies using similar versions of the skewed decision- making task, there were also no age-related differences in skew bias (Frank et al., 2024). This suggests that the positive skew bias may not be as robust of a finding as initially thought and supports the idea that this effect may be highly sensitive to changes in the task design.

While these results are unexpected, we felt it was important to share the findings to be transparent. Instead of wasting valuable time and resources, we decided to cease data collection and are continuing to address the question at hand using alternative methods (e.g., eye tracking methodology; Frank & Seaman, forthcoming). This will help us achieve the goal of better understanding what causes older adults increased vulnerability to fraud and scam.

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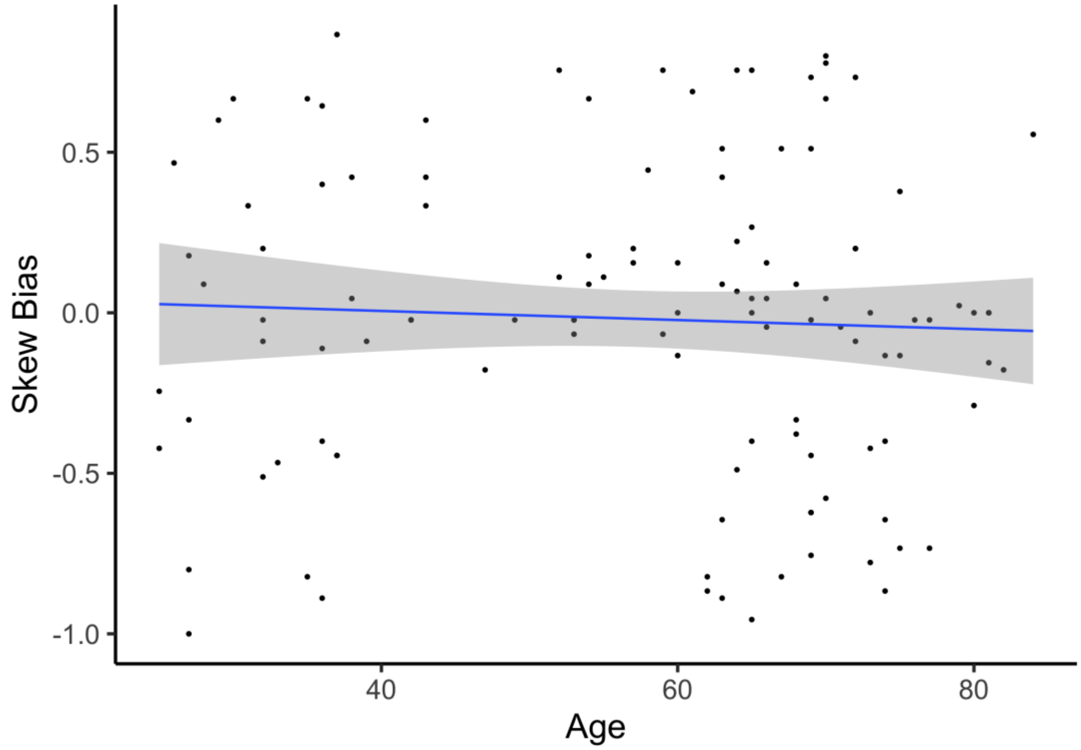
Figure 1

Relationship between age and skew bias (top) and acceptance rates by trial type (bottom).



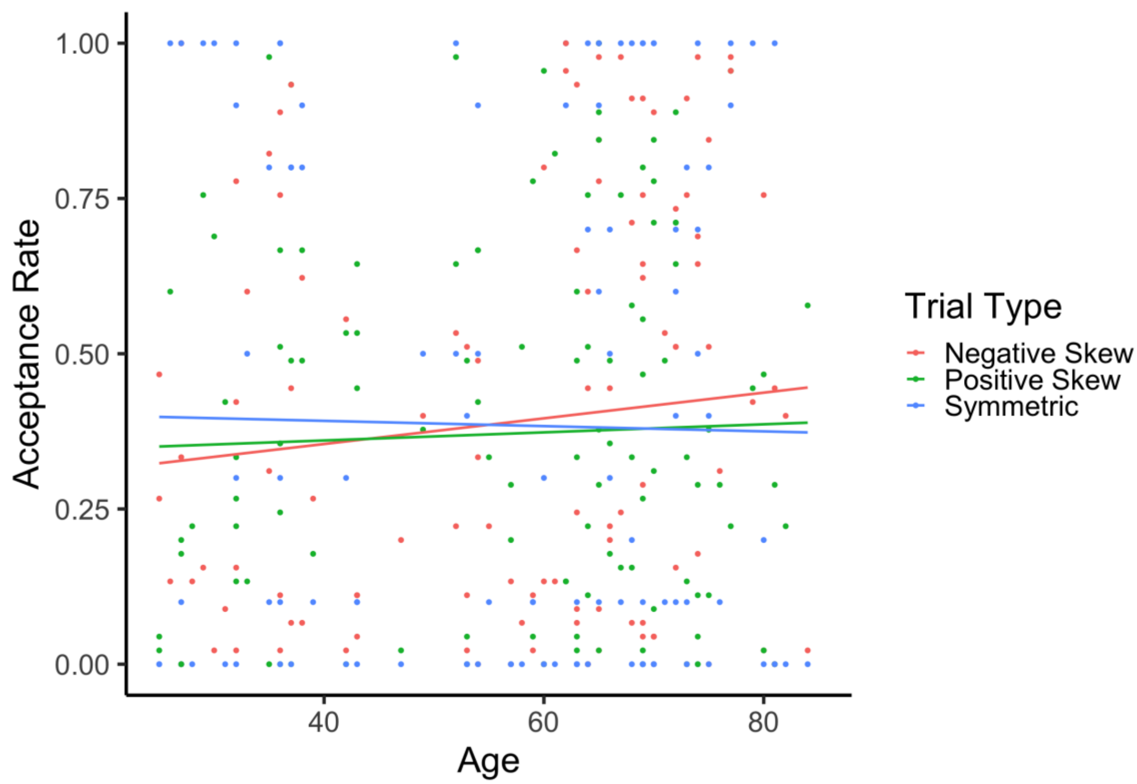


Figure 2

Relationship between age and memory bias (top) and memory performance (unstandardized d') by question type (bottom).