Getting over past mistakes:

prospective and retrospective regret in older adults

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Abstract

Objective: A considerable number of older people who hold powerful positions in governments and corporates are actively engaged in making decisions that have a far-reaching impact on the community. Some of them have to make decisions on behalf of others, and sometimes the outcomes of their decisions for others are unfavorable. We experience retrospective regret when the obtained outcome turns out to be less attractive than the counterfactual one. We also actively make choices to avoid regretful outcomes if we prospectively anticipate the regret. In the current study, we investigated how older adults experience regret and how they make choices to avoid potential regret, in the context of making decisions for themselves and on behalf of others.

Method: Sixty younger and sixty older participants performed a gambling task in which two types of regret were independently measured: prospective (planning to avoid regret during decision-making) and retrospective (feeling of regret following the comparison of alternative outcomes).

Results: Our results showed that compared to younger adults, the older adults were less sensitive to regret-inducing outcomes, whereas they demonstrated comparable ability in using prospective regret to guide decisions, regardless of whether they made decisions for themselves or on behalf of others.

Discussion: Our findings indicate that although older adults experience blunted regret, their ability to avoid future regret to guide subsequent choices remains unimpaired. Our research has implications for understanding how older adults cope with regret.

Keywords: decision-making; counterfactual; self-other discrepancy; disappointment

Introduction

Regret is a negative cognitive or emotional state that involves counterfactual feelings and thoughts of "what if". We experience regret when imagining or realizing that the situation would be better if we had made different decisions (Zeelenberg & Pieters, 2007). Apart from regret that is experienced in retrospective counterfactual comparisons between the chosen and unchosen outcomes, individuals may also attempt to anticipate the prospective regret during decision-making (Camille et al., 2010; Zeelenberg & Pieters, 2007). In this process, counterfactual thinking generates a forward model of action-outcome associations by prospectively simulating outcome values for each choice option (Camille et al., 2010). Research has shown that individuals tend to choose the option that may help them avoid potential regret, even if the choice is economically suboptimal (Epstude & Roese, 2011).

Although regret is often considered a negative emotion, decision-makers should be sensitive to regret, in order to learn from past mistakes and take the opportunity to rectify the decision. This is particularly critical for individuals who are actively engaged in making decisions that have a far-reaching impact on the community, such as government/institution leaders and chief executive officers (CEOs) in the organization. In many societies, people in such high-ranking positions are senior managers in old age. For example, the average age of the United States senators in the 116th Congress is 63 years old (Manning, 2020). The average age of Fortune 500 and S&P 500 CEOs at hire is about 55 years old in 2021 (from Crist Kolder Associates Volatility Report 2021, https://www.cristkolder.com). Thus, it is important to study how older people experience retrospective regret and how they make choices to avoid prospective regret, in order to better understand their characteristics of decision-making.

Previous research has mainly focused on the self-reported emotional response to regret-inducing outcomes and showed less regret as people get older (Bauer et al., 2008; Bjälkebring et al., 2013; Wrosch et al., 2007; Wrosch et al., 2005). For example, Bjälkebring et al. (2013) conducted a week-long diary study and found that compared to young people, older adults reported less regret in daily-life decisions. Research has suggested that older adults favor positive over negative information, compared to younger adults, in order to maintain positive emotions, which is known as the "positivity effect" (Carstensen & Mikels, 2005). The diminished experience of regret in older age may be linked to this age-related positivity effect . Older adults may be less sensitive to negative information and emotions, including regret, in order to maintain a satisfying emotional state .

Although there is accumulating evidence showing age-related cognitive and decision-making deficits (Evered et al., 2017; Finucane et al., 2005), it remains unclear whether the motives and capacity to use prospective regret signals to guide decisions are also changed in older adults or not. It is possible that beyond and above cognitive deficits, motivational factors may further contribute to age-related behavioral changes. According to the selective engagement hypothesis proposed by Hess (2014), due to the aging-related declines in cognitive resources, aging is associated with an increase in the costs of cognitive engagement, which motivates older adults to be increasingly selective in the engagement of demanding tasks that are beneficial for their cognitive health. Moreover, older people are more confronted with threats to resources. They may shift their goals and motivations to preserve what they already have and to prevent/compensate for the potential losses (Ebner et al., 2006; Freund, 2006). The Strength and Vulnerability Integration (SAVI) also posits that older adults engage in strategies that mitigate the elicitation of negative emotions more than younger adults (Charles, 2010). Due to such motivational changes, older adults may be well motivated to avoid regret.

In addition, research suggested that older adults may be as accurate or even more accurate than younger adults in affective forecasting in the decision-making domain. For example, old adults were equally good at predicting their future satisfaction with product choices (Kim et al., 2008). Older adults were even better at forecasting their emotions in reward processing (Nielsen et al., 2008) and predicting emotional responses to the US presidential election among supporters of the winning candidate (Scheibe et al., 2011). The intact ability to make affective forecasting in older age may support older adults to avoid potential regret prospectively.

Making decisions for others may also elicit regret (Berndsen et al., 2004; Uprichard & McCormack, 2018; Zeelenberg & Breugelmans, 2008). A considerable number of older adults who hold powerful positions in governments and corporates have to make decisions on behalf of others, and sometimes the outcomes of their decisions for others are unfavorable. It is important to understand how older adults cope with these regretful situations that have an impact on others. Younger adults usually differentiate between decisions made for themselves and decisions made for others (Hsee & Weber, 1997; Polman & Wu, 2019), known as the *self-other discrepancy* in decision-making. Research has shown that when making financial decisions for others, younger adults were less sensitive to expected values, less risk-averse, and less loss-averse (Beisswanger et al., 2003; Mengarelli et al., 2014; Sun et

al., 2017), compared to making decisions for themselves. In contrast, our previous study found that the self-other discrepancies in several decision-making tasks were diminished in older adults, suggesting that older adults had a diminished sensitivity to social distance (Pornpattananangkul et al., 2018). It is possible that, unlike young adults who may show stronger regret for decisions made for themselves than for decisions made for others, older adults may experience a comparable level of regret when making decisions for themselves and others.

Yet, the majority of previous studies on regret and aging have employed self-report, which is difficult to dissociate the prospective and retrospective regrets, as well as to separate other related emotions involved in decision-making, such as disappointment. Regret is often differentiated from disappointment (Zeelenberg et al., 1998). Particularly, regret occurs when outcomes arising from one's choice are worse than outcomes from unchosen alternatives, while disappointment occurs when outcomes produced by the chosen option could have been better. In short, regret arises from bad decisions while disappointment originates from unfulfilled expectations. In the current study, we adopted a counterfactual gambling task (Camille et al., 2010) and used computational models to investigate the age-related differences in retrospective and prospective regret, in the context of making decisions for themselves and on behalf of others. The task allows us to examine these two types of regret independently, as well as to dissociate other related constructs in this process. Our research focused on the age-related changes in prospective and retrospective regrets and explored other related variables, such as disappointment. We hypothesized that compared to younger adults, the older adults may be less sensitive to regret-inducing outcomes, whereas they may demonstrate comparable ability in using prospective regret to guide decisions. Furthermore, age may have significant interaction effects with self/other conditions on retrospective and/or prospective regrets.

Methods

Participants

In our study, two older participants failed to understand the task and were excluded. The remaining sixty older Chinese Singaporean participants (23 males; age M = 69.68 years, SD = 4.60; education M = 9.23 years, SD = 3.30) performed the experiment at a center that conducts training, assessment, and research for older adults. Sixty Chinese Singaporean young adults (23 males; age M = 22.07 years, SD = 2.08; education M = 14.63 years, SD =

1.39) took part in the experiment conducted at the university. The local Institutional Review Board approved the study, and all participants provided informed consent. Participants received a show-up fee (S$70) and additional payment depending on their performance in the task.

The sample size in our study (n = 120) was relatively larger than three previous studies that used a similar design (average sample size = 42, SD = 15.58) (Baskin-Sommers et al., 2016; Camille et al., 2010; Gillan et al., 2014). A sensitivity analysis using G*Power (Faul et al., 2014) with an alpha of 0.05, a sample size of 60 in each group for the between-group effect, and the analysis showed that this study had 80% power to detect an effect size (*d*) of 0.52, comparable to the effect sizes in previous research (Bjälkebring et al., 2013).

Given the bilingual nature of Singapore, we conducted the study in the participant's preferred language (Mandarin or English). The older participants were screened for their ability to participate in the experiment by trained nurses as part of a larger longitudinal study. We only invited participants without a history of psychiatric and neurological disorders. Older participants also completed a battery of age-appropriate questionnaires to assess their mental health, including the Geriatric Depression Scale (GDS) (Yesavage et al., 1983), Geriatric Anxiety Inventory (GAI) (Pachana et al., 2007), and Perceived Deficit Questionnaire (Sullivan et al., 2002). All older participants had scores less than 6 in GDS and less than 10 in GAI, suggesting the generally good mental health of our older participants. We also screened older participants' basic cognitive functioning using the Singaporean version of the Mini-Mental State Examination (MMSE). All older participants presented adequate proficiency in their basic cognitive functioning based on their assessment scores (M = 29.80, SD = 0.44). To control for the influence of socioeconomic status on financial decisions, we measured the subjective socioeconomic status (S-SES) using the social ladder task (Adler et al., 2000). In this task, participants chose their position on a ladder with 10 rungs that represented Singapore society. Higher rungs indicated higher S-SES. There was no statistically significant difference between older (*M* = 5.67, *SD* = 1.72) and younger (*M* = 6.10, *SD* = 1.39) participants for S-SES, $t(118) = -1.52$, $p = 0.13$. All demographic information collected is shown in **Table 1**.

Experimental task and procedures

We used a modified counterfactual gambling task (Baskin-Sommers et al., 2016; Camille et al., 2010; Gillan et al., 2014). At the beginning of each trial, participants chose between two wheels that displayed potential gains and losses, as well as their respective probabilities. Each wheel contained two out of four possible outcomes: -210, -70, +70, and +210 points. The probability of the obtained outcome was indicated by the proportion of the wheel occupied by the outcome and could be 0.25, 0.5, or 0.75. Participants were required to select a wheel by clicking on the mouse. Next, a red ball began to move within the chosen wheel. The ball would eventually stop on one of the segments in the wheel, indicating the outcome obtained. Here, participants only saw the outcome of their chosen choice (but not their unchosen choice), which is considered the "partial-outcome" stage. At this stage, participants were asked to rate how pleased they felt in response to the obtained outcome of their chosen choice, ranging from "Very disappointed" (0) to "Very pleased" (100). Following the partial-outcome stage was the "full-outcome" stage when the outcome of the unchosen wheel was revealed. Participants once again rated how pleased they felt in response to the obtained outcome in relation to the revealed outcome from the unchosen wheel (**Figure 1**).

We manipulated the beneficiary of each decision. In the Self condition, the participant would be the recipient of the obtained outcomes, whereas, in the Other condition, the obtained outcomes would be given to another person (participant). To reduce the potential "own age" bias, participants were not informed of the specific age of the "other person". To make the task realistic, participants were asked to choose one ID which they would like to make decisions for. In every trial, the Self/Other manipulation was indicated below the wheels by the caption "Your $$/Other's $$". Trials of Self and Other conditions were presented in separate blocks, with 10 trials of Self and 10 trials of Other conditions presented alternately. The cumulative score was then presented on the screen. In total, there were 80 Self trials and 80 Other trials in a randomized order for each participant. The bonus reimbursement was implemented based on the accumulated scores for both the participant and the chosen Other recipient respectively.

Data analyses

Bayesian linear mixed-effects models

We used Bayesian linear mixed-effects models in which each parameter was treated as a random variable with an assigned prior distribution. Our Bayesian analyses involve updating the prior distribution with observed data according to Bayes' theorem. This allowed us to directly approximate the posterior probability of the parameters of interest, giving a probabilistic interpretation without reference to hypothetical sampling distribution. To make certain that our Bayesian approach was in line with traditional, frequentist statistics, we also conducted analyses using a linear mixed model with restricted maximum likelihood estimation (see Supplementary Results). The overall results were consistent for the two approaches.

We performed Bayesian linear mixed-effects models in R3.5 (R Core Team, 2018) using the *brms* package (Bürkner, 2017). Specifically, we used the Hamiltonian Monte Carlo (HMC) algorithm as implemented in Stan (2018) to run the Markov chain Monte Carlo (MCMC) sampling. We selected the priors to reflect vague (i.e., uninformative) to strong beliefs (i.e., informative) of the effects of interest [i.e. Normal (0, 10), Normal (0, 1) and Normal (0, 0.05)]. For the most part, we found that the results were robust to the choice of priors. Here, we mainly presented the results and plots with parameter estimates from the models with a very vague prior, i.e., Normal (0,10). Four MCMC chains were used. For each chain, we randomized its initial value and drew 4,000 samples in addition to 1,000 burn-in samples, leaving a total of 16,000 samples across chains. We investigated the 95% highest density interval (HDI) of the posterior distributions of the effects of interest. The HDI summarized the uncertainty of the estimation by providing the most credible span of estimated values (Kruschke, 2014).

We ran three Bayesian linear mixed-effects models: 1) decision-making, 2) affective rating following the partial outcome and 3) affective rating following the full outcome. In the three models, Age (younger vs. older), Self/Other (Self vs. Other conditions), and their interaction were included as fixed-effect predictors. Age and Self/Other were coded as binary indicators. In order to control for subjective SES, we also included S-SES as a fixed-effect predictor of no interest. For the random effects, we followed a recommendation to include the maximal random effects structure justified by the design (Barr et al., 2013). As such, we entered both random intercepts for participants and by-participant random slopes.

Mixed-effects models

Decision-making: prospective regret, expected value, and risk aversion

Following previous studies (Baskin-Sommers et al., 2016; Gillan et al., 2014), we estimated the probability of choosing Wheel 1 on each trial for each participant based on the three decision-making variables: prospective regret (i.e., the difference between the lowest and highest potential outcomes across both wheels), expected value (i.e., the anticipation of the potential outcomes of each wheel based on their probabilities and values), and risk aversion (i.e., the difference in variance between the two wheels) (see Supplementary Methods for more details).

$P(Wheel\ 1)_{trial,\ participant} = 1 - P(Wheel\ 2)_{trial,\ participant}$

$= F(\text{Prospective Regret}_{W1<W2}, \text{Expected Value}_{W1>W2}, \text{Risk Aversion}_{W1<W2})$

(i)

where $P(Wheel\ \#)$ indicates the probability of choosing Wheel #, *trial* indicates the trial number, *participant* indicates individual participant, F is the inverse logit function, $F(\theta) = e^{\theta} / (1 + e^{\theta})$, and θ is the logit predicted by the individual values of $\text{Prospective Regret}_{W1<W2}$, $\text{Expected Value}_{W1>W2}$, and $\text{Risk Aversion}_{W1<W2}$ in the logistic regression.

Our model estimated the main effects of $\text{Prospective Regret}_{W1<W2}$, $\text{Expected Value}_{W1>W2}$, and $\text{Risk Aversion}_{W1<W2}$, Self/Other, Age as well as their interactions in explaining Decision (i.e., wheel choice):

$\text{Decision} \sim (\text{Prospective Regret}_{W1<W2} + \text{Expected Value}_{W1>W2} + \text{Risk Aversion}_{W1<W2}) \times \text{Self/Other} \times \text{Age} + \text{S-SES} + (1 + (\text{Prospective Regret}_{W1<W2} + \text{Expected Value}_{W1>W2} + \text{Risk Aversion}_{W1<W2}) \mid \text{Subject})$

(ii)

Here, Decision was a binary outcome variable (coded 1 for choosing Wheel 1 and 0 for choosing Wheel 2). $\text{Prospective Regret}_{W1<W2}$, $\text{Expected Value}_{W1>W2}$, $\text{Risk Aversion}_{W1<W2}$, Self/Other, Age, and S-SES were fixed-effect predictors. The two-way and three-way interaction terms of $(\text{Prospective Regret}_{W1<W2} + \text{Expected Value}_{W1>W2} + \text{Risk Aversion}_{W1<W2}) \times \text{Self/Other} \times \text{Age}$ were also included as fixed effects. Random intercept and random slopes

of Prospective Regret$_{W1<W2}$, Expected Value$_{W1>W2}$, and Risk Aversion$_{W1<W2}$ for every subject were included as random-effect factors.

Affective rating following partial outcome: disappointment, partial-outcome reward sensitivity

The model estimated the main effects of disappointment, i.e., the difference between the obtained and non-obtained outcomes from the same chosen wheel (chance counterfactual), partial-outcome reward sensitivity, Self/Other, Age as well as their interactions in explaining the affective rating following partial outcome :

Partial-Outcome Affective Rating ~ (Chance Counterfactual + Partial-Outcome Reward Sensitivity) x Self/Other x Age + S-SES + (1 + (Chance Counterfactual + Partial-Outcome Reward Sensitivity) x Self/Other | Subject)

(iii)

Here, Chance Counterfactual, Partial-Outcome Reward, Self/Other, Age, and S-SES were fixed-effect predictors. The two-way and three-way interaction terms of (Chance Counterfactual + Partial-Outcome Reward Sensitivity) x Self/Other x Age were also included as fixed effects. Random intercept and random slopes of Chance Counterfactual and Partial-Outcome Reward Sensitivity for every subject were included as random-effect factors.

Affective rating following full outcome: retrospective regret, full-outcome reward sensitivity

Our model estimated the main effects of retrospective regret, i.e., the difference between the obtained outcome from the chosen wheel and the non-obtained outcome from the unchosen wheel (agent counterfactual), full-outcome reward sensitivity, Self/Other, Age as well as their interactions in explaining the affective rating following full outcome:

Full-Outcome Affective Rating ~ (Agent Counterfactual + Full-Outcome Reward Sensitivity) x Self/Other x Age + SES + (1 + (Agent Counterfactual + Full-Outcome Reward Sensitivity) x Self/Other | Subject)

(iv)

Here, Agent Counterfactual, Full-Outcome Reward Sensitivity, Self/Other, Age, and S-SES were fixed-effect predictors. The two-way and three-way interaction terms of (Agent Counterfactual + Full-Outcome Reward Sensitivity) x Self/Other x Age were also included as

fixed effects. Random intercept and random slopes of Agent Counterfactual and Full-Outcome Reward Sensitivity for every subject were included as random-effect factors.

Modeling the effects of age differences in Self and Other conditions

We first tested the interaction between Age and Self/Other in each decision-making and affective rating parameter. We computed the highest density interval (HDI) of the posterior distribution of the interaction [Other - Self] x [Older - Younger]. If the 95% HDI of this interaction effect does not include zero, we can be 95% confident that Age and Self/Other interact on the associated parameter. Next, to understand the directionality of this interaction, we examined marginal effects in two directions (i.e., [Older - Younger] in the Self and Other conditions; [Other - Self] in the Older and Younger groups). The detailed results are shown in Supplementary **Table S1**.

Results

Decision making

Analyses on *Prospective Regret*$_{W1<W2}$ showed that the 95% HDI for the interaction between Age and Self/Other included zero (95% HDI = -0.17, 0.12, Mean = -0.02), providing unsubstantial evidence for the interaction (**Figure 2A**). The 95% HDI for the marginal effects of Age [Older - Younger] included zero in both Self (95% HDI = -0.32, 0.18, Mean = -0.06, **Figure 2B**) and Other (95% HDI = -0.33, 0.17, Mean = -0.08, **Figure 2C**) conditions. These results suggest that when making decisions, older adults demonstrated comparable ability in anticipating prospective regrets, as younger participants did when making decisions for themselves and others. The results of *Expected Value*$_{W1>W2}$ showed that the interaction between Age and Self/Other was justified (95% HDI = 0.33, 0.75, Mean = 0.54, **Figure 3A**). The marginal effects of Age [Older - Younger] was justified in both Self (95% HDI = -1.16, -0.65, Mean = -0.90, **Figure S1A** in Supplementary Results) and Other (95% HDI = -0.59, -0.12, Mean = -0.36, **Figure S1B**) conditions. Compared with younger participants, older participants were less sensitive to the expected value in general. For *Risk Aversion*$_{W1<W2}$, there was sufficient evidence for the interaction between Age and Self/Other (95% HDI = 0.03, 0.32, Mean = 0.17, **Figure 3B**). The marginal effects of Age was not justified for both Self (95% HDI = -0.23, 0.27, Mean = 0.02, **Figure S1C**) and Other (95% HDI

= -0.05, 0.45, Mean = 0.19, **Figure S1D**) conditions. There is no sufficient evidence to support the age-related differences in Self and Other conditions.

Partial-Outcome Affective rating

Results of the *Chance Counterfactual* showed that there was insufficient evidence for the interaction between Age and Self/Other (95% HDI = -1.90, 2.38, Mean = 0.23, **Figure 3C**). The marginal effects of Age were negative and justified for Self (95% HDI = -4.29, -0.37, Mean = -2.23, **Figure S2A**), but unjustified for Other (95% HDI = -4.47, 0.47, Mean = -2.00, **Figure S2B**) conditions, suggesting that older adults felt less disappointment only when the outcomes were for themselves. Analyses on *Partial-Outcome Reward Sensitivity* revealed that the interaction between Age and Self/Other was unjustified (95% HDI = -1.18, 6.06, Mean = 2.30, **Figure 3D**). The marginal effects of Age were unjustified in both Self (95% HDI = -5.05, 2.13, Mean = -1.65, **Figure S2C**) and Other (95% HDI = -3.85, 5.28, Mean = 0.65, **Figure S2D**) conditions, suggesting a comparable sensitivity to the obtained reward between the younger and older people.

Full-Outcome Affective Rating

Results on *Agent Counterfactual* showed that the interaction between Age and Self/Other was justified (95% HDI = 0.86, 6.34, Mean = 3.50, **Figure 2D**). The marginal effects of Age [Older - Younger] were negative and justified in both Self (95% HDI = -16.85, -8.11, Mean = -12.48, **Figure 2E**) and Other (95% HDI = -13.71, -4.21, Mean = -8.97, **Figure 2F**) conditions. This suggests a reduced level of retrospective regret in older adults when making decisions for themselves and others. We did a correlation analysis between retrospective and prospective regrets and found no significant correlation, r = -0.08, p = 0.37, suggesting that these two types of regret may be independent.

The results of *Full-Outcome Reward Sensitivity* were similar to the *Partial-Outcome Reward Sensitivity*, which provides little evidence for the overall effect of age-related differences (interaction effect: 95% HDI = -3.38, 4.14, Mean = 0.33, **Figure 3E**; Age effect in Self: 95% HDI = -4.62, 2.42, Mean = -1.10, **Figure S3A**, and in Other: 95% HDI = -5.06, 3.72, Mean = -0.77, **Figure S3B**)

Discussion

In the current study, we used a counterfactual gambling task combined with computational modeling and found that compared with younger adults, older adults experienced less retrospective regret after making decisions, regardless of the outcome recipients. However, we did not find the age-related difference in using prospective regret signals to guide decision-making, suggesting that older adults have an intact ability to anticipate and avoid potential regret during the decision-making process. Both age groups showed an enhanced tendency to choose options that minimize potential regret when making decisions for themselves than for others.

Compared to younger adults, our older participants showed diminished sensitivity to retrospective regret and disappointment (in Self condition only). This finding is consistent with results from previous research using questionnaires and diary reports (Bauer et al., 2008; Bjälkebring et al., 2013; Wrosch et al., 2007; Wrosch et al., 2005). We also found that older adults demonstrated comparable sensitivity to rewards at partial- and full-outcome affective rating stages **(Figure S2&3)**, indicating that the diminished experience of regret in older people could not be simply explained by their insensitivity to obtained rewards. There might be different mechanisms underlying such age-related diminished retrospective regret. Firstly, the age-related positivity effect in older adults may result in their blunted responses to negative emotions, such as regret, in order to optimize emotional states (Tamir & Gross, 2011). Previous research found that the loss aversion effect (a stronger sensitivity to losses than to gains) was diminished in older adults, suggesting that older adults are less sensitive to negative outcomes and may focus more on positive aspects of events (Pachur et al., 2017). Secondly, older adults may focus less on the unchosen outcomes and were less likely to engage in counterfactual comparison. Research showed that after making choices, older adults recalled more positive and fewer negative features of the chosen options than the rejected options (Mather & Johnson, 2000), suggesting that older adults may pay less attention to the unchosen option. Future studies are needed to further investigate underlying factors that contribute to the diminished experienced regret in older adults.

However, using a mathematical model of participants' decision-making process, we found that the ability to use prospective counterfactual comparisons of action-outcome alternatives to guide decision-making remains intact with increasing age. Moreover, we found that both age groups demonstrated similar self-other discrepancy in prospective regret, i.e., both younger and older adults were more likely to avoid the potential regret when making decisions for themselves than for others. The finding that older adults showed an intact ability to integrate prospective regret into consideration when making choices also supports the view that older adults retain the capacities in decision-making and affective forecasting, even though their cognitive abilities decline (Hess et al., 2012; Lim & Yu, 2015; Mikels & Reed, 2009). Neuroimaging research found that the orbitofrontal cortex (OFC) activity was correlated with regret-avoidant decision-making (Coricelli et al., 2005). Previous studies have also demonstrated that patients with OFC damage showed behavioral regret insensitivity (Camille et al., 2004; Sommer et al., 2009). It is possible that the age-related volume loss in OFC is not as pronounced as in the other regions (Salat et al., 2002). Our findings suggest that the two emotional regulation strategies, i.e., making decisions to avoid regretful outcomes and reacting less to the actual regretful and disappointing outcomes, may reflect the critical resilient factors for emotional health in older age. In addition, in the decision-making process, older adults also showed comparable sensitivity to risk. But they were less sensitive to expected values, suggesting that they may less likely to consider maximizing long-term gains when making decisions. These results may indicate an adaptive motivational change that is more present-oriented in older people.

In the current study, we found no significant correlation between retrospective and prospective regrets, indicating that these two types of regrets are distinct and dissociable. Research showed that people are often not good at predicting the potential emotional response in the future when using their present hedonic state (Loewenstein et al., 2003). For example, Kermer et al. (2006) found that people greatly overestimate the expected negative effect of loss compared to the actually experienced emotion of loss. The intact ability to anticipate potential regret in older adults is consistent with the results of previous studies showing that older adults can even outperform younger adults in certain financial decision-making tasks (Lim & Yu, 2015), and in affective forecasting (Nielsen et al., 2008; Scheibe et al., 2011). Researchers may underestimate the influence of possible protective factors in

everyday life associated with older age, such as increased experience and shifts in motivations.

The current study also produced some interesting findings related to the self-other discrepancies in regrets (Supplementary **Table S1**). Compared to younger participants, the older participants showed diminishing self-other discrepancies in retrospective regret, while they demonstrated comparable self-other discrepancies in prospective regret. One possible mechanism is the enhanced emotional empathy found in older people. For instance, upon seeing others in need, older adults in previous research had higher heart-rate reactivity and self-reported empathy (Sze et al., 2012). Retrospective regret is related to the feeling of regret itself, while prospective regret is related to planning to avoid the potential feeling of regret (Zeelenberg & Pieters, 2007). Thus, when older participants found out that their decision caused others to lose in retrospective regret, they may have felt as if it was their own loss. However, planning to avoid regret in prospective regret may not invoke such a strong feeling. Both young and older adults showed high motivation to avoid regret prospectively for themselves. There were no Self-Other effects on disappointment in both groups, suggesting that this self-other effect is not generalized to all emotions.

A few caveats about the present study should be mentioned. Firstly, only hypothetical monetary gains and losses were involved in the current study. Previous studies did show that hypothetical rewards and real rewards generate similar behavioral patterns, such as risk preferences, in older adults (Horn & Freund, 2022). Nevertheless, it is unclear whether the findings can be extended to situations where there are real consequences for participants. Secondly, our participants were recruited from Singapore, a country where "East meets West". There might be potential cultural differences in regret experience and regret-related behavioral patterns, such as individualism and collectivism. Thirdly, our study was not designed to fully differentiate genuine ability from the tendency to avoid future regret. In our study, participants were generally not able to clearly report the exact strategies they used. Future studies may explore whether behavioral interventions, such as explicit knowledge or extensive feedback-based training, could modify such behavioral tendencies. Finally, the neural basis of prospective and retrospective regrets in young and older adults is still unclear.

Neuroimaging studies are needed to better understand the age-related changes in these two types of regrets at the neural level.

In summary, our results suggest that older adults demonstrate a more blunted affective response to the regret-inducing outcomes despite the fact that their ability to use prospective regret signals to guide choice behavior appears to be preserved, supporting the idea that older adults' blunted emotional response to regret does not affect their ability to avoid regret in the economic decision-making process. We now live in a world where older adults often hold positions of great power. Our research has theoretical and practical implications for understanding how older adults cope with regret in the context of themselves and others being the recipients of their decisions.

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Table and figure captions

Table 1. Demographic of the older and younger participants.

	Older	Younger
Age	69.68 (4.60)	22.07 (2.08)
Gender	23 males, 37 females	23 males, 37 females
Years of education	9.23 (3.30)	14.63 (1.39)
S-SES	5.67 (1.72)	6.10 (1.39)
MMSE	29.80 (0.44)	--
GDS	0.53 (1.14)	--
GAI	0.79 (2.34)	--
PDQ	6.90 (7.66)	--

Note. Means and standard deviations are in parentheses. S-SES: Subjective Social Economic Status; MMSE: Mini-Mental State Examination; GDS: Geriatric Depression Scale; GAI: Geriatric Anxiety Inventory; PDQ: Perceived Deficit Questionnaire.

Figure 1. The counterfactual gambling task. Participants saw two wheels that had different magnitudes and probabilities of outcomes. They were required to select one wheel, and their selection was highlighted. Then participants saw the outcome of the chosen wheel while not being informed about the outcome of the unchosen wheel. At this "partial-outcome" stage, they were required to give their affective ratings about the outcome. After that, participants saw the outcome from the unchosen wheel they could have obtained if they had made a different choice. At this "full-outcome" stage, they were fully aware of outcomes from the chosen and unchosen wheels and were required to give affective ratings again. The text below the wheels was "Your $$" and "Other's $$" in the Self and Other conditions, respectively. At the end of each trial, "Your total points" or "Other's total points" was presented to indicate the cumulative score of participants themselves or the other person. p_{w1} and p_{w2} refer to the probabilities of obtaining the highest outcomes of wheels 1 and 2, respectively.

Figure 2. Age difference in prospective and retrospective regret. ***(A)*** Age and Self/Other modulated the relationship between Prospective Regret$_{W1<W2}$ and the probability of choosing Wheel 1. The 95% HDI for the marginal effects of Age on prospective regret included zero in both ***(B)*** Self and ***(C)*** Other conditions, providing little evidence for the overall effect of aging. ***(D)*** Age and Self/Other modulated the relationship between Agent Counterfactual and Full-Outcome Affective Rating. The 95% HDI for the marginal effects of Age on retrospective regret were negative and did not include zero in both ***(E)*** Self and ***(F)*** Other conditions, suggesting that, in general, the level of retrospective regret was reduced in older adults. The blue bars indicate the 95% Highest Density Interval (HDI). Shading around lines represents 95% Credible Intervals for point estimates. The black dots indicate the mean of the posterior distributions.

Figure 3. Age difference in the other parameter estimates. Age and Self/Other modulated the relationship between Expected Value $_{W1>W2}$ ***(A)***, Risk Aversion $_{W1<W2}$ ***(B)***, and the probability of choosing Wheel 1. Age and Self/Other modulated the relationship between Chance Counterfactual ***(C)***, Partial-Outcome Reward Sensitivity ***(D)***, and Partial-Outcome Affective Rating. Age and Self/Other modulated the relationship between Full-Outcome Reward Sensitivity ***(E)*** and Full-Outcome Affective Rating. Shading around lines represents 95% Credible Intervals for point estimates.

Figure 1

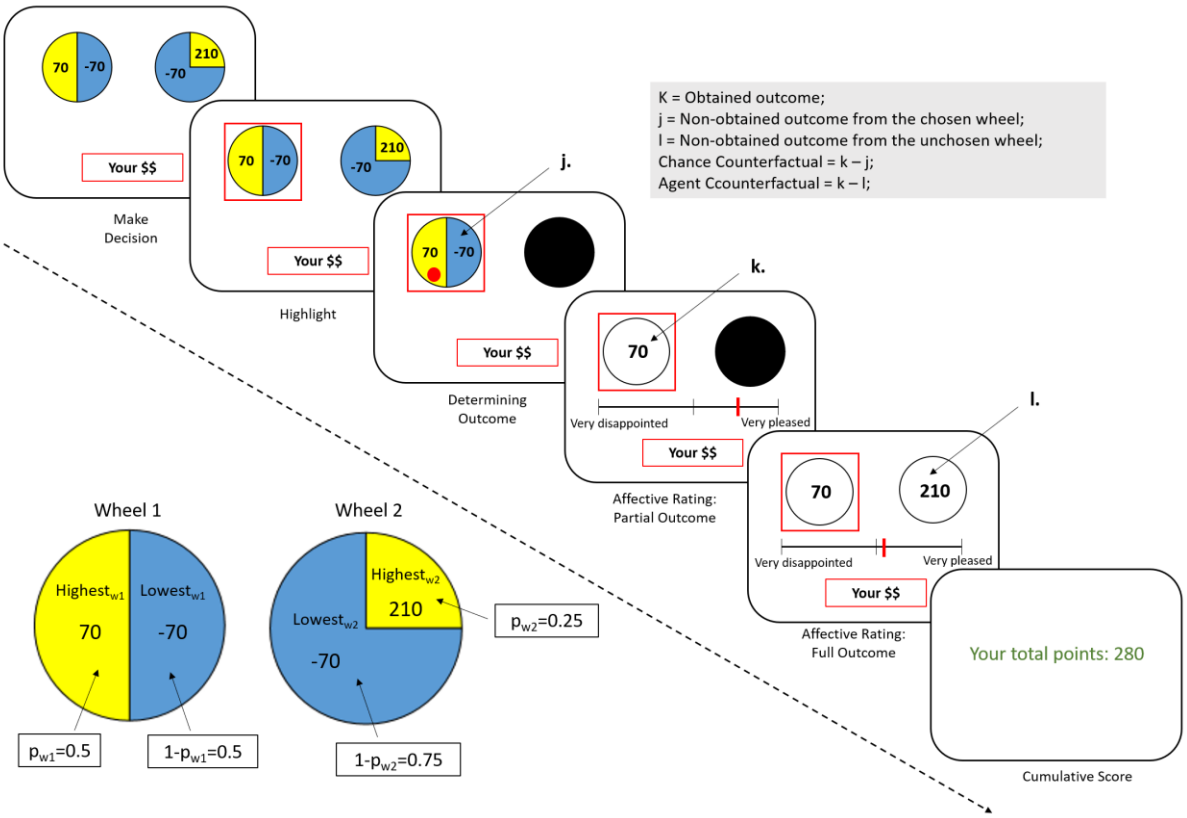

Figure 2

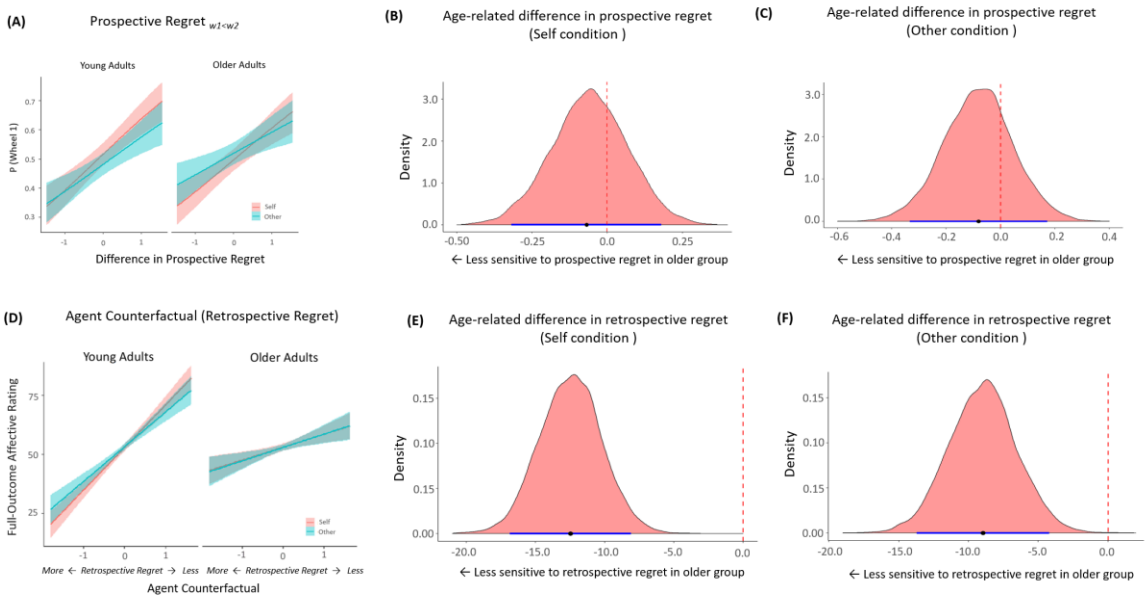

Figure 3