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Older adults' decision-making following bad advice

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Abstract

There is minimal research investigating the influence of advice on decision-making in older age. The present study investigated the effect of different types of bad advice, relative to no advice, on young and older adults' decision-making in the Iowa Gambling Task (IGT). Fifty-four older adults and 59 young adults completed the IGT after receiving no advice, or advice to select from disadvantageous deck A (small, high-frequency losses), or disadvantageous deck B (larger, low-frequency losses). Corrugator EMG, memory and fluid intelligence were assessed. Averaged across advice conditions, older adults made more disadvantageous selections than young adults. There were no age-related differences in responding to bad advice, nor in corrugator activity in response to losses (i.e. frowning), or in learning to avoid deck A faster than deck B. Selecting from deck B was associated with reduced education among older adults, and reduced fluid intelligence among young adults. The data suggest that older adults make more disadvantageous decisions than young adults, and this is not exacerbated by bad advice. Both young and older adults are slower at learning to avoid choices resulting in low frequency relative to high-frequency losses, and this may be associated with individual differences in cognitive processing.

KEYWORDS

advice-taking, bad advice, decision-making, IGT, loss frequency bias

Global populations are ageing (Van Den Bruele et al., 2019), and evidence suggests that older adults prefer less autonomy in decision-making than young adults (Finucane et al., 2002; Mather, 2006). They also rely more on the advice of an advisor labelled as a novice, but not an advisor labelled as an expert (Bailey et al., 2021). Expert advice is perceived as rewarding (Meshi et al., 2012), and while good advice has the potential to improve decision outcomes, bad advice can impair decision-making and potentially

Statement of contribution

It is known that one-time advice, including bad advice, can have a lasting effect on young adult decision-making in tasks such as the Iowa Gambling Task. We aimed to determine whether the influence of different types of bad advice would be exacerbated among older adults relative to young adults. We also aimed to extend limited evidence for an increased focus on frequency rather than severity of loss (i.e. a loss frequency bias) among older adults.

Our findings indicated that

- Older adults made more disadvantageous decisions than young adults, but were not more vulnerable to bad advice.
- Loss frequency bias was equivalent for young and older adults.
- Large low-frequency losses (i.e. deck B selections) were associated with reduced education among older adults, and reduced fluid intelligence among young adults.

leave older adults vulnerable to exploitation, or poorer health and financial outcomes that cannot be rectified in later life. Previous advice-taking research with older adults has not provided feedback from which older adults can learn about the quality of advice. The current study therefore aims to understand whether there are age-related differences in the tendency to rely on advice that results in negative outcomes.

Choice in the face of uncertainty

Generally, people rely more on advice when decisions are difficult (Bailey et al., 2022; Bonaccio & Dalal, 2006), which includes uncertain decisions (Biele et al., 2009). The Iowa Gambling Task (IGT) involves decisions under uncertain conditions where the size and frequency of wins and losses vary. It contains repeated selections of four possible choice options (i.e. four decks of cards), through which participants learn the reward and penalty structures without receiving explicit instruction (Bechara et al., 1994). Decks C and D (the advantageous decks) have smaller gains, but no large losses, while decks A and B (the disadvantageous decks) have larger gains and larger losses, with the largest loss coming from deck B. On average, the advantageous decks lead to larger winnings than the disadvantageous decks. The decks also vary in their frequency of losses, with decks A and C incurring more frequent but smaller losses than decks B and D. The probabilistic nature of the rewarding and punishing outcomes of the IGT makes determining the best choice difficult. It has been suggested that selecting more from deck B, which has high wins and infrequent high losses, reflects a focus on the short-term, while selecting more from decks C and D reflects a focus on the long-term (Beitz et al., 2014).

In studies investigating decision-making using the IGT, healthy control participants initially select more from the disadvantageous decks, and then avoid them to select more from the advantageous decks (Bechara et al., 1994, 2000). This suggests sensitivity to infrequent punishing consequences of the disadvantageous decks. In contrast, some individuals persist in selecting the disadvantageous decks despite the losses (Bechara et al., 1994, 2000). Typically, deck A is avoided more often than deck B (Beitz et al., 2014; Kumar et al., 2019). While both are disadvantageous decks, the former has a higher frequency of losses than the latter. Thus, the frequency of losses may be more important than the overall severity of the loss in suppressing choice—a phenomenon referred to as loss frequency bias, which has been found to increase with age (Beitz et al., 2014).

Decision-making in older age

IGT studies involving older adults present mixed findings. Performance has been shown to improve from childhood to early adulthood, and then decline in older age (Beitz et al., 2014). Older adults are also reported to have difficulty learning to avoid the disadvantageous decks (Denburg et al., 2005; Fein et al., 2007), and show a greater loss frequency bias (Beitz et al., 2014). These findings have been attributed to age-related cognitive declines, particularly in working memory (Beitz et al., 2014; Fein et al., 2007) and perceptual reasoning (Ramchandran et al., 2020). Another study found older adults performed as well as young adults on the IGT, however, the older adults paid more attention to gains than young adults (Wood et al., 2005). Cognitive modelling revealed older adults relied heavily on recently experienced information when making their decisions. This may reflect declines in working memory, resulting in poorer recall of previous outcomes (Beitz et al., 2014). Thus, older adults may reduce cognitive burden by focusing on loss frequency rather than net outcomes. In contrast, young and middle-aged adults have been found to prefer high-net outcome decks, leading to more advantageous selections (Beitz et al., 2014; Cauffman et al., 2010).

Advice and decision-making

It is possible that the following advice, whether good or bad, may represent a strategy for reducing cognitive load in older age, particularly when decisions are difficult. Additionally, cognitive declines may influence how effectively older adults evaluate advice. When bad advice (i.e. advice to select more from the disadvantageous decks A and B) was provided in the form of a paper-based marked selection from an unknown other participant, young adults made fewer selections from the more advantageous decks, C and D. It was suggested that people may evaluate outcomes from recommended options more positively than those from non-recommended options (Biele et al., 2009). Advice from an expert activates neural mechanisms that process reward (Meshi et al., 2012), and older adults have been found to discriminate less between expert and novice sources of advice (Bailey et al., 2021). Moreover, older adults' working memory capacity was negatively correlated with the value given to novice advice, while fluid intelligence was positively correlated with the value given to expert advice (Bailey et al., 2021), suggesting a relationship between cognitive ability and the evaluation of advice, particularly in older age. Consistent with socioemotional selectivity theory and the age-related positivity effect (Reed & Carstensen, 2012), older adults attend more to positive information (Mather & Carstensen, 2005; although see Rolison, 2019), and report more satisfaction with their decisions (Kim et al., 2008; Löckenhoff & Carstensen, 2007).

When there is a lack of available information about the quality of advice and/or advisor, people draw upon their own internal information to infer what they do not know (Hawthorne-Madell & Goodman, 2019). This may contribute to more optimistic beliefs about advisors. Consistent with this idea, an optimism bias in young adults has been found to increase advice-taking (Leong & Zaki, 2018). Given that relative to young adults, older adults place more trust in untrustworthy sources (Bailey & Leon, 2019), initial optimistic beliefs, or greater neglect of negative information, may contribute to the vulnerability of older adults to follow bad advice. Thus, even in the context of receiving disadvantageous outcomes in the IGT, older adults may persist with selections in the belief that taking advice may be a better strategy than not taking advice.

To assess how positive or negative a particular outcome is experienced in an objective fashion, physiological responses captured with facial electromyography (i.e. a measurement of facial muscle activity) can reveal valence and intensity of experience (Cacioppo et al., 1986; Lang et al., 1993), including in older adults (e.g. Bailey et al., 2020). Corrugator (frown muscle) activity has been associated with rated displeasure (Lang et al., 1993), while self-reported positive affect inhibits such activity (Larsen et al., 2003). Reduced corrugator activity in response to loss outcomes in the IGT, after receiving bad advice relative to no advice, would be consistent with advice influencing outcome valuation. It would suggest negative emotion in response to disadvantageous outcomes.

The present study

The current study aims to provide the first investigation of age-related differences in the tendency to rely on advice that results in negative outcomes. In line with Biele et al. (2009), it was hypothesized that relative to the no-advice group, the bad-advice groups would be slower to learn to avoid the disadvantageous decks A and B. However, we also expected that, in the bad-advice groups, older adults would select more than young adults from the disadvantageous decks A and B and that this would be correlated with less corrugator activity in response to the initial losses from those decks, and reduced cognitive functioning, as assessed by measures of working memory and fluid intelligence. In line with Beitz et al. (2014), it was expected that, relative to young adults, older adults would demonstrate a larger loss frequency bias (i.e. sensitivity to the frequency of losses rather than the amount lost), regardless of advice condition. This loss frequency bias would be indicated by greater avoidance of deck A than deck B, with the former providing more frequent but smaller losses relative to the latter.

METHOD

Participants

Sixty-two young adults and 56 older adults participated in this study. The Mini-Addenbrooke's Cognitive Examination (Australian Version A) was administered to older adults as a brief screening test for cognitive impairment. Data for two older adults were excluded because they scored lower than 22 out of 30 (Hsieh et al., 2015), leaving a total sample of 54 older adults (M_{age} = 71.54, SD = 5.59; age range 60–83 years; 28 female). Three young adults were excluded due to indicating a current neurological condition, leaving a total sample of 59 young adults (M_{age} = 21.42, SD = 4.56; age range 17–39 years; 44 female). Older adults were community-dwelling and were recruited via a University database and advertisements in the local community. Older adult participants were reimbursed $20 per hour. Younger adults were undergraduate students, participating in exchange for course credit.

As indicated by a G*Power (Faul et al., 2007) analysis, 120 participants were required to detect a medium-sized effect of age group ($1–\beta = .80$; $a = .05$). We included 7 fewer participants in the analyses due to restrictions on face-to-face testing during a COVID-19 pandemic lockdown period. All participants gave written informed consent, and the study was approved by the Western Sydney University Human Research Ethics Committee (H12559).

Background information is provided in Table 1. As is typical of studies investigating age-related differences, relative to older adults, young adults reported more years of education and greater depression, anxiety and stress, as assessed by the short form Depression Anxiety Stress Scales (DASS) (Lovibond & Lovibond, 1995). Young adults achieved higher fluid intelligence scores than older adults. Ten older adults also completed a judge-advisor task for a separate study not reported in the current paper.

Materials

Cognition

Short-term and working memory were assessed with the forward and backward Digit Span tests, respectively, from the Revised Wechsler Adult Intelligence Scale (Wechsler, 1981). Fluid intelligence was assessed with two sets of 12 progressive matrices, as validated by Schniter and Shields (2014) for use in a broad age range. In each matrix task, participants identified which image, in a pattern of eight images, was missing. The cognitive tasks were counterbalanced between participants.

TABLE 1 Descriptive and inferential statistics for age group differences in background measures.

	Young adults		Older adults		Age group differences			Effect size
	M	*SD*	*M*	*SD*	*t*	*p*	*df*	*d*
Education	14.4	2.22	12.5	2.79	3.78	<.001	93	0.74
Health	5.7	1.12	5.5	0.89	0.94	.349	109	0.18
Depression	9.6	8.26	5.6	6.83	2.79	.006	110	0.52
Anxiety	9.1	6.30	4.6	5.86	3.96	<.001	111	0.74
Stress	12.8	6.11	7.4	5.95	4.70	<.001	111	0.88
Short-term memory	9.9	2.75	10.1	2.26	0.41	.681	110	0.08
Working memory	6.2	2.11	6.2	1.80	0.10	.923	110	0.02
Fluid intelligence	20.5	4.45	16.2	6.21	4.18	<.001	95	0.79

Note: Three older adults did not specify their years of education. Self-reported health was rated on a scale from 1 (Poor) to 7 (Excellent).

Computerized IGT

The program presented a screen with four decks of cards, each labelled deck A, B, C, or D. Each participant started the game at 1000 play dollars and selected a card from each deck until the game concluded at 100 trials (100 card selections). The advantageous decks were C and D, yielding wins of $50 and incurring losses of −$25 to −$75 (Deck C) and −$250 (Deck D). Decks A and B were the disadvantageous decks, yielding wins of $100 and incurring losses of −$150 to −$350 (Deck A), and −$1250 (Deck B). The payoff schedule was identical to that described in Bechara et al. (1994). Low-frequency decks were those with rare but higher losses (decks B and D at 10% frequency), and high-frequency decks were those with frequent but lower losses (decks A and C at 50% frequency). As per Bechara et al. (1999), the inter-trial interval between two consecutive card selections was set to 6 s to allow for physiological recordings. Following previous studies (e.g. Nicholson et al., 2021), trials were broken down into five blocks of 20 trials for analysis.

Participants played the IGT, adapted from Bechara et al. (2000) and Beitz et al. (2014). They were first provided with general information about the task as follows: "Each time you select a card, the computer will tell you that you won some money. Every so often, you may also lose some money. You are free to switch from one deck to another at any time, and as often as you wish. The goal of the game is to accumulate as much money as possible. Please keep selecting cards until the game stops. Please treat the play money in this game as real money, and any decision on what to do with it should be made as if you were using your own money. Be aware that some decks are worse than the others. No matter how much you find yourself losing, you can still win if you stay away from the worst decks". There were no monetary incentives based on performance in this task.

Participants in the bad advice conditions were given additional information as follows: "we recommend always selecting from Deck A" or "we recommend always selecting from Deck B". All information was provided both verbally and in writing on the computer screen. Advice conditions were counterbalanced between participants.

Corrugator activity

Facial electromyography (EMG) was used to measure corrugator muscle activity (i.e. frowning) in line with the recommendations of Fridlund and Cacioppo et al. (1986). Baseline corrugator activity was established as 1 s pre-outcome onset, and the post-outcome period was 1 s following presentation of the loss outcome. Percentage change in corrugator activity was then calculated for each 1 s epoch following the average 1 s baseline. Physiological recording and processing details are provided in the Data S1.

RESULTS

See Data S1 for details of software and packages related to analyses.

Selections from disadvantageous Decks A and B

An Age Group (Young, Older) × Advice Condition (Advice Deck A, Advice Deck B, No Advice) × Deck (A, B) × Block (1 through to 5), mixed analysis of covariance (ANCOVA) was conducted. Deck and Block were repeated measures factors, while age group and advice condition were between-subjects factors. Years of education, fluid intelligence and DASS scores served as covariates because the two age groups differed on each of these variables. Greenhouse–Geisser corrections were made where sphericity was violated. Post hoc tests were performed on significant interactions using Tukey's adjustments. There was no significant Age Group × Advice Condition × Deck interaction ($F(2, 97) = 2.33$, $p = .103$, $\eta_p^2 = .05$). However, there were main effects of Age Group, Advice Condition, and Deck ($F(1, 97) = 5.94$, $p = .017$, $\eta_p^2 = .06$; $F(2, 97) = 8.56$, $p < .001$, $\eta_p^2 = .15$; $F(1, 97) = 11.27$, $p = .001$, $\eta_p^2 = .10$, respectively). The main effect of the age group showed that averaged across other conditions, older adults ($M = 0.25$, $SD = 0.18$) selected more from the disadvantageous decks than young adults ($M = 0.23$, $SD = 0.15$).

The interaction between Advice Condition × Deck × Block was statistically significant ($F(6, 307) = 2.56$, $p = .018$, $\eta_p^2 = .05$). Figure 1, which shows the proportions of deck A and B selections in the different advice groups, reveals that: in Block 1 the Advice Condition A group had a higher proportion of selections from deck A compared to the no-advice group ($p = .017$), and the Advice Condition B group had a higher proportion of selections from deck B compared to the no-advice group ($p = .034$); in Block 2, the Advice Condition B group selected more from deck B than the no-advice group ($p = .005$); and in Block 3, both the Advice Condition A group and the Advice Condition B group had higher proportions of selections from deck B than the no-advice group ($p = .023$, and $p = .002$ respectively). No differences were identified in blocks 4 and 5 (all ps $> .05$). This suggests that across age groups, the bad-advice groups learnt to avoid the recommended decks A and B by Block 4, but this learning was faster for deck A than for deck B. There was also an interaction between Deck and the Education covariate ($F(1, 97) = 4.92$, $p = .029$, $\eta_p^2 = .05$). A linear model revealed that there was a negative relationship between Education and deck A selections ($p < .001$).

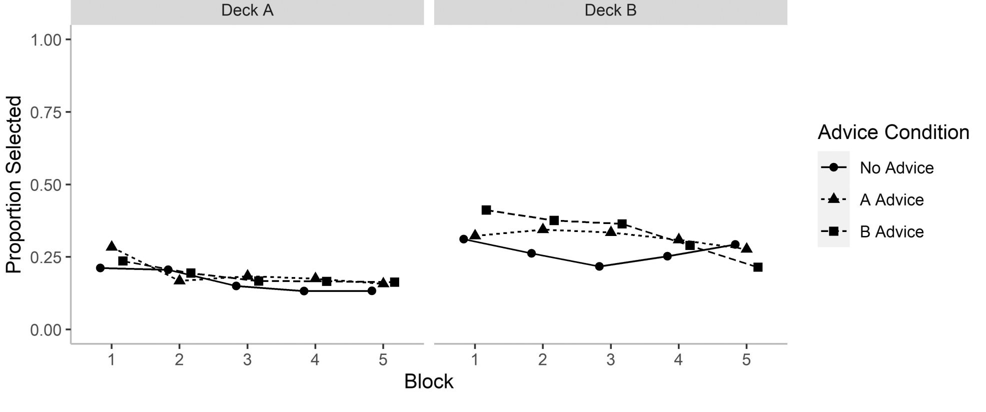

FIGURE 1 Proportion of deck A and B card selections across blocks for each advice condition.

Corrugator activity in response to Decks A and B

Percentage change in corrugator activity was assessed in response to the first loss from each disadvantageous deck. Due to technical issues, data from seven older adults were excluded from this analysis. In addition, two older adults did not make any deck A selections and one young adult did not make any deck B selections, and were also excluded from the analysis.

Due to unequal group sizes, a linear mixed effects analysis was performed with Age Group (Young, Older), Advice Condition (No-Advice Condition, Advice Condition A, Advice Condition B) and Deck (A, B) as fixed effects. Block (1, 2, 3 and 5—No losses occurred in block 4 for any of the included participants) was added as a covariate, participant ID was specified as a random effect and the average percentage change was the outcome variable. As per Table 2, the results indicated no significant main effect of the older age group in comparison to the young age group, and no main effects of the Advice Condition A and Advice Condition B groups in comparison to the No-Advice Condition group. Additionally, there was no main effect of Deck B in comparison to Deck A. There were no interaction effects of Age Group × Advice Condition, indicating that older adults in the advice conditions did not show less corrugator activity than the young adults (age group *M*s and *SD*s of corrugator activity by advice condition and deck are presented in Table 3). Additionally, there was no interaction effect of Age Group × Deck, or Age Group × Deck × Advice Condition. Thus, there were no significant differences between young and older adults' corrugator activity to either Deck A or Deck B losses. Given the wide confidence intervals present, caution is recommended with the interpretation of these results.

Correlations with cognitive ability

Correlation analyses assessed the relationship between cognitive ability and the proportion of deck A and B selections by young and older adults (see Table 4). Years of education and DASS scores (stress, anxiety and depression) were also explored given the age group differences in these background variables. The proportions of deck B selections were negatively correlated with fluid intelligence scores for the young adults, and negatively correlated with education for older adults. There were no significant correlations between deck A selections and fluid intelligence scores for either age group.

DISCUSSION

The present study investigated the repeated decision-making of young and older adults in the IGT after receiving bad advice, or no advice. As expected, relative to the no-advice group, the bad-advice groups were slower to learn to avoid the disadvantageous decks A and B. Partially supporting the hypothesis that, relative to young adults, older adults in the bad-advice groups would select more from the disadvantageous decks, the older adults made more disadvantageous selections averaged across the bad advice and no-advice conditions. The hypothesis that reduced working memory and fluid intelligence would be associated with disadvantageous selections among the older adults was not supported. However, selecting from deck B was associated with reduced education among the older adults, and reduced fluid intelligence among the young adults. We consider in greater detail how education may be related to cognitive function below. Contrary to our predictions, although both age groups showed an increase in corrugator activity in response to first losses, we did not find differences between older and younger adults. There was also no support for the prediction that older adults would demonstrate a greater loss frequency bias than young adults. Rather, both age groups demonstrated a loss frequency bias by avoiding deck A (high-frequency losses) more than deck B (low-frequency losses), averaged across all other conditions.

TABLE 2 Linear mixed model of Age Group, Advice Condition, and Deck on Average Corrugator Activity.

Fixed effects					
	Estimate/Beta	***SE***	**95% CI**	***t***	***p***
Intercept	103.02	6.86	89.49, 1116.56	15.01	<.001
Block (Block 2)	3.69	7.07	−9.73, 17.13	0.52	.603
Block (Block 3)	−19.69	12.77	−43.94, 4.58	1.54	.125
Block (Block 5)	−23.14	24.08	−68.78, 22.48	0.96	.338
Age group (Older)	−7.48	10.29	−26.99, 12.02	0.73	.468
Advice condition A	2.32	9.86	−16.36, 21.00	0.24	.814
Advice condition B	−14.64	9.71	−33.03, 3.75	1.51	.133
Deck B	14.43	10.43	−5.46, 34.20	1.39	.169
Older adults × Advice condition A	−3.51	15.34	−32.56, 25.55	0.23	.820
Older adults × Advice condition B	25.05	15.02	−3.41, 53.50	1.67	.097
Older adults × Deck B	−16.91	14.23	−44.00, 10.15	1.19	.238
Advice condition A × Deck B	−7.00	13.40	−32.61, 18.43	0.52	.602
Advice condition B × Deck B	2.07	13.17	−22.98, 27.17	0.16	.876
Older adults × Advice condition A × Deck B	9.85	20.71	−29.47, 49.41	0.48	.635
Older adults × Advice condition B × Deck B	−12.25	20.39	−51.06, 26.55	0.60	.549
Random effects					
	Variance		***SD***		**ICC**
Participant ID (Intercept)	87.59		9.36		0.09
Model Fit					
R^2	**Marginal**				**Conditional**
	0.10				0.18

Note: Model equation in R: Percentage Change ~ Block + Age Group * Advice Condition * Deck + (1|Participant ID).

TABLE 3 Age group % change in corrugator means and standard deviations by advice condition, and deck.

	Young adults		**Older adults**	
	M	***SD***	***M***	***SD***
No-advice condition	109.78	33.24	94.61	18.53
Advice condition A	109.59	38.03	95.26	12.08
Advice condition B	96.97	41.45	99.99	19.15
Deck A	98.93	25.03	98.01	16.95
Deck B	111.86	46.87	94.98	17.35

No age-related difference in loss frequency bias

In the bad-advice groups (i.e. advice to select from deck A, or deck B), averaged across age, learning to avoid deck A, which incurred high frequency smaller losses, was faster than learning to avoid deck B, which incurred less frequent but more severe losses. In addition, selections were greater for deck B than deck A, consistent with previous research (Beitz et al., 2014; Kumar et al., 2019; Steingroever et al., 2013). These findings suggest a loss frequency bias—that is, the tendency to avoid choices resulting in more frequent losses (i.e. deck A), relative to choices resulting in less frequent but more

TABLE 4 Intercorrelations among the variables for young (above diagonal) and older (below the diagonal) age groups.

Variable	1	2	3	4	5	6	7	8	9
Young adult *n*	58	59	59	59	59	59	59	59	59
Older adult *n*	50	54	54	54	54	54	54	54	54
1. Education		.22	.02	.25	.05	−.10	.20	.25	.07
2. Short-term memory	.01		.45***	.40**	.16	.00	.03	−.09	.01
3. Working memory	.05	.53***		.33*	.01	−.04	.02	−.22	−.13
4. Fluid intelligence	.25	.39**	.27		−.03	−.28*	.00	−.04	−.26*
5. Stress	.23	−.13	−.14	−.02		.75***	.64***	−.09	.01
6. Anxiety	.05	.06	−.02	−.06	.58***		.48***	−.11	.07
7. Depression	.18	.05	−.07	−.09	.65***	.45***		−.18	.01
8. Deck A selections	−.01	.04	−.15	−.10	−.02	.17	.03		−.05
9. Deck B selections	−.34*	.18	−.13	.18	.03	.05	.10	.07	

*$p<.05$. **$p<.01$. ***$p<.00$.

severe losses (i.e. deck B). While Beitz et al. (2014) found greater loss frequency bias with age, the current study identified no age-related differences in relative preference for deck A versus deck B. Interestingly, the addition of advice in our study may have masked a greater tendency to focus on more frequent losses in older age.

Older adults in the current study produced lower scores than young adults on tests of cognitive function, yet this did not increase loss frequency bias among older adults. It may be that monitoring loss frequency is as cognitively demanding as monitoring overall losses. The effect of loss frequency bias may also relate to difficulties in how individuals engage in reversal learning—that is, the ability to update or inhibit previously learnt contingencies between deck choices and outcomes. Indeed, it has been argued that good performance on the IGT is related to an individual's reversal learning ability (Kovalchik & Allman, 2006; Pasion et al., 2017). Some previous research reported reduced reversal learning among older relative to young adults (Kovalchik & Allman, 2006), while others reported no age-related differences (see Pasion et al., 2017 for a meta-analysis), and the present findings appear to support the latter.

Age-related differences in decision-making

The current results indicate that older adults select more from the disadvantageous decks than young adults, which is consistent with previous accounts of older adults' difficulties in learning to avoid the disadvantageous decks (Denburg et al., 2005; Fein et al., 2007). Bad advice did not exacerbate this age-related learning difficulty. Rather, the older group appeared to be less sensitive to punishments in general. It was recently shown that punishment-insensitive individuals failed to learn the association between their own control over the environment and aversive outcomes (Jean-Richard-dit-Bressel et al., 2021). Consistent with this idea, Rönnlund et al. (2019) found a relationship between older adults' decision-making competence and their perception of time. A present-fatalistic time perspective had a negative effect on decision-making competence. It is, therefore, possible that older adults may either have a low awareness of, or inability to learn, the controllability of certain outcomes. Older adults in the current study may have perceived their choices as having little influence over the outcomes of the IGT, and this may account for the greater proportion of selections from the disadvantageous decks by this age group.

An alternate explanation is that the older adults may have simply processed the outcomes from the disadvantageous decks as being less negative than they actually were. This explanation would be consistent with a socioemotional selectivity theory account of the positivity effect (Carstensen, 2006). Older adults, however, did not show less corrugator activity than young adults towards the first losses from either disadvantageous deck in the current study. Given the wide confidence intervals in the corrugator activity analysis and limited older adult data, a larger sample may have been needed to detect this age group difference. Alternatively, Jean-Richard-dit-Bressel et al. (2021) reported that both punishment-sensitive and insensitive people equally disliked punishment, but only the punishment-sensitive were aware of how their actions influenced the occurrence of negative outcomes. In future research, a difference in rated dislike of the disadvantageous decks may help to differentiate whether older adults are punishment-insensitive, or whether they experience the losses as less subjectively negative.

Participants initially heeded the bad advice provided immediately prior to the commencement of the IGT in the current study. That is, those that were advised to select from deck A, and those that were advised to select from deck B, were more likely to select from those recommended decks relative to the no-advice group in the first block. The speed with which the bad-advice groups learnt to avoid losses varied as a function of the disadvantageous deck A or B. Following the first block, only participants who were advised to select from deck B continued to follow the bad advice and select more from that deck relative to participants in the no-advice condition. This indicates that the advice A group learnt to avoid deck A more quickly than advice B group learnt to avoid deck B, possibly due to the frequency of losses encountered in deck A (high loss frequency) versus deck B (low loss frequency). Studies of punishment sensitivity in young adults show that when punishment is more infrequent (e.g. deck B outcomes), insensitivity to punishment increases (Jean-Richard-dit-Bressel, et al., 2023). This has been attributed to difficulty noticing, and becoming aware of, the source of infrequent losses. This awareness may depend on cognitive resources, which is consistent with more selections from deck B correlating with greater fluid intelligence in young adults, and higher educational attainment in older adults.

Interestingly, in block 3, the advice A group also selected more from deck B than the no-advice group. It is possible that in recommending the disadvantageous deck A which delivered frequent losses, this group focused more on short-term outcomes such as the larger gains delivered by deck B (Beitz et al., 2014). This comes at the cost of engaging in reversal learning and performing well at the conclusion of the task by considering which actions will lead to the best overall result. In real-world decision-making, this may suggest that, in some circumstances, individuals provided with bad advice may make decisions that are beneficial in the short-term, but detrimental in the long-term.

Among young adults, fluid intelligence was negatively associated with deck B selections. Similarly, among older adults, years of education were negatively associated with deck B selections, which may suggest that increased education relates to a cognitive factor that was not assessed in the current study. Education is also an indicator of cognitive reserve (Boyle et al., 2021). These findings may indicate that cognitive abilities provide a buffer against the tendency to select from deck B that offers short-term gain at the cost of long-term outcomes. Interestingly, there were no associations between education, cognitive variables and the proportion of selections from deck A. Consequently, it cannot be concluded that cognitive variables are essential to learning to avoid selecting from disadvantageous decks. Instead, cognitive function may be more important in learning contingencies where there are less frequent but larger losses (i.e. deck B) relative to contingencies with smaller but more frequent losses (i.e. deck A).

Limitations and future directions

There are aspects of the present study that limit the conclusions that can be drawn. For example, there was no middle-aged sample, thus, age group differences might be restricted to between young and older age groups. The inclusion of middle-aged adults would allow for the examination of a linear effect of age. Additionally, to address potential cohort effects between age groups longitudinal studies are needed, to tease apart whether levels of cognitive ability/reserve are related to years of education. Although gender does not tend to influence advice-taking (Bailey et al., 2022), the higher proportion of female participants in the younger participant sample may also have influenced the current findings. Future studies should investigate the potential effect of gender on age-related differences in advice-taking. The payoff schedule of the IGT has been criticized for not being as ambiguous as was originally reported, and it has been argued that participants are able to consciously differentiate between the advantageous and disadvantageous decks (Cauffman et al., 2010; Dunn et al., 2006). To investigate this possibility, future studies involving the IGT and advice-taking should include a question to participants about their awareness of the overall deck outcomes. It is possible that the advice in the present study may have been viewed by participants as coming from the experimenter, and thus, from an expert. In real-world decision-making scenarios, bad advice can be delivered by an expert either in error or intentionally. Future research should examine age-related differences in taking bad advice from someone labelled as an expert versus a novice, or advice from a close friend versus a stranger. In addition, the current study assessed the influence of unsolicited advice. Given age-related differences in advice-seeking (Fan, 2021), the solicitation of advice is likely to represent an important avenue for future IGT and ageing research. Conversely, the provision of the advice offered by older adults deserves further attention (see Van Vleet et al., 2022). The final points to consider include that age group differences in deck preference may be clearer when comparing selections from advantageous versus disadvantageous decks. To examine this possibility future research should include two additional advice conditions for decks C and D (the advantageous decks). Future research should also investigate advice-taking across a range of decision-making tasks, including in real-world settings, to ensure external validity of findings.

CONCLUSION

The current study found that older adults are not more susceptible than young adults to once-off bad advice in the IGT. Relative to young adults, older adults made more disadvantageous selections regardless of whether or not they received bad advice. This suggests that older adults may be less sensitive to punishment than young adults. The findings also indicated that both young and older adults preferred an option resulting in a larger, but lower frequency loss, indicating a loss frequency bias. This bias was associated with lower educational attainment in older adults and reduced fluid intelligence in young adults. Due to the additional cognitive effort required to monitor infrequent losses, those losses may go unnoticed, and this may be attributable to different cognitive mechanisms within each age group. Overall, these results suggest that, regardless of bad advice from others, older adults may be susceptible to making decisions that result in losses that may be difficult to recuperate in later life.

AUTHOR CONTRIBUTIONS

Tarren Leon: Conceptualization; investigation; writing – original draft; methodology; visualization; writing – review and editing; formal analysis; project administration; data curation; validation. **Gabrielle Weidemann:** Conceptualization; funding acquisition; writing – review and editing; resources; methodology; supervision. **Phoebe E. Bailey:** Supervision; resources; software; conceptualization; investigation; funding acquisition; writing – review and editing; methodology; project administration.

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CONFLICT OF INTEREST STATEMENT

The authors declare none.

DATA AVAILABLITY STATEMENT

The data corresponding to this research are accessible at the Open Science Framework (https://osf.io/fbr95/?view_only=09a996b23adc452e8452eb50dd0227e0).

ETHICS STATEMENT

The study was approved by the Western Sydney University Human Research Ethics Committee (H12559).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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