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MYOPIA FOR THE FUTURE OR HYPERSENSITIVITY TO REWARD? AGE-RELATED CHANGES IN DECISION-MAKING ON THE IOWA GAMBLING TASK

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Abstract

It has been shown that older adults perform less well than younger adults on the Iowa Gambling Task (IGT), a real-world type decision-making task that factors together reward, punishment, and uncertainty. To explore the reasons behind this age-related decrement, we administered to an adult life-span sample of 265 healthy participants (median age = 62.00 +/- 16.17 years; range [23–88]) two versions of the IGT, which have different contingencies for successful performance: A'B'C'D' requires choosing lower immediate reward (paired with lower delayed punishment); E'F'G'H' requires choosing higher immediate punishment (paired with higher delayed reward). There was a significant negative correlation between age and performance on the A'B'C'D' version of the IGT ($r = -.16, p = .01$), while there was essentially no correlation between age and performance on the E'F'G'H' version ($r = -.07, p = .24$). In addition, the rate of impaired performance in older participants was significantly higher for the A'B'C'D' version (23%), compared to the E'F'G'H' version (13%). A parsimonious account of these findings is an age-related increase in hypersensitivity to reward, whereby the decisions of older adults are disproportionately influenced by prospects of receiving reward, irrespective of the presence or degree of punishment.

Keywords

decision-making; aging; older adults; reward

The Iowa Gambling Task (IGT) has been utilized to test decision-making capabilities in various neurological, psychiatric, and healthy populations (e.g., Bechara, 2007; Bechara, Damasio, Damasio, & Anderson, 1994). In particular, the IGT has been very effective in understanding how emotion influences decision-making, at both conscious and non-conscious levels (e.g., Bechara et al., 2000b, 1997; Damasio, 1994). Two variants of the IGT have been created (Bechara, Tranel, & Damasio, 2000a). Both versions have “good” and “bad” decks that, depending on how the participant chooses from among the decks, yield a final net monetary gain or net monetary loss. In the *original* IGT (A'B'C'D'), net winning

requires participants to choose predominantly from decks with lower initial reward (but lower delayed punishment). In the *variant* IGT (E'F'G'H'), net winning requires participants to choose predominantly from decks with higher initial punishment (but higher delayed rewards). In other words, for advantageous decision-making, the A'B'C'D' version requires the participant to forgo the “pleasure” of more up-front reward, whereas the E'F'G'H' version requires the participant to endure the “pain” of more up-front punishment.

A well-replicated finding on the IGT is that neurological patients with damage to the ventromedial prefrontal cortex (vmPFC)—who are notable for making poor decisions in real-world situations—choose disadvantageously on the A'B'C'D' version, preferring up-front high reward at the cost of net losing (e.g., Bechara et al., 1994, 2000a). To explore whether this behavior was being driven by hypersensitivity to reward or insensitivity to future consequences, the E'F'G'H' variant version of the IGT was created, where the reward and punishment schedules were completely swapped (Bechara et al., 2000a). It turned out that this reversal of schedules did not alter the disadvantageous decision-making of vmPFC patients, as they again responded to the up-front contingency (which in the variant E'F'G'H' means that they avoided higher immediate punishment at the cost of net losing). This finding, together with the initial finding of impaired performance on the A'B'C'D' version, indicated that the patients were insensitive to future consequences, whatever they may be, and we suggested that the patients' decision-making could be parsimoniously characterized as “myopia for the future.” By contrast, healthy young and middle-aged participants chose advantageously on both IGT versions (Bechara et al., 2000a), learning to accept lower immediate reward (A'B'C'D') or higher immediate punishment (E'F'G'H') in order to achieve net winning.

The IGT has also been used to investigate decision-making in healthy older adults. As a group, older adults tend to perform less well than younger adults on the original A'B'C'D' version of the IGT, and a subset of older adults performed disadvantageously on the A'B'C'D' version in a manner reminiscent of neurological patients with damage to the vmPFC (Denburg, Tranel, & Bechara, 2005). This could be taken as evidence that older adults have “myopia for the future,” akin to the phenomenon observed in vmPFC patients. However, an alternative explanation is that older adults have “hypersensitivity to reward.” This could account for their poorer performance on the A'B'C'D' IGT, where overall losing is incurred if participants yield to the lure of higher immediate reward. These two accounts—myopia for the future or hypersensitivity to reward—are not adjudicated by findings from the A'B'C'D' version of the IGT alone, and the explanation for older adults' decision-making performance on the A'B'C'D' IGT remains unresolved.

The present study was designed to explore the reasons behind age-related decrements on the IGT, with the more general goal of contributing to a better understanding of decision-making functions in older persons. In particular, we sought evidence that would help adjudicate the two explanations cited above. To this end, two versions of the IGT, original A'B'C'D' and variant E'F'G'H', were administered to an adult life-span sample of healthy participants. Based on the background presented earlier, if there is an age-related increase in hypersensitivity to reward that is the main factor driving older adults' decision-making behavior, we would predict a significant (negative) relationship between age and decision-making performance on the A'B'C'D' version, but no relationship between age and performance on the E'F'G'H' version. By contrast, if an age-related increase in myopia for the future is the main factor driving older adults' decision-making, we would predict a significant (negative) relationship between age and performance on both versions of the IGT.

Methods

Participants

An age- and sex-stratified sample of 265 participants, free of neurological and psychiatric disease, was recruited from the community (see Denburg et al., 2009 for a more extensive description on our adult life-span cohort). Participants were compensated for their time. Descriptive data for the sample, involving demographic and neuropsychological variables, are provided in Table 1, including age (in years), education (in years), affective symptomatology (as indexed by the Beck Depression Inventory-II; Beck, Steer, & Brown, 1996), mental status (as estimated by the Mini-Mental State Examination; Folstein, Folstein, & McHugh, 1975), and current (as measured by the Wechsler Abbreviated Scale of Intelligence (WASI); Wechsler, 1999) and premorbid (as estimated by the Wide Range Achievement Test-3 Reading subtest; Wilkinson, 1993) intellectual ability.

Procedures and Measures

Participants completed the A'B'C'D' IGT, followed by E'F'G'H' IGT, using computerized administration and simulated money (after Bechara, 2007 and Bechara et al., 2000a). In both versions, the decks are rigged such that there are “good” decks and “bad” decks, and such that advantageous decision-making over the long term requires one to forgo less favorable immediate consequences in preference of more favorable delayed consequences. Specifically, choosing the “good” decks will initially yield a lower immediate reward in the A'B'C'D' version, or a higher immediate punishment in the E'F'G'H' version, but over time the “good” decks will yield a net gain in money. The “bad” decks, by contrast, provide more immediate allure (higher monetary gain in A'B'C'D' or lower monetary loss in E'F'G'H'), but over time result in a net loss of money. Instructions for both versions of the IGT are provided in the Appendix.

A'B'C'D'—This version of the IGT contains four decks each with an equal number of cards. Participants are told to pick from any deck they wish. The task is completed after 100 card selections; however, participants are not told when the game will end. They are additionally instructed that some decks are more advantageous than others, but are not told which decks are “good” and which are “bad.” This version of the IGT always delivers an immediate reward (gain in money) regardless of deck choice. However, occasionally there is a delayed punishment (loss of money) following the immediate reward. The decks are rigged such that the decks with the lower immediate reward (C' and D') provide an even lower long-term punishment, while the decks with the larger immediate reward (A' and B') provide an even larger long-term punishment. If more cards are chosen from decks C' and D' (the “good” decks), there will be a net gain in money, while a larger number of picks from decks A' and B' (the “bad” decks) will result in a net loss of money.

E'F'G'H'—This version of the IGT also contains four decks each with an equal number of cards. Participants are asked to pick from any deck they wish (again, not told to the participant, the game ends after 100 card selections). This version always delivers an immediate punishment followed on occasion by a delayed reward. The decks are rigged such that the decks with the larger immediate punishment (E' and G') yield an even larger delayed reward, while the decks with the smaller immediate punishment (F' and H') yield an even smaller delayed reward. If more cards are chosen from decks E' and G' (the “good” decks), there will be a net gain in money, while a larger number of picks from decks F' and H' (the “bad” decks) will result in a net loss of money.

Because of intricacies of contingency learning on the IGT, counterbalanced administration of the A'B'C'D' and E'F'G'H' versions of the IGT is problematic, leading to increased noise

in the data and uninterpretable outcomes (Hernandez, Lu, Hyonggin, & Bechara, 2006). Also, in the Hernandez et al. (2006) study, older ($n = 17$) and younger ($n = 75$) adults were administered the original version of the IGT (A'B'C'D') first, followed by a variant version termed K'L'M'N', in which the same basic contingencies were used (the advantageous decks had lower up front reward, but the arrangements of the decks and the exact amounts of rewards in the good decks were manipulated). In these tasks, the younger adults performed well on both versions, whereas the older adults did not perform well on either version. These findings suggest that older adults failed to learn the basic contingencies of the tasks (which in both cases involved lower up front reward and lower long-term punishment for successful performance), even after completing two comparable versions of the task and having an extended learning opportunity. In the current study, we followed the precedent of Bechara et al. (2000a), and administered the A'B'C'D' and E'F'G'H' versions sequentially.

Data Analysis

The dependent variables of interest were IGT performances for versions A'B'C'D' and E'F'G'H'. For each version, the total number of selections from the “bad” decks was subtracted from the total number of selections from the “good” decks to create a Net Score $[(C' + D') - (A' + B')]$ and $[(E' + G') - (F' + H')]$. A positive Net Score signifies that the participant chose more advantageously, while a negative Net Score signifies more disadvantageous selections. Simple linear regression was used to examine if participants' age predicted performance on IGT versions A'B'C'D' and E'F'G'H', where age was used as a continuous predictor variable and IGT performance was the outcome variable. In these analyses, if an age-related increase in hypersensitivity to reward was a main factor driving task performance, we would expect a negative correlation between age and Net Score on the A'B'C'D' version, but no relationship between age and Net Score on the E'F'G'H' version. By contrast, if an age-related increase in myopia for the future is a main factor driving task performance, we would expect a negative correlation between age and Net Score on both versions of the IGT.

Results

Main Predictions: Myopia for the Future or Hypersensitivity to Reward?

For the A'B'C'D' version, age entered significantly in the linear regression (unstandardized β coefficient = $-.32$, $t(263) = -2.59$, $p = .01$). By contrast, for the E'F'G'H' version, age was non-significant (unstandardized β coefficient = $-.16$, $t(263) = -1.19$, $p = .24$). Said another way, a significant negative correlation was found between age and performance on the A'B'C'D' version of the IGT ($r = -.16$), while there was essentially no correlation between age and performance on the E'F'G'H' version ($r = -.07$)¹. These outcomes support the hypersensitivity to reward explanation, and not the myopia for the future explanation.

The linear regression analyses were re-run using the demographic and neuropsychological variables (Table 1) as covariates. Inclusion of these covariates did not change the relationship between age and A'B'C'D' performance, which remained significant in all cases. Similarly, age remained a non-significant predictor of performance on the E'F'G'H' version, even after taking each of the covariates into account.

¹Polynomial models were fit to look for nonlinear aspects of the relationship between age and IGT. For the A'B'C'D' version, a linear model best fit the data. For the E'F'G'H' version, none of the models fit the data ideally (consistent with age being a poor predictor of E'F'G'H' performance), and thus a linear model remained the simplest model to fit.

Rates of Impaired Decision-Making: A Descriptive Analysis

Following our previous work, we added a descriptive analysis to explore rates of impaired, unimpaired, and borderline decision-making performances on the IGT. This analysis was focused on the older adults in the sample, as rates of impairment in younger adults were too low to make such a follow-up analysis meaningful in the younger participants. Following methodology used previously, older adults were defined as individuals aged 56 years of age and older (Denburg et al., 2005; Fein, McGilivray, & Finn, 2007); a total of 164 participants met this definition. Under the assumption that random behavior on the IGT would yield a Net Score of zero, we categorized each participant as “Unimpaired” or “Impaired” based on whether the Net Score differed significantly from zero (using the binomial test), and in which direction. Participants who had Net Scores that were significantly different from zero in the positive direction were categorized as “Unimpaired,” and participants who had Net Scores that were significantly different from zero in the negative direction were categorized as “Impaired.” Participants with IGT performances that were not significantly different from zero in either direction were classified as “Borderline.”

Figure 1 shows the percentages of older adults that were Impaired, Unimpaired, or Borderline on the A'B'C'D' and E'F'G'H' versions of the IGT. For A'B'C'D', 23% ($n = 37$) were Impaired, 54% ($n = 90$) were Unimpaired, and 23% ($n = 37$) were Borderline; by contrast, on E'F'G'H', 13% ($n = 22$) were Impaired, 61% ($n = 100$) were Unimpaired, and 26% ($n = 42$) were Borderline. A paired samples t -test contrasting the rates of Impairment between the two IGT versions yielded a significant difference ($t(163) = 2.26, p = .025$). (The rates of Unimpairment and Borderline were not significantly different.) In sum, older adults had a higher rate of impairment on the A'B'C'D' version, compared to the E'F'G'H' version—in fact, the rate of impairment was nearly twice as high for the A'B'C'D' version (23%) than for the E'F'G'H' version (13%).

Discussion

The findings from this study indicate that on a version of the Iowa Gambling Task (IGT) in which successful decision-making requires choosing lower immediate reward paired with lower long-term punishment (A'B'C'D'), increasing age (across a sample of 265 participants aged 23 to 88 years old) was associated with poorer performance. By contrast, on a version of the IGT in which successful decision-making requires choosing higher immediate punishment paired with higher long-term reward (E'F'G'H'), there was no association between age and performance. It was also found that in participants aged 56 or greater, the rate of decision-making impairment (defined by Net Scores significantly below zero) was nearly twice as high for the A'B'C'D' version (23%) as compared to the E'F'G'H' version (13%). A major strength of our study is the large sample size, which bolsters confidence in the reliability of the results.

The original and variant versions of the IGT have also been studied in various patient groups, in addition to the neurological patients reported by Bechara and colleagues (2000a). For example, individuals with substance dependence disorders have been found to fall into one of three subgroups based upon their scores on the original and variant IGTs (Bechara, Dolan, & Hindes, 2002). The first subgroup included participants with substance dependence disorders who responded to the original and variant tasks in ways comparable to healthy advantageous scoring participants. A second subgroup resembled patients with vmPFC lesions, and performed disadvantageously on both versions of the IGT. A third subgroup performed disadvantageously on the A'B'C'D' version, but performed advantageously on the E'F'G'H' version. This latter finding is intriguing, and can be likened to the finding we obtained in older adults—a sort of “hypersensitivity to reward” whereby participants are drawn to the higher reward, which is a winning strategy in E'F'G'H' but not

in A'B'C'D'. Studies involving patients with major depressive disorder (Must, Szabó, Bódi, Szász, Janka, & Kéri, 2006) and female patients with fibromyalgia (Verdejo-Garcia, López-Torreallas, Calandre, Delgado-Rodríguez, & Bechara, 2009) also showed that performance was disadvantageous on A'B'C'D' and advantageous on E'F'G'H'. Again, this suggests a “hypersensitivity to reward” phenomenon, and could indicate that participants with these disorders opt for positive outcomes (whatever the associated punishment) as a way to compensate for their symptomatology (e.g., chronic pain).

The idea of an age-related increase in hypersensitivity to reward finds additional traction in the context of socioemotional selectivity theory (SST) (Carstensen, Isaacowitz, & Charles, 1999). This theory posits that secondary to the realization of constraints of life longevity, old age is associated with a focus on and bias towards positively-valenced material. In shorthand, this phenomenon can be termed a “positivity effect.” Empirical support for SST and an age-related positivity effect has been established in multiple domains, including attention (e.g., Mather & Carstensen, 2003), emotional memory (e.g., Leigland, Schulz, & Janowsky, 2004), social interactions (e.g., Dudley & Multhaup, 2005), and pursuit of interests (e.g., Adams, 2004), where in all cases, older adults demonstrate a bias towards and preference for positively-valenced information (usually together with low responsiveness to negatively-valenced information). Not all of the evidence has been consistent, however, and the positivity effect in aging has not gone unchallenged (Fung et al., 2008; Labouvie-Vief, 2003; Mullins et al., 1996). The positivity effect may also play a role in the decision-making of older adults, as shown for example in studies indicating that older adults more closely follow positively-valenced material in making healthcare decisions for themselves and others of the same age (Lockenhoff & Carstensen, 2008). In studies of temporal discounting, the notion that one disregards future outcomes in favor of an immediate consequence, older adults have been found to weigh immediate and future consequences more equally than their younger counterparts and this was found to be more pronounced when older adults were allowed to choose between rewards and less so when the choice was between punishments (Lockenhoff et al., 2011). Additional research has suggested that older adults' motivation to maximize positive emotion in the present, rather than focus on past losses, leads to a decrease in some irrational decision-making biases (i.e., the sunk-cost fallacy) across the life-span, particularly in late life (Strough, Karns, & Schlosnagle, 2011). Another consistent line of evidence in this context is a functional neuroimaging study that showed similar patterns of brain activation (involving ventral striatum and insula) in younger and older participants in anticipation of a monetary gain, but different age-related neural activation patterns in anticipation of a monetary loss, suggesting preservation of reward processing functions among older adults (Samanez-Larkin et al., 2007).

There are limitations to our study. The IGT is but one of several well-studied decision-making tasks (e.g., Cambridge Gambling Task (Rogers et al., 2003); Game of Dice Task (Brand et al., 2005); Cups Task (Levin & Hart, 2003)), and it will be important to determine whether other complex decision-making tasks (see Mata, Josef, Samanez-Larkin, and Hertwig, 2011, for a review) reveal age-related increases in “hypersensitivity to reward.” Also, it would be of interest to monitor other response indices during decision-making performance, e.g., autonomic responses, which have been used to investigate putative emotional signals that guide decision-making (cf. Bechara et al., 2000b; Bechara et al., 1996; Damasio, 1994; Denburg et al., 2006). An interesting question in this vein is whether older adults would show higher autonomic responses to rewarding stimuli, as predicted by the “hypersensitivity to reward” account (Bechara et al., 2000a).

In summary, the current results add critical new evidence to previous work on age-related changes in decision-making, and help pin down a more unequivocal interpretation of how decision-making changes with age. Our findings point to an age-related increase in

hypersensitivity to reward. This explanation would account for the apparent tendency for older adults to perform less well on the IGT when the contingencies call for opting against higher up-front reward (as in A'B'C'D'), and to perform better when the contingencies call for opting for higher long-term reward (as in E'F'G'H'). By contrast, the idea that older adults might have a more general “myopia for the future,” reminiscent of what we have called attention to in neurological patients with damage to the ventromedial prefrontal cortex (e.g., Bechara et al., 2000a), appears less likely, and is not compatible with our finding of no correlation between age and task performance on the E'F'G'H' variant. To conclude, a parsimonious account of the current findings is an age-related increase in hypersensitivity to reward, whereby the decisions of older adults are disproportionately influenced by prospects of receiving reward, irrespective of the presence or degree of punishment.

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Appendix: Instructions for the Iowa Gambling Task versions A'B'C'D' and E'F'G'H'

Instructions for A'B'C'D'

1. In front of you on the screen, there are 4 decks of cards: A, B, C, and D.
2. When you begin the game, I want you to select one card at a time by clicking on a card from any deck you choose. Each time you select a card, the computer will tell you that you won some money. I don't know how much money you will win. You will find out as we go along. Every time you win, the green bar gets bigger. Every so often, when you click on a card, the computer will tell you that you won some money as usual, but then it will say that you lost some money as well. I don't know when you will lose or how much. You will find out as we go along. Every time you lose, the green bar gets smaller.
3. You are absolutely free to switch from one deck to the other at any time, and as often as you wish.
4. The goal of the game is to win as much money as possible and avoid losing as much money as possible. You won't know when the game will end. Simply keep on playing until the computer stops.
5. I am going to give you \$2000 of credit, the green bar, to start the game. The red bar is a reminder of how much money you borrowed to play the game, and how much money you have to pay back before we see whether you won or lost.
6. The only hint I can give you, and the most important thing to note is this: Out of these four decks of cards, there are some that are worse than others, and to win you should try to stay away from bad decks. No matter how much you find yourself losing, you can still win the game if you avoid the worst decks. Also note that the computer does not change the order of the cards once the game begins. It does not make you lose at random, or make you lose money based on the last card you picked.

Instructions for E'F'G'H'

1. In front of you on the screen, there are 4 decks of cards: E, F, G and H.
2. When you begin the game, I want you to select one card at a time by clicking on a card from any deck you choose. Each time you select a card, the computer will tell you that you lost some money. I don't know how much money you will lose. You will find out as we go along. Every time you lose, the green bar gets smaller. Every so often, when you click on a card, the computer will tell you that you lost some money as usual, but then it will say that you won some money as well. I don't know when you will win or how much. You will find out as we go along. Every time you win, the green bar gets bigger.
3. You are absolutely free to switch from one deck to the other at any time, and as often as you wish.
4. The goal of the game is to win as much money as possible and avoid losing as much money as possible. You won't know when the game will end. Simply keep on playing until the computer stops.
5. I am going to give you \$2000 of credit, the green bar, to start the game. The red bar is a reminder of how much money you borrowed to play the game, and how much money you have to pay back before we see whether you won or lost.
6. The only hint I can give you, and the most important thing to note is this: Out of these four decks of cards, there are some that are worse than others, and to win you should try to stay away from bad decks. No matter how much you find yourself losing, you can still win the game if you avoid the worst decks. Also note that the computer does not change the order of the cards once the game begins. It does not make you lose at random, or make you lose money based on the last card you picked.

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Figure 1.

Data are presented for 164 older participants (aged 56 years or greater), as a function of Iowa Gambling Task version (original A'B'C'D' vs. variant E'F'G'H'), depicting the percentages of Impaired (black), Borderline (light gray), and Unimpaired (dark gray) older adults.

Table 1

Descriptive data are presented for the entire sample ($N = 265$) for the following characteristics: age (in years), education (in years), affective symptomatology, mental status, and current and premorbid intellectual ability.

Characteristic	Mean (SD)	Range
Age (years)	59.10 (16.71)	23–88
Education (years)	15.76 (2.52)	8–20
Beck Depression Inventory-II	4.26 (4.16)	0–20
MMSE	29.29 (0.90)	26–30
WASI Verbal IQ	115.72 (11.18)	89–140
WASI Performance IQ	116.34 (11.98)	87–147
WASI Full Scale IQ	117.69 (10.77)	91–144
WRAT-3 Reading	109.42 (7.07)	88–122

Raw scores are provided for each of the following characteristics except where otherwise noted. Shown are age, education, Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996); Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975); Wechsler Abbreviated Scale of Intelligence (WASI) Verbal, Performance, and Full Scale Intelligent Quotient (IQ) in standard scores (Wechsler, 1999), and Wide Range Achievement Test Revision 3 (WRAT-3; Wilkinson, 1993) reading subtest in standard score.