Published in final edited form as:

Ann Behav Med. 2009 April ; 37(2): 164–172. doi:10.1007/s12160-009-9094-7.

Poor Decision Making Among Older Adults Is Related to Elevated Levels of Neuroticism

N. L. Denburg, Ph.D.,

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA, Department of Neurology, #2007
RCP, University of Iowa, Hospitals and Clinics, 200 Hawkins Drive, Iowa City, IA 52242-1053,
USA

J. A. Weller, Ph.D.,

Decision Research, Eugene, OR, USA

T. H. Yamada, B.A.,

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA

D. M. Shivapour, B.S.,

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA

A. R. Kaup, B.S.,

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA

A. LaLoggia, B.A.,

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA

C. A. Cole, Ph.D.,

Department of Marketing, University of Iowa, Iowa City, IA, USA

D. Tranel, Ph.D., and

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience,
University of Iowa College of Medicine, Iowa City, IA, USA

A. Bechara, Ph.D.

Department of Psychology, University of Southern California, Los Angeles, CA, USA

N. L. Denburg: natalie-denburg@uiowa.edu

Abstract

Background—A well-studied index of reasoning and decision making is the Iowa Gambling Task (IGT). The IGT possesses many features important to medical decision making, such as

weighing risks and benefits, dealing with unknown outcomes, and making decisions under uncertainty.

Purpose—There exists a great deal of individual variability on the IGT, particularly among older adults, and the present study examines the role of personality in IGT performance. We explored which of the five-factor model of personality traits were predictive of decision-making performance, after controlling for relevant demographic variables.

Methods—One hundred and fifty-two healthy cognitively intact adults (aged 26–85) were individually administered the IGT and the NEO Five-Factor Inventory.

Results—In the older adults, but not the younger, higher NEO neuroticism was associated with poorer IGT performance.

Conclusions—Our findings are discussed in the context of how stress may impact cognitive performance and cause dysfunction of neural systems in the brain important for decision making.

Keywords

Neuroticism; Decision making; Aging; Frontal lobe; Personality; Stress

Introduction

Decision making, be it social, academic, occupational, or medical, is a fundamental aspect of human existence across the life span. However, the elderly are faced with a greater risk for illness and disease [1, 2], thereby placing a premium on medical decision making during older adulthood. Moreover, medical decisions bear a certain degree of clinical uncertainty, even under ideal conditions, given that health outcomes are necessarily probabilistic. Thus, it is vital to gain an understanding of how older adults approach decisions under uncertainty and to identify individual difference variables that are associated with optimal and suboptimal decision making.

Research suggests that the aging brain may undergo differential decline of neural structures in the prefrontal region (as opposed to other regions of the cerebral cortex), possibly contributing to older persons having compromised ability to make well-reasoned and well-informed judgments and decisions. The “frontal lobe hypothesis” of aging [3], in broad terms, implies that some older adults have disproportionate age-related changes of prefrontal brain structures and, concomitantly, of associated cognitive functions, such as mental flexibility, inhibition, working memory, and decision making. This hypothesis is supported by multiple and growing sources of evidence, involving neuropsychological (e.g., [4–7]), neuroanatomical (e.g., [8–11]), and functional neuroimaging (e.g., [12, 13]) investigations.

Studies examining age differences in medical decision making are few, but those that do exist indicate similar findings: older adults demonstrate declines in the thoroughness of the information search process and in the amount of information used, as well as a shorter interval between symptom onset and the decision to seek medical care. For example, Meyer et al. [14] conducted a study in which nearly 100 women completed a medical decision-making questionnaire as “patients” and were presented with unfolding medical scenarios involving breast cancer. Participants were provided information about breast cancer and

“their” particular condition, as well as treatment options and advice from medical professionals. They were then asked to choose a treatment option and explain their rationale. Actual treatment decisions did not vary by age group, as the safest treatment option was chosen regardless of age. However, older women were more likely to make more immediate decisions regarding treatment, even when provided with supplementary information and alternative options. Decision rationale differed in that older women were more focused on the need for an immediate treatment before the disease spread, whereas younger women felt that gathering more information about the disease and treatment was integral to their decision-making process. Moreover, older women were less likely to provide reasons for their decision rationale and were less able to recall factual information presented about disease and treatment.

Comparable findings were obtained by Zwahr et al. [15], in which older women considered fewer treatment options, made fewer comparative judgments among choices, and had an overall lower quality of rationale for their decisions, as compared with younger women. In another study, Meyer and colleagues [16] created unfolding medical scenarios involving prostate cancer and found that male “patients” who delayed treatment decision making were often younger, had better working memory functioning, utilized a number of resources, and their decision rationale incorporated more information and justifications for their choices. Finally, Leventhal and colleagues [17, 18] interviewed patients during a medical appointment to determine how they had decided to seek medical care. In comparison with middle-aged patients, older patients decided more quickly that they were ill and sought medical care significantly sooner. Taken together, these studies support the position that older adults attempt to conserve diminishing cognitive resources, perhaps by turning over responsibility to a physician. A potential reason behind these findings is age-related decrement in the prefrontal structures of the brain.

Over the past decade, a well-validated paradigm called the “Iowa Gambling Task” (IGT) [19] has been used to assess the decision-making impairments of a wide variety of neurological and psychiatric patient groups, as well as nonclinical populations [20, 21]. Although originally developed as a laboratory task, the IGT is considered a close analog to real-world decision making in the manner in which it factors reward, punishment, and unpredictability [19, 22]. Further, the IGT possesses many of the features important to medical decision making, namely, weighing risks and benefits, dealing with unknown outcomes, and making decisions under uncertainty. Of particular interest, several studies have demonstrated deficits in IGT performance among older adults [23–27].

More specifically, Denburg and colleagues [23–25] have demonstrated that there exists a great deal of individual variability in IGT performance among older adults, with some older adults (approximately one third) performing as well if not better than their younger counterparts and yet another subgroup of older adults (approximately one third) performing very poorly [23–25], in a manner reminiscent of patients with acquired brain damage to the ventromedial prefrontal cortex (VMPC) [28]¹.

¹A borderline subgroup also exists, performing neither advantageously nor disadvantageously on the IGT, and, as a result, they have not been studied further.

Investigating the factors that account for this variability represents an important first step in identifying an underlying diathesis for the development of poor decision making among older adults. One individual difference variable that has had some success in predicting IGT decision-making performance among adolescents and young adults is personality ([29, 30]; see [31, 32] for negative findings, however). To date, there have been no studies examining the influence of personality on IGT performance among older adults, and we seek to fill this gap.

Personality traits are routinely interpreted as being a part of five overarching broad factors, commonly referred to as the Five-Factor Model of Personality (FFMP; [33–35]). The FFMP involves the affect-relevant domains of neuroticism, extraversion, openness, agreeableness, and conscientiousness, which are believed to be relatively stable over the life span (see [36], for a meta-analysis of the stability of personality traits). Individuals with high trait neuroticism are prone to experience negative affective states such as fear, anxiety, sadness, embarrassment, anger, guilt, and disgust. Those who report low levels of neuroticism tend to be emotionally stable, do not become preoccupied with minor perturbances, and feel self-assured [37]. Individuals with high trait extraversion are sociable, socially dominant, optimistic, assertive, and energetic [34, 37, 38]. Extraversion is also associated with sensation seeking and may be reflective of an underlying approach-oriented motivational system (Behavioral Activation System; [39, 40]). Individuals with high trait openness have a mental and experiential life that can be described as creative, original, and complex. Such individuals are likely to be accepting of experimentation and more tolerant of conditions of ambiguity [35]. Individuals with high trait agreeableness are prosocial, altruistic, tender-minded, trustful, and modest, while those who are disagreeable are generally self-interested and tough-minded. Finally, individuals with high trait conscientiousness think before they act, delay gratification, follow norms and rules, and plan, organize, and prioritize tasks, whereas individuals low in conscientiousness may possess a more carefree orientation, be less punctual, and are less able to inhibit impulses and tend not to consider consequences [41, 42].

Our objective in the present study was to extend our work with the IGT and to investigate specifically how the influence of individual differences in personality traits is associated with decision-making performance in older adults. For the sake of being comprehensive, we also included a cohort of younger adults, as this allows us to compare older and younger cohorts and to determine whether we can replicate IGT–personality associations in younger participants, e.g., such as those previously reported by Crone et al. [29] and Suhr and Tsanadis [30]. One hundred and fifty-two healthy cognitively intact adults (aged 26 to 85) were individually administered the IGT and the NEO Five-Factor Inventory (NEO-FFI), a widely used self-report instrument to assess the FFMP traits [41]. We propose that studying the personality correlates of decision making will help both clinicians and researchers gain insight into how younger and older individuals make prospective decisions, and such data may ultimately provide ways to convey information to help individuals make well-informed medical and health decisions.

Method

Participants

One hundred and fifty-two healthy adults participated, forming two age groups. (We chose to create age groups, as well as use age as a continuous variable, depending on the demands of the particular statistical analysis.) Participants were referred to as younger adults if they were less than or equal to 64 years of age. This resulted in a younger adult group of 73 participants, with a median age of 49.0 years (range [26–64]), a mean education of 15.89 years ($SD=2.00$; range [12–20]), and 63% females. Similarly, participants aged 65 and older were referred to as older adults. This resulted in an older adult group of 79 participants, with a median age of 73 years (range [65–85]), a mean education of 15.81 years ($SD=2.63$; range [11–20]), and 63% females. There were no differences between younger and older groups on the demographic variables of education, $t(150)=0.21$, $p>0.05$, gender distribution ($\chi^2=0.000$, $p>0.05$), or level of affective symptomatology (Beck Depression Inventory II; [43]), $M_{\text{younger}}=3.78$, $SD=4.05$; $M_{\text{older}}=4.69$, $SD=4.37$, $t(150)=-1.24$, $p>0.05$. Using a method described previously [44], a structured interview screening procedure determined that all persons enrolled in the study were neurologically healthy and free of significant psychiatric disease. Demographic and cognitive characteristics of the sample are provided in Table 1.

Measures

The Iowa Gambling Task [19, 22, 28]—The computerized IGT consists of four decks of cards, referred to as A, B, C, and D, shown on a large monitor. With a computer mouse, the participant makes card selections one at a time (100 selections in total, but this number is unknown to the participant). With some card selections, participants win money, but with other card selections the wins are followed by monetary losses. More specifically, two of the decks provide large monetary gains and even larger losses (“bad” decks), while the other two decks lead to small gains and even smaller losses (“good” decks). Strong performers learn to choose cards primarily from the “good” decks. As is conventionally done, a learning profile during the IGT can be discerned from an examination of the card selections in blocks of 20 cards across the 100 card choices (block 1, cards 1–20; block 2, cards 21–40... Block 5, cards 81–100).

NEO Five-Factor Inventory Form S [41]—The NEO-FFI is a brief (60-item) self-report version of the larger (240-item) NEO Personality Inventory Revised (NEO PI-R; [41]), comprised of scales that represent each of the FFMP traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness). For each item, presented in the form of a statement, the participant was asked to rate their response on a five-point Likert scale ranging from strongly disagree [1] to strongly agree [5] (with neutral corresponding to “3” on the scale). The NEOFFI has been shown to possess strong psychometric properties [41]. Independent samples t tests were conducted to test for any mean level differences on the FFMP scales between the younger and older groups. There were no significant mean level differences between the two age groups on any of the NEO scales (see Table 2).

Neuropsychological Tasks [45]—All participants were administered a brief battery of neuropsychological tasks to ensure that their mental abilities were within expectations and

could thus be considered cognitively intact. Specifically, participants were administered the Mini-Mental Status Examination (MMSE) [46], a cognitive screening instrument; the Reading subtest of the Wide Range Achievement Test Third Edition [47], a measure of single-word decoding; the Wechsler Abbreviated Scale of Intelligence [48], a four-subtest measure of intellectual functioning; the Digit Span subtest of the Wechsler Adult Intelligence Scale Third Edition, a measure of attentional ability [49]; and the Beck Depression Inventory Second Edition [43], a self-report measure of mood.

Procedure

Participants were tested individually in a quiet and comfortable laboratory room. The present tasks took approximately 1 h to complete and were a part of a multivisit larger project investigating the neuroscientific correlates of decision making among older adults. All participants were financially compensated for their involvement.

Data Analysis

For the IGT, the primary dependent variable was quantified by dividing the 100 trials into five discrete blocks of 20 selections each and then, for each trial block, calculating the number of cards selected from the good decks, and the number selected from the bad decks. For each participant and for each trial block, we calculated a performance score by subtracting the number of bad deck picks from the number of good deck picks. For some statistical analyses, these trial block scores were summated to create a cumulative IGT performance variable. Scores below zero indicate “disadvantageous” performance (a net loss of money), and scores greater than zero indicate “advantageous” performance (a net gain of money). For the NEO-FFI, the primary dependent variables were the (1) total score for the neuroticism scale (12 items); (2) total score for the extraversion scale (12 items); (3) total score for the openness scale (12 items); (4) total score for the agreeableness scale (12 items); and (5) total score for the conscientiousness scale (12 items). We conducted several analyses, involving independent-sample *t* tests, two-tailed Pearson correlations, and hierarchical regression.

Results

Addressing first the background demographic and cognitive variables, we contrasted the younger and older participants using either independent-sample *t* tests or chi-squared tests. The outcomes are presented in Table 1. The data indicated similarity between the two groups on all variables, with the exception of the MMSE. More specifically, there were no differences in education, gender and handedness distribution, emotional status (Beck Depression Inventory; [43]), reading ability (Wide Range Achievement Test Revision 3 reading subtest; [47]), overall intelligence (Wechsler Abbreviated Scale of Intelligence Full-Scale Intelligent Quotient; [48]), or attention skills (Wechsler Adult Intelligence Scale Third Edition digit span; [49]). Although the two groups differed statistically with regard to brief mental status testing (MMSE; [46]), examination of the mean score for each group indicated that the differences were of no practical significance ($M_{\text{younger}}=29.5\pm0.9$ and $M_{\text{older}}=29.1\pm0.9$). In addition, the median MMSE performance among the older group was 29 (out of 30), and the lowest MMSE performance was 27, which is considered to be within normal

expectations [50]. Thus, we concluded that the younger and older groups were exceptionally well matched with regard to present-day intellectual abilities and, further, that all participants' scores on our neuropsychological tasks were within normal limits.

As expected, we found that age was negatively associated with IGT performance, $r=-0.22$, $p<0.01$. Younger adults performed better on the IGT, $M=23.29$, than older adults, $M=5.35$, $t(150)=2.96$, $p<0.01$. Estimates of effect size indicated that this difference was moderately strong (Cohen's $d=0.48$), according to Cohen [51, 52]. Gender was also predictive of IGT performance. Overall, women performed worse on the IGT than men, $M=8.04$ and 24.13 , respectively, $t(150)=2.54$, $p=0.01$, $d=0.43$. Additionally, years of education were positively associated with IGT performance, $r=0.27$, $p<0.01$.

Correlations between the FFMP traits, as measured by the NEO-FFI, and performance on the IGT as a function of age group are presented in Table 3. While we did not observe any age-related differences for the association between four of the five NEO factors, we found a striking disparity when comparing the IGT-NEO neuroticism correlations of the two groups. For the older group, we found moderately high correlations between neuroticism and IGT in terms of overall performance. Notably, these correlations became stronger as the IGT progressed, suggesting that elevated neuroticism scores were associated with a failure to shift their card selections toward the good decks with advantageous outcomes, even at a late stage of the task. By contrast, for the younger group, the neuroticism-IGT correlations were near zero. Using an $r-z$ transformation and a subsequent z test, statistical analysis revealed that the overall difference for the neuroticism-IGT correlation between groups was statistically significant, $z=3.01$, $p<0.01$.

The goal of the current study was to determine whether individual differences in the FFMP traits would account for a significant proportion of variance beyond that of demographic variables such as age, gender, and education. Hierarchical regressions were used to test this. Variables were mean-centered to minimize multicollinearity [53]. The demographic variables of age, gender, and education were entered first. In the second step, we entered all the NEO scales (i.e., neuroticism, extraversion, openness, agreeableness, and conscientiousness). Lastly, we tested whether the age $\times$ trait interactions would significantly contribute to explaining the variability in IGT performance. Nonsignificant higher-order interactions were trimmed and the model was rerun. We report the results of this analysis in Table 4.

As shown, the final model yielded several independent predictors which made significant contributions to explaining the variance in IGT performance. Of the demographic variables, both the participant's age and education level made unique contributions to explaining the variance. Age was negatively associated with IGT performance, whereas years of education were positively associated with performance.

Consistent with the correlational analyses, extraversion, openness, agreeableness, and conscientiousness did not significantly contribute to explaining the variance in IGT performance. Only neuroticism accounted for a significant proportion of variance in IGT performance. Specifically, neuroticism was associated with poorer performance on the IGT.

The main effect for neuroticism, however, needs to be interpreted within the context of a significant age $\times$ neuroticism interaction. This interaction made a significant independent contribution to the variance in overall IGT performance ($R^2=0.20$) beyond that of both the demographic variables and all NEO trait scales. For the sake of ease in visual appreciation of the data, we performed a median split on neuroticism, so that we could create four groups: younger adult–low neuroticism; younger adult high neuroticism; older adult low neuroticism; and older adult high neuroticism. Figure 1 depicts IGT performance as a function of age and neuroticism, for each of these four groups. We observed a strong pattern in which older adults who reported high levels of neuroticism performed poorly on the IGT. More specifically, although these individuals made similar selections to other participants in the early stages of the IGT, they failed to switch from the bad decks to the good ones as the task progressed. By comparison, both older adults who reported low neuroticism and younger adults (regardless of NEO neuroticism score) performed comparably in their ability to make advantageous decisions on the IGT.

Discussion

Are individual differences in personality associated with decision making in older adults? Our research demonstrates that this question can be answered in the affirmative. Specifically, the current study revealed that individual differences in neuroticism predicted prospective decision making in older adults, such that higher neuroticism was associated with poorer decision-making performance. Our findings may help to explain why some older adults retain their decision-making abilities while others demonstrate drastic declines, in the context of normal aging. A straightforward interpretation is that, in life span terms, older adults have had a longer period of time to encounter and accrue the potential negative psychological effects associated with neuroticism, such as chronic stress and higher incidence rates of depression and other psychopathological conditions (e.g., [54]). Also, older adults may be at greater risk than their younger counterparts to suffer the deleterious behavioral, cognitive, and/or physiological consequences that are believed to arise from chronic stress related to neuroticism, which would be consistent with our finding that, in younger participants, high neuroticism was not related to poor IGT performance.

Neuroticism has been associated with heightened stress responses to daily stressors [55–57]. In fact, individuals who report high levels of neuroticism show elevated levels of salivary cortisol, among numerous other physiological changes [58–60]. Relevant to the present study, heightened stress responses over time have been implicated in impairments of cognition (see [61], for a review), involving decision making [62], problem solving [63], inductive reasoning [64], and memory [65, 66] deficits.

Glucocorticoids (e.g., as indexed by cortisol in humans) may have particular relevance to this association between stress and cognitive dysfunction in the elderly. Importantly, these hormones cross the blood–brain barrier with relative ease, accessing the brain where they bind to glucocorticoid receptors in the hippocampus and frontal lobe [61]. Because the risk of vascular insults increases with age (given the higher incidence of hypertension, for example), the blood–brain barrier of an older adult may be particularly permeable [67, 68], thereby increasing the likelihood of stress affecting neural integrity and thus cognition.

A lifetime of heightened stress responses could potentially damage the brain [69], specifically the prefrontal cortex [70, 71]. Higher levels of neuroticism may be associated with adverse changes in the underlying neural systems that subserve decision making, involving the VMPC, dorsolateral sector of the prefrontal cortex, insula, and right hemisphere somatosensory cortices (see Damasio [72] for a review of the neural basis of decision making). For instance, Wright et al. [73] investigated morphologic brain changes among older adults and found that reduced cortical thickness in the region of the right superior and inferior frontal cortices, as well as the right anterior temporal cortex, was negatively associated with measures of neuroticism, as measured by the NEO-FFI. In another study, Knutson et al. [74] found that individuals who reported high levels of neuroticism and negative affect were observed to have a lower brain volume. Such findings, of course, should be considered preliminary, but it makes neurobiological sense that chronic stress over long periods of time could adversely affect neural structure and function.

As noted earlier, we were also interested in whether we could replicate previous research investigating broad personality traits and IGT performance in younger adults. In two large samples, both Casillas [31] and Weller [32] found no evidence that broad level measures of neuroticism (i.e., negative temperament as measured by the Schedule for Nonadaptive and Adaptive Personality [75] and neuroticism as measured by the Big Five Inventory [76]) significantly predicted IGT performance. However, a recent study found that state negative affect was associated with disadvantageous IGT performance among a sample of 87 college students [30]. We would note, however, that in our study we are referring to dispositional sources of affect (i.e., traits), whereas Suhr and Tsanadis [30] utilized state affect, which is, by definition, more intense and could therefore produce greater interference with cognition, at least temporarily. Thus, the state versus trait distinction may account for the difference in findings of the Suhr and Tsanadis [30] study relative to our data.

A limitation of our study was the use of the NEO-FFI rather than NEO PI-R, inasmuch as the latter questionnaire would have provided a more fine-grained analysis of the five-factor model of personality. In particular, it would be useful to investigate lower-order personality traits associated with neuroticism, such as impulsiveness and vulnerability to stress [41], in relation to decision-making ability. Such a study is currently underway. Also, the modest size of the present sample may have limited our ability to detect small effects.

Our study was not designed to test any anatomical hypotheses. Nevertheless, it is tempting to speculate that, among the older adults with higher NEO-FFI neuroticism ratings, disproportionate anatomic changes in ventromedial prefrontal brain structures would be apparent, leading to the suboptimal performance on the IGT. Addressing this question would be an obvious future direction for research. Moreover, studies directly linking chronic stress, measured by using both behavioral and neuroendocrinal methods, with decision making in older adults would serve to more clearly address the relationships among aging, chronic stress, and cognition.

To summarize, our data indicated that older adults with relatively high levels of trait neuroticism evidence impairments on an ecologically valid laboratory decision-making task. Our results suggest that neuroticism may be a specific vulnerability factor which may signal

a greater likelihood of age-related neurocognitive decline. Practically speaking, given that individuals with high trait neuroticism display heightened symptom perception (e.g., [77]) and are more likely to rate their health symptomatology as more severe [57] than their counterparts with relatively low neuroticism, older neurotics may find themselves making more frequent medical decisions. In turn, this may cascade into more frequent instances of poorer long-term prospective decisions. If this is the case, the use of pharmacologic and behavioral interventions to reduce stress and negative affect may not only serve to preserve decision-making capabilities but may also decrease the number of individuals on conservatorship by family or public guardians, thereby reducing judicial and governmental costs.

Acknowledgments

Preparation of this article was supported by a National Institute on Aging Career Development Award to Natalie L. Denburg (K01 AG022033), by fellowship funding from the Iowa Scottish Rite Masonic Foundation, and by an Agency for Healthcare Research and Quality (AHRQ) Centers for Education and Research on Therapeutics cooperative agreement #5 U18 HSO16094.

References

1. Karlamangla A, Tinetti M, Guralnik J, Studenski S, Wetle T, Reuben D. Comorbidity in older adults: Nosology of impairment, diseases, and conditions. *J Gerontol Biol Sci Med Sci*. 2007; 62:296–300.
2. Yancik R, Ershler W, Satariano W, Hazzard W, Cohen HJ, Ferrucci L. Report of the national institute on aging task force on comorbidity. *J Gerontol Biol Sci Med Sci*. 2007; 62:275–280.
3. West R. An application of prefrontal cortex function theory of cognitive aging. *Psychol Bull*. 1996; 120:272–292. [PubMed: 8831298]
4. Haaland KY, Price L, LaRue A. What does the WMS-III tell us about memory changes with normal aging. *J Int Neuropsychol Soc*. 2003; 9:89–96. [PubMed: 12570362]
5. Moscovitch, M.; Winocur, G. The neuropsychology of memory and aging. In: Craik, FIM.; Salthouse, TA., editors. *The Handbook of Aging and Cognition*. Hillsdale: Lawrence Erlbaum; 1992. p. 315–372.
6. Robbins TW, James M, Owen AM, et al. A study of performance on tests from the CANTAB battery sensitive to frontal lobe dysfunction in a large sample of normal volunteers: Implications for theories of executive functioning and cognitive aging. *J Int Neuropsychol Soc*. 1998; 4:474–490. [PubMed: 9745237]
7. West RL, Murphy KJ, Armilio ML, Craik FIM, Stuss D. Lapses in attention and performance variability reveal age-related increases in fluctuations in executive control. *Brain Cogn*. 2002; 49:402–419. [PubMed: 12139961]
8. Jernigan TL, Archibald SL, Fennema-Notestine C, et al. Effects of age on tissues and regions of the cerebrum and cerebellum. *Neurobiol Aging*. 2001; 22:581–594. [PubMed: 11445259]
9. Raz N, Lindenberger U, Rodrigue K, et al. Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cereb Cortex*. 2005; 15:1676–1689. [PubMed: 15703252]
10. Resnick SM, Pham DL, Kraut MA, Zonderman AB, Davatzikos C. Longitudinal magnetic resonance imaging studies of older adults: A shrinking brain. *J Neurosci*. 2003; 23:3295–3301. [PubMed: 12716936]
11. Salat DH, Kaye JA, Janowsky JS. Selective preservation and degeneration within the prefrontal cortex in aging and Alzheimer's disease. *Arch Neurol*. 2001; 58:1403–1408. [PubMed: 11559311]
12. Gur RC, Gur RE, Orbist WD, Skolnick BE, Reivich M. Age and regional cerebral blood flow at rest and during cognitive activity. *Arch Gen Psychiatry*. 1987; 44:617–621. [PubMed: 3606327]

13. Melamed E, Lavy S, Shlomo B, Cooper G, Rinot Y. Reduction in regional cerebral blood flow during normal aging in man. *Stroke*. 1980; 11:31–34. [PubMed: 7355426]
14. Meyer BJF, Russo C, Talbot A. Discourse processing and problem solving: Decisions about the treatment of breast cancer by women across the life span. *Psychol Aging*. 1995; 10:84–103. [PubMed: 7779321]
15. Zwahr MD, Park DC, Shifren K. Judgments about estrogen replacement therapy: The role of age, cognitive abilities, and beliefs. *Psychol Aging*. 1999; 14:179–191. [PubMed: 10403707]
16. Meyer BJF, Talbot AP, Ranalli C. Why older adults make more immediate treatment decisions about cancer than younger adults. *Psychol Aging*. 2007; 22:505–524. [PubMed: 17874951]
17. Leventhal EA, Leventhal H, Schaefer P, Easterling D. Conservation of energy, uncertainty reduction, and swift utilization of medical care among the elderly. *J Gerontol Psychol Sci*. 1993; 48:78–86.
18. Leventhal EA, Easterling D, Leventhal H, Cameron L. Conservation of energy, uncertainty reduction, and swift utilization of medical care among the elderly: Study II. *Med Care*. 1995; 33:988–1000. [PubMed: 7475405]
19. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*. 1994; 50:7–15. [PubMed: 8039375]
20. Dunn BD, Dalgleish T, Lawrence AD. The somatic marker hypothesis: A critical evaluation. *Neurosci Biobehav Rev*. 2006; 30:239–271. [PubMed: 16197997]
21. Yechiam E, Busemeyer JR, Stout JC, Bechara A. Using cognitive models to map relations between neuropsychological disorders and human decision making deficits. *Psychol Sci*. 2006; 16:973–978. [PubMed: 16313662]
22. Bechara, A. Iowa Gambling Task (IGT) Professional Manual. Lutz: Psychological Assessment Resources; 2007.
23. Denburg NL, Cole CA, Hernandez M, et al. The orbitofrontal cortex, real-world decision-making, and normal aging. *Ann N Y Acad Sci*. 2007; 1121:480–498. [PubMed: 17872394]
24. Denburg NL, Recknor EC, Bechara A, Tranel D. Psychophysiological anticipation of positive outcomes promotes advantageous decision-making in normal older persons. *Int J Psychophysiol*. 2006; 61:19–25. [PubMed: 16426691]
25. Denburg NL, Tranel D, Bechara A. The ability to decide advantageously declines prematurely in some normal older persons. *Neuropsychologia*. 2005; 43:1099–1106. [PubMed: 15769495]
26. Fein G, McGillivray S, Finn P. Older adults make less advantageous decisions than younger adults: Cognitive and psychological correlates. *J Int Neuropsychol Soc*. 2007; 13:480–489. [PubMed: 17445297]
27. MacPherson SE, Phillips LH, Della Sala S. Age, executive function, and social decision making: A dorsolateral prefrontal theory of cognitive aging. *Psychol Aging*. 2002; 17:598–609. [PubMed: 12507357]
28. Bechara A, Tranel D, Damasio H. Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain*. 2000; 123:2189–2202. [PubMed: 11050020]
29. Crone EA, Vendel I, van der Molen MW. Decision-making in disinhibited adolescents and adults: Insensitivity to future consequences or driven by immediate reward? *Pers Individ Differ*. 2003; 35:1625–1641.
30. Suhr JA, Tsanadis J. Affect and personality correlates of the Iowa Gambling Task. *Pers Individ Differ*. 2007; 43:27–36.
31. Casillas A. Personality and neuropsychological correlates of impulsivity (Doctoral dissertation, University of Iowa). *Diss Abstr Int*. 2005; 66:4476.
32. Weller, JA. Unpublished doctoral dissertation. University of Iowa; 2007. The role of affect in decisions under varying levels of uncertainty: Converging evidence from neurological and temperament perspectives.
33. Digman JM. Personality structure: Emergence of the five-factor model. *Annu Rev Psychol*. 1990; 41:417–440.
34. McCrae RR, Costa PT. Validation of a five-factor model of personality across instruments and observers. *J Pers Soc Psychol*. 1987; 52:81–90. [PubMed: 3820081]

35. McCrae, RR.; Costa, PT. *Personality in Adulthood*. New York: Guilford; 1990.
36. Roberts BW, Walton KE, Viechtbauer W. Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychol Bull.* 2006; 132:1–25. [PubMed: 16435954]
37. Tellegen, A. Structures of mood and personality and their relevance to assessing anxiety, with an emphasis on self-report. In: Tuma, AH.; Maser, JD., editors. *Anxiety and the Anxiety Disorders*. Hillsdale: Erlbaum; 1985. p. 681-706.
38. Eysenck, HJ.; Eysenck, SBG. *Manual of the Eysenck Personality Inventory*. San Diego: Educational and Industrial Testing Service; 1975.
39. Carver CS, White TL. Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *J Pers Soc Psychol.* 1994; 67:319–333.
40. Gray JA. The psychophysiological basis of introversion–extraversion. *Behav Res Ther.* 1970; 8:249–266. [PubMed: 5470377]
41. Costa, P.; McCrae, R. *Revised NEO Personality Inventory-Revised (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI) Professional Manual*. Lutz: Psychological Assessment Resources; 1992.
42. Lee K, Ashton MC. Further assessment of the HEXACO personality inventory: Two new facet scales and an observer report form. *Psychol Assess.* 2006; 18:182–191. [PubMed: 16768594]
43. Beck, AT.; Steer, RA.; Brown, GK. *Beck Depression Inventory Manual*. 2. San Antonio: Psychological Corporation; 1996.
44. Tranel D, Benton A, Olson K. A 10-year longitudinal study of cognitive changes in elderly persons. *Dev Neuropsychol.* 1997; 13:87–96.
45. Tranel, D. Theories of clinical neuropsychology and brain-behavior relationships: Luria and beyond. In: Morgan, JE.; Ricker, JH., editors. *Textbook of Clinical Neuropsychology*. New York: Taylor and Francis; 2007. p. 27-39.
46. Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”: A practical method for grading the mental state of patients for the clinician. *J Psychiatr Res.* 1993; 12:189–198. [PubMed: 1202204]
47. Wilkinson, GS. *Wide Range Achievement Test-3*. Wilmington: Jastak; 1993.
48. Wechsler, DA. *Wechsler Abbreviated Scale of Intelligence*. New York: Psychological Corporation; 1999.
49. Wechsler, DA. *Wechsler Adult Intelligence Scale-III*. New York: Psychological Corporation; 1997.
50. Crum RM, Anthony JC, Bassett SS, Folstein MF. Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA.* 1993; 12:2386–2391. [PubMed: 8479064]
51. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*. 2. Hillsdale: Erlbaum; 1988.
52. Cohen J. A power primer. *Psychol Bull.* 1992; 112:155–159. [PubMed: 19565683]
53. Aiken, LS.; West, SG. *Multiple Regression Test and Interpreting Interactions*. Thousand Oaks: Sage; 1991.
54. Clark LA, Watson D, Mineka S. Temperament, personality, and the mood and anxiety disorders. *J Abnorm Psychol.* 1994; 103:103–116. [PubMed: 8040472]
55. Bolger N, Shilling EA. Personality and the problems of everyday life: The role of neuroticism in exposure and reactivity to daily stressors. *J Pers.* 1991; 59:355–386. [PubMed: 1960637]
56. Mrozek DK, Almeida DM. The effect of daily stress, personality, and age on daily negative affect. *J Pers.* 2004; 72:355–378. [PubMed: 15016068]
57. Watson D, Pennebaker J. Health complaints, stress, and distress: Exploring the central role of negative affectivity. *Psychol Rev.* 1989; 96:234–254. [PubMed: 2710874]
58. Jacobs N, Germeyns I, Derom C, Delespaul P, van Os J, Nicolson N. A momentary assessment study of the relationship between affective and adrenocortical stress responses in daily life. *Biol Psychol.* 2007; 74:60–66. [PubMed: 16942831]
59. Miller GE, Cohen S, Rabin BS, Skoner DP, Doyle WJ. Personality and tonic cardiovascular, neuroendocrine, and immune parameters. *Brain Behav Immun.* 1999; 13:109–123. [PubMed: 10373276]

60. van Eck MM, Berkhof H, Nicolson N, Sulon J. The effects of perceived stress, traits, mood states and stressful daily events on salivary cortisol. *Psychosom Med*. 1996; 58:447–458. [PubMed: 8902896]
61. Lupien SJ, Maheu F, Tu M, Fiocco A, Schramek TE. The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain Cogn*. 2007; 65:209–237. [PubMed: 17466428]
62. Baradell JG, Klein K. Relationship of life stress and body consciousness to hypervigilant decision making. *J Pers Soc Psychol*. 1993; 64:267–273.
63. Klein K, Boals A. The relationship of life event stress and working memory capacity. *Appl Cogn Psychol*. 2001; 15:565–579.
64. Yee PL, Edmonson B, Santoro KE, Begg AE, Hunter CD. Cognitive effects of life stress and learned helplessness. *Anxiety Stress Coping*. 1996; 9:301–319. [PubMed: 21892848]
65. Neupert SD, Almeida DM, Mroczek DK, Spiro A. Daily stressors and memory failures in a naturalistic setting: Findings from the VA normative aging study. *Psychol Aging*. 2006; 21:424–429. [PubMed: 16768588]
66. Sliwinski MJ, Smyth JM, Hofer SM, Stawski RS. Intraindividual coupling of daily stress and cognition. *Psychol Aging*. 2006; 21:545–557. [PubMed: 16953716]
67. Mooradian AD. Effect of ageing on the blood–brain barrier. *Neurobiol Aging*. 1988; 9:31–39. [PubMed: 3288893]
68. Wardlaw JM, Sandercock PAG, Dennis MS, Starr J. Is breakdown of the blood–brain barrier responsible for lacunar stroke, leukoaraiosis, and dementia? *Stroke*. 2003; 34:806–812. [PubMed: 12624314]
69. Lupien SJ, de Leon M, de Santi S, et al. Cortisol levels during human aging predict hippocampal atrophy and memory deficits. *Nat Neurosci*. 1998; 1:69–73. [PubMed: 10195112]
70. Sapolsky RM, Krey LC, McEwen BS. The neuroendocrinology of stress and aging; The glucocorticoid cascade hypothesis. *Endocr Rev*. 1986; 7:284–301. [PubMed: 3527687]
71. Wolf OT, Convit A, de Leon MJ, Caraos C, Qadri SF. Basal hypothalamo–pituitary–adrenal axis activity and corticotrophin feedback in young and older men: Relationships to magnetic resonance imaging-derived hippocampus and cingulate gyrus volumes. *Neuroendocrinology*. 2002; 75:241–249. [PubMed: 11979054]
72. Damasio, AR. *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Grosset/ Putnam; 1994.
73. Wright CI, Feczko E, Dickerson B, Williams D. Neuroanatomical correlates of personality in the elderly. *Neuroimage*. 2007; 35:263–272. [PubMed: 17229578]
74. Knutson B, Momenan R, Rawlings R, Fong GW, Hommer D. Negative association of neuroticism with brain volume ratio in healthy humans. *Biol Psychiatry*. 2001; 50:685–690. [PubMed: 11704075]
75. Clark, LA. *Schedule for Nonadaptive and Adaptive Personality: Manual for Administration, Scoring, and Interpretation*. Minneapolis: University of Minnesota Press; 1993.
76. John, OP.; Srivastava, S. The big five trait taxonomy: History, measurement, and theoretical perspectives. In: Pervin, LA.; John, OP., editors. *Handbook of Personality: Theory and Research*. 2. New York: Guilford; 1999. p. 102-138.
77. Williams PG, Wiebe DJ. Individual differences in self-assessed health: Gender, neuroticism and physical symptom reports. *Pers Individ Differ*. 2000; 28:823–835.

Fig. 1.

Decision-making performance on the IGT (good/advantageous deck selections) for younger and older participants, grouped into low neuroticism and high neuroticism, and graphed as a function of trial block

Table 1

Demographic and cognitive characteristics of younger and older participants

Characteristic ^a	Statistic ^b	Participant group		<i>p</i> ^c
		Younger (<i>n</i> =73)	Older (<i>n</i> =79)	
Age	<i>M</i>	48.6	74.0	<i>p</i> <0.0001
	SD	11.9	5.6	
Education	<i>M</i>	15.8	15.8	ns
	SD	2.0	2.6	
Gender	% female	63%	63%	ns
Handedness	% RH	84%	87%	ns
BDI-II	<i>M</i>	3.8	4.7	ns
	SD	4.1	4.4	
MMSE	<i>M</i>	29.5	29.1	<i>p</i> <0.05
	SD	0.9	0.9	
WRAT-3 reading	<i>M</i>	51.1	50.9	ns
	SD	3.5	4.0	
WASI FS IQ	<i>M</i>	114.7	118.1	ns
	SD	10.8	11.6	
WAIS-III digit span	<i>M</i>	18.3	17.4	ns
	SD	4.4	4.2	

ns nonsignificant

^a Shown are age, education, sex (percentage of female), and handedness (percentage of right-handed). Raw scores are provided for each of the cognitive variables, with the exception of those noted. Shown are Beck Depression Inventory II (BDI); Mini-Mental State Exam (MMSE); Wide Range Achievement Test Revision 3 (WRAT-3) reading subtest; Wechsler Abbreviated Scale of Intelligence (WASI) Full-Scale (FS) Intelligent Quotient (IQ) in standard scores; and Wechsler Adult Intelligence Scale Third Edition (WAIS-III) digit span

^b Means and standard deviations are given for each variable unless otherwise indicated

^c Post hoc comparisons were computed using independent-sample *t* test, or chi-square test where appropriate

Table 2

Comparison of mean-level differences in the FFMP traits between younger and older adults

NEO scale	Younger adults	Older adults	<i>t</i>
Neuroticism	15.52 (7.15)	13.96 (7.39)	1.31
Extraversion	28.70 (6.58)	30.27 (5.84)	-1.50
Openness	28.97 (7.00)	28.27 (6.63)	0.60
Agreeableness	29.36 (4.00)	29.11 (4.35)	0.34
Conscientiousness	35.01 (6.27)	35.34 (5.97)	-0.30

N=73 for younger adults; *N*=79 for older adults

Table 3

Correlations between IGT and NEO scales for younger and older adults

Personality variable	IGT trial block					
	IGT perform	1	2	3	4	5
Younger adults						
Neuroticism	-0.05	0.01	-0.05	-0.03	-0.18	-0.01
Extraversion	-0.11	0.00	-0.07	-0.02	-0.07	-0.11
Openness	0.06	0.14	0.01	0.13	0.08	-0.03
Agreeableness	-0.08	-0.16	0.06	-0.04	-0.16	-0.13
Conscientiousness	0.00	0.01	-0.01	-0.12	0.04	-0.03
Older adults						
Neuroticism	-0.50**	-0.01	-0.18	-0.36**	-0.47**	-0.50**
Extraversion	0.00	0.07	-0.05	-0.12	0.01	-0.01
Openness	-0.01	-0.04	-0.10	-0.02	0.07	0.09
Agreeableness	0.10	-0.24*	0.20	0.03	0.14	0.04
Conscientiousness	0.18	0.18	-0.03	0.10	0.13	0.18

N=73 for younger adults; N=79 for older adults

*
 $p < 0.05$ **
 $p < 0.01$

Table 4

Hierarchical regression analysis testing the unique predictive power of interaction effects between neuroticism and age in explaining IGT performance

	β		
	Step 1	Step 2	Step 3
Demographic variables			
Age	-0.22**	-0.27**	0.19
Gender (0=male, 1=female)	-0.12	-0.09	-0.11
Education	0.23**	0.20*	0.18*
NEO trait scales			
Neuroticism		-0.32**	-0.30**
Extraversion		-0.15	-0.15
Openness		0.08	0.08
Agreeableness		0.01	-0.01
Conscientiousness		-0.04	-0.03
Age $\times$ trait interaction			
Age $\times$ neuroticism			-0.20**
<i>R</i>	0.37	0.47	0.51
<i>R</i> ²	0.13	0.22	0.26
<i>R</i> ²		0.09**	0.04**

N=152. *R*² values presented in italics

* *p*<0.05.

** *p*<0.01