Journal of Research in Personality 42 (2008) 1646–1650

Contents lists available at ScienceDirect

Journal of Research in Personality

journal homepage: www.elsevier.com/locate/jrp

Brief Report

Delay discounting: Interactions between personality and cognitive ability

Jacob B. Hirsh [a,*], Dominique Morisano [b], Jordan B. Peterson [a]

[a] Department of Psychology, University of Toronto, 100 St. George Street, Toronto, Ont., Canada M5S 3G3
[b] Department of Educational and Counselling Psychology, McGill University, 3700 McTavish Street, Montreal, Que., Canada H3A 1Y2

ARTICLE INFO

Article history:
Available online 26 July 2008

Keywords:
Personality
Delay discounting
Big Five
Decision making
Delay of gratification

ABSTRACT

Delay discounting describes the extent to which the value of a reward decreases as the delay to obtaining that reward increases. Lower discounting rates predict better outcomes in social, academic, and health domains. The current study investigates how personality and cognitive ability interact to predict individual differences in delay discounting. Extraversion was found to predict higher discounting rates at the low end of the cognitive distribution, while emotional stability was found to predict lower discounting rates at the high end of the cognitive distribution. These findings support recent models of discounting behavior and suggest that personality and cognitive ability interact in shaping decision making.

1. Introduction

Pitting the demands of long-term goals against short-term desires is among the most difficult tasks in human decision making. The temptations that emerge from one's immediate surroundings can often conflict with the requirements of longer-range plans. Reaching long-term goals requires the ability to modulate the desire for immediate gratification. As might be expected, the choice of larger future rewards over smaller immediate rewards is associated with many positive life outcomes, including better academic performance, healthier relationships, and improved social functioning. Individuals who tend to choose smaller but more immediate rewards are characterized by impulsive stimulus-driven behaviors that can interfere with long-term goal pursuits (Mischel, Shoda, & Rodriguez, 1989). It is important to note, however, that the benefits of delayed gratification accrue primarily to those in stable environments; investing in the future only makes sense when the future is relatively predictable.

In economic models, delay of gratification is discussed in terms of the related concept of temporal discounting, also termed "delay discounting" or "future discounting" (see Frederick, Loewenstein, & O'Donoghue, 2002, for a review). These models state that the value of a given reward decreases as the delay to receiving the reward increases. All other things being equal, receiving $50 today is valued more than the promise of getting $50 next year. Money received in the present can be immediately invested or enjoyed, whereas there is always some degree of uncertainty as to whether future rewards will be delivered. The rate at which a reward's value changes, depending on its arrival time, is known as the rate of temporal discounting (formalized as k). Individuals with higher discounting rates will experience a greater reduction in the subjective value of a reward as the delay toward reaching it increases. These individuals are thus more likely to prefer smaller and more immediate rewards to larger delayed ones.

In psychology, discounting behavior has been studied most often within a clinical context, due to its associations with addictive behavior. Higher rates of discounting have been found among cocaine and heroin users, alcoholics, pathological gamblers, and cigarette smokers (Bickel & Marsch, 2001). In each of these cases, the rate of discounting is especially high

* Corresponding author. Fax: +1 416 978 4811.
E-mail address: jacob.hirsh@utoronto.ca (J.B. Hirsh).

0092-6566/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.jrp.2008.07.005

for addiction-related rewards (e.g., cigarettes or alcohol). Neuropsychological models of addiction suggest that increased discounting after exposure to addiction-related stimuli is due to the activation of powerful dopaminergic incentive-reward circuits in the ventral striatum (Hyman & Malenka, 2001). Once these systems are activated, they effectively take control over goals, perception, and behavior, such that higher cortical processes no longer exert the same degree of influence.

A similar process appears to occur in healthy individuals, although to a lesser extent, as the choice between an immediate or a delayed reward depends upon the relative balance of activity between dopaminergic midbrain reward centers and frontal-parietal cognitive control networks (McClure, Laibson, Loewenstein, & Cohen, 2004). This conflict between "hot" and "cool" processes is mirrored in behavioral models in which the regulation of basic motivational impulses requires a significant amount of top-down cognitive control (Metcalfe & Mischel, 1999). Not surprisingly, individual differences in cognitive ability also relate to delay discounting, with better performance on measures of intelligence and cognitive control predicting reduced discounting rates (Shamosh & Gray, in press). The relationship appears partly mediated by improved anterior prefrontal cortical function in intelligent individuals (Shamosh et al., in press). Individuals who do not have sufficient cognitive resources available during decision-making are thus likely to favor smaller but more immediate rewards. Individuals with greater cognitive ability, in contrast, have an improved capacity for top-down control of basic stimulus-driven motivational systems.

While numerous studies have examined the relationship between cognitive ability and delay discounting, few have examined its relation to personality in a healthy population. The studies that have been done suggest an important role for extraversion (Ostaszewski, 1996), such that more extraverted individuals prefer immediate rewards. Interestingly, extraversion has been linked to the strength of the midbrain dopaminergic incentive reward system, with more extraverted individuals receiving a larger phasic burst of dopamine in response to a potential reward (Depue & Collins, 1999). While cognitive ability appears to index the strength of "cool" cognitive control networks, extraversion appears to reflect the strength of "hot" incentive motivation networks.

Discounting behavior can also be influenced by an individual's current stress levels. Specifically, the release of stress hormones appears to have a disruptive effect on the cognitive control networks of the prefrontal cortex, resulting in more impulsive behavior (McEwan & Sapolsky, 1995; Metcalfe & Mischel, 1999). This type of negative-affect driven impulsivity, sometimes termed "urgency," has been associated with the personality trait of neuroticism (Whiteside & Lynam, 2001). The strong negative emotional reactivity of neurotic individuals potentially reduces their ability to employ cognitive control mechanisms for the purposes of behavioral regulation.

Given that discounting behavior depends on the relative strength of one's cognitive control networks and the emotional salience of the reward, it is reasonable to presume that dispositional factors related to these variables should interact in predicting discounting. The current study examined this possibility by examining how personality and cognitive ability interact to predict delay discounting rates. The strength of the impulse toward an immediate reward should theoretically be a stronger predictor of discounting when fewer cognitive resources are available to regulate behavior. It was thus hypothesized that the extraversion–discounting relationship would be moderated by cognitive ability, such that extraversion would be a stronger predictor of discounting at the low end of the cognitive distribution. Additionally, the ability of stress and anxiety to disrupt higher-order cognitive function suggests that stress-related personality traits might counteract any benefits associated with improved cognitive ability. Accordingly, we expected that emotional stability (reversed neuroticism) would predict lower discounting rates, but only at the higher ends of the cognitive distribution.

2. Methods

2.1. Participants

Participants included 97 undergraduate students from McGill University (66 female), with an age range of 17–27 years ($M = 20.3$, $SD = 1.6$). Students were recruited from introductory-level undergraduate classes and via flyers posted around campus. Recruitment was geared toward students with low- to mid-range cumulative GPAs, in order to capture greater variability in cognitive ability. At the end of testing, participants were remunerated for their time ($80 as part of a larger study). The sample consisted mostly of students from European-Canadian (54.6%) and East-Asian (15.5%) backgrounds.

2.2. Materials

2.2.1. Monetary choice questionnaire

(MCQ; Kirby, Petry, & Bickel, 1999). The MCQ is a self-report questionnaire. Respondents are asked to choose repeatedly between two hypothetical sums of money: a smaller amount now or a larger amount in the future (e.g., "Would you prefer $27 now or $50 in three weeks?"). The scale features 27 choices of varying sizes and delays, with each choice contributing to the estimate of the respondent's discounting rate. Higher discounting rates on this questionnaire are associated with self-reported impulsivity and real-life impulsive behaviors.

2.2.2. Big Five Inventory

(BFI; John & Srivastava, 1999). The Big Five personality traits were measured with the Big Five Inventory, a reliable and widely used measure of the five factors. The BFI contains 44 items spread across the five dimensions of extraversion, agreeableness, conscientiousness, emotional stability (neuroticism reversed), and openness. Participants rate the extent to which they can be described by the items on a 5-point scale (1 = *strongly disagree*; 5 = *strongly agree*).

2.2.3. Fake-proof Big Five scale

(FPBF; Hirsh & Peterson, 2008). The FPBF was designed to be robust against socially desirable responding by requiring that participants make a number of choices between equally desirable trait descriptors. After a number of such choices are made, dimensional scores can be extracted from the number of times that items from each of the Big Five domains were chosen. Hirsh and Peterson (2008) found that this measure correlates well with standard Big Five measures, and is a better predictor of criterion-related performance outcomes under situations of socially desirable responding.

2.2.4. Brief cognitive measure

(BCM; Morisano, 2008). The BCM was designed as a brief scholastic aptitude test, featuring a mix of 28 SAT-like items assessing verbal (critical reading; 18 items) and quantitative (a mix of trigonometry, geometry, and algebra questions; 10 items) ability. An unweighted total score of correct items was utilized for subsequent analyses. Tests containing such reasonably representative question sets provide a good proxy for measuring general cognitive ability, weighted somewhat towards crystallized intelligence (Jensen, 1998). The BCM demonstrates good convergent validity, as it correlates with performance on a battery of tasks assessing dorsolateral prefrontal cortical function (Morisano, 2008).

2.3. Procedure

Participants completed the MCQ, BFI, FPBF, and a demographic questionnaire online as part of a larger study (see Morisano, 2008). They were emailed instructions and a username for accessing the questionnaires online, and were required to sign an online informed consent form before completing any tasks. In order to maximize the accuracy of personality assessment, the two Big Five measures were each administered at two separate times, separated by approximately four months. The BCM was administered in a McGill University classroom approximately two to three weeks after the second BFI was given, over several group sessions (6–14 students per group). Students were informed that they had one hour to complete the BCM. All students finished within the hour.

3. Results

In order to maximize the validity of the personality assessment, the standardized domain scores from the BFI and FPBF at Times 1 and 2 were averaged within traits to create robust composite measures of the Big Five dimensions. These composite scores correlated highly with BFI and FPBF measurements at Times 1 and 2 (mean $r = .87$). Good test–retest reliabilities were also observed for each of the Big Five dimensions in the BFI (mean $r = .81$) and FPBF (mean $r = .88$). The use of composite measures across instruments and times reduces the probability of observing spurious relationships, thereby increasing the likelihood that observed effects could be replicated in other samples.

These composite-trait scores were correlated with MCQ discounting. Only extraversion predicted greater discounting rates ($r = .20$, $p < .05$). A significant negative relationship was also observed between discounting and cognitive ability as measured by the BCM ($r = -.21$, $p < .05$). Table 1 presents the observed correlations and descriptive statistics for the variables of interest. Mean values for the composite-trait scores are zero because they are derived from standardized results.

To examine interaction effects, multiple regressions were conducted for each composite personality trait, with the mean-centered trait, BCM score, and trait × BCM interaction term entered into a model predicting discounting rates. As expected, cognitive ability interacted significantly with extraversion in predicting discounting behavior, $\beta = -.20$, $t(93) = -1.98$, $p < .05$. For the main effects, R^2 change = .07, $F(2,94) = 3.75$, $p < .05$; for the interaction term, R^2 change = .04, $F(1,93) = 3.93$, $p < .05$. Additionally, the hypothesized interaction between cognitive ability and emotional stability was significant, $\beta = -.32$, $t(93) = -3.24$, $p < .01$. For the main effects, R^2 change = .50, $F(2, 94) = 2.25$, $p > .05$; for the interaction term, R^2 change = .10, $F(1,93) = 10.49$, $p < .01$.

Regression lines were computed for individuals at 1 *SD* above and below the mean on the trait measures, and results are shown in Fig. 1 (Preacher, Curran, & Bauer, 2006). For extraversion, the slope decreased linearly as the BCM values increased: For $Z = -1$, $\beta = .46$, $t(93) = 2.65$, $p < .01$; for $Z = 0$, $\beta = .23$, $t(93) = 1.89$, $p = .06$; for $Z = 1$, $\beta = -.01$, $t(93) = -0.07$, $p = .95$. The

Table 1
Descriptive statistics

	1	2	3	*M*	*SD*
1. Extraversion	–			0.00	0.88
2. Emotional stability	.03	–		0.00	0.81
3. BCM	−.16	.08	–	19.61	3.55
4. MCQ	.20*	−.06	−.21*	−5.11	1.06

* $p < .05$, two-tailed. BCM, brief cognitive measure. MCQ, monetary choice questionnaire.

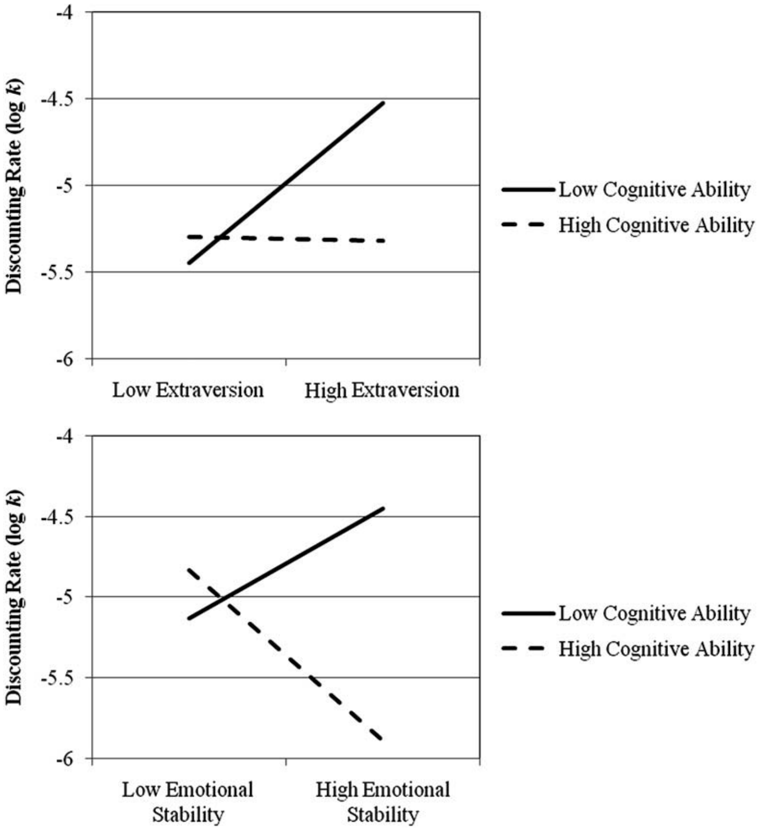

Fig. 1. Delay discounting rates as a function of cognitive ability, extraversion, and emotional stability. High = 1 *SD* above the mean, low = 1 *SD* below the mean.

relationship between extraversion and delay discounting was most pronounced at the lower end of the cognitive ability spectrum. At this lower end, individuals with higher levels of extraversion demonstrated greater discounting levels; at the upper ends of the cognitive distribution, extraversion did not appear to be related to discounting behavior.

For emotional stability, a similar pattern was observed, with the slope decreasing linearly as the BCM values increased: For $Z = -1$, $\beta = .32$, $t(93) = 1.96$, $p = .06$; for $Z = 0$, $\beta = -.09$, $t(93) = -0.75$, $p = .46$; for $Z = 1$, $\beta = -.53$, $t(93) = 2.73$, $p < .01$. The relationship between emotional stability and discounting was most pronounced at the high ends of the cognitive distribution, with less emotionally stable individuals demonstrating higher discounting rates. Although non-significant, there was a trend toward a reversed relationship between emotional stability and discounting at the lower ends of the cognitive distribution.

Discounting rates were slightly higher in males ($M = -4.9$, $SD = .98$) compared to females ($M = -5.2$, $SD = 1.10$), but this difference was not significant, $t(96) = 1.24$, $p > .05$, $d = 0.28$. Statistically controlling for gender did not alter the main findings reported above. No relationships were observed between discounting rate and age or parents' income.

4. Discussion

The results of this study demonstrated that personality and cognitive ability are important predictors of delay discounting. In particular, extraversion predicted a preference for smaller but immediate rewards, while greater cognitive ability predicted a preference for larger but delayed rewards. As expected, these variables interacted in the prediction of discounting behavior: Extraversion predicted greater discounting at lower levels of cognitive ability, while it was emotional stability that predicted reduced discounting at higher levels of cognitive ability.

Higher levels of extraversion appear to increase discounting rates by influencing the strength of the initial incentive motivation toward an immediate reward (Ostaszewski, 1996). Extraversion is strongly related to the sensitivity of the dopaminergic reward systems of the ventral striatum (Depue & Collins, 1999), leading extraverts to experience most stimuli as more rewarding than introverts. These midbrain reward systems are also more responsive to immediate rewards than to delayed rewards (McClure et al., 2004), making the subjective appeal of a short-term temptation stronger for an extravert.

While extraversion appears related to the strength of the initial desire for a reward, cognitive ability appears to reflect the strength of self-regulatory control networks. When individuals have fewer cognitive resources, the motivational appeal of the immediate reward appears to be a stronger determinant of discounting behavior. With more cognitive resources available, it becomes possible to regulate the initial impulse towards the immediate reward in favor of longer-term goals (Shamosh & Gray, in press).

According to this framework, extraverts discount more at the low end of the cognitive distribution because they are less able to use higher-order control mechanisms to regulate their motivational impulses. For introverts at this end of the cognitive spectrum, it is not as important to have strong regulatory mechanisms, because their initial impulses are not as strong. These findings support the view that discounting behavior emerges from the relative strength of "hot" and "cool" response networks (Metcalfe & Mischel, 1999). Neuropsychologically, this appears instantiated as the relative strength of midbrain reward centers and the cognitive control networks in frontal and parietal cortex (McClure et al., 2004).

Although greater cognitive ability helps to regulate behavior towards long-term goals, such higher-cognitive functions can be disrupted by stress and negative affect (McEwan & Sapolsky, 1995). Our findings support this view by demonstrating that higher levels of emotional stability were only able to predict reduced discounting at the higher ends of the cognitive distribution. Individuals at the lower end of the cognitive distribution should have comparatively weakened or underdeveloped cognitive control networks to begin with. Reduced levels of emotional stability for such individuals thus do not seem to produce any further increases in delay discounting; it is only for those individuals who have more cognitive resources to begin with that emotional stability becomes a limiting factor in determining the extent to which these resources can be utilized. It is also worth noting that increased discounting rates in response to stress and anxiety could be an adaptive process. The more stressors an individual is currently experiencing, the less likely it becomes that any future rewards can be enjoyed. In dangerous or threatening environments, waiting for a large delayed reward might actually be less adaptive due to the inherent uncertainty of long-term planning in such environments (cf. Gray, 1999).

Although the current study presents some interesting findings, some limitations should be noted. First, despite the MCQ's ability to predict real-world impulsivity, it nonetheless relies on hypothetical monetary choices. Although hypothetical monetary choices are a useful analog to real-world decisions, delay discounting studies could benefit from a combination of laboratory and real-world measures. Additionally, the current study looked only at monetary discounting rates, and it is possible that a different pattern of results might be observed when examining the discounting of other reward types (e.g., directly consumable rewards such as food). Finally, the BCM was used as a proxy for general cognitive ability, but future research could benefit from examining the role of more specific cognitive processes. A sample with a broader range of cognitive abilities could also be useful in this regard.

Overall, the current study provides support for neurocognitive models of delay discounting. In particular, it demonstrates how an individual-differences approach can help to illuminate the processes underlying discounting behavior. While previous research has examined personality and cognitive ability in isolation, the current analyses demonstrate the value of examining their interactions. Combining such variables in future research is likely to provide a more detailed understanding of individual differences in discounting behavior.

References

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction, 96*, 73–86.

Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences, 22*, 491–517.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature, 40*, 351–401.

Gray, J. R. (1999). A bias toward short-term thinking in threat-related negative emotional states. *Personality and Social Psychology Bulletin, 25*, 65–75.

Hirsh, J. B., & Peterson, J. B. (2008). Predicting creativity and academic success with a "fake-proof" measure of the Big Five. *Journal of Research in Personality, 42*, 1323–1333.

Hyman, S. E., & Malenka, R. C. (2001). Addiction and the brain: The neurobiology of compulsion and its persistence. *Nature Reviews Neuroscience, 2*, 695–703.

Jensen, A. R. (1998). *The g* factor: The science of mental ability. Westport, CT: Praeger Publishers/Greenwood Publishing Group, Inc.

John, O.P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In Pervin, L. A. & John, O. P., (Eds.), *Handbook of Personality: Theory and Research* (2nd ed., pp. 102–138). New York: Guilford.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General, 128*, 78–87.

McClure, S. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science, 306*, 503–507.

McEwan, B. S., & Sapolsky, R. M. (1995). Stress and cognitive function. *Current Opinion in Neurobiology, 5*, 205–216.

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification dynamics of willpower. *Psychological Review, 106*, 3–19.

Mischel, W., Shoda, Y., & Rodriguez, M. I. (1989). Delay of gratification in children. *Science, 244*, 933–938.

Morisano, D. (2008). *Personal goal setting in university students*. Unpublished doctoral dissertation, McGill University, Montreal, Canada.

Ostaszewski, P. (1996). The relation between temperament and rate of temporal discounting. *European Journal of Personality, 10*, 161–172.

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*, 437–448.

Shamosh, N. A., DeYoung, C. G., Green, A. E., Reis, D. L., Johnson, M. R., Conway, A. R. A., et al. (in press). Individual differences in delay discounting: Relation to intelligence, working memory, and anterior prefrontal cortex. *Psychological Science*.

Shamosh, N. A., & Gray, J. R. (in press). Delay discounting and intelligence: A meta-analysis. *Intelligence*, 10.1016/j.intell.2007.09.004.

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*, 669–689.