Who Can Wait for the Future? A Personality Perspective

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Who Can Wait for the Future? A Personality Perspective

Vaishali Mahalingam[1], David Stillwell[1], Michal Kosinski[1], John Rust[1], and Aleksandr Kogan[1]

Abstract

Who can wait for larger, delayed rewards rather than smaller, immediate ones? Delay discounting (DD) measures the rate at which subjective value of an outcome decreases as the length of time to obtaining it increases. Previous work has shown that greater DD predicts negative academic, social, and health outcomes. Yet, little is known about *who* is likely to engage in greater or less DD. Taking a personality perspective, in a large sample ($N = 5{,}888$), we found that greater DD was predicted by low openness and conscientiousness and higher extraversion and neuroticism. Smaller amounts were also discounted more than larger amounts; furthermore, amount magnified the effects of openness and neuroticism on DD. Our findings show that personality is one predictor of individual differences in DD—an important implication for intervention approaches targeted at DD.

Keywords

decision making, individual differences, hierarchical linear modeling/multilevel modeling, personality, social network, delay discounting, time preference

People do not like to wait; thus, more distant rewards—that people have to wait for—have less subjective value than immediate rewards. Delay discounting (DD) is the rate at which the subjective value of a reward decreases as the length of time (delay) before it is obtained increases. For example, would you rather have US$90 now or US$100 in a year? US$50 now or US$100 in a year? A higher rate of discounting implies that one is ''impatient'' and prefers smaller immediate rewards rather than waiting for larger rewards at a later time. Such a preference has been associated with a range of addictive and impulsive behaviors, including smoking (Krishnan-Sarin et al., 2007; Reynolds et al., 2007), drug use (Kirby & Petry, 2004), and obesity (Weller, Cook, Avsar, & Cox, 2008). In contrast, lower rates of discounting—having a preference for larger rewards in the future—have been linked to better academic performance and social functioning, such as social relationships and self-control behavior (Kirby, Winston, & Santiesteban, 2005; Mischel, Shoda, & Rodriguez, 1989).

One important mechanism that determines the degree to which people engage in DD is the reward size—the ''magnitude effect.'' While some have suggested that degree of DD is a constant trait (Odum, 2011), experimental evidence shows that rate of discounting varies as a function of amount (Lane, Cherek, Pietras, & Tcheremissine, 2003). Most studies that tested the magnitude effect found individuals discount smaller rewards more steeply than larger ones (Green, Fristoe, & Myerson, 1994; Green, Fry, & Myerson, 1994; Kirby, 1997; Raineri & Rachlin, 1993). In other words, it takes relatively longer for the *proportionate* subjective value of larger rewards to decrease, compared to small rewards.

While previous work has documented the important practical consequences of individual differences in DD, there is a paucity of data exploring in depth *who* is likely to actually engage in greater or less DD. Studies that explored the relationship between age and DD have found contradictory results (Green, Myerson, & Ostaszewski, 1999; Harrison, Lau, & Williams, 2002; Hirsh, Morisano, & Peterson, 2008; Read & Read, 2004; Reynolds, Richards, Horn, & Karraker, 2004).

Studies exploring personality and DD have been limited to main effects and usually to certain traits (Becker, Deckers, Dohmen, Falk, & Kosse, 2012; Daly, Harmon, & Delaney, 2009; Ostaszewski, 1996). We take a holistic personality perspective to examine how individual differences in the Big Five personality traits are related to DD overall, and, specifically, the magnitude of the reward. We focus on two core questions: (a) Are there personality differences in propensity to engage in

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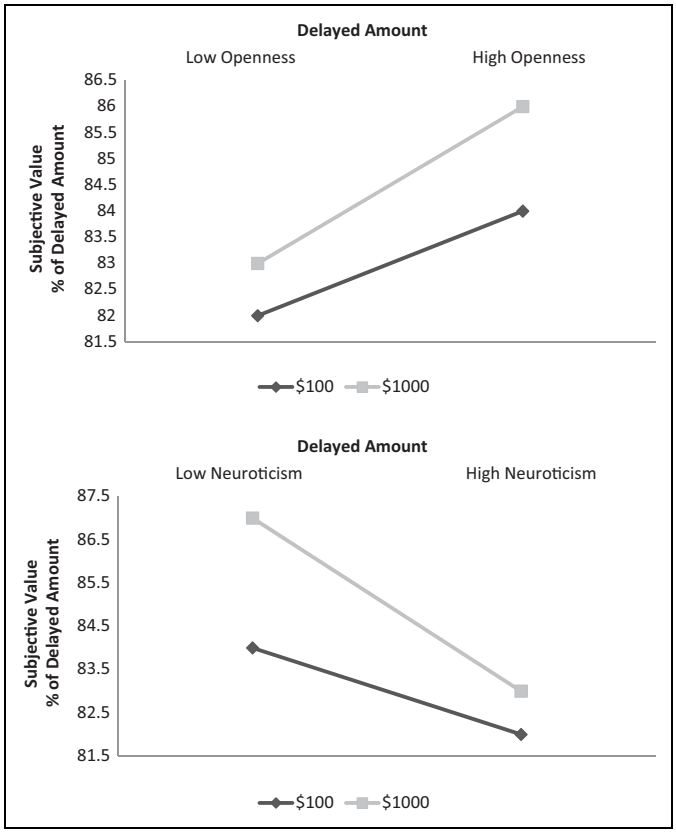

Figure 1. Delay discounting rates as a function of delayed amount and personality (1 standard deviation [*SD*] above/below the mean).

DD? (b) How do personality differences moderate the well-established "magnitude effect?"

Personality and DD

The dominant model used in personality research is the five-factor model (FFM; Costa & McCrae, 1992; Goldberg, 1990). The "Big Five" is composed of the traits: (a) openness to experience (artistic vs. conservative), (b) conscientiousness (self-controlled vs. easygoing), (c) extraversion (outgoing vs. reserved), (d) agreeableness (compassionate vs. antagonistic in thoughts and feelings), and (e) neuroticism (emotionally unstable vs. stable).

Our theoretical analysis suggests that several Big Five personality dimensions should be important in explaining individual differences in DD. Specifically, steeper discounting rates are operationalized as an indicator of impulsivity (Bickel, Odum, & Madden, 1999; Logue, 1988; Reynolds, 2006)—a construct that has become increasingly important in behavioral research. According to Depue and Collins (1999, p. 495), "impulsivity comprises a heterogeneous cluster of lower-order traits that includes terms such as impulsivity, sensation seeking, risk-taking, novelty seeking, boldness, adventuresomeness, boredom susceptibility, unreliability, and unorderliness."

Impulsivity is conceptually related to four domains of the FFM. Costa and McCrae (1992) theorized that low self-control is measured by the impulsiveness and self-discipline facets, which are part of the neuroticism and conscientiousness domains, respectively. Impulsive individuals are said to be moody, irritable, and excitable, while those low in self-discipline are lazy, disorganized, and lacking meticulousness. The conscientiousness domain also includes a deliberation facet. Individuals low on this facet are hasty, careless, and impatient (Whiteside & Lynam, 2001). The extraversion domain includes an excitement-seeking facet that is similar to venturesomeness (Eysenck & Eysenck, 1977) or sensation seeking (Zuckerman, 1994). Individuals high in excitement seeking are pleasure seeking, audacious, and adventurous. Finally, Soto and John (2009) identified adventurousness as a facet under the domain of openness to experience. Individuals high in adventurousness have a preference for novel and intense experiences and have had unusual experiences. These characteristics are similar to the excitement seeking (Costa & McCrae, 1992) or gregariousness (Soto & John, 2009) facet within the extraversion domain. Thus, we developed four hypotheses:

Hypothesis 1: Individuals high in neuroticism will engage in steeper DD.

Hypothesis 2: Individuals low in conscientiousness will engage in steeper DD.

Hypothesis 3: Individuals high in extraversion will engage in steeper DD (Hirsh et al., 2008; Reynolds et al., 2004).

Hypothesis 4: Individuals high in openness to experience will engage in steeper DD.

Agreeableness is characterized by cooperation, empathy, and consideration (Thompson, 2008). We did not see a strong theoretical reason to hypothesize a link between agreeableness and DD, although those low in agreeableness may be likely to engage in steeper discounting due to their suspicious and skeptical nature. However, we viewed this last hypothesis as weak at best.

Past research addressing personality effects on DD have identified important, yet inconsistent, roles played by conscientiousness, extraversion, and neuroticism. Daly, Harmon, and Delaney (2009) and Dohmen, Falk, Huffman, and Sunde (2010) found contradictory evidence regarding correlations between conscientiousness and DD. Ostaszewski (1996) found a positive relationship between extraversion and DD, while Hirsh, Morisano, and Peterson (2008) identified interaction effects between both neuroticism and extraversion, and cognitive ability on DD. However, these findings are limited in important ways. Much of DD research has been conducted on relatively small ($n < 150$) and homogenous student samples (Daly et al., 2009; Hirsh, Guindon, Morisano, & Peterson, 2010; Hirsh et al., 2008; Ostaszewski, 1996, 1997). Small samples result in poor statistical power, leading to high risk of erroneous findings and low generalizability. In studies with large samples, other methodological issues persisted, such as poor psychological measures of personality or DD. For

example, a study by Rustichini, DeYoung, Anderson, and Burks (2012) compared the predictive power of measurements derived from decision theory and personality theory in a relatively large sample ($N = 1{,}065$) of American truck drivers. They used the Multidimensional Personality Questionnaire (Tellegen & Waller, 1992) and mapped its scales on Big Five constructs—but, without empirical evidence of its validity. Further, studies conducted from an economic perspective often fail to be grounded in psychological theory or take a holistic personality approach. Thus, we took a psychological perspective in a large-scale study to provide a more precise test of how personality can explain individual differences in DD.

Personality as Moderating the "Magnitude Effect" in DD

Previous work has documented the robustness of the "magnitude effect"—people are comparatively more impatient for low-value rewards than rewards of higher value. But whereas aggregate differences across groups are well established, nothing is known about individual differences in its strength—are some people less or more impatient for small versus large rewards? If so, people would respond differentially to delays of larger/smaller amounts—an important implication for real-life outcomes. For example, obesity represents a failure to wait for small rewards; perhaps it would show a better correlation with DD of small rewards.

Established methods of calculating DD (i.e., hyperbolic discounting; see Rachlin, Raineri, & Cross, 1991; Takahashi, Ikeda, & Hasegawa, 2007, for detailed description) account for the ratio between the immediate and delayed amount but not the magnitude of the delayed amount. Thus, our second aim was to examine how Big Five personality traits moderated the relationship between magnitude of the delayed amount and DD. At present, no work has examined the role of personality in moderating the impact of amount on DD. Studies do show that nonmonetary rewards/consumables including food, drugs, access to video games, and so on, are discounted more steeply than money, even among the "normal" population (Estle, Green, Myerson, & Holt, 2007; Navarick, 1982; Odum, Baumann, & Rimington, 2006; Petry, 2001)—possibly pointing to the role of other factors. There are also theoretical reasons to expect individual differences in size of the "magnitude effect." For instance, decision by sampling theory (Stewart, Chater, & Brown, 2006) suggests that individuals change their subjective value of rewards according to values they're used to dealing with in everyday life. Personality may also explain individual differences in the "magnitude effect," since it plays a pervasive role in our responses to daily life situations. However, given the dearth of empirical data about mechanisms behind the magnitude effect, we did not formulate specific hypotheses about how personality would moderate the effect of magnitude on DD.

Present Study

Our study had two aims: First, to test specific hypotheses about how the Big Five personality traits explained individual differences in DD and second, to test in an exploratory fashion the moderating role of personality on the "magnitude effect." In a large-scale study ($N = 5{,}888$), we assessed people's personalities and discounting behavior for variable amounts. Through such a large sample, we were able to detect even subtle effects of personality, offering the strongest test to date of the role of personality in DD.

Method

Participants and Procedure

Data were collected via the "myPersonality" application on Facebook (Stillwell & Kosinski, 2011) between June 2010 and 2011. A total of 9,334 international users responded to a questionnaire called "Today or Tomorrow" and the 100-item *International Personality Item Pool* personality questionnaire (Goldberg et al., 2006). All measures were administered in English. From the pool of 9,334 participants who completed the DD measure, subsets of $N = 5{,}909$ for the main effects model and $N = 5{,}888$ for the interaction effects model were used in our analyses, based on the measures they had responded to. A total of 58 participants were omitted from the final subset ($N = 5{,}888$) as they were outliers of 3 standard deviation (*SD*s) above or below the DD mean. It was not compulsory to answer all measures, and participants could opt out at any time by exiting the application. Of the participants who provided demographic details, 2,468 were male (38%) and 3,987 were female (62%), while average age was 23.64 ($SD = 9.06$; see Appendix A).

Before starting, users selected the currency that they were most comfortable using from nine currencies (British Pound, Canadian Dollar, Euro, Filipino Peso, Indian Rupee, Indonesian Rupiah, Singapore Dollar, South African Rand, and United States Dollar). Since the delayed amounts were based on previous research using U.S. dollars, Google's exchange rate function (on June 22, 2010) was used to convert the monetary values to all nine currencies. Users were also told that they would not actually receive any monetary rewards at the end of the questionnaire,[1] and to assume no inflation when deciding on their responses.

DD Measure

Seven sets of questions were presented in a randomized order to each participant. Participants were asked to repeatedly choose between two hypothetical monetary values—various smaller amounts now compared to larger amounts at different points in the future. The amounts used as immediate rewards were US$1,000, US$950, US$900, US$850, US$750, US$600, US$500, US$400, US$250, US$150, US$100, US$60, US$20, US$10, and US$1; while 1 week, 2 weeks, 1 month, 6 months, 1 year, and 5 years were used as time delays. All these amounts and time delays were compared to US$1,000 at the future time point. An additional set of questions asked participants to choose between immediate rewards with amounts one tenth of those listed above (e.g., US$100,

US$95) and a 1-month delay compared to US$100 at future time points. We calculated the level of DD as parameter k using established methods[2] (i.e., hyperbolic discounting; see Rachlin et al., 1991; Takahashi et al., 2007, for a detailed description).

A hyperbolic function best explains DD in humans because it accounts for time inconsistent discounting. This is the switch individuals make from future rewards to immediate rewards as the relative length of delay decreases (Rachlin et al., 1991; Takahashi et al., 2007). For example, people are likely to prefer US$1,000 in 1 year and 1 day over $990 in 1 year, but will prefer US$990 immediately rather than US$1,000 tomorrow; short delays have a relatively greater impact than longer delays. The hyperbolic delay also fits individuals' discounting data better than the exponential function (Rachlin et al., 1991). The hyperbolic function uses the formula:

$$V = A/(1+kD).$$

Parameter k refers to the individuals' estimate of DD (i.e., steepness of the curve), A the undiscounted reward amount, D the length of delay, and V the subjective discounted value of the reward.

The highest immediate and lowest delayed monetary values the participant selected were averaged to establish a point of inflection (Bickel et al., 1999; Stillwell & Tunney, 2012) and then calculate parameter (k). Further, log transformation (to the base 10) was used to normalize the data.

Results

Data Analysis

Appendix A provides sample demographics by currency used, while Appendix B provides descriptive statistics and correlations between trait-level (Level 2) variables.

As traditional analysis of variance and multiple regression methods assume independence of observations, we used hierarchical linear modeling (HLM) techniques to take into account multiple observations from the same user (Raudenbush & Bryk, 2002). The different delayed amounts (US$100 and US$1000) were considered interdependent (Level 1) compared to personality factors and demographic variables that were measured only once (Level 2). Using maximum-likelihood estimation, HLM yields independent estimates of the relationships among *within-subject* variables (Level 1) and models them *between subjects* (at Level 2) as a random effect (Snijders & Bosker, 1999). Further, all continuous variables were centered (Aiken & West, 1991) to minimize multicollinearity. The dependent variable, log(k; i.e., rate of discounting), was calculated for each participant at delayed amounts of US$100 and US$1000. All data were analyzed using R statistics with the lme4 package (Bates, Maechler, & Bolker, 2012). P values are not available within the lme4 package because there is continued debate about what the appropriate degrees of freedom are for a significance test in the multilevel context. However, t values are provided. Given our large sample (main effects model: Level 1 N = 40,982 and Level 2 N = 5,909; interaction effects model: Level 1 N = 11,545 and Level 2 N = 5,888), we treat t values that are greater than 2 as significant. Furthermore, we provide pseudo R^2 as a measure of effect size and confidence intervals for all slopes at $\pm$ 2.00 $\times$ SE levels. It should be noted that moderate t scores (within 2.0–7.0 approximately) will invariably have small effect sizes. The large sample size should be considered when interpreting statistical findings.

DD and Personality

Our first goal was to test whether the Big Five personality traits predicted individual differences in DD (k). Thus, an HLM was constructed as shown below (for more details, see Main Effects Model section present in Appendix C):

$$\begin{aligned}\mathrm{DD} = {} & \pi_{00} + \pi_{10}\mathrm{TIME} + \pi_{20}\mathrm{AMOUNT} + \pi_{01}\mathrm{OPENNESS} \\ & + \pi_{02}\mathrm{CONSCIENTIOUSNESS} + \pi_{03}\mathrm{EXTRAVERSION} \\ & + \pi_{04}\mathrm{AGREEABLENESS} + \pi_{05}\mathrm{NEUROTICISM} \\ & + \pi_{06}\mathrm{AGE} + \pi_{07}\mathrm{GENDER} + \pi_{08-16}\mathrm{CURRENCY} + e + u_0.\end{aligned}$$

In these analyses, we controlled for currency—to rule out purchasing power parity as a covariate of delayed reward amount and length of delays—and age and gender to rule out important covariates of personality. However, the effects remained highly similar when these covariates were not included. All five personality traits were entered as simultaneous predictors to examine their unique effects.

As Table 1 shows, openness, conscientiousness, extraversion, and neuroticism significantly predicted DD. Consistent with our prediction, individuals with greater conscientiousness showed smaller k values—representing less DD. Similarly, individuals who were more extraverted and neurotic showed greater DD. On the other hand, individuals higher in openness to experience engaged in less steep discounting; thus, disproving our hypothesis. Agreeableness was unrelated to DD. These findings demonstrate that personality differences provide part of the answer to understanding how DD rates vary between individuals.

The effect size estimates (see Table 1) for this model indicate that the magnitude of the delayed amount explains approximately 6% (pseudo R^2 = .056) of the variance in discounting rates within each individual. Individual personality factors explain between 0.3% and 1% of variance (pseudo R^2 = .003 to .01) in discounting behavior between individuals. It should be noted that moderate t scores (within 2.0–7.0 approximately) will invariably have small effect sizes. The large sample size should be considered when interpreting statistical findings.

Moderating Role of Personality on the "Magnitude Effect"

Our second goal in the present article was to examine whether Big Five personality traits moderated the "magnitude effect." The effect size estimates for the main effects model indicate that the magnitude of the delayed amount explains approximately 6% of variance in discounting rates within individuals, while personality factors explain approximately 1% of variance

Table 1. Main Personality Factors on Delay Discounting (*k*).

Predictors	*b*	*t*	CI_{95}		Pseudo R^2
			Lower	Upper	
Level 1					
Delayed amount	−0.292	−45.45	−0.304	−0.279	.056
Length of delay	−0.209	−150.09	−0.211	−0.206	.392
Level 2					
Openness	−0.056	−4.290	−0.081	−0.030	.003
Conscientiousness	−0.070	−6.690	−0.095	−0.045	.008
Extraversion	0.067	7.23	0.049	0.085	.01
Agreeableness	−0.015	−1.3	−0.038	0.008	.0001
Neuroticism	0.070	7.06	0.051	0.090	.009
Age	−0.001	−1.05	−0.002	0.001	—
Gender	0.008	0.5	−0.022	0.037	—
Currency—British pound	0.015	0.64	−0.031	0.061	—
Currency—Canadian dollar	−0.134	−3.940	−0.200	−0.067	—
Currency—Euro	0.023	0.86	−0.030	0.077	—
Currency—Filipino peso	0.262	4.54	0.149	0.374	—
Currency—Indian rupee	0.201	3.17	0.077	0.325	—
Currency—Indonesian rupiah	0.422	4.33	0.231	0.613	—
Currency—Singapore dollar	0.103	1.96	0.000	0.206	—
Currency—South African rand	−0.142	−1.520	−0.324	0.041	—

Note. All numbers are unstandardized regression coefficients. The American dollar was used as the reference group when creating dummy variables for currency. Age, gender, length of delay, and currency were entered into the model as control variables.

in discounting behavior between individuals. Considering this still leaves significant variance to be explained at the individual and group level, we investigated whether personality factors moderated the effect of delayed amount on discounting rates (cross-level interactions).

To test this hypothesis, we first tested whether our participants showed the ''magnitude effect.'' Consistent with past research, participants showed less DD for larger amounts, $b = -0.15$, $CI_{95}[-0.16, -0.14]$, $t = -20.51$. We next tested whether each of the Big Five personality dimensions moderated the effect of amount on DD (see Table 2), such as (for more details, see Interaction Effects Model section present in Appendix C):

$$\begin{aligned} DD = {} & \pi_{00} + \pi_{10}\text{AMOUNT} + \pi_{01}\text{PERSONALITY} \\ & + \pi_{11}\text{AMOUNT} \times \text{PERSONALITY} + \pi_{02}\text{AGE} \\ & + \pi_{03}\text{GENDER} + \pi_{04}\text{CURRENCY} + e + u_0. \end{aligned}$$

In these analyses (see Table 2), we again controlled for currency, age, and gender—and again, results were highly similar without these controls. In order to study the magnitude effect of delayed amounts, we compared the rate of discounting ($\log(k)$ values) with delayed amounts of US$100 and US$1000 at 1 month in the future. We found that openness and neuroticism dimensions significantly moderated the impact of amount. Specifically, people who are higher in openness tend to discount US$100 less than those low in openness, $b = -0.05$, $CI_{95}[-0.08, -0.02]$, $t = -2.95$; larger amounts *magnify* this effect by 60%, with people higher in openness discounting US$1000 far less, $b = -0.08$, $CI_{95}[-0.11, -0.05]$, $t = -4.98$, than people low in openness. In the opposite direction, individuals high in neuroticism tend to discount US$100, $b = 0.05$, $CI_{95}[0.02, 0.07]$, $t = 3.95$, more than individuals low in neuroticism. Larger amounts also *magnified* this effect by 60%, with highly neurotic people engaging in even greater discounting of US$1000, $b = 0.08$, $CI_{95}[0.05, 0.10]$, $t = 6.43$, than less neurotic people. Thus, for openness and neuroticism, greater amounts magnify people's personality tendency to engage in less (openness) or more (neuroticism) DD (see Figure 1).

Discussion

In this study, we took a personality perspective to understand who is more or less likely to engage in DD. Partly in accordance with Daly et al. (2009), our findings indicate that conscientiousness and openness are both negatively related to DD—people who are highly conscientious and/or highly open to experience tend to discount future rewards less than individuals who are low in either trait. In contrast, we found that extraversion and neuroticism positively predicted DD, indicating that people who are highly extraverted and/or neurotic are less likely to wait for future rewards and more likely to go after immediate gains than individuals low in extraversion and/or neuroticism. Past research found similar relationships between extraversion and discounting behavior (Hirsh et al., 2010; Ostaszewski, 1996, 1997). Agreeableness, on the other hand, was unrelated to DD—given our large sample, we can conclude there is likely an inappreciable relationship between agreeableness and DD in the general population. While some previous studies have looked at certain personality dimensions, studied small, homogenous samples, or used less robust measures of

Table 2. Interactions Between Amount and Personality Factors on Delay Discounting (*k*).

Predictors	*b*	*t*	CI_{95}	
			Lower	Upper
Level-1 predictors				
Delayed amount	−0.15	−19.6	−0.164	−0.134
Level-2 predictors				
Openness	−0.05	−2.95	−0.078	−0.016
Conscientiousness	−0.08	−5.85	−0.1	−0.05
Extraversion	0.066	5.79	0.044	0.088
Agreeableness	−0.02	−1.09	−0.044	0.013
Neuroticism	0.048	3.95	0.024	0.072
Age	−0	−0.89	−0.003	0.001
Gender	−0.02	−1.02	−0.056	0.01
Currency—British pound	0.027	1.056	−0.024	0.078
Currency—Canadian dollar	−0.13	−3.35	−0.2	−0.052
Currency—Euro	0.003	0.083	−0.056	0.062
Currency—Filipino peso	0.269	4.245	0.144	0.394
Currency—Indian rupee	0.208	2.938	0.069	0.347
Currency—Indonesian rupiah	0.411	3.841	0.201	0.621
Currency—Singapore dollar	0.16	2.763	0.046	0.274
Currency—South African rand	−0.18	−1.73	−0.384	0.024
Level 1 × Level 2 interactions				
Delayed Amount × Openness	−0.03	−2.35	−0.059	−0.005
Delayed Amount × Conscientiousness	0.013	1.18	−0.008	0.034
Delayed Amount × Extraversion	0.012	1.28	−0.007	0.032
Delayed Amount × Agreeableness	0.016	1.3	−0.008	0.04
Delayed Amount × Neuroticism	0.03	2.92	0.01	0.05

Note. All numbers are unstandardized regression coefficients. The American dollar was used as the reference group when creating dummy variables for currency. Age, gender, and currency were entered into the model as control variables.

personality or DD—we do so (a) in a large, diverse sample, (b) using robust psychometric measures and methodology, and (c) model the direct effects of all Big Five personality dimensions simultaneously.

In addition to the above main effects, we examined how Big Five personality traits interact with the well-established ''magnitude effect''—that is, people being more willing to wait for larger amounts, while showing steeper discounting for smaller amounts. Interestingly, we found that amount to be received in the future acted as a *magnifier* for the effects of openness and neuroticism. As discussed previously, openness predicted less DD, whereas neuroticism predicted more; however, these effects became even stronger when the delayed amount at stake was larger. People highly open to experiences are even more likely to wait for future gains if these gains are large as compared to people low in openness to experience. In stark juxtaposition, people high in neuroticism were especially likely to *not wait* for larger gains as compared to their low-neuroticism counterparts. Thus, the relationship between openness to experience and neuroticism to DD is not simple; rather, it is highly dependent on the specific size of the reward one will receive in the future.

What might explain this pattern of results? As opposed to our initial hypotheses, individuals high in openness in fact engage in less steep discounting than those low in openness. An alternative explanation might be that impulsiveness makes one have insufficient patience to explore new ideas or concepts comprehensively; and, hence, less open to experience (Berlin & Rolls, 2004). Further, Berlin and Rolls (2004) found that openness to experience negatively correlated with self-reported impulsivity. This questions whether openness causes individuals to be impulsive or vice versa.

Neuroticism, on the other hand, is characterized by emotional instability and impulsiveness. Costa and McCrae (1992) theorized that low self-control is measured by the impulsiveness facet of neuroticism. Those high in neuroticism may discount the future more because they have problems delaying gratification due to poor self-control (Hettema, Neale, Myers, Prescott, & Kendler, 2006; Ostaszewski, 1996). This is magnified when the amounts are larger because the reward is likely to be perceived as far more enticing.

Our findings have several important implications for both the study of DD and the interventions predicated on impulsivity and/or DD principles (Chapman, Nelson, & Hier, 1999; Swift & Callahan, 2009). First, our results suggest that individual differences in certain aspects of personality determine variations in the discounting function for different delayed amounts. In accordance with recent findings, our findings imply different *k* values at different delayed amounts, as opposed to one overall *k* and DD curve for each individual. The interaction between openness and/or neuroticism and size of reward suggests that certain personality traits may determine individual variation in the DD curve. Thus, it appears that the discounting function

is more complicated than simple (economic) decision-making theories assume. Second, understanding the role of different personality dimensions in DD can set the stage for the emergence of new intervention approaches. For example, the above findings can be used in rehabilitation of patients with borderline personality disorder (BPD). Impulsivity is a key characteristic of BPD and research shows that it may be linked to deficits in time perception. Patients with BPD may be encouraged to be more deliberate in their actions—and are given verbal feedback on doing so—as part of their rehabilitation (Berlin & Rolls, 2004). Similarly, intervention methods aimed at reducing the lure of small rewards could focus on the neuroticism trait, teaching individuals to control their emotions better. Preferring smaller immediate rewards over larger delayed rewards has various implications including failure to save for the future, credit card usage, health-related maladaptive behavior such as smoking and overeating.

Limitations to our study suggest certain future directions. One drawback of our study is that we did not have information on the socioeconomic status (SES) of our participants and, thus, could not control for its potential effect. Future work should explain the role SES plays in DD, and in particular, how it might affect the personality effects we have identified. Another limitation to our study is that we presented participants with only two different delayed amounts (US$100 and US$1000) and a single delay length. Further research could include a few more delayed amounts and/or time delays. Such a study should be conducted carefully as too many immediate and delayed amounts can confuse participants and cause them to mix-up immediate and delayed values.

Overall, the current study provides support for individual differences in the DD curve. The findings highlight who are likely to engage in such behavior and the complexity of the dynamics with relation to the magnitude of the reward being discounted. Some individuals show more or less impulsivity/impatience for small delayed amounts than predicted by their discounting rate for larger delayed amounts. Personality partly explains the variation in DD functions, implying that these differences are not merely the result of random noise, but rather a systematic variation related to stable personality traits. Openness and neuroticism strongly moderated the relationship between delayed amounts and discounting rate. Based on these findings, there is scope for further research on the dynamics of discounting rates between various subsets of the population, such as substance abusers, gamblers, and obese individuals.

Appendix A

Sample Demographics by Currency Used

Currency	Conversion per US$1	*N* (Male/Female)	Mean Age (*SD*)	Mean log(*k*)[a] (*SD*)
British pound	0.68	959 (262/408)	25.24 (10.02)	−0.93 (0.58)
Canadian dollar	1.02	448 (112/199)	22.76 (8.99)	−1.08 (0.59)
Euro	0.81	666 (222/264)	25.6 (8.3)	−0.97 (0.57)
Filipino peso	45.45	161 (48/44)	23.49 (8.02)	−0.73 (0.59)
Indian rupee	45.65	155 (48/30)	23.02 (5.67)	−0.75 (0.57)
Indonesian rupiah	9009	50 (16/15)	23.21 (6.62)	−0.55 (0.64)
Singapore dollar	1.38	186 (52/67)	19.99 (5.46)	−0.9 (0.57)
South African rand	7.51	64 (14/26)	26.61 (8.89)	−1.03 (0.52)
United States dollar	1	6645 (1,694/2,934)	23.34 (9.08)	−0.97 (0.56)

Note: Conversion per US$1 based on Google's exchange rate function on June 22, 2010.

[a]Parameter "*k*" refers to the individuals' estimate of delay discounting (i.e., steepness of the hyperbolic discounting curve). Larger values indicate steeper discounting, that is, the subjective value of a reward in the future decreases immensely. Natural log transformation was used to normalize the data.

Appendix B

*Correlations Between All Level 2 (*Between-Individuals*) Variables*

	Variables (*M*/*SD*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Openness (4.041/0.561)															
2	Conscientiousness (3.328/0.721)	−.035														
3	Extraversion (3.192/0.838)	−.009														
4	Agreeableness (3.482/0.652)	−.019	.225	.193												
5	Neuroticism (2.826/0.832)	−.001	.109	.148	.217											
6	Age (2.359/0.909)	.025	−.069	−.287	−.342	−.332										
7	Gender	.034	.023	.206	.060	.088	−.052									
8	British pound	.012	.016	−.005	.043	.065	.193	.048								
9	Canadian dollar	.002	−.072	−.055	.004	.017	.060	.051	−.004							
10	Euro	.015	−.007	−.028	−.021	−.019	.010	−.020	.005	−.074						
11	Filipino peso	−.011	.066	−.023	−.001	−.031	−.029	.062	−.048	−.096	−.062					
12	Indian rupee	.007	−.032	.020	.012	−.017	−.013	−.002	−.035	−.042	−.027	−.035				
13	Indonesian rupiah	.008	−.004	.000	.005	−.017	−.026	−.004	−.054	−.038	−.024	−.032	−.014			
14	Singapore dollar	−.003	−.026	−.007	−.008	−.013	−.003	−.004	−.022	−.024	−.016	−.020	−.009	−.008		
15	South African rand	−.013	−.049	−.022	−.019	−.040	.017	−.055	−.021	−.047	−.030	−.039	−.017	−.015	−.010	
16	American dollar	.015	.011	.017	.013	.001	−.004	.027	.003	−.026	−.016	−.021	−.009	−.008	−.005	−.010

Note: Please refer to Appendix A for descriptive statistics by currency group.

Appendix C

Explanation of Hierarchical Linear Models Constructed During Data Analyses

Main Effects Model.

$$\begin{aligned} DD = {} & \pi_{00} + \pi_{10}\text{TIME} + \pi_{20}\text{AMOUNT} + \pi_{01}\text{OPENNESS} \\ & + \pi_{02}\text{CONSCIENTIOUSNESS} + \pi_{03}\text{EXTRAVERSION} \\ & + \pi_{04}\text{AGREEABLENESS} + \pi_{05}\text{NEUROTICISM} \\ & + \pi_{06}\text{AGE} + \pi_{07}\text{GENDER} + \pi_{08-16}\text{CURRENCY} + e + u_0. \end{aligned}$$

In this model, π_{00} is the person's average delay discounting (DD) when all other factors equal zero. In the present study, both Level-1 variables have the same average for all participants (since all participants received the same scenarios), and thus cannot explain any Level-2 variance. Furthermore, Level-2 variables in the model only account for *between-subjects* (Level 2) variance. Thus, the Level-2 control variables (age, gender, and currency) in the model have no effect on the variance explained by AMOUNT and/or TIME.

π_{20}AMOUNT refers to the difference in DD between delayed amounts of US$100 and US$1000, assuming other Level-1 factors (i.e., π_{10}TIME) are average. π_{10}TIME refers to the change in DD for one-unit increase in TIME assuming AMOUNT = 0 (i.e., $100). Since Level-2 continuous variables—including personality factors and AGE—were grand-mean centered, π_{01}OPENNESS refers to the change in DD for one-unit increase in OPENNESS, assuming all other Level-2 variables are average, similarly for π_{02}CONSCIENTIOUSNESS, π_{03}EXTRAVERSION, π_{04}AGREEABLENESS, π_{05}NEUROTICISM, and π_{06}AGE. π_{07}GENDER is the difference in DD between men and women, assuming other Level-2 factors are average, similarly for each of the currency groups (π_{08-16}CURRENCY). Finally, e refers to the residual error *within subjects*, while u_0 refers to the random effect *between subjects*.

Interaction Effects Model.

$$\begin{aligned} DD = {} & \pi_{00} + \pi_{10}\text{AMOUNT} + \pi_{01}\text{PERSONALITY} \\ & + \pi_{11}\text{AMOUNT} \times \text{PERSONALITY} + \pi_{02}\text{AGE} \\ & + \pi_{03}\text{GENDER} + \pi_{04}\text{CURRENCY} + e + u_0. \end{aligned}$$

Here, π11AMOUNT × PERSONALITY is the change in slope between PERSONALITY (i.e., Big 5 traits) and DD for one-unit increase in AMOUNT, or the change in slope between AMOUNT and DD for one-unit increase in PERSONALITY (i.e., Big Five traits).

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Notes

1. No significant effect of reward type was found in studies comparing hypothetical and real rewards (Johnson & Bickel, 2002; Madden et al., 2004).
2. Preliminary analyses showed that a hyperbolic, time inconsistent function fit the data better than an exponential, time consistent function.

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