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Positive Mood Effects on Delay Discounting

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Delay discounting is the process by which the value of an expected reward decreases as the delay to obtaining that reward increases. Individuals with higher discounting rates tend to prefer smaller immediate rewards over larger delayed rewards. Previous research has indicated that personality can influence an individual's discounting rates, with higher levels of Extraversion predicting a preference for immediate gratification. The current study examined how this relationship would be influenced by situational mood inductions. While main effects were observed for both Extraversion and cognitive ability in the prediction of discounting rates, a significant interaction was also observed between Extraversion and positive affect. Extraverted individuals were more likely to prefer an immediate reward when first put in a positive mood. Extraverts thus appear particularly sensitive to impulsive, incentive-reward-driven behavior by temperament and by situational factors heightening positive affect.

Keywords: personality, delay discounting, positive mood, emotion, affective decision making

Delay discounting describes the psychological tendency for the subjective value of a given reward to decrease as the delay to obtaining that reward increases. Higher discounting rates indicate a preference for smaller immediate rewards over larger delayed rewards. It is important that this preference has been associated with negative outcomes in a variety of life domains, including worse academic performance and poor self-regulation (Kirby, Winston, & Santiesteban, 2005; Mischel, Shoda, & Rodriguez, 1989). Additionally, higher discounting rates have been associated with a variety of addictive and impulsive behaviors such as alcoholism, pathological gambling, heroin use, and cigarette smoking (Bickel & Marsch, 2001; Kirby, Petry, & Bickel, 1999). The ability to work toward long-term goals instead of focusing on immediate gratification appears to be an important psychological process with real-world consequences.

Behavioral models of delay discounting have identified the competing influence of the "hot" and "cool" psychological processes that are involved when choices are made between current and future rewards (Metcalfe & Mischel, 1999). According to such models, "hot" processes are driven by the motivational appeal of the immediately available rewards, while "cool" processes reflect the strength of top-down cognitive-control networks that emphasize the importance of long-term goals. The relative strength of these "hot" and "cool" systems is thought to determine whether an individual ultimately chooses to pursue immediate gratification or a delayed reward. Neuropsychologically, this decision process appears to be instantiated as a conflict between the reward centers of the mesolimbic dopamine system and the cognitive control networks in frontal and parietal cortex (McClure, Laibson, Loewenstein, & Cohen, 2004). When greater activity is observed in frontal-parietal regions, it is the preference for the larger, delayed reward that holds greater sway. When greater activity is observed in the mesolimbic reward circuits of the ventral striatum, by contrast, the desire for the immediate reward dominates an individual's behavior. This process can be seen most clearly in the extreme case of addictive behavior, in which the midbrain dopaminergic circuitry gains disproportionate control over an individual's actions (Hyman & Malenka, 2001).

The strength of these "hot" and "cool" systems appears to vary substantially across individuals, with some people experiencing a stronger incentive pull toward rewards of a given size, and others demonstrating a greater capacity to control and regulate their motivational impulses. In the former case, a stronger incentive pull is associated with the strength of the mesolimbic dopamine system. The perception of reward cues is associated with phasic releases of dopamine (Schultz, 2002), as well as the experience of positive affect (Burgdorf & Panksepp, 2006), both of which appear to facilitate incentive motivation during goal pursuit. In terms of individual differences, the dopaminergic response to a potential reward has been linked to the personality trait of Extraversion (Depue & Collins, 1999; Wacker, Chavanon, & Stemmler, 2006). Extraverted individuals appear to have more responsive dopaminergic circuits and, as a result, tend to be more sensitive to rewards in general, while also experiencing greater positive affect (Cohen, Young, Baek, Kessler, & Ranganath, 2005; Lucas, Diener, Grob, Suh, & Shao, 2000). Thus, when compared to introverts, extraverts experience a stronger subjective reward for any given objective reward. It therefore appears easier to trigger the "hot" motivational systems of extraverts. As predicted by behavioral and neuropsychological models of delay discounting, extraverts also tend to prefer immediate gratification over delayed rewards (Hirsh, Morisano, & Peterson, 2008; Ostaszewski, 1996).

The strength of the "cool" cognitive process, meanwhile, appears to be reflected in measures of general cognitive ability, with higher IQ scores predicting reduced discounting rates (partly me-

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diated through the improved anterior prefrontal cortical function of intelligent individuals; Shamosh et al., 2008; Shamosh & Gray, 2007). With more cognitive resources available, intelligent individuals are better able to deliberatively regulate their motivational impulses, calculate the optimal choice strategy, and integrate their decisions within more long-term goals.

Discounting behavior also appears to be influenced by the situational manipulation of these "hot" and "cool" systems, as well as their dispositional status. The "cool" system can, for example, be disrupted by manipulations that reduce the availability of cognitive resources. Increasing an individual's working memory load ties up cognitive resources, leading to higher discounting rates (Hinson, Jameson, & Whitney, 2003). In the case of the dopaminergic "hot" system, discounting rates tend to increase following the presentation of cues for incentive reward (Wilson & Daly, 2004). Indeed, during states of "hot" emotional arousal, people tend to increase the value that is given to immediate gratification (Ariely & Loewenstein, 2006). Based on neuropsychological models of discounting behavior, this appears to be due to the increased dopaminergic activity that follows exposure to reward cues (Schultz, 2002).

There is reason to suspect, however, that the consequences of emotional arousal for decision-making processes might not be the same for all individuals. In particular, the net activation of the "hot" circuitry should reflect a combination of its dispositional strength and the current situational influence. Because extraverted individuals appear to have higher dispositional levels of "hot" reward-related dopaminergic activity, they should exhibit even stronger motivational impulses during situations of emotional arousal. As a result, the previously observed relationship between Extraversion and higher discounting rates should be strengthened following the induction of positive mood. The current study tested this possibility by examining the personality predictors of delay discounting following a positive mood manipulation. It was hypothesized that higher levels of induced positive affect would result in greater discounting of future rewards among extraverted individuals (hypothetically due to increased dopaminergic responsivity). Conversely, induced negative affect was not expected to influence the discounting behavior of extraverts, as it should not be related to the heightened incentive motivation associated with dopaminergic activity.

Method

Participants

Participants included 137 undergraduate students (99 female) from the University of Toronto, with an age range of 18 to 25 years ($M = 20.1$, $SD = 1.5$). Participants were recruited from an introductory psychology class for a study on decision making, and were given course credit for completion of the experiment. The sample consisted of mostly European-Canadian (46%) and East-Asian (35%) participants.

Materials

Delay discounting measure. Participants were asked to choose repeatedly between receiving various amounts of money now or in the future on a computerized task that took approximately 15 minutes to complete. This type of hypothetical monetary choice task has been validated as an effective measure of actual monetary decisions, with no differences being observed between real and hypothetical choices (Johnson & Bickel, 2002; Lagorio & Madden, 2005; Madden, Begotka, Raiff, & Kastern, 2003; Madden et al., 2004). While the size of the immediate reward option varied on each trial, the delayed reward option was always $1,000 (large) or $20 (small) after a short (1 week), medium (6 months), or long (1 year) delay. Altogether, the task presented 114 separate monetary choices, one at a time, in random order, from a predetermined list of delays and immediate amounts (ranging from $2 to $20 for small rewards and $100 to $1,000 for large rewards). For each delay and reward size, the indifference point was obtained at which the participant was equally likely to choose the immediate and delayed rewards. Most decisions were consistent with the observed indifference points ($M = 92\%$, $SD = 5\%$), such that immediate rewards were chosen primarily on trials that were below the indifference point and delayed rewards were chosen primarily on trials that were above the indifference point.

A hyperbolic discounting rate was estimated using the formula $V = A/(1 + kD)$, where k is the rate at which delayed rewards are discounted, A is the size of the delayed reward, V is the present value of the delayed reward (i.e., the indifference point), and D is the delay in days toward obtaining the delayed reward (cf. Kirby et al., 1999). Discounting rates for each reward magnitude (small, large, overall) were estimated by fitting the equation above to the obtained data with the Solver subroutine in Microsoft Excel, 2007. Statistical analyses employed the log-transformed discounting rates, to ensure normality. Higher discounting rates indicate a preference for immediate rewards.

Big Five Inventory (BFI; John & Srivastava, 1999). The Big Five personality traits were measured with the BFI, a reliable and widely used measure of the five factors. The BFI contains 44 items spread across the five dimensions. Participants rate the extent to which they can be described by the items on a 5-point scale (1 = *strongly disagree*; 5 = *strongly agree*). Sample items include "Is helpful and unselfish with others," and "Is a reliable worker."

Positive and Negative Affective Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS was used to assess the participants' levels of positive affect (PA) and negative affect (NA) following the mood manipulation. The questionnaire features two 10-item Likert scales assessing an individual's current levels of positive and negative affect.

Wonderlic Personnel Test (WPT; Wonderlic, 1983). The WPT was used as a brief (12-min) measure of cognitive ability. The 50 items on the WPT are based on those from the original *Otis Test of Mental Ability*, and scores correlate highly with full-scale IQ as measured by the *Wechsler Adult Intelligence Scale*, Third Edition ($r = .92$; McKelvie, 1989).

Procedure

After signing an informed consent form, each participant completed the WPT, and computerized versions of the BFI and PANAS. As a cover story, each participant was told that the next section of the study required manual administration, and would be completed simultaneously with another participant (a confederate). As part of this task, the participant and the confederate were brought together at a table with the experimenter to complete three commercially available puzzles: "Tangled Nails," "Tangoes," and "Crazy Blocks." For each of these puzzles, it typically requires between 2 and 5 minutes to discover the correct solution. The confederate was already familiar with the puzzle solutions, and could modify his or her behavior to contrast with the true participant's performance.

In the "participant success" condition, the confederate did not complete the puzzles until after the participant had already done so. In the "participant failure" condition, the confederate completed the puzzles quickly, and always prior to the participant. In the neutral condition, there was no confederate. The use of puzzles instead of a written or computerized task allowed the progress of both the participant and the confederate to be readily apparent to both parties. At no time was any type of competition or social comparison explicitly indicated, and no explicit performance feedback was given. Upon completion of the puzzle session, the participant returned to the original computer workstation, and was again asked to complete the PANAS, followed by the delay-discounting task. Participants were fully debriefed at the end of the experiment.

Results

The PANAS was characterized by high alpha reliability before (PA = .88, NA = .84) and after (PA = .93, NA = .89) the mood manipulation. Similar alpha reliabilities were obtained when independently examining the postmanipulation affect scores in the positive (PA = .94, NA = .83), negative (PA = .92, NA = .85), and neutral (PA = .88, NA = .95) conditions. No baseline differences were observed between the three groups for either positive, $F(2, 134) = 1.46$, $p = .24$, or negative affect, $F(2, 134) = 0.09$, $p = .91$. Postmanipulation differences, however, were observed across groups for positive affect, $F(2, 134) = 3.02$, $p < .05$, and negative affect, $F(2, 134) = 3.78$, $p < .05$. As a manipulation check, paired sample t tests were used to confirm the emotional consequences of the success and failure conditions. After the puzzle task, participants in the success condition were characterized by increased positive affect ($M_1 = 2.23$, $M_2 = 2.59$), $t(45) = 2.96$, $p < .01$, $d = 0.40$, with no significant change in negative affect, whereas participants in the failure condition were characterized by increased negative affect ($M_1 = 1.44$, $M_2 = 1.79$), $t(49) = 4.11$, $p < .01$, $d = 0.55$, and decreased positive affect ($M_1 = 2.47$, $M_2 = 2.23$), $t(49) = -2.59$, $p < .05$, $d = 0.28$. No significant changes in positive or negative affect were observed in the neutral condition. As situationally induced affect (rather than dispositional levels of affect) was the variable of interest, PANAS difference scores (Time 2 minus Time 1) were utilized in subsequent analyses.

Multiple regression analyses were employed to examine whether Extraversion interacted with positive affect to predict discounting behavior across the entire sample. As in previous research, discounting rates were smaller when using the large reward (mean $k = 0.0091$, $SD = 0.0501$) compared to the small reward (mean $k = 0.0415$, $SD = 0.1534$). Separate regressions were therefore employed to predict the discounting of small and large rewards, as well as overall discounting rates. Variables entered in the model were Extraversion, WPT performance, difference scores for positive and negative affect (postmanipulation minus premanipulation values), and the Extraversion by affect interaction terms. Table 1 displays the beta weights and significance values for all three regression analyses.

As found in previous studies, delay discounting was significantly predicted by Extraversion and cognitive ability. While no main effects were observed for situationally induced changes in positive or negative affect, Extraversion and induced positive affect interacted significantly in predicting discounting behavior. Both the main effects and the interaction term were stronger predictors in the large compared to the small reward condition. Probing the interaction for the overall discounting rate confirmed that Extraversion became a stronger predictor of discounting rates as levels of induced positive mood increased: For $Z = -1$, $\beta = -.20$, $p = .26$; for $Z = 0$, $\beta = .18$, $p < .05$; for $Z = 1$, $\beta = .56$, $p < .001$ (see Figure 1). In contrast, negative affect did not interact with Extraversion in predicting discounting behavior. Controlling for gender made no significant difference to the observed results, although the sample was biased somewhat toward female participants.

Discussion

As in previous studies, preferences for immediate gratification were positively associated with Extraversion and negatively associated with cognitive ability. Individual differences in Extraversion are thought to reflect the dispositional strength of "hot" incentive motivation systems, and differences in cognitive ability appear to reflect the strength of the "cool" cognitive-control networks involved in the pursuit of long-term goals. While measures of personality and cognitive ability reflect the dispositional strength of these networks, the present findings suggest that situational inductions of positive affect can also influence discounting behavior. In particular, induced positive affect interacted with Extraversion to predict a preference for immediate rewards. Previous research has suggested that discounting rates increase when "hot" motivational systems are situationally activated (Metcalfe & Mischel, 1999; Wilson & Daly, 2003), and the current results suggest that this affective influence is most pronounced for individuals with high levels of Extraversion.

Neuropsychologically, this interaction appears to be due to the increased sensitivity of extraverted individuals to the release of dopamine in response to reward cues (Cohen et al., 2005; Depue & Collins, 1999; Wacker et al., 2006). Positive affect is associated with an increased release of dopamine in the ventral striatum

Table 1
Standardized Regression Weights for Predicting Delay-Discounting Rates

	Small reward ($20)	Large reward ($1000)	Overall
Positive affect	.04	.04	−.02
Negative affect	−.03	.07	.06
Cognitive ability	**−.17***	**−.26***	**−.24***
Extraversion	**.17***	**.19***	**.18***
E × PA	**.18***	**.38***	**.36***
E × NA	.05	.12	.12

* Significant at $p < .05$. E = extraversion; PA = positive affect; NA = negative affect

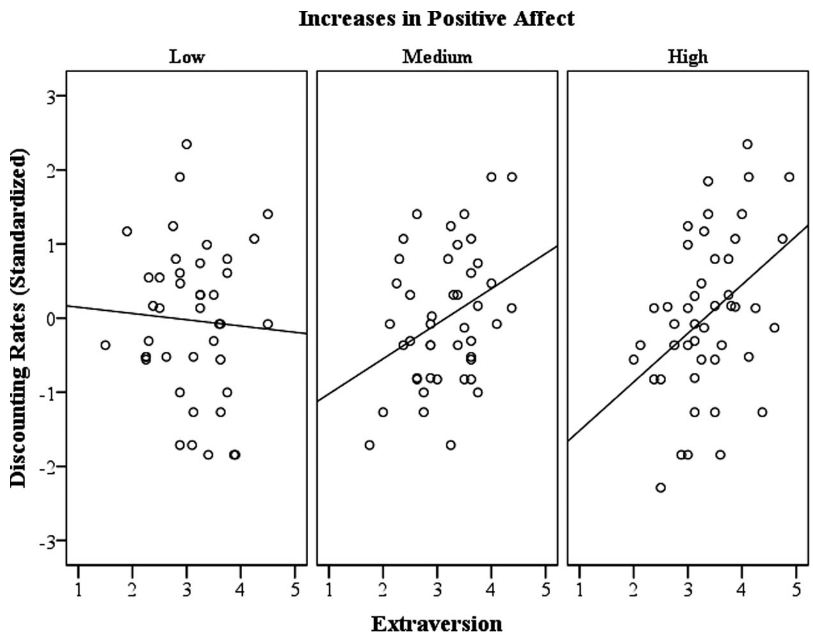

Figure 1. Scatterplots of extraversion and standardized delay discounting rates. The three panels reflect a tertiary split of the sample based on increases in positive affect as a result of the mood manipulation.

(Burgdorf & Panksepp, 2006). When extraverted individuals experience high levels of positive affect, the increased dopaminergic response to potential rewards appears to tilt decision-making processes even further toward a preference for immediate gratification. This finding is in keeping with neuropsychological models of intertemporal choice (McClure et al., 2004). In contrast, levels of negative affect did not influence the discounting rates of extraverts. It is worth noting that while the current study examined only general positive affect, it is possible that greater differentiation could be observed when looking at specific positive emotions. However, models of discounting behavior would predict that any approach-related emotional activity would have a similar effect.

It is worth noting that while positive mood inductions interacted with Extraversion in predicting discounting rates, there was no main effect for positive mood. In light of previous research linking states of “hot” emotional arousal to increased impulsivity (e.g., Metcalfe & Mischel, 1999), the lack of main effect for positive emotion in the current study might be due to the use of a relatively mild mood manipulation. This manipulation appears to have been sufficient to alter the decision making of extraverted individuals, who already have higher levels of dispositional positive affect driving their “hot” motivational systems. Extraverted individuals thus appeared to require smaller increases in positive mood to facilitate the observed behavioral consequences. It is possible that less extraverted individuals would require a stronger mood manipulation to produce the same behavioral effects (cf. Larsen & Ketelaar, 1989).

Positive affect is generally considered to be highly desirable. Indeed, high levels of positive affect have been associated with increased creativity (Isen, Daubman, & Nowicki, 1987), successful life outcomes (Lyubomirsky, King, & Diener, 2005), and personal growth and flourishing (Fredrickson, 2004). However, the current findings suggest that among extraverted individuals, who already have higher dispositional levels of positive affect, situational inductions of positive mood can bias decision making toward immediate rewards and away from long-term investments. From an evolutionary perspective, an increased focus on immediate rewards during periods of positive affect is a strategy for taking advantage of spontaneous opportunities as they arise (Wilson & Daly, 2004). Indeed, high levels of Extraversion have been linked with strategies that promote the immediate pursuit of available rewards over more cautious and deliberative approaches (Nettle, 2005). Although such impulsivity is designed to maximize immediate rewards, it can also have a number of negative long-term consequences, as reviewed earlier. The current results indicate that high levels of positive affect can serve to increase this reward-focused impulsivity among extraverted individuals.

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