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Now for Me, Later for Us? Effects of Group Context on Temporal Discounting

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Abstract

Delayed rewards are less valuable than immediate rewards. This well-established finding has focused almost entirely on individual outcomes. However, are delayed rewards similarly discounted if they are shared by a group? The current article reports on three experiments exploring the effect of group context on delay discounting. Results indicate that discount rates of individual and group rewards were highly correlated, but that respondents were more willing to wait (decreased discounting) for shared outcomes than for individual outcomes. An explanatory model is proposed suggesting that decreased discount rates in group contexts may be due to the way the effects of both delay and social discounting are combined. That is, in a group context, a person values both a future reward (discounted by delay) and a present reward to another person (discounted by the social distance between them). The results are explained by a combined discount function containing a delay factor and a factor representing the social distance between the decision maker and group members. Practical implications of the fact that shared consequences can increase individual self-control are also discussed.

Keywords

self-control; social cognition; social influences; delay of gratification

INTRODUCTION

Temporal discounting refers to a decrease in the subjective value of a reward because of delay (Bickel et al., 2007). The tendency to discount the value of future rewards can be understood by imagining the following two scenarios: (a) you just received a deposit of \$1000 into your checking account and (b) you just received a note telling you a \$1000 deposit will be made into your account in exactly 1 year. These two scenarios, while dealing with the same absolute amount of money, are not psychologically equivalent. Rather, the delayed deposit (b) is less valuable than the immediate deposit (a). The degree to which an amount of money is discounted as a result of delay is well described by the hyperbolic

model presented by Mazur (1987) (Kirby, 1997; Kirby & Markovic, 1995; Rachlin, Raineri, & Cross, 1991):

$$v = \frac{V}{1+kD} \quad (1)$$

As shown in Equation (1), the hyperbolic discounting model predicts that the discounted subjective value (v) of a reward is a function of the undiscounted value (V) of the reward divided by the effect of time. The effect of time is a product of both the delay to the outcome (D) and the individual discount rate (k). The greater is k , the larger is the impact of time (D) on the discounted value (v) of the outcome.

An extensive literature shows delay discounting to be a ubiquitous characteristic of real-world behavior that can reveal individual differences. Discount rates are positively correlated with substance abuse and dependence (Bickel & Marsch, 2001; Reynolds, 2006), needle sharing in opioid-dependent individuals (Odum et al., 2000), risky sexual behavior in college students (Chesson et al., 2006), and pathological gambling behavior (Dixon et al., 2003). Discount rates are negatively correlated with college grade point average (Kirby et al., 2005), financial planning and savings (Joieman et al., 2005), intelligence scores (Shamosh & Gray, 2008), and working memory (Bickel et al., 2011; Shamosh et al., 2008). All of these studies draw the same conclusion: the greater the behavioral dysfunction, the steeper the delay discount function (i.e., the larger the value of k).

Given the real-world correlates of delay discounting, it is important to understand the factors that influence individual discount rates. Rate of discounting is sensitive to demographic factors such as age (Green et al., 1994), gender (Kirby & Marakovic, 1996), and cultural background (Du et al., 2002). Rate of discounting is also sensitive to contextual parameters. For example, discount rates are lower for larger magnitude outcomes than smaller outcomes (the so-called *magnitude effect*; Green et al., 1997) and for certain commodity types (money) compared with others (food, alcohol; see Charlton & Fantino, 2008, for a review). Finally, discount rates are higher when the availability of the delayed alternative is presented in terms of time from the present rather than as an actual calendar date (Read et al., 2005).

Despite the breadth of work demonstrating the contextual and individual factors that influence discount rates, there have not been any studies on the effect that making a delayed choice for a group of persons rather than the self only might have on discounting. Many real-world decisions can be viewed as having either individual or group outcomes. The decision of an alcoholic to “have just one drink” can be viewed as either a personal choice or as a decision that will ripple across the entire family. Similarly, the decision to continue in school or drop out can be viewed either as individual preference or a family decision. Will reframing the discounting question so that the choice made by an individual decision maker influences a group of individuals, not just the decision maker, affect the rate of temporal discounting? The majority of the discounting literature is based on decision tasks that affect only the decision maker; little is known about intertemporal decision making when choice by an individual affects outcomes shared by others.

Although the discounting literature does not directly address this question, the wider psychological literature presents abundant evidence that the inclusion of others influences decision making (see Cialdini & Goldstein, 2004, for a review). For example, one method of increasing cooperative behavior in social dilemmas is to increase group identity (Simpson, 2006); Kramer and Brewer (1984; Brewer & Kramer, 1986) found that participants explicitly labeled as part of a common group cooperated more often than participants in a group with fewer shared interests. Similarly, Jackson (2008) found that group membership

promoted greater cooperation on experimental tasks, particularly when the in-group was perceived to be in the majority. An extensive literature demonstrates that opinions and attitudes often shift in the presence of others (e.g., *group polarization*; Myers & Lamm, 1976). Finally, the mere presence of others during the decision-making task influences the outcome of the decision. For example, the classic study of conformity conducted by Asch (1951) found that participants changed their responses in an easy choice task based on the presence, behavior, and characteristics of a social group.

This literature demonstrates that others are an important component of the decision context, suggesting that the inclusion of others in a delay discounting task should influence intertemporal decision making. Research conducted by Jones and Rachlin (2006; Rachlin & Jones, 2008, 2009) clearly showed that outcomes to others have subjective value, albeit discounted as a function of social distance. Their *social discounting* model is similar in form to the hyperbolic model of temporal discounting presented by Mazur (1987),

$$v = \frac{V}{1 + sN} \quad (2)$$

where v is the discounted value of the outcome, V is the undiscounted value, N is the social distance between the participant and the recipient, and s is the social discount rate, or degree to which the outcome's value is influenced by social distance. Rachlin and Jones (2008) found that participants were easily able to choose between delayed rewards for themselves and immediate rewards for another person. The shape of the function relating delay to social distance was predicted from the individual delay and social discount functions.

Given that discounting by delay and social distance share quantitative features and can be equated, how they combine when a reward is discounted by both delay and social distance may model the variation of discounting as a function of group context. A simple possibility is that social and delay discounts are combined multiplicatively as follows:

$$v = \frac{V}{(1 + kD)(1 + sN)} \quad (3)$$

Where both immediate and delayed outcomes are shared equally, as in the present experiments, s and N are constant, resulting in

$$v = \frac{V}{(1 + kD) \times \text{constant}} \quad (3.1)$$

Multiplying the denominator of a function by a constant changes the overall value (intercept) of the outcome but maintains the same relative spacing between values (same slope) compared with the equation without the constant. When considered as a proportion of V at $D = 0$, the multiplicative model predicts that the slope of the combined delay discount function for a group of people will be equal to that of a single delay discount function for one person. Summing the values to the self and others, the multiplicative model predicts the same discount rate for the group context as for the self (simulation shown in Figure 1; detailed algebra and a working demonstration of this model are shown in Appendix A).

An alternative possibility is that delay and social discounts are combined additively as follows:

$$v = \frac{V}{1 + sN + kD} \quad (4)$$

The additive account implies that social distance and delay are combined by addition (of social and delay discount factors), and the value is discounted by the combination. For a group sharing equally,

$$v = \frac{V}{1 + kD + \text{constant}} \quad (4.1)$$

Adding a constant to the denominator changes the overall value of the outcome (intercept) and changes the relative distance between values (slope) compared with the equation without the constant. When considered as a proportion of V at $D = 0$, the additive model predicts that the slope of the combined delay discount function for a group of people will be less than that of a single delay discount function for one person. Summing the values to the self and others, the additive model predicts a lower discount rate for the group compared with the self (Figure 1; Appendix A).

A corresponding flattening of the hyperbolic delay discount function (reduced k) has been found when a fixed delay is added to the varied delay (e.g., Green, Myerson, & Macaux, 2005; Rachlin & Green, 1972); this flattening of the discounting curves has been held to be responsible for the crossing of temporal discount functions that, in turn, explains delay preference reversals (Loewenstein & Prelec, 1992). In other words, the additive model indicates that giving a reward to another person is similar (in its effect on value for a person) to delaying the reward for that person. The common effect is a reduction in the slope of the delay discount curve. Note that when the decision maker shares a reward with one other person who is close enough to the decision maker so that N_1 is effectively zero (mother and child, husband and wife, etc.), then both multiplicative (Equation (3)) and additive (Equation (4)) models would reduce to the standard hyperbolic temporal discounting model (Equation (1)), resulting in identical slopes for individual and group delay discounting. Appendix A applies the multiplicative and additive models to the specific procedure of the present experiments.

Several theoretical accounts of social and individual relationships have stressed the analogy between the interests of other people and one's own interests at a later time (Ainslie, 1992; Rachlin, 2000, 2002; Read, 2001; Trope & Liberman, 2003). These accounts imply that a person's future self is in essence like another person. If the slopes of the group delay discount functions of the present experiments are found to be less than the slopes of individual delay discount functions (all else held equal), this finding would constitute some (but not conclusive) evidence for these theoretical accounts. Such a finding, however, would be strong evidence against a multiplicative account.

EXPERIMENT 1: TESTING FOR THE EFFECT OF TOTAL SHARED OUTCOME

Method

Thirty-two college students volunteered to complete two paper-and-pencil-based temporal discounting questionnaires in exchange for extra credit points in one of their psychology courses. Each participant (within-subject) completed a temporal discounting questionnaire with outcomes for the participants themselves (individual temporal discounting (ITD)) and a

questionnaire where the outcomes were for a group of 10 persons, including the participant (group temporal discounting (GTD)). The questionnaires were modeled on the 27-item Monetary Choice Questionnaire presented by Kirby et al. (1999). For each item in the questionnaires, participants were required to indicate preference between hypothetical monetary outcomes available either immediately (option A) or after a specified delay (option B). Based on the pattern of responses to these questions, discount rates were estimated for each participant for both the ITD and GTD questions. For example, the first item on the ITD presented the choice of \$54 right now or \$55 in 186 days. In the GTD condition, participants were presented the choice of \$540 to be split evenly between 10 persons right now or \$550 to be split evenly between 10 persons in 186 days (for the exact question values and an explanation of how discount rates are estimated, see Appendix B; also, see Kirby et al., 1999, for additional details).

In the ITD condition, each choice option was followed by the phrase “for you alone.” For example: (A) \$34 now for you alone or (B) \$35 in 186 days for you alone. For the GTD condition, participants were instructed that the group outcome would be *equally divided* 10 ways between themselves and 9 unknown others. Additionally, the outcomes of the ITD were multiplied by 10, and the phrase “for the group” replaced “for you alone” (although participants were instructed that the group outcome would be split evenly, it was presented as a single lump sum). For example: (A) \$340 now for the group or (B) \$350 in 186 days for the group. *If participants evaluated only the outcomes they themselves obtained from their choices, ignoring the outcomes to the unknown others, the ITD and GTD conditions would be identical.* The order of the two discounting conditions was counterbalanced. After completing the first discounting task, participants completed a decomposed prisoner’s dilemma (PD) game (Messick & McClintock, 1968; Van Lange et al., 1997). This “game” classifies participants into three social orientations: Prosocial, Individualistic, and Competitive. The decomposed PD task served as a distracter task as it is sufficiently different from either the ITD or GTD and was completed between the two discounting tasks (statistical analysis confirmed that the decomposed PD task did not correlate with either the ITD or GTD task). This task was common across groups and cannot explain group differences.

Discount rates were determined at three different magnitudes (small: \$25–\$35, medium: \$50–\$60, and large: \$75–\$85) as in those in the study by Kirby et al. (1999). As applied to the present data, in cases where delay and social discounting are combined, obtained discount rates do not necessarily yield the k -values of the simple delay discount function (Equation (1)) for which the method was originally devised. Rather, obtained k -values are summary measures of v in Equations (3.1) and (4.1). Nevertheless, the ordinal qualities of the obtained k -values are preserved; higher obtained k -values indicate steeper discounting. Henceforth, we call the obtained k -values k' to distinguish them from k in Equations (1)–(4). The inclusion of three magnitudes of delayed outcomes on each procedure served as a manipulation check for both the ITD and the GTD conditions as this measure typically reports decreasing discount rates from the smallest to largest magnitude outcomes (the *magnitude effect*).

Results

Although putatively associated with social discounting, data from the decomposed prisoner’s dilemma game were not associated with any measures and are not discussed further. All analyses of discount rates were conducted using natural-logarithm transformed k' -values. The relationship between discount rates from ITD and GTD, analyzed with Pearson correlations for the small, medium, and large magnitudes ($r = +.477, p < .005$; $r = +.686, p < .0001$; $r = +.289, p > .05$), indicated that individuals who highly discount delayed rewards for themselves also highly discount delayed rewards for the group (Figure 2).

Individual temporal discounting and GTD were compared using a 2 (condition)×3 (magnitude) repeated-measures analysis of variance (ANOVA). Significant main effects of condition ($F(1,31) = 65.15, p < .0001, \eta^2 = .678$) and magnitude ($F(2, 62) = 25.66, p < .0001, \eta^2 = .453$), with a non-significant interaction ($F(2, 62) = 2.30, p > .05, \eta^2 = .069$), indicated that the discount function slopes were less in GTD compared with ITD while exhibiting the magnitude effect (greater slopes for smaller magnitude outcomes; Figure 2, left panel) within each procedure. Follow-up tests revealed significant differences between the following magnitude conditions: medium and large ($p < .0001$); small and large ($p < .0001$).

Discussion

The present analyses confirmed (1) a strong and positive relationship between temporal discounting by participants within individual and group contexts and (2) reduced temporal discounting (shallower slopes; lower k -values) when a group context indicates that decisions will affect others. Both of these outcomes are consistent with predictions made by the additive model, Equation (4). The observation of a difference between ITD and GTD is interesting given that the social distance (N) between the nine anonymous others and the participant might be expected to be quite large. Given the association between high temporal discount rates and various problem behaviors, the reduction of discounting as a function of group context may have significant implications for the minimization of such behaviors.

There is an alternative interpretation for the reduced discounting in GTD: the *direct magnitude effect*. The present form of the discounting questionnaire is sensitive to the *magnitude effect*, as can be seen in the comparison of the small, medium, and large outcomes. Thus, the possibility exists that if the participant did not adequately consider that outcomes were split evenly in the GTD condition, the impact of the larger magnitudes listed might have elicited an essential *magnitude effect*. Experiment 2 addressed this possibility.

EXPERIMENT 2: TESTING AN ALTERNATIVE EXPLANATION: MAGNITUDE EFFECT

To explore the possibility of the *magnitude effect* as a possible alternative explanation of the observed results of Experiment 1, the same magnitudes were presented in both the ITD and GTD conditions. If the *magnitude effect* alone is responsible for the results of Experiment 1 and the group context has no effect, then the same discount rates should be observed in both conditions.

Method

Thirty-two college students completed the ITD and GTD questionnaires and received course credit in the psychology department. All elements of Experiment 2 were identical to those of Experiment 1, except the magnitudes of outcomes in the ITD condition were increased to be equivalent to the GTD condition (all ranging from \$110 to \$850). Participants were instructed that the amount in the ITD condition was for the participant alone and that the total in GTD would be divided equally among the participant and nine others. As with Experiment 1, participants completed both the GTD and the ITD surveys.

Results

Pearson correlations once again confirmed a strong relationship between discounting in the individual and group contexts ($r = +.59, p < .0005$; $r = +.601, p < .0005$; $r = +.463, p < .01$ for the small, medium, and large magnitudes, respectively). ITD and GTD were compared using a 2 (condition) 3 (magnitude) repeated-measures ANOVA, which revealed a significant main effect of condition ($F(1, 31) = 7.34, p = .011, \eta^2 = .198$), a significant main effect of magnitude ($F(2, 62) = 4.64, p = .013, \eta^2 = .130$), and non-significant interaction ($F(2, 62) =$

1.50, $p > .05$, $\eta^2 = .046$). Specifically, discount rates were lower in GTD than in ITD (Figure 3, center panel). Follow-up tests revealed significant differences between the following magnitude condition: small and large ($p < .05$).

Discussion

As in Experiment 1, significant correlations were observed between discount rates in the ITD and GTD conditions and the rate of discounting was lower in the GTD than the ITD condition. The hypothesis that the *magnitude effect* might explain the differences observed in ITD and GTD in Experiment 1 was disconfirmed. If the *magnitude effect* was the reason that individuals in GTD discount less, then identical discount rates should have been observed in the ITD and GTD conditions of the present experiment because the same magnitudes were employed in both. Surprisingly, not only was there a difference between the two conditions but also discounting in GTD continued to be significantly less than in ITD even though the outcomes to the individual were substantially less in GTD than in ITD condition (if participants considered only outcomes to themselves).

EXPERIMENT 3: GROUP CONTEXT EFFECT REVISITED – SEPARATE BUT EQUAL OUTCOMES FOR THE GROUP

Although Experiment 2 provides evidence that the group context has a significant impact on temporal discounting, another condition may provide conclusive evidence that social context affects individual delay discount functions; the GTD alternatives can be presented as some amount for each of 10 individuals rather than some amount divided 10 ways (Appendix B provides a summary of the framing of the GTD and ITD conditions across the three experiments). Presenting the information as the amount available to each individual eliminates the need for the participant to mentally calculate her individual outcome, eliminates the possibility that the participant misconstrues the possibility that their share of the final outcome is negotiable, and places an emphasis on the similarity in the outcomes across the ITD and GTD tasks. Given that the same magnitudes can be presented in ITD and GTD, this comparison would rule out the *magnitude effect* as an alternative explanation for the group context effect.

Method

One hundred eight college students completed the ITD and GTD questionnaires and received course credit in the psychology department. All elements of Experiment 3 were identical to Experiment 1, except (1) the choice options in the GTD were presented as (A) \$X for each of the 10 members of the group right now and (B) \$Y for each of the 10 members of the group in [DELAY] and (2) the magnitudes were equal to the ITD condition. All other procedures remained the same. Instructions clearly stated that the group consisted of nine unknown others plus the participant (10 members total).

Results

Pearson correlations once again confirmed a strong relationship between discounting in the individual and group contexts ($r = +.774$, $p < .0001$; $r = +.825$, $p < .0001$; $r = +.742$, $p < .0001$ for the small, medium, and large magnitudes, respectively). ITD and GTD were compared using a 2 (condition) $\times$ 3 (magnitude) repeated-measures ANOVA, which revealed a significant main effect of condition ($F(1, 107) = 15.54$, $p = .0001$, $\eta^2 = .127$), a significant main effect of magnitude ($F(2, 214) = 121.54$, $p < .0001$, $\eta^2 = .531$), and non-significant interaction ($F(2, 214) = .22$, $p > .05$, $\eta^2 = .002$). As expected and consistent with the additive model (Equation (4)), less discounting was observed in the GTD condition compared with the ITD (Figure 3, right panel). Follow-up tests revealed significant differences between the

following magnitude conditions: small and medium ($p < .0001$); medium and large ($p < .0001$); small and large ($p < .0001$).

Discussion

As in the previous experiments, a correlation was evident between intertemporal decision making in individual and group contexts and the group context produced a decrease in the discount rate. A direct *magnitude effect* cannot be offered as an alternative explanation for the present results given that the same magnitudes were employed in both the ITD and GTD tasks.

However, comparison of GTD across the three experiments indicates that magnitude does play a role. Although the effective outcomes for the participant in GTD across three experiments were identical, discounting was significantly less when the group outcome was presented as a large sum divisible by 10 rather than a smaller sum to each of the 10 group members. The combination of the ITD/GTD comparisons and the GTD conditions across experiments indicates that both the group context and *magnitude effect* contribute to the reduction in discounting when a group outcome is presented as a divisible lump sum.

GENERAL DISCUSSION

The current studies demonstrate that the *slopes* (k') of the discount functions are shallower in the group context (GTD) than the individual (ITD). The results of these experiments are consistent with an additive model of how delay and social discounting are combined and inconsistent with the multiplicative model (see Appendix A for both a mathematical explanation of these predictions and a simulation of the outcomes). The additive model (Equation (4)) implies that delayed outcomes are relatively more valuable (lower slopes, less discounting) when others are involved in a discount decision—because of the addition of social to delay discounting. Such a finding is consistent with the speculations of psychologists, economists, and philosophers who view the overlap of interests between a person's present and future selves as commensurate with the overlap of interests between a person and others (Ainslie, 1992; Parfit, 1984; Rachlin, 2000, 2002; Read, 2001; Simon, 1995; Trope & Liberman, 2003). Although the present study did not specify the degree of overlap between the individual and the remaining group members, participants' choices undoubtedly indicate some degree of overlapping interests. Perhaps the identification of the individuals as members of a group was adequate, implying commonalities between group members on some dimension (e.g., college students). Nonetheless, even when the identity of others in the context of a group decision is unknown, individuals ascribe some value to rewards obtained by those others.

In addition to the predictions tested in this paper, the group context model will allow for future studies exploring the parameters of the group context effect. Initially, the degree to which social groups influence discount rates should be a function of group size. Specifically, as the size of the group increases, the rate of discounting should decrease. Furthermore, the impact of group context should influence group membership/identity. Specifically, the additive model implies that rate of discounting should increase as social closeness (elevated membership/identity) decreases. If there is a high degree of overlap between the welfare of another person and one's self, then the temporal discounting for that other person would be the same as temporal discounting for one's self, with nearly zero distance added resulting from social distance. If there is a low degree of overlap between the person and the self, then a large social distance will be added to the overall distance. Correspondingly, *temporal* discount functions in which the delay factor is added to lower *social* distance factors will be steeper than temporal discount functions in which the delay factor is added to higher social distance factors; high closeness to the group should result in higher group temporal discount

rates (albeit lower in absolute height) than low closeness to the group. The specific predictions generated by the group context model are appropriate for continued research.

In addition to studies exploring the predictions of the additive model (Equation (4)), it would be valuable to understand the role of social context across groups that show differences in discount rates for individual outcomes. For example, substance abusers discount at greater rates than do non-substance abusing controls. Would this population similarly discount less when provided the future outcomes in a social frame? Similarly, Rounds et al. (2007) reported that individuals with high levels of social anxiety discount the future more rapidly than participants with low levels of social anxiety (under a non-threat condition). Given the characteristics of this population, would a social frame decrease, or increase, discount rates?

Although the experiments reported here found consistent and robust effects, future studies can improve on the current methodology. First, the generality of the group discounting effect needs to be demonstrated with real outcomes. Several studies demonstrate no significant difference between hypothetical and real outcomes in individual social discounting tasks (Locey, Jones, & Rachlin, 2011) and delay discounting tasks at both the behavioral level (Johnson & Bickel, 2001; Madden et al., 2003; Madden et al., 2004) and at the neurological level (Bickel et al., 2007). Nevertheless, it is possible that participants will perform differently in combined social-delay contexts when real money is involved. Second, the current studies were completed with undergraduate students in a group setting. It is possible that performance in the social context was influenced by the close proximity of others and/or the potential for social referencing.

Despite these methodological issues, the outcomes of this series of studies have practical as well as theoretical implications. The consistency of these findings allow us to conclude that shared consequences can have a positive influence on individual behavior and suggests that the presentation of discounting tasks as group outcomes may be a method for decreasing impulsive decision making. Although we may be willing to engage in suboptimal decision making when the decisions affect only ourselves, we may be more likely optimize our behavior when the decisions affect others as well. For example, several successful treatment programs employ an informal version of this concept. Alcoholics Anonymous and Weight Watchers both create a social in-group where the participant's progress is monitored and celebrated by the entire group. It may be that a factor contributing to the success of these groups is the shared value of future outcomes across group members.

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APPENDIX A

1. MATHEMATICAL EXPLANATION OF THE MULTIPLICATIVE AND ADDITIVE MODELS

The calculation of outcome for the self or for another person can be modeled using either a multiplicative (Equation (3)) or an additive approach (Equation (4)). As discussed in the introduction, how the temporal and social distances are combined in calculating the value of the group outcomes has important implications for the current experiments. The material below explains the mathematical reasoning behind the predictions of the multiplicative and additive models.

Multiplicative model (Equation (3))

Suppose a person (P_0) is sharing a reward (of amount nV) equally with n other people ($P_1, P_2, \dots, P_n$) and that the value for P_0 is the sum of the discounted values of her own and all of the other people's rewards. The multiplicative model assumes

$$v = v_0 + v_1 + \dots + v_n = \frac{V_0}{1+kD_0} + \frac{V_1}{(1+kD_1)(1+sN_1)} + \dots + \frac{V_n}{(1+kD_n)(1+sN_n)}$$

where N_n is the social distance between P_0 and P_n . If V and D are the same for all sharers (as in the current experiments):

$$v = v_0 + v_1 + \dots + v_n = \frac{V}{1+kD} + \frac{V}{(1+kD)(1+sN_1)} + \dots + \frac{V}{(1+kD)(1+sN_n)}$$

$$v = v_0 + v_1 + \dots + v_n = \frac{V}{1+kD} \left(1 + \frac{1}{1+sN_1} + \frac{1}{1+sN_2} + \dots + \frac{1}{1+sN_n} \right)$$

When delay is varied as in typical studies of delay discounting, the second term in the previous equation (in parentheses) is constant (M). The inclusion of the constant M in the discounting equation changes the absolute value of the outcome but maintains the same *relative* spacing between the outcomes; thus, the multiplicative model predicts that the slope of the combined delay discount function (k) for a group of people will be equal to that of a single delay discount function for one person.

Additive model (Equation (4))

As with the previous discussion, assume that a reward is being shared between the decision maker and n other persons. The additive model assumes the value of this outcome to be

$$v = v_0 + v_1 + \dots + v_n = \frac{V}{1+kD} + \frac{V}{1+sN_1+kD} + \dots + \frac{V}{1+sN_n+kD}$$

When N is non-zero and N is fixed, a constant is added to the denominator for each outcome to another person. The result of the *added* constant is that the *relative distance* between the outcomes is decreased compared with an individual decision. The inclusion of the social discounting constant in the denominator reduces discounted value (v_n), increasing the absolute degree of discounting. However, the *slope* of the discount function relating normalized value to delay (with constant s) is predicted to be *less* with greater added constants in the denominator (more socially distant individuals).

2. SIMULATION OF THE MULTIPLICATIVE AND ADDITIVE MODELS

The table below simulates the predictions made by Equation (1) (discounting for the self), Equation (3) (the multiplicative model), and Equation (4) (the additive model) for a \$100 reward as the delay to its occurrence increases from immediate to 1 year (in approximate 1-month increments). The predictions under the heading "Other" model the multiplicative (Mult) and additive (Add) equations for another person. The predictions under the heading "Group of 10" are the predictions for a group consisting of the decision maker (self) and nine others. The two columns under the heading "Group of 10" model are the choice

contexts used in the current experiments. Finally, the three columns under the heading “Proportion of V” show the relative change for the individual choice (self) compared with the group choice (Group of 10 columns).

Delay (days)	Other			Group of 10		Proportion of V		
	Self	Mult	Add	Mult	Add	Self	Mult	Add
0	100.00	28.57	28.57	357.14	357.14	1.00	1.00	1.00
30	40.00	11.43	20.00	142.86	220.00	0.40	0.40	0.62
60	25.00	7.14	15.38	89.29	163.46	0.25	0.25	0.46
90	18.18	5.19	12.50	64.94	130.68	0.18	0.18	0.37
120	14.29	4.08	10.53	51.02	109.02	0.14	0.14	0.31
150	11.76	3.36	9.09	42.02	93.58	0.12	0.12	0.26
180	10.00	2.86	0.00	35.71	82.00	0.10	0.10	0.23
210	8.70	2.48	7.14	31.06	72.98	0.09	0.09	0.20
240	7.69	2.20	6.45	27.47	65.76	0.08	0.08	0.18
270	6.90	1.97	5.88	24.63	59.84	0.07	0.07	0.17
300	6.25	1.79	5.41	22.32	54.90	0.06	0.06	0.15
330	5.71	1.63	5.00	20.41	50.71	0.06	0.06	0.14
360	5.26	1.50	4.65	18.80	47.12	0.05	0.05	0.13

$V=100; k=0.05; s=0.5; N=5.$

Four main conclusions can be drawn from the aforementioned simulation:

1. The value of the outcome for another is viewed as less valuable than the outcome for the self.
2. The multiplicative model predicts greater discounting than the additive model.
3. The relative rate of change for an outcome to the self and to either another or a group of 10 is identical when modeled using the multiplicative model.
4. The relative rate of change for an outcome to another or a group of 10 is *less* than for the self when calculated using the additive model.

APPENDIX B

MCQ: ITEMS AND DISCOUNT RATE ESTIMATION

The table below presents the 27 questions of the Monetary Choice Questionnaire (MCQ) as they appeared on the individual temporal discounting (ITD) measure for Study 1. For simplification, the questions are sorted by magnitude and Discount Rate. The Order column identifies the ordering of questions on the actual measure (adapted from Table 3, Kirby et al., 1999).

Order	Immediate	Delayed	Magnitude	Discount rate
13	\$34 right now	\$35 in 186 days	Small	.00016
20	\$28 right now	\$30 in 179 days	Small	.0004

Order	Immediate	Delayed	Magnitude	Discount rate
26	\$22 right now	\$25 in 136 days	Small	.001
22	\$25 right now	\$30 in 80 days	Small	.0025
3	\$19 right now	\$25 in 53 days	Small	.006
18	\$24 right now	\$35 in 29 days	Small	.016
5	\$14 right now	\$25 in 19 days	Small	.041
7	\$15 right now	\$35 in 13 days	Small	.1
11	\$11 right now	\$30 in 7 days	Small	.25
1	\$54 right now	\$55 in 186 days	Medium	.00016
6	\$47 right now	\$50 in 160 days	Medium	.0004
24	\$54 right now	\$60 in 111 days	Medium	.001
16	\$49 right now	\$60 in 89 days	Medium	.0025
10	\$40 right now	\$55 in 62 days	Medium	.006
21	\$34 right now	\$50 in 30 days	Medium	.016
14	\$27 right now	\$50 in 21 days	Medium	.041
8	\$25 right now	\$60 in 14 days	Medium	.1
27	\$20 right now	\$55 in 7 days	Medium	.25
9	\$78 right now	\$80 in 162 days	Large	.00016
17	\$80 right now	\$85 in 157 days	Large	.0004
12	\$67 right now	\$75 in 119 days	Large	.001
15	\$69 right now	\$85 in 91 days	Large	.0025
2	\$55 right now	\$75 in 61 days	Large	.006
25	\$54 right now	\$80 in 30 days	Large	.016
23	\$41 right now	\$75 in 20 days	Large	.041
19	\$33 right now	\$80 in 14 days	Large	.1
4	\$31 right now	\$85 in 7 days	Large	.25

In general, the discount rate for each magnitude was calculated as the midpoint (geometric mean) between the discount rate for the last question where the delayed outcome was selected and the first question where the immediate outcome was selected for the nine questions at that magnitude. For full details on how the discount rates for these experiments were estimated using the MCQ, see Kirby et al., 1999, pp. 80 – 81.

MCQ: Item modification for the ITD and GTD presentation across Experiments 1, 2, and 3

The information below presents an illustrative example of how the ITD questions from the aforementioned table were modified for each of the three studies. Note that the same modification was used for all 27 items and that participants were always instructed that the outcome in the GTD condition would be split evenly between 10 individuals (the participant plus nine unknown others).

Experiment 1: GTD values presented as a lump sum equal to 10 times the ITD values

ITD: \$34 right now; \$35 in 186 days

GTD: \$340 to be split 10 ways right now; \$350 to be split 10 ways in 186 days

Experiment 2: ITD and GTD values both presented as 10 times the standard ITD values

ITD: \$340 right now; \$350 in 186 days

GTD: \$340 to be split 10 ways right now; \$350 to be split 10 ways in 186 days

Experiment 3: ITD and GTD values both presented as the standard ITD values

ITD: \$34 right now; \$35 in 186 days

GTD: \$34 for each of the 10 group members right now; \$35 for each of the 10 group members in 186 days.

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Figure 1.

The three lines model the value of the individual (Self; X) and group (self + nine anonymous others) outcomes using both the multiplicative (Mult; open circles) and additive (Add; closed diamonds) equations. The subjective value is represented as a proportion of the value at time $D=0$. Note that the change in value for the group outcome modeled with the multiplicative model and the individual context show the *same* rate of discounting ($k = .050$), whereas the rate of discounting for the additive model is slower ($k = .019$).

Figure 2.

Scatterplots, with linear regression lines, of log-transformed discount rates from the individual temporal discounting task (ITD, x -axis) and the group temporal discounting task (GTD). The left, center, and right panels represent the small, medium, and large magnitude outcomes, respectively. All correlations are positive

Figure 3.

Mean log-transformed discount rates as a function of condition, with dark bars representing the individual temporal discounting task (ITD) and the light bar representing the group temporal discounting task (GTD). The left, center, and right panels represent Experiments 1, 2, and 3, respectively. Discount rates are significantly lower in the GTD condition in all experiments.