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Social Discounting and Delay Discounting

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ABSTRACT
Social discounting was measured as the amount of money a participant was willing to forgo to give a fixed amount (usually $75) to another person. In the first experiment, amount forgone was a hyperbolic function of the social distance between the giver and receiver. In the second experiment, degree of social discounting was an increasing function of reward magnitude whereas degree of delay discounting was a decreasing function of reward magnitude. In the third experiment, the shape of the function relating delayed rewards to equally valued immediate rewards for another person was predicted from individual delay and social discount functions. All in all, the studies show that the social discount function, like delay and probability discount functions, is hyperbolic in form. Copyright © 2007 John Wiley & Sons, Ltd.

KEY WORDS discounting; delay discounting; hyperbolic discounting; magnitude estimation; probability discounting; social discounting

INTRODUCTION
Twentieth-century economists, such as Akerlof (1997), Becker (1981), and Simon (1995) have attempted to take some of the mystery out of the concept of altruism by incorporating altruism into utility functions or discount functions. Simon suggested that a person’s allocation of available goods can be described in terms of a three-coordinate system: (a) current consumption by the person herself, (b) consumption by the same person at later times [delay discounting], and (c) consumption by other people [social discounting]. He said: “Instead of a one-dimensional maximizing entity, or even the two-dimensional individual who allocates intertemporally, this model envisages a three-dimensional surface with an interpersonal ‘distance’ dimension replacing the concept of altruism” (p. 367). The word “distance” was properly put in quotes by Simon because there was then no existing scale by which interpersonal, or social, distance might be measured. The present experiments, and those previously reported by Jones and Rachlin (2006), form the basis for the establishment of such a scale and relate it to well-established measures of delay discounting.

Simon’s three-dimensional discounting space implies that consistent tradeoffs can be made between one discounted reward and another. That is, a person should be able to choose consistently among $X for herself available immediately, $Y for herself delayed by 1 month, and $Z to be given to her sister tomorrow. One

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apparent problem with this conception is that social distance itself is multidimensional. Familiarity, affection, blood relationship, common interest, and physical proximity all may be reasonably expected to enter into social distance. Which of these variables determines how much of some good one person will allocate to another? Jones and Rachlin (2006) avoided breaking down social distance to its components and just asked participants to judge the resultant—social distance itself. Participants were first asked to imagine that they had made a list of the 100 people closest to them (without actually making the list). Social distance was assumed to be equal to ordinal position on the list. Then participants were asked to choose between amounts of money for themselves and (usually, but not always, lesser) amounts to be given to people at various social distances thus defined. The form of the obtained social discount function, like that of commonly obtained delay discount functions (Green & Myerson, 2004), was hyperbolic.

Perhaps because Simon was modeling allocation of fixed amounts of goods, he did not consider a third mode of discounting—probability discounting (Kahneman & Tversky, 1979; Rachlin, Logue, Gibbon, & Frankel, 1986)—the degree to which reward value decreases as its probability decreases. But people can choose consistently among delayed and probabilistic rewards. Also, probability discounting, like delay discounting, is hyperbolic (Green & Myerson, 2004; Raineri & Rachlin, 1993).

A hyperbolic function that describes the results of empirical studies of delay and probability discounting expresses discounted value $v$ of rewards of value $V$ as follows (Rachlin, 2006):

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

$$v = \frac{V}{1 + k\theta}$$  \hspace{1cm} (2)

where $v$ and $V$ are discounted and undiscounted reward values, and the discounting variable is delay ($D$) as in Equation 1 or odds against $[\theta = (1 - p)/p]$; $p$ = probability] as in Equation 2, and $k$ and $s$ are parameters.

According to Equation 1, the current value of a given reward at a given delay varies inversely with $k$. Equation 1 says that a person with a low individual $k$-value is more likely to prefer a given larger-later reward to a given smaller-sooner reward than is a person with a high individual $k$-value. A general preference for larger-later over smaller-sooner rewards may be defined as good self-control or lack of impulsivity (Ainslie, 1992; Rachlin, 2000).

Consider how the value of a single reward varies as its delay elapses according to Equation 1. Let us set a time counter at zero at the beginning of a specific delay ($t = 0$). As time passes, $t$ increases until $t = D$, at which time the reward is obtained:

$$v_c = \frac{V}{1 + k(D - t)}$$  \hspace{1cm} (3)

where $v_c$ is the current value of the reward during the delay. The term $(D - t)$ is the time remaining or “time left” or “waiting time.” Equation 3 says that as time passes during the delay period (as the denominator decreases), the value of the delayed alternative ($v_c$) grows. That is, value varies inversely with waiting time.

Green and Myerson’s (2004) hyperbolic delay discounting equation is:

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

Except at low values of $D$ this form of the equation is virtually congruent with Equation 1. When $s = 1$, as has been found with social discounting, and with delay discounting by pigeons (Mazur, 1987), the two forms are identical. We prefer Equation 1 because of its consistency with Stevens’ (1957) psychophysical power law and with psychological and economic choice theories (Rachlin, 2006).
We may ask whether the time left to reward (or waiting time) can directly influence behavior. Gibbon and Church (1981) found that choices of nonhumans are highly sensitive to the time left to reward as a waiting period elapses; the delay of gratification studies of Mischel, Shoda, and Rodriguez (1989) show that human children are sensitive to this variable as well. One problem caused by real-world hyperbolic discounting is that, because time left (along with reward magnitude) determines value, two alternative rewards of equal current values but with different times left will necessarily come to differ in value as time passes. Hyperbolic discount functions thus may cross. Crossing delay discount functions may cause problems in self-control because an initial preference for a larger-later reward may reverse, as time passes, to a preference for a smaller-sooner reward (Ainslie, 1992).

Delay discount functions other than Equation 1 have been proposed. One such is the exponential function:

\[ v = V e^{-kD} \]  

(4)

Exponential functions are used in economics to calculate continuously compounded interest. The current principal plus interest grows over time by a constant fraction of its current value regardless of when in the past it was deposited and when in the future it will be withdrawn. A useful feature of exponential discount functions is that since current value and interest rate are sufficient to determine future value, the value of two alternatives (differing in overall amount and delay) of equal current value and with the same interest rate will remain equal over time regardless of their differing delays. Thus, exponential discount functions with the same interest rate can never cross; if people discounted future rewards exponentially they would have no problems of self-control. The fact that people almost universally do have problems of self-control is prima facie evidence that they do not discount delayed rewards exponentially. Moreover, hyperbolic discount functions have almost always described choices among delayed (and probabilistic) rewards significantly better than have exponential discount functions (Green & Myerson, 2004).

The hyperbolic form of delay and probabilistic discounting is implied by a generalized form of Herrnstein’s (1961) matching law (Baum, 1974). The matching law expresses the relative value of a choice alternative as the product of relative magnitude, immediacy (the inverse of delay), overall rate, and whatever other variable (such as odds against) may be found to influence choice—each exponentiated by \( s \), representing sensitivity of choice to the variable in question. The precise form of the matching equation has been a matter of recent debate but the dependence of the subjective value of an alternative on a power function of its physical value has been repeatedly upheld in both human and nonhuman choice experiments (Baum, 1979). Equation 5, a form of matching, expresses relative value of two delayed rewards as a function of their subjective immediate values (where subjective values are power functions of physical values) and the inverse of their subjective immediacies:

\[ \frac{v_1}{v_2} = \frac{V_1}{V_2} \left( \frac{1 + D_2^s}{1 + D_1^s} \right) \]  

(5)

The experiments by which discount functions are typically obtained are choice experiments where the magnitude of an immediate smaller reward equal in value to a series of larger delayed reward is determined. In Equation 5, if reward-two is immediate, \( v_2 = V_2 \) and \( D_2 = 0 \). This yields the delay discount function, Equation 1. But, of course, the validity of the equation is an empirical issue, not a theoretical one, and Equation 1 has considerable empirical support with both human and nonhuman discounters (Green & Myerson, 2004).

Consistent with the above, Raineri and Rachlin (1993) speculated that a reward to another person at some specified social distance might enter into the matching equation just as the magnitude and delay of a reward to the chooser himself or herself enters into it and that the form of Equation 1 might be applied to social discounting as well as delay and probability discounting as follows:

\[ v = \frac{V}{1 + kN^s} \]  

(6)
where \( v \) and \( V \) are discounted and undiscounted value as in Equations 1 and 2, \( N \) is a measure of social distance (the inverse of social closeness), and the exponent \( s \) and coefficient \( k \), parameters determining sensitivity and degree of social discounting, or “selfishness.” Henceforth we will distinguish delay and social discounting parameters as \( k_{\text{delay}} \), \( k_{\text{social}} \), \( s_{\text{delay}} \), and \( s_{\text{social}} \).

Jones and Rachlin (2006) found that when participants chose whether to keep a certain amount of money for themselves or forgo some money so as to share with another person, the greater the social distance of the other person from the participant (\( N \)), the less money the participant was willing to forgo. That is, “generosity” was discounted by social distance. Social distance as thus measured is an ordinal scale, not a ratio scale. Nevertheless it has the property of beginning at zero (the participant himself or herself) and increasing indefinitely with social distance from the receiver. The dashed line in Figure 1 represents the fitting of Equation 6 to Jones and Rachlin’s data with \( s = 1.0 \), \( v = \text{money forgone} \), \( V = \$83 \) (the best-fitting value of \( v \) at \( N = 0 \)), and \( k = 0.052 \). The proportion of variance of the Jones and Rachlin (2006) data accounted for (\( R^2 \)) is 0.997. In the Jones and Rachlin experiment the “generous” alternatives always involved sharing: \$75 for the participant and \$75 for the \( N \)th person on the list. In the present Experiment 1, the “generous” alternatives did not involve sharing: just \$75 for the \( N \)th person on the list. That is, in Experiment 1, participants chose between an amount of money for themselves, with none for Person \( N \) (the “selfish” alternative), and an amount of money for person \( N \) with none for themselves (the “generous” alternative). The present series of experiments explores the parameters of social discounting to see whether social discounting has properties similar to those of delay discounting so that social distance might form a continuous discounting space with delay.

**EXPERIMENT 1**

Experiment 1 tests whether the form of the all-or-none discount function of the present experiment will be hyperbolic as it was in Jones and Rachlin (2006) where money was shared. If hyperbolic, would the discounting parameter \( k \) be the same whether or not the money was shared? In Jones and Rachlin’s experiment participants preferred giving \$75 to Person 1 on their lists (keeping another \$75 for themselves) to...
$155 for themselves alone—when they could have chosen the $155, given the same $75 to Person 1, and kept $80 for themselves. The equivalent choice for participants in Experiment 1 was more stark: $75 for Person 1 versus $80 for themselves. Experiment 1 therefore determined whether the “hyper-generous” choices found by Jones and Rachlin would be maintained when the alternatives were more distinct.

On the basis of relatively generous behavior typically found in experiments where participants shared rewards (Fehr & Schmidt, 1999), we believed that we would find more selfish behavior in the present experiment, where the alternatives were all-or-none, than in the Jones and Rachlin’s experiment. Nevertheless, it is an empirical question whether people will be any less generous when choosing all-or-none between money for themselves versus money for someone else than they would be when choosing between money for themselves versus sharing with someone else.

Participants
Two-hundred-forty-two Stony Brook University undergraduates (111 male, 131 female) were given a series of written questions. Participants, students in an introductory psychology class, were tested all at once in a classroom.

Procedure
Each participant answered questions in a booklet of 9 (8.5” × 11”) pages. The first page asked for gender, age, and frequency of smoking, drinking alcohol, and eating unhealthy meals. Answers to these questions did not vary sufficiently to provide meaningful relationships to discounting. The same questions were also asked in the subsequent experiments with similar inconclusive results and will not be discussed further.

The following instructions were printed on the second page of the booklet:

The following experiment asks you to imagine that you have made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at position #1 to a mere acquaintance at #100. The person at number one would be someone you know well and is your closest friend or relative. The person at #100 might be someone you recognize and encounter but perhaps you may not even know their name. You do not have to physically create the list—just imagine that you have done so.

Next you will be asked to make a series of judgments based on your preferences. On each line you will be asked if you would prefer to receive an amount of money for yourself versus an amount for the #N person on the list. Please circle A or B for each line.

(A) $85 for you alone (B) $75 for the #N person on the list

(A) $75 for you alone (B) $75 for the #N person on the list

(A) $65 for you alone (B) $75 for the #N person on the list

(Continued down to)

(A) $5 for you alone (B) $75 for the #N person on the list

The A-column listed 9 amounts decrementing by $10 on each line between $85 and $5. For half of the participants the money amounts decreased from $85 to $5 as above; for the other half the order was reversed. Column-B differed on each page by social distance [N]. The social distances were: 1, 2, 5, 10, 20, 50, and 100 in random order. On each line, participants were asked to choose between an amount of money for themselves and $75 for Person-N.
One apparent weakness of this procedure is its use of hypothetical rewards. Participants might honestly imagine that they would be generous in a certain situation with hypothetical rewards yet choose selfishly when real rewards are offered. But amounts of money offered in real-reward experiments are typically much lower than those in real-life situations; results with real rewards may not be any more indicative of what people will do in real-life situations, where motives and incentives are strong, than are results with larger, hypothetical rewards. Moreover, where they have been compared, discount functions for real and hypothetical rewards have been similar (Madden, Begotka, Raiff, & Kasten, 2003).

Results
Crossover points were obtained for each participant at each tested N-value. The crossover point was estimated as the average of the last selfish (Column-A) choice and the first generous (Column-B) choice. For example, if a participant preferred $65 for herself to giving $75 to N and preferred to give $75 to N to $55 for herself, then the crossover point was estimated as $60 for that participant at that N-value. All the data from participants who crossed over twice at any N-value were excluded. There were 23 such participants. At low N-values many participants chose the generous option ($75 for N) over $85 (the maximum selfish option tested) for themselves. For these participants there was no observed crossover point. In such cases we estimated the crossover point at $90. That is, we assumed that the participant would have chosen the selfish alternative at $90 if that were an option. Equation 6 was fit to the crossover points of each participant; all the three parameters (V, k, and s) were allowed to vary freely. The median obtained values of the parameters were: V = $90, k = 0.055, s = 1.03 (median \( R^2 = 0.911 \)). As in Jones and Rachlin (2006) the exponential function accounts for a lower proportion of variance relative to the hyperbolic function, and deviates systematically from the data.

Figure 1 (filled circles) shows median crossover points across participants. These points are medians of the amounts of money participants were willing to forgo to give $75 to Person-N. Setting s = 1.0, the median points were fit with only two parameters, V and k. The solid line is the best fitting social discount function (Equation 6) with V = 79 and \( k_{social} = 0.049 \) (\( R^2 = 0.969 \)). The solid line in Figure 1 shows Equation 6 with these parameters.

As in Jones and Rachlin (2006), \( k_{social} \) determined from the discount function fit to the medians in Figure 1 (0.049) roughly approximated \( k_{social} \) determined from the median of the individual-participant discount functions (0.055)—indicating that the hyperbolic functions of Figure 1 are not artifacts of averaging.

As is evident from visual inspection of Figure 1, the hyperbolic discount function obtained in this experiment is nearly congruent with that obtained by Jones and Rachlin (2006). Moreover, as in Jones and Rachlin (2006), the obtained \( V \) of Equation 6 (the intercept on the ordinate of Figure 1) was greater than $75. The median participant preferred to give $75 to the person at \( N = 1 \) than to obtain $75 for herself. Participants were very generous to people very close to them but their generosity fell off hyperbolically as social distance increased.

Fitting an exponential function (Equation 4 with \( N \) replacing \( D \)) to the data of Figure 1 (dotted line), \( V = 72, k = 0.023 \), and \( R^2 = 0.927 \). As in Jones and Rachlin (2006), the exponential function accounts for a lower proportion of variance relative to the hyperbolic function, and deviates systematically from the data.

Discussion
The main result of the current experiment was the similar steepness of discounting between this experiment (where participants chose between an amount of money for themselves alone and $75 for another person alone) and in the Jones and Rachlin’s (2006) experiment (where participants chose between a greater amount of money for themselves alone and $75 for themselves plus $75 for Person \( N \)). In both experiments undergraduates indicated that they would be very generous to people close to them and much less so to those
socially distant from them. For example, in both experiments, the median participant was willing to forgo at least $80 for himself in order to give $75 to the person closest to him (Person #1). In a way, this behavior is irrational. After all, the participant could have chosen the $80, given $75 to Person #1, and still have kept $5. Instead, the median participant chose, in the present experiment, to give Person #1 the same $75, keeping nothing. Possibly the participants believed that the $80 had to be spent and could not be shared, or perhaps they just wanted to express as strongly as possible their social closeness to the people on top of their list. Since this “hyper-generosity” was a pervasive finding throughout these experiments, it will be discussed further in the General Discussion.

The near congruity of the two hyperbolic discount functions in Figure 1 despite differences in procedure, which were not minimal, testifies to the robustness of the simple hyperbolic form in social discounting (s of Equation 6 = 1.0). The fact that the hyperbolic form and its parameters remained constant when social discounting was measured in two different ways, and the fact that social discounting followed the same functional form as delay discounting, are evidence for the stability of social discounting. Experiment 2 was designed to further test the correspondence between delay and social discounting by varying the amount of money delayed or given to another person.

EXPERIMENT 2

A ubiquitous property of human delay discounting is the amount effect. High amounts of money or other commodities are discounted less steeply than lower amounts. To take an extreme example, for the median participant, a hypothetical $1 000 000 delayed by a year is worth an average of about $950 000 now but $10 delayed by a year is worth much less than $9.50 now (Raineri & Rachlin, 1993). With probability discounting, on the other hand, a reverse amount effect is often found (Green & Myerson, 2004); higher amounts of money are discounted more by odds against (inversely related to probability) than are lower amounts. Experiment 2 studies social discounting with varying amounts. The experiment asks whether an amount effect will be found and if so whether social discounting is more like delay or probability discounting in this respect.

Participants
One-hundred-forty-three Stony Brook undergraduates (67 male, 72 female, and 4 who did not indicate gender) completed paper and pencil measures of social and delay discounting in a class session as in Experiment 1. Of these, 17 crossed over more than once on a page; their data were not used in further analysis.

Procedure
Participants were tested for both social and delay discounting using booklets as in Experiment 1. Each participant was required to make choices at four social distances (N = 1, 10, 50, and 100) and four delays (D = 1 day, 1 month, 6 months, and 1 year). The number of social distances and delays was reduced relative to Experiment 1 to minimize the number of choices and keep attention focused. The object of this experiment was not to determine absolute k-values but to find out how k varies with amount. Such comparisons are valid as long as the number of points tested is uniform across amounts. Instructions for social discounting were identical to those of Experiment 1. The delay instructions were as follows:

Each of the following questions will ask for your preference between a certain amount of money given to you right now and a larger amount given to you after a delay. Although the money is hypothetical, please try to imagine which you would choose if it were real.
On each line you will be asked if you would prefer to receive an amount of money immediately versus an amount of money delayed after a time. Please choose one option for each line.

Whether social or delay discounting was tested first and the order of the Column-A amounts (up–up, up–down, down–up, or up–down for social and delay discounting, respectively) were counterbalanced. Page order within each measure was randomized but, to avoid confusion, within a specific social or delay discounting test, all the Column-A amounts were in the same order.

Social discounting measures were obtained at three undiscounted amounts: $7.50 for Person \( N \) and $7.50 for the participant; $75 for Person \( N \) and $75 for the participant; $75 000 for Person \( N \) and $75 000 for the participant. Delay discounting measures were obtained at three undiscounted amounts: $15, $150, and $150 000. So as to keep Column-A amounts equal throughout, undiscounted delayed amounts were double than those for social discounting. Each participant was tested at only one amount (low, medium, or high) for both delay and social discounting—55 at low amounts, 37 at medium amounts, and 34 at high amounts. The Column-A alternatives for the lowest amounts (the $7.50 social amount and the $15 delay amount) were: $16, $15, $14, $13, $12, $11, $10, $9, $8, and $7.50; those for the medium and high amounts were proportionally greater.

Results

Crossover points were obtained for each participant at each amount, delay, and \( N \)-value as in Experiment 1. Discount functions (Equation 1 for delay discounting, Equation 6 for social discounting) were fit to the median crossover points for each of the six conditions. The parameters \( V, s, \) and \( k \) are not independent. The variable of interest in these experiments is \( k \), degree of discounting, our measure of impulsivity with delay discounting and selfishness with social discounting. So as to assign maximum variance to \( k \) we fixed as many other parameters as possible. The parameter, \( V_{\text{delay}} \) was fixed at its nominal value (150 000, 150, or 15 in this experiment) as it is in virtually all the studies of delay and probability discounting with humans (Green & Myerson, 2004). Since \( s_{\text{social}} \) was found to be nearly unity by Jones and Rachlin (2006), and in Experiment 1, that parameter was fixed at 1.0 here. The exponent, \( s_{\text{delay}} \) was fixed at 0.82, the best-fitting exponent when all of the delay data were normalized, combined, and fitted by Equation 1.

Table 1 (upper section) shows values of the social discounting parameters \( V_{\text{nominal}}, V_{\text{obtained}}, k, s, \) and \( R^2 \). The lower section shows corresponding values for delay discounting. Figure 2 (small filled squares) shows the best-fitting \( k \)-values for each condition as a function of reward amount.

Discount functions were also obtained for each participant for each condition. To fit these functions to the individual-participant data, the \( V \) and \( s \)-values of Table 1 were used; only \( k \) was allowed to vary across participants. The median \( k \)-values of the individual functions are shown in Figure 2 as open circles connected by lines. The slope of \( k_{\text{social}} \) as a function of amount is significantly different from zero (\( F(2,114) = 7.510, p = 0.001 \)) reflecting the fact that that \( k \) increases with \( V \); this is called a reverse amount effect. The slope of \( k_{\text{delay}} \) as a function of reward amount is significantly different from zero (\( F(2,114) = 11.334, p = 0.000 \)) reflecting the fact that \( k \) decreases with magnitude of \( V \); this is the standard amount effect.

Discussion

A significant amount effect with delay discounting is typical of delay discount studies. With probability discounting, on the other hand, a reverse amount effect has typically been found (Green & Myerson, 2004). That is, as the amount of a gamble increases, people become more risk-averse. Thus, with regard to the effect of reward amount, social discounting is more like probability discounting than delay discounting. In what way does social discounting resemble probability discounting but differ from delay discounting? At least part of the incentive for generosity in these experiments may have been perceived common interest in that the
participants may have expected some return for their generosity in terms of enhanced value of that common interest. Such a return is clearly probabilistic; when you give money to someone else you may or may not benefit. The probability that you will benefit would be greater with people who are closer to you. On the other hand, in delay discounting studies, the return is stated to be certain. Nevertheless, it remains unclear why the amount effect should go one way for probabilistic rewards, even when they are delayed as in social discounting, and the other way for delayed rewards when they are certain, as in delay discounting.

In Experiment 2 delay and social discount functions were obtained by balancing a fixed delayed amount of money or a fixed amount of money given to another person against a variable amount of money (usually a lesser amount) available now to the participant. The immediate amount of money for the participant equivalent to the delayed or forgone amount was measured. That equivalent amount was found to be a hyperbolic function of delay ($D$) or social distance ($N$). The purpose of the following experiment was to use
the results of Experiment 2 to predict the shape of the function relating delayed rewards ($D$) directly to equally valued immediate rewards for another person ($N$).

EXPERIMENT 3

The present experiment eliminated the variable amount of money and directly balanced a fixed, delayed monetary reward for the participant against the same fixed, immediate monetary reward for another person. For each social distance ($N$) we found the delay that made the reward equal in value, for the participant, to the same reward given to $N$ immediately. As $N$ increased, the equivalent delay was expected to increase as well. That is, for someone socially far, the participant was expected to tolerate a large delay of his own reward rather than give the money to $N$; for someone socially near, the participant was expected to tolerate only a small delay of his own reward rather than give the money to $N$. From the results of Experiment 2 we can predict the function relating obtained delay to $N$.

Participants in the present experiment chose between:

(A) A (hypothetical) $75 reward for only themselves to be received after a delay ($D$).
(B) A (hypothetical) $75 to be immediately given to a person at a certain social distance ($N$) from the participant (nothing for the participant).

For each $N$ ($N = 1, 2, 10, 20, 50,$ and $100$) we determined the delay (the value of $D$) at which the participants were indifferent between rewards A and B. From Experiment 2 we can express Choice A as:

$$v_D = \frac{V_D}{1 + k_{delay}D}$$

(delay discounting)

And Choice B as:

$$v_N = \frac{V_N}{1 + k_{social}N}$$

(social discounting)

Since, in the present experiment, we determined, at each $N$, the delay at which $A = B$:

$$v_D = \frac{V_D}{1 + k_{delay}D} = \frac{V_N}{1 + k_{social}N} = v_N$$

where $v_D$ and $v_N$ are current values to the participant of delayed and socially distant rewards of (undiscounted) values $V_D$ and $V_N$. Assuming $V_D \approx V_N$ (not strictly equal but approximately equal for a fixed amount):

$$k_{delay}D = k_{social}N$$
$$D' = \frac{k_{social}}{k_{delay}}N$$
$$D = \left(\frac{k_{social}}{k_{delay}}N\right)^{1/s}$$

Setting $c = \left(\frac{k_{social}}{k_{delay}}\right)^{1/s}$:

$$D = cN^{1/s}$$

(7)

Since the value of $s$ in the delay discounting study of Experiment 2 (see Table 1) was less than unity (and the value of $s$ in the social discounting studies of Experiments 1 and 2 was unity), the exponent of Equation 7 is predicted to be greater than 1.0. Since the value of $k_{social}$ was greater than that of $k_{delay}$ (measured in days) in Experiment 2 (see Table 1) the coefficient, $c$, is also predicted to be greater than 1.0.
Participants
Fifty-four Stony Brook undergraduates from an online subject pool signed up for the experiment and were tested in the laboratory. The participants received course credit. Six participants crossed over more than once and were excluded from further analysis.

Procedure
Due to the anticipated difficulty of the choices to be made in this experiment, participants were tested individually. Each participant provided demographic information and answered the same questionnaire (smoking, alcoholic drinking, and unhealthy eating) as in Experiment 1. Following the questionnaire, participants were given the following instructions both in writing and orally:

Imagine that you have made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at position #1 to a mere acquaintance at #100. The person at number one would be someone you know well and is your closest friend or relative. The person at #100 might be someone you recognize and encounter but perhaps you may not even know his or her name. You do not have to physically create the list—just imagine that you have done so.

Given your imaginary list, you will be asked to make a series of choices between two alternatives. One alternative will be $75 for one of the people on your list: and that person would receive the money right now. The other alternative will be a certain amount of money for you alone (nothing for the other person): but you would receive this amount only after a delay.

The two alternatives will be written on two cards, One card will state a number indicating the position of the person on your list to get the $75 right now, this will be on blue cards. The other card will state $75.00 to be given to you alone and how long you would have to wait to receive the money; this will be on red cards. We ask you to choose between the alternatives by indicating which card you prefer.

Each participant played the card game with the experimenter. As noted in the instructions, participants were presented with two colored cards, one blue and one red. The blue cards stated an $N$-value and the amount of money (always $75) that $N$ would receive (nothing for the participant). The $N$-values tested were: 1, 2, 10, 20, 50, and 100. The blue cards were randomized (shuffled) at the beginning of each sequence of tests. The red cards indicated the amount of money the participant alone would receive (always $75) and its delay ($D$). The delays were: 0 (now), 2 days, 5 days, and 10 days, 1 month, 2 months, and 6 months, 1 year, 2 years, 5 years, and 10 years. The red cards were presented in order, always increasing or always decreasing within a sequence. The two cards (blue and red) were placed side by side on a table in front of the participant and he or she was asked to choose between them. The blue card remained stationary while the red cards were flipped until the participant changed his or her preference from one color to the other (“crossed over”); then two more cards were flipped to make sure that the crossover point was stable. A sequence was complete when all the crossover points were obtained for each $N$-value.

All of the participants completed two sequences. For half of the participants, delays increased in the first sequence and decreased in the second sequence; for the other half, the reverse. Thus, two crossover delays were obtained for each participant at each social distance ($N$).

Results
Crossover delays were determined as in Experiment 1 except with delay rather than current amount of money as the variable. The arithmetic mean of the up and down crossover points was calculated for each participant; medians of the average crossover points were determined across participants at each $N$-value. Figure 3 shows logs of median crossover delay as a function of log $N$. A straight line fit the data well ($R^2 = 0.955$). A straight
line on this log–log plot represents a power function of the nonlog variables. The best-fitting exponent (the slope of the straight line) was 1.5, above 1.0 as predicted on the basis of Experiment 2. The above-unity exponent indicates that socially near rewards were balanced by very brief delays but, as social distance increased, equivalent delay accelerated. The obtained value of the intercept \( c \) was 1.6, also greater than 1.0 as predicted on the basis of Experiment 2.

**Discussion**

Raineri and Rachlin (1993) found that people were able to consistently balance delayed rewards against probabilistic rewards. The present experiment shows that they were equally able to balance delayed rewards for themselves against immediate rewards to other, socially distant, people and to do it in a manner consistent with their independent judgments of immediate monetary value of delayed and socially distant rewards. This experiment was a form of cross-modality matching where first participants estimate the magnitude of one modality (say, a light) by assigning numbers to different intensities; then participants estimate the magnitude of another modality (say, a sound) also by assigning numbers to different intensities. In a final procedure participants adjust a light to match a sound or a sound to match a light (eliminating the numbers). The slope of the power function obtained in this last (cross-modality matching) procedure may be predicted from the slopes of the power functions obtained by the first two procedures. Just as cross-modality matching validates independent judgments of sensation magnitudes (Stevens & Marks, 1965), this experiment validates the independent delay and social discounting procedures of Experiments 1–3.
GENERAL DISCUSSION

Taken together the three experiments reported here are consistent with Simon’s contention that delay discounting and social discounting may serve as coordinates in determining reward value. The discount functions obtained in these experiments are behavioral descriptions. They say little about the internal mechanism or mechanisms underlying altruism. The generosity indicated by participants may have been due to an impulsive natural tendency to act for the benefit of others or by the expectation of future reciprocity or by group identification. The meaning of the functions obtained lies only in their ability to predict behavior under conditions varying from those tested—what economists call “revealed preference” (Houthakker, 1950). In economics a utility function or discount function obtained under one set of constraints is used to predict behavior under another set of constraints. That is, the parameters of discount functions obtained under one set of conditions reveal preferences which then may be used to predict behavior under other conditions. For example, in Experiment 3, the shapes of individual social and delay discount functions were used to predict the shape of the function relating delay to social discounting. Prior experiments relating individual delay discounting parameters to degree of addiction to cigarettes, gambling, heroin, or cocaine (Bickel & Marsch, 2001) are also examples of revealed preference. Whether social discounting will prove as meaningful remains to be tested.

The above-unity exponent obtained in Experiment 3 indicates that multiplying delay by a given factor has less of an effect on value than multiplying social distance by the same factor. For example, the same percentage reduction of value obtained by multiplying social distance by 10 would be obtained only after multiplying delay by about 32. In other words, Stony Brook undergraduates were, not surprisingly, more generous to their future selves than they were to other people at the present time. Cooperating in prisoner’s dilemma games against tit-for-tat is a form of self-control while defecting in such games is a lack of self-control (Rachlin, 2002). The fact that increases of social distance diminished value much more than increases of delay in Experiment 3, may explain the results of Silverstein, Cross, Brown, and Rachlin (1998) and Brown and Rachlin (1999). In those experiments undergraduates who learned to cooperate when playing repeated prisoner’s dilemma games against tit-for-tat (playing against themselves at future time periods) defected when playing identical games against other people. That is, as in the present experiments, participants cooperated more with themselves at other times than they did with other people (at the present time).

It has not yet been determined whether people can choose consistently among rewards that are both delayed and socially distant and also how delay and social distance combine to determine reward value. Such determination should be a priority for future work. As Simon (1995) argues, the combination of temporal and social discounting may underlie the common tendency for charities to solicit pledges (commitments to donate later) rather than immediate donations. Suppose a person prefers to consume now rather than to give to charity now. However, delay and social discounting interact so that he also prefers to consume now and to give to a charity later rather than to consume both now and later. Then, as Simon points out (p. 377), a pledge, committing him to give to charity later would enable him to attain what he prefers now. Otherwise, he would consume in both periods.

A general difference between social and delay discounting in all of the present experiments is the hyper-generosity we found with social discounting. All the participants preferred a given amount of money now to that same or a lesser amount later. But most of the participants preferred to give $75 to Person 1 on their list than to obtain $80 for themselves when they presumably could have taken the $80, given the $75 to Person 1, and had $5 left over for themselves. As speculated previously, this may have been due merely to an attempt to demonstrate how close they felt to Person 1. However, there are other possible explanations for this pervasive effect. There is a small implicit cost of transferring money to another person (banks charge for this service). For a choice of $80 for himself, this cost would have to be borne by the participant whereas, for a choice of $75 for Person 1, the cost would be borne by the experimenter. Still another possibility is that forgoing the extra $5 was the price of employing a self-control device much like pledging money to charity.
discussed above. The participants may rather have had the experimenter give the money to Person 1 than to have received the money and then given it to that person because, once having gotten the money, they might be tempted to spend it on themselves.

We have freely used the words generosity and selfishness as labels for patterns of choice. We mean nothing deeper by these words. Neither, we believe, does altruism have any deeper meaning (Rachlin, 2002). As Simon writes (pp. 375–376):

The conceptual framework employed here obviates the age-old question about whether an act of giving by one individual to another should properly be labeled “altruism,” or whether instead one is “really” being “selfish” by making oneself feel good. An individual’s discount weights vis-à-vis other individuals may be considered a full description of the individual in this connection, assuming that the individual’s behavior corresponds to his or her discounts in relation to other individuals. In this scheme, there is no place for intentions, and hence there are no false intentions. Revealed preferences constitute the entire system.

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