Temporal Discounting in Choice Between Delayed Rewards: The Role of Age and Income

Leonard Green, Joel Myerson, David Lichtman, Suzanne Rosen, and Astrid Fry
Washington University

This study examined the effects of age and income on temporal discounting (i.e., the decrease in the subjective value of a reward as the delay to its receipt increases). The value of delayed hypothetical monetary rewards was discounted at similar rates by adults of different ages but similar income levels, but at different rates by adults of similar age but different income levels. Specifically, lower income older adults showed a greater degree of temporal discounting than did either upper income older adults or upper income younger adults, but there were no age differences in discounting between the upper income groups. Comparison of these findings with those of a previous study (Green, Fry, & Myerson, 1994) suggests that impulsivity in decision making declines rapidly in young adulthood, reaching stable levels in the 30s. Further, age and income appear to interact in determining the impulsivity of decision making by adults.

Many important decisions in life involve choices that pit one's short-term interests against one's long-term interests. For example, one must make many lifestyle choices involving acts (e.g., cigarette smoking) that may bring immediate pleasure but may have delayed negative consequences. One also frequently chooses between purchases that may have smaller initial cost but do not last very long and those that have larger initial cost but last longer, or between investments that provide more immediate, smaller gains and those that provide more delayed, larger gains. An important but rarely studied question is whether the way in which one chooses between one's long- and short-term interests changes across the life span.

When people choose between long- and short-term interests, they frequently weight the immediate consequences of their decision more heavily than the delayed consequences. In accounting for this tendency, overvalue more immediate outcomes, psychologists and economists frequently invoke a process termed temporal discounting (e.g., Ainslie, 1992; Green & Myerson, 1993; Loewenstein & Prelec, 1992; Rachlin & Raineri, 1992). Temporal discounting refers to the decrease in the subjective value of a reward as the delay to its receipt increases. The longer it will be until a reward can be received, the lower its present subjective value.

At issue in comparisons of decision making by different age groups is whether older and younger adults show similar patterns of temporal discounting. It is by no means obvious a priori whether or not there are age-related differences, and if there are, what form such differences take. There is an extensive literature suggesting that young adults are less likely to take the long-term consequences of their behavior into account (e.g., Ball, Farnill, & Wangeman, 1984; Wilson & Herrnstein, 1985; Zuckerman, Eysenck, & Eysenck, 1978). Thus, older adults appear to be less impulsive and might therefore be expected to weight long-term interests more heavily. However, if they were to take the decreased number of years remaining to them into account, they might be expected to be less influenced by the possible long-term consequences of their decisions.

In a previous study (Green, Fry, & Myerson, 1994), we compared temporal discounting of hypothetical, monetary rewards by young and older adults. The results of this study revealed significant quantitative differences between the groups in the degree of temporal discounting; the younger participants discounted future rewards to a greater extent than did the older participants. However, the form of the temporal discounting function was the same in younger and older adults. That is, for both older and younger participants, the same equation (but with age-specific parameters) described the relation between the present value ascribed to a delayed reward and the duration of the delay interval. This finding suggests that the temporal discounting process is qualitatively similar in both groups. The difference in discounting rate could have been due to differences in age, income level, or both. The present study pursued this issue further by comparing temporal discounting by groups of older and younger adults matched on income, as well as by comparing discounting by older adult groups that differed in income level.

Method

Participants

Three groups of volunteers participated: An upper income younger adult group (M = 33.3 years; 5 men and 15 women), an upper income older adult group (M = 70.7 years; 3 men and 17 women), and a lower income older adult group (M = 70.8 years; 7 men and 13 women). In both of the upper income groups, half of the participants had annual household incomes of between $40,000 and $50,000, and half had annual incomes greater than $50,000. All but 1 of the lower income older participants had incomes under $10,000; 1 had an income of between $15,000 and $20,000. Most participants had at least some college edu-
cation (95% of the younger adults, 80% of the upper income older adults, and 75% of the lower income older adults). The younger adult group was recruited from university employees and residents of the surrounding community. The upper income older adult group was recruited from a participant pool maintained by the Aging and Development Program of the Department of Psychology at Washington University and from residents of a private housing complex for older people. The lower income older adult group was recruited from residents of an apartment complex subsidized by the Department of Housing and Urban Development.

Procedure

The procedure was the same as that used by Green et al. (1994). Participants made a series of choices between hypothetical amounts of money, a smaller amount available immediately and a larger amount available after a delay. The amounts and delays were printed on sets of 4 x 6 index cards, hole-punched, and attached to a two-ring desktop calendar holder.

Each participant was tested individually. Two sets of index cards were placed on a table at a comfortable distance from the participant. One set of cards, located to the participant's right, indicated the delayed amount (e.g., $1,000 in 1 week), and the other set, located to the participant's left, indicated the immediate amount (e.g., $500 now). Participants indicated their preference by pointing to one of the two cards (either the delayed amount or the immediate amount). Each preference was recorded by the experimenter, who then flipped the card or cards to the next set of choices.

The possible values of the delayed amounts were $1,000 and $10,000. There were eight possible delays at which these two amounts could be obtained: 1 week, 1 month, 6 months, 1 year, 5 years, 10 years, and 25 years. The values on the immediate-amount cards varied depending on the delayed amount to which it was compared. When the delayed amount was $1,000, the 30 possible values of the immediate amounts were $1, $5, $10, $20, $40, $60, $80, $100, $150, $200, $250, $300, $350, $400, $450, $500, $550, $600, $650, $700, $750, $800, $850, $900, $920, $940, $960, $980, $990, and $1,000. When the delayed amount was $10,000, the immediate values were those listed for $1,000 multiplied by 10.

Participants received the following instructions:

The purpose of the present study is to compare your preferences for different amounts of money to the preferences of individuals of different ages. In this experiment you will be asked to make a series of hypothetical decisions between monetary alternatives. As you can see, there are two sets of cards in front of you. The cards on your left will offer you an amount of money to be paid right now. This amount will vary from card to card. On the cards on your right, the amount will be either $1,000 or $10,000, but its payment will be delayed. Please look at the example cards at this time. It will be your job to choose between the two cards presented and to point to the card you would prefer. You will be given four practice trials before you begin, and the experimenter will turn the cards for you. Once the trials begin, the experimenter will no longer be able to answer your questions. Therefore, please ask for clarification if you do not understand the procedure at this time.

All participants first received one of the delayed amounts presented with every possible value of the appropriate immediate amount, treated both up and down (e.g., $1,000 in 1 week paired with $1 now to $1,000 now, in ascending order, followed by $1,000 in 1 week paired with $1,000 now to $1 now, in descending order). This procedure was followed for each of the 8 delays (i.e., from 1 week to 25 years). The entire procedure was then repeated with the other delayed amount.

The order of presentation of the delayed amounts (i.e., either $1,000 followed by $10,000 or vice versa) and the corresponding titration of the immediate amounts (either ascending or descending in value) were counterbalanced within groups. For all participants, however, the order of the delays was always from the shortest (1 week) to the longest (25 years).

For the $1,000 and $10,000 amounts, equivalence points were obtained at each delay for each participant. These points were calculated by taking the average of the value at which the participant switched preference from the immediate to the delayed amount on the descending titration and the value at which the participant switched preference from the delayed to the immediate amount on the ascending titration. A participant was considered to have switched to a previously nonpreferred alternative (i.e., from the immediate to the delayed amount or vice versa) after two consecutive choices of the new alternative. These equivalence points represent the values at which the delayed amount is subjectively equivalent to the immediate amount.

Results

For each group, the rate of temporal discounting was measured based on the equation

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

where $V$ is the present value ascribed to the delayed reward, $A$ is its nominal amount (i.e., either $1,000 or $10,000), $D$ is the delay until its receipt, and $k$ is a free parameter whose estimated value provides a measure of the degree to which delayed rewards are discounted. Higher values of $k$ represent greater discounting of delayed rewards. The preceding hyperbolic function has been used successfully in describing temporal discounting of both real and hypothetical monetary rewards and other commodities in human participants as well as delayed food rewards in animals (e.g., Ainslie, 1992; Mazur, 1987; Rachlin, Raineri, & Cross, 1991; Raineri & Rachlin, 1993). Although a similar two-parameter function (in which the denominator is raised to a power) provides a more precise description of temporal discounting under certain circumstances (Green et al., 1994), comparisons between groups are greatly simplified by using a function with a single free parameter. Moreover, as will be seen, the just-mentioned hyperbolic function provides extremely good fits to the present data.

Figure 1 presents the median equivalent immediate amounts for the $1,000 (left column) and $10,000 amounts (right column) as a function of delay. The curves are the best fitting hyperbolic functions. Data from the younger group, the upper income older group, and the lower income older group are shown in the top, middle, and bottom panels, respectively. For all three groups, the change in present value as a function of delay was well described by the hyperbolic function. This was true for both the $1,000 and $10,000 delayed amounts. In all cases, the percentage of variance accounted for was greater than 96%.

Values of the $k$ parameter, which provides an index of the rate of temporal discounting, were estimated by analyses conducted at both the group and individual levels (see Table 1).\(^1\) Similar

---

1 The $k$ parameter of the hyperbolic function was estimated using AR, the derivative-free, nonlinear curve-fitting module of BMDP (Dixon & Brown, 1988). Multiple nonlinear regression with age group as an indicator (or dummy) variable was used to test for possible differences in the regression parameters (Gallant, 1987). That is, the multiple regression equation was $V = A/[1 + (k_1 + Z \times k_2)D]$, where $Z$ is an
Figure 1. Present value of the $1,000 (left column) and $10,000 (right column) rewards as a function of delay. For each reward at each delay, the present value (solid circles) represents the median amount of the immediate reward selected as being equivalent in value to the delayed reward; dashed lines represent the 25th and 75th percentiles. The solid curves represent the best fitting hyperbolic discounting functions for each age and income group. Data from the younger adults are shown in the two top panels; data from the upper and lower income older adults are shown in the two middle panels and the two bottom panels, respectively.

results were obtained at both levels. For the group-level analyses, the value of \( k \) was estimated for each group at each delayed amount (i.e., $1,000 and $10,000) on the basis of fits of the preceding equation to the group median subjective values. Median values were used because for a specific amount at a given delay, the distributions of subjectively equivalent immediate amounts are characteristically skewed because of the limits imposed on the participants’ choices (Rachlin et al., 1991). These group-level analyses revealed no significant differences in temporal discounting between the upper income younger and older groups at either delayed amount: \( t(14) = 0.72 \) and 2.03 for $1,000 and $10,000, respectively. However, the lower income
Table 1
Estimates of k Based on the Group Median Subjective Values and 25th, 50th, and 75th Percentile Values of k for Individual Participants

<table>
<thead>
<tr>
<th>Amount</th>
<th>Upper income, younger adults</th>
<th>Upper income, older adults</th>
<th>Lower income, older adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000</td>
<td>0.010</td>
<td>0.010</td>
<td>0.046</td>
</tr>
<tr>
<td>k based on group medians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th percentile of individual k's</td>
<td>0.005</td>
<td>0.008</td>
<td>0.012</td>
</tr>
<tr>
<td>50th percentile of individual k's</td>
<td>0.011</td>
<td>0.010</td>
<td>0.032</td>
</tr>
<tr>
<td>75th percentile of individual k's</td>
<td>0.024</td>
<td>0.013</td>
<td>0.126</td>
</tr>
<tr>
<td>$10,000</td>
<td>0.007</td>
<td>0.009</td>
<td>0.044</td>
</tr>
<tr>
<td>k based on group medians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th percentile of individual k's</td>
<td>0.003</td>
<td>0.006</td>
<td>0.009</td>
</tr>
<tr>
<td>50th percentile of individual k's</td>
<td>0.008</td>
<td>0.009</td>
<td>0.056</td>
</tr>
<tr>
<td>75th percentile of individual k's</td>
<td>0.012</td>
<td>0.012</td>
<td>0.135</td>
</tr>
</tbody>
</table>

The older group did differ from both the upper income older and younger groups in the rate at which they discounted both the $1,000 and $10,000 delayed amounts: all $t$s (14) > 6.6, all $p$s < .001. That is, the lower income group had significantly higher rates of discounting (i.e., larger k values) than did both of the higher income groups at both delayed amounts.

For the individual-level analyses, the value of k was estimated for each individual at each delayed amount. These values were then used to compare temporal discounting by the individuals from the different groups. As was the case for the group-level analyses, there were no significant differences between the two upper income groups, Mann-Whitney $U (n_1 = n_2 = 20) = 177$ and 176 for $1,000 and $10,000, respectively. Again, however, the lower income older individuals had significantly higher values of k than did individuals in either of the upper income groups at both delayed amounts: for the upper income versus the lower income older individuals, $U = 101.5$ and 91.0 for $1,000 and $10,000, both $p$s < .01; for the individuals from the upper income younger adult group versus those from the lower income older adult group, $U = 119.5$ and 73.5, $p < .05$ and $p < .01$ for $1,000 and $10,000, respectively.

Discussion

The results of this study revealed that delayed rewards were discounted at similar rates by adults of different ages but similar income levels, but at different rates by adults of similar age but different income levels. Specifically, the lower income older adult group showed a greater degree of temporal discounting than did either of the upper income groups, but there were no age differences in discounting between the upper income groups.

These findings may be contrasted with those of our previous study of age differences in choice between immediate and delayed rewards (Green et al., 1994). In that study, the rate of temporal discounting decreased systematically across the life span from childhood to old age. Other research has indicated that various kinds of impulsive behavior are more likely to occur in the earlier parts of the life span, even when such behaviors are associated with considerable risks (e.g., Ball et al., 1984; Wilson & Herrnstein, 1985; Zuckerman et al., 1978). Taken together, these findings are consistent with the view that the age-related decrease in temporal discounting reflects a decrease in impulsivity, an interpretation derived from the fact that high rates of discounting indicate preference for more immediate rewards, even if these rewards are of smaller amounts than the delayed alternatives (e.g., Ainslie, 1992; Green & Myerson, 1993; Rachlin & Raineri, 1992).

To compare the results of the present study with those of our previous research using the same procedure, the value of k, the discount rate parameter, was plotted as a function of age. Figure 2 shows results from the $1,000 condition in the previous study (Green et al., 1994), represented by filled circles, as well as those for the upper income participants in the corresponding condition of the present study, represented by open circles. As may be seen, there is remarkable correspondence between the k values for the present upper income groups and those of the older participants ($M = 67.9$ years) in the Green et al. (1994) study. A telephone survey of the Green et al. group revealed that of the 12 older participants, 6 had incomes of between $20,000 and $40,000 per year, and 4 had incomes greater than $40,000. Thus, these participants were clearly more similar to the upper income older group than to the lower income group of the present study, and this similarity in income is also reflected in their temporal discounting.

The undergraduates ($M = 20.3$ years) who composed the Green et al. (1994) young adult group attended an expensive private university. Thus, it is likely that their families had incomes comparable to those of the upper income individuals in the present study. If this is true, then the present results taken...
Figure 2. Estimates of the k parameter in the hyperbolic discounting function as a function of age. Results for the $1000 delayed reward from both the present study and a previous study by Green, Fry, and Myerson (1994) are shown.

together with those of Green et al. suggest that when income is held constant, temporal discounting rates decrease markedly between the ages of 20 and 30 years but then remain relatively stable into old age. This interpretation may be related to previous findings concerning personality traits if one recalls that high rates of temporal discounting are assumed to reflect impulsivity (e.g., Ainslie, 1992; Green & Myerson, 1993; Rachlin & Rainieri, 1992). Personality traits in general appear to become stable around 30 years of age (e.g., Costa & McCrae, 1989). Impulsive and risk-taking tendencies in particular tend to decrease rapidly from high levels in late adolescence and young adulthood to much lower levels by around age 30, and then they decrease slightly or remain relatively stable for the next 30 or more years. Examples of this trend are apparent in automobile accident rates (Evans, 1988), arrest rates (Wilson & Herrnstein, 1985), and in the incidence of illegal drug use and binge drinking (e.g., Hilton, 1991).

Although we favor this interpretation of our data, its validity depends on whether or not the college students in the Green et al. (1994) study should be considered an upper income group, and it must be acknowledged that evaluating the role of wealth in students' decision making is a difficult task. Should one be considering the students' personal financial state or that of their parents? If it is that of the students, then the participants in the Green et al. (1994) study might be considered poor; if it is that of their parents, then they might be considered wealthy. In either case, a further consideration is whether young adults' decision making is influenced by their current financial condition, that in which they were raised, or that which they anticipate for the future.

The task of examining the role of wealth uncontaminated by differences in other demographic factors is generally difficult in any age group. No low income, young adult group was included in the present study because initial efforts to recruit one revealed that such young adults would likely be much less educated than the other adult groups in either the present investigation or our previous study (Green et al., 1994). One way of assessing the interaction of age, income, and education (as well as other potentially influential variables) would be to study a large number of individuals varying in all these characteristics and analyze the resulting data using multiple-regression techniques. For the present, the results of the current study clearly identify income as an important variable in decision making. Therefore, studies of age-related differences in adult decision making need to either evaluate its role directly or to equate financial status in the different age groups under consideration.

The effect of income on temporal discounting is particularly intriguing because previous studies (Benzion, Rapoport, & Yagel, 1989; Green et al., 1994; Myerson & Green, 1995; Rainieri & Rachlin, 1993; Thaler, 1981) have reported an effect of the amount (or nominal value) of a delayed reward on the rate at which it is discounted. Specifically, amounts of greater value are discounted less steeply than smaller amounts. One might expect that if a poorer person and a richer person were both asked to judge the subjective value of a particular amount of monetary reward, the poorer person would judge it to be of greater value. Therefore, a poorer person might be expected to discount a given delayed reward less steeply than a richer person. In the present study, however, poorer participants showed steeper discounting than did richer participants when both made decisions about the same amounts. Thus, the present findings are not easily explainable in terms of the effect of income on the subjective value of monetary rewards. Future research on the process underlying the effects of income on impulsivity and other aspects of decision making, and on how this process interacts with age, is clearly needed.

Temporal discounting is of theoretical importance because of its hypothesized involvement in impulsivity and self-control (e.g., Ainslie, 1992; Green & Myerson, 1993; Rachlin & Rainieri, 1992). In the present context, the question of age differences in temporal discounting bears on the long-standing question of whether older adults are more cautious than younger adults (e.g., Botwinick, 1984). The varied answers that have been obtained to this question result in part from the various ways that cautiousness has been operationalized. This study focuses on one particular aspect of what people think of as cautiousness, namely, the extent to which individuals take long-term consequences into account in their decision making. Our results reveal that whether one concludes that older adults are more cautious, in the sense of being less impulsive, may depend on the younger age group with which they are compared. When possible income differences are controlled, older adults appear to be less impulsive than persons in their 20s but equivalent to persons in their 30s in the extent to which they discount the future financial consequences of their decisions.

References


Received December 12, 1994
Revision received May 30, 1995
Accepted May 30, 1995