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Age Differences in Temporal Discounting: The Role of Dispositional Affect and Anticipated Emotions

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We examined age differences in temporal discounting, the tendency to devalue delayed outcomes relative to immediate ones, with particular emphasis on the role of affective responses. A life-span sample completed an incentive-compatible temporal discounting task involving both monetary gains and losses. Covariates included demographic characteristics, cognitive functioning, personality traits, affective responses, and subjective health. Advanced age was associated with a lower tendency to discount the future, but this effect reached statistical significance only for the discounting of delayed gains. An examination of covariates suggested that age effects were associated with age differences in mental health and affective responses rather than demographic or cognitive variables.

Keywords: aging, temporal discounting, time discounting, intertemporal choice, anticipated emotions

Many of life's most important choices require people to weigh the immediate consequences of their actions against delayed consequences in the near or distant future. When faced with such 'intertemporal' choices, most people show a relative disregard for delayed gains and losses relative to immediate ones. This tendency to weigh positive or negative outcomes less heavily as they occur farther into the future is referred to as temporal discounting or delay discounting (Frederick, Loewenstein, & O'Donoghue, 2002), and the degree to which a given person devalues future consequences relative to immediate ones is referred to as their discount rate.[1] Although much of the research on temporal discounting is laboratory based, the phenomenon can be readily observed in real-life settings. The majority of lottery winners, for example, choose a smaller, immediate lump-sum payment over a much larger, but temporally delayed payout (Aghdami, 1999). Indeed, temporal discounting is a standard assumption in empirical economic research.

Temporal discounting has particular practical relevance in advanced age. Aging is associated with a range of momentous decisions about the future in areas such as healthcare (CDC, 2007) and retirement planning (Hershey, Jacobs-Lawson, McArdle, & Hamagami, 2007) and individual differences in discount rates have been linked to real-life health behavior (Bradford, 2010) and investment choices (Ersner-Hershfield, Garton, Ballard, Samanez-Larkin, & Knutson, 2009). Previous research, however, on age differences in temporal discounting is equivocal with regard to the size and direction of age-related changes (Chao, Szrek, Pereira, & Pauly, 2009) and little is known about underlying mechanisms. In particular, it not clear how well-documented age differences in emotional processing (Scheibe & Carstensen, 2010) affect people's tendency to discount the future. In order to address this knowledge gap, the present study examined age differences in an incentive-compatible temporal discounting task that involved realistic gains and losses. We assessed various aspects of affective responses as well as a range of other relevant covariates. Overall, we predicted that advanced age, because it is associated with better emotion regulation and insight, would also be associated with less discounting of future consequences. To provide the theoretical background for our predictions, we briefly review the literature on age differences in temporal discounting and decision-making as well as the role of emotional factors in temporal discounting.

Age Differences in Temporal Discounting

Empirical evidence regarding age differences in temporal discounting is scarce. There are only a handful of pertinent studies and their results are contradictory. Whereas some studies found that advanced age was associated with a decreased tendency to discount the future (Green, Fry, & Myerson, 1994; Green, Myerson, & Ostaszewski, 1999; Whelan & McHugh, 2009), others found curvilinear age effects with minimal discounting rates in mid-life (Harrison, Lau, & Williams, 2002; Read & Read, 2004), or an absence of age effects (Chao et al., 2009). Taken together, these findings raise more questions than they provide answers. Age

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[1] Note that while temporal discounting is related to delay of gratification, the two concepts have distinct correlates and may differ in underlying processes (Reynolds & Schiffbauer, 2005).

effects are not only inconsistent across studies, a finding that could be explained by substantial differences in the nature and national origin of samples, but age effects within a single study differ in discounting rates for hypothetical monetary gains, positive experiences, and negative experiences (Read & Read, 2004). With one exception (Harrison et al., 2002) previous studies examine hypothetical (not realistic) monetary gains and not a single study contrasts age differences in discounting of monetary gains and losses. More importantly, little is known about the underlying mechanisms. Some studies provide intriguing hints that it may be age-associated variables such as subjective probably of survival, not chronological age itself, that drive the observed effects (e.g., Chao et al., 2009). However, existing research does not control for individual differences in cognitive ability and personality that were previously found to be associated with both age and temporal discounting (e.g., Hirsh, Morisano, & Peterson, 2008). Moreover, prior research failed to examine the potential role of well-established age differences in emotional functioning. This is a critical omission since emotional goals and reactions may be just as relevant for discounting rates as economic considerations (Loewenstein & O'Donoghue, 2007).

Aging, Emotion, and Decision-Making

A growing body of research has documented systematic age differences in emotional experience and processing (for a review see Scheibe & Carstensen, 2010) that have direct implications for decision-making contexts. With regard to everyday emotional experience, convergent evidence suggests that average mood states are less negative and more positive in advanced age (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Mroczek & Kolarz, 1998; Teachman, 2006). In addition, older adults report better emotion-regulatory skills than younger adults (Gross et al., 1997; Kessler & Staudinger, 2009; Lawton, Kleban, Rajagopal, & Dean, 1992) and they appear to be faster at down-regulating negative emotions in everyday life (Carstensen et al., 2000).

In decision contexts, age differences in emotion-regulatory skills may influence choice-related emotional responses, that is, emotional responses elicited by the decision task itself as opposed to its potential outcomes (Luce, 2005). Löckenhoff & Carstensen (2008), for example, found that whereas younger adults experienced a decline in positive emotions over the course of several emotionally challenging choice scenarios, older adults' positive emotions remained stable over time.

In part, age differences in decision-related emotional responses may be due to systematic biases in information processing. Compared to younger adults, older adults tend to prioritize emotionally salient material over neutral information and positive over negative material in a variety of cognitive tasks (for reviews see Carstensen & Mikels, 2005; Mather & Carstensen, 2005; Scheibe & Carstensen, 2010). This age-related 'positivity effect' (Carstensen & Mikels, 2005) has been shown to affect decision making as well. In computer-based scenarios presenting positive, negative, and neutral information about different healthcare choices, older adults reviewed and recalled a greater proportion of positive than of negative information compared with young adults (Löckenhoff & Carstensen, 2007, Löckenhoff & Carstensen, 2008). Further, although age groups do not differ in responses to potential monetary gains, older adults are less responsive to signals of monetary loss than their younger counterparts (Mikels & Reed, 2009; Samanez-Larkin et al., 2007).

Insight into one's emotional reactions differs by age as well. Older adults are better than younger adults in predicting their future emotional responses with regard to monetary gains and losses in laboratory settings (Nielsen, Knutson, & Carstensen, 2008) and with regard to positive real-world events (Scheibe, Mata, & Carstensen, in press). Consistent with these findings, emotional intelligence–the ability to understand and manage one's emotions–was found to be higher in advanced age (Kafetsios, 2004).

Theoretical explanations of age differences in emotional processing have proposed alternative mechanisms that may be responsible for the observed effects. Socioemotional selectivity theory (Carstensen, 2006) argues that age differences in emotional processing are the results of age-related changes in motivational priorities. Specifically, age-associated limitations in future time perspective are thought to shift the focus from goals aimed at optimizing the future (e.g., information acquisition, career promotion) towards present-oriented goals aimed at emotional well-being (Carstensen, 2006). From this point of view, older adults' focus on the positive as well as their better emotion regulatory and affective forecasting skills are explained as the result of a chronic activation of emotion-focused goals. Alternatively, age differences in emotional processing have been explained as the result of age-related cognitive decline. Specifically, dynamic integration theory (Labouvie-Vief, 2003) argues that age-related decrements in cognitive resources lead older adults to optimize their emotional well-being at the cost of differentiation and complexity.

In summary, previous research suggests that age groups differ in everyday mood, emotion-regulatory skills, decision-related emotional responses, relative attention to positive versus negative aspects of choices, and affective forecasting. Conceivably, these effects may influence intertemporal choice−especially since they may be linked to age-related limitations in future time perspective. Yet, this rich body of knowledge has not been adequately integrated with the literature on affective components of temporal discounting which we now discuss in more detail.

The Role of Affect in Temporal Discounting

Whereas early theoretical perspectives on temporal discounting were primarily inspired by economic considerations, more recent work shows an increasing appreciation for the role of affective responses. According to one prominent perspective, temporal discounting is governed by dual systems: A 'hot' affective system responding primarily to concrete immediate rewards, and a 'cool' emotionally neutral system evaluating abstract rewards and tradeoffs among present and future rewards (Laibson, 1997; Loewenstein & O'Donoghue, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004; Metcalfe & Mischel, 1999; although see Kable & Glimcher, 2007). Conceivably, the relative balance between these two systems might be affected by the age-related changes in emotional processing outlined above.

On the one hand, one might argue that older adults' preferential processing of emotionally salient material (Carstensen & Mikels, 2005) as well as age-related limitations in cognitive resources (Labouvie-Vief, 2003) and future time perspective (Carstensen,

2006) could shift the relative balance between the two systems in favor of the 'hot' system. From this point of view, older adults should be more likely to discount the future than their younger counterparts. On the other hand, emotion-regulatory ability appears to improve with age (Kafetsios, 2004; Kessler & Staudinger, 2009) which likely confers advantages in down-regulating the 'hot' system in favor of a more deliberate consideration of available trade-offs. From this perspective, one would expect to see an age-related decrease in the tendency to discount future events.

This latter hypothesis is further supported by findings suggesting that advanced age is associated with better affective forecasting skills (Nielsen et al., 2008; Scheibe et al., in press). In the context of temporal discounting, a more accurate anticipation of one's future emotions would include the realization that temporally discrepant events will likely have similar affective consequences–regardless of whether they occur immediately or at some point in the future. Such age differences in anticipated affect could lead to more realistic interpretations of trade-offs among present and future rewards in the 'cool' system and thus contribute to lower discounting rates in advanced age.

Overall, these theoretical considerations make a stronger case for age-related decreases (as compared to increases) in temporal discounting. However, given older adults' tendency to prioritize positive over negative material (Carstensen & Mikels, 2005) and their reduced sensitivity to loss- versus gain-cues (Samanez-Larkin et al., 2007), this effect may be more pronounced in scenarios involving gains than in scenarios involving losses because the former are more salient to older adults.

The Present Study

Previous research suggests that affective variables play a major role in temporal discounting behavior, and age differences in emotional aspects of decision-making would seem to have important implications for such effects. However, the two research traditions have yet to be integrated. Understanding the role of affect in age differences in temporal discounting is not only of theoretical interest but also has practical implications. As discussed above, old age is fraught with health and financial decisions that require a careful balance among immediate and future consequences. A better understanding of the mechanisms that govern such decisions could help to develop interventions aimed at optimizing intertemporal choice across the life span.

As a first step in this direction, we examined age differences in multiple aspects of affective responses to a temporal discounting task involving both gains and losses. We further extended prior research by implementing an incentive-compatible paradigm with realistic payouts in a controlled laboratory setting, utilizing a demographically homogenous life-span sample, and assessing a wide range of relevant covariates.

Based on the considerations outlined above, we expected that because of age-related improvements in emotion regulation, advanced age would be associated with a reduced tendency to discount future outcomes. Consistent with an age-related positivity effect, we predicted that age differences in temporal discounting would be more pronounced for choices involving gains rather than losses. We further expected that age differences in discounting patterns would be driven by age differences in affective variables. Although theoretical considerations suggest that anticipated affect is particularly relevant for temporal discounting, affective variables may influence decision-making along multiple pathways. Therefore, we also explored the role of ambient mood, task-related affect, outcome-related affect, and dispositional affect (as captured by personality traits and mental health).

In addition, we used statistical estimation procedures (Laibson, 1997; Loewenstein & O'Donoghue, 2007; McClure et al., 2004) to compare the relative contributions of the 'hot' versus 'cool' systems to age differences in temporal discounting. Although we had no firm predictions, our findings provide a first look at such effects.

Further, to control for the influence of age-related cognitive and physical decline, we included measures of processing speed, vocabulary, memory span, numeracy, and self-rated health. Finally, because it has been proposed that age differences in emotional processing are driven by life-span changes in perceptions of the future (Carstensen, 2006) we also assessed future time perspective and perceived continuity with future selves.

Method

Participants

One-hundred participants were recruited from the local community in Tompkins County, NY, via media announcements and through an existing database. At the time of recruitment the sample was stratified by gender, education, and income. Because our goal was to recruit a homogenous sample of community-dwelling adults, undergraduate students were excluded from participation. Data from two participants were lost because of equipment malfunction.

The final sample (n = 98) ranged in age from 19−91 (M = 52.0, SD = 20.5) and was 58% female. Education (assessed on an 8-point scale ranging from 1 [*did not complete High School*] to 8 [*Graduate/Professional Degree*] was fairly high (M = 5.4, SD = 1.77), and self-reported annual income was moderate (M = 48,526, SD = 41,371). The majority of participants were non-Hispanic White (87%), the remainder were Asian (6%), Hispanic (3%), African American (2%), and mixed/other (2%). Demographic characteristics were unrelated to age ($p > .1$) with the exception of ethnicity: Compared to non-Whites, Whites were significantly older, M = 54.2, SD = 20.2 versus M = 36.1, SD = 15.5, $t(94)$ =, p = .003, d = 1.0. In preliminary analyses, the pattern of results did not change if non-White participants were excluded. Subsequent analyses therefore present findings for the sample as a whole.

Participants received $15 as base pay for their participation. Any net monetary gains from the discounting task were added to this amount.

Temporal Discounting Task

Temporal discounting was assessed with a task adapted from Mitchell (1999) and implemented on a laptop computer using E-prime (version 2.0) experimental software. Participants were asked to make a series of choices between a smaller outcome affecting them immediately and a larger outcome affecting them at some time in the future. For example, they saw the options "gain

$5 now" and "gain $7.50 in 90 days" and used the computer keyboard to select one of the options.

Each choice was either a choice between an immediate gain versus a delayed gain (henceforth referred to as the "gain condition") or a choice between an immediate loss versus a delayed loss ("loss condition"). For each outcome valence (gain or loss), the immediate amount of $5 was held constant across trials. There were seven levels of delayed amounts ($4.75, $5.25, $5.50, $6.00, $6.50, $7.00, $7.50) presented at four delays (7, 30, 90, and 180 Days). Each combination of amounts and delays was presented once in the gain condition and once in the loss condition. Figure 1 shows sample screenshots for each condition.

The combination of two conditions (gain vs. loss), four delays, and seven levels of delayed outcomes resulted in a total of 56 trials. The trials for the gain and the loss condition were presented in separate blocks. The order of the conditions (i.e., gain first vs. loss first) was randomized across participants. Within each outcome valence, the sequence of items and the side of the screen showing the immediate option were randomized as well. There were no time constraints on responses.

To implement realistic monetary losses without creating ethical problems, participants were given a "starting capital." Specifically, they were shown two envelopes containing $8 each. They were told that the money in the envelope labeled "now" would be available immediately and the money in the envelope labeled "later" would be available after a delay. They were told that experimental gains and losses would be applied to this starting capital. At the end of the experimental session, one of each participant's choices was picked at random and the appropriate consequences were applied to the immediate and delayed "starting capital." Participants were then paid out the remainder of the immediate starting capital and received a dated "I owe you" for the remainder of the delayed starting capital. A check covering the corresponding amount was mailed out on the appropriate date. For example, consider a participant who had chosen the option "lose $5.50 in 90 days" over "lose $5 now." At the end of the study, he or she would receive the full amount ($8) of the immediate starting capital and an "I owe you" for $2.50 ($8 minus $5.50). A check for $2.50 would be mailed to the participant after 90 days.

Measures

We assessed affective responses to various aspects of the discounting task: Anticipated affective responses to choice outcomes, affective state at baseline, affective responses to the choice task, and affective responses to actual choice outcomes. All affect assessments used two 7-point rating scales (adapted from Nielsen, Knutson, & Carstensen, 2008). Arousal was rated on a scale from 1 (*not aroused*) to 7 (*very aroused*) and valence was rated on a scale from 1 (*very negative*) to 7 (*very positive*). We now describe the context for each of the affect assessments in more detail.

Anticipated affective responses were assessed in a block of questions presented before the discounting task. Participants were asked to rate how they would feel about a variety of future financial outcomes at the time of their occurrence. Participants rated how positive/negative and aroused they would feel when losing or gaining $5 and $10 at each of the four delays. For example, they were asked "How aroused would you feel when losing $5 in 90 days?" Answers were provided on the two scales described above. Preliminary analyses indicated that patterns of results did not differ by monetary amount. Thus, responses for $5 and $10 were averaged in subsequent analyses.

To assess *affective state at baseline*, we asked participants to rate their current affect right before the beginning of the discounting tasks. *Task-related affective responses* were assessed at regular intervals (every seven trials) during the discounting tasks for a total of eight assessments. For both baseline affect and task-related affect, participants rated their current emotional state (e.g., "How aroused do you feel right now?") on the two scales described above.

Outcome-related affective responses were collected when participants received the outcomes of their choice at the end of the experiment (e.g., "How aroused do you feel about gaining $5?").

A manipulation check was administered after the temporal discounting tasks to assess participants' confidence that the delayed outcome would be received exactly as it was described. Ratings were given on a 7-point scale from 1 (*not confident at all*) to 7 (*very confident*).

Cognitive abilities were assessed with a battery of four measures. To assess vocabulary, we administered the vocabulary portion of the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993) which consists of 25 multiple-choice items that require participants to match a target word with its definition. To assess verbal working memory, we administered the Digit-Span subtest of the Wechsler Adult Intelligence Scale (WAIS, Wechsler, 1981) which requires participants to repeat dictated strings of digits both forwards and backwards. Perceptual-motor speed was assessed

Gain Condition Loss Condition

Figure 1. Sample Screenshots for the Two Discounting Conditions

with the Digit-Symbol subtest of the WAIS, a timed task which asks participants to match a sequence of digits with a set of corresponding symbols. Numeracy was assessed with a 4-item measure adapted from Schwartz, Woloshin, Black, and Welch, (1997) which requires participants to interpret numerical information.

Five-factor personality traits were screened with the Ten Item Personality Measure (TIPI, Gosling, Rentfrow, & Swann, 2003) which employs ten Likert-type items to assess levels of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. For example, to assess extraversion, participants are asked whether they see themselves as outgoing and sociable. In spite of its short length, acceptable psychometric characteristics and convergence with longer Big Five measures have been reported (Muck, Hell, & Gosling, 2007).

Subjective health was assessed with the 12-item Short Form Health Survey (SF-12, Ware, Kosinski, & Keller, 1998), a widely used and well-validated measure which yields separate scores for mental and physical health. Multiple-choice and Likert-type items require participants to rate their general health as well as aspects of mental well-being and functional health.

Future time perspective was measured with the Future Time Perspective scale, a 10-item scale asking participants to rate perceived time and opportunities left in their lives (Carstensen & Lang, 1996). Higher scores indicate a more expansive time perspective.

Future self-continuity was measured with a 7-point Likert-type item asking participants to indicate their similarity to their future self ten years from now (Ersner-Hershfield, Garton, Ballard, Samanez-Larkin, & Knutson, 2009).

Procedure

Experimental sessions lasted 60–90 minutes and were conducted in a laboratory setting or at a quiet location in the participants' home. After providing informed consent, participants completed a demographic questionnaire, the Future Time Perspective Scale, and the Future Self-Continuity item. Next, they rated their anticipated affective responses to gains and losses occurring at various levels of delay. Right before the temporal discounting task, participants received the envelopes with the immediate and delayed starting capital and completed a baseline assessment of current affective state. Additional ratings of current affect were collected every seven trials within a given block of the discounting task. Participants also completed additional choice scenarios that differed in question format and response alternatives and are not reported here. Afterwards, participants completed the manipulation check, cognitive and numeracy measures, as well as the TIPI and the SF-12. Finally, participants received immediate monetary payouts, rated their corresponding affective responses, and were debriefed. As each new task was introduced, participants were prompted for questions and received additional explanations as needed. About halfway through the protocol, participants were offered the opportunity to take a break.

To deliver delayed payments, 98% of participants could be successfully reached by mail. An examination of bank records indicated that among those who received a mailed check, all but two of the participants cashed the check shortly after receipt. This indicates that delayed payments were received as planned.

Results

Data Reduction and Preliminary Analyses

As a first step, we converted the choice data from the temporal discounting task into a measure of temporal discounting. In preliminary analyses, we pursued three different approaches: (a) a tally-based score, (b) a hyperbolic model with a single discounting parameter, and (c) a quasi-hyperbolic model with two discounting parameters. All yielded the same pattern of findings and subsequent analyses focus on the quasi-hyperbolic model because it has the advantage of estimating separate parameters corresponding to the "hot" and "cool" systems. We now describe each analytical approach in more detail.

For the tally-based scores, we simply tallied the number of times each participant made a present-optimizing choice in the gain and loss conditions (i.e., preferring a smaller immediate gain over a larger, delayed gain and preferring a larger delayed loss over a smaller immediate loss, see Ersner-Hershfield et al., 2009; Magen, Dweck, & Gross, 2008).

We also fit a hyperbolic discount function for each participant and each condition (gain vs. loss), to estimate a single discount parameter k with higher scores indicating steeper discounting (using the same technique as below except using $V(O,d) = O(1 + kd)^{-1}$, Mitchell, 1999).

In our preferred approach, we fit the quasi-hyperbolic model proposed by McClure et al. (2004). Specifically, this model assumes that a person's subjective value (V) for an outcome O received with delay d is $V(O,d) = (1 - \omega)O\beta^d + \omega O\delta^d$ with β restricted to be no larger than δ. In this model, β can be interpreted as the time preference of the present-oriented, "hot system", δ as the time preference of the delay-oriented, "cool system", and ω as the relative weight of the cool system. Lower β and δ indicate steeper discounting.[2]

For each participant and each condition (gain vs. loss), we estimated β, δ, and ω using maximum likelihood estimation assuming a logistic choice rule. We also estimated a temperature parameter m that reflected the inverse of the variance of the choice error. Higher values for m reflect a more precise fit of the data. Because β and δ do not conform to criteria of normality, subsequent analyses of these discounting parameters used nonparametric statistics.

Within each condition (i.e., gain or loss), the hyperbolic k parameter and the simple tally score showed strong negative correlations with the δ parameter of the quasi-hyperbolic model (for all correlations, Spearman's $\rho < -.7$). Also, the pattern of significant associations with age and other correlates of discounting was the same for δ, k, and the tally-based score, which attests to the robustness of our findings.

There were no age differences in model fit (as indicated by log-likelihood), relative weighting of β versus δ (as indicated by

[2] We prefer this model to the simpler β-δ model frequently used in economics, $V(O,d) = O\beta\delta^d$ (Laibson, 1997), because it provides a more natural dual-system interpretation in which the hot system and cold system both discount the future, but the hot system does so in a more impatient way.

ω), or the temperature parameter m (all ps > .2). This suggests that data quality and decision function did not vary by age.[3]

The manipulation check variable indicated that participants had high confidence that they would actually receive the delayed outcome ($M = 6.42$, $SD = 1.17$, on a 7-point scale). Confidence ratings were not significantly correlated with age and excluding three participants with confidence ratings below 4 did not alter the pattern of results. Subsequent analyses are therefore reported for the sample as a whole.

Age Differences in Temporal Discounting and Individual Difference Measures

When examining age differences in discounting parameters, we found a positive association between age and δ. This suggests that with advanced age the "cool" system shows less devaluation of future outcomes with increasing delay. We expected this effect to be stronger in the gain condition than in the loss condition. In fact, the effect only reached significance in the gain condition (Spearman's $\rho = .33$, $p < .001$), but remained at trend level in the loss condition (Spearman's $\rho = .18$, $p = .07$).[4] There were no age differences in β which suggests that the function of the "hot" system does not vary by age. The β scores were therefore excluded from further analyses.

In a next step, we examined individual difference measures that might potentially account for the observed age differences in δ. Table 1 shows descriptive information as well as correlations with age and δ for each of the measures. As seen in the third column of Table 1, age was negatively associated with perceptual speed (Digit Symbol) and numeracy, but positively associated with vocabulary. There were no age differences in Digit Span. Consistent with prior research (Carstensen, 2006; Roberts, Walton, & Viechtbauer, 2006), age was positively associated with agreeableness and conscientiousness, but negatively associated with neuroticism, openness to experience, and future time perspective. Further, although advanced age was negatively associated with self-rated *physical* health, self-rated *mental* health showed a positive association with age.

The δ scores showed few associations with these covariates (Table 1, columns 4 and 5). In the gain condition, higher future continuity, better mental health, and more positive affect at baseline were associated with a lower tendency to discount the future (i.e., larger scores on δ). In the loss condition, no significant correlations were found.

Mental health was the only individual difference measure that showed significant correlations with both age and δ_{gain}. We used a distribution-independent bootstrapping approach (Preacher & Hayes, 2004; Preacher & Hayes, 2008) to test the mediation model shown in Figure 2 with mental health as the mediator. We found a significant indirect path from age to δ_{gain} via mental health (ab path = .001, $SE = .0007$, 95% CI: $.0002 \leq ab \leq .0032$, 5000 Bootstrap resamples). When including mental health, the direct path from age to δ_{gain} was no longer significant ($p = .2$) which indicates that mental health fully mediated the effect of age on δ_{gain}.

Age Differences in Affective Responses

Age differences in anticipated affect. To examine the influence of age on anticipated affective responses, we computed

Table 1
Individual Difference Measures: Descriptive Information and Correlations With Age and Discounting Rates

	Descriptives		Correlations		
	M	*SD*	Age (r)	δ_{gain} (ρ)	δ_{loss} (ρ)
Cognition					
Digit Symbol	54.19	14.98	−.66**	−.05	−.11
Digit Span	16.52	4.01	−.12	.01	.03
Vocabulary	17.83	4.34	.37**	.16	.14
Numeracy	2.60	1.37	−.30**	−.01	.03
Personality traits					
Neuroticism	6.43	2.91	−.23*	−.19	−.14
Extraversion	8.59	2.62	−.04	.04	−.12
Openness	10.71	2.20	−.20*	−.03	−.01
Agreeableness	10.44	2.17	.32**	.13	.17
Conscientioussness	10.91	2.43	.29**	.19	.13
Future perceptions					
Future Time Perspective	4.51	1.17	−.43**	−.15	.00
Future Continuity	5.52	0.94	.14	.21**	.05
Subjective Health					
SF-12 Mental Health	47.69	11.45	.40**	.33**	.14
SF-12 Physical Health	48.85	10.30	−.27**	−.01	.04
Affective responses					
Baseline Valence	5.29	1.38	.07	.27**	.17
Baseline Arousal	4.29	1.62	−.10	.01	−.14

Note. Correlations for δ scores use Spearman's ρ instead of Pearson's r to address deviations from normality.
* $p < .05$. ** $p < .01$.

repeated-measures ANCOVAs with outcome valence (gain or loss) and delay as within-subject variables, age as a covariate, and anticipated affect as the dependent variable. Separate analyses examined anticipated valence and arousal. If applicable, Greenhouse-Geisser corrections addressed deviations from the sphericity assumption. To explicate interactions involving the continuous age variable, age was trichotomized into young, middle-aged, and old for posthoc analyses.

For *anticipated valence ratings,* there were no main effects of age or delay, but there was a significant effect of outcome valence with gains eliciting more positive ratings than losses, $F(1, 288) = 31.68$, $p < .001$, $\eta_p^2 = .25$, and an outcome valence by delay interaction, $F(2.59, 248.75) = 26.67$, $p < .001$, $\eta_p^2 = .22$, indicating that with increasing delay, gains were perceived as less positive and losses were perceived as less negative. However, this effect was qualified by an outcome valence by age by delay

[3] To further probe for age differences in the consistency of responses, we examined the distribution of switch points. For this purpose, we arranged delayed outcomes in descending order of value and observed at which point participants switched their preference from the immediate to the delayed option and vice versa. Consistent with previous research (Mitchell, 1999) a substantial group of participants (39%) showed multiple switch points for at least one level of delay within a given condition. However, the number of switch points did not differ by age (all *p*s > .5).

[4] Supplemental analyses examining the normally distributed tally scores indicated that age differences in gain discounting were linear in nature. There was no evidence of quadratic or cubic effects of age. Also, while age effects only reached significance in the gain condition, Steiger's Z indicated that the strength of the association between age and discounting did not differ between the gain and the loss condition ($Z = -.79$, n.s.).

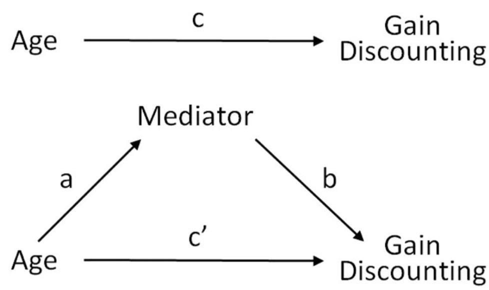

Figure 2. Proposed mediation model of the association between age and gain discounting.

interaction, $F(2.59, 248.75) = 10.82$, $p < .001$, $\eta_p^2 = .10$. Comparisons of means and 95% confidence intervals in the age-trichotomized sample revealed that the influence of delay on anticipated valence ratings was less pronounced in advanced age (see Figure 3). In other words, older adults' anticipated emotion ratings were less sensitive to delay than those of younger adults.

For *anticipated arousal ratings*, a repeated measures ANCOVA found no main effects of age or outcome valence but a significant main effect of delay with participants reporting lower arousal for longer delays, $F(1.93, 141.84) = 8.40$, $p < .001$, $\eta_p^2 = .08$. This effect was qualified by an age by delay interaction, $F(1.93, 141.84) = 3.36$, $p = .04$, $\eta_p^2 = .03$. Means and confidence intervals in the age-trichotomized sample suggested that the influence of delay on anticipated arousal ratings was less pronounced in advanced age.

In summary, younger adults appear to expect that emotional reactions to gains and losses will feel less intense and arousing if they occur farther into the future. With advanced age, however, participants are more likely to appreciate that gains and losses will likely feel the same, regardless of how far in the future they occur.

Age differences in task-related affect. To examine whether task-related affect differed by age and condition or varied over the course of the discounting tasks, we conducted repeated-measures ANCOVAs with condition (gain vs. loss) and time of assessment (after 7, 14, 21, or 28 trials) as within-subject variables, age as a covariate, and valence and arousal ratings as the dependent variables. Again, the age variable was trichotomized for posthoc analyses.

For *task-related valence ratings*, we found a main effect of condition, $F(1, 285) = 17.39$, $p < .001$, $\eta_p^2 = .16$, indicating that participants reported more positive emotions when choosing among gains than when choosing among losses. This main effect was qualified by an age by condition interaction, $F(1, 285) = 4.29$, $p = .04$, $\eta_p^2 = .04$. An observation of means and confidence intervals in the age-trichotomized sample revealed that whereas younger adults reported more positive emotions when choosing among gains versus losses, older age groups showed less differentiated emotional responses to gains and losses. There were no main effects of age or time nor any higher-order interactions. Also, for *task-related arousal ratings*, none of the main and interaction effects reached significance.

Age differences in outcome-related affect. To examine age differences in outcome-related affect, we computed linear regressions with age and the actual financial outcome (i.e. amount of money gained or lost) as predictors and outcome-related valence and arousal ratings as the dependent variables. For valence, there was a significant effect of financial outcome, $B = .22$, $SE\ B = .04$, $\beta = .48$, $p < .001$, indicating that that more positive financial outcomes were associated with more positive affect. For arousal there was a marginally significant effect of financial outcome, $B = .10$, $SE\ B = .05$, $\beta = .20$, $p = .05$, indicating that more positive outcomes were associated with higher arousal. There were no significant age effects on outcome-related valence or arousal.

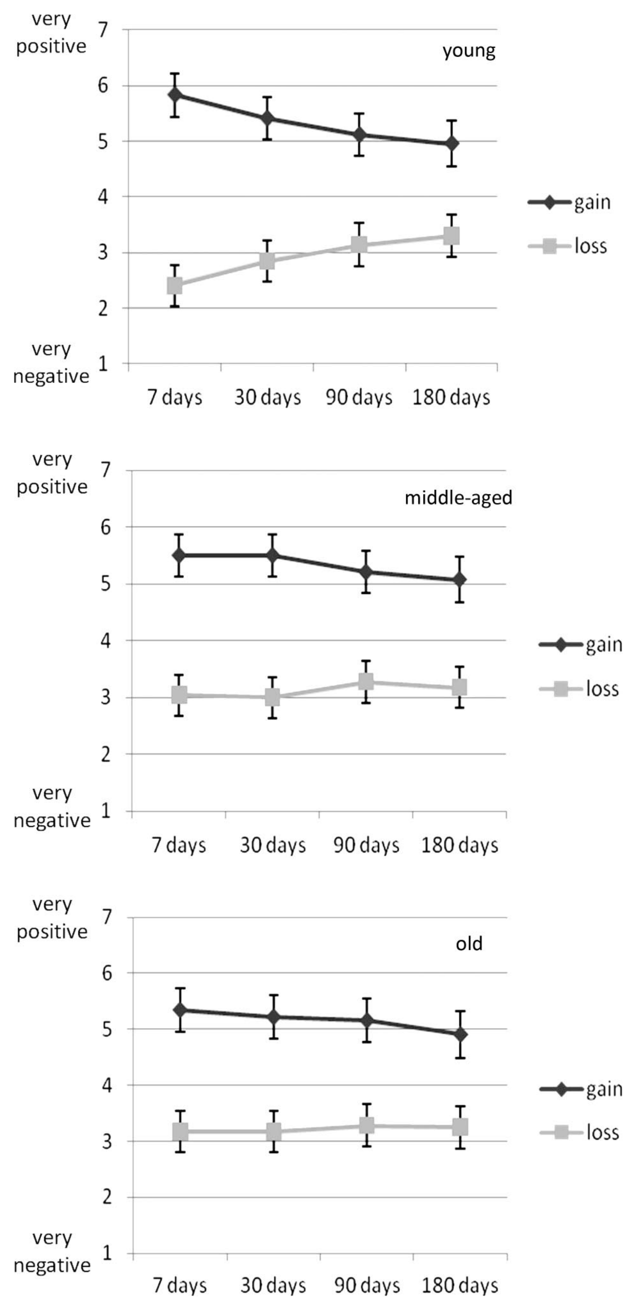

Figure 3. Anticipated valence of monetary gains and losses by age group and temporal delay; error bars show confidence intervals.

Taken together, we found that although there are no age differences in participants' actual affective responses to a given financial outcome, adults of different ages vary in their anticipated affective responses to future outcomes and their affective responses to the decision-making process itself.

The role of affective responses in age differences in discounting. To examine the extent to which age differences in affective responses account for age effects in discounting, we computed a set of individual-level indices of anticipated and choice-related affect and examined their association with age and $\delta_{gain.}$

Delay sensitivity scores were based on the absolute difference between anticipated emotion ratings at seven versus 180 days of delay and capture the sensitivity of anticipated affect ratings to temporal delay. Higher scores indicated that anticipated intensity decreases as delay increases. Lower scores indicate that anticipated intensity is independent of delay. We obtained separate scores for valence and arousal. Because age effects on anticipated affect did not differ by condition (gain or loss), scores were averaged across the conditions.

As predicted, delay sensitivity scores for valence and arousal ratings were negatively associated with both chronological age ($rs < -.26$, ps $< .01$) and the discounting parameter δ_{gain} (Spearman's $\rho < -.28$, $p < .01$). In mediation analyses, however, the indirect paths from age to δ_{gain} via delay sensitivity did not reach statistical significance ($p > .05$).

Task sensitivity scores are based on the absolute difference between affective responses to the loss task as compared to the gain task. Higher scores indicate that a person's affective state is more sensitive to task type. Because age differences in task-related affect were only found for valence but not for arousal, we only computed a task sensitivity score for valence ratings.

As predicted, the task sensitivity score for valence was negatively associated with age ($r = -.21$, $p < .05$), but the association with δ_{gain} and the indirect path from age to δ_{gain} via task sensitivity did not reach significance ($p > .05$).

Discussion

The present findings extend existing research on age differences in temporal discounting in several important ways. First, we assessed age differences in discounting in a controlled laboratory environment (as compared to survey studies) and used an incentive-compatible paradigm involving real monetary outcomes. Our study is also the first to explicitly compare age effects in discounting rates for monetary gains and losses. Moreover, we systematically examined the role of affective responses and controlled for a range of theoretically and empirically implicated covariates. Finally, we recruited a demographically homogenous life-span sample and explicitly excluded undergraduate student participants, whose discounting rates may be skewed by their unique life situation.

As predicted, we found that advanced age was associated with a reduced tendency to discount future outcomes. Importantly, this effect was only found for the delay-oriented "cool" system (δ) which tracks the relative weight assigned to rewards at different levels of delays. There were no age differences in the "hot" system (β) suggesting that the allure of immediate rewards does not differ by age.

We had also expected that age effects would be stronger when discounting future gains as compared to losses. Consistent with this hypothesis, age effects reached significance for the condition involving gains, but not for the condition involving losses. However, supplemental analyses indicated that the age slopes in the gain and loss condition did not differ significantly from each other. Thus, although an age-related positivity effect (Carstensen & Mikels, 2005) cannot be ruled out, future studies are needed to examine age differences in gain versus loss discounting in more detail.

In contrast to some previous studies (Harrison et al., 2002; Read & Read, 2004) we found no evidence for curvilinear age effects. One possible reason for this discrepancy is that previous studies used representative samples in which age groups likely differed in demographic factors and other relevant covariates whereas the present study selectively recruited a demographically homogenous sample of healthy, community-dwelling adults.

Among the range of covariates included in the present study, only a small portion showed significant associations with the observed age differences in the discounting of future gains. Importantly, although we found familiar patterns of age differences in cognitive functioning (Salthouse, 2006), personality traits (Roberts et al., 2006; Terracciano, Costa, & McCrae, 2006), and subjective physical health (CDC, 2007), none of these showed any association with discounting rates. Moreover, in-depth analyses of switch points and discounting functions showed no indication that the consistency of response patterns differed by age. This suggests that age-related declines in cognitive and physical functioning are not responsible for age differences in temporal discounting.

Consistent with prior research (Ersner-Hershfield et al., 2009) participants who reported more similarity between their present and future selves were less likely to discount the future. However, this future continuity measure did not differ by age. Further, although the future time perspective scale was negatively associated with age, it showed no significant link with discounting rates. At first glance, it may seem surprising that individuals who perceive their time horizons as more limited would not be more likely to discount the future. One possible explanation is that the present study used a maximum delay of 180 days, which may have been too short to capture the effects of limited future time perspective.

Overall, affective variables showed the greatest promise in explaining age differences in temporal discounting. For one, age was positively associated with *dispositional affect* (as captured by subjective mental health). This is consistent with previous research indicating that everyday affect and emotional stability improve in later life (for a review see Scheibe & Carstensen, 2010). With regard to *anticipated affect*, we found the expected pattern of age effects: Younger adults assumed that monetary gains and losses would feel less positive or negative and less arousing the farther in the future they occurred. In advanced age, however, participants were more likely to expect that monetary outcomes would feel the same, regardless of their temporal distance. In other words, younger adults' construals of anticipated emotions were more sensitive to delay than those of older adults. This adds to earlier findings indicating that older adults have greater insight in the dynamics of emotional reactions than their younger counterparts (Kafetsios, 2004; Nielsen et al., 2008; Scheibe et al., in press).

Among all covariates, subjective mental health and delay sensitivity scores were the only variables that showed significant associations with both age and gain discounting, making them potential candidates for mediation effects. However, only mental health emerged as a significant mediator whereas mediation effects for delay sensitivity remained at the trend level. An examination of individual SF-12 items indicated that associations with age and discounting were primarily driven by self-reported interference of emotional problems with accomplishments, work/activities, and social involvement as well as feeling "downhearted and blue." Taken together, these findings imply that age differences in the ability to forego immediate temptation in favor of later, larger gains are primarily driven by age differences in dispositional emotions–particularly the ability to prevent emotional factors from intruding into everyday functioning. Age differences in anticipated emotions may play a role as well, but additional research is required to determine their specific influence.

In addition to anticipated and dispositional affect, we assessed several other components of affective responses. Although these variables did not account for age differences in temporal discounting, they warrant some further discussion. For one, it is important to note that age was not significantly associated with affective responses to the actual monetary outcomes administered at the end of the task. This suggests that the amounts of monetary gains and losses involved in the present study were similarly attractive or aversive across the life span. Further, when examining task-related affect (i.e., emotional responses to the discounting task itself), we found that differences in affective responses to the gain versus loss condition diminished with age. Future research should examine possible reasons for this phenomenon.

Although ambient mood was not significantly associated with age, individuals who reported more positive affect before the discounting task were less likely to discount future outcomes. These findings are consistent with previous research indicating that positive mood can serve as a resource in tasks involving self-control (Isen & Reeve, 2005; Tice, Baumeister, Shmueli, & Muraven, 2007). Our results extend evidence for this phenomenon to a temporal discounting paradigm. If replicated by future research, this suggests promising pathways for manipulating discounting rates via targeted mood inductions.

Of course, several important limitations of the present study need to be acknowledged. For one, we included a limited set of theoretically implicated covariates with a strong focus on aspects of affective processing. Future research should examine other correlates of age and temporal discounting (e.g., locus of control, Plunkett & Buehner, 2007) that might contribute to the observed age effects.

Also, to maintain incentive compatibility, we examined discounting rates for small amounts of money over a relatively limited time frame of up to half a year. A different pattern of age effects may emerge for tasks involving larger trade-offs over more extended delays. Age differences in future time perspective and physical health in particular may be more likely to affect discounting over longer time frames of years or decades.

Further, although the discounting task was incentive compatible, it was administered in a laboratory setting. While prior research has found substantial links between laboratory-based discounting rates and real-life behaviors (e.g., Bradford, 2010; Ersner-Hershfield et al., 2009) more research is needed to examine the extent to which our findings map onto various life contexts. Moreover, we exclusively studied monetary outcomes. As indicated in previous research (Read & Read, 2004), age effects in temporal discounting may differ across decision domains and future research should examine other relevant outcomes including health-related and lifestyle choices.

Finally, our sample was relatively small and not representative of the U.S. population. Although the selective recruitment of a demographically homogenous sample was advantageous for our goal of studying 'pure' age effects net of any age differences in demographic variables, further research is needed to understand age effects in temporal discounting among more diverse populations.

In summary, our findings contribute to the literature by addressing several important gaps in previous research on age effects in intertemporal choice. Most importantly, our findings suggest that age differences in emotional functioning, particularly dispositional affect, play a crucial role in accounting for age effects in temporal discounting. If corroborated by future research examining a wider range of outcomes, delays, and choice domains, these findings have important implications for understanding real-life intertemporal choices. Ultimately, our findings can aid in the development of interventions aimed at promoting good decision-making across the life span. Younger adults in particular may benefit from decision aids that highlight the emotional salience of delayed outcomes and help them to gain greater insight into the dynamics of their emotional reactions.

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