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# Adult age differences in decision making across domains: Increased discounting of social and health-related rewards

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## Abstract

Although research on aging and decision making continues to grow, the majority of studies examine decisions made to maximize monetary earnings or points. It is not clear whether these results generalize to other types of rewards. To investigate this, we examined adult age differences in ninety-two healthy participants aged 22–83. Participants completed nine hypothetical discounting tasks, which included three types of discounting factors (time, probability, effort) across three reward domains (monetary, social, health). Participants made choices between a smaller magnitude reward with a shorter time delay / higher probability / lower level of physical effort required and a larger magnitude reward with a longer time delay / lower probability / higher level of physical effort required. Older compared to younger individuals were more likely to choose options that involved shorter time delays or higher probabilities of experiencing an interaction with a close social partner or receiving health benefits from a hypothetical drug. These findings suggest that older adults may be more motivated than young adults to obtain social and health rewards immediately and with certainty.

## Keywords

aging; decision making; discounting; reward; domain specificity

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## Introduction

Decisions – both big and small – are all around us. Should I visit my children over break or take the opportunity to catch up on meetings with colleagues and visit the kids later? Should I invest my holiday bonus in the volatile stock market or leave it in my savings account? Should I walk or bike into work today or take the car? It's clear from these examples that in our attempts to maximize financial well-being, social satisfaction, and physical health, the decisions we make require the weighing of expected benefits with other associated decision features. This involves taking into account factors such as varying amounts of temporal delays until outcomes are realized, uncertainty about the outcome of a choice, or the exertion of effort required to achieve various outcomes (Floresco, Onge, Ghods-Sharifi, & Winstanley, 2008; Mitchell, 2004; Phillips, Walton, & Jhou, 2007). Depending on an individual's preferences, these factors may systematically diminish the subjective value of decision outcomes. Recent functional neuroimaging studies have revealed partially shared representations of these discounting factors in frontal and temporal brain regions (Burke, Brünger, Kahnt, Park, & Tobler, 2013; Massar, Libedinsky, Weiyan, Huettel, & Chee, 2015; Peters & Buchel, 2009) which undergo structural and functional changes with age (Bennett, Madden, Vaidya, Howard, & Howard, 2010; Davis et al., 2009; Fjell et al., 2014; Head, Snyder, Girton, Morris, & Buckner, 2005; Raz et al., 2005). Thus, age-related changes in the function of these brain regions may uniformly shift preferences for time, probability, or effort across adulthood. However, behavioral research has only recently started to examine how these discounting factors may similarly or differentially influence decision making across adulthood and into old age (Samanez-Larkin & Knutson, 2015).

Emerging theories suggest that changes in cognition, emotion, motivation, and experience across adulthood influence decision making, leading older adults to sometimes outperform or underperform in reward-maximizing decision tasks relative to young adults (Brown & Ridderinkhof, 2009; Hsu, Lin, & McNamara, 2008; Laibson, Gabaix, Driscoll, & Agarwal, 2008; Mather, 2006; Peters, Hess, Västfjäll, Auman, & Vastfjall, 2007). For instance, age has been associated with decreased probabilistic learning (Frank & Kong, 2008; Mell et al., 2005; Rieckmann & Bäckman, 2009; Simon, Howard, & Howard, 2010), potentially leading to inaccurate integrated representations of expected value (i.e., reward times probability) and poorer decision making. Beyond the question of optimal decision making there are also significant individual differences in preferences that can be affected by age. Recent studies of risky decision making and intertemporal choice across multiple decision domains have revealed substantial variability in the magnitude and direction of age differences (Jimura et al., 2011; Josef et al., 2015; Rolison, Hanoch, Wood, & Liu, 2014). The goal of this study is to extend these initial findings by focusing on age differences in how discounting factors (time, probability, and effort) influence preferences across a range of reward domains.

### Time

Over the past 15 years a number of behavioral studies have examined age differences in the effects of time on decision making. While some studies with hypothetical or real monetary rewards have reported a slight increase with age in the tolerance of short temporal delays in both humans (Eppinger, Nystrom, & Cohen, 2012; Green, Fry, & Myerson, 1994; Löckenhoff, O'Donoghue, & Dunning, 2011) and rats (Simon et al., 2010), it is important to note that many studies find no age differences (Chao, Szrek, Pereira, & Pauly, 2009; Rieger & Mata, 2013; Roalf, Mitchell, Harbaugh, & Janowsky, 2012; Samanez-Larkin et al., 2011; Whelan & Mchugh, 2009) or the opposite effect (Read & Read, 2004). The first study to explore the potential psychological mechanisms underlying age differences in temporal discounting identified affective rather than cognitive mediators (Löckenhoff et al., 2011). Older adults made more accurate affective forecasts of the experience of these rewards over various delays, had higher trait levels of mental health, and had lower discount rates (i.e., were more tolerant of temporal delays). In general, at least in a monetary domain, it seems that older adults may be slightly more tolerant of temporal delays than young adults (Löckenhoff, 2011). Despite inconsistencies in the literature, we expected to observe an approximately linear decrease in time discounting across the adult life span.

## Probability

Despite popular stereotypes of older adults being more risk averse than young adults in the face of uncertainty, a quantitative meta-analysis revealed that tolerance of lower probabilities for rewards do not globally differ between younger and older adults (Mata, Josef, Samanez-Larkin, & Hertwig, 2011). Although different patterns of risk taking or risk aversion emerge for certain classes of decisions (Mata et al., 2011), these differences appear to be more related to cognitive limitations than true preferences. Older adults simply make more mistakes when making cognitively demanding decisions. Thus, when cognitive demands are minimized, overall tolerance of probabilistic rewards appears to remain relatively stable across adulthood. However, the meta-analysis described above only indirectly examined how cognitive factors influenced decision making; it is possible that motivation could also influence choice behavior. Because cognitive demands have been minimized in the tasks used here, we expect that overall behavioral risk preferences will remain relatively stable across the adult life span.

## Effort

To the best of our knowledge, there are no existing studies on preferences for physical effort in older adults. Yet, effort is a rapidly growing area of interest in both clinical psychology (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009; Treadway & Zald, 2011) and decision neuroscience (Kurniawan, 2011; Mai, Sommer, & Hauber, 2012; Wardle, Treadway, Mayo, Zald, & de Wit, 2011), which highlights a critical role of the mesolimbic dopamine (DA) system in effort expenditure. Stereotypes of retirement age as a time of physical relaxation and leisure might suggest that tolerance of physical effort declines across adulthood. Although there is not yet any available empirical evidence related to physical effort and decision making in old age, age-related DA decline may contribute to a lower tolerance for effort (Floresco et al., 2008) with age. This lowered tolerance may be further exacerbated by, or even primarily due to, an increase in physical motor limitations and increase of muscle fatigue with age (Faulkner & Brooks, 1995). Together, this led us to predict a linear increase in discounting of physical effort across the adult life span.

## Rewards

One important limitation of the current literature is that almost all existing studies of tolerance of time delays and uncertainty are based on evidence from economic tasks where the goal is to maximize points or money earned (Löckenhoff, 2011; Mata et al., 2011). This initial work has not yet been extended to other reward domains. Recent work in healthy young adults has provided evidence for relatively consistent preferences for time delays (Jimura et al., 2011) and uncertainty (Levy & Glimcher, 2011) across domains and a recent neuroimaging meta-analysis has revealed shared representation of discounted value in the ventral striatum and medial prefrontal cortex across a variety of reward domains (Bartra, McGuire, & Kable, 2013). Interestingly, for older adults, behavioral studies reveal that preferences may be less domain general (Josef et al., 2015; Weber, Qian, & Baldassi, 2011). For example, older adults show reduced discounting of temporal delays for money but equivalent or even increased temporal discounting for primary rewards like juice (Jimura et al., 2011). A recent study also showed adult age differences in risky decision making for monetary rewards but no age differences for social rewards (Josef et al., 2015). Very little is currently known about how preferences may change differentially across domains over adulthood. Either due to financial changes over adulthood (in earnings or savings rate) or motivational changes in goal priorities (Carstensen, 2006) or some combination, further increasing wealth may be less important for older adults compared to other domains of utility maximization. Indeed, other domains, such as social or health-related decision making, may be more salient or a more primary focus of motivational priorities. Here, we directly compare decision making across monetary, social, and health domains across adulthood.

## Social Rewards

To date, few studies have explicitly examined changes in social decision making during aging. These initial studies have emphasized changes in social economic decisions related to competition in economic games (Mayr, Wozniak, Davidson, Kuhns, & Harbaugh, 2012) or tolerance of financial inequity (Roalf et al., 2012). In contrast to these social-economic tasks, there is an interesting earlier line of research focused on social partner preferences (Carstensen & Fredrickson, 1998; Fredrickson & Carstensen, 1990; Fung, Carstensen, & Lutz, 1999), where the core dependent variables of interest were social decisions. In this purely social domain, older adults routinely chose to prioritize close social partners. For example, when faced with 30 minutes of free time and asked to make a decision between spending time with the author of a book they have just read, a recent acquaintance with whom they seem to have much in common, or a close social partner (very close friend or family member), older adults (or individuals with short perceived time horizons) most often chose to spend time with the close social partner (Carstensen & Fredrickson, 1998; Fredrickson & Carstensen, 1990; Fung et al., 1999). These findings were foundational components of socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999; Carstensen, 2006), arguably the most widely recognized theory of motivation and aging. Despite the early impact of this line of work, the literature on aging and decision making to date has largely ignored social reward.

### Health Rewards

Another domain that may be more motivationally relevant than wealth accumulation for older adults is physical health. Some psychological research on health-related decision making has focused on the cognitive and affective processes that may influence decisions (Lockenhoff & Carstensen, 2004). Many of these studies have explored information search strategies or how the valence of decision features differentially influence choice in younger and older adulthood. For example, in choices among potential physicians or health care plans, older adults review and remember more positive relative to negative features (Löckenhoff & Carstensen, 2007). There is also evidence that older adults make more optimal health care decisions when relying on their subjective emotional reactions to the choices, whereas younger adults make more optimal decisions by focusing on the details of the information provided (Mikels et al., 2010). These studies suggest that emotional processing plays a key role in health decisions for older adults and contribute to more adaptive decision making in this age group. However, these studies have focused primarily on emotional valence effects and have not systematically examined age differences in the general effects of the different decision features described above.

It is presently not clear whether the emerging findings on monetary decision making and aging will generalize to these other domains. With age, goal priorities shift and some decisions become more motivationally salient than others. In an attempt to balance the overwhelming focus in recent work on monetary decision making across adulthood, this study examines age differences in social and health-related decisions, along with monetary decisions, using a cross-sectional design. Based on early work that formed the basis of socioemotional selectivity theory (Fredrickson & Carstensen, 1990), we hypothesize that older adults will be more motivated in the social than the monetary domain. As a result, we expect older adults to show differential sensitivity to, and tolerance of, time delays, lower probabilities, and physical effort demands when making social decisions. Due to the increasing salience of health concerns in older age, we expect to observe relatively similar effects in the health domain. In other words, we predicted that older individuals would choose social and health rewards associated with less temporal delays, higher probabilities, or lower levels of physical effort.

## Method

### Participants and Procedures

Ninety-two adult volunteers (age: M = 49.66, Range = 22 to 83 years old) were recruited from the Nashville community using the Vanderbilt School of Medicine subject database of health adults, Research Match (www.researchmatch.org), and a combination of newspaper, radio and local television advertisements. Participants completed the tasks and questionnaires described below as part of a multiday multimodal neuroimaging study on decision making and were compensated $350 for the entire study. The Vanderbilt University and Yale University Institutional Review Boards approved all experimental procedures and participants gave informed consent. These behavioral tasks described below were completed on the third day of the larger multimodal neuroimaging study.

## Cognitive Assessment

To verify that all subjects had normal cognitive abilities, participants also completed a battery of cognitive and motivational assessments during the first session of the study. Table 1 displays the mean performance on this test battery and correlation of each measure with age. As can be seen in Table 1, the sample displayed normal performance on neuropsychological tests, with the expected significant age-related declines in measures of fluid intelligence (e.g. Digit Span) and maintenance of crystallized intelligence (e.g. Vocabulary) across the adult life span.

## Future Time Perspective

Individual differences in perceptions of remaining time to live, or future time perspective (FTP), could influence decision making (Löckenhoff & Carstensen, 2007). FTP was quantified using an English version of the Future Time Perspective Scale (Lang & Carstensen, 2002; Carstensen & Lang, 1996). For each of 10 items on the scale, participants rated from 1(Very Untrue) to 7 (Very True) how true the item was for them. Sample items include “My future is filled with possibilities,” “I can do anything I want in the future,” and “I have the sense that time is running out.”

## Tasks

We sought to examine differences in behavioral sensitivity to three types of discounting factors (temporal delay, probability, physical effort) across three reward domains (monetary, social, health) in a within-subjects design. To this end, participants completed 42 trials of each of the nine two-alternative forced-choice tasks described below (Figure 1). The order of tasks was completely randomized across participants.

## Temporal Discounting Tasks

The temporal discounting tasks were adapted from a previously used paradigm (McClure, Laibson, Loewenstein, & Cohen, 2004). On each trial, participants chose between an early reward and a late reward. The delay of the early reward was set to today, 2, or 4 weeks, while the delay of the late reward was set to 2, 4, or 6 weeks after the early reward. The early reward was from 1% to 50% less than the late reward and the three different variants of this task used monetary, social, and health rewards. The outcome variable was the proportion of choices for the sooner (less delayed) reward.

## Probabilistic Discounting Tasks

The probabilistic decision making paradigm is similar to a number of recent two-alternative forced choice mixed gamble tasks (e.g., Levy & Glimcher, 2011). On each trial, participants chose between a smaller reward with a higher probability and a larger reward with a lower probability. The higher probability reward was from 1% to 50% lower in magnitude compared to the lower probability reward and the three different variants of this task used monetary, social, and health rewards. The outcome variable was the proportion of choices for the higher probability rewards.

### Effort Expenditure for Rewards Tasks (EEfRT)

The EEfRT tasks was adapted from an existing paradigm that used finger pressing as the effort required for earning a reward (Treadway et al., 2009). On each trial, participants chose between a smaller reward available for a lower amount of physical effort (button presses) and a larger reward available for a higher amount of effort. The effort required for the smaller reward was set as 20%, 40%, or 60% (of each participant's maximum press rate), while the effort required for the larger reward was set as 20%, 40%, or 60% higher than the smaller reward. The number of button presses required for each level of effort was individually determined based on an initial calibration procedure in which participants pressed a button as many times and as rapidly as possible in a few short intervals. The smaller magnitude reward was from 1% to 50% lower magnitude than the larger reward and the three different variants of this task used monetary, social, and health rewards. The outcome variable was the proportion of choices for low effort (easier) rewards.

### Decision Domains

All decision tasks described involved gains. For each type of task, participants either gained hypothetical rewards (money, positive social interaction, health improvement) or not (no money / social interaction / health improvement). In the financial domain, rewards were a monetary gain, with a maximum of $40 per trial. In the social domain, reward magnitude was the amount of time that could be spent with a close social partner (inner circle family member or best friend) with whom the subject wishes they spent more time. Importantly, it was the same social for each task and participants were reminded to keep this social partner in mind for all social trials. The maximum amount of time was capped at 80 minutes per trial. For the health domain, reward magnitude was the degree to which (via drug dosage) a new medication improves general organ function and cognition. Maximum drug dosage was set to 800mg per trial.

## Results

An omnibus Discounting Factor (Time, Probability and Effort) × Reward Domain (Money, Social, Health) ANCOVA with continuous Age as a covariate on decision preferences revealed main effects of Factor [$F$(2,180) = 256.31, $p < .001$, $\eta_g^2 = .551$], Reward Domain [$F$(2, 180) = 33.66, $p < .001$, $\eta_g^2 = 0.53$], and Age [$F$(1,90) = 3.94, $p = .050$, $\eta_g^2 = .008$]. These main effects were qualified by significant interactions between Factor and Reward, $F$(4, 360) = 14.98, $p < .001$, $\eta_g^2 = .036$, and Factor and Age, $F$(2, 180) = 6.29, $p < .002$, $\eta_g^2 = .029$. As displayed in Table 2, discounting on the tasks with the same discounting factors were strongly related to each other, even when controlling for age. The effects within reward domain were not as consistent; behavior on tasks with social rewards were all related to each other, and behavior on the time and effort tasks with monetary rewards were related to each other. However, there were no significant relationships between tasks with health rewards.

Because we were specifically interested in the influence of age, we examined the effect of age on choice behavior within each discounting factor/reward domain separately. Also, given that prior studies suggest age effects may be nonlinear across adulthood (Read & Read, 2004; Rolison et al., 2014), we also tested the quadratic effect of age. Figure 2 displays a scatterplot with linear and quadratic effects of age for each discounting factor/reward domain.

### Time

As displayed in Figure 2, while there were no significant effects of age in the monetary domain, there were significant linear effects of age in the social and health domains (Table 3) such that age was associated with the selection of more immediate outcomes (higher discount rates). Older adults were less willing to wait to receive social and health rewards than monetary rewards.

### Probability

Likewise, there were no significant effects of age in the monetary domain for probability discounting (Table 3). However, there was a significant quadratic effect of age in the social domain, such that those in middle age were more likely to select higher probability options than young adults and older adults. In the health domain, there was a linear effect of age, such that older adults were more likely to select the higher probability option than their younger counterparts. Thus, middle aged and older adults were less tolerant of lower probabilities for social and health rewards.

### Effort

The age effects on effort discounting were quite different from the other two discounting factors (Table 3). For monetary rewards, there were both significant linear and quadratic effects of age. Age was associated with an increased willingness to choose the easier option, but those in middle age were less likely to accept the easy option. For social rewards, there was a significant quadratic effect of age with those in middle age being less likely to accept the easy option. In the health domain, there were no significant effects of age on effort discounting. However, these results across the three domains should be interpreted with caution because, as displayed in Figure 2, there is a strong floor effect in the data. Although the effort task was calibrated to each participant, the fact that participants chose the more difficult option most or all of the time suggests that the more difficult option was not perceived to be very challenging by participants. Also, the effort task was different from the other tasks in that both the time and probability tasks had a “no cost” condition where participants could choose to earn a given reward without delay (now) or with certainty (100%). Because of the pronounced floor effect in the effort data, the discussion will focus on the time and probability results.

## Discussion

This study examined the influence of age and motivation on temporal, probability, and physical effort discounting across monetary, social and health domains. Age was associated with increased temporal and probability discounting for health and social rewards.

The age effects (increased discounting) in the social and health domains are opposite of previously reported findings in the monetary domain. Some prior studies of age and temporal discounting have found *decreased* discounting with age (Eppinger et al., 2012;

Green et al., 1994; Löckenhoff et al., 2011). It has been suggested that this is due to the decreased saliency of immediate rewards because of age-related decreases in dopaminergic response to immediate reward (Eppinger et al., 2012). However, this interpretation is not consistent with studies showing preserved function of striatal responses to both immediate and delayed rewards (Samanez-Larkin et al., 2007; Samanez-Larkin, Worthy, Mata, McClure, & Knutson, 2014). Additionally, the studies that found decreased discounting with age used monetary rewards, which may not be as motivating to older adults. Because of age-related changes in priorities, social and health rewards may be more salient to older adults, which may enhance reward-related signals in the brain. This is consistent with a neuroimaging study that showed an interaction between age and domain (monetary, social) in a simple reward-based task (Rademacher, Salama, Gründer, & Spreckelmeyer, 2014). A region of the striatum was more sensitive to social than monetary rewards in older adults whereas the opposite was true for younger adults. The results reported here extend this domain effect by demonstrating *increased* discounting with age for social and health rewards. Future studies should examine age-related changes in dopaminergic response specifically (e.g., using ligand displacement PET imaging) to different types of rewards, particularly social and health rewards, and how age differences in neural responses influences choice behavior.

As predicted, the results showed that older adults were more likely to choose options that involved higher probabilities of experiencing social interactions. These results are consistent with socioemotional selectivity theory (SST; Carstensen, Isaacowitz, & Charles, 1999; Carstensen, 1995, 2006) because the hypothetical social interaction was with a close social partner. SST posits that shrinking time horizons in older age lead to systematic changes in goals and preferences. Specifically, as people age and experience a limited time horizon, they focus more on maximizing their emotional experience by maintaining close social relationships.

The results also demonstrated that older adults were more likely to discount temporally delayed and probabilistic health benefits from a hypothetical drug. Because age is typically associated with lower self-rated health (Earles, Connor, Smith, & Park, 1997; Earles & Salthouse, 1995), this is consistent with the idea of scarcity – that a perceived lack of a specific resource creates a temporal focus on current circumstances, even at the expense of the future. Researchers have demonstrated scarcity effects in a variety of discounting factor and reward domains, including money and time, and suggest that scarcity can increase the saliency of immediate rewards (Shah, Mullainathan, & Shafir, 2012). Thus, as they approach the perceived end of life, older adults may view their health as a scarce resource, be more focused on improving their current health, and thus discount future health rewards more than younger adults. The age effect might be more strongly related to perceived changes in health status over adulthood (which we did not directly measure here) than future time perspective in general. It remains possible that older adults may discount future health rewards because their health is declining more rapidly than it is for young adults.

Although some studies of temporal discounting for monetary rewards have found reduced discounting (more tolerance of time delays) with age (Eppinger et al., 2012; Green et al., 1994; Löckenhoff et al., 2011), here we found no significant effect of age on temporal or probability discounting in the monetary domain. These results are consistent with other studies that have used this particular temporal discounting task (Samanez-Larkin et al., 2011), so it is possible that specific aspects of the experimental design contributed to these null results. It is also possible that the effect of age on temporal discounting for monetary rewards is relatively small, and we were unable to detect this small effect with our sample size. However, this seems unlikely given that (1) our sample size is comparable to, or larger than, the studies cited above that found an age effect and (2) we were able to detect an age effect in other reward domains. Alternatively, one study has suggested that income may be a better predictor of discounting behavior than age, finding that low-income older adults had steeper discount rates than high-income older adults (Green, Myerson, Lichtman, Rosen, & Fry, 1996). In this sample, we found no relationship between age, income, and discounting behavior for monetary rewards. However, in general age is associated with increased monetary resources (Ortman, Velkoff, & Hogan, 2014), so it is possible that prior studies showed decreased discounting with age because older adults had more financial resources. Total financial assets may be more important variable than income. Regardless, compared with the other rewards used in this study, the results suggest that older adults may have been relatively less motivated to earn additional money.

Because social and health rewards are difficult to control experimentally, this study used hypothetical rewards. There is much debate in the decision making literature about the importance of using real rewards in experimental studies (e.g. Hertwig & Ortmann, 2001), and the use of hypothetical rewards could limit the generalizability of the findings presented here. As part of the larger study, our participants also completed the three monetary tasks (Time, Probability, and Effort) and were compensated with the payout from one trial from each task. Thus, for 86 subjects we also have a measure of discounting for real monetary rewards. To test the generalizability of our results, we compared behavior in the hypothetical tasks presented here to behavior in the complimentary real task. We found strong correlations for each discount factor (Time: $r = .69$, 95% CI [.56, .79]; Probability: $r = .62$, [.47, .74]; Effort: $r = .61$, [.45, .73]), suggesting that the hypothetical tasks used in this study are close approximations of discounting behavior for real rewards.

To our knowledge, this is the first study to examine discounting for time, probability and effort across monetary, social and health reward domains at any age. The results revealed a reduction in tolerance for (and increased discounting of) temporally delayed or probabilistic social and health rewards but not monetary rewards. These results suggest that older adults are more motivated to obtain social and health rewards *immediately* and *with certainty* and demonstrate the importance of considering motivation when examining choice behavior across the adult life span.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## APPENDIX

All subject-level data used for the analyses here are publicly available at mcablab.org.

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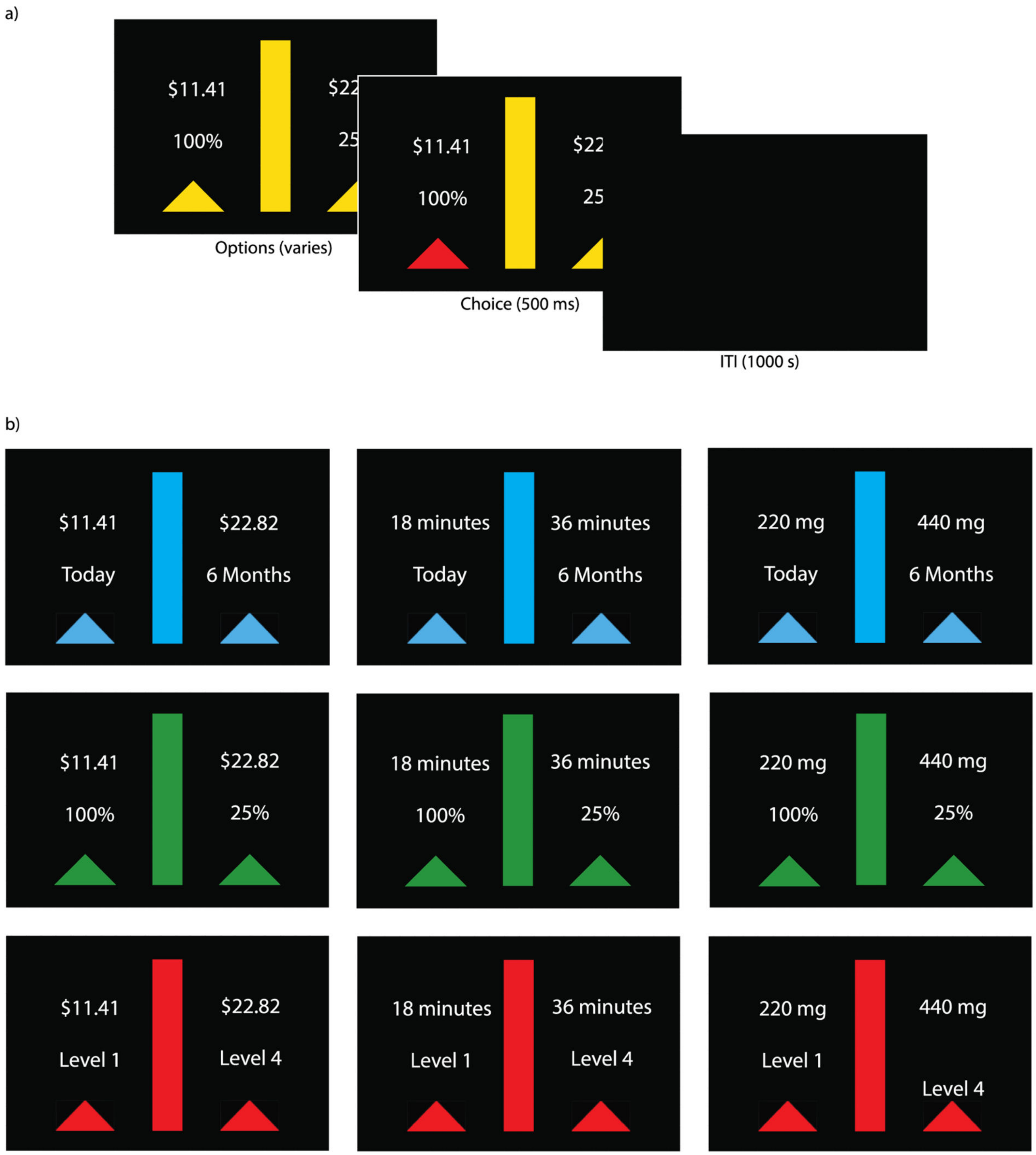


**Figure 1. Hypothetical Discounting Tasks**

(a) Trial structure for discounting tasks. Options were presented onscreen until participants made a choice. (b) Sample options for Temporal Discounting Tasks displayed in the first row, Probability Discounting Tasks displayed in the second row, and Effort Discounting Tasks displayed in the third row. Monetary rewards are shown in the first column, social rewards in the second column, and health reward in the third column.

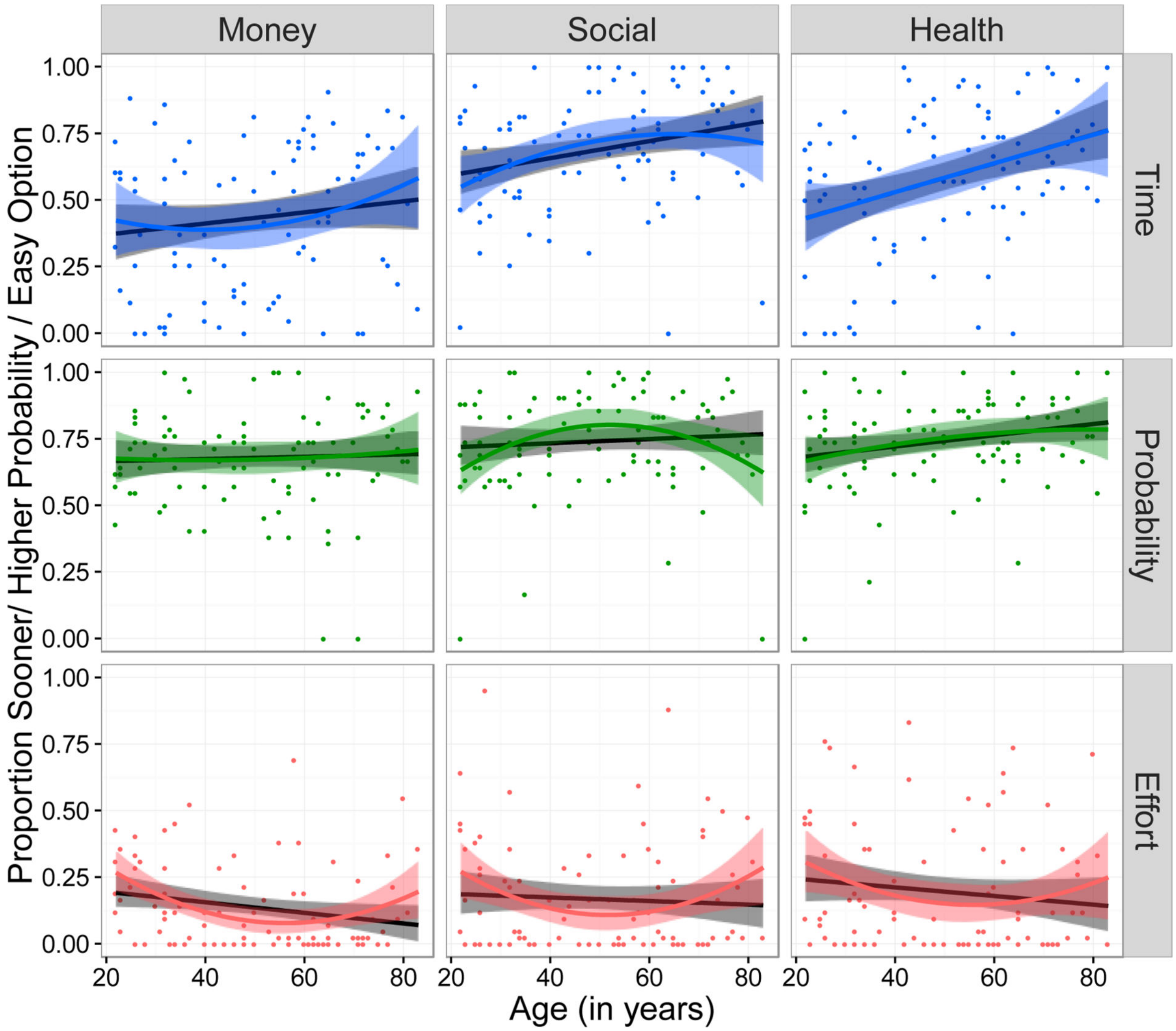


**Figure 2. Age effects on Hypothetical Discounting**

Proportion of more immediate choices as a function of age displayed in the first row, proportion of more certain choices displayed in the second row, and proportion of easy choices in the third row. Monetary rewards are shown in the first column, social rewards in the second column, and health reward in the third column. Linear effects are shown in black and quadratic effects are shown in color. Shaded region denotes 95% confidence interval.

## Table 1

Participant Characteristics

| | | Young Adults | Middle Age | Older Adults |
|---|---|---|---|---|
| **Variable** | ***r* [95% CI] with Age** | ***M* (*SD*)** | ***M* (*SD*)** | ***M* (*SD*)** |
| Age | | 28.81 (4.96) | 50.61 (6.49) | 70.23 (6.72) |
| Gender | | 17F/14M | 19F/12M | 19F/11M |
| Numeracy | **−0.3 [−0.47, −0.1]** | 12.45 (1.57) | 11.84 (4.56) | 10.63 (2.5) |
| Trails Test[a,] | **0.23 [0.03, 0.42]** | 31.89 (36.61) | 38.46 (27.33) | 52.5 (28.18) |
| Digit Span | **−0.31 [−0.49, −0.11]** | 17.68 (4.23) | 15.81 (3.85) | 14.63 (3.44) |
| Paired Associates Delayed Recall[b,] | **−0.62 [−0.73, −0.47]** | 7.69 (0.6) | 5.9 (2.34) | 4.34 (2.11) |
| Letter-Number Sequencing | **−0.62 [−0.73, −0.48]** | 13.06 (3.07) | 11.03 (2.07) | 9.37 (2.44) |
| Shipley Vocabulary Subscale | 0.05 [−0.16, 0.25] | 33.23 (4.1) | 32.13 (6.89) | 35.13 (3.72) |
| FTP | 0.07 [−0.14, 0.27] | 4.73 (1.34) | 5.27 (1.33) | 5.1 (1.16) |
| Education | **−0.43 [−0.59, −0.25]** | 17.00 (2.02) | 15.74 (2.28) | 14.83 (2.41) |
| Total Household Income | 0.00 [−0.2-, 0.21] | 6.26 (3.55) | 6.06 (3.81) | 6.53 (3.09) |

Notes.

Numeracy, (E. Peters, Dieckmann, Dixon, Hibbard, & Mertz, 2007); Trails Test, (Corrigan & Hinkeldey, 1987); Digit Span and Paired Associates Delayed Recall from the WMS-III, Wechsler Memory Scale- Third Edition (Wechsler, 1997b); WAIS-ffl, Letter-Number Sequencing, (Wechsler, 1997a); Shipley Vocabulary Subscale, (Shipley, 1940); FTP, Future Time Perspective Questionnaire (Lang & Carstensen, 2002); Education is in years; Total Household Income is from an ordinal scale where 6 = $60,000-$79,999 and 7 = $80,000-$99,999.

Significant correlations denoted in bold.

[a]Trail making score for one participant was not recorded. Trails test score is the difference in time to complete Trail A and Trail B.

[b]Delayed Recall not recorded for four participants

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**Table 2**

Partial correlations [95% CI] between Discounting Factors and Reward Conditions controlling for Age

| **Task Conditions** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| 1. Time_Money | 1 | | | | | | | |
| 2. Time_Social | **.36 [.17, .53]** | 1 | | | | | | |
| 3. Time_Health | **.37 [.18, .54]** | **.43 [.25, .58]** | 1 | | | | | |
| 4. Probability_Money | .16 [−.05, .35] | .06 [−.15, .26] | .12 [−.09, .32] | 1 | | | | |
| 5. Probability_Social | .01 [−.2, .22] | **.34 [.14, .51]** | .06 [−.15, .26] | **.44 [.26, .59]** | 1 | | | |
| 6. Probability_Health | −.13 [−.33, .08] | .06 [−.15, .26] | .04 [−.17, .24] | **.45 [.27, .60]** | **.54 [.38, .67]** | 1 | | |
| 7. Effort_Money | **.21 [.00, .40]** | −.08 [−.28, .13] | .05 [−.16, .25] | .1 [−.11, .30] | −.06 [−.26, .15] | .09 [−.12, .29] | 1 | |
| 8. Effort_Social | .09 [−.12, .29] | **−.28 [−.46, −.08]** | −.08 [−.28, .13] | −.33 [−.50, −.13] | **−.28 [−.46, −.08]** | −.16 [−.35, .05] | **.47 [.29, .62]** | 1 |
| 9. Effort_Health | −.04 [−.24, .17] | −.15 [−.35, .06] | −.09 [−.29, .12] | −.19 [−.38, .02] | −.10 [−.30, .11] | .00 [−.21, .21] | **.50 [.33, .64]** | **.54 [.38, .67]** |

*Note.* Significant correlations denoted in bold

## Table 3

Multiple Linear Regression Analyses on Temporal, Probability and Effort Discounting by Age in each Reward Domain

| | | Time | | | Probability | | | Effort | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Parameter** | **Money** | **Social** | **Health** | **Money** | **Social** | **Health** | **Money** | **Social** | **Health** |
| Model A | Age | .138 [−.069, .345] | **.260 [.058, .463]** | **.361 [.166, .556]** | .041 [−.169, .250] | .073 [−.136, .282] | **.222 [.017, .426]** | **−.225 [−.429, −.021]** | −.058 [−.267, .151] | −.126 [−.333, .082] |
| | $R^2$ | .019 | .068 | .130 | .002 | .005 | .049 | .051 | .003 | .016 |
| Model B | Age | .134 [−.074, .206] | **.266 [.064, .200]** | **.361 [.164, .195]** | .039 [−.171, .209] | .084 [−.118, .201] | **.224 [.019, .204]** | **−.237 [−.433, .195]** | −.068 [−.271, .203] | −.133 [−.339, .205] |
| | Age$^2$ | .109 [−.098, .317] | −.138 [−.339, .064] | −.001 [−.198, .195] | .031 [−.180, .241] | **−.277 [−.479, −.075]** | −.058 [−.264, .147] | **.290 [.094, .486]** | **.249 [.045, .453]** | .171 [−.035, .377] |
| | $R^2$ change | .012 | .019 | 0 | .001 | **.076**** | .003 | **.084**** | **.062*** | .029 |

*Note*: Significant standardized beta values in bold

***$p$<.001

*$p < .05$

**$p$<.01