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Dread-Sensitivity in Decisions about Real and Imagined Electrical Shocks Does Not Vary By Age

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Abstract

Previous research has found age differences in intertemporal choices that involve trade-offs among events or outcomes that occur at different points in time, but these findings were mostly limited to hypothetical financial and consumer choices. We examined whether age effects extend to unpleasant physical experiences that elicit states of dread which lead participants to speed up the outcomes just to get them over with. We asked participants of different ages to choose among electrical shocks that varied in timing and intensity. We also assessed affective responses as a potential mechanisms behind age effects and considered other potential covariates. In Study 1, the choice task involved real outcomes and the sample consisted of younger and older adults. In Study 2, the choice task was hypothetical and the sample was an adult life-span sample. Across both studies, there was no evidence of age differences in the preferred timing of shocks. Instead, dread-sensitive choices were associated with higher conscientiousness. Age effects in dread-sensitive choices remained non-significant even after controlling for a range of age-associated covariates. We discuss possible explanations for the lack of age effects and consider implications for applied and clinical settings.

Keywords

Aging; decision; intertemporal choice; discounting; unpleasant; aversive

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Unpleasant experiences - ranging from bothersome chores to painful medical procedures - are an integral part of life. Although many unpleasant events cannot be avoided altogether, it is often possible to exert some control over their timing. Such decisions have particular relevance in advanced age when medical problems mount, and physical and mental resources decline (CDC, 2007), which makes it more difficult to recover from poor (or poorly timed) choices.

When people decide about the timing of events, they often consider not only the event itself, but also the states of anticipation before the event occurs (Loewenstein, 1987). This may

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entail joyful expectations before a much awaited celebration or anxious concern before a major dental procedure. When events are negative and high in emotional salience they elicit anticipatory dread, an aversive emotional state that is experienced while a person is waiting for a negative event, such as an electrical shock, to occur (Berns, Laibson, & Loewenstein, 2007). Recent evidence suggests that anticipatory dread may affect the preferred timing of aversive events. Introducing a novel paradigm to study *dread-sensitive choices*, Berns and colleagues (Berns et al., 2006) found that when given the choice between experiencing electrical shocks sooner or later, most people preferred to endure them as early as possible. In fact, more than a quarter of participants were willing to expose themselves to more intense negative shocks, just to limit waiting time (Berns et al., 2006). In participants who made a higher number of such dread-sensitive choices (Berns et al., 2006), self-reports and neural responses to the electrical shocks were more dependent on delay than in the rest of the sample suggesting that anticipatory affective responses were contributing to the effects.

So far, the implications of anticipatory dread for decision behavior have not been studied in older samples. To address this open question, the present studies re-implemented the choice paradigm introduced by Berns et al. (2006) and examined age differences in the number of dread-sensitive choices when choosing among real and hypothetical electrical shocks that varied in intensity and delay.

The prior literature offers two lines of evidence suggesting that older adults may be less likely than their younger counterparts to make dread-sensitive choices. First, research on age differences in emotional responses suggests that older adults may be less likely to experience anticipatory states of dread. Across a variety of contexts, advanced age was found to be associated with lower negative emotionality (Carstensen et al., 2011) and reduced attention to fear-related material (Isaacowitz, Wadlinger, Goren, & Wilson, 2006). Such findings extend to anticipatory affective responses. Across two studies (Nielsen, Knutson, & Carstensen, 2008; Samanez-Larkin et al., 2007) age groups did not differ in affective responses when they were anticipating monetary gains, but older adults were less responsive than younger adults when they were anticipating monetary losses. These findings would suggest that older adults are less likely to avoid delays in aversive outcomes than younger adults because they are less likely to experience feelings of dread in their anticipation.

Second, age may not only affect people's anticipatory emotions, but also their evaluations of the outcomes themselves. Although we know little about older adults' time preferences for physically aversive outcomes, research has found age differences in temporal discounting tasks which ask participants to choose between smaller, sooner and larger, delayed monetary payments. Younger adults tend to prefer the sooner payouts, even though they are smaller, because they subjectively discount the value of delayed outcomes (Frederick, Loewenstein, & O'Donoghue, 2002). With advanced age, however, people are more likely to select the highest payout, irrespective of its timing (e.g., Chao, Szrek, Pereira, & Pauly, 2009; Green, Fry, & Myerson, 1994; Green, Myerson, & Ostaszewski, 1999; Harrison, Lau, & Williams, 2002; Löckenhoff, O'Donoghue, & Dunning, 2011; Whelan & McHugh, 2009). This phenomenon has been associated with age differences in affective forecasting where older adults perceive greater consistency between present and future emotional states and experiences (Eppinger, Nystrom, & Cohen, 2012; Löckenhoff et al., 2011; Samanez-Larkin et al., 2011). There are, of course, important conceptual differences between temporal-discounting tasks (in which participants tend to *devalue* delayed outcomes) and dread-sensitive choice tasks (in which participants tend to *overvalue* delayed outcomes). Nonetheless, the age-related tendency to select the best outcome regardless of delay may conceivably generalize across tasks. Thus, one would expect that older adults make fewer dread-sensitive choices than their younger counterparts because they simply select the least intense option regardless of its timing.

In summary, the considerations presented so far consistently suggest that the tendency to make dread-sensitive choices (i.e., choices that favor sooner, more intense shocks over later, less intense shocks) is negatively associated with age ***(Hypothesis 1)*** and there are two separate lines of reasoning supporting this idea.

The first line of reasoning asserts that dread-sensitive choices are associated with stronger anticipatory responses to aversive outcomes (**Hypothesis 2a**) and that the intensity of these anticipatory responses decreases with age (**Hypothesis 2b**).

The second line of reasoning asserts that dread-sensitive choices are associated with a stronger emphasis on delays when evaluating combinations of temporal delays and intensities (**Hypothesis 3a**) and that emphasis on delays decreases with age. (**Hypothesis 3b**).

There are, however, additional factors that may contribute to interindividual differences in dread-sensitive choices. Specifically, we screened for a range of covariates that were previously found to be related to age and/or intertemporal choice including time perspective (Carstensen, Isaacowitz, & Charles, 1999), fluid cognition (Boyle et al., 2012), as well as mental and physical health (Chao et al., 2009).

In addition, we examined the potential role of personality traits. The tendency to discount delayed monetary outcomes, for example, has been linked to both lower conscientiousness and higher neuroticism (Manning, Hedden, Wickens, Whitfield-Gabrieli, Prelec, Gabrieli, 2014). Further, procrastination, the self-reported tendency to needlessly postpone important tasks, is associated with lower conscientiousness (Lee, Kelly, & Edwards, 2006; Tibbett & Ferrari, 2015; Watson, 2001). Extrapolating from these findings, one might expect that dread-sensitive choices are associated with higher scores in neuroticism and/or conscientiousness.

To test our hypotheses, two studies examined age differences in intertemporal choices involving unpleasant physical outcomes (i.e., electrodermal shocks) that forced participants to make trade-offs between intensity and delay. Study 1 used real electrical shocks and compared age differences in choice preferences between younger and older adults. Study 2 used hypothetical shocks and examined age differences in choice preferences in an adult life-span sample.

Study 1

Study 1 was designed as an initial exploration of age differences in dread-sensitive choice scenarios that involve real and physically aversive outcomes. Electrodermal shocks were chosen as outcomes because, in contrast to other methods for delivering unpleasant stimulation (e.g., noise, heat, cold, or mechanical pressure) they activate primary afferent fibers and thus show comparatively small age effects in subjective sensitivity (Gibson & Helme, 2001).

Prior research has also found that pain sensitivity differs by ethnicity (Edwards, Doleys, Fillingim, & Lowery, 2001) and gender (Bek, Uygur, Bayar, & Armutlu, 2002). For this initial study, we therefore opted to control for gender (by recruiting equal proportions of men and women in each age group) and to hold ethnicity constant (by limiting our recruitment to non-hispanic Whites).

To examine the proposed role of affect, we recorded anticipatory responses to the stimulus cues, responses to stimulus administration, and evaluations of various combinations of intensity and delay. As covariates, we included measures of time perspective, fluid cognition, mental and physical health, and personality.

Study 1 - Method

Participants—Younger participants (22–37 years, $n = 31$) and older participants (55–90 years, $n = 31$) were recruited from the local community through an existing database and public advertisements. They received $75 for their participation. Recruitment and payment methods did not differ by age.

To make the two age groups as comparable as possible, undergraduate students were excluded. Age cut-offs for recruitment were 22 to 39 years for the younger group and over 55 years for the older group. Apart from inclusion criteria based on age and race, potential participants were also screened for health-based exclusions including heart, lung, or neurological conditions, use of electronic medical devices, current use of pain medication, skin conditions or allergies interfering with electrode placement, and dementia, which could have interfered with the ability to consent (Mini Mental State Examination, Folstein, Folstein, & McHugh, 1975).

Among participants enrolled in the study, one participant in each age group was excluded because of software failure during testing. Table 1 (top) presents demographic information for the remaining 60 participants by age group. The two groups differed in age but not in gender or education.

Materials

Equipment: A BIOPAC stimulator module (STM100C) and a STMISOC Stimulus Isolation Unit (Biopac Systems, Inc., CA, USA) were controlled with E-Prime experimental software (Psychology Software Tools, Inc.). This configuration was used to administer aversive electrodermal shocks via paired, single-use electrodes applied to the inner surface of the left wrist. Maximum voltage was set to 100 Volt, well below international safety limits (500 Volt according to IEC 601-2-10 standard). Stimulus length was set to 500 milliseconds.

Calibration: To facilitate comparisons with prior research that implemented physically aversive stimuli (Berns, Capra, Chappelow, Moore, & Noussair, 2008; Berns, Capra, Moore, & Noussair, 2007; Berns et al., 2006; Berns et al., 2007; Drabant et al., 2011) we used the same calibration procedures consisting of an upward-stepwise procedure to determine the detection threshold and the point at which a further increase in intensity was perceived as "unbearable". Shocks for the remainder of the study ranged from 10% to 90% on a scale where the perceptual threshold was 1% and the maximum bearable sensation was 100%. Perceptual thresholds for each age group are shown in Table 1.

Dread-sensitivity tasks: The tasks were adapted from Berns et al. (2006) and consisted of a series of *passive trials* aimed at assessing affective responses to various combinations of shock intensities and delays and a set of *choice trials* involving choices between pairs of shocks that varied in intensity and/or delay.

Passive trials consisted of a cue indicating the intensity and delay of the shock (e.g., "50% in 3 seconds") followed by a fixation cross, a gray bar that progressively shortened as the shock approached, and finally a shock of the corresponding intensity (Figure 1a). For each trial, we recorded specific aspects of self-reported affective responses (see below). Three intensities (10%, 50%, and 90%) combined with three delays (3, 9, and 27 seconds) resulted in 9 different trials. The full block of passive trials was presented twice and the order of administration was randomized within each block. For further analyses, responses to each trial were averaged across the two presentations.

Choice trials began with a decision screen (Figure 1b) asking participants to choose between two options varying in intensity (10%, 30%, 50%, 70% and 90%) and/or delay (3, 9, and 27 seconds). Once participants had made their choice, they saw the gray countdown bar for the duration of the chosen delay, followed by a shock of the chosen intensity and, finally, a fixation cross. The duration of the fixation cross was adjusted such that the total length of each trial was equal to the longer of the two delays. This ensured that participants did not simply choose the shorter delay to speed up the experiment as a whole.

To minimize unnecessary shock administration, we selected 36 of the 75 possible choice combinations that were likely to show the greatest interindividual variability. To this end, we excluded choices involving different intensities at the same delay (assuming that participants would always select the option with the lower intensity). Instead, following Berns et al. (2006), we focused on choices requiring participants to trade-off sooner, more intense shocks against later, less intense shocks (70% of possible choice combinations included = 21 choices). For control purposes, we also sampled 60% of the choice combinations involving the same intensity at different delays (9 choices) and 20% of the choice combinations involving trade-offs between sooner, less intense and larger, more intense shocks (6 choices). The 36 trials were presented once in randomized order. The location of the sooner option (left vs. right side of the screen) was counterbalanced across participants.

For further analyses, we computed – for each participant – the number of choices that minimized the potentially dread-inducing delay between cue and shock administration (henceforth referred to as "dread-sensitive" choices). The 21 items involving trade-offs between sooner, more intense and later, less intense shocks formed a coherent scale with high internal consistency (Cronbach's α = .96). Consistent with prior findings (Berns et al., 2006), dread-sensitive choices showed a bimodal distribution indicating that some participants primarily minimized intensity whereas others primarily minimized delay. Subsequent analyses therefore used non-parametric statistics.

As in prior research (Berns et al., 2006), there was little variability among control items involving earlier shocks of equal or smaller intensity than later shocks. More than half (57%) of participants selected the immediate option for all of the control items. Responses to the control items were not significantly associated with the 21 target items, age group, nor with any of the age-associated covariates shown in Table 1. They were therefore not considered further.

Measures—*Affective responses* were assessed on a 9-point scale from "not negative at all" to "extremely negative". This scale was administered multiple times throughout the experiment. A *baseline assessment* captured current affect immediately after completing consent ("How do you feel right now?"). During the passive aversive trials (Figure 1a), participants were prompted to indicate *anticipatory responses* (assessed immediately after the cue for a certain combination of delay and intensity appeared, "How do you feel right now?"), *stimulus-related responses* (assessed immediately after the shock, "How did you feel while the pulse was actually happening?"), and *combined responses* (retrospective ratings of the complete trial involving the combination of delay and shock, "How did you feel about this combination of waiting and pulse?").

Multiple affect assessments were included to capture conceptually different aspects of affective experience. *Baseline assessments* allowed us to account for variations in mood at the onset of the study; *anticipatory responses* were included to test Hypotheses 2a and 2b; *stimulus-related responses* helped to confirm that calibration procedures were successful (i.e., that subjective experience of the shocks did not vary by age); and c*ombined responses* mapped onto the outcome evaluations targeted in Hypotheses 3a and 3b.

Five-factor personality traits were screened with the 10-item BFI-10 (Rammstedt & John, 2007) which consists of 5 pairs of items assessing each of the big five personality traits.

Future time perspective was measured with the FTP scale (Carstensen & Lang, 1996) which consists of 10 items assessing the degree to which the future is perceived as open-ended and full of possibilities as opposed to limited.

Subjective health was assessed with the SF-12 self-report measure which yields separate scores for mental and physical health (Ware, Kosinski, & Keller, 1998).

Fluid cognitive abilities were assessed with the Digit Symbol subtest of the Wechsler Adult Intelligence Scale which captures perceptual speed by asking participants to match symbols to numbers (Wechsler, 1981), and a letter-based version of the n-back task which captures working memory by asking participants whether a given letter in a series matches the letter presented two steps before (Ragland et al., 2002).

Procedure—After providing informed consent, participants first completed the baseline affect rating and the demographic questionnaire. This was followed by assessments of personality traits, subjective health, future horizons, and cognitive abilities. Next, electrodes were placed and participants completed the calibration procedure, followed by the passive trials (interspersed with affect ratings) and the choice trials. Afterwards, participants were thoroughly debriefed and paid. With the exception of the Digit-Symbol measure (which uses paper and pencil), all tasks and measures were administered via E-prime experimental software (Psychology Software Tools, Inc.). All procedures were approved by the Cornell University Institutional Ethics Review Board and there were no adverse events, withdrawals, or participant complaints over the course of the study.

Study 1 - Results

Dread-sensitive choices—Figure 2 (black circles) shows the number of dread-sensitive choices for each respondent plotted by age. As in prior research using this paradigm (Berns et al., 2006) we found evidence for dread sensitivity. The majority of participants (88%) made at least one choice in which they preferred a sooner, more intense over a later, less intense shock and a sizeable minority of participants (13%) always preferred the sooner choice, regardless of shock intensity.

To analyze age differences, we took a two-pronged approach. In a first step, we followed Berns et al.'s (2006) analytical approach of dichotomizing the choice variable. We performed a median split of the choice variable into low and high dread sensitivity and examined the distribution of these categories across the age groups. We found that 53% of young participants and 50% of old participants fell into the high dread sensitivity group, and this age difference was not statistically significant, χ^2 (1, N = 60) = .07, p = .80. To provide a more fine-grained analysis of age differences in choice preferences we also computed a non-parametric correlation treating age and dread-sensitive choices as continuous variables. Again, no significant age difference was found, ρ = .05, p = .71, CI = −.21, .3. Taken together, these analyses are consistent with Hypothesis 2 predicting that there are no age differences in dread sensitivity.

Note however, that older adults had somewhat higher thresholds for the electrical shocks – both for the perceptual threshold and for the maximum bearable intensity (see Table 1). To rule out the possibility that age variations in shock perception obscured age effects in dread sensitivity, we computed non-parametric correlations between continuous age and dread sensitivity partialing out individual differences in threshold levels. The association between age and dread sensitivity remained non-significant, ρ_p = .01, p = .92, CI = −.24, .26.

Affective Responses—Age groups did not differ significantly in negative affect at baseline (Table 1). To examine responses to the passive aversion task, we computed an ANOVA with age group (young vs. old) as a between-subject variable and delay (3, 9, or 27 seconds), intensity (10%, 50%, 90%), and type of rating (anticipatory responses, stimulus-related responses, and combined affect ratings) as within-subjects variables. Where applicable, Greenhouse-Geisser corrections addressed deviations from sphericity.

There were significant main effects of delay, $F(1.48, 85.56) = 18.72$, $p < .001$, $\eta^2_p = .24$ (aversiveness increased with delay), intensity, $F(1.18, 68.30) = 119.13$, $p < .001$, $\eta^2_p = .67$ (aversiveness increased with intensity), and type, $F(1.75, 101.29) = 10.14$, $p < .001$, $\eta^2_p = .15$ (aversiveness was lowest for anticipatory and highest for combined affect ratings). In addition, there were multiple higher-order interactions including a significant 4-way interaction among age group, delay, intensity, and type, $F(5.27, 305.41) = 2.90$, $p < .05$, $\eta^2_p = .05$. To further explore these patterns, we computed separate ANOVAs for each type of affect rating with age group as a between-subjects variable and intensity and delay as within-subjects variables.

Anticipatory responses showed a main effect of intensity, $F(1.20, 69.81) = 81.14$, $p < .001$, $\eta^2_p = .58$, and a main effect of delay, $F(1.60, 90.44) = 4.78$, $p < .05$, $\eta^2_p = .08$. We also found a main effect of age such that older adults showed less intense anticipatory responses than younger adults, $F(1, 58) = 4.76$, $p < .05$, $\eta^2_p = .08$. None of the interactions reached significance, *ps* > .20.

The main effect of age provided partial support for Hypothesis 2b: As predicted, anticipatory responses were less pronounced with age. Hypothesis 2a further predicted that dread sensitivity would be stronger among those who showed stronger anticipatory responses. To test this prediction, we computed the non-parametric correlation between the number of dread-sensitive choices and the average intensity of anticipatory responses. We found that, contrary to Hypothesis 2a, respondents who reported more intense anticipatory responses were *less* likely to show dread sensitivity, $\rho = -.25$, $p = .05$, $CI = -.47, .00$.

Stimulus-related responses showed a main effect of intensity, $F(1.25, 72.69) = 119.31$, $p < .001$, $\eta^2_p = .67$, and a main effect of delay, $F(2, 116) = 3.21$, $p < .05$, $\eta^2_p = .05$. The main effect of age and the various interactions did not reach significance, $p > .10$. The lack of age differences in stimulus-related responses indicates that calibration was successful in yielding similar subjective ratings of the shocks across age groups (even though the calibration thresholds differed by age).

Combined responses showed a main effect of intensity, $F(1.23, 71.05) = 113.66$, $p < .001$, $\eta^2_p = .66$, and a main effect of delay, $F(1.30, 75.31) = 28.10$, $p < .001$, $\eta^2_p = .33$. The main effect of age and the various interactions did not reach significance, $p > .05$.

The lack of age effects did not support the assertion of Hypothesis 3b that older adults' evaluations of combined outcomes would be less sensitive to delays. Hypothesis 3a further predicted that higher delay sensitivity in evaluating combined outcomes would be associated with more dread-sensitive choices. To test this claim, we computed individual delay sensitivity scores by subtracting the average responses to 3-second delays from the average responses to 27-second delays, with higher scores indicating greater delay sensitivity. Contrary to Hypothesis 3a, the association between the delay-sensitivity score and the number of dread-sensitive choices did not reach statistical significance, $\rho = .10$, $p = .44$, $CI = -.16, .35$. For comparison purposes, we also computed an indicator of sensitivity to intensity by subtracting the average responses to 10% shocks from the average responses to 90% shocks. This intensity sensitivity score was significantly associated with dread-sensitive choices, $\rho = -.30$, $p < .05$, $CI = -.51, .05$. Thus, people who made more dread-sensitive choices appeared to be less responsive to intensity rather than more responsive to delays.

Personality and Other Covariates—Beyond the role of age and affective responses, we had screened for possible associations between dread sensitivity and the personality traits of neuroticism and conscientiousness. In partial support of such effects, we found a significant association between conscientiousness and dread sensitivity such that participants with higher conscientiousness made more dread-sensitive choices (Table 1). However, we found no significant association between neuroticism and dread sensitivity. Overall, personality traits varied little with age, with one exception: Older adults reported significantly lower levels of neuroticism than their younger counterparts.

We had also assessed a range of other covariates that are commonly found to be associated with age. As seen in Table 1, age groups did not differ significantly in gender and education, but compared to the younger group, older adults scored significantly higher on mental health and significantly lower on physical health, future time horizons, perceptual speed, and working memory. Working memory also showed a trend towards an association with dread sensitivity. To rule out the possibility that age differences in these background variables obscured any age effects in dread sensitivity, we computed non-parametric correlations between continuous age and dread sensitivity partialing out these covariates. Because of concerns about multicollinearity, covariates were partialed out one at a time. The association between age and dread sensitivity remained non-significant after accounting for the covariates, $|\rho_p| < .01$, $p > .31$.

Study 1 – Discussion

To the best of our knowledge, this study was the first to examine age differences in intertemporal choices about outcomes that are real and physically aversive. In general, our findings replicate Berns et al.'s (2006) original reports on dread sensitivity. Most participants made at least one choice in which they preferred sooner, more intense shocks over delayed, less intense shocks, and there were small groups of respondents who minimized either shock intensity or shock delay across all choices. This suggests that the experimental paradigm was working as intended.

However, we found no significant age differences in dread sensitivity, even after accounting for a broad range of age-associated covariates. Also, the observed effect size for age differences in dread sensitivity was very small ($\rho < .1$), suggesting that the lack of significant age effects was not merely due to limitations in sample size. This was supported by Bayes factor analyses (following procedures outlined by Rouder et al., 2009, and setting r-scale to the default value of .707) which found a JZS Bayes factor of 3.42 in support of the null hypothesis over Hypothesis 1. In other words, given the present data, it is 3.42 more likely that age differences in dread-sensitive choices do not exist than that such age differences do exist. Following the guidelines by Lee and Wagenmakers, 2013, a Bayes factor between 3 and 10 would be considered as "substantial" evidence for the null hypothesis.

With respect to the underlying mechanisms, we examined the role of affective responses in dread sensitivity. Consistent with Berns et al. (2006), affective responses varied not only by stimulus intensity but also by stimulus delay with longer delays eliciting more negative affect. However, specific hypotheses about the associations among age, affect, and choice preferences garnered only limited support. Consistent with Hypothesis 2b, older adults' anticipatory responses to stimulus cues were less negative than for younger adults, but, contrary to Hypothesis 2a, stronger anticipatory responses were linked to lower, not higher dread sensitivity. Also, combined evaluations of shock intensity and delay did not show the expected association with age and dread sensitivity (Hypothesis 3a and 3b). There were no age differences in combined evaluations, and dread-sensitive choices were associated with lower sensitivity to intensity, not higher sensitivity to delay.

With regard to personality traits, finally, we found that dread-sensitive choices were associated with higher levels of conscientiousness. In contrast, we found no link between dread sensitivity and neuroticism even though this trait is associated with general anxiety, threat-specific responses, and risk perception (Drabant et al., 2011; Jylha & Isometsa, 2006). In part, the null findings for neuroticism may be due to the limitations of the short personality measure used in the present study (Rammstedt & John, 2007). In addition, variations in neuroticism seem to be particularly relevant for perceptions of risks and uncertainty (Hirsh & Inzlicht, 2008) whereas outcomes in the present study were implemented exactly as described.

Taken together, these findings suggest that the tendency to make dread-sensitive choices reflects stable personality characteristics rather than variations in age or affective responses. However, Study 1 had important methodological limitations. The sample was small in size, lacked ethnic diversity, and we only compared younger and older adults while neglecting middle age. Furthermore, the use of real electrodermal shocks required a broad range of health-based exclusions. This may have yielded an unusually healthy and active sample of older adults which could account for the lack of age affects. The assessment of relevant covariates was limited as well. With regard to emotional responses, we only assessed negative (but not positive) valence and we did not differentiate between valence and arousal. Further, the conscientiousness assessment was limited to two short screening items assessing the tendency to do "a thorough job" and not "be lazy" (Rammstedt & John, 2007). Within the broader structure of conscientiousness, these items are related to the industriousness component which captures persistence within a given task context (Roberts, Bogg, Walton, Chernyshenko, & Stark, 2004). Further research was needed to replicate these initial findings and examine whether associations with dread sensitivity extended to other components of conscientiousness.

Study 2

Study 2 was designed to confirm the lack of age differences observed in Study 1 while addressing the aforementioned methodological shortcomings. To address concerns about sample selection, we recruited an adult life span sample (aged 21 and over) which reflected the ethnic composition of the local community in Ithaca, NY. Because the strict health-based exclusion criteria in Study 1 might have led to an overly healthy sample, we used a hypothetical version of the task allowing us to drop health-based criteria.

We also included more differentiated assessments for several key variables. To expand upon the unidimensional negative emotion ratings in Study 1, we separately assessed valence and arousal. Further, we assessed a broader range of conscientiousness-related concepts including multiple measures of industriousness (i.e., task persistence, self-regulation, achievement striving, and self-discipline), as well as measures of longer term goal pursuit (i.e., procrastination and grit), orderliness, and decisiveness (Roberts, Chernyshenko, Stark, & Goldberg, 2005). We also included the n-back task to assess working memory since it had shown a marginal association with dread sensitivity in Study 1.

Study 2 – Method

Participants—Participants (*n* = 122) had to be over 21 years of age, able to speak and write fluently in English, and be free of hearing or vision problems that would have interfered with their ability to complete the experimental tasks. Participants were recruited from an existing database and through advertisements in the community. Individuals who had participated in Study 1 and undergraduate students were not eligible. Recruitment procedures did not differ for younger and older adults and all participants were paid $25. To examine whether prior experience with electrodermal shocks influenced choice preferences, we selectively recruited participants such that a portion of the sample (29%) had prior exposure to electrodermal shocks (in the context of an unrelated study in our laboratory conducted several months earlier) whereas the others had no prior exposure. Data from one participant was lost to equipment failure. Table 2 lists the demographic information for the remaining participants.

Measures

Aversive choices: The choice task was modeled after the task used in Study 1, but outcomes were hypothetical. Participants read the description of a laboratory task administering electrical pulses to their wrist and indicated whether they had previously participated in such a task. To help them to imagine the task more vividly, they saw a photo of a hand connected to the electrodes and the actual electrodes were placed on the table next to them. Participants read descriptions of the calibration procedures used in Study 1 and were asked to imagine how pulses at the 1% and 100% threshold would feel. Next, they were told that the hypothetical choices would involve pulses ranging from 10% to 90% and that delays would vary from 3 to 27 seconds. Participants saw countdown timers for each of the three delays and were asked to "imagine how it would feel like to wait for the pulse". They were then asked to rate how they would feel about different combinations of pulses (10% vs. 90%) and wait times (3 vs. 27 seconds). Finally, participants were given the same 36 choice trials as in Study 1, presented in randomized order.

As in Study 1, we computed the number of dread-sensitive choices that minimized the delay between cue and shock. The psychometric characteristics of the choice task were comparable to Study 1. The 21 items requiring trade-offs between sooner, more intense and later, less intense stimuli showed high internal consistency (Cronbach's α = .96), and, again, there was a tendency towards bimodality. Subsequent analyses therefore focused on non-parametric statistics.

The control items (i.e., items for which the sooner stimuli were of equal or lower intensity than the later stimuli) showed little variability. As in Study 1, more than half of all participants (61%) selected the immediate option for all control items. Again, responses to the control stimuli were not significantly associated with the 21 target items, age, or any of the age-associated covariates shown in Table 2. They were therefore dropped from further analyses.

Affective responses: To differentiate valence and arousal, we used two well-established rating scales (Nielsen et al., 2008). Valence was assessed on a scale from "very negative" = −100 to "very positive" = 100 and arousal was assessed on a scale from "not aroused at all" = 0 to "very aroused" = 100. Responses were entered by using the computer mouse to adjust a seamless slider. Since we did not administer actual stimuli, we only included a single affect rating asking participants how they would feel about combinations of delay (3 vs. 27 seconds) and intensity (10% vs. 90%). This rating corresponds to the "combined evaluation" rating in Study 1.

Personality: Trait-like personality characteristics related to conscientiousness were assessed with a battery of measures. Following classifications by Roberts and colleagues (Roberts et al., 2004; Roberts et al., 2005) we aimed to capture a broad range of conscientiousness-related concepts. *Industriousness* was assessed with the Self-Regulation Scale (Schwarzer, Schmitz, & Diehl, 2000) which captures the ability to maintain task-focus when faced with challenges, a Task Persistence measure (Steinberg et al., 2007) which captures the tendency to persist in effortful activities, and the achievement striving and self-discipline facets from the NEO-PI-R's conscientiousness scale (Costa & McCrae, 1992). To assess longer-term goal pursuit we administered the *Procrastination Scale* (Schwarzer, Schmitz, & Diehl, 2000) which measures the tendency to needlessly delay important activities and the *Short Grit Scale* (Duckworth & Quinn, 2009), which assesses perseverance in the pursuit of long-term goals. *Orderliness* was assessed with the order and dutifulness facets of the NEO-PI-R, and *decisiveness* was assessed with the competence and deliberation facets of the NEO-PI-R. To avoid confusion due to varying response formats, participants responded to all questions on a five-point scale from "strongly disagree" to "strongly agree". After reversing any reverse-coded items, we computed the average response across all items for each of the scales.

Working memory: As in Study 1, working memory capacity was screened with a letter-based 2-back task including 40 items (Ragland et al., 2002).

Procedure—Participants provided informed consent. They then entered their demographic characteristics and completed the n-back measure using a screen interface programmed in E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Next, they reviewed the information about the electrodermal shocks and completed the affect ratings, choice task, and conscientiousness-related scales on a screen interface programmed in Qualtrics Survey Software (Qualtrics, Provo, UT). In the same experimental session, they also completed several measures unrelated to the present study including an extended version of the n-back task. After completing the study, participants were paid and debriefed. All procedures were approved by the Cornell University Institutional Ethics Review Board.

Study 2 – Results

Dread-sensitive Choices—Figure 2 (gray and white circles) shows the number of dread-sensitive choices for each respondent plotted by age. Again, we found evidence for dread sensitivity, 72% of the sample made at least one choice in which they preferred a sooner, more intense over a later, less intense shock and 8% of participants always preferred the sooner choice.

To examine age differences, we computed a non-parametric correlation treating age and dread sensitivity as continuous variables. There were no significant age effects, $\rho = -.07$, $p = .47$, *CI*: −.25, .11. Consistent with Study 1, this finding adds further support for a null effect of age on dread-sensitive choices.

Affective Responses—Age was not significantly associated with baseline affect ratings (Table 2). To examine how participants' valence and arousal ratings varied across hypothetical combinations of intensities and delays and by age, we computed ANOVAs with delay (3 vs. 27 seconds) and intensity (10% vs. 90%) as within-subject variables, age (young vs. old) as a between-subjects variable and valence and arousal ratings as dependent variables.

For valence ratings, there was a main effect of intensity, $F(1, 120) = 151.30$, $p < .001$, $\eta^2_p = .56$ (higher intensity was associated with more negative valence), a main effect of delay, $F(1, 120) = 17.90$ $p < .001$, $\eta^2_p = .13$ (longer delay was associated with more negative valence), and a delay by intensity interaction, $F(1, 120) = 9.99$, $p < .01$, $\eta^2_p = .08$ (the effect of delay on valence decreased with higher intensity). There were no significant main or interaction effects involving age.

For arousal ratings, there was a main effect of intensity, $F(1, 120) = 94.19$, $p < .001$, $\eta^2_p = .44$ (higher intensity was associated with higher arousal), and a delay by intensity interaction $F(1, 120) = 6.32$, $p < .05$, $\eta^2_p = .05$ (longer delay was associated with higher arousal for low intensity, but not for high intensity). There was no significant main effect of delay and no main or interaction effects involving age. Thus, contrary to Hypothesis 3b, neither valence nor arousal ratings showed any evidence that sensitivity to delay varied by age.

To test the related claim that sensitivity to delay in affect ratings is associated with dread-sensitive choices (Hypothesis 3a), we computed indicators of sensitivity to delay (by computing the difference between average responses to 3 second delays and average responses to 27 second delays). In support of Hypothesis 3a, the number of dread-sensitive choices was associated with higher sensitivity to delay for valence ratings ($\rho = .26$, $p < .01$, *CI* = .09, .42), but we did not find this effect for arousal ratings ($\rho = .02$. n.s). As in Study 1, we also examined sensitivity to intensity (by computing the difference between average responses to 10% stimuli and average responses to 90% stimuli). We found that dread sensitivity was associated with lower sensitivity to intensity in both valence ratings ($\rho = -.38$, $p < .001$, *CI* = −.52, −.22) and arousal ratings ($\rho = -.24$, $p < .01$, *CI* = −.40, −.07).

Personality, Cognition, and Prior Experience—Table 2 shows associations of conscientiousness-related measures with age and dread sensitivity. Consistent with the findings in Study 1, dread sensitivity was significantly associated with two of the industriousness-related measures - achievement striving and task persistence. However, dread sensitivity was not significantly associated with any of the other conscientiousness-related assessments. Further, while the n-back task was negatively associated with age, it showed no significant association with dread-sensitive choices (Table 2, bottom).

Finally, we examined whether prior experience with experimentally administered shocks was associated with choice behavior and, if yes, whether such effects varied by age. A general linear model examining the effects of age and prior experience (yes/no) on dread-sensitive choices yielded no evidence of main or interaction effects ($ps > .5$), indicating that regardless of age, prior experience did not have any effects on choice preferences.

Study 2 – Discussion

In combination, the results of Study 2 replicated key findings of Study 1 in an independent, more diverse, adult life-span sample. Like Study 1, this second study found no evidence of age differences in dread sensitivity. A Bayes factor analysis (r-scale = .707) found a JZS Bayes factor of 5.16 in favor of the null hypothesis. Again, this would be considered as substantial evidence for the null hypothesis relative to the alternative hypothesis (Lee & Wagenmakers, 2013).

In addition, our findings provided further support for a role of conscientiousness in dread-sensitive choices. Specifically, we found a significant association between industriousness and dread sensitivity, whereas no associations with other aspects of conscientiousness were found. This suggests that the tendency to minimize the delays before aversive outcomes is higher among people who tend to tenaciously engage with a given task.

The patterns of results for affective responses expanded upon those of Study 1. Because of the hypothetical nature of the choice task we could not examine anticipatory responses or responses to stimulus administration. For the combined evaluations of delay and intensity, however, we measured both emotional valence and arousal resulting in a more differentiated pattern than in Study 1 which merely assessed the level of negative affect.

We found that, similar to Study 1, valence ratings reflected both the intensity and the delay of the shocks with more intense and more delayed shocks leading to worse affect. In contrast to Study 1, however, Study 2 also found a delay by valence interaction indicating that the negative effect of delay on valence was less pronounced for more intense shocks. Contrary to Hypothesis 3b, there was no age by delay interaction indicating that there were no age differences in relative sensitivity to delay, but there was a main effect of age indicating that – on average – older adults reported more positive affect in response to the various stimulus combinations. Arousal ratings, in turn, were only sensitive to intensity, but not to valence and showed no main or interaction effects of age.

Regarding the association between affect ratings and dread-sensitive choices, we replicated the finding from Study 1 that participants whose affect ratings were more sensitive to intensity made fewer dread-sensitive choices. In contrast to Study 1, we also found support for Hypothesis 3a which predicted an effect of sensitivity to delay on choice behavior: Participants whose affect ratings were more sensitive to delay made more dread-sensitive choices.

In summary, affective responses were fairly consistent across the studies with a few notable discrepancies which may be due to differences in affect measures or the hypothetical nature of the task in Study 2. In combination, the results suggested that while older adults may be less sensitive to dread inducing stimuli than younger adults, they do not respond differently to delays in such stimuli. Further, while affective responses to delay may play a role in dread-sensitive choices, affective responses to shock intensity are likely to play an even larger role.

The decision to use a hypothetical task in Study 2 warrants further consideration because it entailed both advantages and disadvantages. On the one hand, it allowed us to drop health-based exclusions and this addressed the concern that older adults in Study 1 may have been simply too healthy to show typical patterns of age effects. On the other hand, knowing that the choices would never be implemented could have swayed participants' preferences. Note, however, that the psychometric characteristics of the choice task were highly comparable across studies. Also, participants who had prior experience with electrical shocks did not differ in the amount of dread-sensitive choices from those who had never experienced such shocks. This is in line with the prior literature comparing intertemporal choice scenarios with real versus hypothetical stimuli which has also found little variation in choice preferences across stimulus types (for a review see Locey, Jones, & Rachlin, 2011). Furthermore, both studies found consistent associations between dread-sensitive choices and conscientiousness. Thus, there is no reason to assume that the hypothetical task in Study 2 was any less adequate for examining age effects. There also is practical relevance to comparing results across the hypothetical and real versions of the task since everyday choices about aversive outcomes differ in the extent to which participants have prior experience with the outcomes. Our findings suggest that dread sensitivity occurs even without prior experience of the stimuli.

General Discussion

Taken together, the present studies provide converging evidence that the tendency to avoid periods of dread when anticipating physically aversive outcomes does not differ by age. These results contrast with prior findings on age differences in the temporal discounting of monetary outcomes which show age-related decreases in sensitivity to delay (Rutt & Löckenhoff, 2015), but converge with findings indicating that the temporal discounting of consumable rewards does not differ by age (Jimura et al., 2011). One possible explanation for such discrepancies is the length of the time intervals involved. Whereas studies examining monetary outcomes have examined delays of days and weeks, Jimura et al. and the present study involved delays of seconds to minutes. Future studies are needed to examine whether age differences manifest themselves only after a certain length of the delay.

Another explanation for the lack of age effects in the present studies lies in the influence of affect on dread-sensitive choices. The line of reasoning that led us to propose age differences in dread sensitivity (Hypotheses 2 and 3) hinged on the assumption that age differences in emotional processing would influence affective responses to various aspects of the choice task. However, we found little evidence of such effects. Instead, our findings suggest that conscientiousness, a fairly stable personality trait (rather than more volatile affective responses), plays a role in explaining dread-sensitive choices, and this could contribute to the absence of age effects. Although personality traits develop rapidly in adolescence and emergent adulthood, personality changes in adulthood are much more moderate in size (Roberts, Walton, & Viechtbauer, 2006; Soto, John, Gosling, & Potter, 2011; Terracciano, McCrae, Brant, & Costa, 2005), especially when compared to more pronounced rates of change in emotional experience (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Carstensen et al., 2011). Thus, if dread sensitivity reflects a stable, trait-like tendency to deal with challenging experiences by getting them out of the way, it may show little age-related variation.

Independent of age, the observed association between industriuosness and dread sensitivity warrants further consideration. A growing body of literature indicates that higher levels of conscientiousness are associated with greater engagement in preventive health behaviors and better health outcomes (Lodi-Smith et al., 2010). In the present study, however, the proactive tendency to advance unpleasant outcomes exposed highly industrious participants to more intense unpleasant stimuli. This raises the possibility that, under certain circumstances, conscientiousness may be maladaptive.

Concerns about potentially adverse outcomes of excessive dread sensitivity are particularly relevant for medical contexts. Of course, the mildly unpleasant outcomes in the present study do not map well onto the severe pain and discomfort experienced in medical settings, but, if corroborated by future research addressing these concerns, our findings could have implications for healthcare. In the dentist’s office, for example, patients who are more sensitive to dread may prefer to have their cavity filled before the teeth cleaning rather than vice versa. It is important for clinicians to understand that dread sensitivity varies across individuals and while it does not differ by age, it appears to be associated with the stable tendency to engage with tasks head-first and persist until they are done. In a next step, such tendencies could be screened through self-administered questionnaires alerting clinicians to patients who might benefit from help in managing feelings of dread.

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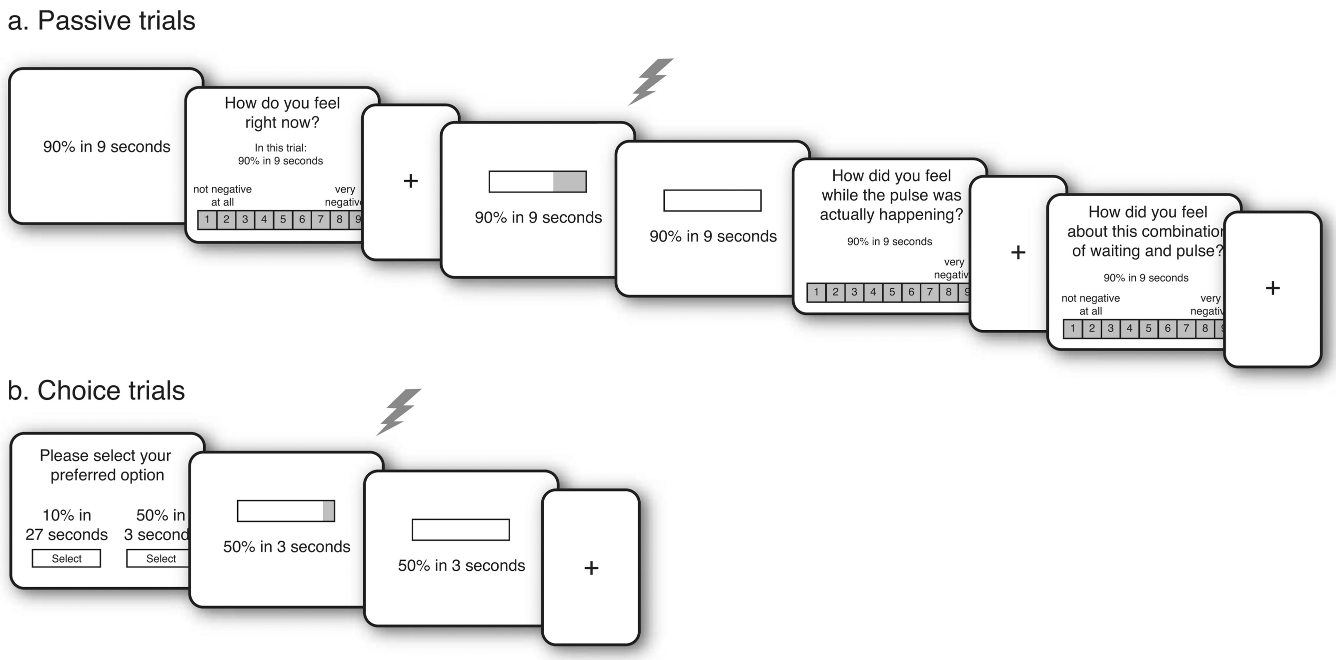

Figure 1.
Schematic Depictions of Passive and Choice Trials in Study 1.

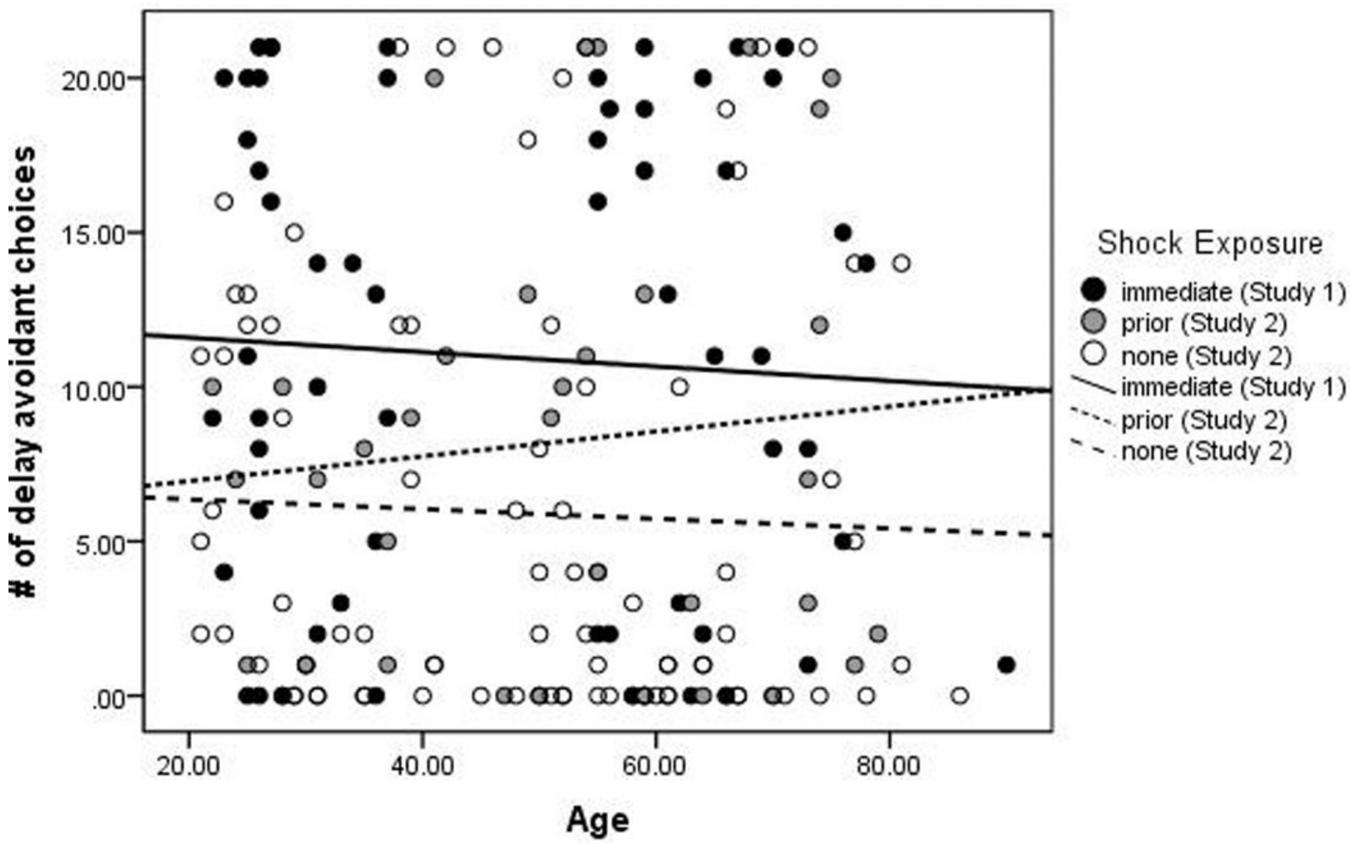

Figure 2.

Number of Dread-Sensitive Choices in Studies 1 and 2 by Age and Prior Experience with Electrical Shocks. Regression Lines show Associations between Age and Dread-Sensitivity for Each Subgroup.

Table 1

Participant Characteristics and their Association with Age and Choice Preferences in Study 1

	Young (n = 30)	Old (n = 30)	$d_{young-old}$	$p_{young-old}$	$\rho_{drd-sens}$	$CI_{drd-sens}$
Demographics						
Age	28.93 (4.75)	64.97 (8.45)	5.26	$p < .001$	.05	−.21, .30
Gender (% female)	50%	50%		$p = 1$	−.01	−.26, .24
Education	5.70 (1.49)	5.90 (2.05)	0.11	$p = .67$	.15	−.11, .39
Thresholds (in Volts)						
Minimum threshold	3.73 (1.96)	4.90 (3.35)	0.43	$p < .11$	−.04	−.29, .22
Maximum threshold	32.23 (18.14)	46.07 (20.52)	0.71	$p < .01$	.13	−.13, .37
Negative Baseline Affect	2.53 (1.61)	2.10 (1.58)	0.27	$p = .30$	−.24†	−.47, .01
Personality traits						
BFI 10 - Neuroticism	5.77 (1.99)	4.30 (1.44)	0.85	$p < .01$	.04	−.22, .29
BFI 10 – Extraversion	6.70 (1.68)	6.53 (1.91)	0.09	$p = .72$	−.08	−.33, .18
BFI 10 – Openness	7.90 (1.56)	7.77 (1.28)	0.09	$p = .72$	.10	−.16, .35
BFI 10 – Agreeableness	6.57 (1.77)	7.23 (1.48)	0.40	$p = .12$	.02	−.24, .27
BFI 10 – Conscient.	7.73 (1.36)	8.20 (1.24)	0.36	$p = .17$	.32*	.07, .53
Future Time Perspective	54.73 (9.99)	45.23 (11.39)	0.89	$p < .001$	.17	−.09, .41
Subjective Health						
Mental	44.55 (10.53)	53.03 (8.62)	0.88	$p < .001$	.04	−.22, .29
Physical	55.52 (5.45)	51.70 (7.77)	0.57	$p < .05$	−.14	−.38, .12
Fluid cognition						
Digit symbol	67.17 (10.45)	51.40 (9.62)	1.57	$p < .001$	−.16	−.40, .10
N-back (% correct)	91.67 (5.46)	84.33 (8.68)	1.01	$p < .001$	−.22†	−.45, .04

Notes:

For continuous measures, standard deviations are shown in parentheses.

For education: 1 = less than high-school education, 8 = graduate degree.

Higher scores on cognitive measures indicate better functioning.

$d_{young-old}$= Cohen's d for comparisons between younger and older adults

$p_{young-old}$= p-values for comparisons between younger and older adults (based on χ^2 for gender and on t-test for all other variables).

$\rho_{drd-sens}$= Spearman's correlation with number of dread-sensitive choices

$CI_{drd-sens}$= 95% confidence interval for $\rho_{drd-sens}$

*$p < .05$,

†$p < .10$

Table 2

Participant Characteristics and their Association with Age and Choice Preferences in Study 2

	M (SD) /%	r_{age}	CI_{age}	$\rho_{drd\text{-}sens}$	$CI_{drd\text{-}sens}$
Demographics					
Age	49.98 (17.44)			−.07	−.25, .11
Gender (% female)	52%	.02	−.16, .19	−.04	−.22, .14
Education	4.90 (1.86)	.03	−.15, .21	−.02	−.19, .16
Race (% White)	84%	.21*	.03, .37	.07	−.11, .25
Affect					
Baseline valence	72.25 (17.59)	.07	−.11, .25	.03	−.15, .21
Baseline arousal	38.34 (24.16)	−.07	−.25, .11	.06	−.12, .24
Personality traits					
C1 – Competence	3.81 (0.50)	.04	−.14, .22	.07	−.11, .25
C2 – Order	3.26 (0.62)	−.02	−.19, .16	.04	−.14, .22
C3 – Dutifulness	3.91 (0.46)	.06	−.12, .24	.01	−.17, .19
C4 – Achievement	3.38 (0.59)	−.10	−.27, .08	.28**	.11, .44
C5 – Self-Discipline	3.54 (0.62)	−.10	−.27, .08	.13	−.05, .30
C6 - Deliberation	3.16 (0.54)	−.04	−.22, .14	.08	−.10, .25
Task Persistence	3.60 (0.74)	−.01	−.19, .17	.28**	.11, .44
Self-Regulation	3.60 (0.50)	.02	−.16, .19	.16	−.02, .33
Procrastination	2.61 (0.58)	−.06	−.24, .12	−.07	−.25, .11
Grit	3.33 (0.62)	.00	−.18, .18	.11	−.07, .28
N-back (% correct)	74.16 (19.80)	−.19*	.01, .36	−.05	−.23, .13

Notes:

For continuous measures, standard deviations are shown in parentheses.

For education: 1 = less than high-school education, 8 = graduate degree.

For valence: −100 = very negative, 100 = very positive

For arousal: 0 = not aroused at all, 100 = very aroused

r_{age}= Pearson correlation with age

CI_{age}= 95% confidence interval for r_{age}

$\rho_{drd\text{-}sens}$= Spearman's correlation with number of dread-sensitive choices

$CI_{drd\text{-}sens}$= 95% confidence interval for $\rho_{drd\text{-}sens}$

* $p < .05$,

† $p < .10$

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