Title

Falling hard, but recovering resoundingly: Age differences in stressor reactivity and recovery.

Journal

Psychology and Aging, 38(6)

Authors

Minton, Alyssa
Waugh, Christian
Snyder, Jason
et al.

Publication Date

2023-09-01

DOI

10.1037/pag0000761

Peer reviewed

HHS Public Access
Author manuscript
Psychol Aging. Author manuscript; available in PMC 2024 September 01.

Published in final edited form as:
Psychol Aging. 2023 September ; 38(6): 573–585. doi:10.1037/pag0000761.

Falling Hard, but Recovering Resoundingly: Age Differences in Stressor Reactivity and Recovery

Alyssa R. Minton[1], **Christian E. Waugh**[2], **Jason S. Snyder**[1], **Susan T. Charles**[3], **Claudia M. Haase**[4], **Joseph A. Mikels**[1]

[1]DePaul University

[2]Wake Forest University

[3]University of California-Irvine

[4]Northwestern University

Abstract

Strength and vulnerability integration theory (SAVI; Charles, 2010) posits that age differences in emotional experiences vary based on the distance from an emotionally eliciting event. Before and after a stressor, SAVI predicts that older age is related to motivational strivings that often result in higher levels of well-being. During stressor exposure, however, age differences are predicted to be attenuated or disappear completely. The present study examined how younger (n = 85; M_{age} = 22.56 years) and older (n = 85; M_{age} = 71.05 years) adults reacted to and recovered from a cognitive stressor using repeated positive and negative emotion probes. Results showed that both age groups were negatively impacted by the stressor, and both reported an initial boost in recovery afterward. However, older adults continued to improve across the recovery period compared to younger adults. This work elucidates that older adults are significantly impacted by stress but exhibit a resounding recovery.

Keywords

age differences; SAVI; stress; recovery; positive emotion

One hallmark discovery over the past several decades is that later life is generally characterized by stability in or greater well-being relative to the earlier years of life. Older adults show stable or lower negative affect and higher or at least commensurate positive affect (Carstensen et al., 2000, 2011; Charles et al., 2001; Jebb et al., 2020; Kunzmann et al., 2000; Mroczek & Kolarz, 1998), greater emotional stability (Roberts et al., 2006), increased or relative stability in life satisfaction (Diener et al., 1999; Jebb et al., 2020), and a lower prevalence of anxiety, mood, and substance use disorders (Kessler et al., 2005) compared to younger adults. These patterns generally hold at least until near the end of life when a decline in well-being has been observed (e.g., Gerstof et al., 2010; Gerstorf et al., 2018), and

Correspondence to: Alyssa R. Minton, Department of Psychology, DePaul University, 2219 N. Kenmore Ave., Chicago, IL 60614, Phone: 773.325.7887, AMINTON3@depaul.edu; Joseph A. Mikels, Department of Psychology, DePaul University, 2219 N. Kenmore Ave., Chicago, IL 60614, Phone: 773.325.8769, jmikels@depaul.edu.

they may be particularly consistent for emotional aspects of well-being (e.g., positive affect, negative affect), rather than cognitive aspects of well-being (e.g., life satisfaction, Baird et al., 2010).

Age-related advantages in emotional well-being emerge consistently across studies using an array of methodologies, including cross-sectional and longitudinal designs (Carstensen et al., 2000, 2011; Charles et al., 2001; Mroczek & Kolarz, 1998), retrospective ratings of average emotional states (Charles et al., 2001), and experience sampling of everyday emotional experiences (Carstensen et al., 2000, 2011). These well-being advantages are often thought to reflect older adults' greater use of emotion regulation strategies focused on avoiding or mitigating exposure to situations that may elicit distress (Charles, 2010). However, strength and vulnerability integration theory (SAVI; Charles, 2010) predicts that age differences will be attenuated, if not disappear completely, when people respond to a stressful event. The present study sought to examine this pattern of age differences in well-being throughout (before, during and after) a stressful experience.

Socioemotional selectivity theory (SST; Carstensen et al., 1999), a pioneering life-span theory of motivation, makes predictions regarding age differences in emotional processes in which older adults seek to maximize positive and minimize negative emotions (Carstensen & Mikels, 2005; Charles & Carstensen, 2009). SST posits that that motivational shifts occur as a function of changes in perception of one's future time horizon associated advancing age. In younger adulthood, future time is typically perceived as vast and expansive, allowing one to prioritize future-oriented goals, such as acquiring information or developing extensive social networks. In older adulthood, one's future time perspective becomes more limited, leading to a shift toward present-oriented goals, such as sharing meaningful and positive experiences with close others or maintaining one's current affective state. These motivations result in older age being related to favoring positive over negative information, a phenomenon referred to as the age-related positivity effect (Carstensen & Mikels, 2005; Reed et al., 2014).

Building from core tenets of SST and considering the balance of older adults' strengths and weaknesses, SAVI (Charles, 2010) focuses on older adults' strengths in their ability to flexibly employ emotion regulation strategies to avoid stressful situations. These situation selection strategies enable older adults to avoid experiencing high arousal situations (Isaacowitz & Ossenfort, 2017). They use less confrontational strategies when dealing with interpersonal conflict or avoid it altogether (Holley et al., 2013), resulting in more positive emotions (Birditt & Fingerman, 2005; Blanchard-Fields et al., 2007; Lefkowitz & Fingerman, 2003). Moreover, older adults are better than younger adults at finding positivity in negative situations (i.e., positive reappraisal; Shiota & Levenson, 2009) and are less likely to engage in repetitive, ruminative thinking in their daily lives (Emery et al., 2020; Nolen-Hoeksema & Aldao, 2011). Although evidence broadly indicates that emotion regulation abilities do not decline in later life, there is notable heterogeneity regarding various age differences in the use and effectiveness of emotion regulation strategies (see meta-analysis by Brady et al., 2018). For instance, older adults show a reduced ability in detached reappraisal (i.e., deliberate redirection of attention to the non-emotional aspects of the situation) relative to younger and middle-aged adults (Shiota & Levenson, 2009). This heterogeneity indicates that age differences in emotion regulation abilities are more nuanced and likely context dependent.

When people cannot avoid a stressor, SAVI posits that the age-related improvements in emotional experience will be attenuated and may disappear completely (Charles, 2010). To date, tightly controlled experimental studies to probe this prediction are missing, but available correlational evidence supports this view. For example, an experience sampling study found that, consistent with SAVI's predictions, older adults reported similar levels of negative affect immediately after a daily stressor compared to younger adults (Scott et al., 2017) and after a social-cognitive task (Wrzus et al., 2014). This pattern of results highlights an important area of potential late-life vulnerability, given findings indicating that high levels of arousal (i.e., stress) are detrimental to physical health (Piazza et al., 2013). This vulnerability may become particularly pronounced when stressors are not only unavoidable but also particularly threatening for older adults. For example, situations that activate and confirm negative age-based stereotypes (e.g., problems with cognition) may be even more stressful for older adults than for younger adults. Indeed, salient age-related stereotypes impair the cognitive performance of older adults (Chasteen et al., 2012), and the detrimental effects of negative age-based stereotypes have also been shown to lead to increased stress responses among older adults (Levy et al., 2000). In studies examining stressful situations that are particularly salient to late life, older adults report as higher if not higher levels of distress than younger adults (Kunzmann et al., 2005). Thus, theory (Charles, 2010; Charles & Piazza, 2009) and research (Luong & Charles, 2014; Levy et al., 2000; Wrzus et al., 2013, 2014) generally suggest that when unpleasant or stressful events are unavoidable, age-relevant (Kunzman & Grühn, 2005), and taxing to one's resources, high levels of affective reactivity are assumed to result, leading to small or no age differences in reactivity to a stressor.

Although SAVI predicts that differences between older and younger adults' emotional experiences will be attenuated or disappear during stress reactivity, older adults are thought to fare better emotionally than younger adults during stress recovery, though physiological recovery (e.g., heart rate, blood pressure) might occur more slowly possibly due to decreased physiological flexibility in older age (Charles, 2010). For example, despite similar emotional reactivity at the time of a stressor, the experience sampling study discussed above also found that older adults reported higher levels of emotional well-being approximately 10 minutes later (Scott et al., 2017), underscoring an important strength of older adults (Charles, 2010). The hypothesized mechanism for why older adults recover from stress better over time is that, after a stressor, chronically activated motivations for positive emotions over negative emotions (i.e., the age-related positivity effect) shift their attention to more positive aspects of the environment.

This shift in attention allocation may underscore their tendency to ruminate less about stressful experiences (though they may still be preoccupied with previous daily hassles and/or stressors; Scott et al., 2013, 2017; Wrzus et al., 2015) than younger adults (e.g., Emery et al., 2020), which could lead to age differences in recovery from a stressor. This work has leveraged experience-sampling approaches to better understand age differences in recovery as they occur naturally in one's life. In addition, a small set of studies have used explicit emotion regulation strategies (e.g., rumination) to examine when older adults might fare better or worse than younger adults during recovery in a laboratory setting. In one laboratory study, explicitly instructing people to ruminate about a previous stressor (i.e., having to do arithmetic before two stern-looking evaluators) made no difference in recovery for younger adults when compared to same-aged counterparts who were free to engage in their normal pattern of thinking, which presumably also included some rumination (Robinette & Charles, 2016). Though other work has found no systematic age differences in emotion regulation strategies according to instruction (see Brady et al., 2018), older adults instructed to ruminate in that study recovered worse than older adults free to engage in their own thought processes, which presumably did not include rumination. However, research suggests that affective (e.g., subjective feeling and arousal) and physiological (e.g., heart rate, blood pressure) recovery varies depending on the time since the unpleasant or stressful event (Scott et al., 2013, 2017; Wrzus et al., 2015), the demand it places on one’s resources (Charles, 2010), and the specific domain or context (e.g., health, interpersonal, cognitive; Charles & Piazza, 2009; Levy et al., 2000; Luong & Charles, 2014; Wrzus et al., 2013; 2014; 2015).

Besides a tendency to ruminate less, older adults also may more quickly shift to focusing on more positive emotions than younger adults. Positive emotions can be a powerful antidote for stress and negative emotions; they can undo the negative physiological and psychological effects brought about by negative emotions (Fredrickson et al., 2000) and improve recovery from negative emotions on stressful days (Ong et al., 2006). In past studies, Monfort et al. (2014) found that just having people reflect on stressors in a positive emotional context helped them effectively regulate their emotional reactions to that stressor. Given older adults’ tendency to focus more on the positive, they may be more likely than younger adults to attend to positive information inherent in positive contexts after a stressful situation, and thus recover better. Alternatively, younger adults may benefit more from exposure to positive experiences after a stressor than do older adults. Older adults have chronically activated goals that shift their attention and memory to positive emotional experiences (i.e., the positivity effect). In contrast, younger adults often display a negativity bias (Baumeister et al., 2001), so they may benefit more from the presence of positive stimuli.

The current study examined younger and older adults’ reactivity to and recovery from a cognitively evaluative stressor. Participants were presented with a challenging anagram task designed to induce stress and were randomly assigned to either watch an interactive 3D video of a positive beach scene or of a neutral office scene to examine stress recovery. Participants indicated how pleasant and unpleasant they felt before the anagram task, after the anagram task, during the recovery period, and after the recovery period and reported on their positive and negative thoughts during recovery.

Guided by SAVI, we hypothesized that when faced with an unavoidable, stereotype-threatening stressor, older adults would be as emotionally reactive, if not more so, than younger adults. We further predicted that older adults would emotionally recover more effectively than younger adults, especially with increased temporal distance from the stressor. Moreover, we explored two potential recovery-aiding mechanisms: (1) whether older adults or younger adults would benefit more from the positive recovery context;

and (2) whether age differences in recovery could be explained by age differences in thought patterns during the recovery period (e.g., younger adults ruminating more than older adults). This study provides novel insight into how older and younger adults recover from a stressor with greater standardization and temporal precision than more naturalistic experience sampling paradigms. In addition, this study sheds light on how older and younger adults recover from stress without explicitly instructing participants like past work has done (e.g., Robinette & Charles, 2016).

Method

Transparency and openness

We report how we determined our sample size, and describe all data exclusions, manipulations, and all measures in the study. De-identified processed data and analysis code are available on Open Science Framework: https://osf.io/8ya2w/?view_only=0887eb3baee348d4afae4196a29a9962. Primary analyses were conducted in JASP (JASP Team, 2022). The mediation analyses were conducted in R (R Core Team, 2021) using the 'lavaan' package (Rosseel, 2012). This study was not pre-registered.

Participants

To determine adequate sample size, we conducted a power analysis using G*Power (Faul et al., 2007). We based this analysis on the critical comparisons of younger versus older adults in either the positive or neutral recovery context before the anagram task, after the anagram task, and after the recovery period (repeated measures). Assuming a small to medium effect size of 0.20, an alpha of 0.05, and the correlation among the repeated measures of 0.5, a total sample size of 168 was needed to detect differences in four groups with 80% power. To account for potential data exclusion, we aimed to recruit 90–100 per age group. Please note that this power analysis is based on an analysis of variance (ANOVA), which was our initial analytic strategy, but after receiving feedback during the revision process, we decided to use multilevel modeling (MLM).

We recruited convenience samples from the community, Prolific online participant system, and undergraduate psychology courses all within the United States. [1] Data collection was completed during 2021. After excluding participants who did not pass the comprehension checks[2] ($N = 12$), these samples were combined to form younger ($n = 85$; $M_{age} = 22.56$, *SD*

[1]We used multiple participant recruitment efforts for this study. The majority of older and younger adults were recruited from the Chicagoland area ($N_{Recruited} = 133$; $n_{Retained} = 127$), but we also used Prolific online participant system ($N_{Recruited} = 45$; $n_{Retained} = 39$). A small portion of younger adults were recruited from undergraduate psychology courses ($N_{Recruited} = 5$; $n_{Retained} = 4$). Participants who did not pass the interactive video comprehension check ($N = 5$; $n_{Prolific} = 2$, $n_{Community} = 3$) and the anagram task comprehension check ($N = 7$; $n_{Prolific} = 4$, $n_{Psychcourse} = 1$; $n_{Community} = 3$) were excluded from analyses (see below for more details). Thus, our final sample included 85 older adults recruited from the community ($n = 79$) and Prolific ($n = 6$) and 85 younger adults recruited from the community ($n = 48$), from Prolific ($n = 33$), and from undergraduate psychology courses ($n = 4$).

[2]To ensure that participants understood the instructions for the interactive 3D video and the anagram task, we included three total comprehension checks. First, after watching the practice tutorial video, participants were presented with two questions. The first comprehension check was a true/false question (i.e., "You can look around in the video by using the mouse"; correct answer = true). The second comprehension check was also a true/false question (i.e., "You can look around and engage in the video at any point"; correct answer = true). Participants who did not pass the comprehension checks were brought back to the interactive video instructions. If they did not pass the comprehension checks the second time, they were not allowed to continue with the study. After participants were provided instructions on the anagram task, participants completed a comprehension check for how to answer the

= 3.65; age range: 18–30 years) and older adult (n = 85; M_{age} = 71.05, SD = 6.08; age range: 60–83 years) samples (see Table 1 for sample characteristics). All participants provided informed consent prior to the study and received financial compensation or course credit in the case of the younger adult participants from undergraduate psychology courses for completing this online study. This study was approved by a university Institutional Review Board (IRB) and meets ethical guidelines (DePaul IRB Approved Protocol # JM021419PSY, "Aging, Emotion Regulation, and Stress").

Materials

Cognitive stressor (anagram task).—We manipulated stress using an anagram task (Yang et al., 2018). Participants attempted to solve 30 five-letter anagrams with varying levels of difficulty (i.e., seven easy, eight medium, seven hard, eight unsolvable; see Table S1). Each letter of the anagram had a corresponding number beneath it (e.g., W L R O D, 1 2 3 4 5; refer to Figure 1 for an example). To unscramble each anagram, participants had 16 seconds to spell out the word using the numbers corresponding to the letters, which also increased cognitive demand. To increase stress related to their cognitive performance, participants received two types of feedback (for 4s): (a) whether or not they got the anagram correct (i.e.., "Correct!" or "Incorrect"), and (b) the percentage of participants who got the anagram correct (e.g., "78% of participants got that one correct"). The "percentage correct" feedback was arbitrarily determined by the research team (Table S1). For the unsolvable anagrams, participants were always given feedback that their response was incorrect and that a majority (from 71%–95%) of participants answered the anagram correctly, which has been shown to reliably induce negative emotions (see Yang et al., 2018 Supplemental Material). The anagram task took approximately 30 minutes to complete.

Recovery period.—Participants were randomly assigned to either the positive (n = 86) or neutral (n = 84) recovery context. Both recovery contexts involved watching an interactive 3D video for three minutes (see Figure 1). In the positive recovery context, participants watched a beach scene and could hear the waves crashing on the beach. In the neutral recovery context, participants watched an office scene with people working and could hear common workplace noise (e.g., keyboards, phones). The positive and neutral videos have been validated in younger adults (age range: 18–22 years; 51% female) to induce positive emotions and a neutral state, respectively (see Song et al., 2018 for actual means). Participants were encouraged to use their computer mouse to move around in the interactive 3D video to allow for a more immersive experience. The videos were presented in three one-minute increments, with emotion probe data being collected after each minute.

Emotion probes.—Two emotion probes were collected at multiple time points throughout the experiment. Rather than using multiple adjectives, we reasoned that using single items for positive and negative affect assessments is appropriate for experimental studies, particularly designs such as the current study in which affect is more heavily tied to a specific situation and is assessed repeatedly and frequently. These types of assessments have

anagrams (i.e., entering the numbers and not the letters). If participants did not answer correctly, they were returned to the example anagram and instructions. If they did not answer the comprehension check correctly the second time, they were not allowed to continue with the study.

been used extensively by the authors of this research (Song et al., 2018; Waugh et al., 2010, 2011). Participants were asked (1) how pleasant they felt and (2) how unpleasant they felt. Responses were made on a visual analog scale that ranged from 0 (*Not at all pleasant/unpleasant*) to 100 (*Very pleasant/unpleasant*). Participants completed emotion probes at the following time points: (1) before the anagram task, (2) after the anagram task, (3) one minute into the recovery period, (4) two minutes into the recovery period, and (5) after the three-minute recovery period.

Thought Content Questionnaire.—After the recovery period, participants completed a modified version of the Thought Content Questionnaire (Yang et al., 2018). Participants were instructed to read each statement (24 total) and indicate how much they endorsed such thoughts while they were watching the video. There were five subscales for this measure: positive thoughts about the anagram task (e.g., "I thought about how I felt in complete control during the anagram task"; 8 items; α = .79), negative thoughts about the anagram task (e.g., "I thought about how frustrated I was with the anagram task"; 7 items; α = .90), positive thoughts about the recovery video (e.g., "I had pleasant thoughts about the content of the video"; 3 items; α = .72), negative thoughts about the recovery video (e.g., "I had unpleasant thoughts about the content of the video"; 3 items; α = .74), and other (e.g., "I thought about things unrelated to the anagram task or the video"; 3 items; α = .52). Responses were made on a 5-point scale, ranging from 1 (*Not at all*) to 5 (*Very much).*

Procedure

After providing informed consent, participants engaged with a tutorial video about how to interact with the recovery video. After the tutorial video, participants completed a measure of positive and negative affect during the past week using the Modified Differential Emotion Scale (mDES; Fredrickson et al., 2003; for details, see Supplemental Materials) as a descriptive measure to characterize the sample. Participants then completed the first set of emotion probes, followed by the anagram task. After the anagram task, participants completed the second set of emotions probes. Next, participants watched the interactive recovery video and completed two sets of emotion probes during this recovery period. After the three-minute recovery period, participants completed the final set of emotion probes. Participants then completed the thought content questionnaire, a cognitive battery (for details, see Supplemental Materials), other coping/emotion regulation measures (for unrelated purposes) and provided demographic information. Finally, participants were debriefed and thanked for their participation. More detailed information regarding the procedure can be found in Supplemental Materials.

Results

Data Analysis Strategy

We used multilevel linear modeling (MLM) to assess our primary research questions regarding whether there are age and recovery context differences in reactivity to and recovery from the stressor. We also conducted two mediation models to explore whether thought content could explain any age differences in recovery.

Following the analyses of Waugh et al. (2010), we used multilevel linear modeling to analyze the emotion probe data. We specified a 2-level MLM model for the pleasant and unpleasant emotion probes separately. Pleasant and unpleasant emotion probes at each time point (before anagram, after anagram, one-minute into recovery, two-minutes into recovery, and after recovery) were included at Level 1 of the models. We included the changes in slopes and intercepts from Level 1 for each participant at Level 2 of the models.

We took the following steps to build each of the MLM models. Models were estimated using the “lmer()” function in the *lmerTest* package (Kuznetsova et al., 2017). We first fit a series of dummy-coded variables that corresponded to our theorized patterns in the data. We used a piecewise regression approach (Llabre et al., 2001) in which we fit different regression lines to different task periods (stressor reactivity, recovery) within one continuous time-series. Each regression line corresponded to one of four possible patterns in the data: (1) *stress magnitude change* (1 during the task, 0’s everywhere else), which reflects the degree of emotion change from right after the stressor compared to baseline (i.e., before the stressor), (2) *recovery magnitude change* (1’s during the recovery period, 0’s everywhere else), which reflects the degree of emotion change during the recovery period (one-minute into recovery, two-minutes into recovery, after recovery) on average compared to baseline, (3) *linear slope during recovery* (centered to the middle of the period), which reflects the slope of emotion change during the recovery period, and (4) *quadratic slope during recovery* (also centered to the middle of the period), which reflects the quadratic curve of emotion change during the recovery period. The stress magnitude change examines our first research question regarding age differences in reactivity to the stressor. The recovery magnitude change and linear and quadratic slopes during recovery examines our second research question regarding age and context differences in recovery from the stressor.

Next, we added *recovery context* and *age group* at Level 2 of the model predicting each of the Level 1 intercepts and slopes. Recovery context was dummy coded as 1 (positive) and −1 (neutral). Age group was dummy coded as 1 (older adults) and −1 (younger adults). We estimated models with recovery context and age group and the interaction terms with stress reactivity and recovery at Level 2. We decomposed significant interactions with a simple slopes analysis with the “sim_slopes()” function in the *interactions* package (Long, 2019). Neither the quadratic effects nor the three-way interactions for either model were significant. We therefore re-estimated the models and removed the quadratic effects and three-way interactions term to retain the simpler model. We therefore report the results for the simpler models below. Model summary results for pleasant and unpleasant emotion probes can be found in Supplemental Materials. To further explore patterns in the data, we report statistics for significant t-tests examining age group or recovery context differences at time points. Figures 2 and 3 present mean pleasant and unpleasant emotion probes, respectively, at each time point by age group and by recovery context. Within the figures, some significant effects are included to further highlight the pattern of results, and all significant effects are reported below.

Pleasant Emotion

Significant main effects of stress magnitude change, $b = -24.71$, $SE = 3.02$, $t(671) = -8.17$, $p < .001$, and age group, $b = 9.42$, $SE = 3.98$, $t(330.08) = 2.37$, $p = .019$, were qualified by an age group by stress magnitude change interaction, $b = -13.79$, $SE = 3.48$, $t(671) = -1.28$, $p < .001$ (see Table S2 for full model results). Consistent with our prediction that older adults would be as reactive to the stressor, the significant interaction indicated that older adults had a greater degree of decrease in pleasantness after the anagram task compared to baseline ($b = -39.93$, $SE = 2.46$, 95% CI [−44.70, 35.10], $t = -16.24$, $p < .01$) compared to younger adults ($b = -26.14$, $SE = 2.46$, 95% CI [−31.00, −21.30], $t = -10.63$, $p < .01$). As predicted, this suggests that both age groups were reactive to the stressor, but older adults had a greater decrease in pleasantness compared to younger adults.

With respect to recovery from the stressor, a significant main effect of recovery magnitude change, $b = -14.95$, $SE = 2.47$, $t(671) = -6.06$, $p < .001$, indicated that, on average, participants still experienced less pleasant emotion during recovery than during baseline. The age group by recovery magnitude change interaction was not significant, $b = -3.64$, $SE = 2.84$, $t(671) = -1.28$, $p = .201$. There was, however, a significant age group by linear slope during recovery interaction, $b = 3.91$, $SE = 1.74$, $t(671) = 2.25$, $p = .025$. Consistent with our prediction that older adults would recover better than younger adults across the recovery period, the significant interaction indicated that older adults' pleasantness continued to increase linearly during the recovery period ($b = 3.43$, $SE = 1.23$, 95% CI [−1.01, 5.84], $t = 2.79$, $p = .010$), whereas younger adults' pleasantness did not ($b = -0.48$, $SE = 1.23$, 95% CI [−2.89, 1.93], $t = -0.38$, $p = .700$). Moreover, after the full recovery period, older adults reported higher pleasantness compared to younger adults, mean difference = 12.27, 95% CI [2.25, 22.29], $t = 3.63$, $p = .005$, Cohen's $d = 0.35$.

To further explore age differences during recovery, we estimated another MLM in which we assessed linear and quadratic slopes starting from the stressor period to the recovery period (excluding baseline data points), which allows us to examine how much individuals recovered from the stress period to the recovery period (see Table S3 for full model results). Again supporting our hypothesis that older adults would recover better across the recovery period compared to younger adults, the age group by linear slope interaction was significant, $b = 4.61$, $SE = 1.06$, $t(504) = 4.34$, $p < .001$, with follow-up simple slopes analyses demonstrating that older adults had a steeper increase in pleasantness from the stressor to the recovery period ($b = 9.67$, $SE = 0.75$, 95% CI [8.16, 11.11], $t = 12.88$, $p < .01$) compared to younger adults ($b = 5.06$, $SE = 0.75$, 95% CI [3.56, 6.51], $t = 6.75$, $p < .01$).

From the initial MLM analysis with all time points included, there was also a significant recovery context by recovery magnitude change interaction, $b = 12.47$, $SE = 2.84$, $t(671) = 4.39$, $p < .001$, which indicated that participants' level of pleasant emotion recovered more and returned closer to baseline in the positive recovery context ($b = -4.30$, $SE = 2.00$, 95% CI [−8.22, −0.38], $t = -2.15$, $p = .030$) than participants in the neutral recovery context ($b = -16.77$, $SE = 2.02$, 95% CI [−20.74, −12.80], $t = -8.30$, $p < .01$). In the follow up MLM extending the linear effects to the stressor period, the recovery context by linear slope interaction was significant, $b = 5.28$, $SE = 1.60$, $t(504) = 4.98$, $p < .001$, with simple slopes analyses demonstrating that participants in the positive recovery context had a steeper increase in pleasantness from the stressor to the recovery period ($b = 9.97$, $SE = 0.75$, 95% CI [8.51, 11.44], $t = 13.37$, $p < .01$) than participants in the neutral recovery context ($b = 4.70$, $SE = 0.75$, 95% CI [3.21, 6.18], $t = 6.22$, $p < .01$). The recovery context by quadratic slope during recovery period was also significant, $b = -3.07$, $SE = 1.19$, $t(504) = -2.60$, $p = .010$, which was likely due to the fact that the participants in the positive recovery context had a steeper increase in pleasantness compared to those in the neutral recovery context.

Unpleasant Emotion

Significant main effects of stress magnitude change, $b = 20.91$, $SE = 3.33$, $t(671) = 6.27$, $p < .001$, and age group, $b = -16.84$, $SE = 4.13$, $t(363.71) = -4.08$, $p < .001$, were qualified by a significant age group by stress magnitude change interaction, $b = 18.15$, $SE = 3.83$, $t(671) = 4.74$, $p < .001$ (see Table S4 for full model results). Consistent with our prediction that older adults would be as reactive or more reactive to the stressor compared to younger adults, the significant interaction indicated that older adults had a greater increase in unpleasantness after the anagram task compared to baseline ($b = 42.55$, $SE = 2.71$, 95% CI [37.20, 47.80], $t = 15.71$, $p < .01$) relative to younger adults ($b = 24.40$, $SE = 2.71$, 95% CI [19.00, 29.7], $t = 9.01$, $p < .01$).

With respect to recovery from the stressor, a significant main effect of recovery magnitude change, $b = 12.07$, $SE = 2.72$, $t(671) = 5.17$, $p < .001$, showed that, on average, participants still experienced more unpleasant emotion during recovery than during baseline. Further, a significant age group by recovery magnitude change interaction, $b = 7.18$, $SE = 3.13$, $t(671) = 2.31$, $p = .022$, indicated that older adults had a greater degree of change in unpleasantness during the recovery period compared to baseline ($b = 15.50$, $SE = 2.21$, 95% CI [11.23, 19.00], $t = 7.01$, $p < .01$) relative to younger adults ($b = 8.32$, $SE = 2.21$, 95% CI [4.04, 12.70], $t = 3.76$, $p < .01$). Although the age group by linear slope during recovery interaction was significant for pleasant emotion probes, it was not significant for unpleasant emotion probes, $b = -3.50$, $SE = 1.92$, $t(671) = -1.83$, $p = .068$. This effect is likely driven by the fact that older adults' unpleasantness at baseline was much lower than that of younger adults, mean difference = −16.84, 95% CI [−27.38, −6.29], $t = -4.20$, $p < .001$, Cohen's $d = -0.84$. When examining just the recovery period, older adults reported lower unpleasantness compared to younger adults during the second minute of the recovery period (see fourth data points in Panel A of Figure 3), mean difference = −10.61, 95% CI [−20.97, −0.24], $t = -3.04$, $p = .032$, Cohen's $d = -0.35$, and after the full recovery period, mean difference = −13.69, 95% CI [−24.06, −3.33], $t = -3.92$, $p = .002$, Cohen's $d = -0.43$.

To further explore age differences during recovery, we estimated another MLM to assess linear and quadratic slopes starting from the stressor period to the recovery period (excluding baseline datapoints), allowing us to examine how much individuals recovered from the stress period to the recovery period (see Table S5 for full model results). The quadratic effect was significant but did not interact with recovery context or age group, so we estimated a simpler model with the quadratic effect only and not the interactions with recovery context and age group. In the simpler model, the quadratic effect was again significant, $b = 5.56$, $SE = 0.61$, t(506 = 9.05, $p < .001$, and the age group by linear slope during recovery interaction was significant, $b = -4.69$, $SE = 1.11$, $t(506) = -4.27$, $p < .001$.

Consistent with our prediction that older adults would recover better than younger adults across the recovery period, follow-up simple slopes analyses indicated that older adults had a steeper decrease in unpleasantness during the recovery period ($b = −8.74$, $SE = 0.78$, 95% CI [−10.23, −7.17], $t = −11.25$, $p < .01$) compared to younger adults ($b = −4.05$, $SE = 0.78$, 95% CI [−5.54, −2.48], $t = −5.21$, $p < .01$). Thus, although the age group by linear slope during recovery period was not significant when age differences at baseline were accounted for, these follow up analyses demonstrates that both age groups improved in their emotion from the stressor, but older adults had better recovery, even though they did not return to their quite low unpleasantness at baseline.

From the initial MLM analysis with all time points included, a significant recovery context by recovery magnitude change interaction, $b = −11.38$, $SE = 3.13$, $t(671) = −3.64$, $p < .001$, indicated that participants in the neutral recovery context had a greater degree of change in unpleasantness during the recovery period compared to baseline ($b = −17.67$, $SE = 2.23$, 95% CI [13.30, 22.00], $t = 7.94$, $p < .01$) relative to participants in the positive recovery context ($b = 6.29$, $SE = 2.20$, 95% CI [1.97, 10.60], $t = 2.86$, $p < .01$), As with the pleasant emotion probes, participants' unpleasantness in the positive recovery context was closer to baseline after the recovery period compared to participants in the neutral context, leading participants in the neutral recovery context to have a larger degree of change in unpleasantness compared to participants in the positive recovery context. In the follow up MLM extending the linear effects to the stressor period, the recovery context by linear slope during recovery interaction was significant, $b = −6.69$, $SE = 1.11$, $t(506) = −6.09$, $p < .001$. Follow up simple slopes analyses indicated that participants in the positive recovery context had a steeper decline in unpleasantness during the recovery period ($b = −9.70$, $SE = 0.77$, 95% CI [−11.22, −8.18], $t = −12.56$, $p < .01$) compared to participants in the neutral recovery context ($b = −3.01$, $SE = 0.78$, 95% CI [−4.54, −1.47], $t = −3.85$, $p < .01$). This is made clear by examining the recovery context differences in unpleasantness at each time point during the recovery period. Specifically, participants in the positive recovery context reported significantly lower unpleasantness than participants in the neutral recovery context during the first minute of the recovery period, mean difference = 11.62, 95% CI [1.92, 22.00], $t = 3.31$, $p = .008$, Cohen's $d = 0.32$, and was larger after the second minute of the recovery period, mean difference = 15.76, 95% CI [5.33, 26.18], $t = 4.48$, $p < .001$, Cohen's $d = 0.45$, and even larger after the full three-minute recovery period was over, mean difference = 18.12, 95% CI [7.70, 28.55], $t = 5.16$, $p < .001$, Cohen's $d = 0.48$.

Did differences in thought content explain age group differences in stress recovery?

Composite averages for each subscale were submitted to separate 2 (Age group) × 2 (Recovery context) ANOVAs. To streamline results, we only summarize the results for the subscales that had significant main effects or interactions (i.e., positive and negative thoughts about the recovery video and other thoughts), but the means, standard deviations, and test statistics for all subscales can be found in Supplemental Materials.

Participants in the positive recovery context reported greater positive thoughts about the recovery video than participants in the neutral recovery context, $F(1, 166) = 62.96$, $p < .001$, $\eta_p^2 = .275$. Older adults reported significantly fewer negative thoughts about the recovery video, $F(1, 166) = 10.87$, $p = .001$, $\eta_p^2 = .061$, and other thoughts about the recovery video, $F(1, 166) = 44.90$, $p < .001$, $\eta_p^2 = .213$, than did younger adults. No other significant effects emerged.

As described above, older and younger adults' pleasantness and unpleasantness improved during the recovery period, but older adults had a steeper increase/decrease in their emotional reactivity compared to younger adults. Could older adults' continued recovery over time be explained by fewer negative thoughts about the recovery video and/or fewer other-related thoughts? To answer this question, we conducted two indirect effects analyses for the pleasant and unpleasant emotion probe data. Age group was the predictor and average composite ratings of negative thoughts about the recovery video and other thoughts (mean-centered) served as parallel mediators. We included the effects of recovery context as a covariate. We focus on the effects of age, but analyses and data to test other effects can be found on our OSF page. For the outcome variable, we used person specific slopes derived from the follow-up MLM analyses that estimated linear slopes from the stressor to the recovery period described above.

For both models, we estimated the direct effect of age group (reference group = younger adults) and recovery context (reference group = neutral) on the person-specific linear slopes across the stressor and recovery periods (*c* path). We also estimated the direct effect of age group and recovery context on average ratings of negative thoughts about the recovery video and other thoughts (*a* paths) as well as the effects of negative thoughts about the recovery video and other thoughts on the person-specific slope (*b* paths). Additionally, we estimated the direct effect of age group and recovery context on the person-specific slopes after accounting for the effects of the mediators in the model (*c*' path). Finally, using the method outlined by Hayes (2009) each estimate of the causal mediation effect (indirect effect) was computed for each of 5,000 bootstrapped samples. The 95% confidence interval was computed from the indirect effect at the 2.5% and 97.5% percentiles for each mediator. Confidence intervals were computed using bias corrected bootstrap sampling via the "bca.simple" type in 'lavaan'. Full test statistics are reported in Figure 4 for both pleasant (Panel A) and unpleasant (Panel B) mediation models.

Pleasant emotion.—Age group significantly predicted negative thoughts about the recovery video and other thoughts, such that older adults had fewer negative thoughts about the recovery period and other thoughts compared to younger adults. Negative thoughts about the recovery video (but not other thoughts) predicted decreases in pleasantness during the recovery period. Although there was not a direct effect of age group on the stress to recovery slope, the indirect effect of age group on stress recovery through negative thoughts about the recovery period was significant. Older adults had fewer negative thoughts about the recovery video, which predicted increases in pleasantness from the stressor to the recovery period. The indirect effect of age group on stress to recovery slope through other thoughts was not significant ($p = .331$). The total effect of age group (and recovery context) on the stress to recovery slope after accounting for both the mediators was not significant ($p = .189$).

Unpleasant emotion.—Because the *a* paths were the same in both models, we observed the same age differences in negative and other thoughts about the recovery period. Negative thoughts about the recovery period (but not other thoughts) significantly predicted increases in unpleasantness, potentially suggesting that having more negative thoughts about the recovery period hinders the ability to sustain the initial recovery. Although the direct effect of age group was not significant, the indirect effect of age group on changes in unpleasantness from stress to recovery through negative thoughts about the recovery video was significant. “Other thoughts” as mediator was not significant ($p = .882$). Older adults had fewer negative thoughts about the recovery video, which predicted decreases in unpleasantness during the recovery period. The total effect of age group (and recovery context) on the stress recovery slope after accounting for both the mediators was not significant ($p = .056$).

Discussion

The current study examined how older and younger adults reacted to and recovered from a cognitively evaluative stressor using repeated positive and negative emotion probes. Guided by SAVI, we predicted that older adults would report more positivity and less negativity before and after exposure to the stressor, but that older adults would be similarly if not more reactive to the stressor than younger adults. After exposure to the stressor, we predicted that older adults would emotionally recover better than younger adults, especially with increased temporal distance from the stressor.

In line with our hypotheses, older adults reported significantly higher pleasantness and lower unpleasantness before the anagram task, which is consistent with previous findings that older adults report lower negative and higher or at least commensurate positive affect compared to younger adults (Carstensen et al., 2000, 2011; Charles et al., 2001; Mroczek & Kolarz, 1998). Though older adults reported significantly higher pleasantness and lower unpleasantness before the stressor relative to younger adults, these differences disappeared immediately after the stressor, which is consistent with SAVI (Charles, 2010) and past research examining age differences in reactivity (Wrzus et al., 2014). Specifically, older adults were significantly impacted by the cognitively evaluative, stereotype-threatening stressor (i.e., the anagram task), with older adults’ pleasantness and unpleasantness decreasing or increasing, respectively, which builds on past research (Scott et al., 2017). Younger adults were also reactive to the stressor, suggesting that both age groups had a relatively appropriate response to changes in their environment. That is, considering that the primary function of emotions is to adapt to changes in the environment (Lazarus, 1991; Levenson, 1999), the finding that emotions changed after the stressor could be considered a marker of adapting to the environment for both age groups, despite older adults’ initially higher pleasantness and lower unpleasantness. One possible explanation for older adults’ greater reactivity could be that older adults’ natural tendency to avoid negative situations results in experiencing stressors less often (Almeida, 2005). But when the stressor is unavoidable, like in the current study, older adults may have an exacerbated response (Charles, 2010). Moreover, the stressor in the current study, a cognitively challenging anagram task with false feedback may have activated or primed stereotype threat among the older participants, leading them to be more reactive (Levy et al., 2000).

With respect to recovery, both older and younger adults reported an initial recovery boost after being exposed to the stressor (i.e., after the first minute of the recovery period), but older adults continued to recover throughout the recovery period to a greater extent than younger adults. During the recovery period, older adults' linear increase in pleasantness and decrease in unpleasantness were almost twice as much as younger adults. Viewed from a functionalist perspective, this resounding affective recovery reflects the important functions that positive emotions serve across the life span (e.g., Fredrickson & Levenson, 1998; Fredrickson et al., 2000) and which may be especially important for late-life outcomes, such as memory functioning (e.g., Hittner et al., 2020) and health and longevity (e.g., Wells et al., in press).

It is interesting that this recovery occurred regardless of recovery context. Though we had speculated that older adults would be better able to capitalize on the positive context relative to the neutral context and relative to younger adults, this hypothesis was not supported. However, there was a clear advantage of the positive recovery context relative to the neutral recovery context for participants, highlighting how positive contexts helped participants regardless of age regulate feelings evoked by the stressor more so than neutral contexts, consistent with past research demonstrating how positive emotional contexts can help stress recovery (Folkman & Moskowitz, 2000; Fredrickson, 1998; Monfort et al., 2014).

Another novel contribution of this work is that we did not explicitly instruct older adults to regulate their emotions in any specific way (cf. Robinette & Charles, 2016; Rompilla et al., 2021). Thus, we were able to observe how younger and older adults recovered naturally in a spontaneous manner from the cognitive stressor. This suggests that emotion regulation can still occur when not explicitly instructed to do so. Moreover, we were able to provide a precise temporal account of how older adults recovered after each minute of the recovery period and could show that older adults' regulatory strengths are leveraged throughout the time course of recovery. We also measured thought content after the recovery period and found that older adults' improved recovery compared to younger adults was indirectly explained by older adults having fewer negative thoughts about the recovery video compared to younger adults (but not for negative thoughts about the anagram task). This converges with past research demonstrating how engaging in negative, ruminative thinking has negative impacts on well-being and can inhibit recovery from stress (Emery et al., 2020; Nolen-Hoeksema & Aldao, 2011). Thus, when older adults are left to their natural propensities to recover from stress, their age-related strengths (e.g., focusing less on negative thoughts) facilitated their recovery.

The contributions of the present study must be interpreted with its limitations. In terms of strengths, we used a tightly controlled experimental design, a potent stressor, multiple recovery contexts, multiple emotion probes, assessed naturalistic thought contents, and made efforts to recruit a diverse sample representative in terms of racial and ethnic background and socioeconomic status. Findings were limited, however, by our reliance on positive and negative emotional experience assessments. Future research could extend this work by incorporating measures of discrete emotions to probe whether older adults respond with different emotions than younger adults (e.g., sadness vs. anger) to stress (Charles & Carstensen, 2008; Haase et al., 2012) as well as physiological measures (e.g., blood pressure, heart rate) to elucidate when older adults' emotion regulation skills may be undermined by sustained physiological arousal evoked by stressors (Charles, 2010; Levy et al., 2000; Wrzus et al., 2013, 2014, 2015). Moreover, the two recovery contexts (positive and neutral videos) were not validated on an older adult sample (only for a younger adult sample in previous work; Song et al., 2018). Future research could be devoted on validating and norming the positive and neutral videos using a younger and older adult sample. Moreover, future research could extend our work by examining naturalistic recovery processes without any recovery context to provide a deeper understanding of how older adults recover from stress. Furthermore, in the current work, we used a stereotype-threatening cognitive stressor to maximally induce stress. Future research could explore the generalizability of our work by using age-comparable or differentially age-relevant sources of stress (e.g., social stressor).

Taken together, this work importantly underscores how older adults exhibit a resounding recovery when negatively impacted by stress. This work brings to light the strengths of older adults and provides insight into the time course of recovery. In line with SAVI, though certain stressors strongly impact older adults, they harness their strengths to ultimately recover and achieve greater well-being that can surpass that of younger adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The ideas and data appearing in the manuscript have not been disseminated previously. This research was partially supported by the National Institute on Aging, grants R21-AG059938 and R01-AG043533, and by the National Science Foundation, grant SES-1536260. We would like to acknowledge the contributions of David Taullahu, Tess Hasan, and Madeline Nievera for their efforts in collecting these data. Data for this work are available via the Open Science Framework (OSF) and can be found at: https://osf.io/8ya2w/?view_only=0887eb3baee348d4afae4196a29a9962

References

Almeida DM .(2005). Resilience and vulnerability to daily stressors assessed via dairy methods. Current Directions in Psychological Science, 14, 64–68. Doi: 10.1111/j.0963-7214.2005.00336.x

Baird BM, Lucas RE, & Donnellan MB (2010). Life satisfaction across the lifespan: Findings from two nationally representative panel studies. Social Indicators Research, 99(2), 183–203. [PubMed: 21113322]

Baumeister RF, Bratslavsky E, Finkenauer C, & Vohs KD (2001). Bad is stronger than good. Review of General Psychology, 5, 323–370. Doi: 10.1037/1089-2680.5.4.323

Blanchard-Fields F, Mienaltowski A, & Seay RB (2007). Age differences in everyday problem-solving effectiveness: Older adults select more effective strategies for interpersonal problems. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 62(1), 61–64. Doi: 10.1093/geronb/62.1.P61

Birditt KS,& Fingerman KL, & Almeida DM. (2005). Age differences in exposure and reactions to interpersonal tensions: A daily diary study. Psychology and Aging, 20, 330–340. Doi: 10.1037/0882-7974.20.2.330 [PubMed: 16029096]

Birditt KS, & Fingerman KL (2005). Do we get better at picking our battles? Age group differences in descriptions of behavioral reactions to interpersonal tensions. The Journals of Gerontology Series B: Psychological Sciences and Social Science, 3, 121–128. Doi: 10.1093/geronb/60.3.P121

Brady B, Kneebone II, Denson N, & Bailey PE (2018). Systematic review and meta-analysis of age-related differences in instructed emotion regulation success. PeerJ, 6, e6051. doi: 10.7717/peerj.6051 [PubMed: 30588398]

Carstensen LL (2006). The influence of a sense of time on human development. Science, 312, 1913–1915. Doi: 10.1126/science.1127488 [PubMed: 16809530]

Carstensen LL, Isaacowitz DM, & Charles ST (1999). Taking time seriously: A theory of socioemotional selectivity. American Psychologist, 54(3), 165–181. Doi: 10.1037/0003-066X.54.3.165 [PubMed: 10199217]

Carstensen LL, & Mikels JA (2005). At the intersection of emotion and cognition: Aging and the positivity effect. Current Directions in Psychological Science Current Directions in Psychological Science, 14(3), 117–121. Doi:10.1111/j.0963-7214.2005.00348.x

Carstensen LL, Pasupathi M, Mayr U, & Nesselroade JR (2000). Emotional experience in everyday life across the adult life span. Journal of Personality and Social Psychology, 79, 644–655. Doi: 10.1037/0022-3514.79.4.644 [PubMed: 11045744]

Carstensen LL, Turan B, Scheibe S, Ram N, Ersner-Hershfield H, Samanez-Larkin GR, Brooks KP, & Nesselroade JR (2011). Emotional experience improves with age: Evidence based on over 10 years of experience sampling. Psychology and Aging, 26, 21–33. Doi: 10.1037/a0021285 [PubMed: 20973600]

Charles ST (2010). Strength and vulnerability integration: A model of emotional well-being across adulthood. Psychological Bulletin, 136(6), 1068–1091. Doi: 10.1037/a0021232 [PubMed: 21038939]

Charles ST, & Carstensen LL (2008). Unpleasant situations elicit different emotional responses in younger and older adults. Psychology and Aging, 23, 495–504. Doi: 10.1037/a0013284 [PubMed: 18808240]

Charles ST, & Carstensen LL (2009). Social and emotional aging. Annual Review of Psychology, 61, 383–409. Doi: 10.1146/annurev.psych.093008.100448

Charles ST, & Luong G (2013). Emotional experience across adulthood: The theoretical model of strength and vulnerability integration. Current Directions in Psychological Science, 22(6), 443–448. Doi: 10.1177/0963721413497013

Charles ST, & Piazza JR (2009). Age differences in affective well-being: Context matters. Social and Personality Psychology Compass, 3(5), 711–724. Doi: 10.1111/j.1751-9004.2009.00202.x

Charles ST, Reynolds CA, & Gatz M (2001). Age-related differences and change in positive and negative affect over 23 years. Journal of Personality and Social Psychology, 80, 136–151. Doi: 10.1037/0022-3514.80.1.136 [PubMed: 11195886]

Chasteen AL, Kang SK, & Remedios JD (2012). Aging and stereotype threat: Development, process, and interventions. In Inzlicht M & Schmader T (Eds.), Stereotype threat: Theory, process, and application (pp. 202–216). Oxford University Press.

Diener E, Suh EM, Lucas RE, & Smith HL (1999). Subjective well-being: Three decades of progress. Psychological Bulletin, 125, 276–302. Doi: 10.1037/0033-2909.125.2.276

Emery L, Sorell A, & Miles C (2020). Age differences in negative, but not positive, rumination. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 75, 80–84. Doi: 10.1093/geronb/gbz109 [PubMed: 31504914]

Faul F, Erdfelder E, Lang A-G, & Buchner A (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39, 175–191. Doi: 10.3758/BF03193146 [PubMed: 17695343]

Fredrickson BL, & Levenson RW (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. Cognition and Emotion, 12, 191–220. Doi: 10.1080/026999398379718 [PubMed: 21852890]

Fredrickson BL, Mancuso RA, Branigan C, & Tugade MM (2000). The undoing effect of positive emotions. Motivation and Emotion, 24, 237–258. Doi: 10.1023/A:1010796329158 [PubMed: 21731120]

Fredrickson BL, Tugade MM, Waugh CE, & Larkin GR (2003). What good are positive emotions in crisis? A prospective study of resilience and emotions following the terrorist attacks on the United

States on September 11th, 2001. Journal of Personality and Social Psychology, 84(2), 365–376. Doi: 10.1037/0022-3514.84.2.365 [PubMed: 12585810]

Folkman S, & Moskowitz JT (2000). Stress, positive emotion, and coping. Current Directions in Psychological Science, 9, 115–118.

Gerstorf D, Ram N, Mayraz G, Hidajat M, Lindenberger U, Wagner GG, et al. (2010). Late-life decline in well-being across adulthood in Germany, the UK, and the US: Something is seriously wrong at the end of life. Psychology and Aging, 25(2), 477–485. Doi: 10.1037/a0017543 [PubMed: 20545432]

Gerstorf D, Hülür G, Wagner GG, Kunzmann U, & Ram N (2018). Terminal change across facets of affective experience and domain satisfaction: Commonalities, differences, and bittersweet emotions at the end of life. Developmental Psychology, 54(12), 2382–2402. 10.1037/dev0000599 [PubMed: 30372096]

Gross JJ (1998). The emerging field of emotion regulation: An integrative review. Review of General Psychology, 2(3), 271–299. doi: 10.1037/1089-2680.2.3.271

Haase CM, Seider BH, Shiota MN, & Levenson RW (2012). Anger and sadness in response to an emotionally neutral film: Evidence for age-specific associations with well-being. Psychology and Aging, 27, 305–317. doi: 10.1037/a0024959 [PubMed: 21843005]

Hayes AF (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. Communication Monographs, 76, 408–420. doi: 10.1080/03637750903310360

Highsmith CM, photographer. (2020) Beach scene in Palm Beach, Florida. Palm Beach County United States Palm Beach Florida, 2020. −01–14. [Photograph in the public domain] Retrieved from the Library of Congress, https://www.loc.gov/item/2020720734/.

Highsmith CM, photographer. Commercial Office Interior. United States, None. [Between 1980 and 2006] [Photograph in the public domain] Retrieved from the Library of Congress, https://www.loc.gov/item/2011634957/.

Hittner EF, Stephens JE, Turiano NA, Gerstorf D, Lachman ME, & Haase CM (2020). Positive Affect Is Associated With Less Memory Decline: Evidence From a 9-Year Longitudinal Study. Psychol Sci, 31(11), 1386–1395. doi:10.1177/0956797620953883 [PubMed: 33090935]

Holley SR, Haase CM, & Levenson RW (2013). Age-related changes in demand-withdraw communication behaviors. Journal of Marriage and Family, 75, 822–836. doi: 10.1111/jomf.12051 [PubMed: 23913982]

Isaacowitz DM, & Ossenfort KL (2017). Aging, attention and situation selection: Older adults create mixed emotional environments. Current Opinion in Behavioral Sciences, 15, 6–9. doi: 10.1016/j.cobeha.2017.05.004 [PubMed: 29082304]

JASP Team (2022). JASP (Version 0.16.2)

Jebb AT, Morrison M, Tay L, & Diener E (2020). Subjective well-being around the world: trends and predictors across the life span. Psychological Science, 31(3), 293–305. doi: 10.1177/0956797619898826 [PubMed: 32045327]

Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, & Walters EE (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. Archives of General Psychiatry, 62, 593–602. doi: 10.1001/archpsyc.62.6.593 [PubMed: 15939837]

Kuznetsova A, Brockhoff PB, & Christensen RHB (2017). lmerTest package: Tests in linear mixed effects models. Journal of Statistical Software, 82(13), 1–26. doi: 10.18637/jss.v082.i13

Llabre MM, Spitzer SB, Saab PG, Schneiderman N, 2001. Piecewise latent growth curve modeling of systolic blood pressure reactivity and recovery from the cold pressor test. Psychophysiology, 38, 951–960 doi: 10.1111/1469-8986.3860951. [PubMed: 12240671]

Lazarus RS (1991). Progress on a cognitive-motivational-relational theory of emotion. American Psychologist, 46, 819–834. [PubMed: 1928936]

Lefkowitz ES, & Fingerman KL (2003). Positive and Negative Emotional Feelings and Behaviors in Mother-Daughter Ties in Late Life. Journal of Family Psychology, 17(4), 607–617. doi: 10.1037/0893-3200.17.4.607 [PubMed: 14640809]

Levenson RW (1999). The intrapersonal functions of emotion. Cognition & Emotion, 13, 481–504. doi: 10.1080/026999399379159

Levy BR, Hausdorff JM, Hencke R, & Wei JY (2000). Reducing cardiovascular stress with positive self-stereotypes of aging. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 55, 205–213. doi: 10.1093/geronb/55.4.p205

Long JA (2019). interactions: Comprehensive, user-friendly toolkit for probing interactions. R package version 1.1.0, https://cran.r-project.org/package=interactions

Luong G, & Charles ST (2014). Age differences in affective and cardiovascular responses to a negative social interaction: The role of goals, appraisals, and emotion regulation. Developmental Psychology, 50(7), 1919–1930. doi: 10.1037/a0036621 [PubMed: 24773101]

Minton AR, Mikels J, Charles ST, Snyder JS, Haase CM, & Waugh C (2022, May 25). Falling Hard, but Recovering Resoundingly: Age Differences in Stressor Reactivity and Recovery. Retrieved from osf.io/8ya2w

Monfort SS, Stroup HE, & Waugh CE (2015). The impact of anticipating positive events on responses to stress. Journal of Experimental Social Psychology, 58, 11–22. doi: 10.1016/j.jesp.2014.12.003

Mroczek DK, & Kolarz CM (1998). The effect of age on positive and negative affect: A developmental perspective on happiness. Journal of Personality, 75, 1333–1349. doi: 10.1037/0022-3514.75.5.1333

Nolen-Hoeskema S, & Aldao A (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. Personality and Individual Differences, 51, 704–708. doi: 10.1016/j.paid.2011.06.012

Ong AD, Bergeman CS, Bisconti TL, & Wallace KA (2006). Psychological resilience, positive emotions, and successful adaptation to stress in later life. Journal of Personality and Social Psychology, 91, 730–749. doi: 10.1037/0022-3514.91.4.730 [PubMed: 17014296]

Piazza JR, Charles ST, Sliwinski MJ, Mogle J, & Almeida DM (2013). Affective reactivity to daily stressors and long-term risk of reporting a chronic physical health condition. Annals of Behavioral Medicine, 45, 110–120. doi: 10.1007/s12160-012-9423-0 [PubMed: 23080393]

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Reed AE, Chan L, & Mikels JA (2014). Meta-analysis of the age-related positivity effect: Age differences in preferences for positive over negative information. Psychology and Aging, 29, 1–15. doi: 10.1037/a0035194 [PubMed: 24660792]

Roberts BW, Walton KE, & Viechtbauer W (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. Psychological Bulletin, 132(1), 1–25. doi: 10.1037/0033-2909.132.1.1 [PubMed: 16435954]

Rosseel Y (2012). lavaan: An R package for structural equation modeling. Journal of Statistical Software, 48(2), 1–36. https://www.jstatsoft.org/v48/i02/.

Rompilla DB Jr., Hittner EF, Stephens JE, Mauss I, & Haase CM (2021). Emotion regulation in the face of loss: How detachment, positive reappraisal, and acceptance shape experiences, physiology, and perceptions in late life. Emotion. Advance online publication. do: 10.1037/emo0000932

Scott SB, Ram N, Smyth JM, Almeida DM, & Sliwinski MJ (2017). Age differences in negative emotional responses to daily stressors depend on time since event. Developmental Psychology, 53, 177–190. doi: 10.1037/dev0000257 [PubMed: 28026195]

Scott SB, Sliwinski MJ, & Blanchard-Fields F (2013). Age differences in emotional responses to daily stress: The role of timing, severity, and global perceived stress. Psychology and Aging, 28(4), 1076–1087. doi: 10.1037/a0034000 [PubMed: 24364410]

Shiota MN, & Levenson RW (2009). Effects of aging on experimentally instructed detached reappraisal, positive reappraisal, and emotional behavior suppression. Psychology and Aging, 24, 890–900. doi: 10.1037/a0017896 [PubMed: 20025404]

Shipley Institute of Living Scale - Vocabulary: Shipley, W. C. (1986). Shipley Institute of Living Scale. Los Angeles, CA: Western Psychological Services.

Song Y, Jordan JI, Shaffer KA, Wing EK, McRae K, & Waugh CE (2018). Effects of incidental positive emotion and cognitive reappraisal on affective responses to negative stimuli. Emotion, 33, 1155–1168. doi: 10.1080/02699931.2018.1541789

Uchino BN, Birmingham W, & Berg CA (2010). Are older adults less or more physiologically reactive? A meta-analysis of age-related differences in cardiovascular reactivity to laboratory tasks. The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 65, 154–162. doi:10.1093/geronb/gbp127

Waugh CE, Panage S, Mendes WB, & Gotlib IH (2010). Cardiovascular and affective recovery from anticipatory threat. Biological Psychology, 84, 169–175. doi: 10.1016/j.biopsycho.2010.01.010 [PubMed: 20096747]

Waugh CE, Thompson RJ, Gotlib IH (2011). Flexible emotional responsiveness in trait resilience. Emotion, 11(5), 1059–67. [PubMed: 21707168]

Wechsler D, Coalson DL, & Raiford SE (2008). WAIS-IV: Wechsler Adult Intelligence Scale. San Antonio, TX: Pearson.

Wells JL, Haase CM, Rothwell ES, Naugle KG, Otero MC, Brown CL, . . . Fredrickson BL. (2022). Positivity resonance in long-term married couples: Multimodal characteristics and consequences for health and longevity. Journal of Personality and Social Psychology. doi:10.1037/pspi0000385

Wrzus C, Luong G, Wagner GG, & Riediger M (2015). Can’t get it out of my head: Age differences in affective responsiveness vary with preoccupation and elapsed time after daily hassles. Emotion, 15, 257–269. [PubMed: 25286070]

Wrzus C, Müller V, Wagner GG, Lindenberger U, & Riediger M (2013). Affective and cardiovascular responding to unpleasant events from adolescence to old age: Complexity of events matters. Developmental Psychology, 49(2), 384–397. doi: 10.1037/a0028325 [PubMed: 22545845]

Wrzus C, Müller V, Wagner GG, Lindenberger U, & Riediger M (2014). Affect dynamics across the lifespan: With age, heart rate reacts less strongly but recovers more slowly from unpleasant emotional situations. Psychology and Aging, 29, 563–575. doi: 10.1037/a0037451 [PubMed: 25244476]

Yang X, Garcia KM, Jung Y, Whitlow CT, McRae K, & Waugh CE (2018). vmPFC activation during a stressor predicts positive emotions during stress recovery. Social Cognitive and Affective Neuroscience, 13, 256–268. doi: 10.1093/scan/nsy012 [PubMed: 29462404]

Author Manuscript

Author Manuscript

Author Manuscript

Public Significance Statement

Despite documented physical and cognitive declines in older adulthood, there are clear gains in emotional well-being with advancing age. This study shows that older and younger adults are comparably affected by a cognitive stressor, but older adults exhibit improved recovery relative to younger adults. These findings highlight the strengths of older adults' ability to recover from stress.

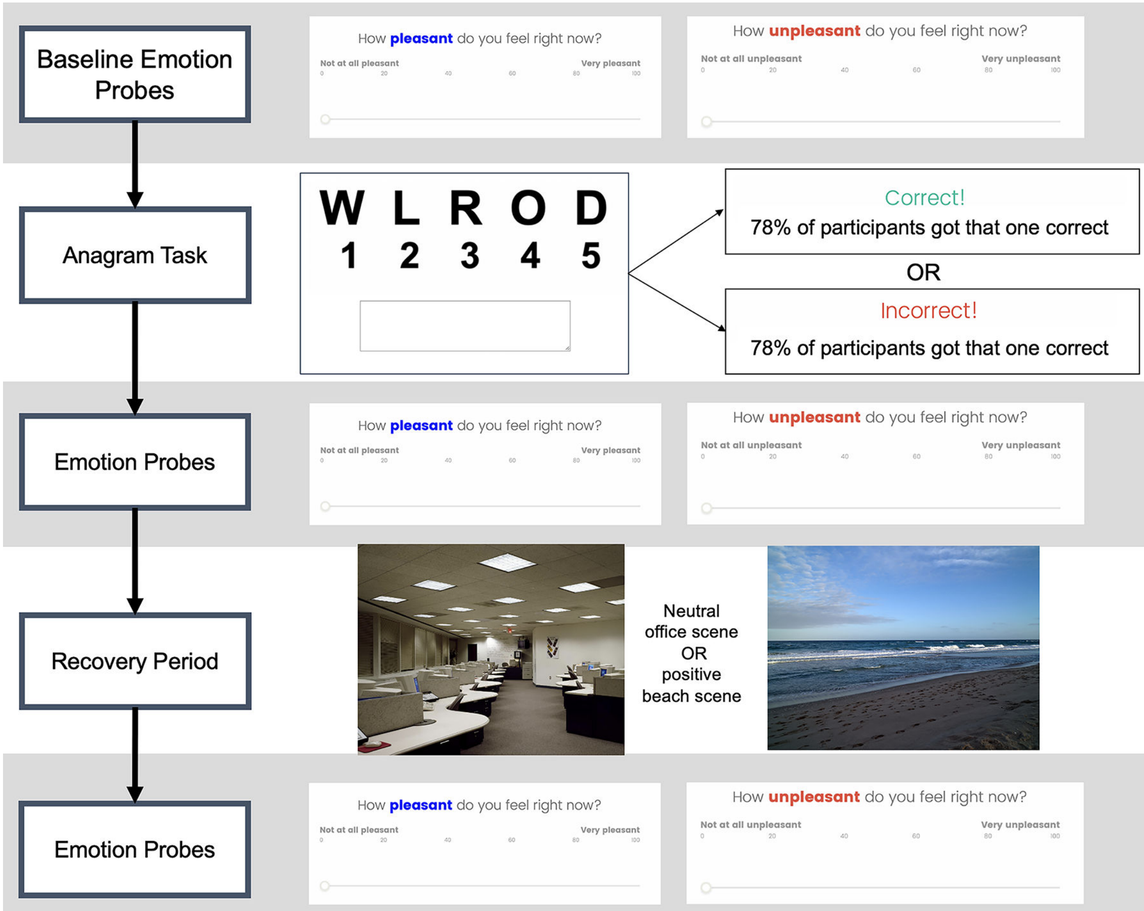

Figure 1.

Visual depiction of the experimental procedure. Note that participants completed two pleasant and unpleasant emotion probes during the recovery period (one minute into recovery, and then two minutes into recovery). Due to copyright permission, the photos of the positive beach scene (Highsmith, 2020) and neutral office scene (Highsmith, n.d.) are close representations of what the recovery videos looked like.

Highsmith, C. M., photographer. (2020) *Beach scene in Palm Beach, Florida* . Palm Beach County United States Palm Beach Florida, 2020. -01-14. [Photograph in the public domain] Retrieved from the Library of Congress, https://www.loc.gov/item/2020720734/.

Highsmith, C. M., photographer. *Commercial Office Interior*. United States, None. [Between 1980 and 2006] [Photograph in the public domain] Retrieved from the Library of Congress, https://www.loc.gov/item/2011634957/.

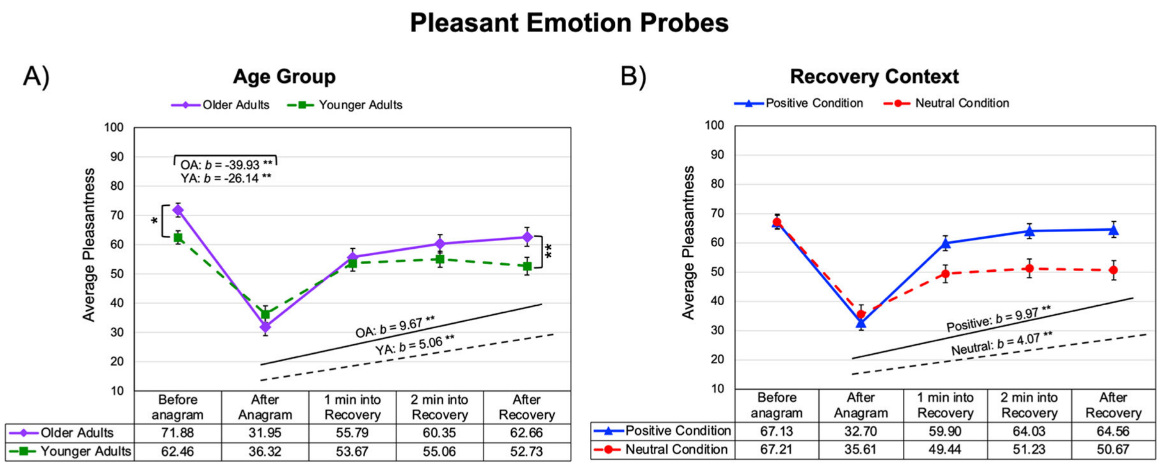

Figure 2.

Panel A presents the means for pleasant emotion probes at each time point for both age groups. Older adults are represented by the solid purple lines with diamond end points. Younger adults are represented by the dashed green lines with square end points. Panel B presents the means for pleasant emotion probes at each time point for both recovery contexts. The positive recovery context is represented by the solid blue lines with triangle end points. The neutral recovery context is represented by the dashed red line with circle end points. Error bars reflect 95% confidence intervals.

* $p < .05$. ** $p < .01$. *** $p < .001$.

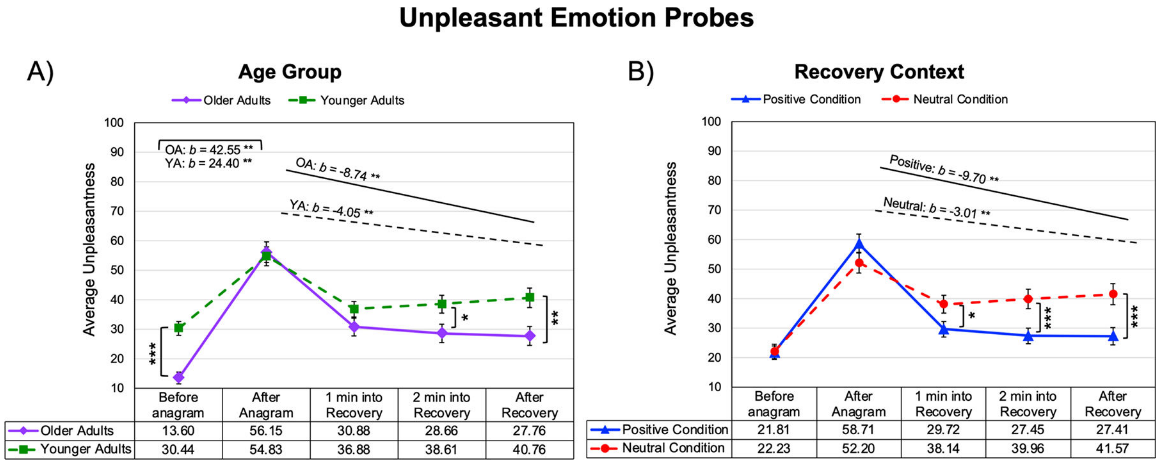

Figure 3.

Panel A presents the means for unpleasant emotion probes at each time point for both age groups. Older adults are represented by the solid purple lines with diamond end points. Younger adults are represented by the dashed green lines with square end points. Panel B presents the means for unpleasant emotion probes at each time point for both recovery contexts. The positive recovery context is represented by the solid blue lines with triangle end points. The neutral recovery context is represented by the dashed red line with circle end points. Error bars reflect 95% confidence intervals.

* $p < .05$. ** $p < .01$. *** $p < .001$.

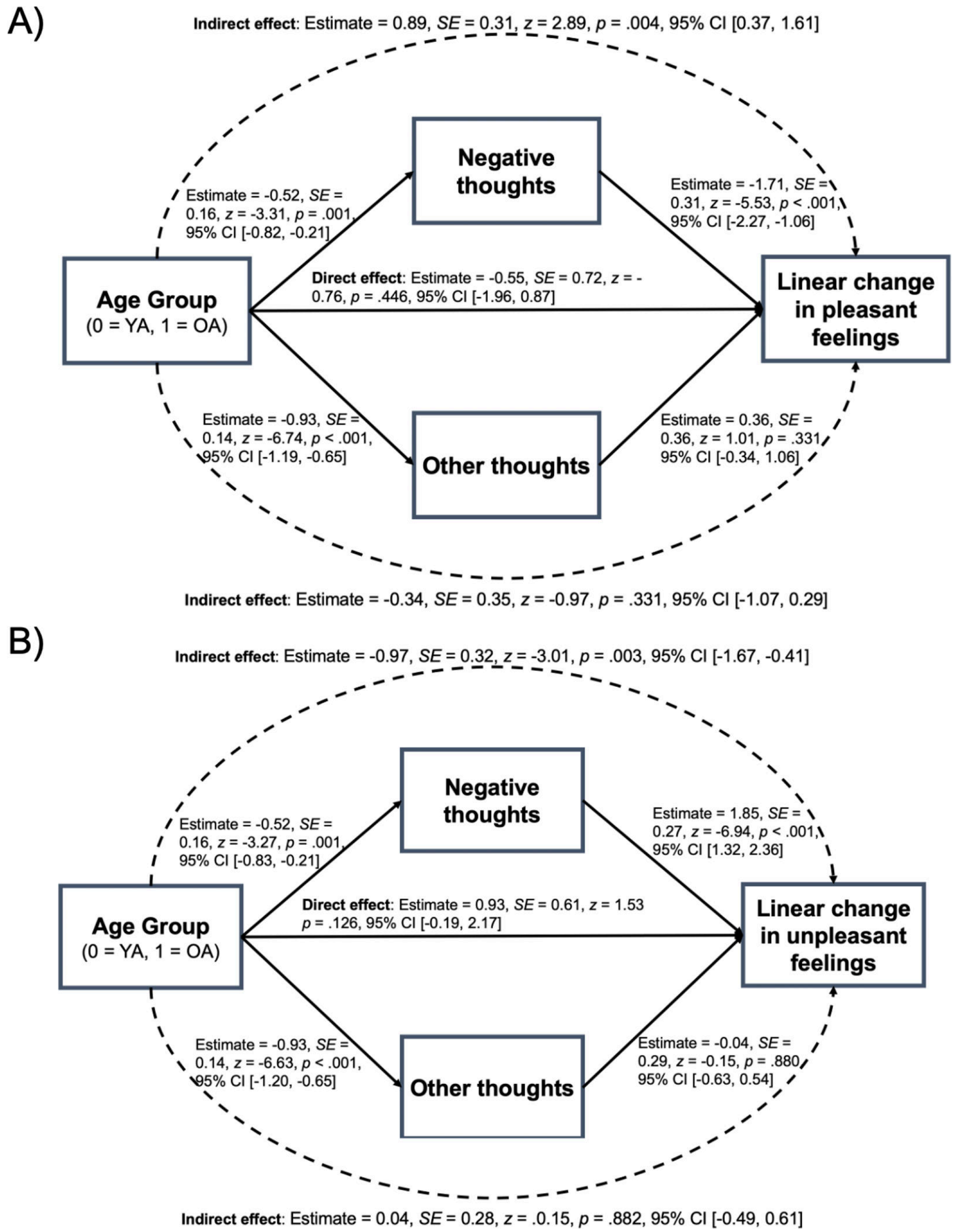

Figure 4.

Panel A and Panel B depict the mediation models exploring whether the effect of age group on the linear change in pleasant and unpleasant feelings during the recovery period, respectively, could be explained by negative thoughts about the recovery video and other thoughts. Bolded lines correspond to the direct effects. Dashed lines correspond to the indirect effects.

Table 1.

Sample Demographics

	Younger Adults (n = 85)			Older Adults (n= 85)			Test Statistics		
Variable	***M***	***SD***	**%**	***M***	***SD***	**%**	***t* or X^2**	***p***	**Cohen's *d***
Age (in years)	22.56	3.65		71.05	6.08		63.31	< .001 ***	9.55
Sex (female)			66%			65%	0.00	> .999	-
Ethnicity (Not Hispanic or Latino)			81%			88%	4.13	.042 *	-
Race							7.99	.045 *	-
White/Caucasian			62%			59%		-	
Black/African American			12%			24%		-	
Asian			12%			6%		-	
Other			14%			11%		-	
Education (in years)	14.87	2.19		16.45	1.97		4.84	< .001 ***	0.76
Socioeconomic Status	2.83	1.03		2.76	1.15		−0.42	.678	−0.07
Positive Affect	2.26	0.77		2.21	0.66		−0.45	.657	−0.07
Negative Affect	1.26	0.70		0.61	0.43		−7.27	< .001 ***	−1.11
Vocabulary	30.58	4.07		35.67	2.81		9.48	< .001 ***	1.45
Letter Comparison	9.88	2.72		5.87	1.71		−11.52	< .001 ***	−1.77
Digit Span	21.46	4.82		21.16	4.94		−0.36	.718	−0.06

Note. Socioeconomic status was measured on a 5-point scale (1 = *Lower income*, 2 = *Lower middle income*, 3 = *Middle income*, 4 = *Upper middle income*, 5 = *Upper income*). Positive and negative affect during the past week were rated on a 5-point scale (0 = *Not at all*, 4 = *Extremely*). Older adults' scores on the vocabulary test ranged from 26–40, and younger adults' scores ranged from 21–40. Older adults' score on the letter comparison task ranged from 2–10, and younger adults' scores ranged from 4–17. Older adults' scores on the digit span task ranged from 11–32, and younger adults' scores ranged from 10–32. Please refer to Supplemental Materials for more detailed information on the cognitive and affect measures.

* $p < .05$.

*** $p < .001$